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**Original Article**

# Architectural and structural fundamentals for the high-risk buildings : Smart architectural model for safe security surveillance point in Sinai

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**Keywords:**

Architectural fundamentals, high-risk buildings, safe security point, smart architectural model, structural fundamentals.

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***Abstract***

The Increase in explosive bombs and terrorist attacks in the last decade whether in the military or non-military building has shown that the impact of it should be taken in the design process.Egypt was one of the countries targeted by terrorism, especially in Sinai, and that resulted ina huge loss, whether in civilians or in the members of the armed forces. In response to this challenge, this study sheds light on the architectural and structural considerations and roles that could mitigate the potential terrorist threat in buildings, especially the military buildings, as well, determine the most important considerations and roles that affect in designing safe fixed security points through an electronic questionnaire examined by multidisciplinary stakeholders (25 experts) involved in making a key decision in this subject, then,according to “ design-based on evidence” a reliable smart architecturalmodel for a safe security surveillance point was suggested for defending and encountering the negative impact of the terrorist attack in Sinai.

## I. INTRODUCTION

In fact, the world confronts the specter of terrorism everyday which leads totremendous destruction of assets and humans caused by an explosive bomb and terrorist attacks whether on military or non-military buildings. In this regard, all previous explosive events and terrorist attack have proven difficult to predict the extent,the severity of damage and injuries, and the best way to reduce these impacts which most of the base studies and governing rules adopted and based on to reduce the effects of explosive events to observe and analyze these past events. It has all proven that it is possible to mitigate damage and injuries by applying some architectural considerations based on the site itself, the building design, and the structure system[1].

In the last decade, Egypt was one of the countries targeted by terrorism, especially in Sinai, and that resulted ahuge loss, whether in civilians or members of the armed forces. This study suggestsa thoughtful design for the fixed security points to mitigate the potential terrorist attack in it, thus, protect the army forces in Sinai.

## II. LITERATURE REVIEW

### II.1. Explosion Definition and Blast Effects

The explosion is an energy in form of light, sound, heat, and shockwave. Indeed, shockwave is considered the main reason for the potential damages to the building because it consists of highly compressed air transfer from the source in hemispherical propagation shape at supersonic velocities (the positive phase), and when it encounters a surface, the wave is reflected resulting in a tremendous amplification of pressure (negative phase). The reflected wave leads to partial vacuum causes two phenomena[2]: (a) airburst creating powerful wind (drag pressure) in all the building surface, (b) portion of the energy is imparted to the ground.

### II.2. Architecture Design Considerations

Architectural design considerations are significant to mitigate the effects of the explosion, raising the building's efficiency,delaying terrorist attacks, and saving livesand assets. Therefore, implementing it early in the building design phase can reduce the potential risks whether in assets, occupants, and in the cost of maintenance in case of the explosion.For a balanced design, both physical security measures - of which the architectural design is a part - and operational measures must be implemented in facilities. In fact, Architectural design considerations include two pillars, first, site considerations, andsecond, building considerations[3].

#### II.2.1. Site and Layout Design Considerations

It is important to determine the type of threat and required protection level while the designer locates the site and sets the layout design considerations to create the controlled access zones, therefore,providing an exclusive zone and stand-off distance surrounding the building[4]. In this regard, the considerations and roles associated with site and layout design include the following as illustrated in (Table1).

**Table 1:** Site and layout design considerations

| N | Design considerations | The most effective role |
|---|---|---|
| 1 | Site location with ratio to roads, | Perpendicular roads to site location are forbidden |
| 2 | visual obstructions and other land uses | Line of sight must be clear (building must be higher) |
| 3 | Traffic flow around site layout | Create overlay zone to address area specific roles |
| 4 | control access zones | Provide Exclusive zone is critical |
| 5 | roadways inside site layout | Serpentine roadways are mandatory |
| 6 | Obstacles between fence and building are required | Stands of trees, and earthen berms around the asset |
| 7 | Land level in relation to the surrounding land's terrain | Land level must be higher than the surrounding land uses |
| 8 | Buildings height and function that surround site layout | Provide performance-based zoning |
| 9 | Offsite parking | One way pass, min (25 M) as a Stand-off distance |
| 10 | Fence height and shape | Triple-standard concertina wire is appreciated, (7 feet height) |
| 11 | Stand-off distance between building and fence | Clear distance (20 to 50 feet) |
| 12 | Stand-off distance between fences and roads | Clear distance (20 feet) |
| 13 | The site entry gates | Provide Pull-over lanes and inspection areas |
| 14 | Entrance vesicle passive barriers location | Center to center spacing should be between (3 and 5 feet) |
| 15 | Main gate and entry control points location | Design access points at an angle to oncoming streets |

Source:Author based on[5, 6, 7, 8]

### II.2.2. Building Design Considerations

Indeed, the architecture design for the facility plays a vital role to mitigate the effect of the terrorist attack, architectural considerations can be studied from four aspects: building shape, functions, indoor finishing, and facades finishing[9]. In this vein, the considerations and their roles associated with building design include the following as illustrated in (Table 2).

**Table 2:** Building Design Considerations

| N | Building design considerations | The most effective role |
|---|---|---|
| | Building shape (profile) considerations | |
| 1 | The basic shape of the building | The cylindrical and conic shape is preferred |
| 2 | The shape of the outer walls | Curved surfaces canbe used, convex shapes are preferred |
| 3 | The shape of outer building edges | Gradual re-entrant corners have less effectwithout overhangs |
| 4 | Building orientation | Horizontally rather than vertically |
| 5 | Building orientation ratio to roads | the primary façade must be shorter than others |
| | Building functions considerations | |
| 6 | The building main function, zones, and inner spaces design | Critical functions must be far from public and services |
| 7 | Number of building entrances | Minimizevehicles access points |
| 8 | Lobby location | Criticalfunctions must not be placed adjacent to the lobby |
| 9 | Location of critical function areas | Must be in the keep-out zone |
| 10 | Entrance placement location in relation to the ground floor | In the front and far from critical functions |
| 11 | Bomb shelter area and location | Must be accommodated the building users |
| 12 | Electromechanical equipment's location | Must be far from the critical function |

| | | |
|---|---|---|
| 13 | The occupant load for each function space | High occupant load must be in higher floors (back zones) |
| 14 | The means of egress for evacuation and safe havens | Minimum 2 egress in twoopposite directions |
| | Indoor finishing considerations | |
| 15 | Finishing materials | Fire-resistant materials are necessary |
| 16 | Type of internal doors and partitions | Glass doors and partitions are forbidden |
| 17 | Type of suspension for ceiling and lighting fixtures | Flexible suspension is mandatory |
| 18 | Mounted items and non-structural elements fixation | Perfect fixation for non-structure items is critical |
| 19 | Furniture locations ratio to the external walls | Furniture near the external wall is forbidden |
| | Facades finishing (envelope) considerations | |
| 20 | Doors&windows frame and glass type | Using steel doors or steel-clad doors with steel frames |
| 21 | Percentage of windows in the lower floors | Not more than (15%) with min sill height (5 feet) |
| 22 | Exterior walls finishing material | Sacrificial exterior wall panels to absorb blast |
| 23 | Façade's cladding and decoration | Minimal ornamentation is recommended |
| 24 | Glazing orientation | Perpendicular to the primary façade |

Source:Author based on[10, 11, 12, 13]

## II.3. Structure Design Considerations

Structure system for the high-risk buildings should be designed based on reducing the potential progressive collapse as a result of the explosive bomb or the terrorists attack, the priority should be given to the critical elements as;(slabs, walls, and columns) to mitigate the extent of collapse[14]. The considerations and roles associated with structure design are illustrated in (Table3).

**Table 3:** Structure Design Considerations

| N | Design considerations | The most effective role |
|---|---|---|
| 1 | Structure design | Must resist blast load |
| 2 | Structure material | Use ductile elements is preferred |
| 3 | Primary structure material | Precast reinforced concrete is recommended |
| 4 | Slab design | The two-way reinforced slab is recommended |
| 5 | Column's design | Columns spacing should be minimized |
| 6 | Walls's design | Shear walls are recommended in the vulnerability facade |

Source:Author based on[15, 16, 17, 18]

## II.4. Tactical Architecture and Structure Design principles

Architectural and structuraldesignermust be provided with a general profile that describes the potential threat as well as,the type of weapons and techniques that can be used by aggressors,to designa safe, economic, and suitable structure system and finishing materials for the facility that can resist this threat.Consequently, and where this study suggests a design for a safe security surveillance point in Sinai, the previous events for the terrorist attacks can identifythe type of used weapons at these attacks as Rocket-Propelled Grenades (RPG), Mortar Grenades, and Guns. In this respect, the tactical architecture and structure design considerations required to resist direct fire caused by these weapons as follow[19]:

- Locate the building on a high point (on a hill) to strike at an oblique angle, which will reduce the effectiveness of the projectile.
- Block the line of sights toward the potential target.
- Provide fences with a minimum (10 m) away from the building and (1.8m to 2.4) height.
- Use pre-detonation screen, standoff distance range between (2 to 15 m).
- Use concrete walls and roofs covered by sandbags and steel plates from outsidethose increases the stiffener of the wall as illustrated in Figure (1) and Figure (2)[20].

