ITU A|Z
VOL:9,NO:1, 56-69, 2012-1

An assessment on traditional timber structures in Süleymaniye and Zeyrek districts of Historical Peninsula

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Received: November 2011 Final Acceptance: April 2012

Abstract:
This study was made on the wooden structural and decorative elements of the 19th century traditional timber buildings in Süleymaniye and Zeyrek Districts, to analyze the structural deteriorations and to identify the woods used.

Istanbul was the capital city of the Ottoman Empire. As in most areas of Istanbul, Süleymaniye and Zeyrek have a lot of beautiful timber structures bearing the memories of past life styles and examples of historical construction techniques. These structures, which are in the World Heritage List, are at risk of disappearing because of lack of care. Most of them are still waiting for restoration.

The spectrum of woods used in these structures is quite large as shown by taxa recognized: Pinus slyvestris, Abies bornmuelleriana, Picea orientalis, Quercus petraea, Tilia tomentosa and Castanea sativa. All species used are being grown naturally in the forests of West Black Sea Region in Turkey.

The works were realized through direct observations, photographing and laboratory analysis methods. The photographs present observations and examples showing the mechanical condition of these timber structures, which have been damaged over time. The main reasons for deterioration of these structures were natural reasons such as earthquake, water and humidity, atmospheric conditions, and man-made reasons including abandonment, fire, incorrect attempts at restoration, economic insufficiency, air pollution, lack of laws to protect these structures and municipal indifference.

For laboratory analysis, a total of 380 wood samples have been taken from 30 structures, which twenty of them were timber and ten of them were masonry buildings. These samples consist of the parts of facings, posts, window profiles, laths, ceilings, floor coverings, floor beams, stairs, handrails, skirting boards, exterior and interior doors. Following the sampling, macroscopic and microscopic diagnoses were conducted to finalize the research.

The main objective for producing this study is based on hope to preserve these structures for future generations. For this purpose, the reasons for deterioration of these structures were analyzed, photographs to illustrate their present conditions were taken and the woods used in these traditional timber structures were identified.

Keywords: *Historical Peninsula, Süleymaniye, Zeyrek, Old Istanbul, timber structures, wooden structure, restoration works, historical buildings.*

Introduction

With their timber structures, narrow and winding streets, Süleymaniye and Zeyrek are the typical districts of Old Istanbul (Figure 1). The ethnic diversity of the district persisted after the conquest of Istanbul and up until the 16th century. Afterwards, the Greek population of the districts moved to the Galata of Old Istanbul, and the other minorities dispersed with time. During the years spanning the conquest and the present, Süleymaniye and Zeyrek have been the districts of dense Muslim Settlement. The majority of the timber structures in these districts were constructed between 1800 and 1840, in an adjoined pattern (Ahunbay 1998; Gülersoy et al., 2008 and 2001).

Figure 1. *Old Istanbul and the case study districts.*

As in most areas of Old Istanbul, fires have caused much devastation in Süleymaniye and Zeyrek. Because the majority of the structures in these districts were made of wood, these fires resulted the destruction of the original urban fabric of Süleymaniye and Zeyrek in various places. After the 1930`s, the construction style shifted from the use of wood to masonry. Despite the changes in material, construction and plans, these new buildings continued to be harmonious with the timber structure pattern of the area (Gülersoy et al., 2008 and 2001).

In 1983, Istanbul (including Süleymaniye and Zeyrek) was inscribed to the World Heritage List. UNESCO began to allot expertise and financial support for projects and restoration activities in 1985.

In the 19th century, wood was used in historical buildings in the districts of Süleymaniye and Zeyrek. These materials were obtained from Pinus slyvestris (Yellow pine), Abies bornmuelleriana (Uludag fir), Picea orientalis (Oriental spruce), Quercus petraea (Sessile oak), Tilia tomentosa (Silver linden) and Castanea sativa (Sweet chestnut) trees, which are being grown naturally in the forests of West Black Sea Region in Turkey.

