URBAN DESIGN GUIDELINES FOR AIRPORT ENVIRONMENTS FROM THE PERSPECTIVE OF PASSIVE DEFENSE (TO DEAL WITH TERRORIST ATTACKS) - CASE STUDY: NORTHERN PART OF THE SPINE ROAD OF IMAM KHOMEINI INTERNATIONAL AIRPORT

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Abstract. This research attempts to identify urban design principles resistant to terrorist explosions in public areas of airports. The research method was descriptive-analytical and data collection was through library method such as literature review and local survey. To use the research results, Tehran Imam Khomeini Airport is used. The findings indicate that three effective characteristics are required to achieve terrorist blast-resistant urban landscape design. All three qualities are functional components of urban design. Some of these provide facilities for the prevention of explosion and the other part of these qualities minimizes the harm to the individuals and the body of the airport. At the end, according to the stated goals, the solutions will be provided in the format of urban design guidelines document in both substantive and procedural aspects.

Keywords: passive defense, urban landscape, airports, terrorist explosion, Imam Khomeini International Airport

1. Introduction

In the last century, one of the most serious types of human challenges is the concept of "terrorists" which more than ever threatens physical and psychological safety of human kind that are the most important social capitals. The use of passive defense in order to deal with terrorist threats and to reduce its damage is a fundamental issue. It covers almost all vital and vulnerable centers of economic, political, military, communications, scientific, cultural, and public areas of cities where serve as gathering place for citizens. So, protecting national security and political, economic and defense independence, vibrant urban life and its social life depend dramatically on comprehensive planning on the subject. Countries that have experienced the damage and losses caused by terrorism, today, pay special attention to the passive defense to preserve their national and social capital and vital resources. They have also paid special attention to the subject in their defense strategies.

Airports, in this context, are of particular importance. They are one of the critical infrastructure of each country that cost a lot of material and human costs and a lot of time to be built and maintained and serve as a bridge between cities and countries and, in fact, human beings. Given that airports are in the third ring of Warden's Five Ring's Theory, they are of the most priority among enemy targets. It has additional priority considering Tehran Imam Khomeini International Airport as vital centers of the Ministry of Interior. It means that there have always been the probability of potential threat, for various reasons, to impair the function of the airport temporarily or permanently. One of these threats, as mentioned, is the terrorism. It often considers the following four objectives in its threats: 1- human targets (figures and ordinary people) 2- facility targets (important, crucial, sensitive, and protectable places) 3- equipment targets (Special, sensitive, important and protectable) 4- soft targets (programs, plans and ...). Therefore, it is essential to plan and implement the passive defense in order to prevent these threats from reaching their intentions. According to aforementioned sensibilities, this research tries to somehow fill the gap of the absence of planning and implementing in passive defense in the public areas of airports. It also attempts to provide effective solutions to deal with classic terrorist attacks (bombings, suicide attacks, remote control explosive cargos) and to minimize vulnerabilities in the field.

2. Literature

According to the research topic, topics like passive defense, threat, general introduction of airport, and concepts and principles of urban design have been discussed in this section.

2.1 Defense and passive defense

Defense are measures taken by one or more allied countries to resist against political, military, economic, social, psychological and technological attacks (Jalali and Hashemi Fesharaki, 2011) . Defense are of two types: active and passive. Tools and technologies are applied to prevent enemy invasion, especially air strikes, are categorized in active defense (Asgharian Jeddi, 2008).

Passive defense is the set of non-armed measures that increase the deterrent power, decrease vulnerability, cause the continuity of the essential activities, enhance national stability and enhance crisis management in the face of threats and military actions (the first paragraph of the general policies of the government in the areas of passive defense, 2011). It also refers to a series of defensive measures we can use to resist against the enemy's surprise invasion with minimal facilities and technical equipment (Asgharian Jeddi, 2008).

2.2 Threat

In general, the threat can be defined as the result of attempts to cause injury and damage and disrupt the current order and activities (Jalali, 2013). In terms of the source, threats categorized as natural and manmade threats and perceived threats to important centers.

Perceived threats to important centers, including civilian airports, have been mentioned with different categories in in different sources. Two examples will be discussed here.

