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A Discussion of the Application's Possibility of the Earth-Sheltered Building Type in Egypt: *Implementation Guidelines*

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Abstract

The Earth-sheltered building type is spreading all over the world in the last decade as an eco-friendly building's style, and as a passive energy saving technique. Most previous researches regarding this type are discussing the energy savings' and measuring the "heating/cooling loads" reduction extent. This research is discussing the subject from the urban point of view, and the application's possibility for the housing projects in the Egyptian deserts. Adopting the quantitative method followed by the qualitative analysis; the research quantified the results of a questionnaire survey, and used the chi-square test to analyze the significant results, in order to be able to generalize the results to the community. Followed by some urban design considerations and applicable recommendations related to this type according to the questionnaire survey results. The practical discussion argued the application's possibility at the housing sector in the Egyptian deserts through discussing the motives behind thinking of the application in the housing sector at the Egyptian deserts; and the application's optimal performance constraints. The research recommends using this type of buildings for housing in the developing projects of the new communities in the Egyptian western deserts, like "Toshka". Moreover, in the new touristic resorts, and in the small and middle-sized projects.

Keywords

Earth-sheltered Buildings; Questionnaire Survey; Sustainable Urbanism; Application's Guidelines.

1. Introduction

The Egyptian development strategies nowadays is focused on encouraging the desert's exploitation. The main problem that constrains the progress in this direction is the desert's harsh climate. This harsh climate raises the problem of the unsuitability of the local building systems for those areas since it consumes a large amount of energy for the active air-conditioning systems, which are growing up to tremendous expenses.

Recently, some kinds of structural attempts had appeared on the architectural scene trying to solve the thermal comfort issue but had gained unsatisfactory psychological results. Such as: using arches, vaults, and domes. Likewise, the case of the new village of "Gorna" which had been immigrated (Heba et al. 2012).

Other pieces of research discussed the psychological aspects of the application at the Egyptian community, (Heba

Hassan et al. 2016a; Ismail et al. 2013). From another point of view, other research discussed the climatic treatments' effect on selecting the typology of the Earth-sheltered building, (Fahmy and Konsowa 2004).

The most relevant research to this one discussed the implementations' guidelines regarding the architectural design and urban design context, based on simulation optimization for thermal comfort, and a questionnaire survey for measuring the psychological acceptance and application's recommendations issues (Heba Hassan and Sumiyoshi 2017a, 2017c).

This research is raising a call for the Egyptian desert reclamation; which represents more than 80% of its area; with a new architectural perspective using the Earth in construction to gain more integration with the environment, and to add another new aesthetic dimension to the surroundings.

The research objective is to emphasize the Earth-sheltered construction system through discussing the site selection, urban planning, and appropriate design methods of this type. Moreover, discussing the suitability extent of this type for the residential use in the Egyptian deserts.

2. Methodology

This research is discussing the possibility of applying this type of building for the domestic sector at the new settlements in the Egyptian deserts. It used the exploratory type, discussing a hypothetical topic, regarding the application of the Earth-sheltered buildings and measuring the expert's attitudes and recommendations towards these buildings. The research used the (EMIC) approach, by using the photo-questionnaire survey beside interviews, to assure the reliability of the results and to avoid the subjectivity bias.

The second part of the research used the "Qualitative" method, depending on the "Quantitative" foundation of the questionnaire survey analysis of the first part, in order to obtain site-specific architectural and urban design considerations.

2.1. Questionnaire Sample

The questionnaire study used a (non-probability) sampling technique, through a purposive sampling, namely (expert sample). The sampling farm were post-graduate students, architects, university teachers at the architectural departments. The sample was divided, as a control variable, into specialists (architects and university teachers), and non-specialists (post-graduate students and others).

2.2. Questionnaire Design

The research used the triangulation technique, to avoid bias and subjectivity (Olsen 2004), such as pilot study, interviews, and the web-based questionnaire, which was in English language, English questionnaire form, 2015. (Heba Hassan 2015). The questionnaire is divided into six parts, as shown in Figure. 2.

- The first part regarding socio-demographic characteristics, we concerned only about the gender. Because most of the sample were from the same age layer, around 30th. to 40th. This age layer influenced the assessment of the Earth-sheltered buildings' style positively. That sample age layer had the experts' experiences, joined with the youth spirit. Therefore, we could count on their opinions to get the right decision with a modern perspective.
- Followed by, the interviewee background idea, and the prior knowledge extent in a four Likert scale question. Moreover, the adjectives related in the mind about the Earth-Sheltering.
- Those two previous introductory sections were followed by two core sections helping in the design guidelines on the architectural design considerations, and on the urban design considerations.

– The question about the respondents major we moved it to the middle. According to the interviewee's major, whether specialist or non-specialist, the rest of the questionnaire would be different. In order to unify the questions at the first half and divide the respondents according to their major at the second half.

– At the cross sections' suitability question, we asked the sample about their reactions about four cross-sections and its suitability from different aspects, regarding elderly, against crime, natural hazards, as a living space, fire escape, and easy architectural design. We added more questions for experts about economical use of air-conditioning energy, sustainability, long life span, and low required maintenance, easy access to maintenance points, economical initial cost, and the best structure performance for bearing loads, as shown in Figure. 1.

– Finally, the last part about usage and location's questions represents the research outcome contribution for the application's guidelines.

