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CURRENT SITUATION IN MEDITERRANEAN GREENHOUSES AND A STRUCTURAL ANALYSIS EXAMPLE (MERSIN PROVINCE)

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ABSTRACT

Greenhouse cultivation is one of the most important income generating branches of agriculture. Nowadays, computer softwares are used for anything as it is being used for planning greenhouses, more robust construction and economical results are obtained this way. Business owners, investing their money in greenhouses, are copying the structural features of existing greenhouses with all wrong calculated parameters and errors. Leaving their valuable cash and future of their investment in the hands of an iron-smith. As a result, the greenhouses which are built without static and strength calculations, more materials are used, or insecure constructions are being applied. When an economic loss occurs depending on structural damage it will unavoidably lead to economic losses for farmers and implicitly for the country. This study, emphasises on the structural analyses of a two-span gothic roofed plastic covered greenhouse, having an area of 900 m^2 located in Mersin province. Structural analysis of the greenhouse was made with SAP2000 program. Mechanical properties of steel used in gothic roofs, plastic covered greenhouse's, theoretical load calculations are made depending on the TS 498 and TS EN 13031-1 Turkish standards.Variable loads on the greenhouse are calculated as distributed loads with classical methods by analyzing the gothic roofed plastic covered greenhouse according to load combinations (wind, plant, fixed) with SAP2000 program.

KEYWORDS:
Greenhouses, Structural Analysis, Mediterranean, SAP2000

INTRODUCTION

A greenhouse is an agricultural structure that can cultivate plants economically during periods, even when the natural environment is not suitable and can provide growth factors needed for plant production and allow mechanization The production of vegetables and fruits in the greenhouse has a broader place in answering the increasing food demand. [1].

No matter how broad agricultural areas are spread, the agriculture sector seems distant from answering the needs of the human population. Therefore about 795 million people are undernourished globally [2].

The increase in crop production is possible with continuity. In the next century, the impact of greenhouse production will increase further, depending on the climatic changes and increasing food demand. However, if greenhouses are built in unsuitable climatic conditions it will eventually lead to loss instead of profit. In recent decades, with the proliferation of plastics all over the world greenhouses are spread all over the world. Site selection is a crucial factor for profitable and sustainable greenhouse cultivation. [3].

A wide variety of greenhouse structural selections are available, from simple plastic houses to very sophisticated glasshouses. To supply high-quality vegetables year-round in the greenhouse packages commonly used for that purpose are with reference to the Mediterranean basin [4]. Decreasing and pollution of natural water resources gradually as a result of global warming forces growers to use marginal quality waters in irrigated agriculture [5]. The intensive cultivation and excessive inorganic fertilizer application in green-house agriculture, causes serious soil-based envi-ronmental problems [6].

Since air temperature and humidity are the two significant parameters affecting thermal comfort significantly, and an evaporative cooling system can handle only sensible load, the conventional evaporative cooling system is suitable for the dry and temperate climate where the humidity is low [7].

Most plants grown in greenhouses are warm-season species, adapted to average temperatures in the range 17–27 °C, with approximate lower and upper limits of 10 and 35 °C. If the average minimum outside temperature is < 10 °C, the greenhouse is likely to require heating, particularly at night. When the average maximum outside temperature is < 27 °C, ventilation will prevent excessive internal temperatures during the day; however, if the average maximum temperature is > 27–28 °C, artificial cooling may be necessary. The maximum

greenhouse temperature should not exceed 30–35 °C for prolonged periods [8]. High temperatures may cause in increased activity of pests along with sunburns, that could cause economic hazards, for example *Tetranychus cinnabarinus*, which is one of the most economically important pests of greenhouse-grown vegetables and ornamentals in the southwestern part of Turkey /Antalya [9]. Therefore, it is concluded that plastic house shading using might potentially reduce insect infestation and improve fruit yield and quality in cucumber during summer time [10].

There is no doubt that operating costs come to the forefront of production. Especially in the plant growing season, more utilization of natural light and heat is essential to decrease the costs. For this, besides the greenhouse construction, the covering material, the position of the greenhouse (orientation), the climate characteristics of the region are also influential. Greenhouses should be built peculiar to climatic characteristics of zones they will be established. For example, in a region with a tropical humid climate, where protection from the rain is the greenhouse's main purpose (prevalence of the umbrella effect), the type of construction preferred may be different from that desirable in a semi-desert or Mediterranean climate region [11].