In the draft of twenty-first discussion about the national building regulations entitled "passive defense", the perceived threats to the important centers have been addressed as follows:

- Natural threats include floods, earthquakes and hurricanes
- Man-made military threats including air, land and sea strikes
- Man-made security threats including terrorism and suicide attacks
- Man-made accidental threats include industrial disasters and negligence (draft of National Building Regulations, 2010).
- The book "Architectural requirements in sustainable passive defense" have also described the threats as follows:
- Natural threats; caused by dust, extreme heat, floods, etc.
- Security threats; terrorist attacks, explosions, hostage-taking, separatist movements, riots and...
- War threats; land, air and missile threats and people-centered operations and irregular wars (Asgharian Jeddi, 2008).

It should be noted, the threat in this study is the terrorist explosions that are among the classic terrorist threats (including bombing, suicide attacks and remote-controlled explosive cargos). However, the perceived threats to the civilian airports are beyond this specific type.

2.3 Airport

Airport is a collection of various facilities and equipment brought together to provide facilities for transferring and air

transport. As marine transportation is required sea port, the airport can also be likened to the Air Port that is indispensable for air transportation (Behina, 1985). It is considered as an integral part of a city infrastructure that helps to enhance its business potential (Nazarian et al., 2011). The main purpose of an airport, also, is to provide access for passengers and cargos to air transport. So, the airport aim is to provide essential link between the air and the ground. (Wells and Yount, 2004).

Progress and development of the aviation industry in the late twentieth century as well as the importance of this industry in recent years have attracted attention to the key role of infrastructure development in the aviation sector in order to achieve sustainable development. The requirement for achieving development in today's world is to increase speed in economic activities, exports, communication with the various sectors within and outside the country and etc. With a little reflection, we realize that all this is not accessible except by upgrading capabilities in the aviation sector. So, airports and relevant communication networks and the sustainability of their activities in times of crisis, not as a requirement, but as an inevitable necessity should be pursued in macro level nowadays. Due to the changing nature of wars and smart approaches of new wars with elements of precision, speed and intensity, airports can be targeted precisely in the early hours of conflicts. As far as the opinion of some experts, dual capabilities for airports should not be expected (Hosseini et al., 2015).

2.4 Urban design and urban landscape

In general, there are various definitions of urban design. The definitions are different based on the time period they belong to or the details that the definition provides. One of the definitions of urban design in its adolescence in the late 80s to 90s is as follows: "Urban design is more than concentrating only on aesthetics of urban environment or artistic deployment of its elements. Urban design is concerned with the creation and maintenance of urban areas in which appropriate responses to ecological issues, economic welfare and collective life have been combined. "

Given that in this study issues related to urban perspective cover the major part of the intersection of urban design and passive defense, its meaning and principals will be discussed in this section.

"Urban landscape" is considered as the contact area of "man" and "city". Good urban landscape can increase the competitiveness of cities. Urban design can be effective in attracting creative classes and top activities and ultimately improving socio-economic status of cities through urban landscape management and improving the quality of the environment. This effect is so that a good urban design and urban landscape can have well defined and measurable "economical", "social" and "environmental" added value for development projects and urban construction (Golkar, 2012). Urban landscape elements include the structural elements (lining, floor), space complementary elements (natural elements), unnatural elements (urban furniture, population, various means of transport). In terms of scale, urban landscape fall into three categories: large-scale and the perspective of the city, mid-scale and inner city landscape and small-scale and the city space.

So, according to all that was said about urban design and urban landscape, it can be concluded that the role of the strength and stability of structural elements of the urban landscape and also the functional targets of urban landscape (like readability of the environment) are undeniable in reducing airport vulnerability against explosions and preventing the explosion. They will also help to enhance the safety of the environment and security of passengers.

2.5 The relationship between urban design and passive defense

Paying attention to the normative design of open spaces based on defensive ideas by designers of biological complex and enforcement officers of urbanization laws increases the safety factor and consequently decreases injuries and damage. These losses can be reduced to a minimum by intelligently integrating urban design elements, natural elements of architectural elements and principles of passive defense. Of course, in many urban areas, it is not possible to make secure all the open spaces. Therefore, we can only secure the limited spaces to enable users to feel safe and secure in vacation and leisure time (Farzam Shad, 2008).

3. Research process

The main objective of this research is to develop general urban design guidelines for the north side of the spine road of Imam Khomeini International Airport based on principals of passive defense. These guidelines are also usable for other international airports. The research method is descriptive-analytical. After reviewing the related literature and the introduction of the site, urban design guidelines from the perspective of passive defense (to deal with terrorist attacks) have been developed for airport environments. Field study and library method were used for data collection.