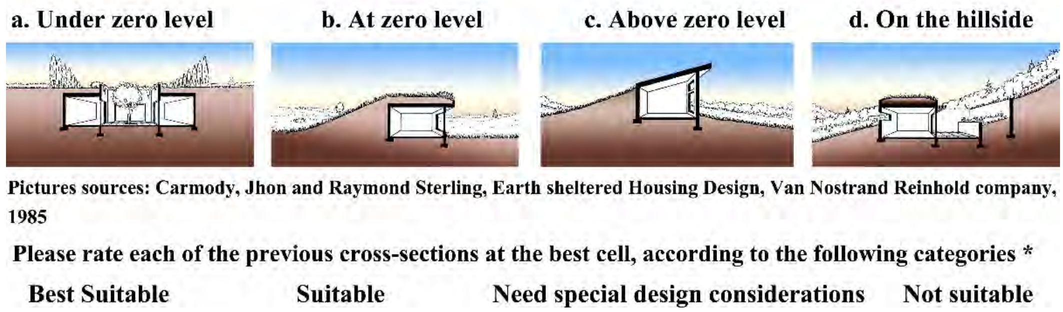


Figure 1. A screenshot of the cross sections' four Likert scale suitability of the questionnaire's questions.

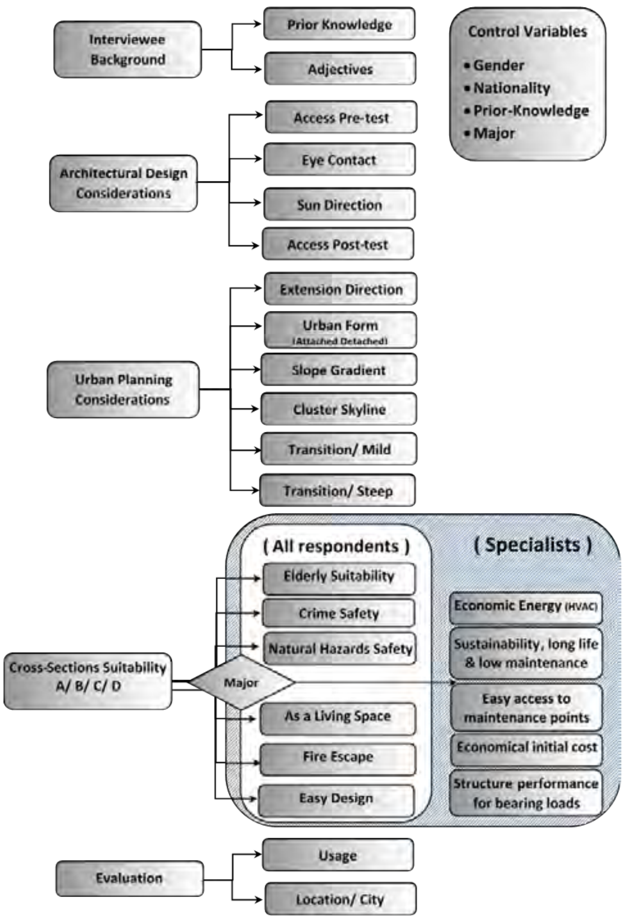


Figure 2. A diagram demonstrating the questionnaire parts and the control variables.

2.3. Statistical Analysis Method

2.3.1. Descriptive Statistics

Responses were analyzed by descriptive statistics, to predict the intellectual trends for both Egyptians and Japanese. We used the contingency tables to tabulate the categorical data, to get the occurrence frequency of possible levels' combination. For continuous data of the Likert scale question, we used the measures of central tendency; the Mean Average. The most important outputs were presented in the form of Excel graphs for better understanding and analysis

2.3.2. Inferential Statistics

The informant responses were analyzed using a statistical method of Chi-square test (χ^2), to be able to generalize the results, as it is the best suitable for categorical data of the interviewee's responses (Lehner 1979). This test assists in rejecting random change variations between two categorical variables. We used a level of significance (P£0.05), to gain 95% confidence of the results. Moreover, we added some crosstabs for different combinations between control and other questions' variables. Finally, we concluded people attitudes from the (χ^2) analysis of the last two questions about city and usage, combined with both open-ended question's comments, and the respondents' interviews, to achieve triangulation methodology. Results

3. Results

In this research we are discussing the urban considerations for implementation in Egypt. Therefore, the results would be focused on analyzing the urban part of the questionnaire survey results. Depending on the Chi-square test analysis, we are discussing the significant results only regarding the urban issues. This research is part of a larger research about guidelines for the earth-sheltered buildings' implementation at Egypt (Heba Hassan et al. 2016a; Heba Hassan and Sumiyoshi 2017b).

In a multi-checkbox question about adjectives related in mind towards earth-sheltered buildings. A question drives the way to construct design strategies to overcome the most negative adjective related with the "Earth-Sheltered" buildings. Around 20% of the sample thought that it is Eco-Friendly. Although, most of the sample chose good adjectives, Figure. 3.

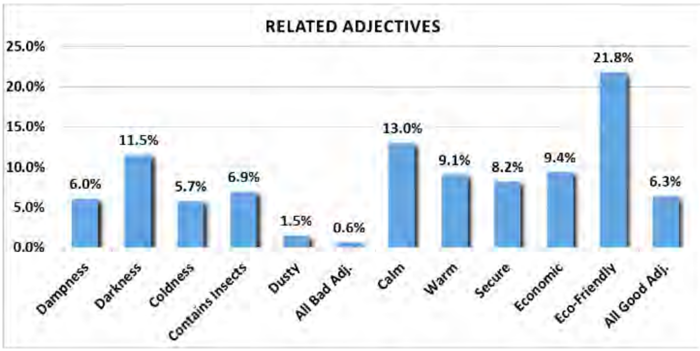


Figure 3. The sample adjectives' selection about adjectives related with the"Earth-sheltered" buildings

3.1. Urban Design Considerations.

Urban design considerations' questions were about, the neighborhood orientation regarding the Sun, the preferred extension direction, the urban form (attached/detached), the slope gradient, the cluster skyline, and the preferred transition between levels at the mild and the steep slopes. Moreover, the recommended usage and location at Egypt.

