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Full Length Research Paper

Structural analysis and functional characteristics of greenhouses in the Mediterranean region of Turkey

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This study was carried out to determine the structural analysis and functional characteristics of the greenhouses in the Mediterranean region where 87% of the greenhouse production area in Turkey is concentrated. Information about types, material and construction properties, placement and arrangement of greenhouses in the research area was gathered by questionnaires; then greenhouses in enterprises were divided into three groups based on the covering material, load bearing materials and directional placement. Five greenhouse types with the most economic cross-section were selected and loads acting on structural members of these were calculated. The stretch ratios, resulting from loads acting on beams of each greenhouse, were analyzed by SAP2000 program. Also, the stretch ratios as per whether greenhouse types and covering materials have a statistically significant effect were examined. According to the obtained data, it was found that all of the selected greenhouses could not carry the dead and/or dynamic loads safely. It was also obtained that covering material has a significant effect on dead loads but not on dynamic loads at 0.05 probability levels whereas dead and dynamic loads were significantly affected by structural materials of the greenhouses.

Key words: Greenhouse, structural analysis, functional characteristic, dead and dynamic loads, Mediterranean region.

INTRODUCTION

Agricultural lands are being misused, population is rapidly increasing and product quantity obtained from unit area is not adequate. Because of these factors, precautions that will help to increase the productivity must be taken as soon as possible. These precautions include providing and distributing the inputs required for use of modern technology in agricultural production, advancing vegetable, fruit production and especially extending greenhouse areas.

One of the purposes in a greenhouse enterprise is to provide and maintain the environment that will result in an optimum crop production or maximum profit. This includes an environment for work efficiency as well as for crop growth (Aldrich and Bartok, 1989). Greenhouses are designed to provide control of solar radiation, temperature, humidity and carbon dioxide levels in the aerial environment. In hydroponics greenhouses, nutrient levels and root temperatures can also be controlled (Kendirli, 2006).

Greenhouse production in Turkey has been carried out since the 1940s. Total greenhouse area has increased from 1,003 ha in 1960 to 25,032 ha in 2006 (Table 1) (Yilmaz et al., 2005). The annual growth rate indicates that there was a steady decrease in expansion up to 1990 but the rate of growth increased in the 2000s. In the reviewed period, annual growth rate was about 6 and 9% for glass and plastic greenhouses, respectively. The likely reason for the higher growth rate of the plastic greenhouses is due to their lower investment costs per unit area compared to glass houses. Greenhouses made up 52.3% of the total glasshouse share in the 1960s but declined in the 1980s. This trend has reversed since the 1980s and is expected to continue (Yilmaz et al., 2005). In 1999, total greenhouse area in Mediterranean countries was around 400,000 ha and Turkey's share was about 10.6% (Baudoin, 1999; Ozcatalbas et al., 2002). In 2006, total protected and total greenhouse areas in Turkey were 46,934 and 25,032 ha, respectively.

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Table 1. Developments of greenhouse production area in Turkey.

Years	Greenhouse area				Total area ha	Annual growth rate* %
	Glass covered		Plastic-film covered			
	ha	%	ha	%		
1960	525	52.3	478	47.7	1003	-
1970	976	38.3	1572	61.7	2548	9.8
1980	925	18.5	4072	81.5	4997	7.0
1990	2000	23.3	6600	76.7	8600	5.6
2000	5656	27.6	14825	72.4	20481	9.1
2006	6840	27.3	18192	72.7	25032	3.4

*Total greenhouse area over the preceding 10 years.

Table 2. Some dimensional characteristics of greenhouses in the Mediterranean region.

Greenhouse type	Width (m)		Length (m)		Height (m)	
	Range	Average	Range	Average	Range	Average
Single, glass covered, saddle roof	11.0 - 26.5	15.6 ± 3.7	30.0 - 100.0	64.5 ± 20.2	1.7 - 2.2	1.9 ± 0.2
Block, glass covered, saddle roof	11.3 - 20.0*	14.4 ± 2.8	38.0 - 120.0	62.0 ± 21.3	1.8 - 2.4	2.0 ± 0.2
Single, plastic covered, saddle roof	10.0 - 40.0	25.5 ± 7.8	27.0 - 114.0	64.5 ± 22.8	3.0 - 5.5	3.6 ± 0.6
Block, plastic covered, saddle roofs	10.3 - 33.0*	22.0 ± 6.1	24.0 - 110.0	68.3 ± 22.2	3.0 - 5.5	4.0 ± 0.9
Block, plastic covered, arch roof	5.0 - 10.0*	6.0 ± 1.3	22.0 - 130.0	59.0 ± 22.7	1.5 - 4.0	2.3 ± 0.6

*Value is for one block.

