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***Research Article***

# Structural Analysis Example of Steel Construction Greenhouses

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**Abstract**

The greenhouse is an agricultural structure which provides the necessary growth factors for plant production and enables the mechanization of the crops. Greenhouse cultivation is one of the most important income generating branches of agriculture. Nowadays, computer software's 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, emphasizes the structural Analysis of a one-span glass covered gable-roofed greenhouse, having an area of 720 m$^2$ located in Antalya province. Structural analysis of the greenhouse was made with SAP2000 program. Mechanical properties of steel used in gable roofs, glass 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 gable-roofed glass-covered greenhouse according to load combinations (wind, plant, fixed) with SAP2000 program. Also, although there is not a big difference in terms of cost, greenhouse security is endangered as the required cross-section element is not used. With an optimized area of 720 m$^2$, the greenhouse saves 2.736 kg of building material. An average of 11.8% of the building materials can be saved in 1 decare area. Considering the same load conditions; the use of SAP2000 analysis reduces the cost, and there is no change in strength.

**Keywords:** Greenhouse, Construction, SAP2000 (Structural Analysis Program), Analysis

# Çelik Konstrüksiyonlu Seranın Yapısal Analiz Örneği

**Öz**

Sera, bitki üretimi için gerekli büyüme faktörlerini sağlayan ve bitki yetiştiriciliği için mekanizasyon imkanlarını kolaylaştıran tarımsal yapıdır. Sera tarımı, tarımın en önemli gelir getirici kollarından birisidir. Günümüzde, bilgisayar yazılımları seraları planlarken de kullanılmaktadır bu şekilde daha sağlam ve ekonomik bir yapı elde edilebilmektedir. İşletme sahipleri, seralara sermaye yatırımı yaparlarken, mevcut seraların yapısal özelliklerini tüm yanlış hesaplamalarla ve hatalarla birlikte kopyalayıp yeni projelere aktarmaktadırlar. Tüm yatırımlar ve yatırımların geleceği yanlış hesaplamalarla ve yapısal sorunlu projelerle tehlikeye atılmaktadır. Sonuç olarak, statik ve mukavemet hesaplamaları yapılmadan inşa edilen seralar, daha fazla malzeme kullanılması, yapısal hasarlar ve bunlara bağlı olarak meydana gelen ekonomik kayıplarla yüz yüzedir. Bu çalışma, Antalya ilinde bulunan 720 m$^2$ alana sahip tek açıklıklı cam kaplı üçgen çatılı bir seranın yapısal analizlerini içermektedir. Seranın yapısal analizi SAP2000 programı ile yapılmıştır. Sera yapımında kullanılan çeliğin mekanik özellikleri, TS 498 ve TS EN 13031-1 Türk standartlarına göre teorik yük hesapları ile yapılmıştır. Seradaki değişken yükler, SAP2000 programı ile yük kombinasyonlarına (rüzgâr, bitki, sabit) göre üçgen çatılı cam kaplı sera analiz edilerek, klasik yöntemlerle dağıtılmış yükler olarak hesaplanmıştır. Ayrıca, maliyet açısından büyük bir fark olmamasına rağmen, gerekli enine kesit elemanı kullanılmadığından sera güvenliğinin tehlikeye girdiği tespit edilmiştir. 720 m$^2$'lik alana sahip olan bu seranın, doğru analizler sonucu elde edilen proje ile inşa edilmesi halinde 2.736 kg yapı malzemesi tasarrufu sağlayacağı belirlenmiştir. 1 dekar alanda inşaat malzemelerinin ortalama %11,8'i tasarruf edilebilmektedir. Aynı yük koşulları göz önüne alındığında; aynı dayanım için SAP2000 analizinin kullanılması maliyeti düşürebilmektedir.

**Anahtar Kelimeler**: Sera, Konstrüksiyon, SAP2000 (Yapısal Analiz Programı), Analiz

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# 1. Introduction

Greenhouses are cultivation structures that climate conditions are under control, and the production period could be prolonged whole seasons. Greenhouses are used to produce plants, seeds, seedlings, to protect plants by controlling factors such as temperature, light, and humidity without being totally or partially dependent on climate-related environmental conditions. It is a plant production structure made with different shapes (Öneş, 1986; Yağanoğlu and Örüng, 1997; Yüksel, 2000; Baytorun, 1995).