As it is commonly known, wood has superior physical and mechanical properties. It is also warm and natural building material. Despite its light density as material, it is highly resistant to pressure, shrinkage, buckling and shearing stresses. It can be equivalent to pre-stressed concrete lintel, if it is kept dry and well ventilated in buildings (Singh, 2002). It is easily workable and elastic material. It is also excellent for heat insulation and acoustics. Among the major construction materials, wood uses the least amount of energy to process and manufacture, it is a renewable resource (Kisternaya and Kozlov, 2009).

On the other hand, wood is sensitive to outdoor conditions, it is easily damaged and inherently susceptible to fungal and insect infestation and decay, if it is not well designed, kept dry and well ventilated. But, the damage can be prevented and it's life span can be extended. The species of wood is so important in terms of it's life span. Thus, under normal conditions, each wooden material has different life span depending on their wood species.

The deteriorations in wooden materials are generally physical, chemical, biological and human-sourced. Heat, water, humidity, mechanical abrasion and atmospheric phenomena cause to physical deteriorations. Fire and corrosion effects cause to chemical deteriorations (Perker, 2008; Dışkaya, 2007; Perker and Akıncıtürk 2006). Germs, fungi and insects cause to biological deteriorations. Wrong choice of wood material, use form, maintenance and repair mistakes cause human-sourced deteriorations (Seçkin, 2008). These deteriorations of timber structures can be seen on the carrying system, exterior deterioration, interior deterioration and building components.

The aim of this study is to analyze the existing deteriorations and to identify the woods used in traditional timber structures in Süleymaniye and Zeyrek Districts, in İstanbul. This is also relevant for restoration work to be carried out. Integration of these efforts save our heritage for future generations.

Materials and Methods

The examination of existing traditional timber buildings in Zeyrek and Süleymaniye Districts were realized through direct observations, photographing and also laboratory analysis methods. All buildings in these districts were observed and taken their photographs. The photographs present observations and examples showing deteriorations in these buildings which have been damaged over time.

For laboratory analysis, a total of 380 wood samples have been taken from 30 buildings, which twenty of them were timber and ten of them were masonry buildings. Samples were collected as carefully as possible. The size of the fragments ranged from 5 to 20 mm in length and 3 to 10 mm in width.

These samples consist of the parts of facings, posts, window profiles, laths, ceilings, floor coverings, floor beams, stairs, handrails, skirting boards, exterior and interior doors. Following the sampling, macroscopic and microscopic diagnoses were conducted to finalize the research.

The macroscopic features of wood material are the anatomical and physical features (color, brightness, odor, texture, hardness, etc.) that could be seen with a magnifying glass, a stereomicroscope or naked eye. In this study, macroscopic examination was performed by Olympus SZ60 stereomicroscope.

For microscopic diagnoses, all samples were boiled in water and sections of 10-20 µm (cross, tangential and radial) were cut on a Leica sliding microtome, analyses were done mounting in glycerine-gelatine. After that, sections were studied under Olympus CX31 microscope connected to a Kameram Image Analysis System for anatomical characterization and identification (Figure 2). Descriptions followed the recommendations of the IAWA Committee (2004, 1989). Plant species were identified using wood anatomy textbooks (Porter, 2006; Merev, 1998), atlases (Schweingruber,1990; Jacquiot, 1955) and on-line databases. The identifications were done at the most detailed level achievable, if possible at the species level.