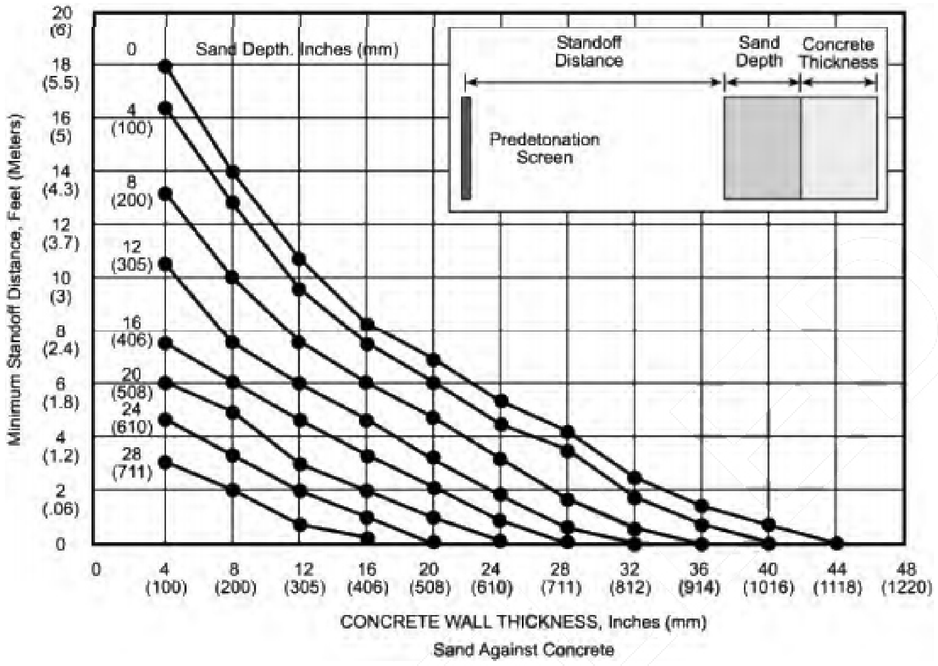



**Fig. 1:** Anti-tank weapon wall retrofit using sand

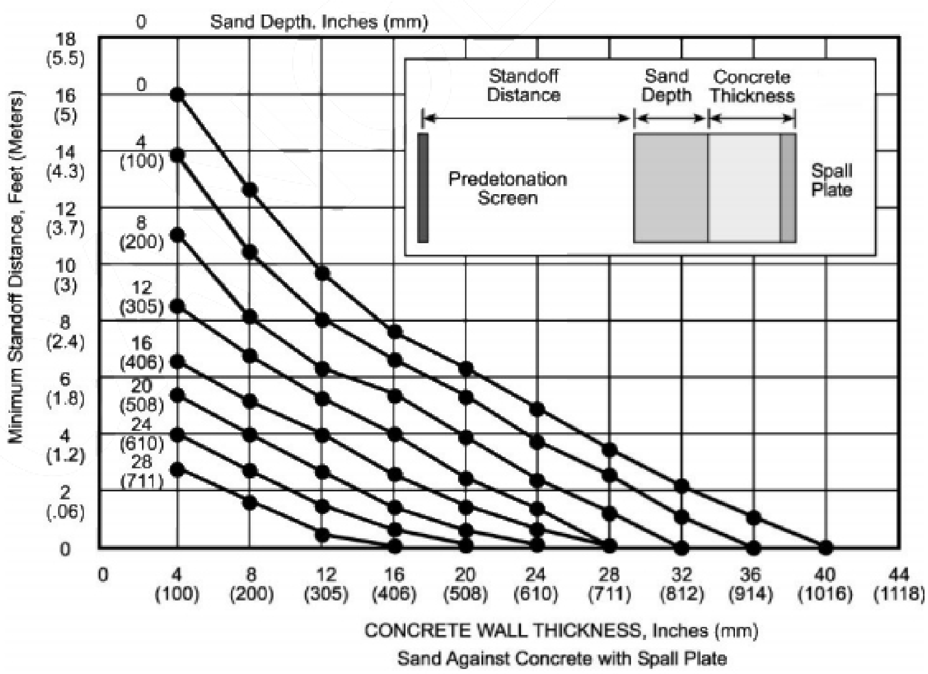



**Fig. 2:** Anti-tank weapon wall retrofit using sand and spall plate

## III. METHODOLOGY

The study was based on four pillars:

III.1. The first pillar (literature review): (Forty-Five design considerations) as:Basic site,layout,building, and structure design considerations were identified from the FederalEmergency Management Agency (FEMA) manuals, academia, and the published articles in this topic using the inductive method.

III.2. The second pillar (baseline survey): An electronic questionnaire was conducted to determine the most important type of considerations (site, building, and structure), then, the most important considerations that affect in designing safe fixed security points in Sinai to mitigate the threat of terrorists and reduce the effect of potential risks.Multidisciplinary stakeholders (25 experts) involved in making a key decision in this issue was selected, then 25 electronic questionnaires were distributed as illustrated in (Table 4).

**Table 4:** The distribution of the electronic questionnaire to the experts

| Participants | Number |
|---|---|
| Ministry of defense | 5 |
| Civil defense | 5 |
| PhD. Architects | 10 |
| PhD. Structure engineers | 5 |
| Total | 25 |

III. 3. The third pillar (statistical analysis): Subsequently, the result of the electronic questionnaire was implicated. Statistical analysis was calculated, starting from calculating the mean value (μ), Standard Deviation (α),and the Coefficient of Variance(CV) to measure the homogeneity of the sample, then, concluding the relative importance index (RII) by using (Likert) classification (k) as (EI) = (Extremely important- (I) = important - (A) = Average- (NI) = Not important - (ENI) = Extremely not important, finally, the study set the importance level and relative rankingfor each design consideration and role ratio to each phase, as well the global ranking ratio to (45) considerations by using the following equations[21]:

$$(\mu) = n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5 / \text{Total number of samples}$$
$$(CV) = (\alpha / \mu) * 100$$

As regards the (CV) result, the average was 12.92(between 10-20), which means that sample was homogeneous and balanced where:

- CV< 10 = Excellent sample
- CV (between 10-20) = Very good
- CV (between 20-30) = Acceptable
- CV (between 30-40) = Low
- CV> 40 = Unacceptable

$$(RII) = n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5 / 5(n_1 + n_2 + n_3 + n_4 + n_5)$$ [22]

- RII = 0: 0.20 = Importance level (Low = L)
- RII = 0.21: 0.40 = Importance level (Medium low = M-L)
- RII = 0.41: 0.60 = Importance level (Medium = M)
- RII = 0.61: 0.80 = Importance level (Medium high = M-H)
- RII = 0.81: 1.00 = Importance level (High = H)

Where (n5) the number of experts scored (EI), (n4) the number of experts scored (I), (n3) the number of experts scored (A), (n2) the number of experts scored (NI), and (n) the number of experts scored (ENI).

III.4. The fourth pillar (suggesting safe security surveillance point):according to “design-based on evidence” concept [23].An architectural and structural model for a safe security surveillance pointwas suggested for defending and encountering the negative impact of the terrorist attack in Sinai, based on the most important considerations that concluded from the result of the electronic questionnaire, the type of the threat, and the literature reviews.

## IV. RESULTS

The results of the study were divided into two sections. The first is related to the electronic questionnaire throughout the experts overall evaluation for the design considerations as illustrated in Figure (3), and the second section is related to the suggested design as illustrated below.

First, from the statistical analysis of the Electronic Questionnaire, and after verification of the questionnaire through (CV) coefficient as shown in (Table 5 amd 6), the most important phase was Site and Layout Design Considerations,and the most important consideration (the highest global weight) was (Traffic flow around site layout), that reflects, as well as, (twenty-one) considerations were ranked (high), and (twenty-four) considerations were ranked (high-medium). More specifically, the analysis result determined the most important considerations which ranked (high) from (1) to (10) ratio to the global rank according to multidisciplinary stakeholders (25 experts) evaluation as:

- (Five) considerations were from the site and layout design where, traffic flow around site layout was ranked (1), control access zones and the site entry gates were ranked (2), buildings height and function that surround site layout was ranked (4), and site location with ratio to roads ranked (8).
- (Four) considerations were from building design where, finishing materials were ranked (5), the building main

function, zones and inner spaces design was ranked (7), bomb shelter area and location was ranked (9), and doors and windows frame and glass type was ranked (10).

• (Two) considerations were from structure design where, structure design was ranked (3), the building main function, walls design was ranked (6).