– A percentage of 72% of the sample recommended directing the neighborhood towards the North, Figure. 4 (a).

– We modified a picture of a proposed hotel in Shanghai, from vertical level to three levels and to horizontal one. However, the interviewee did not prefer the original one (vertical extension). They recommended the two or three level extension direction by 51.0%. Figure. 4 (b).

– It is recommended the detached urban form, 79.0% Figure. 4 (c).

– In addition, they recommended the (30% slope gradient), by 61.0% Figure. 4 (d).

– Moreover, they recommended the river type skyline (closed), by 66.0% Figure. 4 (e).

– About the transition way between slopes (mild/ steep). A percentage of 35.0% of the sample recommended the stairway, for the mild slopes. In addition, 39.0% of the sample recommended using the car or shuttle bus for the transition between steep slopes. Figure. 4 (f, g).

– We consider the location and the usage preferences are the most important output of this research. For the preferred city location, experts recommended to start the application at a touristic city with mild climate (al-Ain-al-Sokhnah port) by 64.0%. However, the usage they preferred to try it with the residential usage by 50.0%. Figure. 5 (a, b).

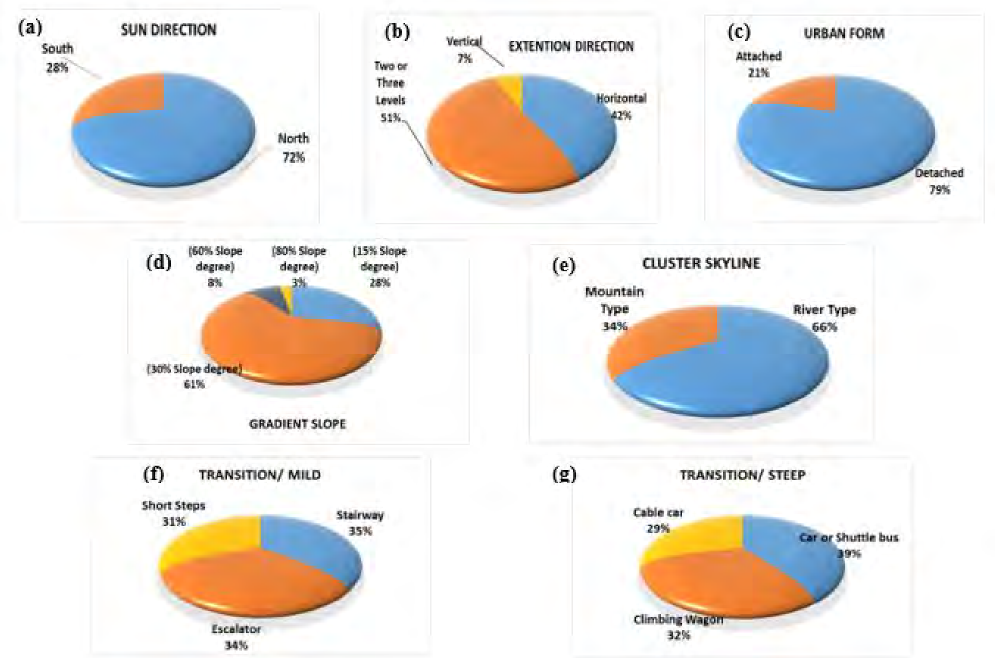


Figure 4. Urban design considerations recommended by Egyptian experts, for the Earth-sheltered neighborhoods.

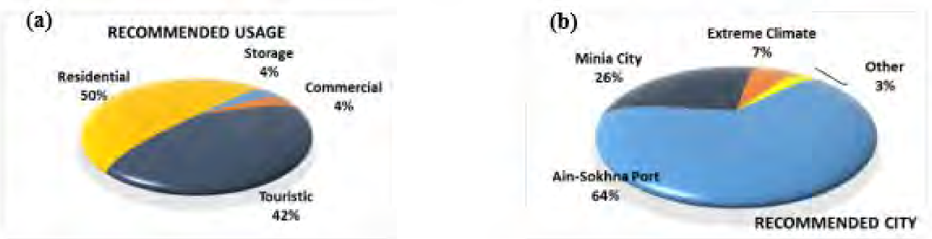


Figure 5. The recommended city and usage for the Earth-sheltered buildings by Egyptian experts.

3.2. General Urban Recommendations.

Depending on the previous questionnaire survey analysis, we created some general guidelines for the proposed application in Egypt. In the following sub-sections, we recommend application's guidelines regarding each issue.

3.2.1. Neighborhood Orientation.

The North direction is the recommended orientation in Egypt in general. Moreover, it was recommended by 72% of the experts' sample, Figure.11 (b).

3.2.2. Extension direction.

Regarding the neighborhood extension; two or three levels are recommended by 51.0% of the Egyptian sample. Which matches the recommendation of the building plan according to Hoyle for the best energy performance to maximize the soil-building contact (Hoyle 2011). The vertical extension is not preferred (Heba Hassan et al. 2016a), Figure. 6.

Figure 6. The extension direction possibilities for an Earth-sheltered neighborhood. The horizontal and two or three levels are acceptable.