4. Introducing the Case Study

Imam Khomeini International Airport Project was planned in 1951 during the Pahlavi era and was called the airport Shah of Iran, but it was after the Islamic Revolution in 1997 that the construction began and continued until 2005. Phase one was completed during the past few years.

Now, Imam Khomeini International Airport has a handling capacity of 4.5 million passengers and 120 thousand tons per year. Its capacity can be increased to 5.6 million per year. In the final phase, it will serve 90 million passengers.

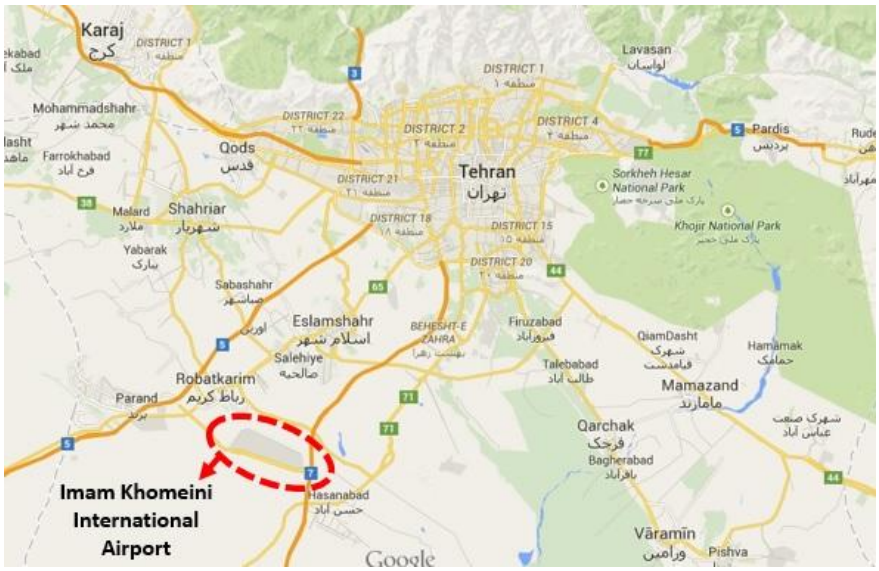


Figure 1: Location of Imam Khomeini International Airport compared to that of Tehran. Source: author

Reviewing studies related to detailed and comprehensive plan of the airport city and Imam Khomeini International Airport Master Plan studies indicate that the spine road of the airport has been dedicated to airport usages (passenger terminal and its parking lots) and commercial corridor that is in relation to the other tourist, cultural, and sports sections in the airport city. Unfortunately, there is no plan for urban design resistant to terrorist bombings in any of future development sections of the airport and airport city. Therefore, there is the gap of urban design guidelines resistant to terrorist bombings in public area of the spine road of the airport.

4.1 Assessment of strategic areas

Strategic area of the research reach to Azadegan highway from north side, Shoor river from south, Tehran-Saveh highway from the west side, Tehran-Qom highway from the east side and to the Industrial Zone of Hasanabad from the southeast side.

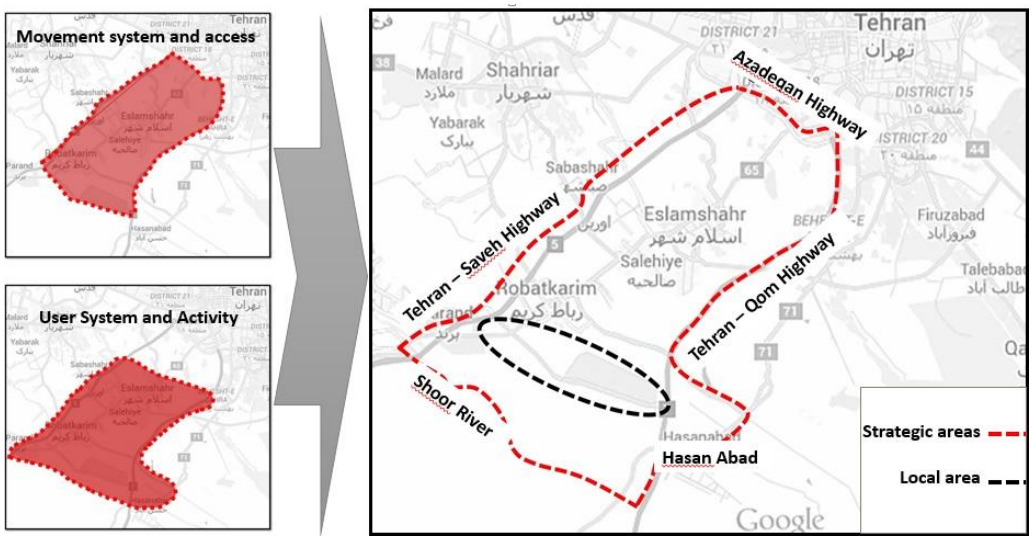


Figure 2: The studied strategic area.