**Table 5:** The statistical analysis of the design phases result

| Code/N | | EI | I | A | NI | ENI | Mean | Standard Deviation | Coefficient of Variance | Relative Important Index | Importance level | Relative ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | μ | α | cv | RII | | |
| Design Phases | II.2.1 | 16 | 8 | 1 | 0 | 0 | 4.600 | 0.365 | 7.938 | 0.920 | High | 1 |
| | II.2.2 | 9 | 14 | 2 | 0 | 0 | 4.280 | 0.388 | 9.069 | 0.856 | High | 3 |
| | II.3 | 15 | 6 | 2 | 2 | 0 | 4.360 | 0.602 | 13.812 | 0.872 | High | 2 |

**Table 6:** The statistical analysis of the Electronic Questionnaire result

| Code/N | | EI | I | A | NI | ENI | Mean | Standard Deviation | Coefficient of Variance | Relative Important Index | Importance level | Relative ranking | Global rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | μ | α | cv | RII | | | |
| Site and Layout Design Considerations | 1 | 8 | 15 | 1 | 1 | 0 | 4.200 | 0.447 | 10.648 | 0.840 | High | 4 | 8 |
| | 2 | 10 | 8 | 6 | 1 | 0 | 4.080 | 0.575 | 14.094 | 0.816 | High | 5 | 11 |
| | 3 | 20 | 3 | 0 | 2 | 0 | 4.640 | 0.544 | 11.725 | 0.928 | High | 1 | 1 |
| | 4 | 16 | 8 | 0 | 1 | 0 | 4.560 | 0.450 | 9.872 | 0.912 | High | 2 | 2 |
| | 5 | 5 | 8 | 10 | 2 | 0 | 3.640 | 0.574 | 15.766 | 0.728 | Medium High | 9 | 24 |
| | 6 | 5 | 12 | 6 | 1 | 1 | 3.760 | 0.613 | 16.308 | 0.752 | Medium High | 8 | 20 |
| | 7 | 3 | 13 | 6 | 3 | 0 | 3.640 | 0.544 | 14.947 | 0.728 | Medium High | 9 | 24 |
| | 8 | 14 | 9 | 1 | 1 | 0 | 4.440 | 0.486 | 10.941 | 0.888 | High | 3 | 4 |
| | 9 | 5 | 8 | 10 | 2 | 0 | 3.640 | 0.574 | 15.766 | 0.728 | Medium High | 9 | 24 |
| | 10 | 2 | 14 | 7 | 2 | 0 | 3.640 | 0.479 | 13.156 | 0.728 | Medium High | 9 | 24 |
| | 11 | 7 | 12 | 6 | 0 | 0 | 4.040 | 0.465 | 11.504 | 0.808 | High | 6 | 13 |
| | 12 | 6 | 13 | 6 | 0 | 0 | 4.000 | 0.447 | 11.180 | 0.800 | Medium High | 7 | 15 |
| | 13 | 16 | 8 | 0 | 1 | 0 | 4.560 | 0.450 | 9.872 | 0.912 | High | 2 | 2 |
| | 14 | 5 | 15 | 5 | 0 | 0 | 4.000 | 0.408 | 10.206 | 0.800 | Medium High | 7 | 15 |
| | 15 | 2 | 13 | 9 | 0 | 1 | 3.600 | 0.516 | 14.344 | 0.720 | Medium High | 10 | 27 |
| | 1 | 3 | 9 | 10 | 3 | 0 | 3.480 | 0.551 | 15.844 | 0.696 | Medium High | 20 | 35 |
| | 2 | 5 | 8 | 11 | 1 | 0 | 3.680 | 0.539 | 14.650 | 0.736 | Medium High | 17 | 31 |
| | 3 | 5 | 13 | 7 | 0 | 0 | 3.920 | 0.444 | 11.332 | 0.784 | Medium High | 12 | 23 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Design Considerations | 4 | 10 | 10 | 5 | 0 | 0 | 4.200 | 0.483 | 11.501 | 0.840 | High | 9 | 18 |
| | 5 | 8 | 13 | 3 | 1 | 0 | 4.120 | 0.494 | 11.989 | 0.824 | High | 11 | 20 |
| | 6 | 15 | 8 | 2 | 0 | 0 | 4.520 | 0.413 | 9.140 | 0.904 | High | 2 | 7 |
| | 7 | 6 | 10 | 8 | 1 | 0 | 3.840 | 0.538 | 14.008 | 0.768 | Medium High | 14 | 28 |
| | 8 | 9 | 14 | 2 | 0 | 0 | 4.280 | 0.388 | 9.069 | 0.856 | High | 7 | 16 |
| | 9 | 9 | 13 | 3 | 0 | 0 | 4.240 | 0.420 | 9.894 | 0.848 | High | 8 | 17 |
| | 10 | 11 | 10 | 4 | 0 | 0 | 4.280 | 0.466 | 10.892 | 0.856 | High | 7 | 16 |
| | 11 | 12 | 12 | 1 | 0 | 0 | 4.440 | 0.369 | 8.306 | 0.888 | High | 3 | 9 |
| | 12 | 8 | 14 | 2 | 1 | 0 | 4.160 | 0.472 | 11.343 | 0.832 | High | 10 | 19 |
| | 13 | 5 | 6 | 8 | 6 | 0 | 3.400 | 0.683 | 20.092 | 0.680 | Medium High | 21 | 36 |
| | 14 | 13 | 9 | 2 | 1 | 0 | 4.360 | 0.513 | 11.755 | 0.872 | High | 5 | 12 |
| | 15 | 18 | 5 | 2 | 0 | 0 | 4.640 | 0.403 | 8.692 | 0.928 | High | 1 | 5 |
| | 16 | 6 | 11 | 7 | 1 | 0 | 3.880 | 0.527 | 13.573 | 0.776 | Medium High | 13 | 25 |
| | 17 | 1 | 6 | 16 | 2 | 0 | 3.240 | 0.420 | 12.948 | 0.648 | Medium High | 22 | 37 |
| | 18 | 5 | 8 | 10 | 2 | 0 | 3.640 | 0.574 | 15.766 | 0.728 | Medium High | 18 | 33 |
| | 19 | 5 | 7 | 9 | 1 | 3 | 3.400 | 0.775 | 22.782 | 0.680 | Medium High | 21 | 36 |
| | 20 | 13 | 9 | 3 | 0 | 0 | 4.400 | 0.447 | 10.164 | 0.880 | High | 4 | 10 |
| | 21 | 4 | 13 | 6 | 2 | 0 | 3.760 | 0.525 | 13.972 | 0.752 | Medium High | 15 | 29 |
| | 22 | 13 | 8 | 3 | 1 | 0 | 4.320 | 0.539 | 12.480 | 0.864 | High | 6 | 14 |
| | 23 | 7 | 7 | 8 | 3 | 0 | 3.720 | 0.646 | 17.366 | 0.744 | Medium High | 16 | 30 |
| | 24 | 4 | 9 | 9 | 3 | 0 | 3.560 | 0.580 | 16.282 | 0.712 | Medium High | 19 | 34 |
| Structure Considerations | 1 | 21 | 3 | 0 | 1 | 0 | 4.760 | 0.420 | 8.814 | 0.952 | High | 1 | 3 |
| | 2 | 7 | 12 | 4 | 2 | 0 | 3.960 | 0.562 | 14.195 | 0.792 | Medium High | 3 | 21 |
| | 3 | 6 | 11 | 5 | 3 | 0 | 3.800 | 0.606 | 15.935 | 0.760 | Medium High | 5 | 26 |
| | 4 | 4 | 10 | 8 | 3 | 0 | 3.600 | 0.577 | 16.038 | 0.720 | Medium High | 6 | 32 |
| | 5 | 6 | 11 | 7 | 1 | 0 | 3.880 | 0.527 | 13.573 | 0.776 | Medium High | 4 | 22 |
| | 6 | 16 | 7 | 1 | 1 | 0 | 4.520 | 0.487 | 10.778 | 0.904 | High | 2 | 6 |
| The average of (Coefficient of Variance) | | | | | | | | | 12.92 | | | | |

Where (EI) = Extremely important- (I) = important- (A) = Average- (NI) = Not important - (ENI) = Extremely not important