3.2.3. Urban form (Attached/Detached).

A percentage of 79.0% of the experts preferred the detached form for the urban community rather than the attached one. It is recommended in order to enlarge the heat exchange contact between the building and the Earth. (Heba Hassan et al. 2016a). The research also recommends using the compact urban cell concept with the geo-space architecture at the hill-side, to gain a high benefit of the unique environmental features of the geo-space, (Golany and Ojima 1996), as shown in Figure. 7.

Figure 7. The detached urban form is recommended for gathering units atnew communities of Earth-sheltered buildings.

3.2.4. Slope Gradient.

A percentage of 61.0% of the experts' sample recommended the slope gradient angle for new communities as of 30% slope degree (Heba Hassan et al. 2016a). Other three slope degrees, 15%, 60% and 80% are not recommended by the experts for the implementation of this kind of construction, as shown in Figure. 8.

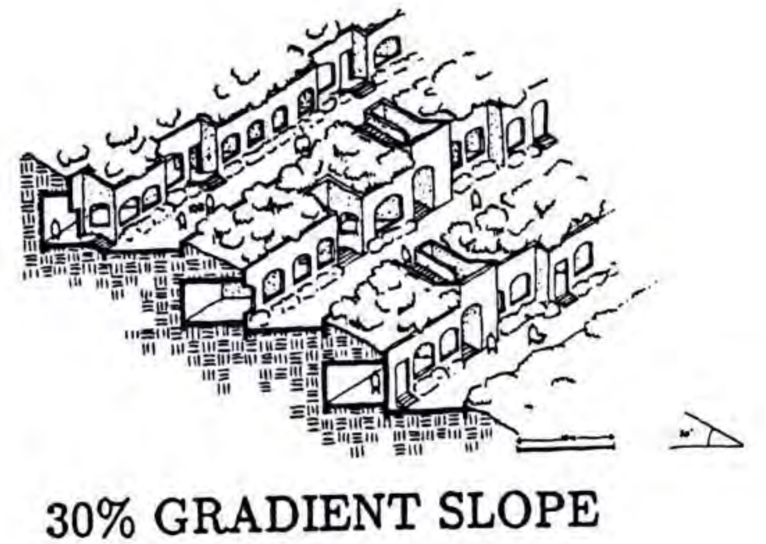


Figure 8. The preferred slope gradient for new earth-shelteredconstruction is 30% degree, (Golany and Ojima1996).

By studying the slope gradient of the earth-sheltered buildings' clusters, and regarding the experts' recommendations at the questionnaire survey, we might conclude the following building densities:

- Building densities on flat sites: It could reach (4-5 units/acre) it is not small building density, since it could not be increased more unless it will affect the amount of natural ventilation and light penetration to the unit, Figure 9.
- Building densities on steep slopes: It could be large, maybe in some cases up to (10- 30 units/acre), compared with conventional buildings which could not be built on steep slopes unless the site slope is flattened, Figure 10.

We may obtain different densities of residential earth-sheltered communities according to the slope degree and the way of urban planning. It could be gradually increased with the slope degree up to 20% - 50%.

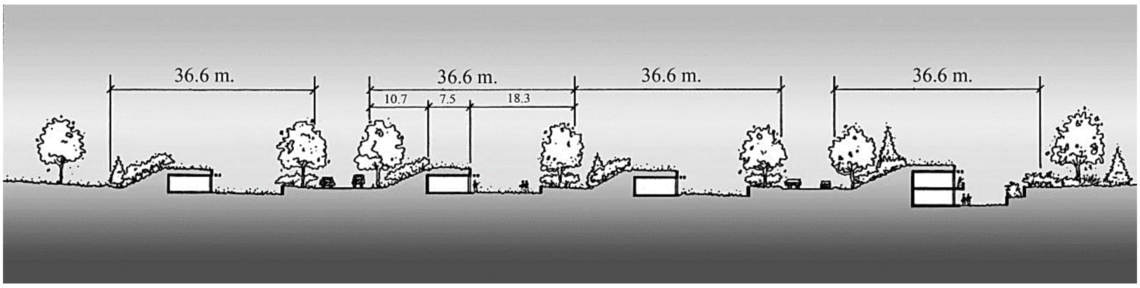


Figure 9. Cross-section for the required distance between units on flat site(Carmody and Sterling 1985).

From the above, it is clear that the greater the slope degree the greater the density of the buildings at the site would be, but the accessibility is difficult to reach the high elevations and units located in the middle of the steep slopes.

On the other hand, the smaller the slope the less the building density we will obtain and the easier to be built, but the construction cost will be high with low densities.

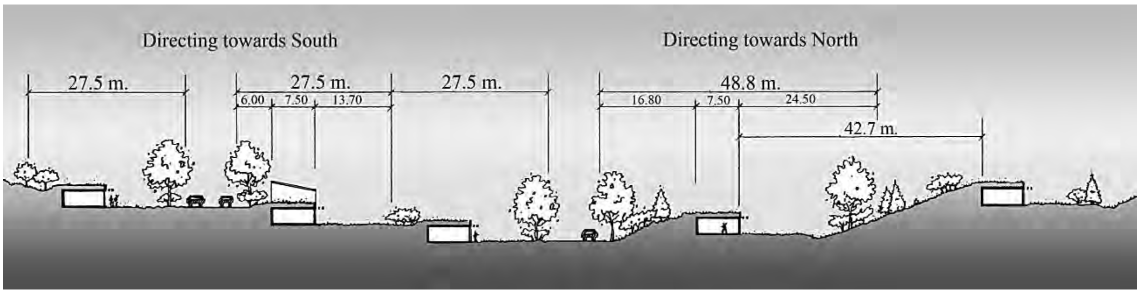


Figure 10. Cross-section showing the differences for the required distance regardingorientation towards the Sun. (Carmody and Sterling 1985).