After scrutinizing strategic area, the system of movement and access, the system of land use and activity, and identification of police, relief and services centers around the site, the physical form and urban landscape systems were studied. The results of this study showed that due to the location of the airport (outside Tehran surrounded by desert and dry areas), the role of use and activity and movement and access systems is important in the event of a terrorist explosion and a crisis. So, strategic area should be scrutinized according to the two systems. Thus, quick and easy access of relief and security forces and the existence of such things with the proper distance to the airport are among the important cases that were considered in the assessment of strategic area.

Terrorist bombing scenario in the Imam Khomeini International Airport

This scenario is played by terrorist groups supported by enemies of the Islamic Republic of Iran. The members or coaches who trained and equipped by necessary trainings and equipment in hostile countries enter into the territory and attempt to bomb with the aim of tarnishing the international image of the country security, showing it as an opposition fostering country, incurring massive human losses and implying the gap between the people and the government. These terrorist acts can occur in areas with public access such as car parking, passenger terminal and access roads. One of the most vulnerable points to the terrorist blast is the terminal entrance. Due to the glassy wall and the possibility

of the bombed vehicle collision with the door, the most damage will be in the airport terminal.

Also, the maximum bang can be in a bombed truck whose losses and risk radius will be72 and 286 meters respectively. So, risk radius of 286 meters is the maximum radius that causes slight damages and leaves the glass cracked or broken. Given that the scope of this survey is the public areas of Imam Khomeini International airport in Northern spine, this number can be used to scrutinize the local area for studies to assess the current situation in the airport. It will be discussed in the next sections.

Figure 3: the radius of loss and the radius of risk

In the event of such a scenario, it has a lot of physical, human, economic and social consequences at the airport.

Substantive assessment of local area

In this study, the criteria for the assessment of local area is based on improving safety and security in the public area of airport and its stability against explosion in the form of use and activity system, movement and access system, urban landscape, public spaces and physical form.

Substantive environmental system assessment was skipped due to the lack of impact on the topic of this article. After assessing the aforementioned systems, integrated analysis has been provided as figure 4.

