

DOI: 10.7596/taksad.v6i3.983

**Citation:** Ghanbarpour, H., Kachoee, M., & Nezafat, M. (2017). A Comparative Study of the Application of Passive Defense Strategies from the Perspective of Urban Design at International Airports: International Airports of Ben-Gurion, Munich and Singapore Changi. *Journal of History Culture and Art Research*, 6(3), 1118-1138. doi:<http://dx.doi.org/10.7596/taksad.v6i3.983>

## A Comparative Study of the Application of Passive Defense Strategies from the Perspective of Urban Design at International Airports: International Airports of Ben-Gurion, Munich and Singapore Changi

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### Abstract

Billions are spent every year to construct vital infrastructures around the world. On the other hand, we witness terrorist crimes and the killing of innocent people and causing serious physical and psychological damages to them every day in every corner of the world. Unfortunately, today this trend has not been stopped and likely will continue. So, due to the fact that the most important issue in urban design is human and the most important goal is to create safe and stable places for them, it can be concluded that in critical infrastructure such as airports, which are a priority to strategies to deal with terrorist threats, public areas vulnerabilities against terrorist threats have to be investigated to understand the weaknesses of the target infrastructures. So, determining its attractiveness for the invasion, civil defense measures can be taken to reduce vulnerability. In this regard, urban design principles should be applied to reduce the blast effects and to minimize the damage in the public areas of airports. In this study, by implementing an analytical-descriptive methodology, we attempt to identify urban design guidelines resistant to terrorist bombings in public areas of airport environments. The findings of this study show that in achieving terrorist blast-resistant urban design, deployment of strategies in the field of building components, atmosphere, design, and urban landscape will reduce the vulnerability of airports.

**Keywords:** Passive defense, Urban design, Airport environments, Terrorist explosion.

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## **1. Introduction**

Providing security, as one of the basic human needs, in addition to meet basic needs (physiological), can be a ground to fulfill other needs. A sustainable city requires a stable and safe environment for its inhabitants. Once the individual's confidence about safety and security decreases, the ability to live a perfect life fails significantly (Gharakhlou and Hosseini, 2006: 174-175).

Defense can be classified as active defense, passive defense, non-military, political, economic, social, and spiritual. "Active defense" is the set of potential and actual facilities of trained manpower and military means that are classified in the form of ground, naval and air forces (Ziari, 2001: 31).

One of the critical infrastructure in the transport network of cities is air transport. Given that airports are on the third ring of Warden's Five Ring's Theory, are of the most priority among enemy targets. One of the key points for the enemy is to use the airport as a base for entry and exit of manpower and military equipment. The enemy tries to use terrorists to damage public areas of airports by bombing and creating chaos and to impair its operation without causing any damage to the airport flight range for its traffic. It wants to occupy the airports before the country.

So, in this article we have tried to study world experience principles in designing civilian airports and extract the urban design solutions to increase sustainability and reduce vulnerability of the international airports in the country against terrorist attacks.

## **2. Theoretical foundations**

According to the research topic, concepts such as passive defense, threat, airport general introduction, concepts and principles of urban design and communication will be discussed in this section.

### **2.1 Passive defense**

Passive defense is a set of optimization of important facilities of the country to minimize the damage in the case of war (Andalib, 2009: 1). Passive defense prevents surprise attacks of the enemy and even can deter the enemy from starting or continuing the war (Setare, 2011: 50). Based on previous experiences from the past two decade's wars and the strategy of destroying centers of gravity, infrastructures and transportation networks, especially airports are among the enemy goals in future attacks. Since, civilian airports of the country are strategically