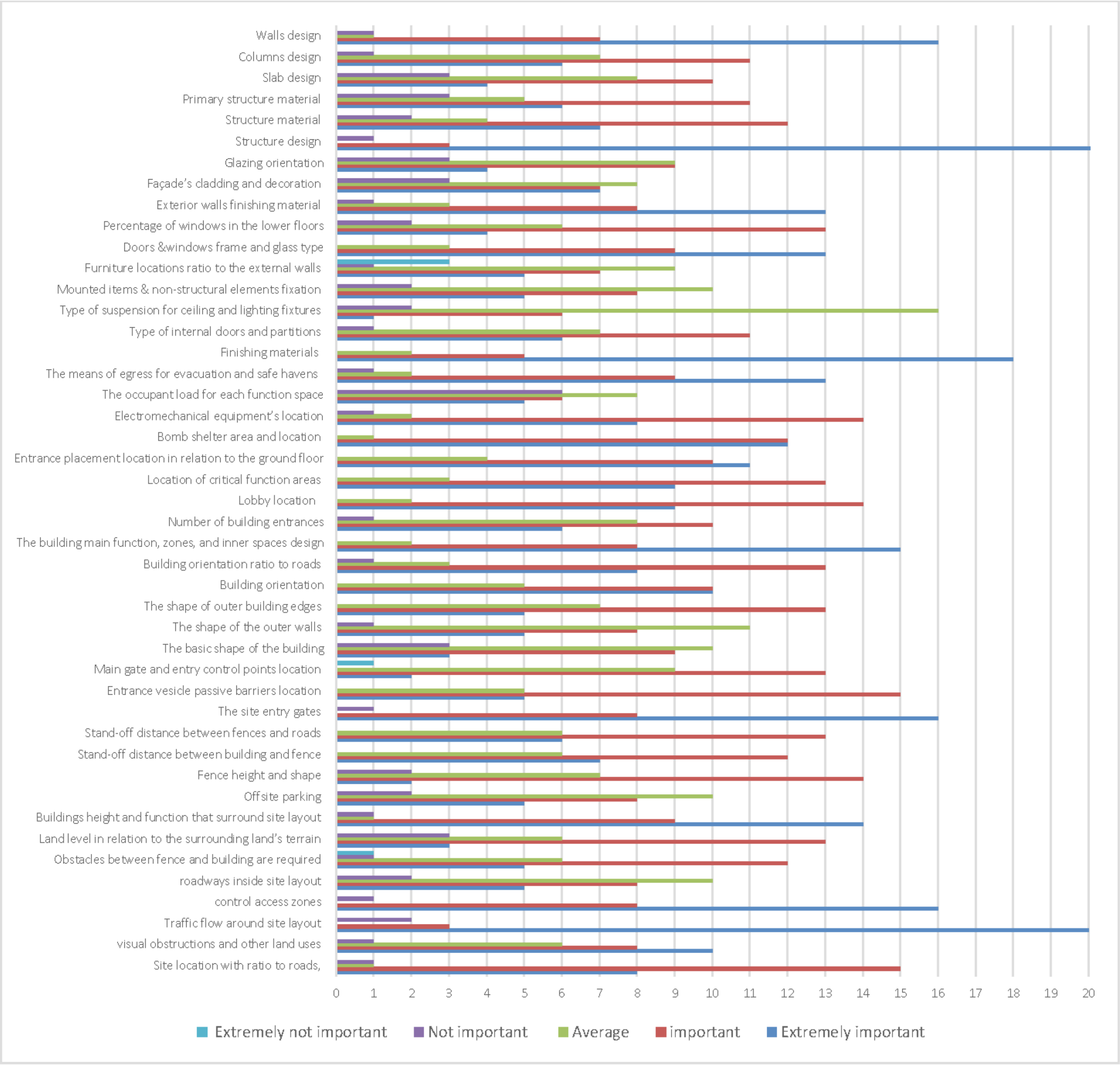



**Fig. 3:** Experts overall evaluation for the design considerations

Second,based on, literature review, the most important considerations that conducted from the electronic questionnaire, tactical engineering principles and structure design discussed as in Figure (1) and (2). A proposed model has been designed for a safe security surveillance point in Sinai as shown in Figures (4) and (5). Concerning the design of the proposed model unit, it consists of:

- Five precast reinforced pipes with radius(1.2 m).The own weight for each one including the furniture (5.8 ton),four of them for soldiers, each pipe accommodates four soldiers, supported with (four) beds, toilet, shower cabin, and (four) lockers.
- Each pipe contains (five) firing slots with (30 cm width, 40 cm height) distributed to cover the line of sight, these slots can be closed by sliding steel plates with a thickness (8mm), as well as, (one) sliding steel door with (70 cm width, 180 cm height) consists of two layers of steel plates with a thickness (6mm for each) and (28.4 mm bullet fiberglass) between them.
- The flooring for the pipes is from grating steel plates with a thickness (6mm), all the pipes painted from inside by (anti-bacterial and fire-resistant painting), all the furniture units were made from stainless steel and galvanized plates with curved edges, and all the outer perimeter of the pipes protected by sandbags with a thickness (40cm) stacked staggered.
- The last pipe is for the battalion commander and the weapons and ammunition store, also it has the same

finishing specifications for the four pipes.

• The five pipes were assembled as illustrated in Figure (4).The roof of the unit consists of threelayers: grating plates with a thickness (8mm), checkered plates with a thickness (2mm), and sandbags with height (20 cm), the access for the roof by external ladder, also the roof corners supported with shooting units protected by sandbags.

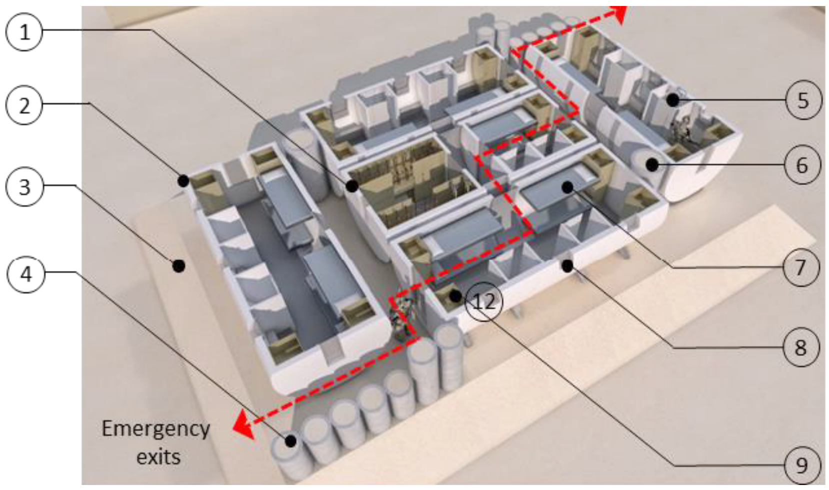
On another hand, a set of design considerations were taken in the site layout to provide high protection for the model as illustrated in Figure (5) and (6)and through the following:

• Locate the model above a hill with height (1.5 m).

• The unit has two emergency exits in two opposite directions, as well as, the pass for escape was protected by pipes filled with sand with (height 1.2 m).

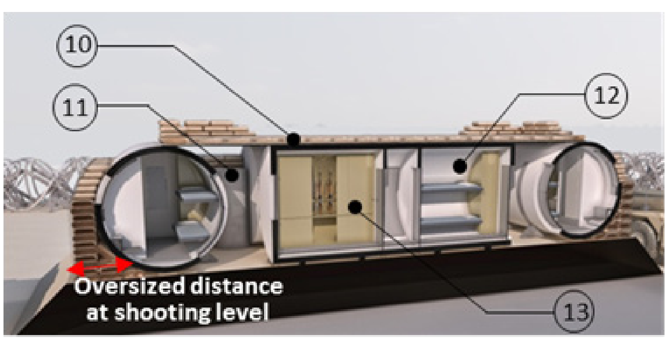
• Provide four pre-detonation screens with standoff distance (15 m).

• The site perimeter forthe unit is protected with a triple standard concertina fence with a clear zone (20m) surrounding.

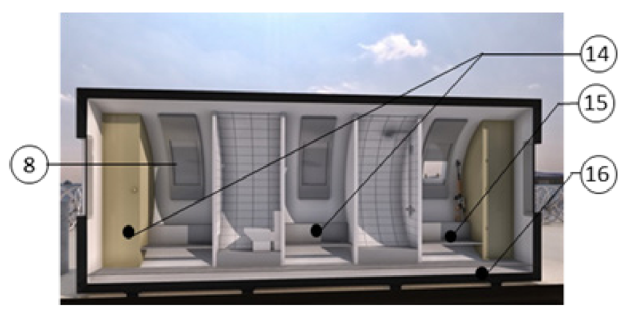



(1) Battalion commander unit with weapons and ammunition store.
(2) Precast reinforced soldier's pipes.
(3) Hill with height 1.5 m.
(4) Protection pipes filled with sand.
(5) Toilets & shower cabins.
(6) Path dead end, protection pipe filled with sand.
(7) Soldier's beds.
(8) Firing slots with sliding steel plates for closing.
(9) Soldier's lockers.
(10) Roof Layers: 8mm grating plates, 2mm checkered plates and 20 cm sandbags.
(11) Dead end pass closed with 1.2 m height pipe filled with sand.
(12) Anti-bacterial and fire-resistant inside wall painting.
(13) Weapons and ammunition store.
(14) Stainless steel and galvanized plates furniture units.
(15) Step-over bench for steadily shooting & for sitting.
(16) 6mm Grating steel plates flooring.

(a) The masterplan of the proposed model and its components

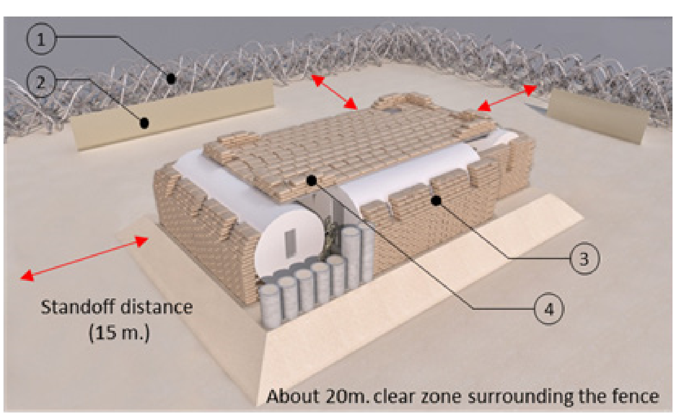



(b) Perspective section passing through the battalion commander's unit



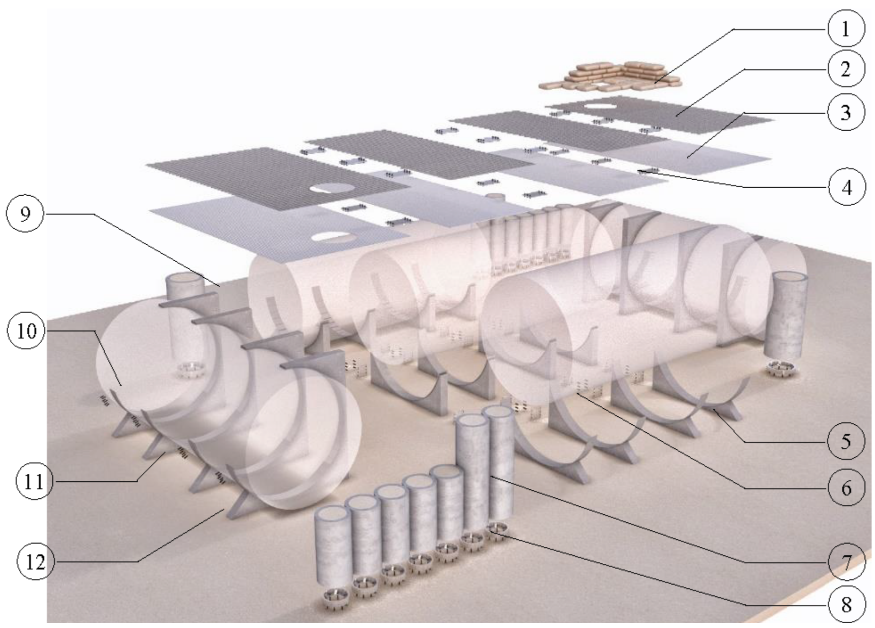

(c) Perspective section passing through one of solders' unit

**Fig. 4:** The model design for safe security surveillance point in Sinai




(1) Triple standard concertina fence around site parameters.
(2) Pre-detonation screens around site sides.
(3) Sandbags around firing slots.
(4) Extra sandbag corners supported shooting points.

