



## Secure Urban Design in Terms of Passive Defense Approach; Analytical Considerations for Improving Form-based Characteristics in Iranian Cities

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**ABSTRACT:** Today, countries that have experienced damages caused by wars, pay special attentions to passive defense in their defense strategies to protect their national properties and vital resources. To this end, observing passive defense considerations in urban development and design has a great impact on reducing the vulnerability of cities, financial losses, and casualties as well as increasing citizens' tolerance threshold which can facilitate urban crisis management. The article analyzes the macro models of urban patterns and their strengths and weaknesses. In this regard, some of the obligations necessary for improving sustainable resistance of these forms under war conditions are proposed. The micro scale form-based considerations as well as the effects of specific small-scale urban design arrangements and requirements such as parcel size, arrangement and layout of structural parts, etc., which can reduce the damages resulting from attacks on cities, have been discussed as well. This study is an original research and upon the purpose of the paper it is based on applied one. Due to the complexity of the morphology design and passive defense, the combination of exploratory and descriptive-analytical research is used as the methodology.

**Keywords:** Passive Defense, Form-based Design, Physical Texture, Security, Design Considerations.

### INTRODUCTION

Experiences obtained from past wars, especially the Iran-Iraq eight-year war, the 43-day Gulf War against Iraq in 1991 (the first Persian Gulf War), the 11-week NATO war against Yugoslavia in 1999, the US and Britain war against Iraq in 2003, the 33-day war between Israel and Lebanon in 2006, the US war in Iraq and other conflicts around the world have confirmed this view that the attacker tries to break the will of the people and the political, economic, and military power of the target country via undertaking strategies to destroy important centers and places especially those in cities. This is usually done by bombardment (Movahedi Nia, 2008).

During the eight-year Iraqi Imposed War against Iran, six major Iranian strategic cities including Khorramshahr, Soomar, Mehran, Naft Shahr, and Hoveize were razed to the ground. In addition, 17 other cities were damaged between 15 to 85 percent as a result of the Iraqi army

force's artillery attacks, air raids, and missiles. During this war, 61 Iranian cities were damaged by military attacks. These attacks were not confined to urban areas. During the eight years of war, 1138 villages in the country were destroyed completely and 2344 villages incurred heavy damage (Abbaszadeh Fard, 1999).

Obviously, despite recent technological advances including development of remote sensing systems, the need for safe and sustainable urban design against the army forces has not been alleviated. However, the current Iranian urban system does not pay enough attention to passive defense and also the urban plans and programs prepared at various scales do not allow for such attitude. urban form is Among the key issues in sustainable urban design. Including appropriate form-based design, alongside paying attention to the structure of macro patterns and physical textures can reduce the vulnerability and casualties resulting from attacks on cities. This paper investigates the importance of passive

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defense and definitions of key related concepts. Then, the current structural form of cities is discussed from two points of view, i.e. macro forms (emphasis on macro urban patterns) and micro forms (physical parts constructing urban texture). Finally, some requirements for safe design based on passive defense considerations will be proposed.

### **PASSIVE DEFENSE; A FORGOTTEN CONCEPT IN URBAN PLANNING AND DESIGN**

Cities are big and stationary targets in physical terms; therefore, they can easily be targeted from a huge distance. Other factors motivating the choice of cities as military targets are as follows: (Shakibamanesh and H.Fesharaki, 2011, p. 24)

- Cities include aggregation of humans and major political, administrative, and military decision-making centers;
- Attack on cities puts politicians and officials under pressure;
- Attack on cities disrupts social order and creates dissatisfaction in the community;
- Attack on cities breaks the unity of people and forces them to leave the cities;
- Attack on cities makes soldiers concerned about the situation behind the front;
- Attack on cities breaks the resistance of support-

management forces stationed in cities;

- Having welfare and livelihood facilities and services, cities play a very effective supportive role in guiding and managing wars;
- A significant proportion of physical and cultural investment is done in cities. Therefore, demolition or elimination of access to these assets will strengthen financial incentives in the invading forces;
- Because cities are considered as models of stability, taking hold of them plays an important strategic role and is considered as an index to prove the military position and operational authority of the invading forces;
- Cities work as transportation links, and centers of regional integration for their rural areas. The government status depends on the resistance or fall of these cities (APA, 2006, p. 350).

Besides the above-mentioned factors, the role of psychological factors and the effects of attack on people's morale in cities are important. Social life in cities and alignment and proximity of constructions make cities an indispensable target for destroying people's morale. Therefore, during World War II, the attacking army forces heavily bombed London, Paris, and Berlin to weaken their social and military morale. The most striking example of this type of attack is the atomic bombing of Hiroshima and Nagasaki by the US that caused Japan to surrender. In addition, in recent wars (Kosovo conflict, the first Persian Gulf War, Iraqi Imposed war on Iran and the US recent wars against Afghanistan and Iraq), examples of threats and bombings against cities are conspicuous.



**Fig. 1. Cities Destroyed During World War II; (B. Glaser, 2011)**

Before addressing safe urban design based on passive defense, first "passive defense" should be defined based on the literature in order to specify important points in available definitions. According to the various sources and published literature by The United States Department of Defense (Chairman of the Joint Chiefs of Staff, 2006;

AIPD, 2008), "passive defense" is defined as a set of non-military measures taken to reduce vulnerability and to minimize the potential damages caused by invading forces. Different measures taken by veterans and military forces in passive defense include early warning, security operations, dispersion policy, protection of important



persons and the general public; medical assistance, especially to counter the deadly effects of Weapons of Mass Destruction (WMD) (nuclear, biological and chemical); recovery of forces, disseminating news and information, staff training, and other techniques, tactics and processes effective in reducing damages caused by attacks.

In the Iranian military and strategic texts, “passive defense” is defined as “a series of nonviolent actions with the purpose of increasing resistance against the enemy’s attacks on residential areas, improving maintenance of essential activities in cities and villages, improving national resistance, and facilitating crisis management against the enemy’s military threats and actions (Iran’s Fourth Development Plan, Clause 11 of the Administrative Procedures Act 121, the Expediency Council; Movahedi Nia, 2008; Asghryan Jeddi, 1996; Ziari, 2001). The use of passive defense measures reduces casualties and the level of vulnerability and damage to critical military and civilian buildings, facilities, and equipment and protects arteries of the country against attacks by the attacking army forces. It can also be helpful in reducing the risks of unnatural incidents.

In some sources, the term “civil defense” is used as an equivalent to “passive defense” and is defined as follows: (Shakibamaneh and H.Fesharaki, 2011, p. 194)

“Civil defense is an effort to protect the citizens of a state (generally non-combatants) from military attacks via using the principles of emergency operations, prevention, mitigation, preparation, response, emergency evacuation, and recovery. Programs of this kind were initially discussed at least as early as the 1920s, but only became widespread in the USA after the threat of nuclear weapons was realized.”

