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Design of architectural models to enhance the security of buildings and urban areas against military with passive defense approach[1]

Hassan Salehi[1], Ehsan Akbari[2], Mohammad Reza Abshenas[3]

Abstract. Today, with the advancement of military technologies, for many reasons ethical principles has been degenerating and different countries threaten each other for unsubstantiated reasons and attack one another. One of the most important defensive strategies that is being considered by many developed countries in the world, is using passive defense requirements for increasing the security of buildings and areas in between buildings against explosion and its peripheral effects. The lack of secure sites in open urban spaces and residential environments poses many risks for the buildings and residents in the event of a crisis. By designing these spaces intelligently, not only most of environment and human resource vulnerability can be prevented, but also by creating a beautiful space it can add to the architectural enrichment of the environment. This is an applied research with main purpose being to explain various methods of reducing the destructive effects of explosions and their resulting waves in buildings and landscapes.

Key words. Urban spaces and inter-building spaces, passive defense, architectural and landscape design patterns, secure sites.

1. Introduction

Passive defense consists of a set of non-military actions that increase deterrence ability, reduce vulnerability, sustain the necessary activities, promote national sustainability, and facilitate crisis management against threats, military actions and unexpected events (Jalali Farahani [1]). Today, passive defense is always considered as one of the most effective and lasting methods of defense against threats by most countries in the world and even countries with considerable military power like USA

[1]Khatam Ol Anbia University, Tehran, Iran; e-mail: h.salehi@srttu.edu
[2]Khatam Ol Anbia Air Defense Base, Tehran, Iran; e-mail: Ehsan.akbariea69@gmail.com
[3]Khatam Ol Anbia Air Defense Base, Tehran, Iran

and Russia pay special attention to this issue. It is for this reason that in recent years and during the Cold War a great deal of design arrangements has been done in this regard, in most countries in the world. Throughout human history, only a few years can be found when a war has not occurred at some spot in the world. As humanity entered an era of prosperity and advancement, not only the trend did not decrease, but also the methods of fighting changed in a way that the death of a large number of people in a fraction of a second became possible (Farzam Shad [2]). War equipment became more advanced day by day and the need for proper defense strategies to counter these weapons is felt more and more. This issue is more important especially in unequal and urban warfare, so as to achieve the best possible defense against the enemy using the least amount of power and equipment.

Passive defense measures can be implemented on a fixed or moving target from conceptual design and study stage until the operation of the target, and these measures include special methods and techniques at various stages of the target's life cycle. Recognizing modern methods and technologies and applying them in the design of secure landscapes and residential complexes in their proper time reduces the cost of secondary measures, and increases the effectiveness of passive measures and preservation and survival of the subject. With intelligent combination of natural elements, the architectural ideas and the principles of passive defense, these injuries can be minimized.

2. Problem statement

Attacking the cities and their strategic spaces (such as public urban areas) is always one of the most important goals of the invading countries and the reason for it is that a blow to these centers has vast destructive effects on military, defensive and psychological functions and that is of key importance in the invader's victory. So much that even the international regulations do not prevent the invading country from attacking such centers and waiving the benefits of its psychological superiority. Therefore, attention to reducing the vulnerability of such sites is important in increasing the defense capability of each city and country. Such an important issue requires finding solutions and preventive measures for decreasing damages to these centers, preserving forces and personnel as human capital (Farzam Shad [2])

Today, due to vast advances in science and technology, by designing long range missiles it is possible to accurately target and take down the targets identified by satellite imagery from very long distances. Now the question that comes to mind is: what can be done to counter the destructive effects of an enemy's air-to-surface and surface-to-surface missiles?

Without doubt the least costly and most effective way is using camouflage patterns and techniques that reduces the destructive power of the explosion wave and creates a good potential to hide and shelter human resources. Now, the main issue of this research is investigating the type, quality and sustainable design methods for public urban spaces and landscapes between the buildings; so that while creating a barrier in front of the destructive power of explosion waves, a good potential for temporary hiding of the human resources in the complex is also provided.

3. Objectives

Today, with the advancement of military technologies, for many reasons ethical principles has been degenerating and different countries threaten each other for unsubstantiated reasons and subject each other to military attacks (Shayesteh Afshar [3]). In this time, USA, as the top military power and a world super power goes unchallenged and in this way has caused irreparable damage to several countries and occupied them.