About 28 and 72% of the total greenhouse are glass and plastic-film covered, respectively (Anonymous, 2007).

In Turkey, greenhouse production is generally located on the coastal regions (Ozkan et al., 1997). Beside the Mediterranean coastal line, greenhouse practices are also expanded to Aegean, Marmara, Black Sea and GAP regions (Cemek, 2005). About 87% of the greenhouse production area in Turkey is concentrated in the Mediterranean region (Ozkan et al., 1997). This region is the best in Turkey with a lot of vast greenhouse production areas (Yuksel, 2004; Atılgan et al., 2008). Therefore, the Mediterranean region was selected as the research area for this study. Greenhouses can be classified according to their covering materials, construction materials and constructional characteristics (FAO, 1988). Based on this classification system, there are five types of greenhouses in the Mediterranean region including glass covered-saddle roof-singular, glass covered-saddle roof-block, plastic covered-saddle roof-singular, plastic covered-saddle roof-block and plastic covered-arch roof-block greenhouses. Some dimensional characteristics of these greenhouses are presented in Table 2.

In the Mediterranean region, investigated greenhouses are used for banana and seedling production (34%), tomato (43%), pepper (10%), eggplant (8%), cucumber (3%) and other vegetables (2%). Tomato is the most common greenhouse vegetable due to its relatively high market demand and its vegetable value (Emekli, 2007; Emekli and Buyuktas, 2009). In the research area, wood steel and steel profile materials are used as construction materials in greenhouse enterprises. Single and block glass greenhouses in the region are generally constructed with steel frame and they are used for vegetable production. In general, glass covered-saddle roof-block greenhouses are in double block. Plastic covered-saddle roof-block greenhouses in the region are generally constructed in double or triple blocks. Steel and wood are used as construction materials and banana production is made in plastic covered-saddle roof-single or -block greenhouses. A large part of greenhouses in the Mediterranean region are arch roof-plastic greenhouses. Number of the blocks in these greenhouses varies from 2 to 15 and generally, they are used for seedling production. Wood steel material is used in arch roof plastic greenhouses. It was observed that construction materials were protected against corrosion by using galvanized steel profiles in steel framed plastic greenhouses used for seedling production for commercial purposes. However, they were not protected in other greenhouses used for vegetable and banana production.

Construction materials which were not protected against corrosion oxidation occurs fast and the resistance of construction materials decrease in time depending on rust and corrosion with the effect of external wheather conditions (Baytorun, 1995).

Many construction systems are being used successfully for greenhouses. Some may have advantages over others for particular applications, but there is no best