According to this definition, civil defense guarantees the safety of the civilian population in wartime (Cristy, 1974). Thus, civil defense aims at the following objectives systematically: (Kummer, 1973)

- Minimizing the effects of military attacks on civilian populations;
- Dealing promptly with emergencies resulting from such attacks; and
- Retrieving and restoring damaged facilities and services as a result of such attacks.

According to this definition, the term “civil defense” is equivalent to the term “passive defense”. However, it also should be mentioned that since the end of the Cold War, some countries have shifted their focus of “civil defense” from military crisis to all hazards and crises in general. Thus, a gap has emerged between passive defense and civil defense in the current scientific sources.

## METHODOLOGY

This study is an original research and upon on the purpose of the paper it is based on applied one. Due to the complexity of the morphology design and passive defense, the combination of exploratory and descriptive-analytical research is used as the methodology.

## URBAN FORM DESIGN AS A MAJOR FACTOR INFLUENCING URBAN DEFENSE AND SECURITY

The real threat to cities at the time of war is generally performed in three ways:

- Bombing and using long-range weapons;
- Using chemical and biological threats; and
- Occupying homelands.

In all these methods, urban form design at macro- (city patterns) and micro- (physical texture of urban areas) levels can be considered effective in increasing cities’ security, reducing their vulnerability to enemy attacks and minimizing casualties in urban areas. This article discusses these two levels in detail.

### *Large-Scale Form - Based Design Considerations (Urban Patterns)*

Urban patterns are associated with particular typologies, properties, units, sets of ‘rules’, ‘models’ and relationships, that can be a subject of study and academic research in its own right. This part of the article sets out the scope of how urban patterns can play effective role in city resistance in war.

Obviously, the large-scale urban patterns and the type of urban network structures can have a significant effect on the casualties and damages resulting from attacks and on the cities’ vulnerability to such attacks. In fact, decision-making about urban macro structures or patterns before their development (as in designing new cities and towns) and modifying and solving physical structure problems in current cities (especially in specific urban areas like city centers, densely populated areas and critical defensive and political areas) should be considered in this regard. On the other hand, spatial distribution, composition, and main functions of the constituent elements of the cities which play an important role in their vulnerability or protection against various events, particularly military attacks against the enemy, largely depend on the macro urban patterns.

Since without systematic specification of urban patterns, design options may be limited to arbitrary



stereotypes, and the evaluation results are liable to be ambiguous or misleading (Marshall & Gong, 2009, p. 7), before engaging the issue of defensive considerations in urban macro models, according to urban design literature, different classification of urban patterns should be briefly discussed.

Table 1 sets out a selection of pattern descriptions. An immediate conclusion here is that there is no single 'fundamental' set of elemental types (Marshall, 2004; 2005). The types or set of types recognized will depend on the purpose of the classification and its intended

application. There is also a confusion of ways in which each label relates to each kind of urban form. In some cases, the same urban pattern could be described by different labels. Conversely, a particular label may have different structural connotations, and could be used to describe quite different patterns in different contexts (Marshall, 2005, pp. 74-75). For example, the label 'linear' could be (and has been) applied to quite distinct kinds of form (Keeble, 1969, p. 110).

**Table 1. Examples of City Pattern Typologies Research Methodology**

Unwin (1920)	Dickinson (1961)	Moholy-Nagy (1968)	Lynch (1981) Satoh (1998)	Satoh (1998)	Frey (1999)
1- Irregular	1. Irregular	1- Geomorphic	1. Star (Radial)	1. Warped Grid	1. The Core City
2- Regular	2.Radial-Concentric	2- Concentric	2. Satellite Cities	2. Radial	2. The Star City
3-Rectilinear	3. Rectangular or	3- Orthogonal-Connective	3. Linear City	3.Horseback	3. The Satellite
4-Circular	Grid	4- Orthogonal-Modular	4.Rectangular Grid	4.Whirlpool	City
5-Diagonal		5- Clustered	City	5.Unique	4. The Galaxy of
6-Radiating Lines			5. Other Grid	Structures	Settlements
			(Parallel, Triangular, Hexagonal)		5. The Linear
			6. Baroque Axial		City
			Network		6.The Polycentric
			7. The Lacework		Net, or Regional
			8. The 'Inward' City (E.G. Medieval Islamic)		City
			9. The Nested City		
			10. Current		
			Imaginings		
			(Megaform, Bubble, Floating, Underground, Undersea, Outer Space)		

(Marshall, 2005, pp. 75- 271).

Among the urban patterns listed in table 1, in Iranian cities, mostly five types of linear, gridiron, irregular, radial (concentric) and ring patterns are seen. Hence, in the following sections, these patterns are investigated in terms of stability and resistance against attacks and their design considerations and requirements are assessed.

***Analysis of Linear Urban Form in Terms of Passive Defense Considerations***

The linear urban form, also known as the ribbon or strip development is characterized by concentration of development along both sides of major transportation routes such as roads, navigable rivers or other forms of transport network (JMC, 2007, p. 1). Indeed, linear cities, most frequently, result from the stringing of minor urban



areas along a confined natural terrain corridor (such as an elongated valley, or a body of water), or man-made ones (such as roads or special uses) (US ARMY, 2011, p. 5).

Although there are many examples of linear urban form around the world which have developed linearly without pre-planning to be so, there are some which have been formed based on 'planned corridor-development' beginning with 1882 plan "Soria y Mata" in Madrid<sup>1</sup>.

In a linear city, unlike a traditional city, not only a city center and suburbs are merged, but also a city expansion is along a line without taking up more space than is necessary. The growth of linear cities is simple, Soria y Mata noted, because the line itself can go on to infinity and at any point a new community can shoot off like the branch of a tree, the tributaries of a river, the veins of the body (Collins, 1965, p. 205).

An essential characteristic of a linear city form is a line. "The LINE", asserts Collins, is "a schema that allows for infinite and integrated expansion of both the core and the periphery of our communities simultaneously" (Collins, 1965, p. 204)." This expansion opportunity presents a chief advantage for the linear city proponents. On the other hand a transport track (railway, tram, motorway, or their combination) usually is the core line of linear city. Different city functions (industrial, commercial, residential, recreational) are organized in the region of this core line, which can be straight, polygonal, or sinuous. Sometimes city functions are grouped into some strips parallel with the core line of transport track (Furundzic & Furundzic, 2012, p. 723).

Since many cities in Iran are formed linearly as a result of natural phenomena (e.g. Makoo, Tonkaban, Ramsar, etc.) their investigation in terms of civil defense is necessary. So, at the following the strengths and weaknesses of linear urban form in passive defense besides some design considerations for improving resistance of this type of cities in war will be discussed.

#### ***A) The Strengths of Linear Urban Form for Passive Defense***

In the northern cities of Iran on the Caspian seaside, which are obvious examples of the linear model, extensive natural beds, gardens and farms play an effective role in the distribution of population in urban areas and in implementation of decentralization strategies aimed at creating opportunities to take refuge in safe areas at the time of attacks. Hence in future development of these cities, preservation and proper distribution of natural green spaces and farms in the structure of these cities can add to their visual richness and ecological values. Moreover, it can increase costs of attacks for enemies and

reduce casualties and damages at wartimes.