**Fig. 5:** Perspective shot for the layout for safe security surveillance point in Sinai




(1) Sand bags with height (20cm).
(2) Checkered plates with a thickness (2mm).
(3) Grating plates with a thickness (8mm).
(4) Galvanized accessories to fix plates.
(5) Galvanized built-up base to fix the pipes.
(6) Galvanized anchors to fix the bases.
(7) Precast reinforced pipes filled with sand.
(8) Galvanized steel base to fix the pipes.
(9) Slab on grade.
(10) Precast reinforced pipes with radius 1.2m.
(11) Bolts to fix pipes with the built-up base.
(12) Galvanized built-up base to fix the pipes.

(a) The structure system for the proposed model

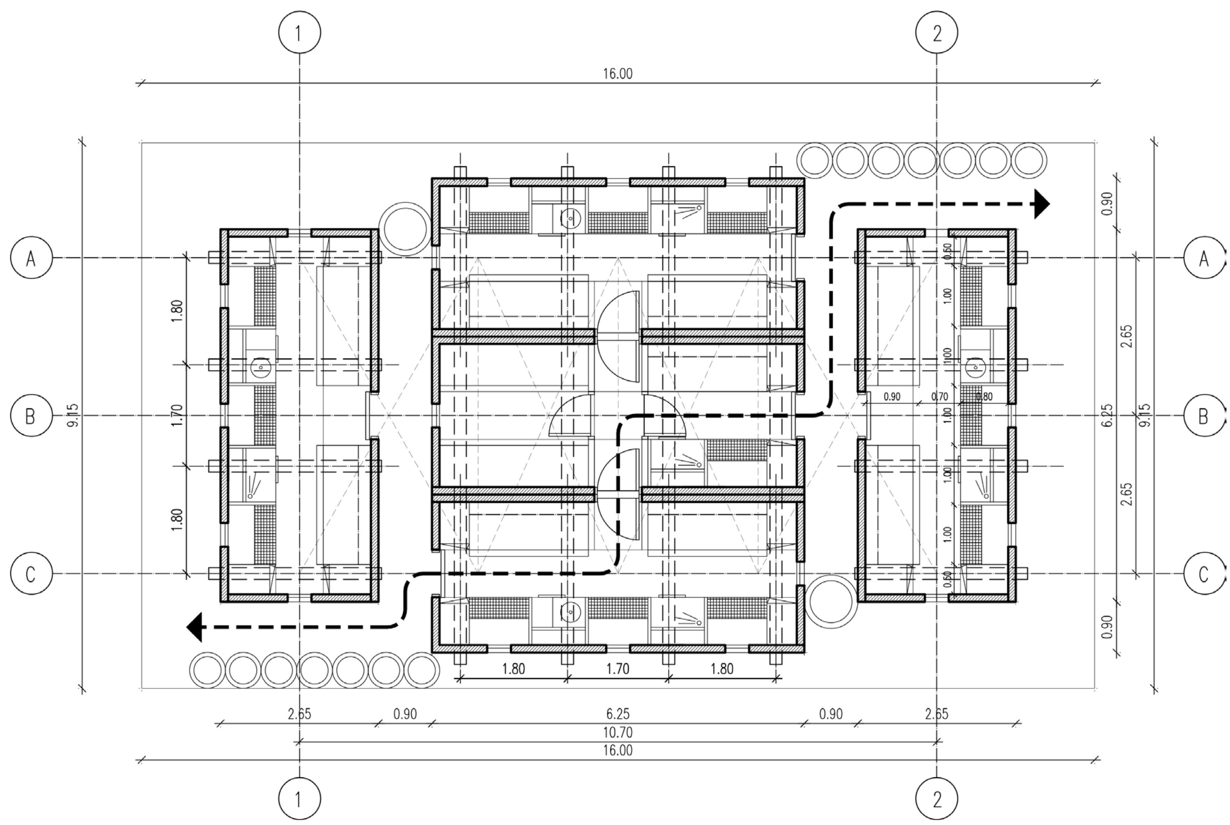



**Fig. 6:** The Architectural masterplan of the surveillance point, and the structure system model.

## V. DISCUSSION

With regard to the evaluation of the electronic questionnaire, (five) roles related to the site and layout design must be applied as: roles create overlay zone to address area-specific, providing exclusive zone is critical, providing performance-based zoning, providing pull-over lanes and inspection areas, and perpendicular roads to site location are forbidden, that reflects the consensus of experts that implementing precautionary procedures during the layout design process plays a vital role in preventing the explosion, or in other words mitigate the impact of the explosion and therefore reducing losses whether in assets or humans to a minimum by moving the potential hazard away from the building.

Similarly,(four) roles related to building design must be applied as: fire resistant materials are necessary, critical functions must be far from public and services, bomb shelter must accommodate the building users, and using steel doors or steel-clad doors with steel frames.The experts' choices for these considerations and rules ensured that experts' concern not only on the assets but also on the souls of the building's users, which the experts considered to be of first priority according to the result of the evaluation. For example, the experts' choice of providing a bomb shelter location with an area that can accommodate the occupant load of the building users reflects the experts' keenness on the building's users before the building itself.

As well as, (two) roles related to structure design must be applied as: Structure design must resist blast load, and using Shear walls are recommended in the vulnerability façade,that reflect the importance of using these criteria in the structure design process to reduce the potential progressive collapse as a result of the explosive bomb or the terrorist's attack.

In the light of the proposed model, the precast reinforced pipes with radius (1.2m) can provide high protection for the army forces, and the ability to be rearranged in many shapes according to the site circumstances, more specifically, each site, buildingand structure considerations were applied related the experts'evaluation for the electronic questionnaire which determines the considerations with priority. Therefore, the advantages of the suggested model can be summarized as:

• It considered a mobile unit where the location can be changed in a short time.

• Easy, fast, and low-cost maintenance and renewal in case of damage as a result of any attack.

• Availability to rearrange the units according to the site circumstances.

• The initial cost for this model is lower than the traditional model.

• The ability for modification to provide more protection in case of war.

• Site mobilization and collecting the units don't need skilled laborers.

• It can be used as an emergency shelter in case of disasters.

• Opportunity for an extension by adding more than one model according to army force needs.

• Wall and roof layers provide high protection against(RPG) and mortar projectiles according to the standards.

• Locating the model on a hill, and the pre-detonation screens can provide protection against direct shots.

In addition, alternative materials and technologies can be used to enhance the performance of the model for instance:

• Use ultra-high performance fiber reinforced concrete (UHPFRC) which provide advanced mechanical properties and lighter weight compared with the (PRC)[24].

• Install bulletproof windows supported with glass or fiberglass instead of the galvanized steel plates.

• Promote the site with solar cells to provide electricity in case of emergency.

• Provide a camera system supported with infra-red to monitor the site.

Despite, using these materials and technologies will improve the model performance but it will increase the cost of implementation and maintenance in case of terrorist attacks, therefore, risk assessment for the potential threat is too important to identify the best treatments whether in choosing the materials and technologies or the arrangement of the pipes.

## VI. CONCLUSIONS

Identifying the architectural, structural, and tactical considerations and roles for high-risk buildings play a vital role in mitigating the hazard of terrorist assaults. It can prevent these events in some scenarios. Traffic flow around site layout, control access zones, the site entry gates location ratio to the building, and structure design must resist blast load, using shear walls to reduce the potential progressive collapse as a result of the explosive bomb or the terrorist attack are considered the most important considerations in design these types of buildings as a result of the multidisciplinary experts' evaluation. In this respect, implementing the design considerations according to its ranks whether relative or global rank which concluded from the electronic questionnaire could enhance the building performance, reduce the cost, save time, and mitigate the impact of potential attacks.

In the relevant context, the suggested smart model for safe security surveillance point in Sinai which is based on the precast reinforced concrete pipes with radius (1.2 m) as a design unit can achieve many advantages either in war or in peace. It has an easy, fast, and low-cost maintenance.In addition to itsavailability torearrange the units according to the site circumstances. Also, the suggested model can be used in peace as a camp unit for labors in the petroleum fields in the high-risk areas.

Finally, the suggested model is a conceptual model that was designed according tothe previous events for the terrorist attacks, therefore, the type of weapons that used in these attacks only (traditional RPG and mortar). So, field experiments could be applied to explore the model's weakness points to improve its performance.

## VII. ACKNOWLEDGMENT

We gratefully thank Prof. Magdy Tammam, and Dr. Omar Ismail for their technical support.

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IX.. APPENDICES

This section includes a google form (the electronic questionnaire) as a pdf file, it contains all the questions and the results as numbers and bars.