Greenhouse production in Turkey consists of mainly plastic covered structures. As of 2011, the total greenhouse area has reached 60000 hectares, 32000 hectares (ha) of which are defined as high tunnel systems. Modern greenhouse cultivation, which has been developing rapidly with the introduction of big investor groups in the sector, has shown a significant improvement in the last decade and has reached 1000 ha levels. Approximately 150-200 ha of land is added each year. Nowadays, 3% of the greenhouse areas are modern greenhouses. This rate is expected to reach 15% in the next ten years (Eker, 2012).

A wide variety of structural greenhouse 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 regarding the Mediterranean basin (Castilla and Hernandez, 2007).

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 a 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 (Zabeltitz, 2011).

Mediterranean region has considerable advantages to build greenhouses because the nighttime and daytime temperature differences are very low; the number of frosty days is minimal and snowy days are rare. This way greenhouse heating costs can be kept to a minimum during the winter season. However, farmers avoid some of the critical 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 (Saltuk, 2005).

While greenhouse production was made in 51 provinces in Turkey in 2011, it has reached 70 provinces in 2014. The increase rate in the last four years (72%) is above 15% which is the average annual growth rate (Doğaka, 2015).

No doubt 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 humid tropical climate, where protection from the rain is the greenhouse's primary 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 (Montero et al. 2013).

Heating systems are applied in greenhouses built in recent years in Turkey. Heating in greenhouses increases product yield, quality, and quantity. Especially in greenhouses heated in the Mediterranean coastline, two-fold productivity can be increased. However, the need for heat energy increases in greenhouses where heat protection measures are not taken and an average of 100 $kWh.m^{-2}day^{-1}$ Heat energy is needed depending on the climate values of the region during the production period. Increased energy costs cause the producer to discuss the profitability of heating. For this reason, it has been determined that energy conservation in greenhouses, as well as heating in greenhouses, is essential in terms of profitability and energy efficiency (Baytorun and Gügercin, 2015).

In a study conducted by Boyacı et al., 2016, the greenhouse agricultural potential of Kırşehir province has been investigated considering the climatic data, geographical location and agricultural structure of the city for many years. When the long-term climate data of Kırşehir province between 1960 and 2015 are examined in terms of greenhouse agriculture, it has been determined that the temperature increases and the relative humidity tend to decrease. Accordingly, when the average annual temperature is low, the number of frost days is higher than the heating costs in Kırşehir province, it was revealed that the use of greenhouse cultivation was not considered to be economical in that time (Boyacı et al., 2016).

The greenhouse sites in Antalya province starts from central parts and longs to the coasts of the western side of the Mediterranean 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. Antalya greenhouse production has shown much improvement in recent years (Anonymous, 2018).

Tekinel, and Baytorun, (1990), point out that greenhouses are costly agricultural structures. 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.

Mandalik, (2001), 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 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. At this point; for detached greenhouses, various profiles any greenhouse structure is constituted by determining appropriate structure system directed towards medium-sized foundations. Moreover, 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. Moreover, furthermore, the applicator can reach the preliminary data about the optimum investment cost of greenhouses.

For the analysis with software, considering the continuity of the upper and lower head during the application phase in the modeling, the bars were 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 (Çağdaş, 2004).

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 appropriately prepared or not; some of them can provide loans based on copy projects various means.

A rare tornado on Thursday left havoc in its wake across the Mediterranean city of Antalya, killing two people. Farmers were particularly affected by the weather event and sought to remove debris and collect unaffected crops, while experts warned of more storms in the area (Anonymous, 2019a).

High winds, heavy rainfall, and a whirlwind devastated agricultural land, greenhouses, villas, and cars close to the shore in Antalya's Kaş, Finike, Demre, and Kumluca districts. According to a local meteorology official, the estimated speed of the whirlwind reached 200 km per hour. (Anonymous, 2019b). It is handy to consider high wind speeds when planning greenhouses. However, if the wind speed is taken into consideration in the greenhouse, the construction cost of the greenhouses will be quite high, and the solar radiation is entering the greenhouse will be quite low. Therefore, the climate of the greenhouse should be considered for many years. This study proposes a solution, to construct proper greenhouses with efficient material durability with exact quantity. So, this way economic harms could be eliminated long before they occur.