#### ***B) Weaknesses of Linear Urban Form for Passive Defense***

- Destruction and blockage of major routes to linear cities due to bomb attacks cut their vital arteries and all routes linking these urban centers with the surrounding environment.

- In many cases, any damage to the main routs can negatively affect inner city roads and make access to the key places, such as hospitals and rescue centers difficult or impossible in times of crisis. It can also stop or constrain firefighting operations and transportation of victims.

- Insufficient width of main roads in these cities is the reason why in emergencies they cannot tolerate large numbers of people who are trying to flee or gain access to surrounding areas and are blocked soon.

- Transmission and spread of fire; explosions and secondary injuries (arising after the attack) resulting from the layout of building blocks in linear model is much more than other models. These secondary damages are doubled if the main roads of these cities are built along the prevailing wind direction.

- Since in the linear model most dense production activities and crowded and dense residential and commercial buildings are located along the main axis (and low-density elements and activities are transferred behind the main axis), in case of bombing and destruction of the main axis, activities and functions of the city are virtually paralyzed. Here, the city faces serious living and economic problems.



Fig. 2. Linear City of Makoo, North West Border of Iran

• Another disadvantage of linear cities is that of using water and gas distribution systems that are often in the form of Dead-end or Tree systems<sup>2</sup> (Fig. 3 left). In the non-linear cities, these systems -in most cases- are designed and implemented in the form of Looped Systems<sup>3</sup> (Fig. 3 right), or Hybrid Systems<sup>4</sup>. At the time of crisis and bombing which damage parts of the water or gas flow in urban areas, this kind of design allows

other parts of the city to continue to have water and gas. However, in case of linear cities which have tree systems, damage to one part of the system blocks the water or gas flow to all other parts of the city which can lead to health and living problems and other negative consequences. Another advantage of looped systems is where the fire is spreading all the valves can be closed to direct water to the fire source (APA, 2006, p. 350).

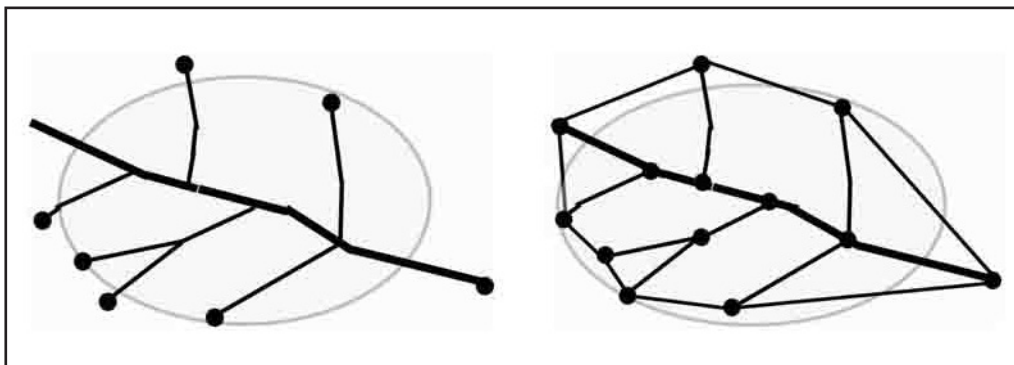
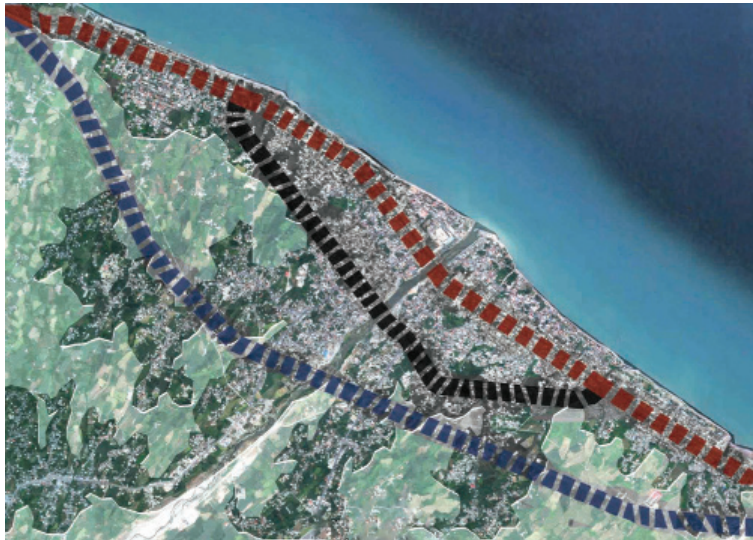


Fig. 3. Schematic Illustration of Looped System (Right) and Tree System (Branched) (Left) Source: (Shakibamanesh & H.Fesharaki, 2011, p. 194)

### C) Design Considerations

• Using the linear model in many cases are imposed on the urban area by the morphological conditions and natural terrain (due to some restrictions in the city (such

as seas, rivers, and mountains)). However, in cities with small populations, the situation can become better if the number of linear passages increases to three or more and a large quantity of green open spaces are created within the structure (Shakibamanesh and H.Fesharaki, 2011).



**Fig. 4. Linear City of Tonkabon, Iran; There Are Three Linear Roads Parallel to Each Other.**

- Obviously, industries, factories, facilities, and networks vital to such cities should create passages for emergency situations through methods such as using natural spaces with implicit camouflage, reducing conspicuity and combining with environment.

- In this pattern, vital<sup>5</sup>, critical<sup>6</sup> and important uses<sup>7</sup> should not be near one another or close to main roads.

- Providing separate firefighting equipments at key strategic points along the main thoroughfares in the linear cities is essential.

- In the main roads, as many shelters as possible should be created using elements of environmental design (such as brooks, balconies, consoles, etc).

- Around sensitive areas, facilities and industries such as harbors, refineries, etc. in a linear city, air defense equipment should be provided for operation during the invasion. The multiplicity of such defense structures can be somewhat effective in deceiving the attacking army forces, even if equipments in some of these spaces are limited.

#### ***Analysis of the Gridiron Pattern in Terms of Passive Defense***

The grid form, in fact, is the most common pattern for planned cities throughout the history (Scott, 1988). Morris (1994) describes that in history the gridiron were made for Greek planned cities, Roman imperial urban planning and some USA cities. Its ubiquitous gridirons went places energetically at mid-nineteenth century and the gridiron provided a simple and logical geometric framework for cities in present day (Morris, 1994).