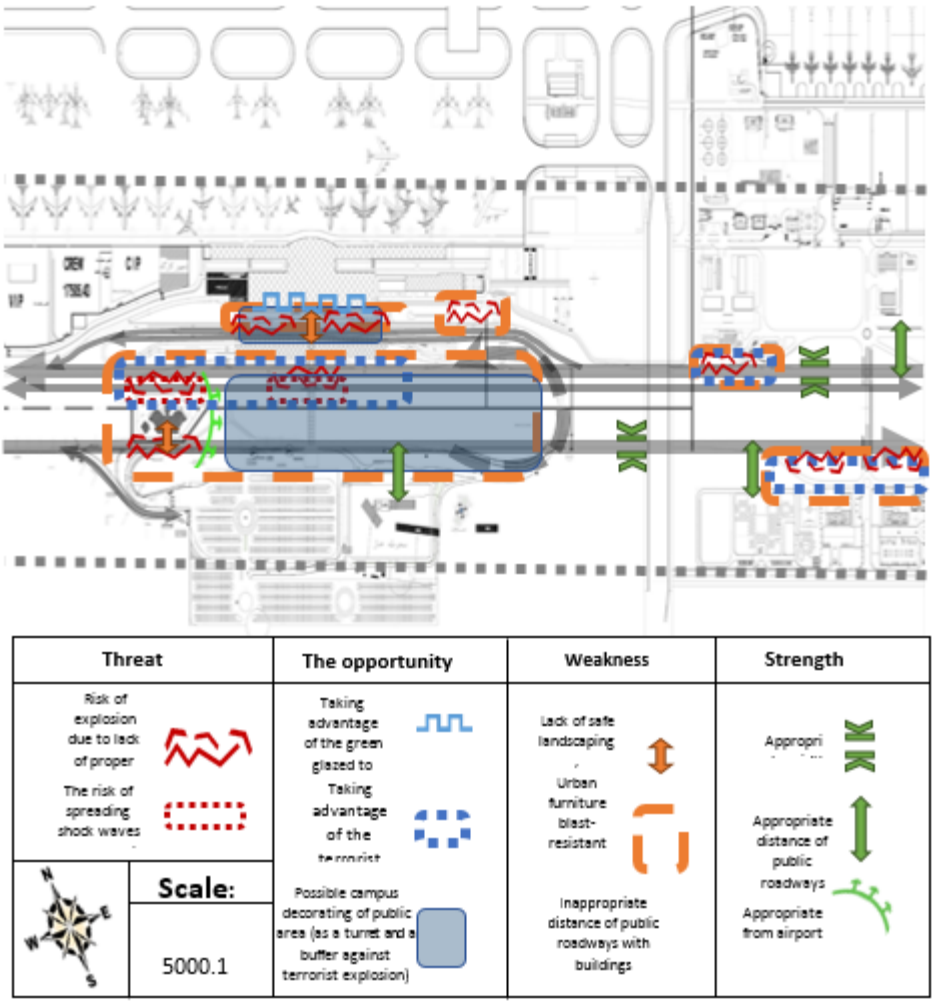


Figure 4: Integrated Analysis.

According to the assessment of the strategic area and all investigated points, it can be concluded that the local area is vulnerable in the terminal and its surrounding access, the public area between the northern and southern spine and also along main roadways and sidewalks next to the important buildings of the airport. In the event of an explosion in the above mentioned three sections, serious losses will be inflicted on the body of the airport and innocent people lives. So, it is necessary to have effective strategies about the urban design in these three sections to deal with the terrorist explosions.

5 Urban Design Guidelines

Design guidelines, as a means of controlling quality content, provide leading details that makes clear how a certain type of development can be implemented in accordance with the policy of designing a design. Design Guidelines is a document to control and guide the qualitative aspects of development.

5-1 Vision Development

Developing a vision of a place aims to offer a goal to residents for all their efforts and to describe something that is likely to be achieved in the future.

There are different ways to develop a vision statement including the "Oregon" model. Oregon Model is a process including four steps. Each of these steps is based on a simple question:

1. Where are we now?
2. Where are we going?
3. Where do we want to be?
4. How to get there?

This study is to answer the third question in the Model (where do we want to be?). Developing macro and micro goals of provided urban design guides will also answer the fourth question (how to get there?).

5.1.1 Vision developing using the Oregon Model

Table 1: Vision developing using the Oregon Model. Source: author

Application of framework in Imam Khomeini International Airport	Vision statement framework		
Iran as a gateway into security and peace	Implicit meaning	Meaning	Main points
Urban design resistant to terrorist explosions	Explicit meaning		
Business-services activities	Economic morphology	Identity	Details
A safe and full of relaxation place to fly to international destinations and a place for leisure time of travelers, greeters and escorts	Socio-cultural morphology.		

Sustainable urban design resistant to terrorist explosions	Physical morphology		
In and out gateway of the country in international scale	Local position	Structure	
	National position		
	Regional-international position		

5.1.2 Vision Statement

1. Where we want to go?

Imam Khomeini International Airport is Iran's secure gateway in year 1400 and is an entry and exit gate of Iran in an international scale. Public areas of the airport located in northern side of spine which includes airport terminal, safe and green public areas, and metro stations have an urban design resistant to terrorist attacks and provide a safe and full of relaxation place to fly to international destinations and is a place for leisure time of travelers, airport greeters and escorts. Public areas between north and south spine that make a proper connection with the metro station, terminal, public parking, hotel building and mosque have become a convenient place for travelers and their companions to stop and spend time due to the blast-resistant urban furniture and secure corners. On the sidelines of the main access routes, especially around the important buildings, there are blast-resistant barriers designed to preserve the tranquility and beauty of the urban landscape while making the buildings secure against terrorist bombings and not disturbing the peace of pedestrians. The main entrances of the terminal and directions to them have blast-resistant urban furniture and their glassy walls with proper exposure to the light, covered with green and blast-resistant plants and they have created a green and beautiful wall. Spine road of Imam Khomeini airport is an example of sustainable urban design resistant to terrorist attacks. It is a window to interact with the international community to lead Iran towards security and peace and to represent the genuine and peaceful spirit of the ancient land of Iran.