Considering its Islamic nature and existing in one of the strategic spots of the world (the Middle East), the Islamic Republic of Iran has always been exposed to various threats by different countries; Therefore it is necessary that it secure itself against any sort of military threats from enemies using the most complete defensive measures. In this regard it can be said that in terms of active defense and military equipment and weapons, most countries in the world are in same situation and level and what determines the result of a war would be war strategies and passive defense associated with nullifying the attacks and surprising the enemy. With the aforementioned points in mind the main objective of this research is exploring and analyzing effective architectural and structural components in defining a pattern for planning and design of residential neighborhoods and public spaces in urban area in order to counter the effects of a terrorist military invasion (from land and air) to the cities. Other secondary objectives of this research include:

- Increasing survival capability, sustaining vital activities and providing services to vital public urban spaces and community centers,
- Maintaining the spirit, solidarity and unity, strategic proposals to reinforce deterring factor and raising people's resistance threshold,
- Increasing the probability of durable structure activity, the continuity of vital activities and the improvement in the level of resilience of buildings and the perimeter spaces during the enemy attack, using proper design methods,
- Reducing the vulnerability and minimizing the damage to equipment and human resources as well as sensitive and strategic points of the complex,
- Saving expenses and time, to camouflage complexes and strategic and sensitive spots in time of danger,
- Attempting to divest the enemy and terrorists from the freedom and initiative by deceiving them through design,
- Decreasing the destructive power of the explosion wave (in a very small amount) and approximate control of its resulting tension, reducing casualties by designing curved guiding shapes and removing corners from landscapes and building facades.

4. Scientific or technical basis and the method of implementing the plan

This is a descriptive-analytic research whose data is collected using theoretical methods and field study. In this regard, by reviewing library resources and approved regulations such as: FEMA Regulations, Architectural and Landscape Design regulations of the USA Department of Defense, and the CD of Landscape Design of

Passive Defense of the Islamic Republic of Iran, practical and at the same time low cost parameters were identified in order to enhance the security of urban public spaces and inter-building landscapes and was then introduced to architects and designers as designable ideas.

5. Comparison of the efficiency of deception and retrofit designs on the safety of semi-buried structures

In this research, the probability of continuity of activity as the main criterion of the efficiency and the efficiency of the scheme of "deception and disturbance" and the "retrofitting" scheme for a buried structure are counted in depth and compared with each other.

In this research, in order to observe the worst computational conditions, the effect of prevention programs on the identification of buried structures is ignored and the visibility of the structure is considered to be 100 %. In this case, two strategies to secure buried structures can be imagined:

Create deception schemes to increase the CEP error of ammunition;

Reinforcing the concrete walls of the structure by adopting a strategy of increasing the thickness of the wall to reduce the permeability of the structural line.

To compare the efficacy of immunization techniques, a simple scenario is used where a buried structure at a low depth of 300 square meters is powered by the GBU-28 Enhanced Paveway III DMLGB bombs combining two types of laser sensors and the satellite is being invaded. For this purpose, the probability of continuity of the structure after the implementation of 10 air strikes was calculated for different levels of rigging and levels of deception. For this purpose, five levels of retrofitting for wall thickness from 30 cm to 1/1 m were considered. Also, five levels of deception for ammo misses were compared from 10 meters to 90 meters. Thus, 25 different statuses were obtained as shown in the table below.

Table 1. Comparison of deception and retrofit schemes (Hosseini, 2013)

	PoC	Wall thickness (m)				
		0.3	0.5	0.7	0.9	1.1
Enemy ammo error (m)	10	0%	0%	0%	0%	0%
	30	23%	32%	37%	40%	42%
	50	59%	66%	70%	72%	73%
	70	76%	81%	83%	84%	85%
	90	85%	88%	89%	90%	91%

Note: PoC - Probability of continuity (in %) of the sample structure after 10 attacks with intruding ammunition

- There is no need for retrofitting for an error value of more than 90 meters (while for a wall thickness of 1 meter, if the enemy's mistreatment error is 10 meters,

the probability of continuity of the structure is zero percent and the structure is completely destroyed.

- The rate of change in efficiency versus the ammunition error is much higher than its rate of change compared to the structural upgrading.

- For a constant error value, the yield variations with a wall thickness increase of up to 28 %, while for a constant thickness, the yield variations are maximally 55 %, about twice as high.