## 2. Material and Method

### 2.1. Material

In this study, a sample glass-covered gable-roofed greenhouse project was developed for analysis and design, and it was analyzed and sized using SAP2000 structural analysis software, which is based on finite-element modeling method. 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 sample greenhouse structure was assumed to be in Antalya province, and snowfall and seismicity of the province were reflected in the design in the light of related regulations and standards. In the study, the opening of the single-lattice truss glass bead is 9.00 m, the scissor range, 5.00 m and the roof inclination angle; 26°. The length of greenhouse construction elements is the meter. Glass-covered gable-roofed greenhouse structural design is given in Table 1.

Table 1. Dimensions of the greenhouse used in the study.

| | | | |
|---|---|---|---|
| Greenhouse Width | 9.00 m | Roof Inclination Angle | 26° |
| Greenhouse Length | 80.00 m | Door Height | 2.10 m |
| Greenhouse Area | 720.00 m$^2$ | Door Width | 3.50 m |
| Ventilation Window Length | 80.00 m | Height | 4.60 m |

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 SAP2000 Some of the section values of the elements used in the construction of the gable-roofed glass greenhouse are given in Figure 1. Greenhouse plan, depending on the data reached; With AutoCAD 2007 program, it was drawn 1/50 and transferred to SAP2000 program (Figure 2). Using the graphical user interface of the program, the construction properties (length, section) and loads (fixed, moving) are entered into the program, and the nodes and rod elements are numbered. (Figure 2).

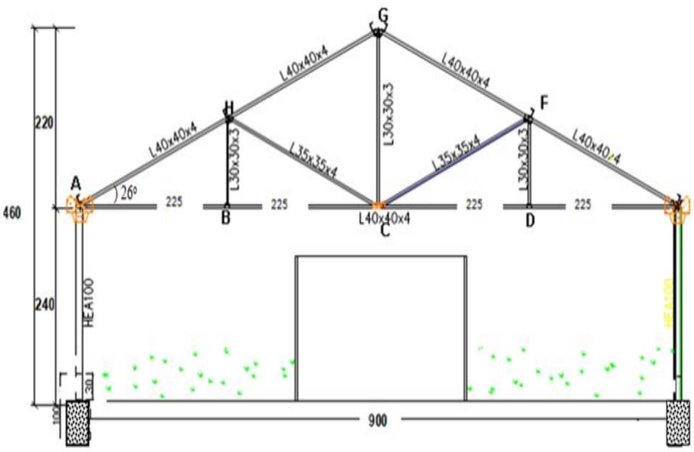



Figure 1. Glass Greenhouse Used in the Study (Section A-A)

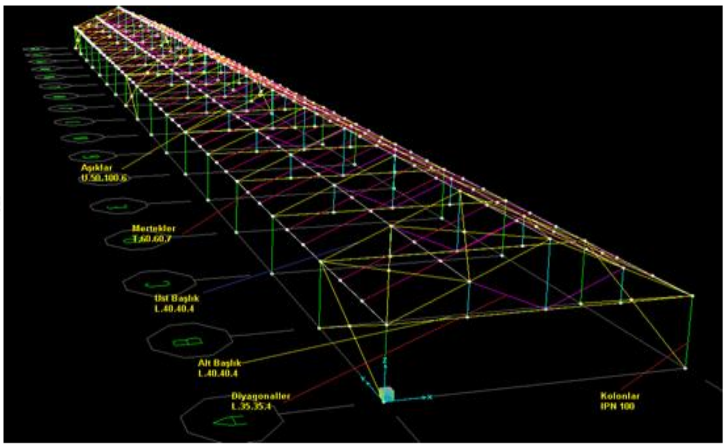


Figure 2. Greenhouse Plan AutoCAD Drawing (3D)

#### *2.1.1. Climatic Situation in Antalya*

In the research area, summers are hot and dry; winters are mild and rainy. The rainiest and coldest months of the year are December, January, and February; the driest and hottest months are June, July, August and September. It is seen that this climate is effective as low as 700-800 m on the lower slopes of the coastal mountains. The highest wind speed in 1997 in Antalya province is 34.2 m/s; The average annual temperature is 15 °C - 20 °C. The average temperature in July is 25 ° C. The average temperature in January is 10 °C in the south and 3 ° C to 7 °C in the interior (Anonymous, 2017).