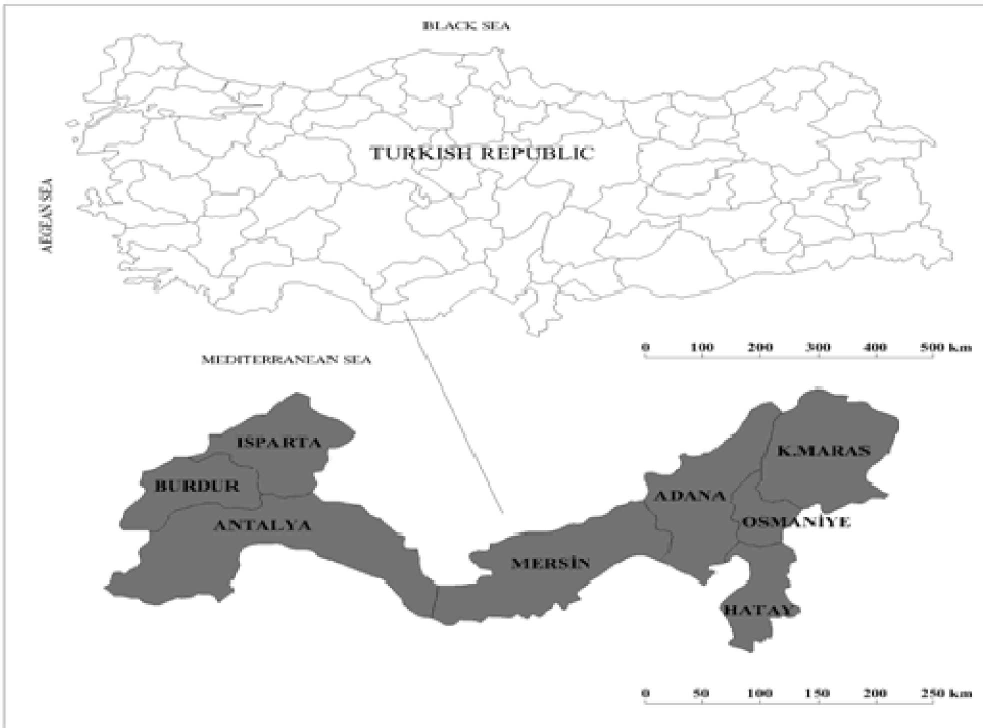


Figure 1. Location of the Mediterranean region in Turkey.

greenhouse (Aldrich and Bartok, 1989). The structural design of a greenhouse must provide protection against damage from wind, rain, heat and cold (Jensen and Malter, 1994). Damage to greenhouses and especially to plastic-film greenhouses, is very often caused by storms and heavy snowfalls, if the main structural components are not designed to withstand such loads. In order to satisfy sufficient margins of safety and to avoid severe damage, the greenhouse structure should be designed in accordance with relevant standards, which offer guidance for the calculation of various design loads (von Elsner et al., 2000). At the same time, the structural members of a greenhouse must be of minimum size in order to permit maximum light transmission to the crop. Design loads for greenhouse structure includes the weight of the structure itself and, if supported by the structure, the heating and ventilation equipment and water lines. The load may also include the weight of crops trained to a support system carried by the greenhouse frame and loads from wind and snow. Greenhouse structures should be designed to resist a wind speed of 130 km/hr. The actual load depends on wind angle, greenhouse shape and size, and the presence or absence of openings and wind breaks (Jensen and Malter, 1994).

Considering the Turkish standards, most of the greenhouses in the Mediterranean region are not appropriately constructed in order to keep initial enterprise expenditure as low as possible. Therefore, optimum environmental conditions inside the greenhouse cannot be provided. As a consequence, intended product quantity and quality cannot be obtained and achieving a more modern appearance of greenhouse enterprise in Turkey is precluded.

The aim of this research is to evaluate the existing structural conditions and functional characteristics of greenhouses in the Mediterranean region. To realize these purposes, greenhouse types in the Mediterranean region were determined and the selected greenhouses were structurally analyzed using SAP2000 program to obtain tension ratio values occurring on each beam of greenhouses due to dead and dynamic loads.

MATERIALS AND METHODS

Study area

The Mediterranean region is one of the seven geographical regions of Turkey. The region takes its name from the sea adjacent to it. It borders the Aegean region, the Mediterranean sea, the Southeastern Anatolia and the Central Anatolia Region in the West South, East and North, respectively. The region is in the form of a strip with a width varying between 120 to 180 km and starts around Köycegiz in the west and extends as far as Cape Basin in Hatay Province in the east. It covers approximately 15% of Turkey with a surface area of 120,000 km^2. The provinces of Hatay, Adana, Mersin, Antalya, Isparta, Burdur and a large portion of Kahramanmaras are in the Mediterranea region (Figure 1).

The Mediterranean region has a Mediterranean climate characterized by warm, relatively humid winters and hot, dry summers. In winter temperatures, it can go as high as 24°C and in summer it is in the upper 30's. In the region, greenhouse practices are commonly dense in coastal line depending on ecological conditions. Antalya is the leading greenhouse production province with 68% of the total greenhouse area in the region and 57% in the country. Its dominant position is explained by climatic factors and by technological and infrastructural advantages. Greenhouse practices in Antalya region are densely applied in coastal line between Kas and Gazipasa. On the other hand, the greenhouses in Mersin province with 30% of the total greenhouse area in the region and 25% in the country are spread and widened in coastal line to the west (Anonymous, 2007).

In the Mediterranean region, greenhouse production is mainly carried out by small family enterprises. These enterprises make production with minimum cost based on existing ecological conditions, so production largely depends on external conditions. The plants grow also in a considerably variable environment. In addition, when product prices are high, no sale is made in local bazaar and profitability is reduced (Anonymous, 2002).

