SECURITY DESIGN AS A PART OF BUILDING DESIGN OF AIRPORT FACILITIES

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ABSTRAKT

Tento příspěvek uvádí výčet mezinárodní a národní legislativy týkající se zajištění bezpečnosti na letištích. Dále se zaměřuje na návrh objektů na letišti z hlediska bezpečnosti. Je demonstrován koncept návrhu pro snížení účinků protiprávního činu – zabránění útoku, oddálení útoku či snížení účinků útoku – pomocí implementace opatření v průběhu návrhu letištního objektu. Následně jsou uvedeny používané typy bezpečnostních opatření pro jednotlivé druhy útoků.

Poslední část příspěvku tvoří diskuse týkající se kombinací různých bezpečnostních opatření, také s uvážením působení různých druhů útoku. Je zdůrazněno, že nejefektivnějšího návrhu z hlediska bezpečnosti je dosaženo pomocí multidisciplinárního návrhu ve spolupráci architekta, stavebního inženýra, statika, bezpečnostního technika a dalších specialistů.

KLÍČOVÁ SLOVA

Letiště • Návrh stavebních objektů • Bezpečnost • Uvážení rizik • Mitigace rizik

ABSTRACT

This paper presents international and national legislation related to airport security. It further focuses on the design of airport facilities in relation to security. The design concept for reducing the effects of an unlawful act – preventing an attack, delaying an attack, or reducing the effects of an attack –is demonstrated. The types of security measures used for each type of attack are then presented.

The last part of the paper consists of a discussion. It regards combination of different security measures, also considering the effects of different types of attack. It emphasizes, that the most effective design in terms of security is achieved through multidisciplinary design. The design demands a full collaboration between the architect, structural engineer, security engineer and other specialists.

KEYWORDS

Airport • Building Design • Security • Risk Consideration • Risk Mitigation

1. INTRODUCTION

Requirements related to airport facility design (given in Section 2) include considering potential terrorist attacks.

The concern of the paper is to provide a general insight into the protection measures which help to reduce the risk stemming from possible terrorist attacks. The protection measures vary according to the attack in consideration. Author focuses on the attacks which have the greatest influence on the structure – that is explosion (Figure 1) and a vehicle collision. The risk quantification both before and after implementation of mitigation measures in the facility design is comprehensively commented in FEMA (FEMA-426/BIPS-06 2011) and thus is not included any further.

The general concept is given in the Section 3.1. The specific protective measures used to mitigate attacks with the power effects – such explosion or vehicle collision – are given in Section 3.2. Section 4 is devoted to discussion on the complexity of the topic and how to best approach it.

The paper is based on our previous work (Štefan et al. 2021). Detailed information about the topic can be found therein.

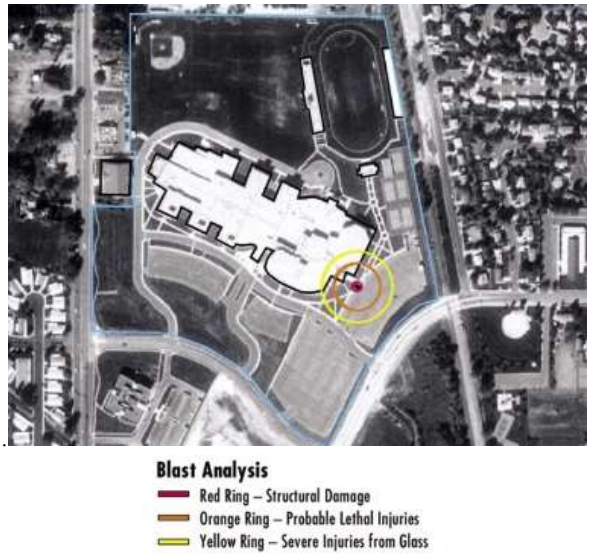

Figure 1: *Blast analysis of a building for a typical car bomb detonated in the building's parking lot. Red radius = 4.5 m, orange radius = 22.5 m and yellow radius = 30 m (FEMA-426/BIPS-06 2011).*

* Školitel: Ing. Radek Štefan, Ph.D., FEng.

2. LEGISLATION RELATED TO AIPORT SECURITY

The protection of civil aviation against unlawful acts (terrorist attacks) is regulated by several international and national documents.