5.2 Developing macro and micro goals

2. How to get there?

In this study, macro and micro urban design goals have been developed to answer to the fourth question of the Oregon Model.

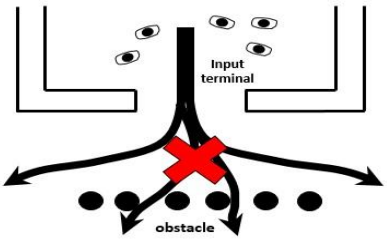
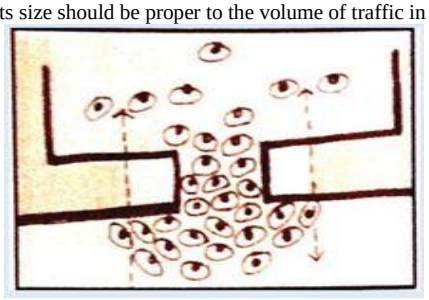
Table 2: Macro and micro goals. Source: author

Micro goals	Macro goals	
Using the terrorist blast-resistant urban furniture Creating safe places and corners in public areas	Promoting public area safety	Substantive aspect
Creating Physical barriers Discharging the blast wave properly	Stability in the terrorist blast	
Immunization of the walls Securing the physical access to the terminal	Improving the quality of the terminal entrance area	
Raising the awareness Increasing social control	Increasing interaction and citizen participation	Procedural aspect

5.3 Developing the urban design guidelines document from the standpoint of passive defense

Urban Design Guidelines document from the perspective of passive defense has been developed in two dimensions: substantive (system of movement and access, the urban landscape system and public spaces system) and procedural. The following figures explain it clearly.

Table 3: Urban design guidelines in the system of movement and access. Source: author

Solution	Micro goal	Macro goal
It is recommended to avoid installing any barriers to movement in the routs  It is recommended to floor streets with soft materials. Emergency entrance should be legible and distinct and as complementary part to the main entrance. It is recommended to Roof the main routes leading to the terminal (to increase safety when explosions and falling debris). Emergency exits size should be proper to the volume of traffic in times of crisis.  Installation caps should be designed in such a way that when evading, not to disturb the movement of people. The caps, for camouflage, should be designed in concert with floor. 	**Secure physical access to the terminal**	**Improve the quality of the terminal entrance area**

Rest of Table 3: Urban design guidelines in the system of movement and access. Source: author

Solution	Micro goal	Macro goal
 It is recommended to Use Bollard, benches and platforms resistant to explosion in front of terminal gates to prevent bombed cars from entering. To Use the waterfront between streets and important buildings to keep the bombed car. To use the retaining walls between the streets and important buildings such as telecommunication building and security building. To use sculpture and other works of art to improve readability of routes.  To have military definition of related symptoms to improve routing and emergency exit in the terminal. To cover retaining walls in front of the entrances and public areas with suitable vegetation or use them to install billboards and educational banner	**Create Physical barriers**	**Resilience in the face of terrorist explosion**

Rest of Table 3: Urban design guidelines in the system of movement and access. Source: author

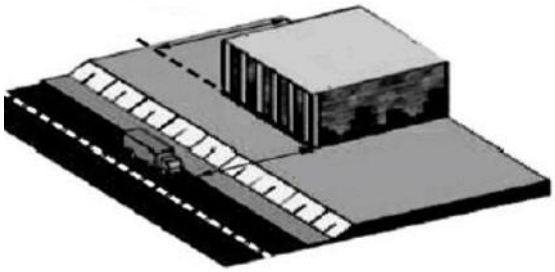
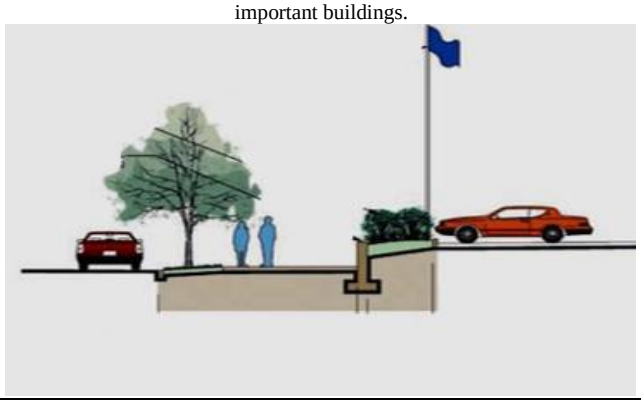
Solution	Micro goal	Macro goal
 To Use obstacles in the form of blast-resistant hills with vegetation between the streets and important buildings such as telecommunication building and security buildings. To use physical barriers such as walls in the form of blast-resistant hills with vegetation around the train rails and between the terminal and control tower building. To create a blast wave absorbent structures with gaps in it for the proper discharge of the blast around the bridge connecting the metro station to the terminal and its underlying passage.  To make street with level difference in front of important buildings where there is not enough space to create retaining walls and hills. To use strong gardens (a combination of retaining walls with gardens and vegetation) between the streets and important buildings. 	**Create physical barriers**	**Resilience in the face of terrorist explosion**