Study materials

The questionnaire contained plant production in the greenhouses, structural properties, design and planning criteria, adequacy of inside environmental conditions and problems of greenhouse growers in the Mediterranean region. Moreover, findings related to ventilation, heating and cooling system of the greenhouses were recorded. These systems are important for designing inside and environmental conditions of a greenhouse. The study was realized using questionnaire survey. To determine the greenhouses to be examined in the study, the data obtained from the records of Provincial Agriculture Directorates were used. According to the data, Antalya and Mersin provinces which have intensive greenhouse growing were intentionally selected. While choosing the greenhouses to be surveyed, simple random sampling method was used (Gunes and Arikan, 1988; Cicek and Erkan, 1996). The formula of the method;

$$n = \frac{N \times \sigma^2}{(N-1) \times D^2 + \sigma^2}$$

Where, n = sample size; N = number of farms in the population; σ^2 = population variance; $D^2 = (d/t)^2$; "d" = deviation at a particular rate (5%) from average; "t" = t table value (1.96) which is equivalent to 95% confidential limit.

The permissible error in sample population was defined to be 5% and the research sample size was calculated to be 172 with 95% reliability.

Information obtained from questionnaire was grouped based on covering material, frame material and directional placement. As a result, five common greenhouse types with the most economic cross section were selected as study materials. In type-1, the loads over the greenhouse are sent to columns without roof truss. Also, the structure of the greenhouse was built on beams and purlins. Type-2 greenhouse has five braces and loads were transmitted on matrix by means of braces. Greenhouse type-3 has seven braces and is only used for banana production. Greenhouse type-4 has no roof truss and was built on beams which have very thin cross-sections. Type-5 is the most common greenhouse construction type in the region and in these greenhouses, steel L cross-section beams were utilized in columns and steel, T cross-section beams which are arc were connected on these beams. Detailed drawings and structural characteristics of these greenhouses selected as study materials are presented in Table 3.

Structural analysis

The structural analysis was performed for the selected greenhouse types by SAP2000 program. Before the application of SAP2000 program, the main loads (dead load, imposed loads, installations, wind load, snow and seismic load), which have to be taken into account in the greenhouse design, were calculated (von Elsner et al., 2000). Hanging basket crop load of 7 kg/m and installation load of 7 kg/m were taken into account for greenhouse design. Snow load was neglected since there was no snow value considering the long-term climatological data for the studied region (Anonymous, 1997; Ones, 1986). No provision for seismic load calculations of greenhouse structures was offered by the corresponding national standards for greenhouse design. Since earthquake does not limit safety of workers, this load can also be neglected in resistance calculations of construction elements (von Elsner et al., 2000). Finally, own weights of the greenhouse structural members, crop load and installation load are taken into consideration as dead loads, whereas wind load is as a dynamic load. Turkish Standard 498 for Greenhouse was used for wind load calculations. All of these dead and dynamic loads were used in SAP2000 program (Anonymous, 1997).

SAP2000 program

SAP2000 is a program which can make static and dynamic analysis of the systems used in building mechanic and engineering. It is a general-purpose program for development, modeling and dimensioning of building system models. The program performs static analysis of bearing system according to finite elements method. Firstly, the model of the building system which is appropriate for its geometry is drawn by the help of "Graphical User Interface" appearing on the monitor. Then, bearers are created at the nodal points of the building system, cross-section properties and types of construction materials which will be used in the beams of the building system are defined. These defined data (type of construction materials, cross-section properties) are given to every single component of the building system. Finally, the statues of dead, dynamic and other loads over the system are defined and the results are obtained by performing the static and dynamic analysis of the system.

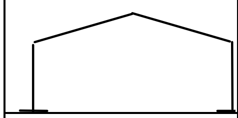
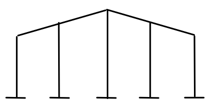
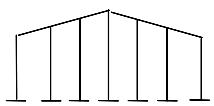
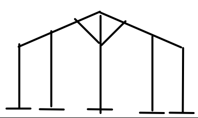
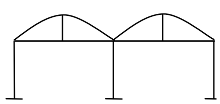
Each beam of greenhouse which can safely carry the loads on itself is taken as a colored diagram (from most safely to least safely; blue, green, yellow and orange) from the SAP2000 program. The beams of greenhouse which cannot safely carry the loads on themselves are obtained as red colored diagrams from the SAP2000 program. Stretch ratios (N/C) occurred at the bars which are obtained at the end of analysis to safety tensions and are given as a diagram by the program. These tension ratios are also expressed by colors. At the end of analysis, if tension ratios are greater than 1, it is considered that the bars given are insufficient otherwise they are sufficient (Cagdas, 2004).