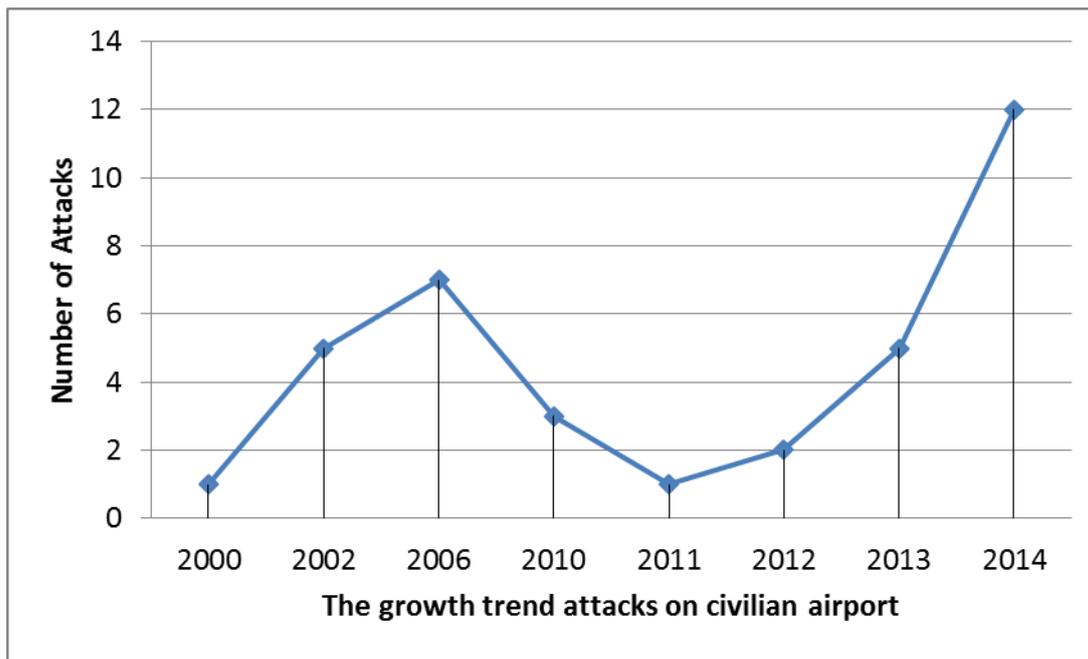
unique and in the field of governing and their political, social, cultural, economic, psychological, and... Influences are transnational. Any disruption, damage or destruction of these centers paralyzes and cancels the majority of the flights, transit of goods and passengers and causes serious physical or mental harms to innocent humans. So, the most important task of passive defense in civilian airports is primarily to do a set of actions that lead to the continuation of airport activities in times of crisis and then is to reduce the human and physical losses and provide security for the passengers in the case of the threat.

## **2.2 Threat**

Human has grown with threat and has taken various measures to deal with it. Some of these threats no longer exist and some threats are more or less or new. In recent decades, the process of dealing with these threats has taken a more scientific way. In particular, the probability of occurrence, damage and how to deal with them have been determined (Asgharian Jeedi, 2007). In general terms, the threat is to scare someone to prevent attack or to achieve a predetermined goal. Anything that is against human security and endangers human security and stability is considered as a "threat" (Jalali, 2011). Threats are of two kinds: natural and artificial (man-made). In this study, by the threat it means the terrorist explosions (man-made) that are classified as one of the classic terrorist threats (bombings, suicide attacks and remote control explosive cargos). However, perceived threats to the civilian airports are beyond this particular type.

## **2.3 Study the history of terrorist threats in civilian airports**

The desire to invade airports has dramatically increased in the international disputes of the last half-century (Figure 1). The reason is undoubtedly the effective role of airports in continuing political, social, economic, and military activities of the countries. This issue has increased its appeal for invading enemies and reflects the wide sphere of influence of airports in all important sectors. Absence of an airport can actually affect the activity of its sphere of influence and paralyze or disrupt it that it has a lot of negative consequences.



**Figure 1:** Growth of deliberate man-made threats to the airports over the last 15 years (Ataei, 2015)

As can be seen in the graph, only in 2014 and until the middle of it 9 attacks have been carried out to civilian airports that implies a dramatic increase. These terrorist attacks have been conducted by paramilitary groups.

According to the history of the threat in civilian airports, it can be concluded that the terrorist bombings in civilian airports have increased significantly all over the world especially in the Middle East in recent years. In addition to the physical effects, it has negative psychological effects on many people in the city. So, it is necessary to implement strategies to reduce the vulnerability.

## 2.4 Airport

Airport is a collection of various equipment, systems, users, staffs and laws by which the function of an Air Port is established. This function includes transfer of passengers, transfer of loads and internal services (Wells & Young, 2004).