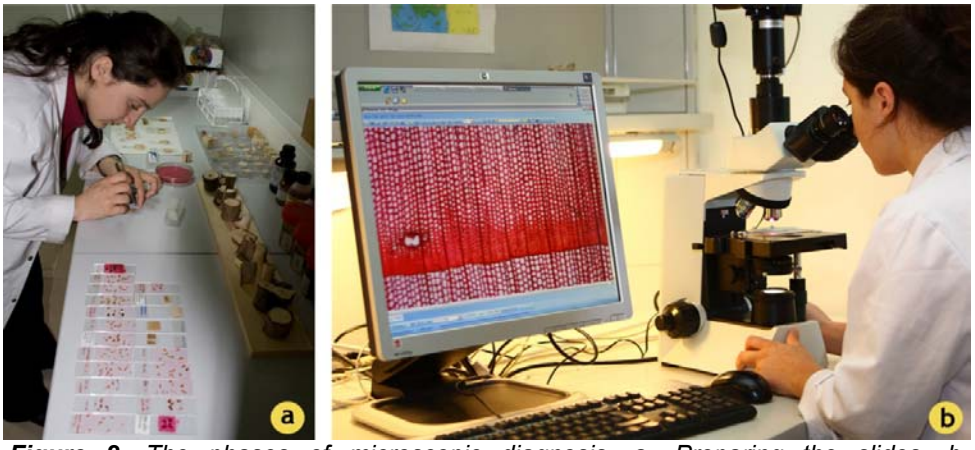

Figure 2. *The phases of microscopic diagnosis. a- Preparing the slides. b- Identification of the sample by microscope.*

Results

Observation results

It is observed that the historical characteristics of traditional timber buildings in Süleymaniye and Zeyrek Districts are being deteriorated, because of the natural reasons such as earthquake, water, humidity, ultraviolet light, frost and wind, fungus and the invasion of insects, and man-made reasons including abandonment, fire, wrong choice of wood materials, fatigued materials, economic insufficiency, air pollution, lack of laws to protect these structures and municipal indifference, defective workmanship and incorrect attempts at restoration. The main structural deteriorations, that are seen on carrier components and their link points such as masonry wall timber structure connections, roofs and eaves, projections and diagonal braces,

posts and beams, and the other building components including facings, laths, windows, doors, stairs, ceilings and floor coverings, as mentioned before, can be classified as physical, chemical, biological and human-sourced.

Understanding of building defects and deterioration are important factors in any conservation work as to minimize the cost of restoration and to protect the buildings from being lost forever. Defects can be satisfactorily repaired only if the causes have been correctly diagnosed.

The observation results can be seen from Table 1 and also from Figures 3-6. The photographs present observations and examples showing the mechanical condition of some existing buildings which have been damaged over time.

Table 1. *Deterioration types of timber building components.*

Building Componets	**Deterioration Types**			
	Physical	**Chemical**	**Biological**	**Human-Sourced**
Facing	Paint blister Color fading	Color change depending on temperature	Swell Breakaway Decay Holes of insects	Abrasion Loss of original details Repair with unqualified material
Posts	-	-	Swell Decay Holes of insects	-
Window profiles	Color fading	-	Decay Holes of insects	Loss of original details Repair with unqualified material
Laths	-	-	Holes of insects	-
Stairs	-	-	Breakaway Holes of insects	Abrasion
Ceilings	-	-	Swell Decay Holes of insects	-
Floor coverings	-	-	Decay Holes of insects	Abrasion
Floor beams	-	-	Decay Holes of insects	-
Entrance doors	Becoming old Color fading	-	Breakaway Decay Holes of insects	Loss of original details
Interior doors	-	-	Breakaway Holes of insects	-
Skirting boards	-	-	Decay Holes of insects	-

Figure 3. *Physical deteriorations. a- Deterioration by humidity effects at the ceiling of a timber house in Süleymaniye. b- Deterioration by atmospheric effects on facade of a timber house in Zeyrek.*

Figure 4. *Chemical deteriorations. a- A timber house damaged by fire in Süleymaniye. b- A timber house damaged by stove in Zeyrek.*

Figure 5. *Biological deteriorations. a- Timber damaged by wood-destroying fungi. Brown rot fungi are the most destructors of historic timber buildings (Kisternaya and Kozlov, 2009). At the final stages of the attack, wood grows brown in color and breaks apart into cube-shaped pieces. b- Timber damaged by wood-destroying insects. Important pests of timber in historical buildings in this region are beetles belong to the family Anobiidae.*

Figure 6. *Human-sourced deteriorations. a- Incorrect attempts at restoration, a house in Zeyrek. b- A house that was abandoned to its fate in Süleymaniye.*

Laboratory results

Thin sections were prepared from the samples taken from the buildings in Süleymaniye and Zeyrek and were viewed under microscope (Figure 7-12). With these samples, species of woods were identified. The results of the microscopic identification of the 380 wood samples are summarized in Table 2.