3.2.5. Cluster Skyline.

The closed (river type) is preferred to avoid the wind turbulence and rain erosion. 66.0% of the sample preferred the closed river skyline type (Heba Hassan et al. 2016a), as shown in Figure.11 (a).

Therefore, we recommend the compact urban cell concept which works to minimize the urban heat island phenomenon (Zhang, Alan, and Turner 2017), which is known as: *"An urban heat island (UHI) is an urban area or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities"* (Zhang, Alan, and Turner 2017) because every cell in the compact unit remains partially isolated from its neighbors, this also contributes to absorbing most of the heat load inside the geo-space. Besides, it contributes to reducing the walking distances between units. Moreover, this compactness raises the shadows created between the building blocks. Also, it minimizes the undesired high air velocity movement, either very hot at the day or very cold at the night.

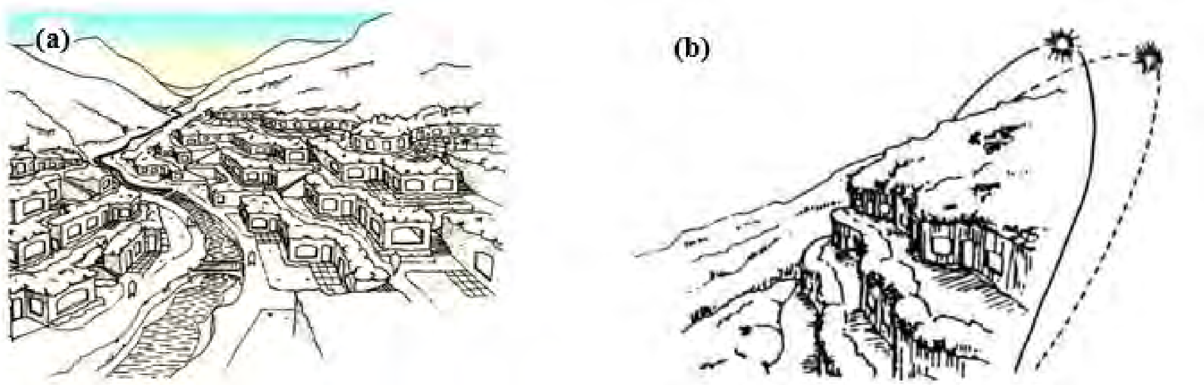


Figure 11. Recommendation of the cluster on the hill-side, using the compact(detached) form, towards the North (Golany and Ojima1996).

3.2.6. Transition (Mild/ Steep).

For the unit accessibility and transition between slopes, it is recommended to the use stairways at the mild slopes, Figure.12 (a). And it is recommended to use a car or shuttle bus at the steep slopes, Figure. 12. (b).

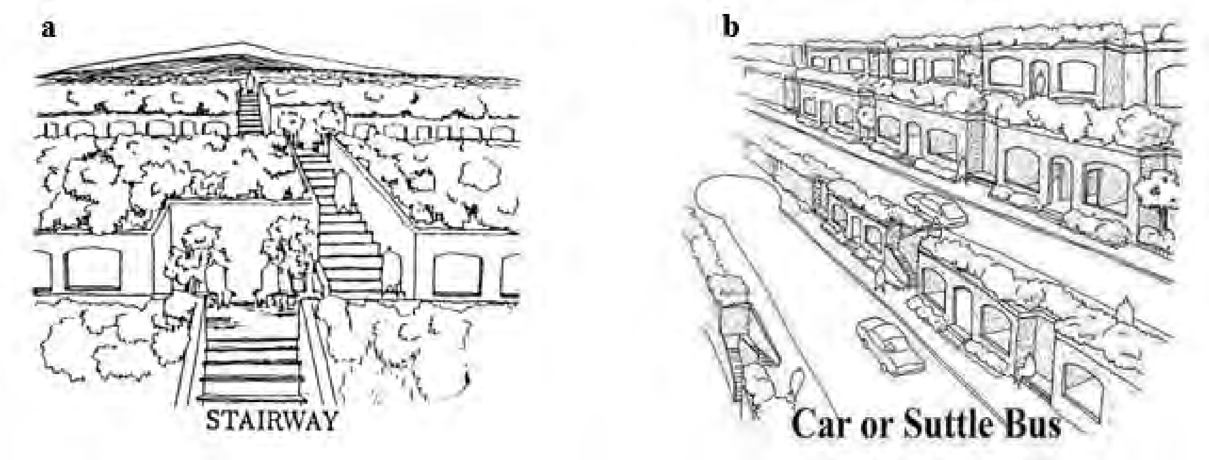


Figure 12. (a) Stairway for mild slopes; (b) Car or shuttle bus for steepslopes accessibility. (Golany and Ojima1996).

3.2.7. Usage and Location.

Most of the votes were directed towards the application in a (touristic city with mild climate), 91 out of 164 was the highest number of experts who chose that kind of city, which was represented by (al-Ain-al-Sokhnah port) Suez city. The (beautiful, hot climate) city came after it with high gap lower rank, with 37 votes, which was represented by (Minya) city. Followed by the (extreme climate) city, and (other) with 25 and 11 votes, respectively. What is worth to be mentioned here is that the hidden answers for (other) were representatives of extreme climate cities, Figure. 13.