### 2.4.1 The main components of an airport

Airports are basically divided into two parts: air and land (Saffarzadeh and Masumi, 2004). The components of an airport collection include a network of airways, airspace of the airport,

runway, taxiways, maintenance and waiting areas, parking area, terminal buildings, turning system of ground vehicles and parking and ground access system.

According to various sections of airports, public areas of civilian airports that are discussed in urban design include communication and access sections, waiting room of the terminal and its surrounding public areas such as commercial and recreational buildings. These spaces have to have safety for physical access of passengers to the airport and have the possibility of an emergency evacuation of passengers in the event of a crisis. Also, the design of the airport should be such that in the event of an explosion the lowest amount of damage to be inflicted to the individuals and the body of the airport.

## **2.5 Urban design and urban landscape**

Urban design is an interdisciplinary and group activity, including problem-solving processes and solutions that aim to organize the physical part of the public areas of cities in a way that would improve the performance and biological quality of urban places (Golkar, 1999: 48).

Urban design is a constant and evolutionary process that must be achieved in the context of ongoing changes. Urban design takes the man into account more than anything else and therefore can be subject to change (Bahreini, 2006: 28).

The importance of the urban landscape, as intermediaries between man and the phenomenon of the city, is so that some have defined it as follow "urban design is the management of the urban landscape (objective and subjective)."

Urban landscape is primarily as an objective fact that exists due to the emergence of physical factors of the environment. But gradually and through the presence of historical conditions and the repetition in front of groups of people who have perceived it, it has received a subjective existence and become the common element linking the community members. In this case, the landscape is an objective-subjective entity (Center of Tehran Urban Planning, 2010).

According to the issues mentioned about passive defense, terrorist threats related to the study, the civilian airport and urban design with an emphasis on the urban landscape, it can be concluded that landscape design resisting against terrorist bombings in public areas of the civilian airports has an important role in airport environments as a joint to link urban design and passive defense.

## **2.6 The relation of passive defense and airport environments**

Airports are the most vital infrastructure of air transport. Preparation and ensuring the continuation of activities of airports in the face of deliberate man-made threats can significantly reduce physical, psychological and financial losses. Since man-made threats have caused the most damage to transport infrastructure, the defense of key assets and equipment of airports have always prioritized in defense plans of different countries.

Therefore, the main objectives of the passive defense measures at the airports are as follows:

1. Increase airport deterrence against enemy invasion
2. Ensure continuity in the event of enemy invasion even in the case of damage
3. Facilitate crisis management in different sectors of the airport in the case of the threat
4. Create necessary preparation to fight against threats
5. Increase resistance threshold against enemy attacks and possible threats
6. Reduce the vulnerability of key assets, facilities, valuable equipment and skilled manpower, personnel and passengers of the airport in the face of threats and attacks of enemy
7. Reduce the possibility of the risk and its adverse consequences to an acceptable level (According to the possibilities and limitations).

## **2.7 The general objectives of appropriate urban design of public areas of airports from the viewpoint of passive defense**

According to the above, two common goals can be developed for achieving appropriate urban design of the public areas of the airports which have the least amount of vulnerability in the face of classic terrorist attacks (bombings, suicide attacks, and remote-controlled explosive cargos):

1. Prevent terrorist attacks and dissuade attackers through the preventive measures in the design
2. Design appropriate landscape in public areas of the airport so that in the event of a terrorist explosion the least harm to be inflicted to the individuals and the body of the airport.

Urban design discusses three general components; functional, aesthetic, environmental (Golkar, 1999). Considering the issue and the subject of each project, the importance of these components is flexible. General objectives and backup qualities of the public areas of airport environments are according to table 1.