Table 4: Urban design guidelines in the system of urban landscape. Source: author

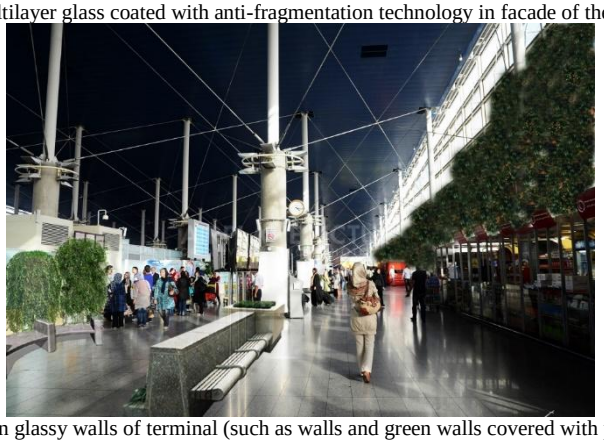
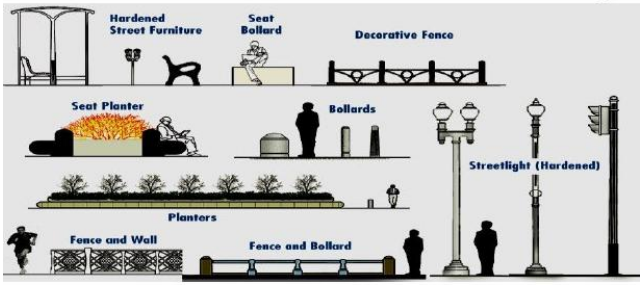
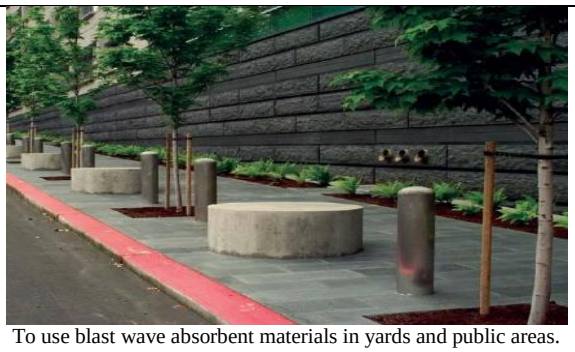
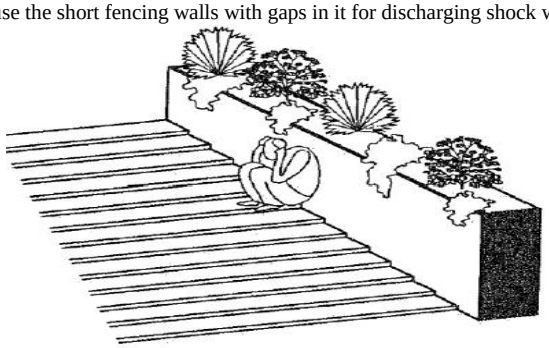
Solution	Micro goal	Macro goal
To use multilayer glass coated with anti-fragmentation technology in facade of the terminal.  To Create filters on glassy walls of terminal (such as walls and green walls covered with plants). Providing appropriate exposure for the terminal, it minimizes the risk of glassy fragments to hit the people. To build the facade of terminal wall with the combination of vegetation and multilayer glass covered with anti-fragmentation technology. -to remove sharp and pointy elements from the walls. To use of blast-resistant barriers such as platforms, sculptures, benches and billboards in the terminal corridor around glassy facades as shelter against glass shrapnel. -to use green walls and green roofs on adjacent buildings and public areas.	**Securing walls**	**Improving the quality of the terminal entrance area**