Contrary to predictions; 71 out of 164, the total number of the expert sample, chose the residential usage. Previous researches outcome argued the unacceptability of living in the Earth-sheltered buildings (Al-Temeemi and Harris 2004; Bartz 1986; Sydney 1981). However, most of them were at the eightieth of this century. Since the pilot study of the research, we investigated about the acceptability of living in or dealing with this kind of buildings (Ismail et al. 2013).

Finally, our research proved the acceptability of residential living as a first choice with 71 votes, followed by 66 votes to the touristic usage, which is also concerned as a representative of the living activity. The two other activities came at a lower rank; the storage and commercial usages by 18 and 9 votes, respectively (Heba Hassan et al. 2016a).

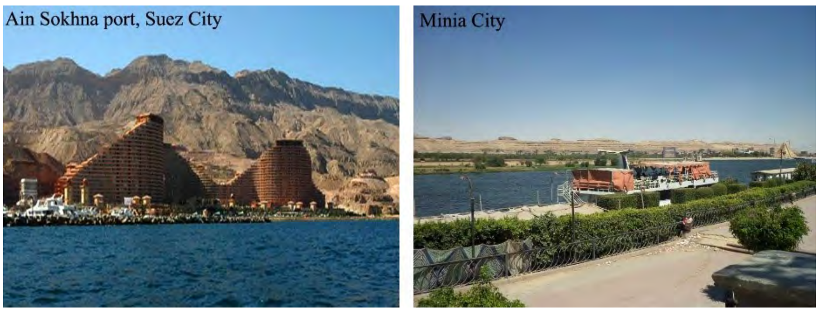
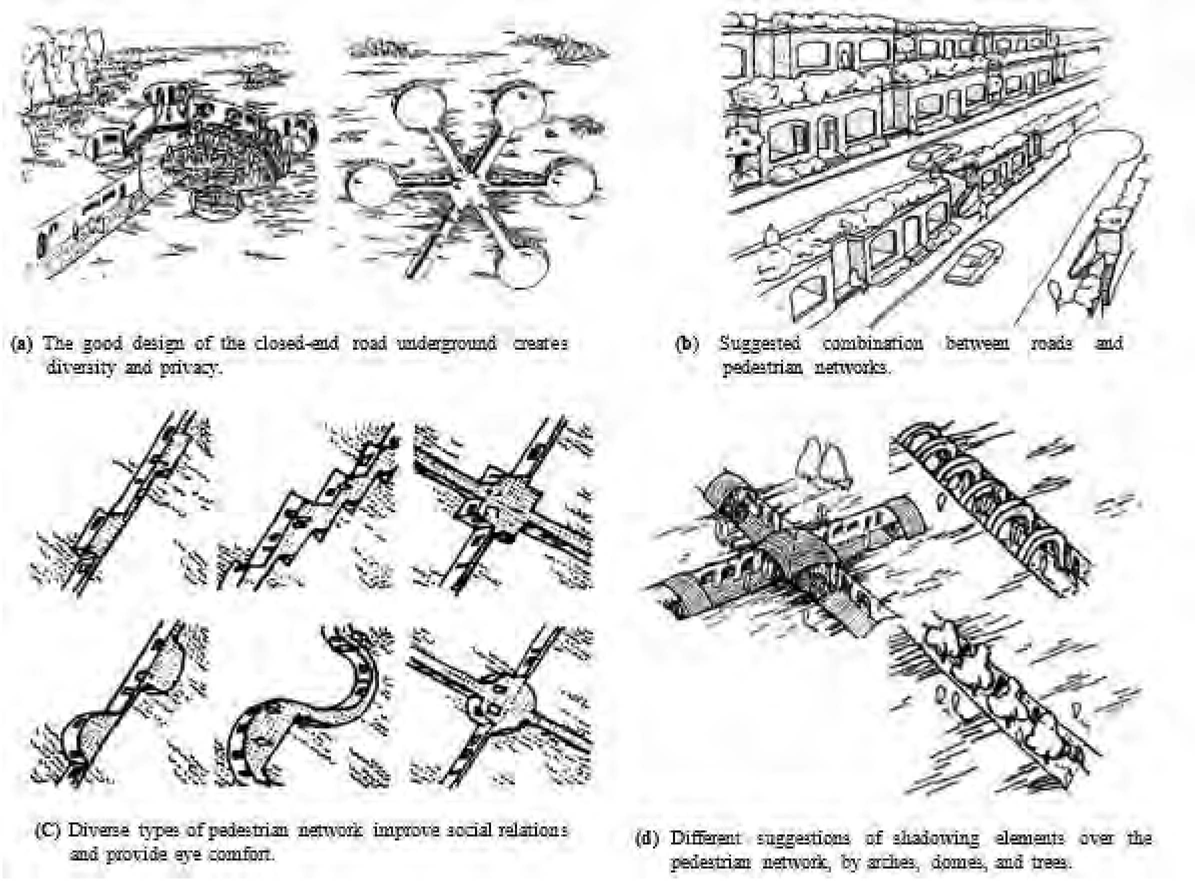


Figure 13. Ain-Sokhnah port Vs. Minya city, was recommended by experts forthe Earth-sheltered buildings' application.

3.2.8. Land use distribution.

There are basic considerations to be taken into account when planning new urban communities in harsh climate areas. The optimal distribution of land uses is one of the most important factors to be considered, especially with the earth-sheltered buildings, (Golany 1983).