**Table 1.** General objectives and backup qualities of public areas of airport environments

<b>Qualities of urban design</b>	<b>General objectives</b>
Access and entrance	Prevent terrorist attacks and dissuade the attackers by adopting preventive measures in the design
Safety and Security	
Quality of public areas	
The use compatibility	
Inclusiveness	
Cleanliness of the environment	
<b>Quality of public areas</b>	Design appropriate landscape in public areas of the airport so that in the event of a terrorist explosion the least harm to be inflicted to the individuals and the body of the airport.
Opening	
Cleanliness of the environment	
Safety and Security	
The use mixing	
Inclusiveness	
Flexibility	
Human Scale	
Sensory richness	
Climatic comfort	

Source: author

### 3. The Cases

In this part, the successful cases of airports from a passive defense viewpoint will be investigated. So, public areas of three international airports of "Ben-Gurion" in Israel,

"Munich" in Germany and "Changi" in Singapore are analyzed from passive defense viewpoint and the most important points are presented in table 2.

In order to evaluate and analyze the public areas of the airports, three different defensive layers of the airports have been investigated according to the division of Risk Management Series, FEMA452 (the first defensive layer includes neighborhoods, the site surrounding, and access leading to it, the second layer includes airport area and the space between terminal and the first layer that is the same as the space between the protected environment and the building or protectable assets, and the third layer includes the public areas inside the passenger terminal) from the perspective of passive defense.

### **3.1 Ben-Gurion Airport**

Ben-Gurion Airport is the largest international airport in Israel. It is located on the outskirts of the city of Lod and 15 kilometers southeast of Tel Aviv's metropolis.

The airport has three passenger terminals, shopping centers and the train station that transfers passengers to the city of Tel Aviv and other major cities (Wikipedia, 2015).



**Figure 1:** Ben-Gurion Airport

Due to the special position of Israel and its ongoing conflict with the Middle East and especially Palestine and Lebanon, the airport has always been threatened by air, land and terrorist threats. Therefore, special attention in the design of the airport has been paid to passive defense that the relevant parts will be discussed here.

- **The first defense layer of the Airport (neighborhoods, the site surrounding and access leading to it)**

As is seen in Figure 2, the only access to Ben-Gurion is the highway that located on the east side. The highway is located beside a river. In fact, the location of the airport and its access have been designed so that it has been surrounded by an artificial river. So, the only access is limited to the highway and attackers will be easily detected and stopped.



**Figure 2:** Location of the artificial river on the south side of Ben-Gurion Airport

- **The second defense layer of the Airport (Airport area and the space between the terminal and the first layer)**

The second layer includes the main entrance and terminal facilities. Important points in designing the landscape of this section from the perspective of civil defense are as follows:

- Vegetation as a hedge against explosions and hideout for systems on the ground
- Suitable Lighting
- Equipping and monitoring the parking
- Car park control in sensitive locations
- Public supervision
- Suitable wide sidewalks



**Figure 3:** Vegetation in public areas of Ben-Gurion Airport

- Bullard and protection between the sidewalk and the street
- Good quality of the street furniture (as a buffer against blast wave)
- Appropriate distance of public parking from passenger terminal and having denser vegetation with a height difference in this sector than other sectors at the airport
- Flexible elements on the facade (columns and edges)



**Figure 4:** Bullard and protection between the sidewalk and the street of Ben-Gurion Airport

- Height difference in the train track and the passenger terminal entrance and the use of sturdy walls and vegetation in the distance.



**Figure 5:** Height deference between the rails and the terminal entrance

- **The third defense layer of the airport (public areas of passenger terminals)**

The third layer involves public areas inside the passenger terminals. Important points in the design of these landscapes from the perspective of passive defense are as follows:

- Ability to public monitor
- Flooring public areas using soft materials (it increases escape velocity and decreases harm to people)
- Linear form of the airport terminal and avoiding centralization to reduce its vulnerability



**Figure 6:** The linear form of Ben-Gurion Airport

- Using platforms and round columns with soft and thick angles (as a buffer for the blast)



**Figure 7:** Using platforms and columns with round angles

### **3.2 Munich International Airport**

Munich Airport (official name: Franz-Josef Strauss Munich Airport's) is one of the most important airports in Germany. The airport is located 28 kilometers northeast of Munich. The airport has two passenger terminals in the middle part of the airport site. In addition to passenger terminals, there are vast lush and unique areas with unique design, public areas, restaurants and recreational spaces such as amusement parks and open and semi-open spaces with the possibility of equipping to hold festivals and events (Wikipedia, 2015).