Indeed the most adaptable and universal form for urban areas is the grid pattern in which lines of streets at right angles to one another forming blocks similar to the pattern of a chessboard (US ARMY, 2011, p. 6). This model consists of a decentralized system where there are large numbers of nodes or intersection points (Gharib, 2007, p. 17). The grid takes the form of a road structure that covers all areas. Unlimited expansion in all directions is theoretically possible. In the case of long distances diagonal roads can shorten routes. There is great flexibility when it comes to usage and priorities (Metrasys, 2012, p. 16). The simple gridiron residential pattern is extremely efficient from a surveying and administrative viewpoint - from an aesthetic outlook and monotonous uniformity is most undesirable. The straight, wide streets of the design encourage large volumes of high-speed through traffic, contributing to numerous intersection accidents and endangering pedestrians (MCPC, 1967, p. 38).

Indeed fast implementation, lower legal and technical problems, lack of centralization, and many other factors are among the reasons why this model has been used in different new Iranian cities and in new developments in older cities of the country such as many new parts of Tehran, Mashhad (in the northwest of Iran), Isfahan, Quchan and Salmas.

#### ***A) Strengths of Gridiron Pattern For Passive Defense***

- Because of its network structure, gridiron pattern makes it possible to establish any use at any point in the cities. This helps a more appropriate distribution of vital political, economic, and industrial uses as well as various municipal facilities and equipments and hereby



decrease the chance of being damaged by the attacking army forces.

- Gridiron pattern cities are consisted of an extensive network of access routes, which provide many options to achieve destinations in the city. This facilitates reaching and providing help to people in different parts of the city using alternative routes during urban crises like enemies' attacks.

- In gridiron pattern there is no certain urban area which is superior in terms of geometrical position to others; therefore, it is possible to create urban centers (linear or point) hierarchically in the form of a network of centers linked together. This model can prevent the formation of centralized city centers (in terms of population and activity); therefore, the distribution of population (stationary and moving) among different parts of these cities becomes easier. Thus, the extent of damage caused by attacks on one or more urban centers (as seen in the cities with radial and central pattern) is reduced in this model.

- In the Gridiron pattern, the enemy needs frequent attacks and more destructive weapons and explosives due to many urban cells and various targets scattered in the entire city. This leads to increase economic pressure on

the attacking forces.

- Water and gas distribution systems in cities with a gridiron pattern, is usually Looped, which, as stated above (under the linear model), is more desirable from a defensive point of view.

#### ***B) Weaknesses of Gridiron Pattern for Passive Defense***

- One of the disadvantages of this model is that cities using the model are easily occupied due to the ease of measures like identification, power distribution, and quick attacks for enemy forces in urban warfare. That is because the cellular texture of the gridiron pattern is quickly understood and makes decision-making about military actions easier.

- Another weakness of the gridiron pattern in cities, especially in Iranian cities, is that open spaces are occupied by building masses and the space-mass ratio is gradually reduced. Thus in these cities, owners of land and properties often build dense constructions without considering the negative effects of this combination in crises and enemy attacks. Lack of space in the gridiron pattern cities increases the risks and negative consequences (such as fire, explosion, etc.) in case of enemy attack.



**Fig. 5. Comparison Between Levels of Open Space in the Gridiron Pattern; Right: An Urban Area in New York; Left: A Neighborhood in Tehran, Iran.**





### C) Design Considerations

- In terms of passive defense, the aerial view of gridiron pattern cities reveals their uniform features. It is suggested that all strategically important buildings such as governmental, political, economic and administrative

buildings as well as vital urban services and infrastructure facilities be constructed consistent with and similar to other buildings in the city. This similarity can be in the structure of the plan, as well as in the geometry and size of the buildings. This will prevent identifying and targeting of important areas by the attacking army forces.

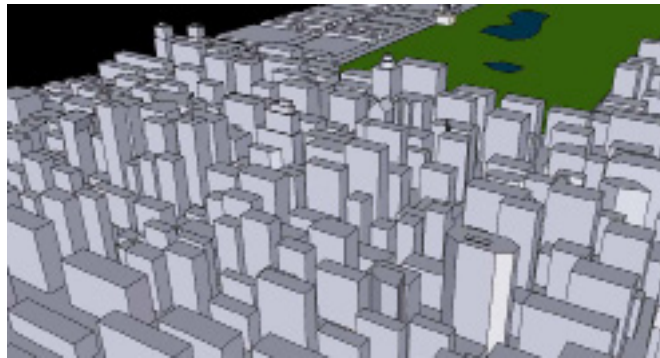


Fig. 6. Part of the Central Urban Area in New York; Notice the Overall Similarity in Terms of Formal and Volumetric Structures.

- Because of its compatibility with various land features (the available topography), gridiron pattern system is considered as one of the few systems in urban networks where taking advantage of the slope, topography and terrain shape and position for defense purposes is possible. Therefore, the strategic areas of these cities with little view from the air (blind spots) and with little maneuverability for the attacking army forces can be used for establishment of strategic uses such as utility, industrial, and service uses. These uses should be compatible with the urban context (and do not include petrochemical uses, huge power plants and the like whose presence in cities is principally incorrect and can be a source of threat).

#### - Analysis the Irregular Urban Form in Terms of Passive Defense

Unwin (1920) and Keeble (1969) both make their first division of pattern into those 'deliberately planned' and those 'unplanned' (irregular) (Marshall, 2004, p. 79). Indeed unplanned or irregular pattern refers to a system in which a pre-planned structure and layout is not used (Hiraskar, 1992) and regardless of the original intent, plan, or vision, existing street patterns emerge from successive plans overlaid one on another. Some are well planned to fit with previous plans while others a haphazard response to explosive urban growth. The result may mix patterns. Urban engineers and planners may also sometimes specifically design irregular patterns for aesthetic reasons (as in many suburban housing

developments) or to conform to marked terrain relief (US Army, 2011, p. 6). In irregular systems, streets are curved and sometimes have different widths. Open spaces are seen at irregular intervals in a discontinuous manner (Hiraskar, 1992). Examples of applying this model in Iran can be seen in cities of Dezful, Rasht, and Lar and in many ancient urban contexts.

#### A) Strengths of Irregular Model for Passive Defense

Regarding passive defense, the most important features of cities with irregular pattern can be the followings:

- Irregular geometry and unpredictability of the network makes the system difficult to be understood to strangers. This is one of the characteristics which can have an effective role in passive defense, because makes identifying and sticking key areas and constructions difficult for the attacking army forces in air strikes (due to difficulty of understanding the precise location and boundaries). On the other hand, in terms of permeability of the context for physical occupation by the attacking army forces in urban warfare, these cities are highly resistant because identification, distribution of forces and attacks in such a context are associated with many difficulties.