RESULTS AND DISCUSSION

General results

The status of being singular or block at placement of greenhouses for the investigated greenhouses is considered important in this study. The percentage of individual and block greenhouses is 38 and 62 respectively. About 41% of the singular greenhouses are placed at east-west whereas 59% are at north-south direction. For block greenhouses, 15% are located at east-west and 85% are at north-south direction. Light is generally considered the most limiting factor in plant growth and development

Table 3. Detailed drawings and structural characteristics of the selected greenhouses.

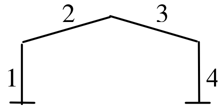
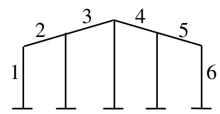
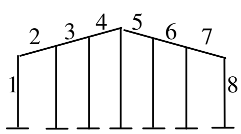
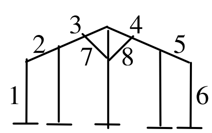
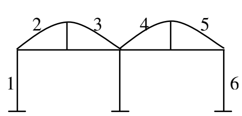
Greenhouse type	Width (m)	Length (m)	Side height (m)	Ridge height (m)	Truss width (m)	Covering Material	Steel Frame material
	16.5	60.0	2.1	5.1	2.5	Glass	$L_{40,40,5}$ $T_{40,40,5}$
	11.3	50.0	1.8	3.9	0.5	Glass	$L_{40,40,4}$ $T_{35,35,4.5}$
	20.0	42.0	4.0	6.0	0.75	Plastic	$L_{50,50,5}$ $T_{35,35,4.5}$
	16.5	50.0	1.8	5.5	2.5	Glass	$L_{40,40,4}$ $T_{30,30,4}$
	11.0	40.0	2.0	3.0	2.0	Plastic	$L_{40,40,4}$ $T_{30,30,4}$

(Aldrich and Bartok, 1989). The effect of orientation on radiant energy transmission is most important during the winter months when solar radiant flux is low and the majority of greenhouse crops are grown (Mastalerz, 1977). Papadakis et al. (1998) reported that placement of singular greenhouses in the east-west direction improves the efficiency of solar energy utilization. For this reason, the single, greenhouses which are placed at north-south direction in the region cannot use the sunlight energy effectively.

Heating is necessary in the Mediterranean region for some winter months to obtain good quality and higher yield. A heat capacity of 80 - 100 W/m is necessary in winter in order to keep inside temperature of greenhouse around 19°C (Zabeltitz, 1992). Greenhouse heating systems in the region tend to be designed to protect the crops from frost rather than to maintain adequate temperature for growing. About 47% of the greenhouses in the region are heated by stove and 8% by hot-water heating systems. There is no heating system for 45% of the greenhouses. As a consequence of this, potential crop yields are not being obtained.

Ventilation is one of the most important tools for controlling greenhouse climate (Baptista et al., 1999). Ventilation is mainly used for controlling of temperature, humidity and concentration of gases, such as CO_2, in the greenhouse. An efficient ventilation performance is a crucial feature of a greenhouse in hot summer conditions (Nielsen, 2000). About 92% of the greenhouses use natural ventilation and 42% of these are only equipped with side vents. There was no measure taken toward the roof ventilators in these greenhouses. Papadakis et al. (1996) and von Elsner et al. (2000) reported that the term “roof ventilators” is used to characterize the openings located at a height above the working space in the greenhouse (that is, a height of 2 m). It has been shown that the roof ventilators generally induce higher ventilation rates when wind driven ventilation is considered. The main reason for this effect is that the side ventilators usually are located at the lower part of the sidewalls, approximately 1 m above the ground. At this height, the wind speed is strongly reduced by the friction with the ground. Moreover, the effect of aerodynamically created pressure differences induced by the shape of the roof is stronger at the roof ventilators. The ratio between ventilation openings and greenhouse floor area varied between 1.0 and 27.0% with an average of 9.1 ± 7.3% for the investigated greenhouses. Zabeltitz (1990) and von Elsner et al. (2000) reported that the ventilation capacity of a greenhouse is usually described by the opening ratio and in Mediterranean climates, the total ventilation area should reach about 18 - 25% of the floor area to ensure sufficient ventilation. Considering these information, it is concluded that about 85% of the investigated greenhouses

Table 4. Dead and dynamic loads on bars in selected greenhouses.