Speaking of which, in today's world agriculture sector is using plastics intensively (plastic cover materials, chemical fertilizers and pesticide boxes, post-harvest wastes and drip irrigation laterals etc..Through conscious use and disposal of materials, especially like plastics the damages that agricultural wastes will pose on nature, soil and water resources will be minimized [12].

Mediterranean region have considerable advantages to build greenhouses because the nighttime and daytime temperature differences are very low, the number of frosty days are minimal and snowy days are rare. This way greenhouse heating costs can be kept to a minimum during the winter season. But, farmers avoid some of key factors such as greenhouse constructions, lighting, ventilation and heating in the greenhouses to avoid initial investment costs. As a result, production decreases and sometimes due to weak construction materials, greenhouses may collapse [13].

[14], point out that greenhouses are costly agricultural structures and due to this, modern day technology must be projected in greenhouses, in recent years there has been an absolute increase in Turkey's greenhouse area, but at the same time, many problems arise due to the wrong applications of modern technology, such as carrier construction, ventilation, heating, cooling, shading, irrigation, air conditioning and so on, many topics can be counted.

A study [15] showed that changing conditions increased the need for greenhouse farming, but also emphasized the importance of the properties that carrier materials should have in greenhouse constructions. The increase in the income from the greenhouses attracts more people and especially the farmers who carried out their agricultural activities in the form of family businesses. As a result, investments in greenhouses have begun to increase day by day. At this point; for detached greenhouses, various profiles any greenhouse structure is constituted by determining appropriate structure system directed towards medium sized foundations. And for each structure, the amount of steel equipment and structure is defined by graphics. By this way, a significant facility is provided for designer and producer. And furthermore, the applicator can reach the preliminary data about the optimum investment cost of greenhouses.

Unfortunately, the construction materials selected for the construction of these greenhouses are not given enough care regarding types, sections, and properties, support, and installation. Even establishments that provide loans to greenhouses do not take any notice if these greenhouse projects are prepared properly or not, some of them can provide loans based on copy projects various means.

This study proposes a solution, to construct proper greenhouses with efficient material durability with true quantity. So this way economic harms could be eliminated long before they occur.

MATERIALS

The greenhouse sites in Mersin province starts from central parts and longs to the coasts of the western side of Mediterannean part. Tomato, pepper, and cucumber are mainly cultivated. Even though the ecological conditions of these areas are favorable, the quality of the product is often low because of the poor production techniques. Despite these, greenhouse investments are spreading. Mersin greenhouse production has shown much improvement in recent years [16]. The intensity of exports, market shares, climate conditions are all important reasons for this development.

In Mersin Province, plastic covered, spring or autumn production with gothic glazed greenhouses are used. For the analysis with software, considering the continuity of the upper and lower head during the application phase in the modeling, the bars were considered to be rigid bound. The load values found as a result of these calculations are combined, and the SAP2000 program has been used to affect the loads in combinations [17]. The current state of the selected greenhouse was compared with the obtained data and the profile characteristics (width, length, length) and post - analysis profile characteristics of the investigated greenhouse. As a result of the comparisons, it was determined that there is no significant difference between the amount of material used in the greenhouse examined and the

amount of material reached after the analysis made with SAP2000 program. However, it has been observed that the security of the greenhouse has fallen into danger because of the erroneous detection of sections of the carrier systems.

TABLE 1
Greenhouse Presence in Mersin Region and Turkey for (2013-2017) [16]

		Mersin	Turkey
Low tunnel (da)	2013	21925	157737,4
	2014	23017	156720
	2015	26067	161541,1
	2016	24965	169867,3
	2017	30066	191399,1
Glass Greenhouse (da)	2013	6343	80739,4
	2014	6472	80975,7
	2015	5970	79976,9
	2016	6300	80137,1
	2017	13763	85748,9
Plastic Greenhouse (da)	2013	72864,9	278661,3
	2014	75253,4	298651
	2015	73184,4	306073,7
	2016	79421,4	328745,4
	2017	87815,5	355120,9
High tunnel (da)	2013	47640,7	97986,4
	2014	54103,2	107095,4
	2015	57287,5	112673,6
	2016	56483,8	112973,6
	2017	58402,8	119898,7

The open space of the two-span plastic gothic roof is 19.70 m, the distance between the scissors is 6.50 m, and the roof slope angle is $\alpha = 26^{o}$. Greenhouse element lengths are cm and cross-section measurements are mm. When the greenhouse dimension analysis is performed, it is determined that it has 45.00 m length, two spans gothic types, 4.00 m height column, and 90 cm depth on a constant basis. The greenhouse was built in 2011.

