ANALYSES OF SUSTAINABILITY REQUIREMENTS OF SOLAR PASSIVE DEFENCE IN DIPLOMATIC BUILDINGS

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ABSTRACT

The energy consumption of different buildings including residential, administrative and commercial buildings is continuously growing. In developing countries, it is in the range of 20% to 40%. Thus, energy saving and the use of new energies like solar energy whether in conventional buildings or sensitive and diplomatic buildings is necessary. On the other hand, the major difference between diplomatic buildings and conventional buildings is summarized in their security debate. The adaptation of active and passive solar systems in diplomatic buildings for passive defense requirements is not an easy task compared to the other building types. Hence, these buildings require specific requirements with both approaches. The most important goal is to apply passive defense in designing site, form and volumes of sensitive buildings to protect individuals and information against threats. This goal is in line with the feasibility of energy efficiency in the passive defense section of Iran's national building codes. For this purpose, to understand the interdependence and pairwise comparison between these items, their importance was assessed by forming a network within criteria and sub-criteria. In addition, their priority was investigated by inserting them into Super Decision software. Ultimately the feasibility of energy efficiency in the context of passive defense in diplomatic buildings was obtained as graph by applying these final output coefficients. The results indicated that the optimal use of solar systems to passive systems is 1 to 3. In addition, the passive solar is mostly in harmony with concealment and camouflage defense sections, while deception is more compatible with the active solar sector.

Keywords:
Solar Passive Defense, Sustainability, Diplomatic Buildings, Energy Efficiency, Adaptation

1. INTRODUCTION

Due to being located at a suitable latitude, Iran can absorb significant amounts of solar energy and thereby provide a privileged position for the use of sustainable and clean energy [1], [2]. Thus, through appropriate strategies adopted in this section, the energy consumption of buildings can be reduced significantly [3]. The sun is the source of energy. This energy is inexpensive and endless and can be consumed in all areas [4]. Therefore, to use this source optimally, it is necessary to consider the ways diplomatic buildings are designed for defensive goals. Architectural requirements in terms of passive defense are categorized in four general categories, design requirements, access and site-selection requirements, management requirements and facility-fortification requirements [5], [6]. These requirements as raw materials have their own peculiar place that takes into account how to utilize solar energy and create a solar energy balance for designing diplomatic buildings [7].

1.1. Analytic Hierarchy Process (AHP)

Multi-criteria evaluation methods have been commonly used in all sciences, including architecture. Among these methods, Analytic Hierarchy Process (AHP) has a widespread application due to its simplicity and flexibility as well as the use of quantitative and qualitative criteria. However, it has some serious limitations. For example, it doesn't take into account the interdependence between the elements and also it is a one-sidedness approach. Therefore, AHP should be changed into ANP (Analytic Network Process) using

"Super Decision" software [8]. In AHP, the decision-making was started through identifying and prioritizing elements which included the objective, criteria and sub-criteria. Thus, at first we developed the structure of AHP for the studied subject.

1.1.1. Building a hierarchy

We assumed that the two options of A and B have been identified for defense-energy actions. It is supposed to select the appropriate option to receive solar energy based on the four criteria including design, access and site-selection, management and facility requirements. The design requirements are divided into three sub-criteria: 1) emergency enters and exits, 2) deception, and 3) camouflage and concealment; the access and site-selection requirement are divided into two sub-criteria: 1) dispersion, and 2) multifunctional spaces; and facilities and fortifications requirements are divided into two sub-criteria: 1) reparability power, and 2) designing infrastructure networks [9]. Therefore, in this diagram, we have a four-level hierarchy including objective, criterion, sub-criteria, and options.