No	Greenhouse type	Bar No	Wind load, kg	Dead loads, kg		
				Installation load	Crop load	Frame element load
1		1	180.00	-	-	-
		2	396.00	288.75	288.75	255.00
		3	484.00	288.75	288.75	255.00
		4	120.00	-	-	-
2		1	180.00	-	-	-
		2	90.00	39.55	39.55	55.00
		3	180.00	39.55	39.55	110.00
		4	300.00	39.55	39.55	110.00
		5	150.00	39.55	39.55	55.00
		6	120.00	-	-	-
3		1	216.00	-	-	-
		2	232.57	105.00	105.00	24.00
		3	465.34	105.00	105.00	47.00
		4	465.34	105.00	105.00	47.00
		5	408.00	105.00	105.00	47.00
		6	408.00	105.00	105.00	47.00
		7	204.00	105.00	105.00	24.00
		8	144.00	-	-	-
4		1	180.00	-	-	-
		2	54.00	288.75	288.75	53.00
		3	162.00	288.75	288.75	155.50
		4	450.00	288.75	288.75	155.00
		5	150.00	288.75	288.75	53.00
		6	120.00	-	-	-
5		1	104.00	-	-	-
		2	336.00	154.00	154.00	13.00
		3	288.00	154.00	154.00	13.00
		4	288.00	154.00	154.00	13.00
		5	240.00	154.00	154.00	13.00
		6	64.00	-	-	-

have problems concerning ventilation.

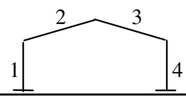
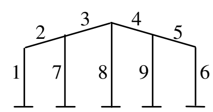
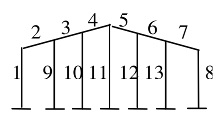
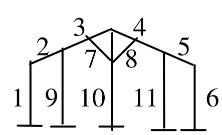
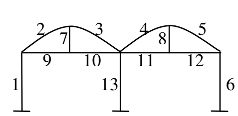
Structural analysis

Before application of SAP2000 program, loads acting on each beam of greenhouses due to own weights of structural members, installation, crop and wind were calculated (Table 4). Units of kilogram and meter were used in SAP2000 program. The model of greenhouse types was drawn on the monitor with graphical user interface appearing on the monitor. This modeling was made with the nodal point in the number which exactly determined the geometry of greenhouse type. Types of material used in greenhouse beams and cross-section properties of greenhouse beams were defined. Dead and dynamic loads acting on greenhouse beams were defined by means of SAP2000. After entering these data to the program, static and dynamic analysis were made for each greenhouse construction.

Calculated stretch ratios for the bars of selected greenhouses are presented in Table 5. Considering stretch ratio calculations, greenhouse types including 1, 2 and 4 which are covered with glass could not carry dead and dynamic loads safely since calculated stretch ratios are greater than 1. However, in plastic covered greenhouse types including 3 and 5, majority of structure elements could carry dead loads but not dynamic loads. Nevertheless, all the investigated greenhouses could not carry the dynamic loads.

It is important to determine whether greenhouse types and covers have a statistical significant effect on the stretch

Table 5. Calculated stretch ratios in selected greenhouses.

No	Greenhouse type	Bar no.	Calculated stretch ratios	
			N/C[a]	N/C[b]
1		1	49.141	51.625
		2	N/C	20.232
		3	N/C	17.159
		4	49.141	25.325
2		1	1.205	8.589
		2	0.524	1.958
		3	0.338	0.736
		4	0.354	0.857
		5	0.480	1.763
		6	1.205	7.424
		7	0.554	2.754
		8	0.740	1.662
		9	0.554	2.780
3		1	1.137	21.598
		2	0.548	N/C
		3	0.274	7.838
		4	0.278	4.234
		5	0.278	3.749
		6	0.274	4.403
		7	0.548	4.504
		8	1.137	17.527
		9	0.346	8.325
		10	0.447	7.033
		11	0.499	5.989
		12	0.447	7.020
		13	0.346	8.428
4		1	1.282	9.513
		2	0.712	2.732
		3	N/C	1.949
		4	N/C	2.059
		5	0.712	2.384
		6	1.282	8.267
		7	0.916	0.478
		8	0.916	0.239
		9	1.169	2.717
		10	N/C	1.382
		11	1.169	2.820
5		1	0.371	5.905
		2	0.589	0.923
		3	0.587	1.126
		4	0.587	1.068
		5	0.589	1.091
		6	0.371	4.789
		7	0.002	0.572
		8	0.002	0.613
		9	0.138	N/C
		10	0.135	N/C
		11	0.135	N/C
		12	0.138	N/C
		13	0.333	3.787