Now that it has been assured that the likelihood of structural survival in deception patterns is more efficient than retrofit patterns, we will examine the possibility of monitoring the targets by imaging satellites in a mathematical model in three different situations. There are three basic ways to calculate the coverage of the circuit:

1. Assuming flatness of the ground;
2. Supposing the globularity of the ground;
3. Assuming an ellipticity using a triangle other than the right side for applications that require high precision. Solving the right triangle can be sufficient (the following):

$$SW_{\mathrm{m}} = \arctan S_{\mathrm{p}} h \,. \tag{1}$$

For most applications, a spherical earth model is desirable. A solution to calculate the ground cover is to depict the satellite's line perpendicular to the surface of the earth, and then the angle (α) between the line drawn from the point of intersection of the radius of the earth and the satellite's line with the center of the earth, and the line between the center of Earth and Satellite (Fig. 1). The distance in the direction of this arc on Earth can be calculated from the following equation:

$$SW_{\mathrm{m}} = \frac{\alpha}{2\pi} R_{\mathrm{e}} \,. \tag{2}$$

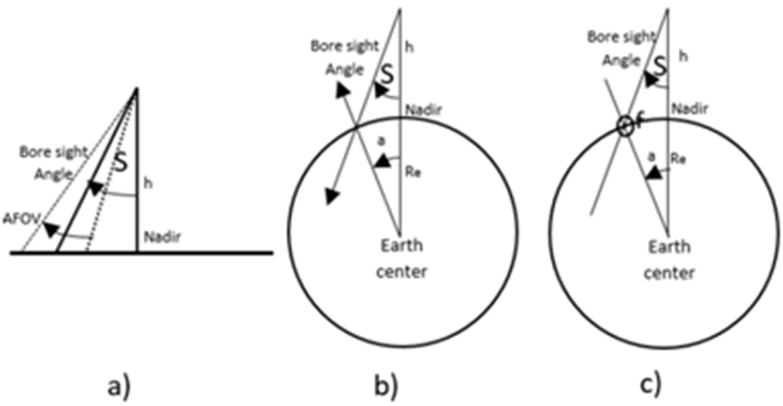


Fig. 1. Determining the satellite image coverage for three modes, flat Earth and spherical Earth (Feizi & Khazaei, 2017)

Another mathematical solution is to find the inclining angle f of an open or steep

triangle and then the peripheral angle. Satellite elevation h, Earth's radius R_{e}, and angle outside Nader S are problem information. The answer to find F is based on sinus law, which is as follows:

$$\sin(f) = \sin(s)(R_{\mathrm{e}} + h)/R_{\mathrm{e}}\,. \tag{3}$$

The algebraic expression can be arranged as follows to obtain the inclining angle f. The three angles α, φ, and s should be 180 degrees in total. Since $f = 180 - \alpha - s$, we get

$$\sin(\alpha + s) = \sin(s)(R_{\mathrm{e}} + h)/R_{\mathrm{e}}\,. \tag{4}$$

Finally, the following equation is obtained:

$$\alpha = \sin^{-1}\{\sin(s)(R_{\mathrm{e}} + h)/R_{\mathrm{e}}\} - s\,. \tag{5}$$

When the bandwidth of the circuit is calculated, the left and right positions on the azimuth maps at angles perpendicular to the satellite's path are as follows:

$$X_{\mathrm{right}} = \cos(\mathrm{heading} - 180) \cdot (-SW)\,, \tag{6}$$

$$Y_{\mathrm{right}} = -\sin(\mathrm{heading} - 180) \cdot (-SW)\,, \tag{7}$$

$$X_{\mathrm{left}} = \cos(\mathrm{heading} - 180) \cdot (SW)\,, \tag{8}$$

$$Y_{\mathrm{left}} = -\sin(\mathrm{heading} - 180) \cdot (SW)\,. \tag{9}$$

6. Landscape design requirements from passive defense viewpoint

Paying attention to principled design of open spaces by residential complex designers and urban planning rules regulators on the basis of defensive ideas, will increase the safety factor of these spaces and, consequently, reduce damages and injuries. With intelligent combination of natural elements, architectural components and passive design principles these damages can be minimized. Of course in many sites and urban spaces securing every open space is not possible. Therefore, it is only possible to secure limited spaces so that users can feel calmer and safer in times of recreation and rest.