METHODS

The research was carried out in three stages, locating of glass and plastic greenhouses in the mentioned area, in-situ examination and office work. Glass and plastic covered greenhouse areas in Mediterranean province, and locations where greenhouses are concentrated especially are appointed with data gathered from provincial and district directorates of agriculture. In this way, the concerned plastic covered, and gothic roofed greenhouse located in Mersin province is chosen for greenhouse structural analysis. Mersin has an essential share regarding greenhouse production in Turkey. Situ measurements have determined the structural elements of the selected greenhouse. Besides, the profiles, types and, sizes of the greenhouses, the conditions (structural features, material properties, roof system, cover material) and their qualifications for cultivation have been determined in the field works. The general principles are applied in the selection of the subdivisions, and greenhouses with different roof and construction characteristics are determined. According to the loads on the platform, the loads on the calculation and projecting of the sections of the tension and compression rods are considered. In the study, the moving loads on the selected greenhouses, simulated with meteorological observation records between 1980 and 2015 taken from the Meteorology Directorate's. Possible [18]. wind velocities and other climatic data in the study area are considered as projecting criteria in the SAP2000 program. The calculation with SAP2000 computer program is explained in detail.
The external loads acting on the bearing systems are calculated according to the materials, the slope of the roof. They are transformed into a uniformly distributed load and altogether applied to the structure. As the external load; wind load, plastic cover load, and plant load were picked. SAP2000 is a static analysis program for both steel and reinforced concrete structures and is a general-purpose structural analysis program used for the analysis and sizing of building system models. The program performs the static analysis of the bearing system according to the finite elements method. The loads specified in Table 2. All operations were performed on the SAP2000 screen with the help of the particular "Graphical User Interface."

According to this;

Fixed loads (H): Core loads (roof weight, plant load)

Moving loads: (HZ): Wind effect; horizontal and lateral wind forces, loads occurring in the installation stages,

The loads applied to the system are added to the system through specific loading situations. These loading states are G, Q, RXP, RXN, RYP, RYN. Shown in Table 2.

FIGURE 1
Steel Level of Stretch Ratio

TABLE 2
Assignment of Loads from Carrier Systems

Snow Load	The coastal areas where the greenhouse is heavily built have not been considered because of the lack of snow [19-20-21].
Wind Load	The highest wind speed measured in Mersin province in February is 34,2 m/s; and taken as $q = \frac{34,2^2}{1600} = 0,74\ kN/m^2 = 74\ kgf/m^2$ [18-20]
Earthquake Load	Earthquake load was not considered in the study because of the small total weight in greenhouse constructions [19].
Cover Load	A load of 250 g / m^2 for 100-micron thick polyethylene (PE) material [19-20]
Plant Load	The plant load for the greenhouse is 15 kg / m^2 [20-21]
Carrier System Weight	ST37 soft structure steel has a unit volume weight of 7.85 t / m^3, a tensile strength of 3.700 kg / cm^2, a yield limit of 2.400 kg / cm^2 and an elasticity modulus of 2.100.000 kg / cm^2. The SAP2000 program calculates the structural weight per unit volume weight according to the cross sections entered [19-20]

• G: Constant load (H):

• Q: Plant load; Plant weights for model greenhouses were taken at avarage15 kg / m^2

• Moving load (Hz):

• RXP: Wind load in + X direction

• RXN: Wind load in the -X direction

• RYP: Wind load in + Y direction

• RYN: Wind load in -Y direction

The SAP2000 program automatically calculates the vertical building loads by taking advantage of the unit volume weight of the materials used. As a result, greenhouse structure is modeled originally regarding carrier system and load distribution. This situation allowed to make a real calculation. These loads, which are defined and added as distributed loads to the elements, are added to the calculations at specific rates by way of combinations. Accordingly, six different loading combinations were created. The program worked according to these load groups. In the event of the most adverse conditions occurring during the analysis, the results are assessed.