Table 2. *The wood identification results of the 380 samples.*

Building Components	Wood samples identified					
	Softwood			Hardwood		
	Abies bornmuelleriana	*Picea orientalis*	*Pinus slyvestris*	*Castanea sativa*	*Quercus petraea*	*Tilia tomentosa*
	Distribution of samples in percent					
Facings	15	10	75	-	-	-
Main strut	-	-	5	10	85	-
Queen posts	-	-	90	-	10	-
Laths	65	20	15	-	-	-
Window profiles	6	6	88	-	-	-
Floor coverings	67	20	13	-	-	-
Floor beams	95	-	5	-	-	-
Ceilings	55	45	-	-	-	-
Stairs	66	34	-	-	-	-
Handrails	5	-	5	5	-	85
Exterior doors	5	5	90	-	-	-
Interior doors	33	67	-	-	-	-
Skirting boards	80	-	20	-	-	-

Softwoods

Softwood species were identified from 332 samples and they belong to Abies sp, Picea sp. and Pinus sp. woods.

Abies sp. was identified due to its anatomical characteristics shown in the Figure 7. In addition to these characteristics the distinguishing features, as reported in the literature, on Abies spp. (Esteban et al, 2009; Özdemir, 2004; As et al. 2001) were paid special attention and the samples are identified as Abies bornmuelleriana.

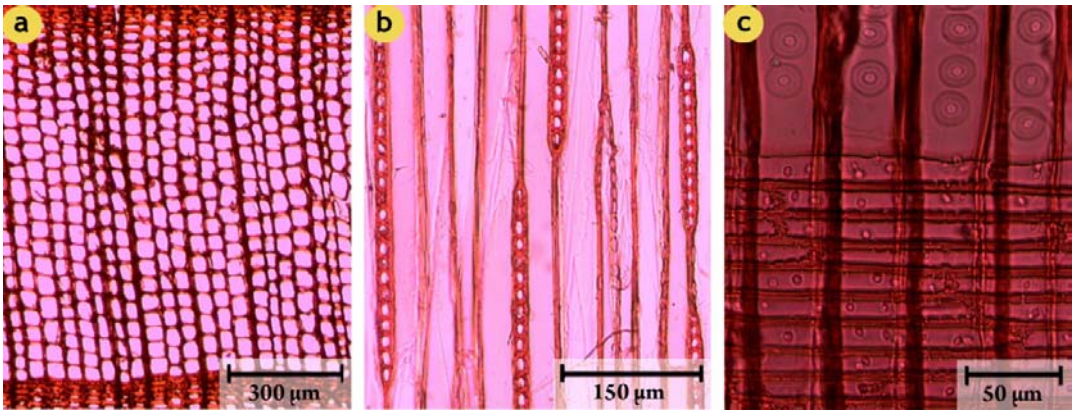

Figure 7. *Abies bornmuelleriana. a- Transverse section: Distinct growth ring boundaries, b- Tangential section: Uniseriate rays, average ray height is 15 to 30 cells. c- Radial section: Homocellular rays, tangential walls of rays distinct nodular chains. cross-field pits taxodioid, usually uniseriate, sometimes biseriate pits in radial tracheid walls. The scale bar for a= 300 µm, for b= 150 µm and for c= 50 µm.*

Picea orientalis was identified due to its anatomical characteristics shown in the Figure 8. Picea orientalis is the only natural species of the genus Picea in Turkey.