The experience of Iraq's imposed war against Iran, the Six-Day War between the Arabs and the Zionist regime and many of the wars in the world shows that the enemy has started a sudden attack on the country using the element of surprise. This causes the people that were in open area to be exposed to serious injuries. These injuries often are due to the following factors:

- Direct impact of shrapnel caused by the explosion,
- Explosion wave,

- Flying pieces of destroyed objects,
- Collapsing debris,
- Explosion of cars and fuel tanks in the area.

Therefore, with intelligent design of the landscapes, vulnerability of the urban environment in times of crisis and enemy attack can be reduced to a large extent.

6.1. Enclosing the space

Enclosing the space is one of the most effective way to create secure spaces that can be achieved using various methods. Some of these methods include enclosure using walls, floor level difference and a row of tress. Of course it should be considered that the proportions in these spaces should never create an unpleasant, monotonous, cold and soulless and prison like environment for the users.

6.2. Creating safe corners

Creating safe corners can be planned and designed in different ways and some of the main methods include:

6.2.1. Creating level difference using ground slope. Ground slope is another possibility that the environment provides for us to create safe corners. Spaces that are on a lower level can be protected from threats on higher levels by setting some arrangements such as building walls, planting trees or creating a cavity in the slope's walls, and creating that make people feel calm and secure.

If the exterior space is leveled higher than the interior there is no need for a tall wall and short walls or a flower box can provide the security for the enclosure. It is necessary that the minimum distance of this level difference from the building be equal to the height of the building to reduce the risk of falling debris (Figs. 2 and 3).

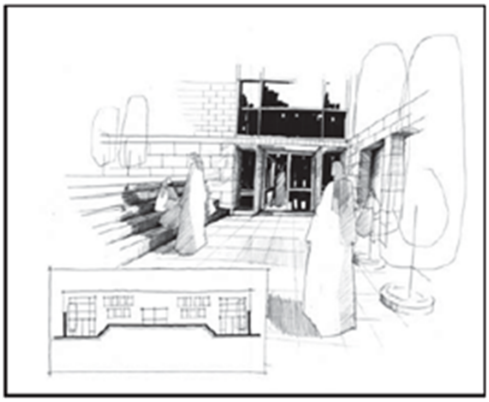


Fig. 2. Enclosing the space using ground slope (Farzm Shad [2])

6.2.2. Buildings around the enclosure. While designing a building, the general form can be designed to create safe spaces and corner in various parts. Also, creating

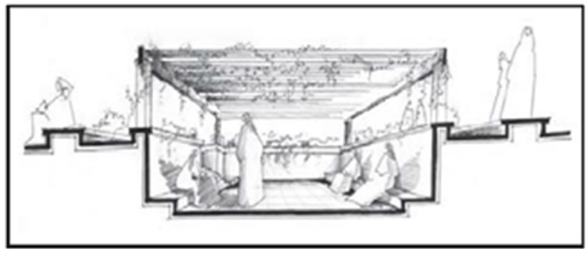


Fig. 3. Enclosing the space using level difference (Farzm Shad [2])

a pilot space under the building can create a warm space and prevent debris from falling on the pedestrians as well as providing a proper roof against sun in the summer and precipitation (Fig. 4). In addition, it causes the wave of explosion to pass from beneath and between the buildings and reduces its friction with the building's engaging surface.

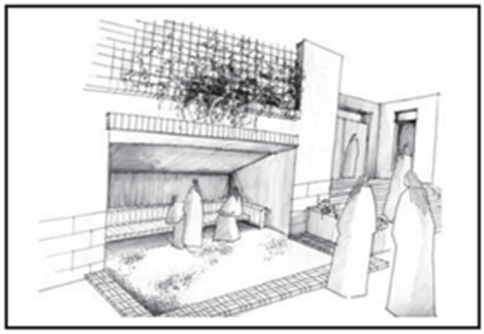


Fig. 4. Creation of safe corners into the building (Farzm Shad [2])

6.3. Form of the buildings

Leaning towards horizontal and staggered shapes can have a considerable effect in preventing debris to collapse into the open space. Also, using filleted corners and curved shapes in the buildings can also play an important role in diverting and depreciating the wave of the explosion.

6.4. Removing appending and ornamental elements from the building

Appending elements to the buildings such as terraces and balconies, shades etc. are one of the most important factors in increasing the damages. Because on one hand these components are separated from the building due to the resulting vacuum and suction from the explosion and will collapse in the yards; and on the other hand anything in them like flower pot, cooler etc. will be thrown around and into the yard and if they hit people or personnel they can cause serious and deadly injuries

to them.