- Gathering the similar uses in one area. Besides, creating a good connection between different facilities within the urban cell, which creates diversity and privacy, Figure. 14 (a).
- Making suitable spaces for residential use, services, entertainment, etc., with a future extension vision. Besides, the integration between the total separation and overlapping of different activities.
- It is recommended to design the traffic network outside the residential neighborhood without crossing it. Besides, total separation between pedestrian and traffic networks. Ending the traffic network with close ends "Cul. Du Sac.", then pedestrian network starts and could be linked by vertical access units, Figure. 14 (b).
- Placing the traffic network above ground, considering their relationship to pedestrian network, and not adjacent to the residential clusters, to prevent harmful vibrations from the structure of the building.
- It is preferred that roads level is less than the buildings, to prevent accumulation of dust and rain.
- Considering the diversity of pedestrian network shapes, which will increase social interaction while maintaining privacy, considering different road width, Figure. 14 (c).
- Streets should be protected from strong winds and high solar radiation, Figure. 14 (d).



(a) The good design of the closed-end road underground creates diversity and privacy.

(b) Suggested combination between roads and pedestrian networks.

(C) Diverse types of pedestrian network improve social relations and provide eye comfort.

(d) Different suggestions of shadowing elements over the pedestrian network, by arches, domes, and trees.

Figure 14. Land-use distribution recommendations (Golany 1983).

4. Discussion.

Despite the advantages of this system, especially climatic, there are still many problems that prevent the effective application of this building type at the Egyptian deserts. Therefore, it was necessary to discuss the following points:

-Motives of thinking of applying this building type on the Egyptian deserts, reasons for focusing on the domestic use, and the application's possibilities in Egypt.
-Application's constraints that might prevent the optimal performance of these buildings.

4.1. The application's possibilities in the Egyptian deserts.

It is found that this type of construction is more suitable for desert areas for several reasons: It has the best thermal performance with harsh climates rather than the moderate ones (Heba Hassan and Sumiyoshi 2017a, 2017c). Using the local raw materials in construction lowers the cost (Heba et al. 2012). Building on the mountain slopes improves the sanitation performance, and enhances the psychological acceptance, and improves significantly the aesthetics with the sustainable buildings (Heba Hassan et al. 2016b).

The lower the cost of the domestic sector cost is, the better the economics of the whole community will be. Furthermore, the residential use should achieve a high level of thermal comfort during long hours per day. About 85% of the international successful contemporary Earth-sheltered cases are considering the residential use (Heba Hassan et al. 2016b; Heba Hassan and Sumiyoshi 2017a), which gives an indicator about the success of this type of construction functionally and psychologically.

On the other hand, The Earth-sheltered building type has a weak performance for the public use; as it has a poor ventilation and very high level of humidity (Jhon Carmody and Sterling 1993). So, it needs the integration of active ways for natural cross ventilation.

4.2. The application's optimal performance constraints.

Below is a quick overview for some obstacles that might face this type of buildings if it is applied in Egypt.

-Possible problems that might face the optimal performance in the Egyptian deserts, (H Hassan et al. 2014). Such as: Exposure to the accumulation of sand, dust, and floods at the desert. The lack of land-marks and the skyline at the urban community, if all buildings were underground, like the case of Matmata village, Tunisia. The possibility of containing insects if it is built under the zero level at the desert. The lack of privacy probability if buildings were built under the road network level. Problems in providing with drinking water, if buildings were at the mountains. The high level of the ground-water is threatening buildings if exists.
-Psychological biases, because of its name related to the "Underground", where the burial occurs, and the relation with death (Heba Hassan et al. 2016a; Ismail et al. 2013).
-The probability of local laws' organizational limitations, because it is new kind of buildings, maybe it will not be acceptable by some cities councils.

5. Conclusion.

The research provided some recommended implementation guidelines for the earth-sheltered buildings in Egypt as a representative of the hot-arid climate. Regarding the discussion and results, we may conclude the following:
-Living inside an earth-sheltered building affects the social activity; it suits more the domestic use.
-The unique nature of the geo-space affects positively the internal environment from many aspects: (steady temperature during the day and the year long, being isolated from the outside noise, fewer pollutants).
-To reach the optimum use of the earth-sheltered buildings at the domestic sector; some related obstacles should be solved: i.e. (the psychological bias against being underground, the lake of architectural expertise).
-The geo-space architecture suits some geomorphologic forms more than others, especially the hill-side form.
-Dealing with slopes has special design considerations: (the more vertical the slope is, the less area available for building, and the best suitable slope is between (15%: 30 %), there will be a balance between the building density and economics of excavation.
-At the hot-humid regions; ex. Red-sea cost and south Sinai; the more suitable location is the hill-side, to gain more cross ventilation. However, at the rest of Egyptian hot arid deserts; the most suitable is the patio type.
-This construction method is recommended as an alternative building type for the development of the new desert areas, such as "Toshka" and the new communities (small and medium-sized).
-To put into consideration planning the geo-space on slopes and underground as an integral part of the design pro-

cess for new projects, by the Urban Planning Authority.
-Developing the historical models at Egypt, like ”Siwa” Oasis and the village of ”Qurna”, to be re-habitable again.

-Starting the application on touristic facilities and workers' residential buildings, at new governmental developed areas, where the combination of public use and domestic use, which motivates individuals for the application at their own buildings, as good alternative to achieve the thermal comfort, aesthetics, and environmental benefits.
-It is also recommended to use this system at the hill-side beside the shore bank; like the old ”Qurna” village; or at the coastal regions, and reserve the flat land for farming and agricultural purpose.
-The legality aspects should have been re-issued for the application of this type.
-Emphasis on compensating the lack of expertise, by making seminars, lectures, conferences, and classes on the educational level about the great environmental benefits of this type of building.
-It is important to measure the thermal comfort aspect by simulation programs, and an optimization analysis.
-For future research, it is important to study the following points:
-Deep pieces of research to serve the complementary design methods that help to improve the Earth-sheltered building performance, such as activating methods of integrated natural ventilation, especially in (warm - humid) climates, to reach the required air quality and thermal comfort.
-Economic study in-depth for the geo-space buildings within slopes, in terms of initial and long-run cost.
-Directing the research to study the physiological effect of the presence in an Earth-sheltered construction, especially at the sleeping period, as studies here are shallow and are not supported by statistics or numbers.