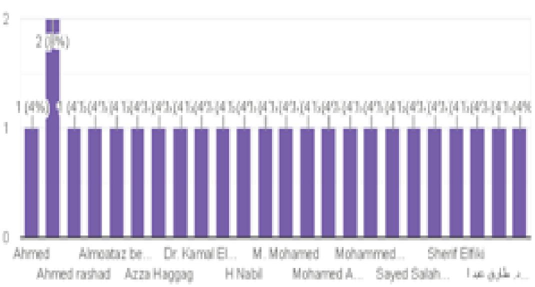
Architecture Design Role in Mitigating Risks for Targeted Buildings

25 responses

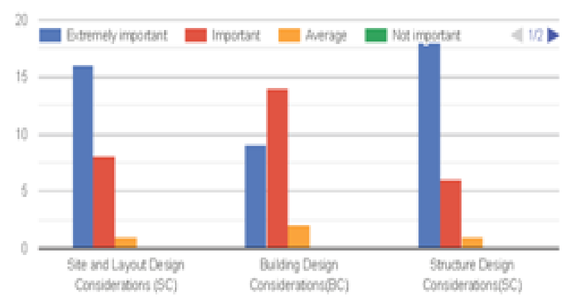
Publish analytics

Expert name:

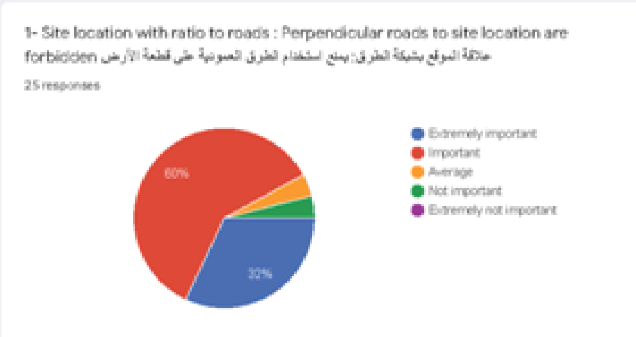
25 responses

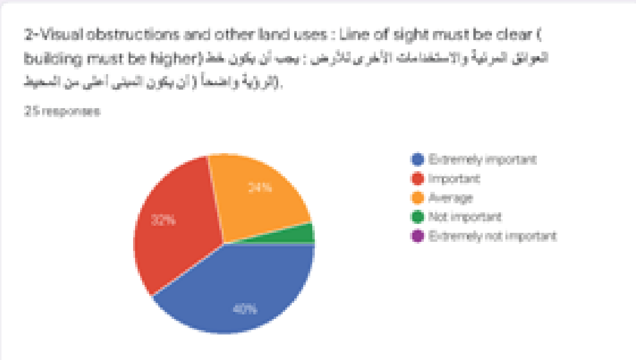


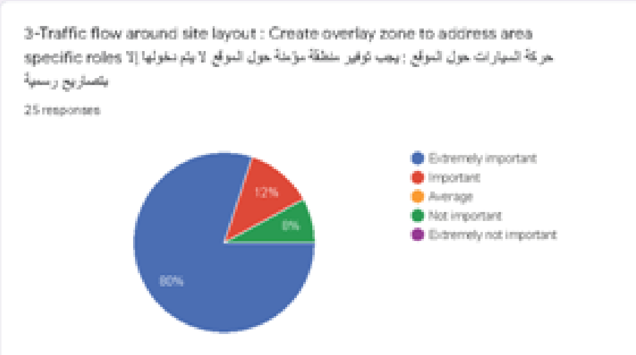

Design considerations for targeted buildings are classified into : Site and Layout Design Considerations (SC), Building Design Considerations(BC) and Structure Design Considerations(SC) ......These considerations can be arranged according to its priority of implementation into as following : تصنف اعتبارات تصميم المباني المستهدفة إلى اعتبارات خاصة بالموقع العام , اعتبارات خاصة بالمبنى نفسه ( شكل المبنى , تصميمه من الداخل, التشطيبات والأعمال التكميلية الداخلية,الواجهات الخارجية) , واعتبارات خاصة بالتصميم الإنشائي ... ويمكن تصنيفها من حيث أولوية التطبيق كالتالي

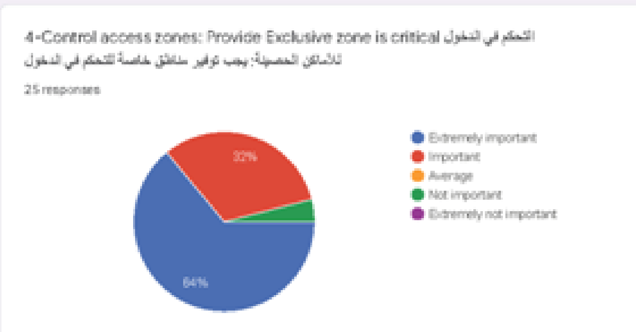


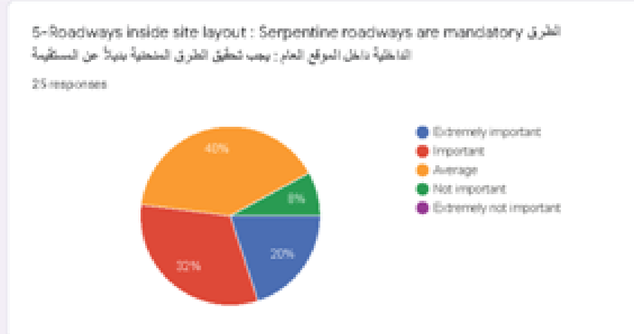

**Architecture Design Considerations First: Site and Layout Design Considerations**


1- Site location with ratio to roads : Perpendicular roads to site location are forbidden علاقة الموقع بشبكة الطرق: يمنع استخدام الطرق العمودية على قطعة الأرض
25 responses
60%
32%
Extremely important
Important
Average
Not important
Extremely not important


2-Visual obstructions and other land uses : Line of sight must be clear ( building must be higher) العوائق المرئية والاستخدامات الأخرى للأرض : يجب أن يكون خط الرؤية واضحاً ( أن يكون المبنى أعلى من المحيط).
25 responses
24%
32%
40%
Extremely important
Important
Average
Not important
Extremely not important

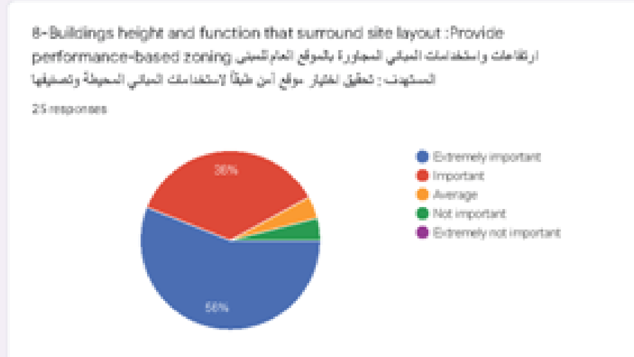

3-Traffic flow around site layout : Create overlay zone to address area specific roles حركة السيارات حول الموقع : يجب توفير منطقة مؤمنة حول الموقع لا يتم دخولها إلا بتصاريح رسمية
25 responses
12%
8%
80%
Extremely important
Important
Average
Not important
Extremely not important

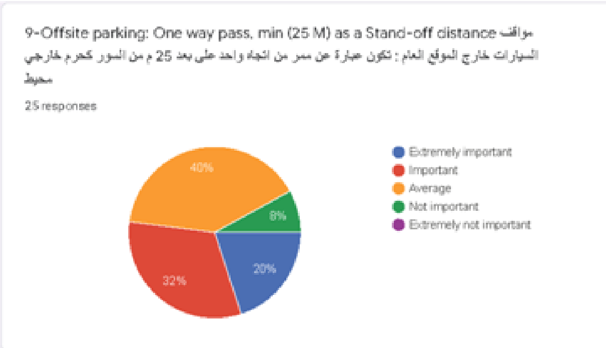

4-Control access zones: Provide Exclusive zone is critical التحكم في الدخول للأماكن الحصينة: يجب توفير مناطق خاصة للتحكم في الدخول
25 responses
32%
64%
Extremely important
Important
Average
Not important
Extremely not important

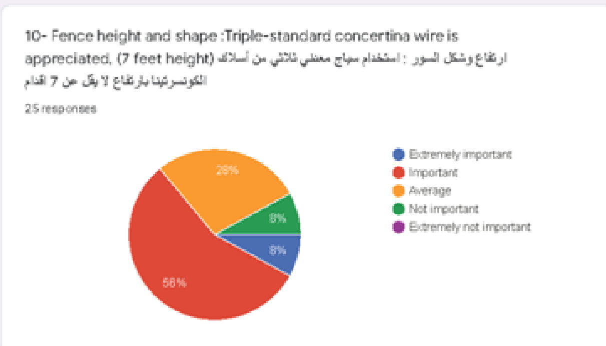

5-Roadways inside site layout : Serpentine roadways are mandatory الطرق الداخلية داخل الموقع العام : يجب تحقيق الطرق المنحنية بدلاً عن المستقيمة
25 responses
40%
8%
32%
20%
Extremely important
Important
Average
Not important
Extremely not important

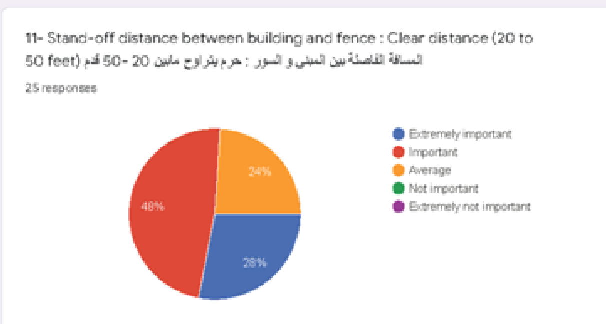

6-Obstacles between fence and building : Stands of trees, and earthen berms around the asset are required وجود عقبات بين السور والبناء: يجب توفير مدرجات من الأشجار والسواتر الترابية حول المبنى المستهدف
25 responses
24%
48%
20%
Extremely important
Important
Average
Not important
Extremely not important