C0: G + 0.3Q (constant + 0.3 moving load)

C1: G + Q (constant + moving load)

C2: G + Q + RXP (constant + moving load + + wind load in X direction)

C3: G + Q + RXN (constant + 0.3 moving load + wind load in -X direction)

C4: G + Q + RYP (fixed + moving load + + wind load in Y direction)

C5: G + Q + RYN (constant +0.3 moving load + wind load in -Y direction)

American AISC-ASD89 standarts and Turkish standarts TS 498 and TS EN 13031-1 are the same. These standarts are selected as the steel design directive. In this regulation, the capacity ratio (Demand / Capacity Ratio Limit) is set to 1. This value can be summarized as the ratio of the most negative stress (kN/m^2) to the steel safety stress (kN/m^2) obtained as a result of the combinations. This ratio should be between 0 and 1 (Figure 1). It is seen that the color scale has the highest steel level of stretch ratio with red color and very little tension in gray color. Therefore, it can be said that the section defined in cases where the tensile ratio is closer to 1 or greater than 1 is insufficient when it is 0, no stress occurs, and between 0.5 and 0.7, it is the optimum section stress.

The primary purpose of dissolving the widely used greenhouse samples in the region is to show that by using the SAP2000 structural analysis program, it is possible to study in detail the exceptional points in the conveying system, the complex junction details and the critical regions to which large loads are transferred, and more accurate results can be achieved.

The applied method is explained in the research findings of selected parameters for design, types of sections, loads, methods of calculating load components, programs used, analysis results according to models, load curves for the equations and components used in dimensioning, section effects and stresses. EUROCODE for the sections used for greenhouse construction. The analysis was carried out with the profile (IPN, HEA, T, UPN, L, 2L) sections selected here. With the SAP2000 program, the horizontal and lateral forces at the joints and stresses that can occur in XZ and YZ axes can be easily seen on the screen. The analysis and the dimensioning of the bearing systems are made according to the flow diagram given in the study.

RESULTS AND DISCUSSION

The sections used in the construction were found in the current situation by making measurements in the greenhouse, and the baseline loads were found by using the information in the method section. SAP2000 program analyzed the gothic roofed plastic glazing greenhouse according to load combinations (wind, plant, fixed). The loads on the greenhouse are calculated as the distributed load with the classical method. These values are; taken into consideration as load values in the SAP2000 program. Considering the characteristics of the building; the values required for load analysis are taken from recalculations of earlier literature. It is also assumed that the roof and side ventilation openings of the greenhouse are closed. Considering

the continuity of the upper and lower head during the application phase of the modeling, the bars were rigidly bound (Figure 2).

Modeling was done in SAP2000, and cross-sectional effects were obtained. As a result of the analyzes, the compression, tensile and bending stresses in the steel profile covered with plastic material are shown in SAP2000. (Figure 3)

In the SAP2000 program, the load characteristics of the load combinations were determined by acting on the short and long axis of the greenhouse regardless of the direction of the wind effect. Strain ratios in greenhouse columns are well above the permissible limit. The strain rate can be expressed as the ratio of the most negative stress to the steel safety stress as a result of loading combinations. The desired stretch ratio is between 0 and 1 (Figure 4).