## 2.2. Method

In the study, the moving loads on the selected greenhouses, simulated with meteorological observation records between 1991 and 2017 taken from the Meteorology Directorate. In this way, 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, glass 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 element 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)

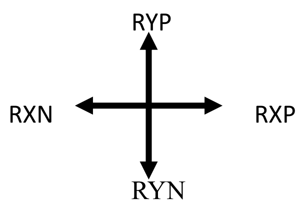
Moving loads: (HZ): Wind effect; horizontal and lateral wind forces, loads occurring in the installation stages,

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.

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. (Anonymous, 1997, 2003) (Simsek, 2014). |
| Wind Load | The highest wind speed measured in Antalya province in 1997 February is 34,2 m/s; and taken as $q=\frac{34,2^2}{1600}=0,74\ kN/m^2=74\ kgf/m^2$ (Anonymous, 2017). |
| Earthquake Load | Earthquake load was not considered in the study because of the small total weight in greenhouse constructions (Anonymous, 1997; Anonymous, 2003). |
| Cover Load | A load of 10 kg /m$^2$ for 4 mm thick glass material (Anonymous, 2012) |
| Plant Load | The plant load for the greenhouse is 15 kg/m$^2$ (Simsek, 2014). |
| Carrier System Weight | ST37 flexible 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 (Anonymous, 1997; Anonymous, 2003) |

- G: Constant load (H):
- Q: Plant load; Plant weights for model greenhouses were taken at average 15 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, the 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 standards and Turkish standards TS 498 and TS EN 13031-1 are the same. These standards 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 3). 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 are given in Figure 3.


Figure 3. Steel Level of Stretch Ratio

## 3. Results and Discussion

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 Figure 4. 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.

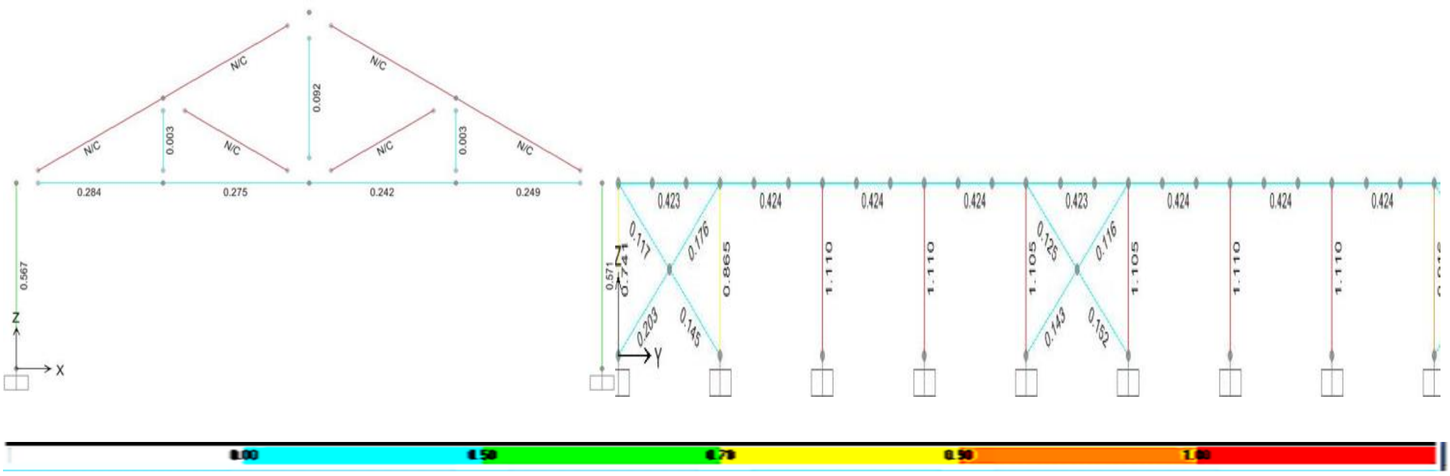



Figure 4. SAP2000 Program (RXP Direction • RYP Direction) Steel Level of Stretch Ratio and stress control and bar sections screen