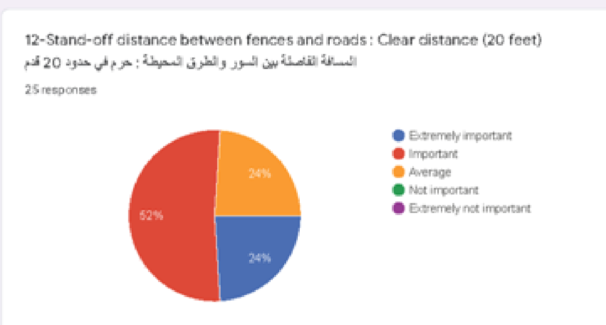

7-Land level in relation to the surrounding land's terrain: Land level must be higher than the surrounding land uses منسوب الموقع مقارنة بتضاريس الأراضي المحيطة يجب أن تكون على مستوى أعلى من المحيط:
25 responses
24%
12%
12%
52%
Extremely important
Important
Average
Not important
Extremely not important

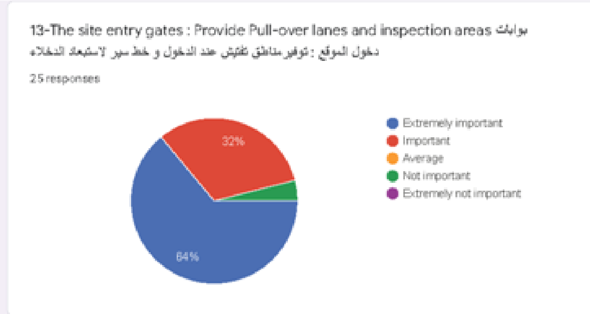

8-Buildings height and function that surround site layout :Provide performance-based zoning ارتفاعات واستخدامات المباني المجاورة بالموقع العام للمبنى المستهدف : تحقيق اختيار موقع آمن طبقاً لاستخدامات المباني المحيطة وتصنيفها
25 responses
36%
56%
Extremely important
Important
Average
Not important
Extremely not important

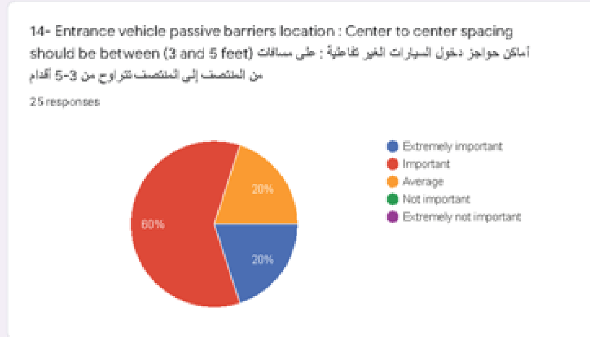


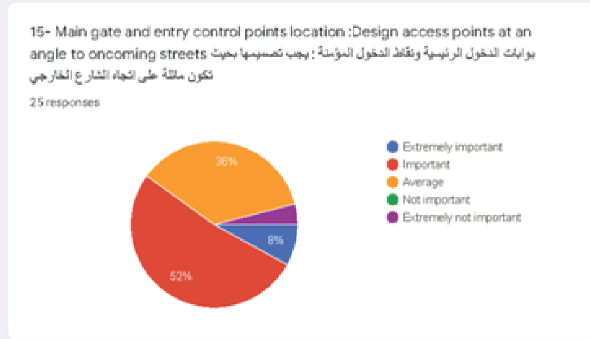



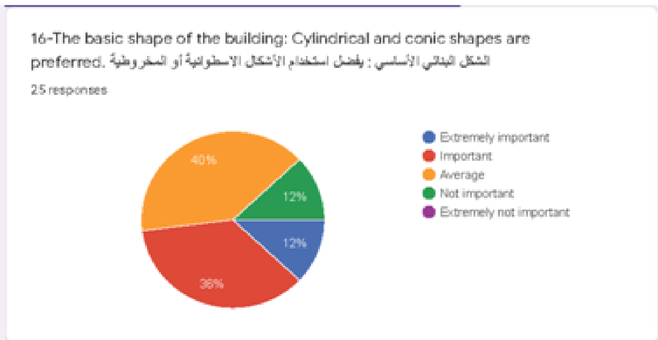



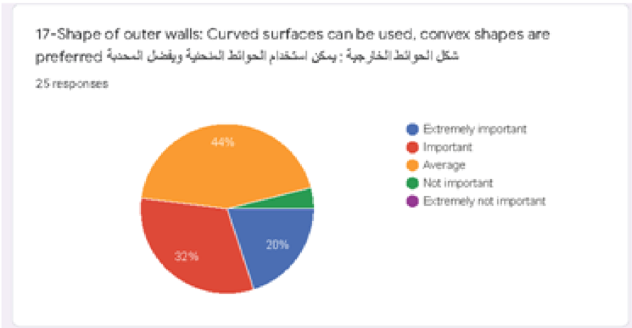



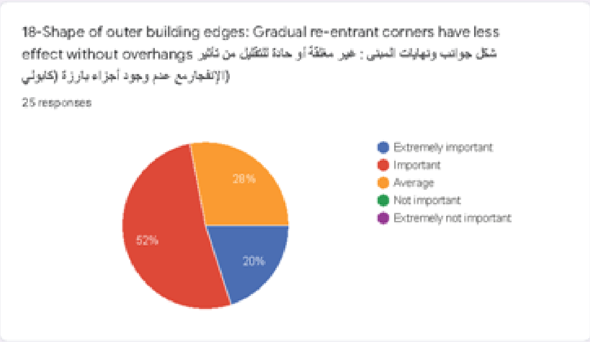



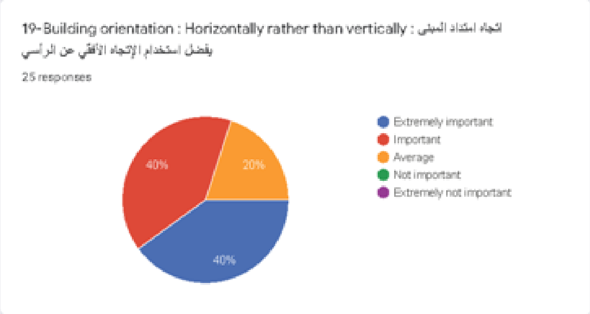



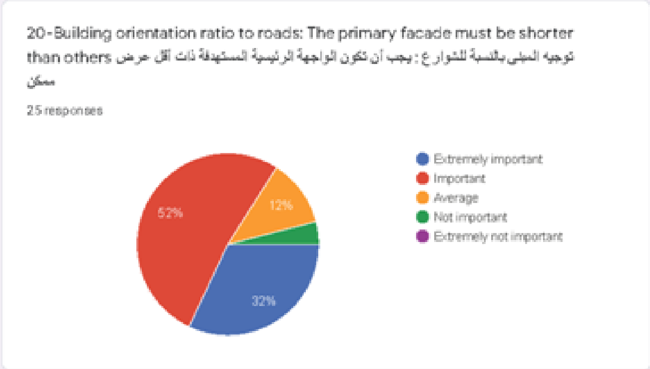

Second: Building Design Considerations: (a) Building shape (profile) considerations