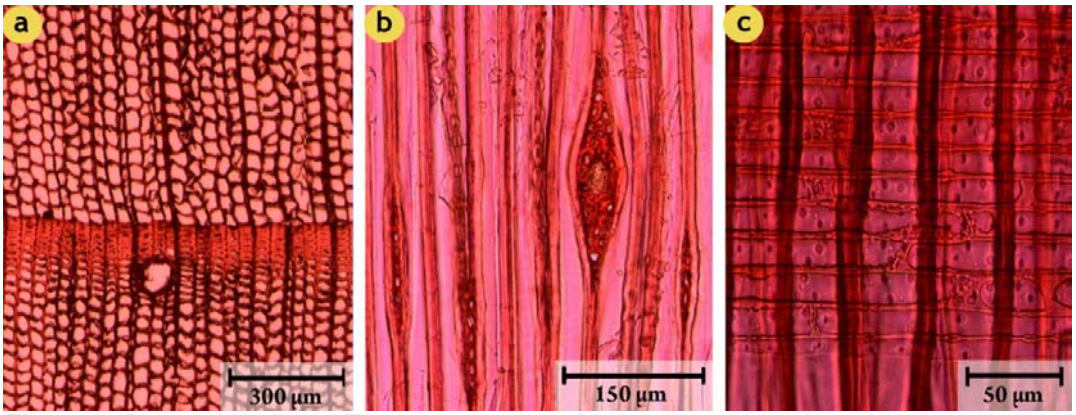

Figure 8. *Picea orientalis. a- Transverse section: Distinct growth ring boundaries, surrounded by thick-walled epithelial cells. b- Tangential section: Rays with resin canals. c- Radial section: Heterocellular uniseriate rays, ray traheids with smooth walls, cross-field pits piceoid, longitudinal tracheids generally with uniseriate, rarely biseriate pits. The scale bar for A= 300 µm, for B= 150 µm and for C= 50 µm.*

Pinus sp. was identified due to its anatomical characteristics shown in the Figure 9. These features belong to both Pinus nigra and Pinus slyvestris. As already known, it is not possible to distinguish between these two species on the basis of their wood anatomy (Schweingruber, 1990). In fact, trees of Pinus slyvestris especially grow in the forests of Black Sea Region (including Uludağ Forests) in Turkey (Pamay, 1992). Therefore, it would seem more prudent to classify these samples as Pinus slyvestris.

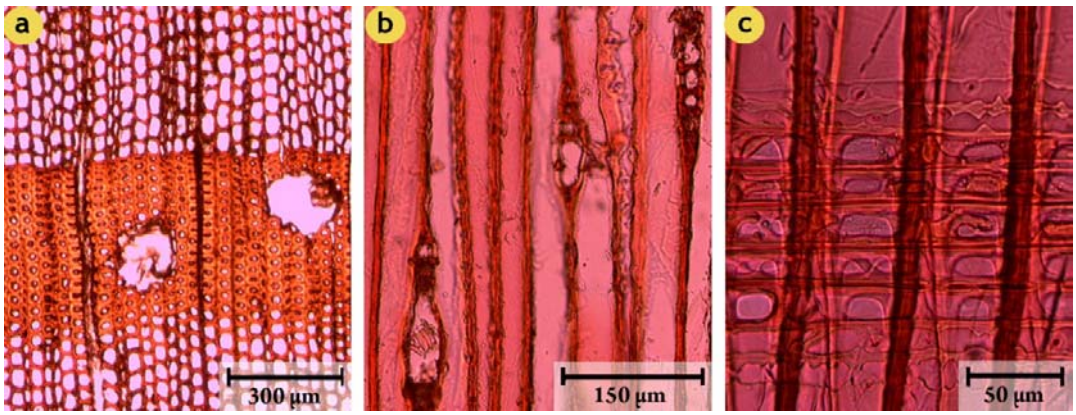

Figure 9. *Pinus slyvestris. a- Transverse section: Distinct growth ring boundaries, large resin canals with thin-walled epithelial cells. b- Tangential section: Rays with resin canals. c- Radial section: Heterocellular rays, ray traheids with dentated walls, cross-fields from parenchyma cells to tracheids with one (rarely two) large fenestriform pits. Tracheid pits almost uniseriate. The scale bar for A= 300 µm, for B= 150 µm and for C= 50 µm.*

Hardwoods

Hardwood species were identified from 48 samples and they belong to Castanea sp., Quercus sp. and Tilia sp. woods.

Castanea sativa was identified due to its anatomical characteristics shown in the Figure 10. Castanea sativa is the only natural species of the genus Castanea in Turkey.