Table 5: Urban design guidelines in the system of public spaces. Source: author

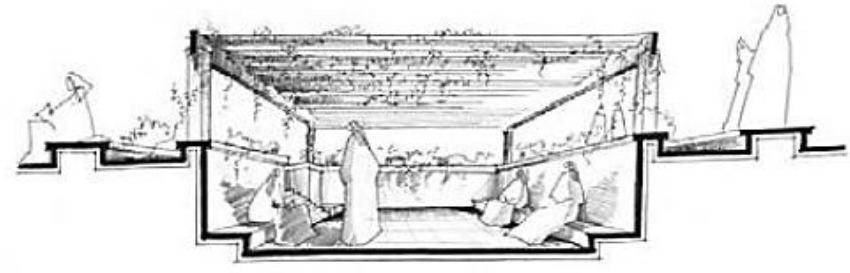
Solution	Micro goal	Macro goal
To create a coordinated and blast-resistant set of urban furniture such as benches, stands, vases and etc. in public areas of the airport which act as shelter and prevent bombed cars from entering into pedestrian passageways and buildings.  To use smart urban furniture such as trash cans equipped with sensors that detect bombs in public places of airport. To use energy-efficient LED lighting which is useful in the event of an explosion and power outages.  To use laminated urban furniture to prevent radiation of toxic gases in case of fire. To use round urban furniture with no sharp corners in the public areas of the airport.  To use decorative elements such as statues and large stones as shelter in public areas of the airport.	**Use the terrorist blast-resistant urban furniture**	**Promoting safety of public areas**



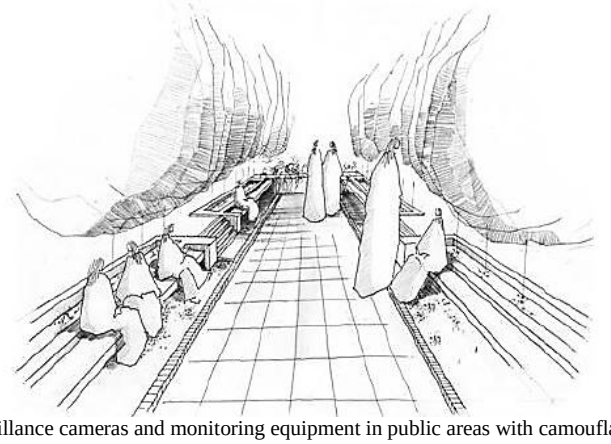
To use blast wave absorbent materials in yards and public areas.
To floor the areas using soft materials.
To use the short fencing walls with gaps in it for discharging shock waves.



To semi-enclose spaces and places to sit in public areas using level difference and vegetation.



To properly use evergreen trees such as pine and boxwood in the public area.



To install surveillance cameras and monitoring equipment in public areas with camouflage suits them.
To use detection and warning systems with the ability to communicate bilaterally in the public areas.
To create an opening in the yards and buildings.
To create gaps in walls and retaining walls around important buildings.

 To create pilot and stepped forms for buildings in the public areas of the airport that will be built in future developments.		

Table 6: Urban design guidelines in the procedural aspect.

Solution	Micro goal	Macro goal
Installing warning, informative and educational signs and having places to show educational short films in public places especially in the terminal.	**Increase people awareness**	**Increase interaction and citizen participation**
To avoid creating dark corners in public area without good vision, especially inside the airport terminal. To crate proper lighting in streets and public areas at night.	**Increase social control**	

6. Conclusion

In this study titled "urban design guidelines from the perspective of passive defense in airport environments ", we attempted to identify urban design principles resistant to terrorist bombings in public areas of airports. After studying the structure of passive defense in the field of classic terrorist threats (including bombing, suicide attacks and remote-controlled explosive cargos) and urban landscape, it was concluded that passive defense, in the area of terrorist threats related to this study, is an instrument to reduce risk and increase efficiency of airport after the terrorist explosion. In the concerned areas, urban landscape provides suitable framework for passive defense. Thus, according to the objectives of the present study and surveys conducted around them, the blast-resistant urban design that simultaneously incorporates urban design concepts and passive defense in the area of terrorist threats identified as a link to join these disciplines.

Finally, an attempt was made to introduce simple and applicable solutions in the public areas of airport environments to fill the gap of the absence of terrorist blast-resistant urban design. So, strategies were provided that are applicable in public areas of all international airports.

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