The basic obligations that states must follow in the field of air transport are given in Annex 17 – protection of civil aviation against unlawful acts (ICAO 1974). These obligations arose from Convention on International Civil Aviation (the Chicago Convention) drafted in 1944 by 54 nation and issued by the International Civil Aviation Organization (ICAO).

Then, European legislation includes Regulation No. 300/2008 on common rules in the field of civil aviation security (Official journal of the European Union 2008). The measures to be implemented to meet the requirements are given in Regulation No. 2015/1998 (Official journal of the European Union 2015). According to the prior, the fundamental measure is to define the following areas at airports:

(a) landside,
(b) airside,
(c) security restricted areas, and
(d) critical parts of security restricted areas.

Then, the access to the non-public and security restricted area needs to be secured. Key security features (scanning devices etc.) should be taken into consideration when designing a facility on the airport. These features prevent bringing in firearms, explosives, or other dangerous devices to the public area. It is also important to divide the passenger flows – that is – those who have been controlled from those who have not yet been controlled. The airport divided into areas can be then perceived as a co-centred circles. Each circle represents the borders which require special attention and security procedures.

3. DESIGN OF AIRPORT FACILITIES

The design of facilities on the airport makes a part of the holistic airport security approach. The general concept is given further followed by specific protection measures. The protection measures are used to mitigate the potential risk to protected aspects.

3.1. General concept of the design

The aim is to protect life and health of the people, protect the property within the facility and the building structure itself in case of a terrorist attack.

The process of the design is simplified and given in the Figure 2.

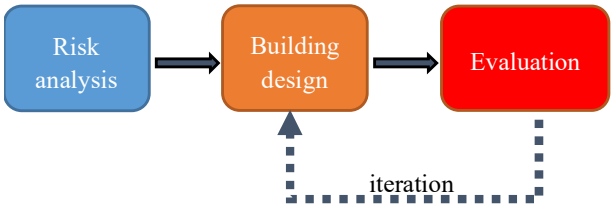

Figure 2: *Simplified diagram showing the method of the design of the facility exposed to potential attack.*

Risk analysis

The airport operator identifies the potential attacks which can occur in the proximity or within the building in question. The threat analysis (what kind of an attack and with what intensity) is conducted by the airport operator, possibly based on information from the state intelligence department (e.g., about formation a terrorist group aiming to disrupt a critical infrastructure element).

The FEMA-based approach (FEMA-426/BIPS-06 2011) uses 3 aspects to determine the risk – both pre-mitigation risk and post-mitigation risk. It is related to the intensity of the attack (how big is the explosion), vulnerability of the building (how vulnerable the building is) and the consequence assessment (what problem would the disruption of the building cause?).

The designers of facilities located at the airport need the information about the attacks that can influence the designed structure. The attack is defined by its type and the intensity. An example would be an attack with 3 kg explosive concealed in a hand luggage. Another example is a vehicle of 9 tons colliding to the facility.

The blast can have various effects on the building. The assessment of the effects is essential for the understanding of the mechanism (Figure 3) and for the correct implementation of the protection measures. The process of the blast effect determination and the structural response assessment is commented further.

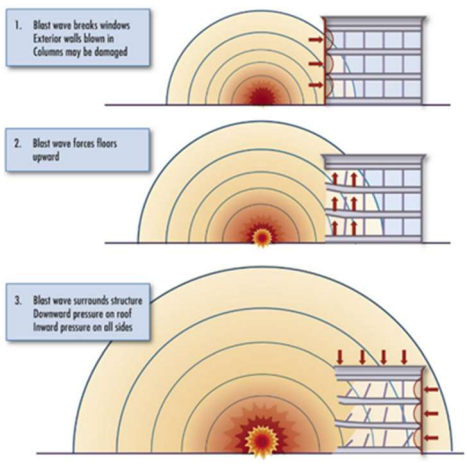

Figure 3: *Reprinted from FEMA (FEMA-426/BIPS-06 2011) and NAVFAC (Naval Facilities Engineering Service Center 1998).*

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Building Design

Before taking on the task of the risk mitigation, the designer evaluates the effect of the force attack. The load can be described by dynamic force (b) or equivalent static force (a).
The response of the structure (c) can be assessed by following. There are simplified methods using single degree of freedom approach or multi degree of freedom. Besides these analytic solution, numerical methods are used. Generally, the fast-dynamic loads, such blast load, are hard solved with analytical methods (Ivanco et al. 2020).