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7. References

1.Al-Temeemi, A. A., and D. J. Harris. 2004. “A Guideline for Assessing the Suitability of Earth-Sheltered Mass-Housing in Hot-Arid Climates.” Energy and Buildings 36(3): 251–60.
2.Bartz, Janet. 1986. “Post-Occupancy Evaluation of Residents of Single- and Multi-Family Earth-Sheltered Housing.” Tunnelling and Underground Space Technology incorporating Trenchless 1(1): 71–88.
3.Carmody, John, and Raymond Sterling. 1985. Earth Sheltered Housing Design. First Edit. ed. Raymond Sterling. Minnesota.: Van Nostrand Reinhold.
4.Fahmy, Mohamad, and Ahmed Konsowa. 2004. “The Interaction between the Climatic Treatments and the Type of Underground Housing in Upper Egypt.” In 5th International Conference On Civil & Architecture Engineering., Cairo: ICCAE, 23–25.
5.Golany, Gideon. 1983. Earth Sheltered Habitat: History, Architecture & Urban Design. New York: VAN NOSTRAND REINHOLD COMPANY.
6.Golany, Gideon, and Toshio Ojima. 1996. Geo- Space Urban Design. New York: John wiilly & Sons Inc.
7.Hassan, H et al. 2014. “Testing the Basements Thermal Performance as an Approach to the Earth-Sheltered Buildings Application at Hot Climates, Case Study (Egypt).” In ASim2014 Proceedings, ed. IBPSA-Asia ASim-Japan. Nagoya, Japan: IBPSA-Asia, 507–14.
8.Hassan, Heba. 2015. “Earth-Sheltered Building's Questionnaire.” English questionnaire form: 7. https://docs.google.com/forms/d/e/1FAIpQLSeTjekzhW1jY50_SVjQVN1hqg6aEUbD9ou9mdj0EHWAzlnYuw/viewform (November 27, 2017).
9.———. 2016a. “Measuring People's Perception towards Earth-Sheltered Buildings Using Photo-Questionnaire Survey.” Sustainable Cities and Society 26: 76–90.

10.———. 2016b. “Measuring People’s Perception towards Earth-Sheltered Buildings Using Photo-Questionnaire Survey.” Sustainable Cities and Society 26: 76–90. http://dx.doi.org/10.1016/j.scs.2016.05.005.
11.Hassan, Heba, and Daisuke Sumiyoshi. 2017a. “Earth-Sheltered Buildings in Hot-Arid Climates: Design Guidelines.” Beni-Suef University Journal of Basic and Applied Sciences. http://linkinghub.elsevier.com/retrieve/pii/S2314853516301585.
12.———. 2017b. “Earth-Sheltered Buildings in Hot-Arid Climates: Design Guidelines.” Beni-Suef University Journal of Basic and Applied Sciences. http://linkinghub.elsevier.com/retrieve/pii/S2314853516301585.
13.———. 2017c. “Evaluation of Basement’s Thermal Performance against Thermal Comfort Model at Hot-Arid Climates, Case Study (Egypt).” Environmental Science and Sustainable Development 1(2): 10.
14.Heba, Hassan Ahmed et al. 2012. “The Possibility of Applying the Earth-Sheltered Building Type for Housing Projects between Humid and Dry Climates - Case Study Egypt and Japan -.” In International Society of Habitat Engineering and Design Conference, ISHED, Shanghai, China: Tongji University, 8.
15.Hoyle, Basil. 2011. Low Energy Building Engineering. First Edit. Delhi: The English Press 4735/22 Prakashdeep Bldg, Ansari Road, Darya Ganj, Delhi.
16.Ismail, Heba, Takafumi Arima, Aly Ahmed, and Yasunori Akashi. 2013. “Measuring the Possibility of Living in the Earth-Sheltered Building Type between Egypt and Japan.” In Building Simulation Cairo 2013 - Towards Sustainable & Green Life, ed. Dr. Mohammad Fahmy BPSA-Egypt. Cairo, Egypt: AGD Publishing Cairo IBPSA-Egypt, 430–441, Part8.
17.Jhon Carmody, and Raymond Sterling. 1993. Underground Space Design: A Guide to Subsurface Utilization & Design for People in Underground Spaces. New York: VAN NOSTRAND REINHOLD COMPANY.
18.Lehner, Philip N. 1979. Cambridg University Press Handbook of Ethological Methods. New York: Garland Press, NY.
19.Olsen, Wendy. 2004. “Triangulation in Social Research: Qualitative & Quantitative Methods Can Really Be Mixed.” In Developments in Sociology, , 1–30.
20.Sydney, A. Baggs. 1981. “Underground Housing: New Life-Styles in an Australian Settlement.” The Journal of Social, Political, and Economic Studies 6(2): 177–205.
21.Zhang, Yujia, T.Murray Alan, and B.L. Turner. 2017. “Optimizing Green Space Locations to Reduce Daytime and Nighttime Urban Heat Island Effects in Phoenix, Arizona.” Landscape and Urban Planning 165: 162–71.