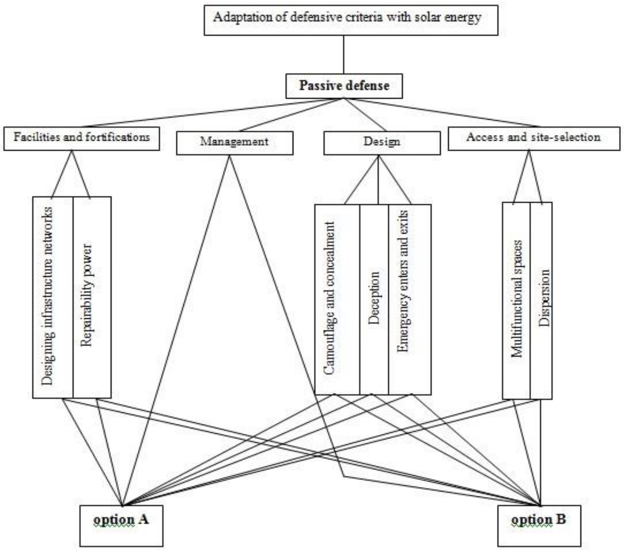

Fig. 1. Analytic Hierarchy Process for Defense-Energy Actions

A: Passive Solar Energy
B: Active solar Energy
H. Designing Infrastructure Networks
I. Reparability power
J. Camouflage and Concealment
K. Deception
L. Emergency enters and exits
M. Multi-functional Spaces
N. Dispersion

1.1.2. The importance factor of criteria and sub-criteria

To determine the importance factor of criteria and sub criteria, at first a pairwise comparison was done. The basis for judgement was the following table [10].

Table 1. 9 numerical scale of (Thomas L. Saaty) for pairwise comparison

Score	Value	Symbol
1	Equal importance	⊕
3	Slight importance	◔
5	Strong important	◐
7	Very strong importance	◕
9	Extreme importance	●

2. EQUATIONS

In the below, the pairwise comparison of criteria for the proposed problem is presented:

$$\begin{array}{l|cccc|} & 1 & 2 & 3 & 4 \\ \text{1.Management} & 1 & 1/9 & 1/7 & 1/5 \\ \text{2. Design} & 9 & 1 & 1 & 3 \\ \text{3. Site Selection} & 7 & 1 & 1 & 3 \\ \text{4. Facilities} & 5 & 1/3 & 1/3 & 1 \end{array} = A_1$$

To calculate the importance factor of the criteria, at first the geometric mean (1) of the matrix rows A were obtained and then were normalized:

$$G.M. = \left[\prod_{i=1}^{n} x \right]^{1/n} \qquad (1)$$

1.Management

$$G.M. = [(1) \quad (1/9) \quad (1/7) \quad (1/5)]^{1/4} = 0.2374$$

2. Design

$$G.M. = [(9) \quad (1) \quad (1) \quad (3)]^{1/4} = 2.2795$$

3. Site Selection

$$G.M. = [(7) \quad (1) \quad (1) \quad 3)]^{1/4} = 2.1497$$

4. Facilities

$$G.M. = [(5) \quad (1/3) \quad (1/3) \quad (1)]^{1/4} = 0.8633$$

After normalization i.e. dividing each number into its sum, the importance factor of the criteria was obtained. As it is seen, the sum of the importance factors for the four criteria is equal to 1, which indicates their relativity:

1. Importance factor of management

$$W_1 = \frac{0.2374}{5.5209} = 0.043$$

2. Importance factor of design

$$W_2 = \frac{2.2795}{5.5209} = 0.4129$$

3. Importance factor of site-selection

$$W_3 = \frac{2.1497}{5.5209} = 0.3877$$

4. Importance factor of facilities

$$W_4 = \frac{0.8633}{5.5209} = 0.1564$$

To obtain the importance factor of the sub-criteria, the following steps were taken:

H. Designing infrastructure networks

I. Reparability power

$$\begin{array}{cc} H & I \\ \hline \end{array} \quad \left[\begin{array}{cc} H & I \\ 1 & 1/5 \\ 5 & 1 \end{array}\right] = A_1$$

$$W_I = 0.833 \qquad W_H = 0.167$$

J.Camouflage and concealment

K. Deception

L. Emergency enters and exits

$$\left[\begin{array}{ccc} J & K & L \\ 1 & 1 & 1 \\ 1 & 1 & 2 \\ 1 & 1/2 & 1 \end{array}\right] = A_2$$

$$W_J = 0.327 \qquad W_L = 0.260 \qquad W_K = 0.413$$

M. Multi-functional spaces

N. Dispersion

$$\left[\begin{array}{cc} M & N \\ 1 & 1/7 \\ 7 & 1 \end{array}\right] = A_3$$

$$W_N = 0.875 \qquad W_M = 0.125$$

2.1. The importance factor of the options

After determining the importance factors of criteria and sub-criteria, the importance factor of the options was calculated, too. At this stage, the priority of each option was judged in relation to each sub-criterion. In the case there was no sub-criteria (e.g., management), the judgment was done directly based on the criteria itself. The basis to judge this comparison is presented in the following 9 numerical table.

Table 2. 9 numerical scale of Thomas L. Saaty for pairwise comparison of options

score	Value
1	Equally preferred
3	Moderately preferred
5	Strongly preferred
7	Very Strongly preferred
9	Extremely preferred
2,4,6,8	Interstitial Preferring

H. Designing infrastructure networks

$$\left[\begin{array}{cc} A & B \\ 1 & 8 \\ 1/8 & 1 \end{array}\right]$$

I. Reparability power

$$\left[\begin{array}{cc} A & B \\ 1 & 1/4 \\ 4 & 1 \end{array}\right]$$

F. Management requirements

$$\left[\begin{array}{cc} A & B \\ 1 & 8 \\ 1/8 & 1 \end{array}\right]$$

J. Camouflage and concealment

$$\left[\begin{array}{cc} A & B \\ 1 & 8 \\ 1/8 & 1 \end{array}\right]$$

K. Deception

$$\begin{bmatrix} A & B \\ 1 & 1/7 \\ 7 & 1 \end{bmatrix}$$

L. Emergency enters and exit

$$\begin{bmatrix} A & B \\ 1 & 5 \\ 1/5 & 1 \end{bmatrix}$$

M. Multi-functional spaces

$$\begin{bmatrix} A & B \\ 1 & 5 \\ 1/5 & 1 \end{bmatrix}$$

N. Dispersion

$$\begin{bmatrix} A & B \\ 1 & 1/4 \\ 4 & 1 \end{bmatrix}$$

The important factor of options in relation to the sub-criteria was determined through normalizing the geometric mean of the rows of pairwise comparison matrices as follows:

H. designing infrastructure networks
F. Management requirements
J. Camouflage and concealment

$$W_A = 0.89$$
$$W_B = 0.11$$

I. Reparability power
N. Dispersion

$$W_A = 0.20$$
$$W_B = 0.80$$

K. Deception

$$W_A = 0.12$$
$$W_B = 0.87$$

M. Multi-functional spaces

L. Emergency enters and exits

$$W_A = 0.61$$
$$W_B = 0.27$$

2.2. Options priority

In this step through the integration of importance factors, the priority of each option was determined according to formula (2), as shown in Diagram 2 and Table 3:

$$S = \sum_{K=1}^{n} \sum_{i=1}^{m} W_K W_i (g_{ij}) \qquad (2)$$

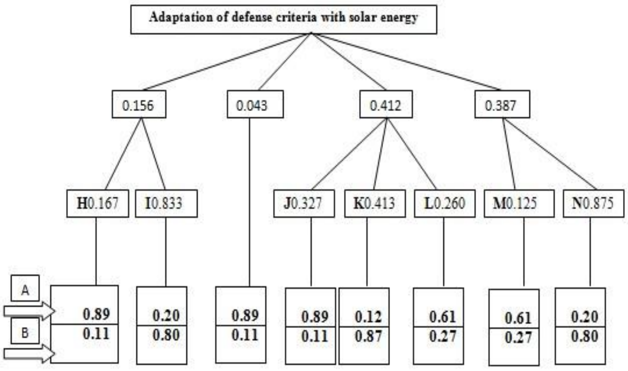

Fig. 2. Importance factors

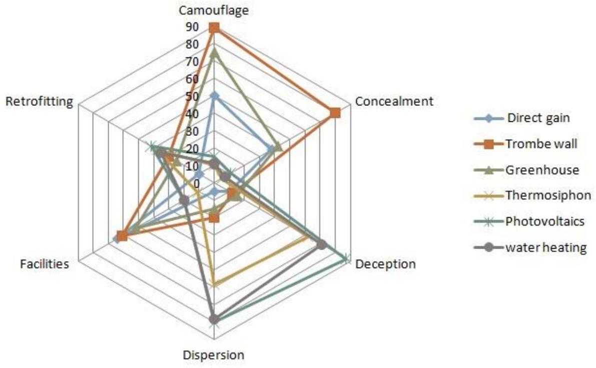

Fig. 3. *The degree of harmony between solar energy and passive defense system*

Table 3. The final result of options

Option	Facilities		Management	Design			Site-selection		Final score
	H	I		J	K	L	M	N	
A	(0.156)(0.167)(0.89)	(0.156)(0.833)(0.20)	(0.043)(0.89)	(0.412)(0.327)(0.89)	(0.412)(0.413)(0.12)	(0.412)(0.260)(0.61)	(0.387)(0.125)(0.61)	(0.387)(0.875)(0.20)	0.583
B	(0.156)(0.167)(0.11)	(0.156)(0.833)(0.80)	(0.043)(0.11)	(0.412)(0.327)(0.11)	(0.412)(0.413)(0.87)	(0.412)(0.260)(0.27)	(0.387)(0.125)(0.27)	(0.387)(0.875)(0.80)	0.386

2.3. From AHP to ANP

Due to one-sidedness of decision-making in AHP model, the values were inserted into Super decision. This was done to investigate ANP as well as the compatibility or incompatibility of analysis process. The calculated value was equal to 0.0734, since it is less than 0.1, thus the compatibility in judgment is respected. In addition, ANP values of options without internal dependence were equal to A=0.622 and B=0.302. The final output is presented in Fig. 3, which shows the degree of harmony between solar energy and passive defense system.

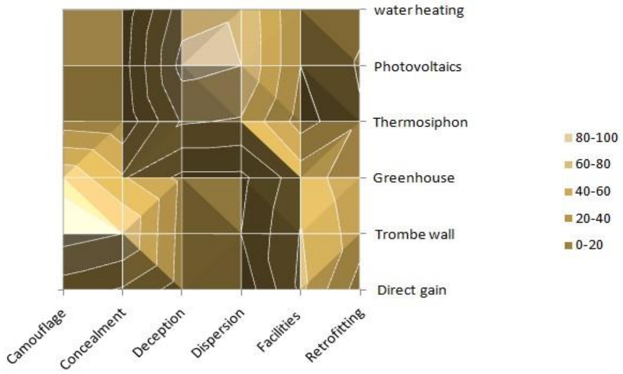

Fig. 4. *The highest and lowest level of coordination*

According to this pattern, line spacing between dispersion and facilities as well as concealment and deception in the range (0%-20%) with the largest area has the least coordination with active and passive solar energy.

3. CONCLUSIONS

According to the composition principle of hierarchy and using the importance factors presented in Fig. 2 and Table 3, the final score of the options indicates that the option A (Passive Solar energy) is the best one for passive defence objectives of diplomatic buildings, and option B (Active solar energy) is the next priority. The optimal use of solar systems to passive defence is 1 to 3. In addition, the passive solar item shows the highest versatility with camouflage and concealment, while deception. The results of this study showed that network analysis process can be applied to the topics related to the architecture.

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