**Figure 8:** Munich airport

- **The first defense layer of the Airport (neighborhoods, the site surrounding and access leading to it)**

As can be seen in Figure 9, accesses leading to public areas and terminals of Munich Airport, located in the middle of the airport, are limited to two lanes in both east and west of the airport and these lanes can be controlled.



**Figure 9:** Access of Munich Airport

• **The second defense layer of the Airport (Airport area and the space between the terminal and the first layer)**

The second layer involves the middle section of the airport site involving passenger terminal areas and public areas in this section. Important points in landscape design of this section from the viewpoint of civil defense are as follows:

- Vegetation as a hedge against explosions and hideout for systems on the ground
  - Appropriate lighting
  - Equipping and monitoring the parking
  - Public supervision
  - Dense vegetation of the site
  - An appropriate area in front of the gates and entrances of buildings
  - Flexible elements on the facade (columns and edges)
- Appropriate width of the sidewalks



**Figure 10:** Vegetation of Munich airport

- **The third defense layer of the airport (public areas of passenger terminals and important public buildings)**

- Linear form and avoiding centralization
- Platforms and round columns with soft and thick angles (as a buffer for the blast)
- public monitoring
- The absence of corners and dark spaces within the terminals and recreational spaces
- The absence of columns with sharp edges
- Vegetation in semi-open spaces and inside the terminals which reduces the damaging effects of the blast wave.
- Flooring public areas using soft materials
- Appropriate lighting



**Figure 11:** Appropriate lighting of Munich airport at night

### **3.3 International airport of "Changi" in Singapore**

Singapore Changi Airport is the most important airport in Singapore and South East Asia. It is located 17 km north east of “Changi” Business Center.

The airport has three terminals and is constantly renovated and regularly new features are added to it. In addition to the passenger terminal, it includes urban areas like retailers, recreation and leisure buildings, amusement park, hotels, and etc.

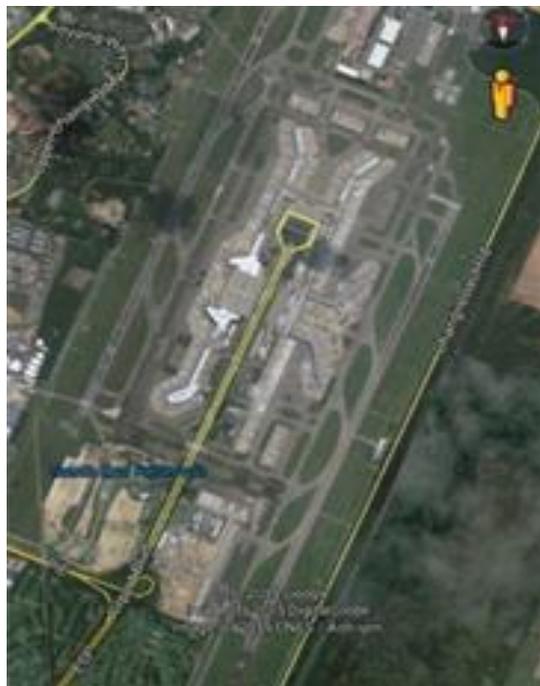
According to Singapore's reputation as the "garden city", the middle section of the terminal includes a valley forest and 5 floor garden with thousands of trees, bushes and shrubs (www.jewelchangiairport.com, 2015)



**Figure 12:** Singapore Changi Airport

- **The first defense layer of the Airport (neighborhoods, the site surrounding and access leading to it)**

As can be seen in Figure 13, access to public areas and terminals of the airport is limited only to a controllable route in the south of the airport site.



**Image 13:** Singapore Changi Airport

- **The second layer of the airport (Airport area and the space between the terminal and the first layer)**

The second layer involves the middle section of the airport site, public parking and space between the terminals. Important aspects in the landscape design are as follows:

- Vegetation as a hedge against explosions and hideout for systems on the ground
- Roof gardens and green walls in view of the important buildings
- Equipping and monitoring the parking
- Appropriate lighting
- Dense vegetation of the site



**Figure 14:** Lighting of public areas of Changi Airport of Singapore

- Appropriate area in front of the gates and entrances
- Appropriate width of sidewalks
- Safe corner and semi-enclosed public spaces and the use of vegetation