In SAP2000, the stresses of the rod forces in the roof truss system of the greenhouse are shown due to the maximum load. Based on these values, it was determined that it could not carry the forces on the greenhouse with the existing sections. As a result of the solution, enough strength was obtained in the structural elements, while the increase in the upper heads and diagonals, and the reduction of the lower headers and sections occurred. Considering the total material consumption of the greenhouse, which is given in the material section, which has the existing section characteristics; with the new cross-section values of the single-span greenhouse after the use of the SAP2000 program, it was determined that the construction of 2.736 kg less steel material would result in a decrease in the total weight of the greenhouse construction materials by 3.79 kg/m$^2$. The reduction in the total amount of steel material in the greenhouse structure will also reduce the construction cost. Reducing the cost did not reduce the strength of the structure. The cross-section change in the upper headers and the diagonals is made as automatic (Auto select). In the automatic selection of the program data, the section values are selected. Accordingly, it was determined that the material could be saved with the right project. To increase the wall thickness of the profiles used or cross-tension between the column is determined as a solution. Increasing these tensioners may increase the strength of the greenhouse and reduce the amount of material. In addition, reduction of lovers can be considered as a different solution. The 2L profile can be used instead of the L profile. More rigid elements in the main carrier elements than the pipe profile; IPN or UPN steel can be preferred. The stiffness can be increased in the conveying system of the structure using each interval. In SAP2000, the stresses of the rod forces in the roof truss system of the greenhouse are shown due to the maximum load. Based on these values, it was determined that it could not carry the forces on the greenhouse with the existing sections. As a result of the solution, enough strength was obtained in the structural elements, while the increase in the upper heads and diagonals, and the reduction of the lower headers and sections occurred. Considering the total material consumption of the greenhouse, which is given in the material section, which has the existing section characteristics; with the new cross-section values of the single-span greenhouse after the use of the SAP2000 program, it was determined that the construction of 2.736 kg less steel material would result in a decrease in the total weight of the greenhouse construction materials by 3.79 kg / m$^2$. The reduction in the total amount of steel material in the greenhouse structure will also reduce the construction cost. Reducing the cost did not reduce the strength of the structure. The cross-section change in the upper headers and the diagonals is made as automatic (Auto select). In the automatic selection of the program data, the section values are selected. Accordingly, it was determined that the material could be saved with the right project. To increase the wall thickness of the profiles used or cross-tension between the column is determined as a solution. Increasing these tensioners may increase the strength of the greenhouse and reduce the amount of material. In addition, reduction of lovers can be considered as a different solution. The 2L profile can be used instead of the L profile. More rigid elements in the main carrier elements than the pipe profile; IPN or UPN steel can be preferred. The stiffness can be increased in the conveying system of the structure using each interval. SAP2000 Analysis Evaluation of results;

- Single-span systems are not economical because they increase the cost of construction and do not increase the product yield.

- Although the number of openings increases, the amount of steel and cover material falling to the unit area decreases; Three-span systems are the most suitable systems due to the ventilation and processing efficiency.

- Greenhouse glass (64 cm x 50 cm, 80 cm x 80 cm, 65 cm x 58 cm, etc.) can be produced in different sizes. However, depending on the frequency of rafters, 80 cm x 80 cm or 100 cm x 100 cm greenhouse glass dimensions have a suitable geometry. Winding damage in the glass cover and the wind damage in the plastic cover. Therefore, the thickness of the glass used in the roof should be at least 4 mm, and the plastic cover should be fixed in such a way that it does not allow ballooning to the construction.

- If the roof angle is between 24$^o$-28$^o$, the wind load on the roof of the greenhouse is minimal in the direction of pressure. This reduces the cross-sectional values in terms of strength.

- 2L profile can be used instead of L profile in glass-covered greenhouses. More rigid elements (HEA, UPN) may be preferred in the main carrier elements instead of the steel tube profile (O). The stiffness can be increased in the conveying system of the structure using each interval.

- Consequently, the greenhouses to be built in the region should be solved in terms of strength with the help of building analysis programs. In addition, the use of steel products that have basic standards and can be found on the market will be one of the most important advantages of greenhouse structures.

## 4. Conclusion

The lack of well-prepared 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 Antalya, the highest wind speed was 34.2 m/s with winds swirling west-southwest in February so that 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 Turkish standards.

- 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 regional climatic conditions.

Recommendations to Producers in Antalya Province and districts;

- Ignoring engineering services in order to make the greenhouse cheaper means faults in the selection of material types and sections of materials for the structural systems of greenhouses are made. Even worse is the fact that local producers have built greenhouses without projectors. This situation may cause greenhouses to collapse and consequently massive financial losses.

- Construction of inner columns with wooden or metal profiles in greenhouses for carrier purposes limits the mechanization of the greenhouse.

- Greenhouse systems with spring roofs are preferred in greenhouses in the region, which are more advantageous for easy installation and ease of use.

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