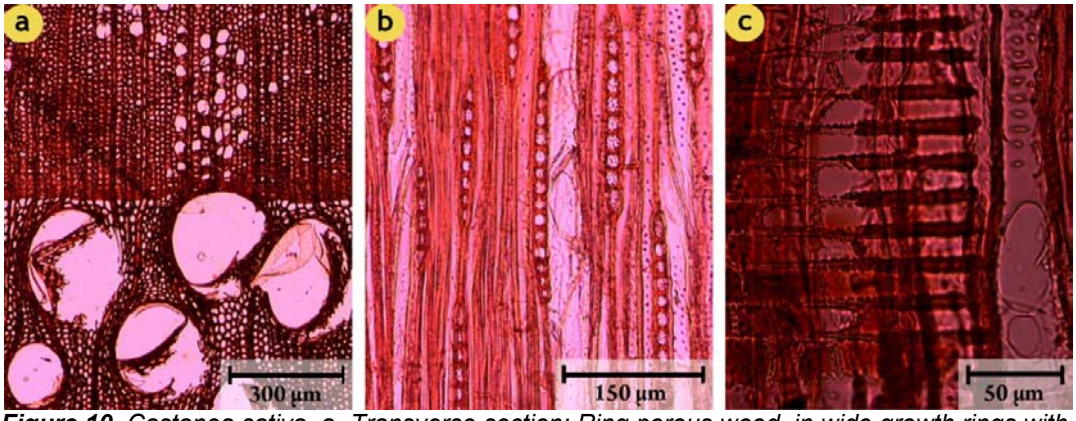

Figure 10. *Castanea sativa. a- Transverse section: Ring porous wood, in wide growth rings with oblique to dendritic orientation, tyloses in earlywood vessels, apotracheal parenchyma diffuse. b- Tangential section: Uniseriate rays. c- Radial section: Rays homogeneous, libriform fibres and vasicentric tracheids, homocellular ray cells procumbent, vasicentric tracheids, apertures of the vessel-ray pits enlarged, round to oval, simple perforation plates. The scale bar for A= 300 µm, for B= 150 µm and for C= 50 µm.*

Quercus sp. was identified due to its anatomical characteristics shown in the Figure 11. They all belong to white oaks group. In addition to this classification, a further study had developed to identify the species of the sample. Due to the microscopic wood characteristics of Quercus spp., which were described by Merev (1998) and Feuillat et al (1997), the samples are identified as Quercus petraea.

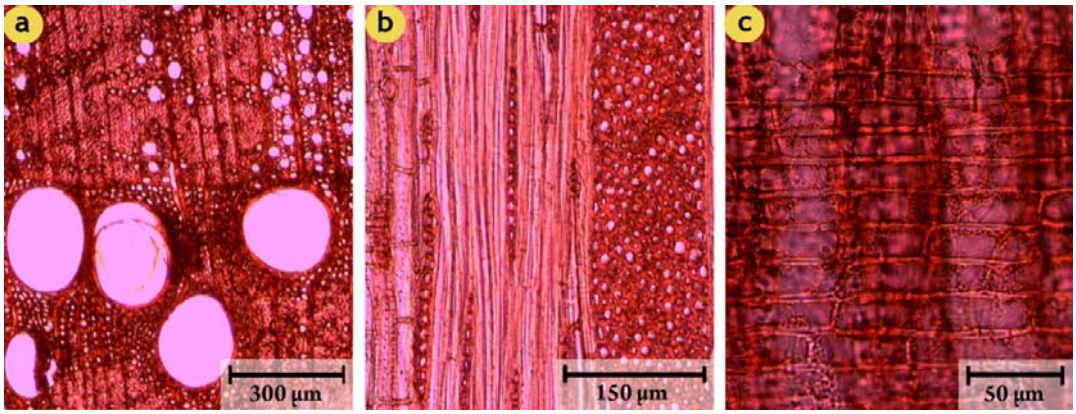

Figure 11. *Quercus petraea. a- Transverse section: Ring porous wood, earlywood ring with one to many rows of pores, more or less compact, latewood pores solitary or in radially orientated to dendritic groups, tyloses in earlywood vessels, apotracheal parenchyma either diffuse or in uniseriate diagonal and tangential bands, frequency variable, broad rays visible to the naked eye. b- Tangential section: Uni- to multiseriate rays, ultiseriate rays up to 1 mm wide. c- Radial section: Rays homogeneous, libriform fibres and vasicentric tracheids, apertures of the vessel-ray pits enlarged, often oval to slit-like, simple perforation plates. The scale bar for A= 300 µm, for B= 150 µm and for C= 50 µm*.