**Figure 15:** Green walls inside Changi Airport Terminal

- **The third defense layer of the airport (public areas of passenger terminals and important public buildings)**

- Avoiding the centralization
- The use of the platforms and round columns with soft and thick edges (as a buffer for the blast)
- Mass surveillance of public areas
- Appropriate lighting
- The absence of corners and dark spaces in the terminals and recreational spaces
- Vegetation and green walls in the interior spaces of the terminal which reduce the damaging effects of the blast wave
- The absence of pointy edges and columns
- Flooring public areas by using soft materials
- The use of decorative elements, platforms and street furniture as shelter



**Figure 16:** Flooring with soft materials at Singapore Changi Airport Terminal

Extracted points from each case are presented in Table 2. A set of urban landscape strategies that are affected from the perspective of passive defense have been presented in the table.

**Table 2:** A set of urban design strategies that are effective from the perspective of civil defense in international cases' experience

Singapore Changi Airport	Munich Airport, Germany	Israel's Ben-Gurion Airport	Vulnerability reduction strategies in airports from the perspective of passive defense
*	*	*	Proper control of access routes

*	*	*	Restricting access leading to the airport terminal and public areas
-	-	*	The use of natural elements as barrier
*	*	*	Vegetation as an obstacle to the explosion and the concealment of ground systems
*	*	-	Located amidst lush vegetation site
*	*	*	Suitable Lighting
*	*	*	Equip and monitor the parking
-	-	*	Car park control in sensitive locations
*	*	*	Public supervision
*	*	*	Appropriate width of sidewalks
-	-	*	There Bullard and protection between the walkways and streets
*	*	*	Good quality of street furniture (as a buffer against blast wave)
-	-	*	Public parking right distance from the passenger terminals with the height difference compared to other sectors
*	*	*	Flexible elements in the facade (columns and edges)
*	*	*	Avoiding centralization
*	*	*	The use of platforms and round columns with soft and thick corners (as a buffer for the blast)
*	*	*	Flooring public areas using soft materials
*	*	*	A yard in front of the buildings and entrances

*	*	*	The absence of corners and dark spaces in terminals and recreational spaces
*	-	-	Roof gardens and green walls in the facades of important buildings
*	-	-	A secure corners and semi-enclosed public spaces with the use of vegetation
*	*	-	Vegetation and green walls inside terminals to reduce the damaging effects of blast wave
*	*	*	The use of decorative elements, platforms and street furniture as shelter

**Source: author**

#### **4. Conclusion**

According to the investigation and the identification and analyses of the effects of terrorist attacks in airports, terrorist blast-resistant urban design has two features including: prevention of the explosion and dissuade the person from committing terrorist bombing by terrorists inhibitor design and urban design so that in the event of an explosion the less damage inflicted to the individual and the body of the airport. In order to achieve a robust urban design with mentioned properties, the presence of three important quality in urban design is required. These qualities that are functional components of urban design include access and permeability, safety and security and the quality of the public areas.

Finally, an attempt was made to introduce simple and applicable solutions in public areas of airport environments to fill the gap of the absence of resistant urban design. So, strategies were made to be used in public areas of all international airports. These guidelines include:

Proper control of access routes

Limiting the access leading to the airport terminal and public areas

The use of natural elements as barrier

Vegetation as an obstacle to the explosion and a concealment for ground systems

Lush vegetation on the site

Suitable lighting

Equipping and monitoring the parking

Car park control in sensitive locations

Public supervision

Appropriate width of sidewalks

There Bullard and protection between the sidewalk and the street

Good quality of street furniture (as a buffer against blast wave)

Right distance of public parking from passenger terminals with a height difference compared to other sectors

Front flexible elements (columns and edges)

Avoiding centralization

The use of platforms and round columns with soft and thick corners (as a buffer for the blast)

Flooring public areas using soft materials

An appropriate yard in front of the buildings and entrances

The absence of corners and dark spaces in terminals and recreational spaces

Roof gardens and green walls in view of the important buildings

Safe and secure corners and semi-enclosed public spaces with the use of vegetation

Vegetation and green walls in the interior part of the terminal to reduce the damaging effects of blast waves

The use of decorative elements, platforms and street furniture as shelter.

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