6.5. Using blast pockets and bends.

In order to prevent the wave of the explosion to enter from one space to another in structures and reduce its effects, corridors and circulation paths can usually be created intricately and at different angles so that in an event of an explosion, less waves can reach other sections through tunnels. It is obvious that in straight tunnels, wave reduction happens slowly; therefore in order to prevent the entrance of explosion waves and reducing their effects on the safe spaces, we can use tunnels with deviating routes and different angles. In Fig. 5, a set of bends at various angles is presented. Symbol K_{p} is a factor that is multiplied by the amount of pressure in lieu of using each bend in the measured path compared to a straight tunnel. For example, a 90-degree bend reduces the peak pressure by about 30 %, and a T-shaped split does this by about 50 %.

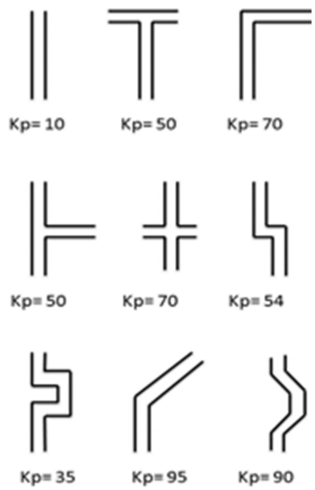


Fig. 5. Comparison between some of wave pressure reductive bends

In addition to bends, at the end of the corridors some blast pockets can be designated to depreciate the resulting waves from an explosion so that less waves can reach other corridors around (Us Army fundamentals of protective design [4]).

6.6. Using trees, elements and proper furniture.

Trees are one of the other components that can play an effective role in creating a safe space. In addition to creation of a pleasant and refreshing environment, they can be a very effective factor against shrapnel from explosion, pressure reduction and deviation of the explosion wave. Thick vegetation is also great for hiding and exiting field of view in aerial attacks. For this purpose, it is recommended to use evergreen trees such as pine and cedar trees and shrubs like Box-tree (see Fig. 6).

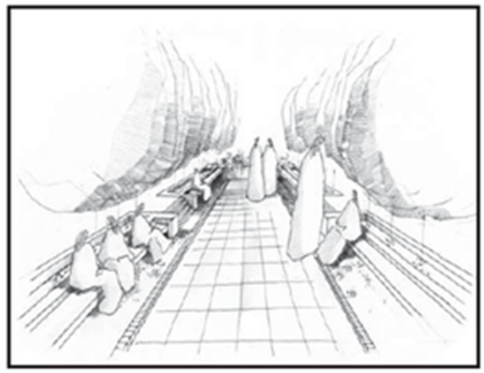


Fig. 6. Proper use of trees and vegetation (Farzm Shad [2])

6.7. Attenuating coatings

The destructive power of an explosion depends on the energy of its waves and to decrease their power, the waves should be weakened in some way or in other words their energy should be depreciated. Positioning the coatings against the waves can cause them to die out faster. These lightweight coatings have an important influence on distribution of the explosion waves and protect the physical integrity of the walls and other elements during the explosion. Available types of coating include:

6.7.1. Protective coatings with liquid mediator. The basis of protection in these protective coatings is their capacity to hold a necessary amount of water. Their main characteristics are their ability to discharge the water at the required time and its easy transfer.

6.7.2. Protective coatings with solid-gas mediator. These coatings are a type of protection that resist the resulting waves from powerful explosions and consist of oval metal beads in a mesh. A large amount of these beads that also contain a gas phase due to the cavity between them are poured in net covers. These covers are then installed on the structure for protection. The top layer must be porous so that the waves can pass through it. If this layer is hard the protection acts as a solid panel and will be destroyed. The high plasticity of this structure considerably depletes the energy of the explosion wave.

6.7.3. Protective coatings with liquid-gas mediator. The efficiency of the explosion waves absorbers increases by replacing the liquid with a liquid-gas mediator and this two-phase mediator reduces the energy of the explosion several folds due to its compressible quality. Linear or non-linear speed reduction by several times in the two-phase mediator affects the explosion wave profile. The three introduced types of coatings have some specific qualities (Keenan, 2002):

- Coatings with liquid mediator: Due to the ability of charging and discharging of a liquid and easy transportation, its usage is recommended in the areas with a

possibility of explosion.