Tilia sp. was identified due to its anatomical characteristics shown in the Figure 12. Turkey has three species of genus Tilia (Tilia tomentosa, Tilia rubra, Tilia platyphyllos) and they all have the same anatomical features. However, the samples could easily be determined as Tilia tomentosa, since Marmara region is the native distribution area of that species.

In fact, all species identified grow in the vicinity of Marmara Region in Turkey.

Discussion

As it is seen from the results (Table 2), Pinus slyvestris has been used mostly at facings, queen posts, window profiles and exterior doors. Abies bornmuelleriana has been used mostly at laths, floor coverings, floor beams, stairs and ceilings. At interior doors, Picea orientalis is the most used material.

Abies bornmuelleriana has low resistance to shock loads and has no insect or decay resistance qualities after logging. Because of these features, Abies wood is considered unsuitable for general timber use, and it is only recommended for indoor use. In accordance with this recommendation, the craftman used it interior construction of the buildings.

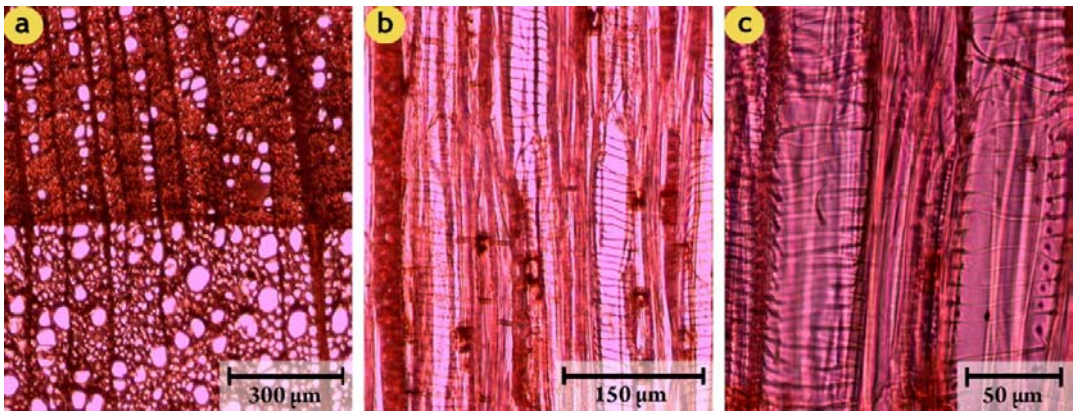

Figure 12. Tilia tomentosa. *a- Transverse section: Diffuse porous wood, pores Often in radially oriented files and groups. Apotracheal parenchyma and generally in short, uniseriate, oblique to tangential bands. b- Tangential section: Rays generally bi- to 4-seriate, very variable height, often up to 10 cells, sometimes up to 50 or more cells. c- Radial section: Generally homogeneous rays, occasionally also with a row of square marginal cells,uniseriate rays generally composed of upright cells, ray-vessel pits numerous and small, vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell. Simple perforation plates, Spiral thickenings Conspicuous in vessels The scale bar for A= 300 µm, for B= 150 µm and for C= 50 µm.*

Picea orientalis has low stiffness, medium crushing and bending strength. It works easily with hand tools, and it is very suitable material for floor coverings, woodworking and interior construction.

Pinus slyvestris has low resistance to shock loads, low stiffness, and low to medium bending and crushing strength. Due to its low stiffness, it works well with hand tools. With this feature, it is a very suitable material for facings, interior joinery, windows, doors and floorings. The wood has satisfactory qualities for painting, varnishing, staining and polishing. Pine can be very durable when painted (Porter, 2006). Therefore, Pinus wood was highly used in the past especially for timber buildings.

Castanea sativa has medium crushing strength, very low stiffness and resistance to shock loads, and good steam-bending properties. It has a high natural resistance to decay (Porter, 2006). The wood is flexible and woodworking, it is effortless. Thin carving fractures can not be avoided when the wood is not adequately moist.