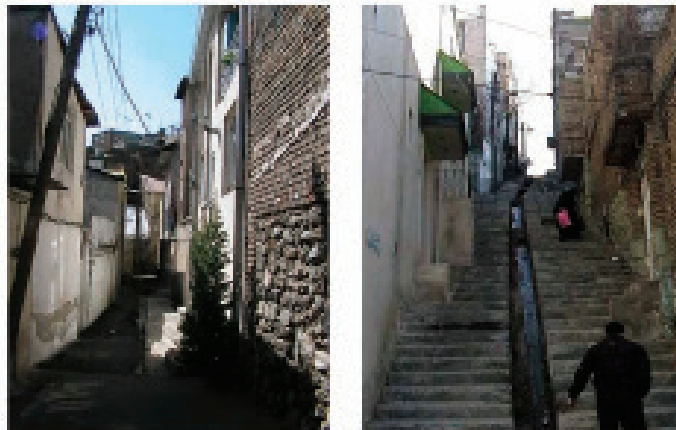
- In the irregular pattern, as in the gridiron pattern, the compatibility between network and available topography is high and thus it is possible to take advantage of natural ground slopes and features for deploying specific uses in strategic areas.



### ***B) Weaknesses of Irregular Pattern for Passive Defense***

• One of the main disadvantages of irregular pattern in cities, especially in Iranian cities, is many problems in the network including low width of passages, sometimes non-matching geometry in traffic networks, long pedestrian cul-de-sacs (sometimes more than 60 meters), lack of standard curves in streets, use of steps

to link different sectors with different levels of elevation, etc. These shortcomings in the irregular network cause many problems in regular times (such as traffic problems, weather problems (such as lack of sunlight due to low width of passages and changing angles) and difficulties in providing urban services, etc). Moreover, providing services or helping residents is difficult in crises situations and military attacks.



**Fig. 7. An Example of Stepped Passages in a Neighborhood in Bagh Shater, Tehran (Right) and Dead End Passages with Very Small Widths (Sometimes Nearly 1 Meter) in Tappeh Gheitarieh, Tehran (Left)**

### ***C) Design Considerations***

• In cities with irregular pattern, two scenarios are possible. The first scenario is to correct security and defense defects in numerous contexts found in current Iranian cities. The second scenario is to design new urban structures with logical irregular patterns (with a pre-thought design carried out on current urban design and planning). Therefore, using this model as a general framework in the design alternatives can correct major flaws like network problems mentioned earlier (in terms of hierarchy, standard width, network integration, authorized curves and adaptability with public transport networks in accordance with the scale and scope of the area in question) to reduce the damages caused by air strikes and fights within the city.

• In areas where it is possible, passages should be interconnected in a network form and the difficult-to-access blind spots within the context should be minimized. Also in smaller scales, such as urban neighborhoods, alongside observing the principles common with the local

networks (such as keeping calmness and preventing the non-local vehicle traffic from passing through internal networks), physical permeability, especially in sensitive and key areas (especially in the neighborhood centers) should be increased and alternative means of access should be provided.

• According to standards of irregular pattern available in urban design literature, there should not be passages over 60 meters of length in the area in question, because they limit movements and the process of providing help during crisis times. Lack of open spaces caused by these kinds of passages increases vulnerability due to building debris falling on pedestrians.

• In irregular pattern, we should try to construct types of buildings in which the minimum open space required for the crisis management is provided in the form of yards-via voluntary and forced urban design criteria and guidelines. In addition, in such contexts, building density should be as low as possible and regulations should be established to control building heights.



**Fig. 8. A Neighborhood with Irregular Pattern in the West of Lar; There is Enough Space between and within Buildings (Yards) with a Low-Density Altitude.**

***- The Radial (Concentric) and Ring Urban Forms from the Perspective of Passive Defense Considerations***

The radial or concentric urban form reflects an outward expansion of urban development from the city center/core induced by the construction of new circumferential and radial roads (JMC, 2007, p. 2). In this form expansion by extending the radial roads themselves or adding some in between is possible to a limited extent only and all traffic flow is based on the center point (Metrasys, 2012, p. 16). This spatial pattern matches the Core City which has the unique characteristic of concentrating development into one continuous body originating from the center or core. This urban form redirects future development in and around the city center; extending to the adjoining barrios. Confining development into one continuous body implies high density urban activities that can increase discomfort. Likewise, housing types are limited to high-rise apartments or compact dwelling units to maximize space (JMC, 2007, p. 2). In this form the core links network

components together and the city is like a star (Gharib, 2007, pp. 16-17).

Examples of these networks can be seen in the city of Mashhad in Iran. However, in many cases in order to decentralize networks in radial cities, the radial roads are linked together in parts of passages and make wide ring streets. In this system, the rings are applicable by different radial roads and the number of rings can be an indicator of rate of development (Gharib, 2007, pp. 16-17). This form redirects development away from the urban core or city center toward identified urban growth areas or nodes. The major center provides specialized facilities and services to its nodes and acts as its external linkage to other centers of the city, while the nodes support the major center in different ways (JMC, 2007, p. 2). Hamadan in Iran is a good example city based on a typical ring system (Farid, 2009).

Since many of the considerations relevant to these two urban forms are similar in terms of passive defense, at the following they will be analyzed together.

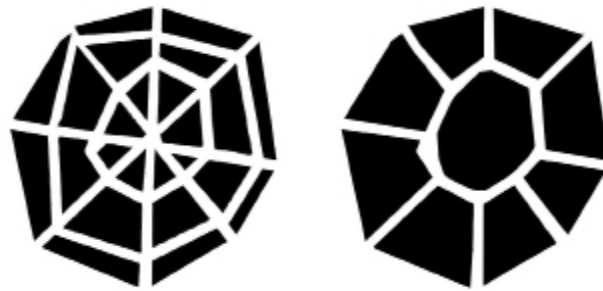


Fig. 9. Schematic Illustration of the Radial Pattern (Right) and the Ring Pattern (Left).

**A) Strengths of Radial and Ring Patterns for Passive Defense**

- Both radial and ring patterns have much lower permeability than a gridiron pattern. Therefore, given the fact that radial roads connecting the city center to ring roads are limited, in crisis time and sometimes even in regular times they are blocked. The ring pattern creates a better condition than does a radial pattern in terms of passive defense, because it provides more linking alternatives and enhances permeability of the metropolis. Besides faster evacuation of the population in times of crises and enemy attacks (as in Moscow, through a subway system consistent with the ring pattern of the city), it reduces the risk of blockage of the main routes and facilitates supporting and equipping forces.

- Around radial cities, ring highways are developed with a certain distance from the city center and connect development areas. Usually, no building is constructed in ring highway areas; therefore, they can be used as temporary accommodation at evacuation times.