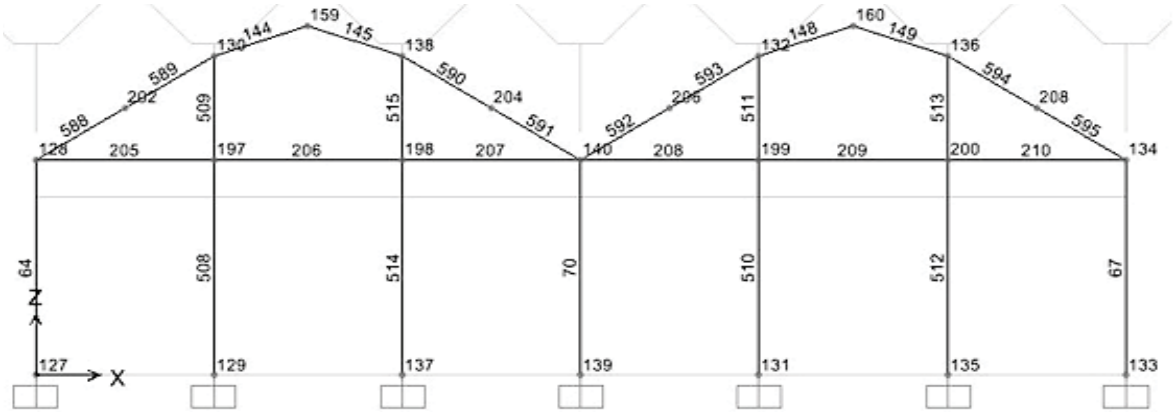

FIGURE 2
The numbering of Gothic Roofed Greenhouse Construction Elements

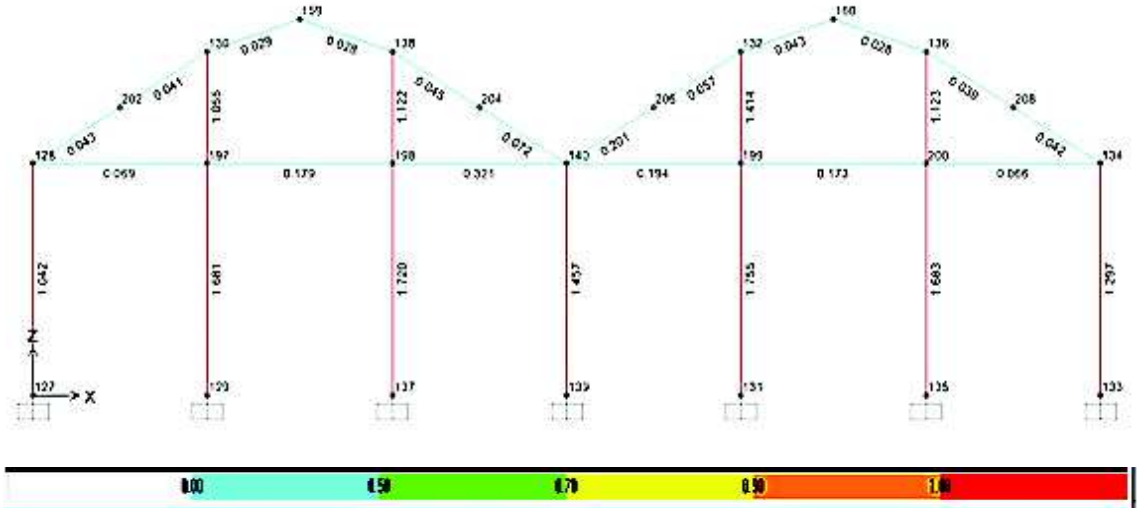

FIGURE 3
SAP2000 Program (RXP Direction) Steel Level of Stretch Ratio

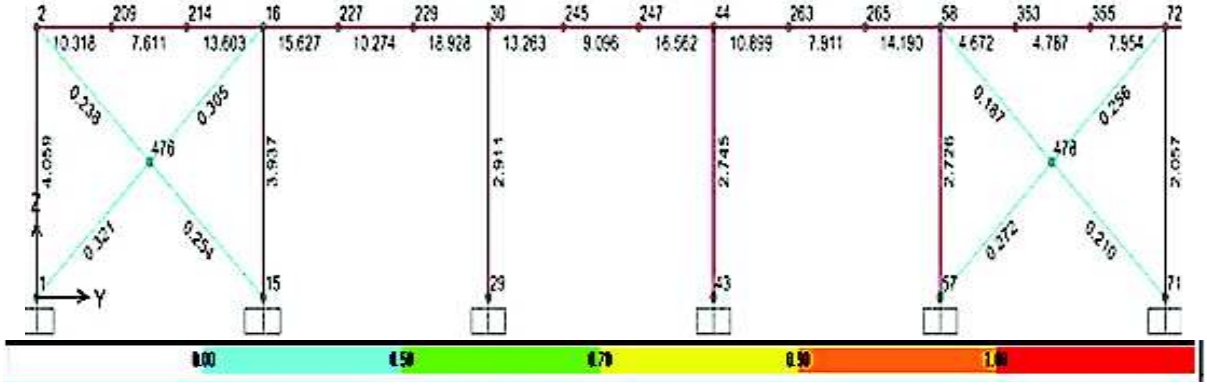

FIGURE 4
SAP2000 Program (RYP Direction) Steel Level of Stretch Ratio

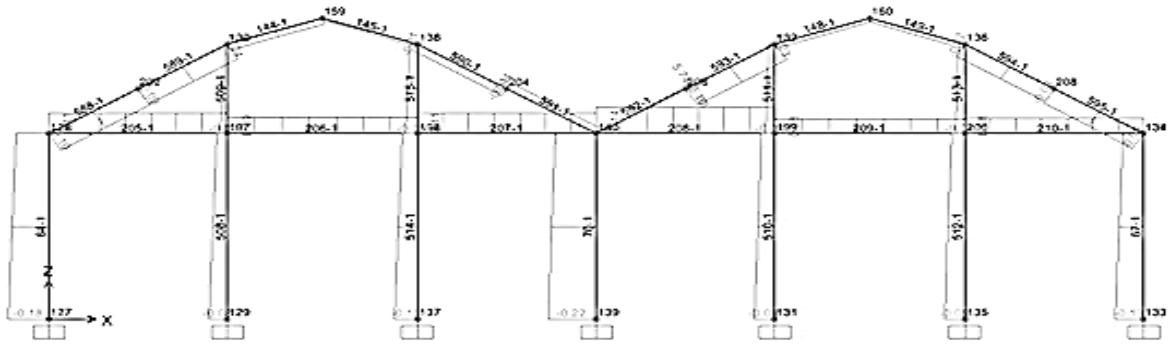

FIGURE 5
Demonstration of Spreading Loads on the Short Axis (XZ) of Gothic Roof Greenhouse in SAP2000 Program

The connections of the columns of the upper and lower heads were made as joints and regulated. When all the structural members were considered rigidly connected, it was observed that the cross sections of the upper and lower head beams were enough. The wind load on the greenhouse is effective both in the short and the long axis. Wind load was determined to be active on the greenhouse, depending on the height of the greenhouse and the length of the windshield area. (Figure 5)

As a result of SAP2000 analysis, a structural element which is insufficient in Figure 4,5,6 is shown. In this element, which is defined as a bifurcated rigid, only a force is generated in the axial direction, and therefore, tension is generated in the axial direction. Fa = 919.118> Fe = 756.694. (K * L / r). In this case, the cross-section can be replaced with the upper sections or the length (L) can be shortened with intermediate members (such as tensioner, diagonal). According to the analysis results obtained with SAP2000; this ratio is seen like 2 or more in the columns. Therefore, it has been determined that the identified sections are insufficient. It was determined that it would be economical to construct 2 ½ "(B76,1X3,25) steel pipes used on rooftops with 2" (B60,3X3,25) steel pipes after analysis. In the present case in the column section, 3 "(B88, 9x4) light series are used. In the present case, colonization needs to be improved. 3 "medium (TS301 / 3) or thick series (TS301 / 4) can be used to provide sufficient strength. Also, if a different profile can be used, 4 "(B114,3x4) light steel tubing must be used in the columns. As a result of the analysis made with SAP2000 program, the top headings of the greenhouse are not changed regarding saving in construction; it is necessary to increase the cross-section of the greenhouse columns. More rigid elements may be preferred over the main bearing elements instead of the pipe profile. HEA or NPU steel profiles. By using crosses in every range, the stiffness of the structure of the structure can be increased. In summary; under specified loads, the specified sections are insufficient.