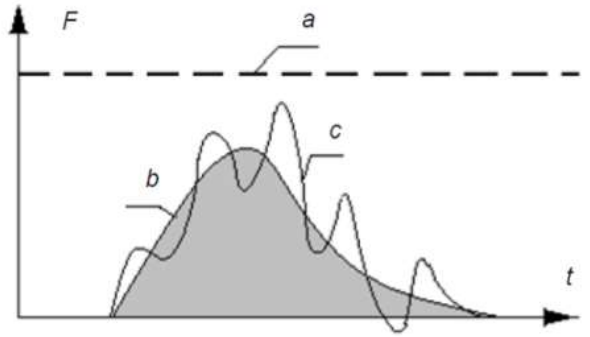

Figure 4: *Reprinted from part 1-7 of Eurocode 1 (BSI 2006).*

The, the designer's task is to mitigate the risk (or harm caused by the attack in other word) to an acceptable limit. Naturally, the sooner this information about potential attack makes its way to the designer from the airport operator, the more comprehensive measures can be implemented. E.g., if the design is still in the initial state of architectural design of the building or of the close area, a separation distance can be provided. That is – not to let a car with IED (improvised explosive device) to the proximity of the building (by anti-collision equipment). Moreover, if the part of the airport is still in the design process, checkpoints may be arranged not to let suspicious cars in the airport area at all.
Generally, three concepts are applied:

A) Preventing the attack from happening: That usually complies with the **urbanistic planning of the airport,**
B) Establishing the security concept (the building design making a fundamental part) to provide for the elimination of the attacker by **conceptual and architectural design of the building and its vicinity,**
C) Minimizing the consequences of attack (lethal or other injuries caused by the attack directly or indirectly by structural damage) by the **building layout and structural design**.

Evaluation

The risk, which was determined by the airport operator (pre-mitigation risk) should now be assessed after the implementation of the protection measures (post-mitigation risk). The evaluation takes place to decide, whether the adequate level of risk (a safety level in other words) is reached. If it is not the case, another protection measures need to be implemented (going back to the building design) and evaluated again afterwards. The design is an iterative process.

3.2. Types of protection measures

In this section, the general concept of the design is demonstrated using the specific protection measures (e.g., separation distance, strengthening the load-bearing structural elements or implementation of protective layers).

A) Urbanistic planning of the airport

Principle: The attack can be diverted by actual physical measures.
Achieved by: Cooperation between the airport operator, security specialist and urbanist-architect.

- **Checkpoints** To ensure adequate control of cars driving to the area (especially when parking there).
- **Speeding restriction** By curved routing, and designing the communication not to be perpendicular to the protected facilities.
- **To use the natural obstacles as anti-collision elements** Such as ditches, trees, embankments, or small lakes.
- **Situational transparency** To provide for comprehensive security surveillance.

B) Conceptual and architectural design of the building and its vicinity

Principle: The establishment of a sensible layout of the building and the proximity of the building, that can provide for a possible elimination of the attack.
Achieved by: Cooperation between the architect and security specialist.

- **Separation distance** Is the most effective protection measure to minimize the effects of the power attacks. It can be implemented also in the architectural design.

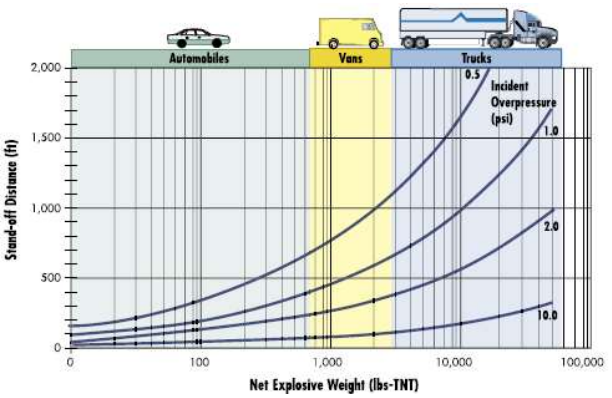

Figure 5: *Overpressure measured in pounds per square inch, as a function of stand-off distance and net explosive weight (FEMA-426/BIPS-06 2011).*

- **Building layout** Divide the space into separate areas according to the Regulation No. 300/2008 (Official journal of the European Union 2008). Enable for the security checks between these areas. Protected elements (e.g., the

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security surveillance centre) place further from the building's perimeter. At contrary, place the high-risk areas near the building's perimeter.