- In cities with a ring pattern, in connection points of main roads system, there is a potential to create a network of urban centers with different spatial-functional hierarchies. This can reduce the concentration points of populations, capitals, services, and administrative areas in the main city center and hence reduce losses and human casualties in times of crisis. Here, if the main center is

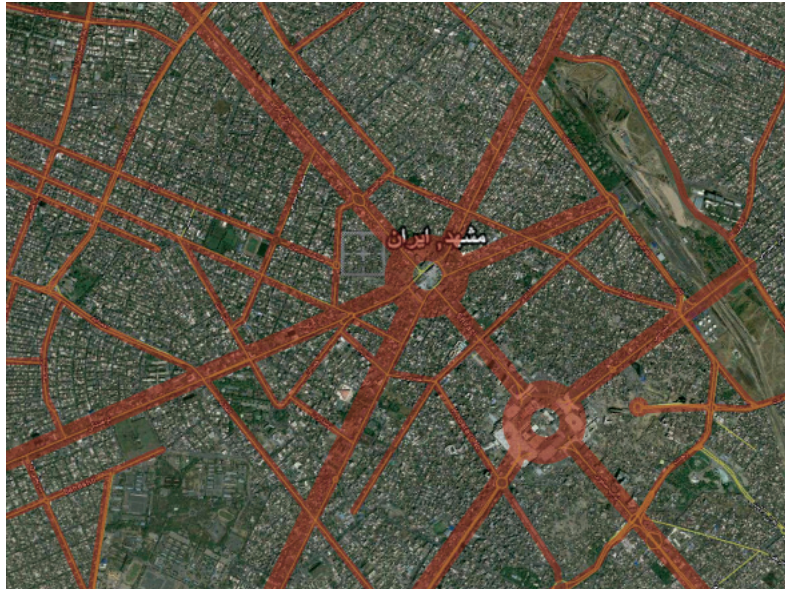
damaged, other layers of the hierarchy will continue to operate and satisfy the livelihood needs of most people which help the city continue its biological process.

- Like the gridiron pattern, in cities with ring and radial pattern, the design of water and gas systems is often looped or hybrid. Therefore, these cities take advantage of such structures and facilities in terms of passive defense.

**B) Weaknesses of Radial and Ring Patterns for Passive Defense**

- One of the disadvantages of radial and ring forms of cities is density of city centers in terms of physical texture. High-density urban areas increase financial and physical damage rates as well as clean-up and rebuilding costs in times of war.

- Having a major center with dense population and activities, cities with a radial pattern are vulnerable and sensitive to the crises and military attacks which is considered undesirable in terms of passive defense. In fact, destruction of such centers can paralyze the whole city.



**Fig. 10. Central Part of Mashhad with a Dominant Radial Pattern.**

### ***C) Design Considerations***

- For both radial and ring patterns, a hierarchical network from peripheral centers, and their proper distribution across the city should be designed so that it facilitates better distribution of uses and their related population.

- In radial and ring cities, if the strategic uses are deployed far from the city center especially in some open spaces, we can eliminate the possibility of their sudden and abrupt destruction. Moreover, it reduces damage to surrounding residential areas.

- Since in many cases use of these two patterns in major Iranian cities is often associated with heavy traffic, evacuation of the population of these cities in emergencies and crises requires advanced public transportation systems such as subways and Mono rail.

### ***Small-Scale Form - Based Design Considerations (Physical Parts of Urban Texture)***

Small-scale forms can be important in terms of defense considerations. In the previous sections of this paper, the impacts of different patterns on the vulnerability of large urban areas in times of war were discussed. However, considering some small-scale measures, such as gradation and layout and arrangement of physical parts (in relation to one another, and to open spaces) can also greatly help to reduce losses resulting from the enemy attacks.

In terms of morphology, texture of Iranian cities has undergone a remarkable change during the past few decades. Unlike in the past, today, urban context is often created without considering the minimum defensive requirements. Direct linear passages based on gridiron pattern are common in today's contexts. Many buildings do not have structural- physical homogeneity and similarity with each other, but many efforts are done to make them distinctive with a unique personality. The distinction is created in different ways including dramatic differences in size and form, distinctive materials, completely inconsistent heights with the adjacent constructions, etc. In fact, unlike the features inherent in previous textures, new ones (especially in large cities) includes buildings with distinctive and unique features in the surrounding neighborhood or even in the city, propagated by modern designers and architects. The result is emergence of deep problems in terms of urban design and planning and defense.



**Fig. 11. Lack of Coordination of Buildings in Large Cities in Iran and Efforts to Distinguish the Heterogeneous Architecture Through Sizes, Forms, Materials, etc.**

Here are some tips that can be used to improve urban texture design and planning in terms of passive defense:

- Using Dissimilar Patterns (Irregular Design) in Urban Areas. The use of irregular networks in the past had presented advantages and special features for cities and urban textures. Nowadays, although the use of cars as a necessary requirement in the urban context is considered, it does not mean that the irregular system of passages in new designed textures is unusable. In fact, using irregular networks and taking advantage of compressed and complex physical textures can be beneficial in relation to establishment of vital uses, which are hard to destroy and can improve passive defense. This kind of network makes distribution of attacking army forces difficult; facilitates use of urban defense tactics by city's forces, and reduces the attacking army force's power in occupying urban areas.

- Homogenous Physical Structures. Using structures

homogeneous in terms of three-dimensional physical structure and plan (in terms of physical separation and components associated with open spaces) could greatly help protect the vital uses by passive defense. Therefore, these uses should be designed and located using homogeneous sizes, forms and geometry of parcels (proportional to the separation performed on the site), and those materials and architectural details should be used which make rapid identification, destruction and damage by the attacking army forces difficult.

- Modifying Strategic Physical Components with Unconventional Scale. In the urban context, sometimes, the strategic macro-scale uses (such as military bases, airports, etc) are established pressed together among the masses of urban texture. These uses are usually easily detected and attacked by enemy sensors due to their apparent differences with the surrounding context.

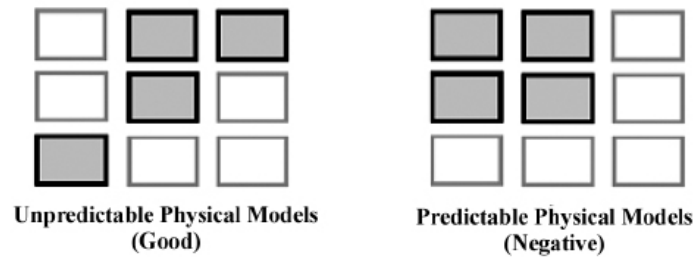


**Fig.12. Urmia Military Base as a Macro Piece in the Central Area of Urmia.**



To reduce harmful effects of this problem, we advise to separate large volumes and breaking them down into smaller parts so that from aerial view they are seen as neighboring physical parts. In fact if we cannot break down large volumes or put them in surrounding physical texture, they should be designed as a set of independent