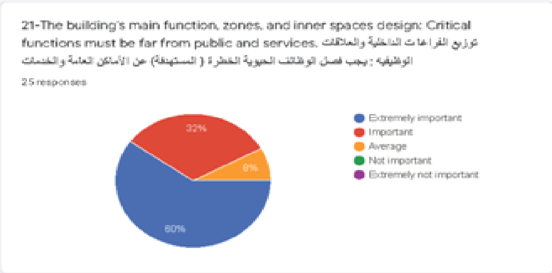



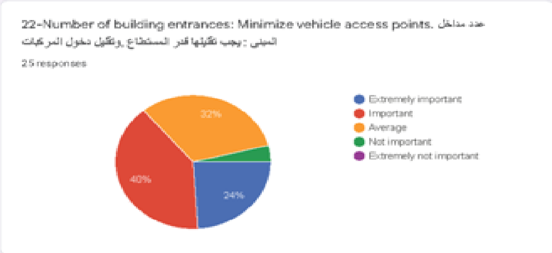


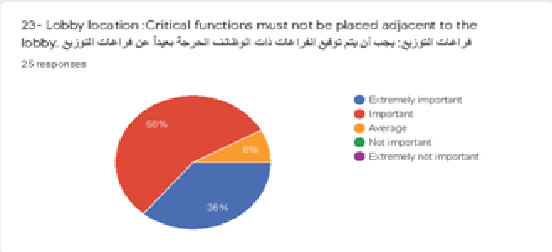



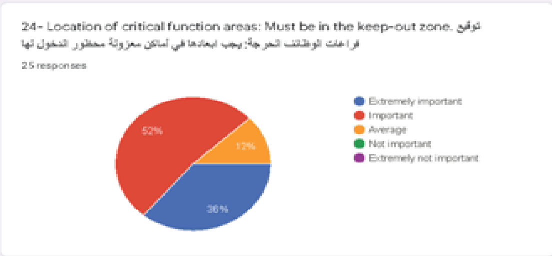



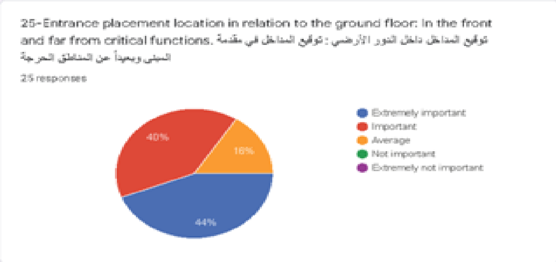

Second: Building Design Considerations: (b) Building functions considerations

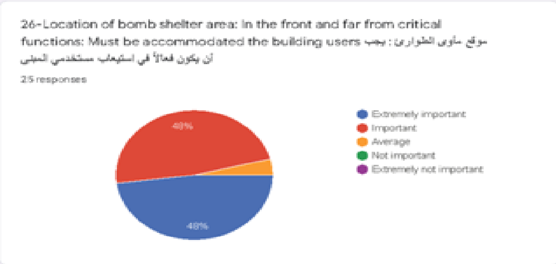


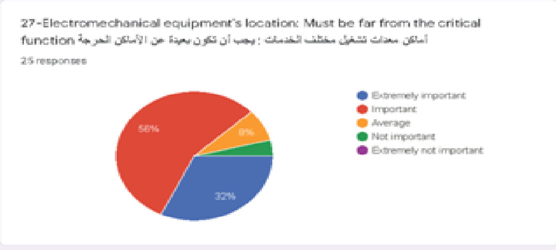



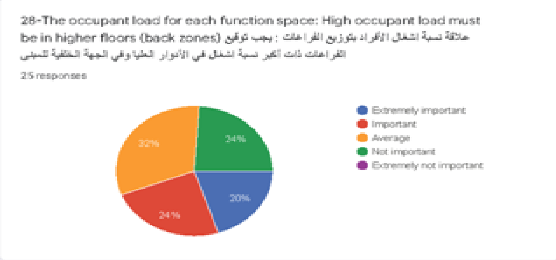



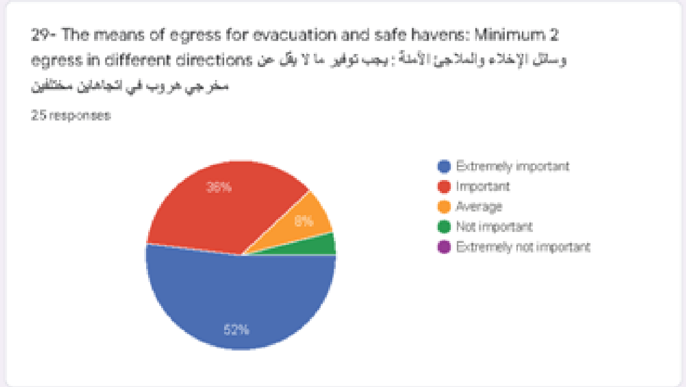



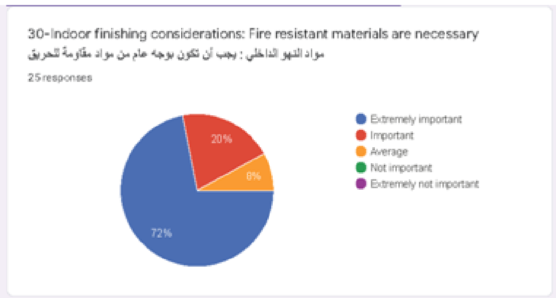



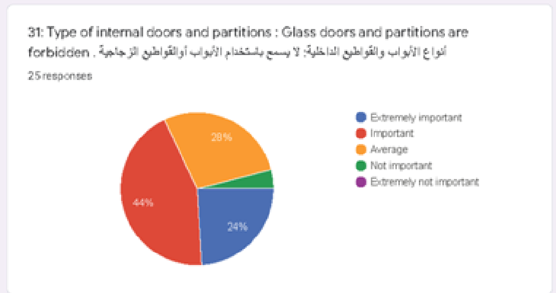



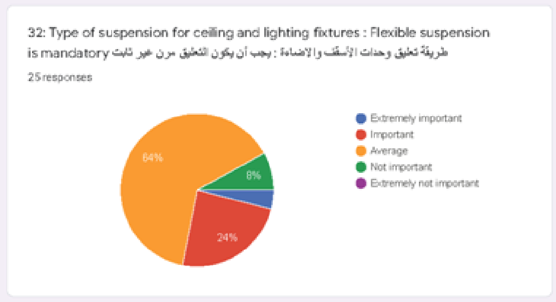



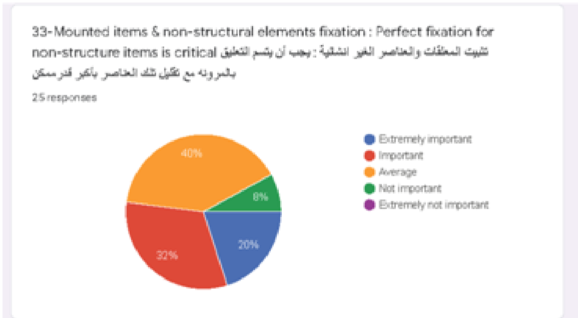


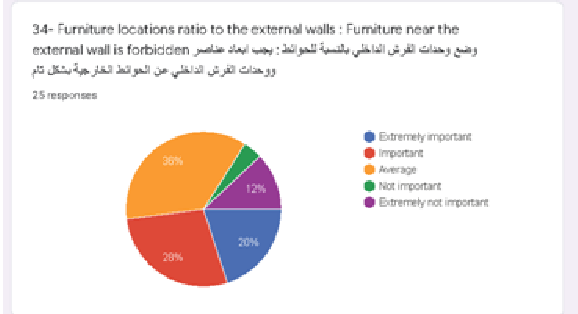

Second: Building Design Considerations: (c) Indoor finishing considerations



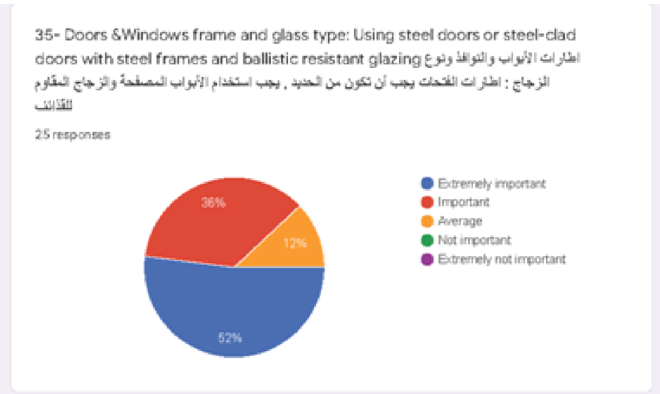



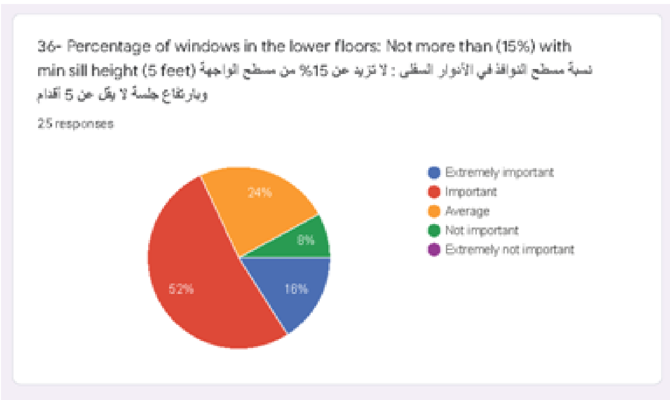



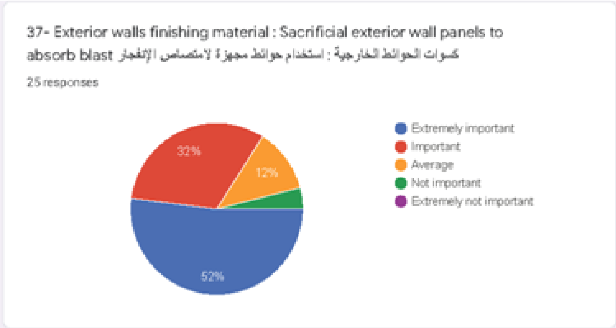



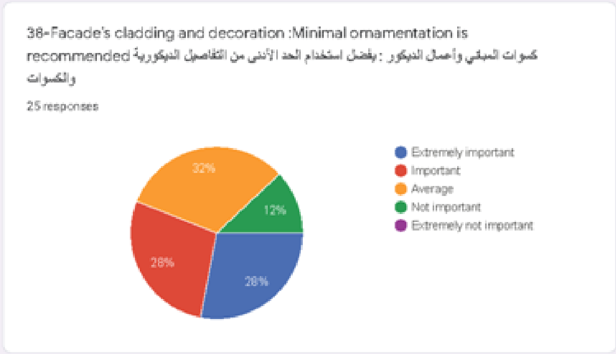



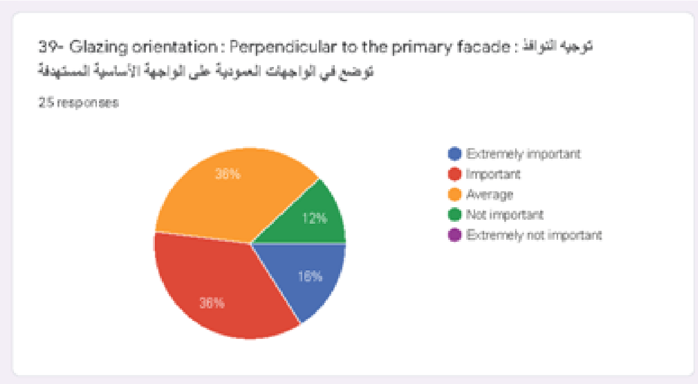

Second: Building Design Considerations: (d) Facades finishing (envelope) considerations






Third: Structure Design Considerations