- Coatings with solid-gas mediator: Due to its high plasticity, this structure can considerably depreciate the explosion wave.

- Compounds with liquid-gas mediator: Due to the gas phase of this coating it can reduce the speed and lengthen the time it takes for the explosion wave to pass on.

6.8. Refuge and protective walls

In open spaces, having large and smooth area is not acceptable. Therefore using simple components on surfaces can enrich the space for intended activities in normal circumstances as a well as creating immediate refuge.

- The location of the refuges should be placed outside range of rubble.

- Low capacity refuges with high distribution are better than high capacity but concentrated ones.

- Since the best body position against explosion forces is the prone position, refuges should be designed according to this position in the open space complexes (FEMA 430). Best surfaces that provide refuge in prone for a person are ornamental walls, flower boxes, benches and kennels (Fig. 7). Maximum distance radius to a refuge in open space, considering average running speed (about 3 meters per second) is suggested to be 30 meters to be reached in 10 seconds.

Fig. 7. Using flower box as a refuge (FEMA 430)

- Length of the parapet edge or any other hard barrier should be as short as possible with bends along the way in proper distances to help speed up the depletion of the explosion waves.

Wall is one of the most important elements that can provide security in open spaces; provided that materials texture and shape of the walls be taken into consideration. Vast flat surfaces in yards and gathering places are not acceptable from a security stand point. By building ornamental walls in various shapes (parallel, intersecting, etc.) we can create safe corners as well as nice and diverse spaces (Figs. 8, 9). It should be noted that any edge in an emergency is a refuge.

Also creating bends in walls not only adds to the walls resistance against lateral forces but also prevents the wall from becoming monotonous and creates small spaces and corner along the wall that will be useful as a refuge (Fig. 10).

Fig. 8. Using wall as a refuge (Naghsh Novin CD)

Fig. 9. Using ornamental walls as refuge (Naghsh Novin CD)

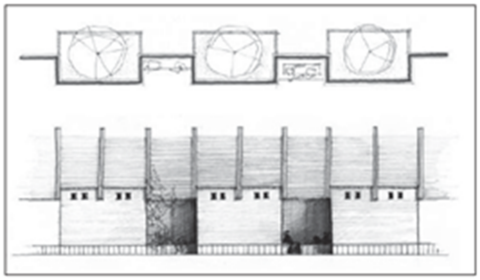


Fig. 10. Creating bends and breaks in the walls as refuge (Farzam Shad [2])

6.9. Using plasma vapor

The first time it was Russia that accidentally discovered the ability of ionized materials in changing the nature of waves. After they sent a satellite into orbit and lost the contact with in after a few days, they started searching for the possible reasons and found out that a layer of ionized oxygen exists above Earth's atmosphere and when radar waves hit this layer their nature changes and are no longer readable by the receivers on earth. They used this method in designing radar evading air crafts and getting out of missiles range (Hashemi Fesharaki, 2008). Nowadays, since the missiles are guided to the target with radar waves, special generators can be used to create ionized materials and use them with tubes on the ground level to misguide the missiles.

6.10. Polystyrene materials

Polystyrenes are materials that are achieved through polymeric processes. Polystyrene foams are very light and white in color and are made from polystyrene beads. According to the studies expanded polystyrenes has been shown to have an acceptable performance in reducing tensions caused by shock waves. Making use of inhibitors such as cavities, blocks etc. can reduce the maximum tension as well as delaying the arrival of a shock wave (Journal of Engineering Regulatory Organization, No, 524, 2009).

6.11. Landscape flooring

Anything that limits speedy escape from danger should be omitted from the landscape. The floor of open public gathering spaces should be made from soft materials. Hard, uneven surfaces like decorative and stone floors are not recommended because they may cause additional injuries. At the same time, surfaces that limit freedom of movement like soft, dry sand or sticky and muddy surfaces are recommended only in the small scale. The floor of play areas should be made from soft materials if possible. Movement paths should be made without uneven patches or unnecessary steps, especially single steps because these pose a tripping risk in the time of crisis. Ramps are recommended in such instances as they suit the situation better than steps. The slope of the ramp should be 5 percent at most and the diameter should be at least 1.8 meters for the speedy passage of two people side by side (Fig. 11).