CONCLUSION

The lack of ready-made greenhouse projects, the lack of knowledge of the necessary structural features and the lack of care during construction make the greenhouses poorly engineered agricultural production structures. Greenhouses are simple structures, making as much use of the existing ecological conditions as possible. This leads to a significant loss of productivity and quality.

To prevent structural damage;

• The use of large cross-section structural construction material reduces both the amount of light entering the greenhouse and the interior columns of the wood or profile used restrict the in-house greenhouse mechanization. To avoid this, the smallest sections that can provide the necessary strength in the plan and the most significant openings that will allow for the mechanization need to be identified.

• Due to easier installation and ease of use of materials in plastic covered greenhouses, bowed roof systems should be preferred.

• According to long years measurements; For Mersin, the highest wind speed was 34.2 m/s with winds swirling west-southwest in February [18]. The long axis should be positioned taking into consideration the prevailing wind direction while planning the runway. Considering the wind load, the sidewall heights in the study area should be at least 2 m and at most 4 m.

• Project selection and construction must be strictly carried out under the supervision of agricultural engineers, for greenhouse construction standards [20-21].

• Applications such as heating, irrigation, fertilization, ventilation, and construction planning, which require high technology and therefore require high installation costs, should be automated and controlled by the computers and current programs.

• Appliances made by public or private companies; must have a plastic or glass covered spring or cradle roof and automation that is up-to-date, conforming to European Union standards and re-

gional climatic conditions. [21-22].

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