N/C[a]: The ratio of stretch resulting from dead loads; N/C[b]: ratio of stretch resulting from dynamic loads; N/C: very high stretch ratios.

Table 6. The ANOVA results of calculated stretch ratios.

Subject	N/C[a]			N/C[b]		
	MS	F	P	MS	F	P
Greenhouse type	3148.231	196.939	0.000	551.702	13.842	0.000
Greenhouse cover	1682.922	6.946	0.011	0.584	0.007	0.934

N/C[a]: The ratio of stretch resulting from dead loads; N/C[b]: the ratio of stretch resulting from dynamic loads.

Table 7. Duncan test results for mean separation of calculated stretch ratios, $p < 0.05$.

Greenhouse type	N/C[a]		N/C[b]	
	Subset		Subset	
	1	2	1	2
1	59.5703[a]		28.5853[a]	
2		0.6616[b]		3.1692[b]
3		0.5045[b]		8.9983[b]
4		4.0171[b]		3.1400[b]
5		0.3058[b]		6.2180[b]

N/C[a]: The ratio of stretch resulting from dead loads; N/C[b]: the ratio of stretch resulting from dynamic loads.

ratios resulting from dead and dynamic loads. Therefore, the variance analysis (ANOVA) was per-formed by means of statistical package for the social sciences (SPSS) program (Table 6). Considering the test results, it can be concluded that greenhouse types have statistically significant effect on the stretch ratios resulting from both dead and dynamic loads ($p < 0.01$). On the other hand, effects of greenhouse covers were only statistically significant on the stretch ratios resulting from dead load ($p < 0.05$). Duncan multiple comparisons test results performed for comparing greenhouse types wise are given in Table 7. According to average values of tension ratios, greenhouse type-1 was significantly different from those of the greenhouse type-2, 3, 4 and 5. For green-house type-1, since the load over the greenhouse is sent to columns without roof truss and the sections of structure elements are rather small, this type is the least resistant among selected greenhouse types (Aldrich and Bartok, 1989; Jensen and Malter, 1994).

Conclusion

In the Mediterranean region, glass and plastic greenhouses which are generally used for vegetable production are constructed without any project or planning criteria. For these kinds of greenhouses, the entrepreneurs go to local blacksmiths and construct greenhouses without taking any standard or engineering information into account. This causes usage of excessive or deficient material used for building greenhouse. When deficient material is used, collapse and demolition is the case in stormy weathers. When excessive material is used, on the other hand, shadowing ratio increases in the greenhouse. These conditions prevent provision of necessary environmental conditions for plant growth in greenhouses. In order to have a more modern appearance in the greenhouses and to create controlled areas for the plants, greenhouses should be built according to standards and ecological conditions of the region.

In this study, SAP2000 analysis program was used for determining whether the greenhouse in the Mediterranean region of Turkey could carry the loads safely. Using the data entered to the program, tension ratios resulted from loads on greenhouse beams were obtained. According to the results, all of the selected greenhouse types could not carry the loads over them. In addition, in this study it was found that effects of greenhouse types and cover materials on stretch ratio were statistically significant. After finding the significance in ANOVA test, Duncan multiple com-parisons test was performed for comparing greenhouse types wise. The values obtained from greenhouse type-1 were significantly higher than those of the other greenhouse types. This greenhouse type has the lowest resistance in the region. Based on study results, following recommendation can also be made:

(1) The SAP2000 software can be used for static and dynamic analysis of different greenhouse projects.
(2) Users could make analysis of greenhouse project with a few inputs since the data which is used in the static and dynamic analysis of greenhouse project were previously

entered to the software.

(3) To create controlled areas for the plants, greenhouses should be built according to standards and ecological conditions of the region

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