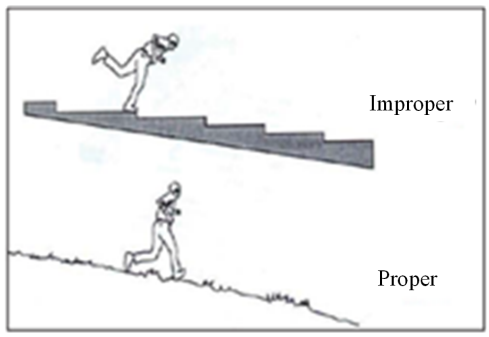


Fig. 11. Using ramps instead of stairs (National Building Regulations: Topic 21)

Green areas should be covered by grass when possible. Any kind of small stone structures (with little resistance against blast forces) is not recommended in these areas for decorative purposes. But big stone structures without sharp corners that can serve as decoration as well as a resistant shelter are a good choice (Fig. 12)

Benches are another part of open area furniture that with the right design can also be used for shelter in addition to their main purpose (FEMA 430), see Figs. 13 and 14.

Fig. 12. Using ornamental elements as refuge (FEMA 430, 4–28)

Fig. 13. Using bench as refuge (FEMA 426, 2-48)

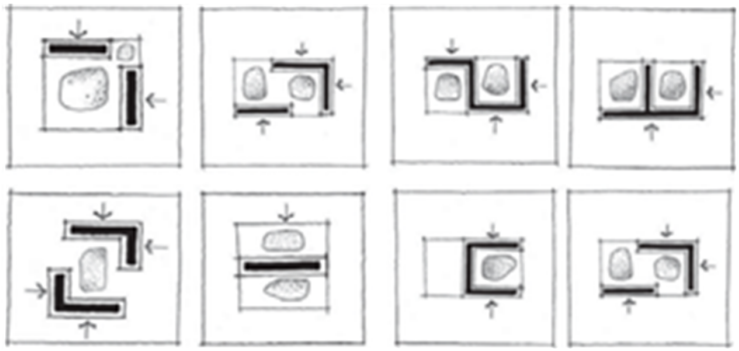


Fig. 14. Arrangement patterns for landscape benches and usage as refuge (Farzam Shad [2])

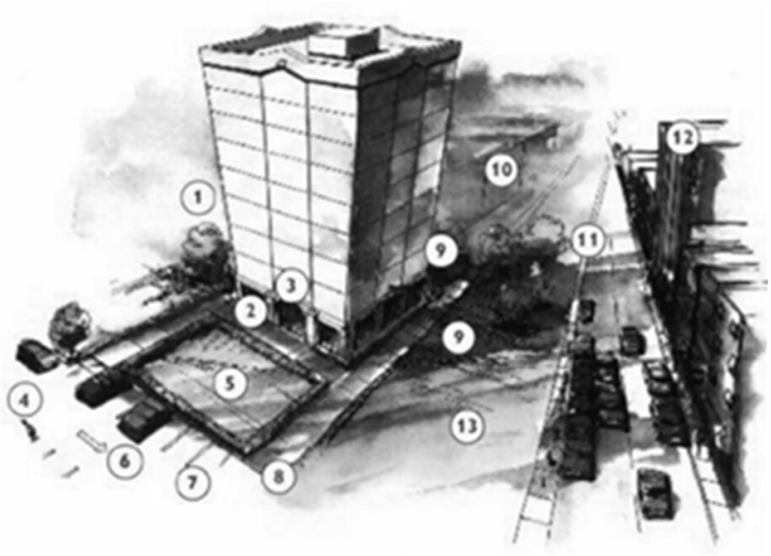
6.12. Windows and facades adjacent to the landscape

Using glass facades and large windows adjacent to yards without carrying out the necessary precautions can be an effective factor in increasing damages and casualties in the area due to pieces of glass getting thrown around. In case of using these components, firstly the glass parts should be as small as possible and be restrained in a frame, and secondly type of the glass that is used should be armed. Recessed windows can also be effectively helpful in reducing damages.

6.13. Proper distance between building blocks and the landscape

To prevent collapsing debris from destroyed buildings into the site and the people in it, proper distance between them must be observed. Also, appropriate distance between building blocks plays an important role in keeping the passages between them safe and the open space can be used for temporary accommodation and relief and rescue operations (Fig. 15).