- **Anti-collision equipment** To prevent a car from accessing the facility. That can usually be benches, big and heavy flowerpots (usually concrete), lamps, and other equipment such knee walls, jersey barriers and fixed bollards.
- **Building shape** To adapt the building shape and height according to the effect of the potential attack.

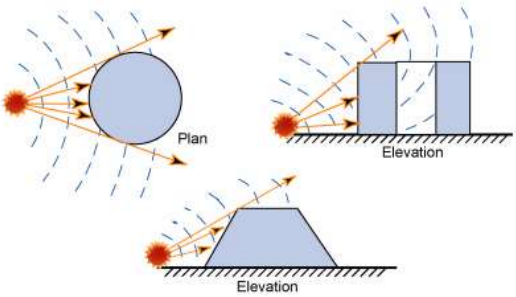

Figure 6: *Building shapes that dissipate air blast (FEMA-426/BIPS-06 2011).*

C) Building layout and structural design

Principle: When the attack is assigned to a proximity or inside a building, the aim is to prevent progressive collapse of the construction and to ensure ductility of the structural elements and the joints. The previous can be combined with implementing architectural elements or cladding material as protective layer.

Achieved by: Cooperation between the architect and structural engineer.

- **To prevent progressive collapse of the construction** That is achieved by combining different consideration during the design. The distribution of load is a key aspect determining whether the progressive collapse occurs. Another aspect is assuring alternate load path - for the load to be transferred to the base when the primary paths are destroyed. The redundancy of the construction makes the potential collapse less likely and less extensive. The attention must be paid to vertical stiffening elements and strengthening the masonry walls. The structural system should be evaluated for possible tensile and shear failure in case of the load direction change (in case of explosion or vehicle collision the direction differs from the gravitational loads).
- **To ensure ductility of the structural elements and the joints** That ensures absorbing some of the energy originating from the force attack in the form of plastic deformation. At the same time, the creation of the projectiles is minimized.
- **To implement architectural elements or cladding material as protective layer** The material properties of the protective layer opt for ductile materials rather than brittle. That ensures minimizing the effect of the creation of the projectiles.

Figure 7: A*rchitectural elements covering the load-bearing structures (Daily Sabah 2022).*

4. DISCUSSION

Assume the risk analysis identifies a possibility of a blast of an equivalent 20 kg TNT in the underground parking in a planned administration building on the airport. The structural engineer calculates the effect of the blast to the structure. Then, adequate protection measures are provided – stronger reinforcement of the elements, implementation of protective layers – yet the post-mitigation risk might still by unacceptable. Another protection measures could be financially unfeasible or simply not possible. Another option needs to be considered.

For example – based on communication with the security specialist – to ensure the parking lot is a security-restricted area with a high-level control on its entrance. The protection measures then might not be needed at all. The architect must then make sure there is a proper space for placing the checkpoint.

However, that solves the problem of high risk, not the problem of the need of more public parking. The urbanist-architect should now be at hand, also in cooperation with the airport operator, to ensure an adequate alternate solution. That could be a plan of public parking area in the distance from the main airport facilities. This could, however, take few more years.

This example aimed at showing the complexity of the topic. The need for long-term planning is emphasized. Also, the risk analysis conducted by the airport operator may designate different types of attack – e.g., a blast and CBR (Chemical, Biological and Radiological) attack. The multidisciplinary cooperation is preferred from the very beginning of the facility design, preferably from the beginning of the area planning. The preferred option is to invite the architect, structural engineer, security engineer and other specialists to the urban planning of the whole airport or the expansion of an existing one.

5. CONCLUSIONS

The paper lists the standards and recommendations related to consideration of a terrorist attack during the airport facility design.

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The concern of the paper was to provide a general insight into the protection measures reducing the risk stemming from possible terrorist attacks. The focus was given to the attacks which have the greatest influence on the structure (that is explosion or a vehicle collision).

The general concept of the design was given. The specific protective measures used to mitigate the attack with power effects – such explosion or vehicle collision – were listed. Finally, discussion on the complexity of the topic and how to best approach it was included.

ACKNOWLEDGEMENTS

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