Quercus petraea is a fairly hard, heavy and dense material, with high crushing and bending strength, low stiffness and resistance to shock loads (Porter, 2006). With these properties, it is suitable to use in wood construction.

Tilia tomentosa is easy to work with both hand and machine tools. Because of this, it is valued for carving and quality joinery as it is in the examples of this study.

Woods which could be found easily around the region were preferred for construction, in general. In the historical buildings at both districts, proper material had been mostly used in suitable place. At the present, it is easy to obtain these materials from the domestic market.

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Tarihi Yarımada' da Süleymaniye ve Zeyrek bölgelerindeki geleneksel ahşap yapılar üzerine bir değerlendirme

Bu çalışma Istanbul' un Süleymaniye ve Zeyrek bölgelerindeki 19. yüzyıl geleneksel ahşap yapılarının yapısal ve dekoratif ahşap elemanlarındaki yapısal bozulmaları analiz etmek ve kullanılan ahşap cinslerini teşhis etmek amacıyla yapılmıştır.

Istanbul, Osmanlı İmparatorluğu'nun başkentiydi. Istanbul' un çoğu bölgelerinde olduğu gibi, Süleymaniye ve Zeyrek, eski yaşam tarzının hatırasını ve tarihi yapım tekniklerinin örneklerini taşıyan birçok güzel ahşap yapılara sahiptir.

Dünya Mirası Listesi'nde yer alan bu yapılar, bakımsızlık yüzünden yok olma tehlikesiyle karşı karşıyadır. Pekçoğu restorasyon çalışmalarına muhtaçtır.

Bu yapılarda kullanılmış olan ahşap türleri çeşitlidir. Başlıcaları Pinus slyvestris (Sarıçam), Abies bornmuelleriana (Uludağ göknarı), Picea orientalis (Doğu ladini), Quercus petraea (Sapsız meşe), Tilia tomentosa (Gümüşi ıhlamur) and Castanea sativa (Anadolu kestanesi) ağaçlarının ürünleridir. Kullanılan tüm türler Türkiye'nin Batı Karadeniz bölgesi ormanlarında doğal olarak yetişmektedir.

Çalışma; gözlem, fotoğraflama ve laboratuvar analiz yöntemleriyle gerçekleştirilmiştir. Fotoğraflar, zaman içinde çeşitli nedenlerle zarar gören ahşap yapıların mekanik durumunu belgeleyen gözlem örneklerini göstermektedir.

Laboratuvar analizleri için 10'u kâgir, 20'si ahşap olmak üzere 30 adet yapıdan toplam 380 adet ahşap malzeme örneği alınmıştır. Bu örnekler; cephe kaplaması, taşıyıcı dikme, pencere doğraması, bağdadi çıta, tavan kaplaması, döşeme kaplaması, döşeme kirişi, merdiven basamak kaplaması, merdiven trabzanı, dış ve iç kapı, süpürgelik elemanlarından oluşmuştur. Örnek alımının ardından, örneklerin makroskobik ve mikroskobik teşhisleri yapılmıştır.

İnceleme bölgelerindeki yapıların tahrip olmasındaki ana nedenler; fiziksel, kimyasal, biyolojik ve insan kaynaklıdır. Bu yapılar sözkonusu nedenlerin etkisiyle çeşitli zararlara uğrayarak giderek yıpranmış ve yok olmaya yüz tutmuştur. Tarihsel, kültürel, mimari ve yapısal olarak büyük değerler taşıyan bu yapıların korunması ve gelecek kuşaklara taşınması restorasyon çalışmalarının bilinçli yapılmasına bağlıdır.

Bu çalışma, inceleme bölgelerindeki, Dünya Mirası Listesi'nde yer alıp pekçoğu yoğun ölçüde tahrip olmuş bulunan önemli sivil mimari örneklerinden tescilli tarihi yapıların ahşap yapı elemanlarının halihazır durumları ile zarar görme şekillerinin ve ahşap malzeme ağaç cinslerinin belirlenmesi ve elde edilen özgün bulguların yapılacak restorasyon çalışmalarına ışık tutması ve bu yapıların gelecek kuşaklar için korunması ümidi ve amacıyla yapılmıştır.