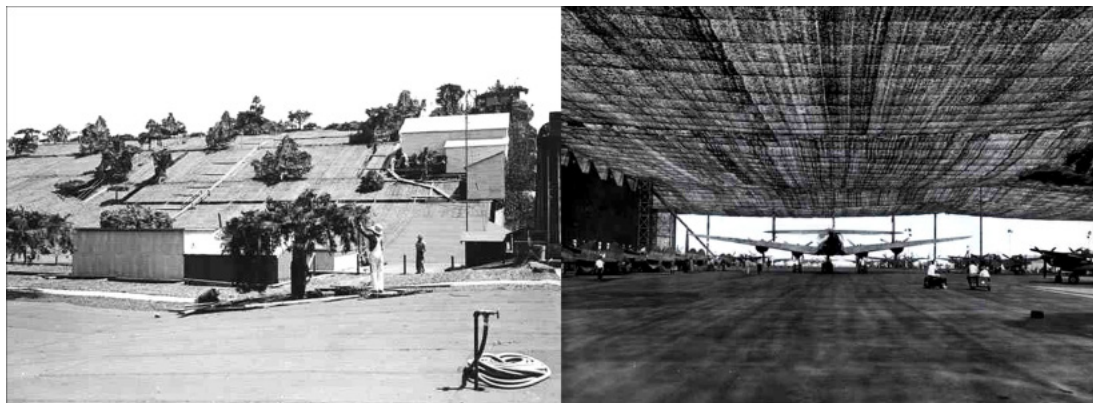
micro volumes (which are interconnected functionally), thereby creating a texture composed of similar non-distinct parts. Use of fractal architecture patterns and chaotic layout for establishing these components together can be much better than predictable geometric patterns (Shakibamanesh & H.Fesharaki, 2011, p. 133).



**Fig. 13. Schematic Illustration of Predictable Physical Models (Negative) (Right) and Unpredictable Physical Models (Good) (Left); (Shakibamanesh and H.Fesharaki, 2011, p. 133).**

Also using some traditional practices like use of perspective-making elements, plant, and artificial covers can cause the site to appear as distinct and separate

parts from aerial view. In this regard, using plants and trees with extensive tops and using special distinctive pavements can be beneficial.



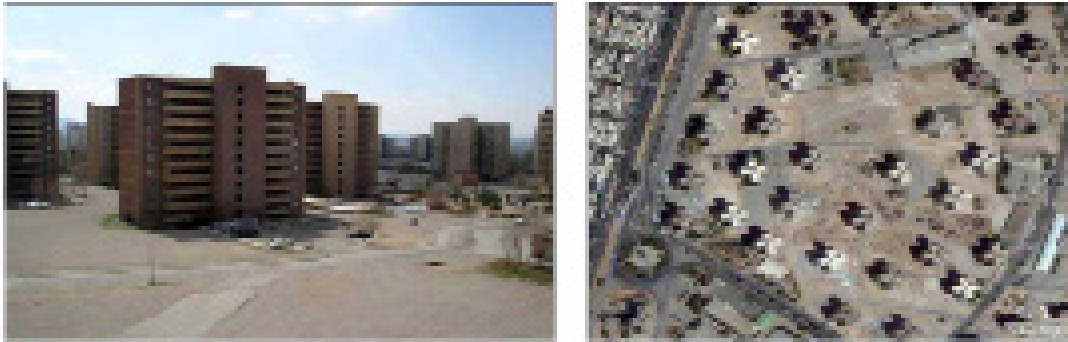
**Fig. 14. Using Plants and Special Pavements for Camouflaging a Military Aircraft Site; (S.Lingo, 2014)**

• Designing and Creating Distances between Different Parts. The distances between buildings, can be an important factor in reducing or increasing vulnerability of uses and activities. This factor can be studied and analyzed in two ways:

A) The first approach entails a close investigation of compact residential textures where lack of distance and open space in arrangement of buildings together increases injuries and damages in times of crisis due to crumbling buildings in narrow passages. After attacks, providing

help and crisis management in these areas will slow down due to minimum amount of open space and short distances between buildings. Designing and creating open spaces preferably in the form of neighborhood centers can solve the problem.

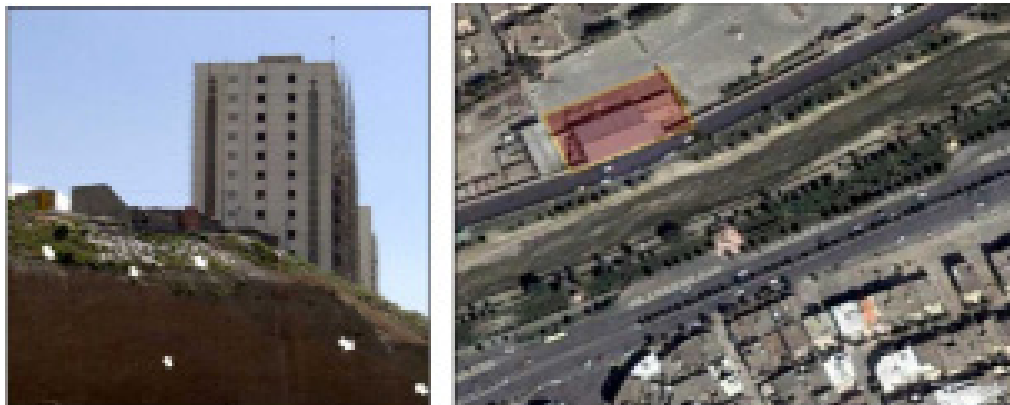
B) From political, military, and economic perspective, often large distances between buildings reduce the possibility of establishing vital and strategic uses or make their place insecure.



**Fig. 15. Large Unconventional Distances between Buildings and the Increased Vulnerability Against Attacks; Apartments Built in the Eastern Part of Afsariye, Tehran**

• **Creating Spatial Layers for Strategic Uses.** Obviously, positioning key uses in first layers of main street and also in adjacent layers of an open urban space can increase their visibility and reduce their security. Therefore, internal layers with lower visibility should

be used for positioning vital and strategic uses in urban texture -taking into account the neighboring uses (lack of macro open spaces like parks and green spaces in their vicinity) and vacant distances between the two edges.



**Fig. 16. Examples of Buildings in the First Spatial Layer.**

• **Texture Design and Establishment of a Forgotten Key Element: Shelter**

One of the physical elements from the perspective of passive defense is that of city shelters. Shelters should be commensurate with their position and their prospective users. Thus, in the crowded and densely populated urban centers, and in administrative, commercial and working centers, shelters with different functional and protection scale from those in a local area are required. However, the accessibility for these shelters and the arrangements of their surrounding physical textures should be designed in a way that can tolerate huge volumes of people in times of crisis. The most desirable location for shelters

is in the geometrical center of physical-spatial areas. For example, in a neighborhood with a shelter located in the center with access routes of 300 to 375 meters (2 to 3 minutes distance), all buildings will have a desirable access to the shelter. Locating these crucial parts in other areas of the urban context (e.g. neighborhood, district, and regional centers) should be done in a way that can provide access for as many people as possible in the shortest time possible. In this regard, in general planning or special passive defense plans, it is necessary to prepare a comprehensive map of urban shelters for each urban area (Shakibamanesh, 2009).

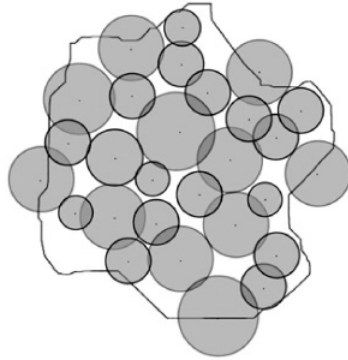
The distribution of shelters in the city at different





scales should be done in a way that shelters cover some overlapping areas to ensure entire coverage of all buildings. The best and most desirable shelters in terms of usability and maximum responsiveness to emergency needs of individuals are shelters in a neighborhood scale.