Cars and fuel tanks are risk factors that in case of explosion can cause a lot of damage to the surrounding area. Therefore it is important that a safe distance between parking and the site be observed so that if a fire broke, it would not reach the buildings and also for a suitable place to be provided for reservoirs with protective measures and if possible lower than ground level or buried.



6.14. Kennels

Kennels, if designed with proper dimensions, are a good place to take refuge. The minimum depth of the kennel should be 5 cm more than the average body thickness of a male human and therefore about 40 cm. The material of the kennels should also be strong and resistant against explosion forces.

6.15. Using dampers

In strengthening the structures, one of the methods of reducing the lateral forces resulting from explosions is to use dampers. During the explosion a great amount of energy is applied to the structure. This energy is applied to the structure as both kinetic and potential energy that is either absorbed or depreciated. If the structure

1. Locate assets stored on site, but outside the building within view of occupied rooms in the facility.	8. Minimize vehicle access points.
2. Eliminate parking beneath buildings.	9. Eliminate potential hiding places near the building; provide an unobstructed view around building.
3.Minimize exterior signage or other indications of asset locations.	10. Site building within view of other occupied buildings on the site.
4. Locate trash receptacles as far from the building as possible.	11. Maximize distance from the building to the site boundary.
5. Eliminate lines of approach perpendicular to the building.	12. Locate building away from natural or manmade vantage points.
6. Locate parking to obtain stand-off distance from the building.	13. Secure access to power/heat plants, gas mains, water supplies, and electrical service.
7. Illuminate building exteriors or sites where exposed assets are located.	

Fig. 15. A graphic design of the general set of measures to enhance the safety of the site and residents of the building (FEMA 426)

does not have dampening qualities the vibrations will be continuous but due to the dampening effect of the materials, the vibrations will be reduced.

Dampers, depending on their function, are categorized into some types such as frictional, metal (yielding), viscous, viscoelastic, shape-memory alloys (SMA) and mass dampers (Journal of Engineering Regulatory Organization, No. 524, 2009). Therefore, depending on the amount of impact analyzed software such as Autodyne in a modeled space, dampers with appropriate hardness and correct arrangement (serial, parallel, and serial-parallel) can be used to absorb maximum amount of energy in the initial cycles (see Fig. 16).

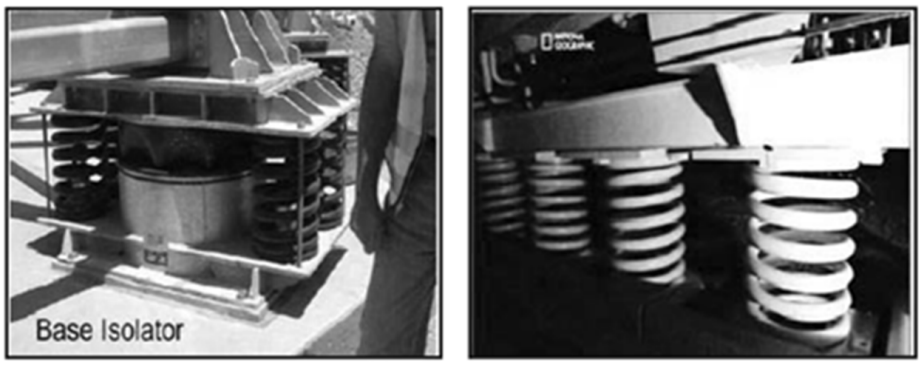


Fig. 16. A view of the damper springs at NORAD control and command center (Alhamad, 1996)

6.16. Using dampers

Damage to grids such as electricity or gas can exacerbate the losses; because gas leakage in space, can create large fires. It is necessary that proper security measures like burial of gas pipes at proper depth, automatic cut-off valves and other regulations be foreseen and for aerial passage of electricity cables be prevented.

7. Conclusion

In this paper, various methods of improving the security of urban public spaces and inter-building landscapes were investigated. In this regard, In this regard, firstly, possible threats and damage, such as the explosion wave and its destructive effects, were identified on the basis of previous experiences, and solutions for creating a sanctuary, reducing the demolition power of waves, and the manner in which design of the site and placement of space, flooring and walls of the landscapes should be done were suggested. Results clearly showed that it is possible to create beautiful and pleasant spaces without affecting their functions using architectural measures as well as reducing the severity and extent of the enemy's attacks in times of crisis; without it requiring exorbitant costs.

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