Among the uses located in neighborhood centers that can be used in equipping a neighborhood center for crisis situations, mosques, and local green and open spaces (local parks) can be mentioned (Shakibamanesh, 2009).



**Fig. 17. Need for Hierarchical Layout Taking into Account the Ease of Access to Shelter, the Spatial Area in Question (Neighborhood, District, Regional and Municipal Centers.), the Users of Space, and Overlaps with each other at Different Service Providing Levels in the Whole City; Source: (Shakibamanesh, 2009).**

- Introducing Open Spaces in Designing Urban Areas, and Locating Empty Lots in Existing Urban Areas. Urban design and considering open and green spaces in urban neighborhoods in the form of local parks (preferably in geometrical and neighborhood centers) can have positive effects in ecologic and social dimensions in regular times and can improve achievement of passive defense objectives (Shakibamanesh, 2009). On the other hand, vacant and arid lands in key and major points of urban areas are capable of being used in such special conditions

for establishment of refuges, service and health facilities, helicopter landing areas and so on, in crisis time. For example, the following piece of wasteland in the satellite images which is unsuitable for construction and farming (due to slopes, land type etc.) and is located in the context of an urban neighborhood in northern Tehran, has many capabilities in terms of defense for decision makers and planners in this area (Shakibamanesh and H.Fesharaki, 2011).



**Fig. 18. Finding Vacant Land and Wasteland to Be Used for Passive Defense Purposes (Bagh Shater Neighborhood in North of Tehran).**



- The Need to Prepare a Comprehensive Plan for Physical Stability Required for Passive Defense. Matching the data of exact location of the urban parcels and buildings with the satellite images and using GIS can help us do a comprehensive analysis in terms of passive defense. Analysis of data such as material type, construction type, building age, texture compression, location slope, width of streets related to parcels, being in the vicinity of special uses (garrisons, power stations, gas and water systems and etc.), and type of land (in terms of strength, depth of soil, gradation (size) and etc.) and matching them with satellite images can help identify and classify areas and sub areas in terms of physical stability

and determine their potential resistance against attacks in times of attacks. Obviously, this can help us identify the volatile components and textures, and provide the correct policy to strengthen them and to reduce damages, increase safety, change textures etc., in urban design (comprehensive, detailed, and guideline and etc.) or in the form of new projects that aim at passive defense.

- Taking Advantage of Three-Dimensional Computer Modeling in Strategic Analysis of Safety of Parcels. 3D modeling can be used to analyze strategic areas and buildings from a defensive perspective and to change the position or modify their physical-spatial elements if necessary.



Fig. 19. Strategic Analysis of Components Using Computer-Aided Three-Dimensional Modeling; (Al-Douri, 2006, p. 63)

- Prevent Access Blocking to the Core and Strategic Zones. From a defensive perspective, many uses are considered strategic because they have a particular military, political, economic, or service importance. Therefore, designing these uses and urban zones and the physical texture around them requires observing specific requirements. One of the most important requirements in designing the textures surrounding such parcels is that they should have alternative access networks so that people continue to have access to them in case of destruction and blockage of the main access routes. For example, in many cities, especially in small towns where the railroad passes, there is usually a main road parallel to the railroad passing near the station. However, because enemy attacks to the railway and stations can lead to destruction of this main road, it is recommended to design multiple roads parallel to the main one so that in times of crisis they can be used as alternative routes to the strategic uses.

## CONCLUSION

This study tried to express the importance and necessity of passive defense in urban design, as well as the safety effects of proper urban design in terms of form (at both macro and micro scales). In fact, as it was pointed out, macro urban patterns can play an important role in reducing or increasing the damages and vulnerabilities resulting from attacks. Therefore, decision making about the structure and patterns of cities before their development (designing new cities and towns) as well as solving problems of the current urban patterns (especially in some special urban area like city centers, densely populated areas, critical areas in terms of defense, political places, etc.) can make our cities more sustainable from a defensive perspective. Hence in this paper, after discussing the strengths and weaknesses of the major types of urban patterns (linear, gridiron, irregular, radial (concentric) and ring), the



requirements in relation to promoting sustainability of each pattern in war times and crisis were suggested. It is suggested that form-based design can play an important role in defensive issues. In fact, taking into account some provisions and requirements at small-scale urban design, such as segmentation, configuration and arrangement of buildings and urban lots (in relation to each other and open spaces) etc. helps us reduce damages and casualties resulting from enemy attacks. Hence, important points and considerations related to this level of urban form and design from a passive defense perspective were discussed. Obviously, the requirements listed in this article are not comprehensive. However, the author tried to look at the passive defense issue from a specialized urban design perspective rather than a sole military one.

In this paper, the effects of designing the form-based features on the city's resistance are discussed and it has been attempted to pave the way for further studies on urban design with a passive defense approach. In this regard, topics for future researches that can reduce the vulnerability of the urban physical texture to attacks include: the effect of geometry, shape and size of super blocks on the cities' strength against military attacks; how to design urban texture with compound patterns in order to reduce the physical vulnerability against air strikes; and defensive and stability analysis of different patterns of urban layouts with an emphasis on the third dimension of space.

## ENDNOTES

1. However in this regard, Doxiadis states that Soria y Mata did not design a linear city but rather a "small scale corridor-like expansion of cities or connection of cities" (Doxiadis, 1967 p. 35). Doxiadis states that, however the plan is titled 'Ciudad Lineal' (meaning 'Linear City'), it is essentially a design for a limited extension of an existing city and that; "Soria was not thinking of cities but of parts of cities only, as well as of very long connections between distant cities. These parts of cities have no central function and therefore do not form cities" (Doxiadis, 1967 p. 35). In Doxiadis' view on the city, the presence of a 'central function' is very persistent and it is one of the main themes in his theories for (linear) urban planning and design (Sap, 2007 p.15).

2. The Dead-end or tree systems are the simplest water system consisting of a set of straight pipelines with peripheral branches. The water flow is one-way and from the bigger to the smaller branches.

3. If we connect the ends of pipelines in a tree system, the result will be a looped system, which is more reliable and is used in most urban water distribution projects.

4. This system is a combination of tree and looped systems.

5. Vital uses are those whose total or partial destruction will cause crisis, and serious damage in the political, leadership, control and commandship, productive and economic, logistics, communication, social or defensive systems with national effects.

6. Critical uses are those whose total or partial destruction will cause crisis, and serious damage in the political, leadership, control and commandship, productive and economic, logistics, communication, social or defensive systems with regional effects.

7. Important users are those whose total or partial destruction will cause crisis, and serious damage in the political, leadership, control and commandship, productive and economic, logistics, communication, social or defensive systems with local effects.



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