



## Mechanical Properties of Wood Members in Santa Maria Church

Engin Derya GEZER\* Cenk DEMİRKİR Turgay ÖZDEMİR  
Karadeniz Technical University, Faculty of Forestry, Forest Industry Engineering, Trabzon, Turkey

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\* [id](https://orcid.org/0000-0001-9657-7290): <https://orcid.org/0000-0001-9657-7290>  
[id](https://orcid.org/0000-0003-2503-8470): <https://orcid.org/0000-0003-2503-8470>  
[id](https://orcid.org/0000-0002-2484-828X): <https://orcid.org/0000-0002-2484-828X>

**\*Corresponding author's:**

Engin Derya GEZER  
Karadeniz Technical University, Department  
of Forest Industry Engineering  
61080 Trabzon, Turkey.  
✉: [engin\\_gezer@yahoo.com](mailto:engin_gezer@yahoo.com)  
Mobile telephone: +90 (539) 365 34 10  
Telephone : +90 (462) 377 15 32  
Fax : +90 (462) 325 74 99

**Abstract:** Wood is one of the oldest building materials used on earth. Wood as a building material; it has been evaluated in different ways according to the socio-economic, cultural and natural resource structures of the countries. In addition, wood is a building material used in the construction of places of worship such as mosques and churches according to the belief structures of the societies. Our country, which has a deep-rooted culture and history, is also rich with its places of worship, houses, architecture and use of houses. It is possible to come across some of these building examples in the black sea region. One of them is the Santa Maria church, which was built between 1869-1874 in the Merkez Kemer kaya district in Trabzon, and is a religious center where foreigners who visit the city still worship. The aim of this study is to evaluate the performance of the wooden materials of the church of Santa Maria by testing them non-destructive test methods. In this way, it was aimed to determine the current bearing properties without damaging the structural materials in a wooden structure built in our country and surviving for many years. For this purpose, the damage, defects and resistance properties of the building's bearing elements were tried to be determined with non-destructive test devices. The results obtained were compared with the values specified in the EN 338 standard. It was determined that most of the wooden elements in the structure still maintained their load-bearing properties and provide the minimum mechanical resistance properties specified in the standards.

**Keywords:** Non-destructive tests, historical wooden structures, santa maria church, deterioration and decay.

## Santa Maria Kilisesindeki Ahşap Taşıyıcıların Mekanik Özellikleri

**Öz:** Ahşap, yeryüzünde kullanılan en eski yapı malzemelerinden biridir. Yapı malzemesi olarak ahşap; Ülkelerin sosyo-ekonomik, kültürel ve doğal kaynak yapılarına göre farklı şekillerde değerlendirilmiştir. Ayrıca ahşap, cemaatlerin inanç yapılarına göre cami ve kilise gibi ibadethanelerin yapımında kullanılan bir yapı malzemesidir. Köklü bir kültüre ve tarihe sahip olan ülkemiz ibadethaneleri, evleri, mimarisi ve ev kullanımıyla da zengindir. Bu yapı örneklerinden bazılarında Karadeniz Bölgesinde rastlamak mümkündür. Bunlardan biri, Trabzon'un Merkez Kemer kaya Mahallesi'nde 1869-1874 yılları arasında inşa edilen ve şehri ziyaret eden yabancıların hala ibadet ettikleri bir dini merkez olan Santa Maria Kilisesidir. Bu çalışmanın amacı, Santa Maria Kilisesi'nin ahşap malzemelerinin performansını, hasarsız test yöntemleriyle test ederek değerlendirmektir. Bu sayede ülkemizde yapılan ve uzun yıllar ayakta kalan ahşap bir yapıda yapı malzemelerine zarar vermeden mevcut taşıyıcı özelliklerin belirlenmesi hedeflenmektedir. Bu amaçla binanın taşıyıcı elemanlarının hasar, kusur ve dayanım özellikleri hasarsız test cihazları ile belirlenmeye çalışılmıştır. Elde edilen sonuçlar EN 338 standardında belirtilen değerlerle karşılaştırılmıştır. Söz konusu yapıdaki ahşap elemanların birçoğunun halen taşıyıcı özelliklerini koruduğu tespit edilmiştir.

**Anahtar kelimeler:** Tahribatsız testler, tarihi ahşap yapılar, santa maria kilisesi, tahribat ve çürüklük.

**\*Sorumlu yazarın:**

Engin Derya GEZER  
Karadeniz Teknik Üniversitesi, Orman  
Endüstri Mühendisliği Bölümü,  
61080 Trabzon, Türkiye.  
✉: [engin\\_gezer@yahoo.com](mailto:engin_gezer@yahoo.com)  
Cep telefonu : +90 (539) 365 34 10  
Telefon : +90 (462) 377 15 32  
Faks : +90 (462) 325 74 99

## INTRODUCTION

Wood is one of the oldest building materials used on earth. Wood as a building material; It has been evaluated in different ways according to the socio-economic, cultural and natural resource structures of the countries. In addition, wood is a building material used in the construction of places of worship such as mosques and churches according to the belief structures of the societies. Our country, which has a deep-rooted culture and history, is also rich with its places of worship, houses, architecture and use of houses. It is possible to come across some of these building examples in the Black Sea Region. One of them is the Santa Maria Church, which was built between 1869-1874 in the Merkez Kemerkeya District in Trabzon, and is a religious center where foreigners who visit the city still worship.

The aim of this study was to determine the defects and damages in Santa Maria Church through non-destructive methods such as drilling resistance, screw holding, shear and elasticity modulus and to develop appropriate protection techniques that can contribute to the solution of the problems encountered.

## MATERIALS AND METHODS

In this study, Santa Maria Church (Figure 1) which is about 150 years old was studied. The damage and defects in the Santa Maria Church were determined by non-destructive test devices including Resistograph and FAKOPP Screw withdrawal resistance meter. In addition, screw holding, shear and elasticity modulus of the wooden beams in the structure were determined.



Figure 1. Santa Maria Church.

**Resistograph:** The IML-RESI F-300 instrument is used to determine the internal decay and defects in wooden structures, poles and beams. Possible defects are usually found in the interior of the wooden structures and can't be observed from the outside. The IML-RESI System is based on a drilling resistance measuring method. The variation in resistance results in increases and decreases in

the amount of torque applied to the drill shaft. A drilling needle with a diameter of 1.5 mm to 3.0 mm penetrates into the wooden structure with a regular advance speed, and the drilling resistance is measured. The data is recorded on a wax paper strip at a scale of 1:1 and also transferred to computer for further evaluation. The wood is only insignificantly injured, and the drilling hole closes itself due to a special drilling angle that was customized for the drill bit (Gezer et al., 2015).

**Screw withdrawal resistance meter:** The beams in Santa Maria Church were tested using screw withdrawal resistance meter (Figure 2). Screw withdrawal force is an indicator of the wood material strength, density and shear modulus. Fakopp Enterprise developed a portable screw withdrawal force meter. The applied screw diameter is 4mm, the length of the thread is 18 mm. The screw withdrawal force is a local parameter but selecting a representative location on a beam it is a useful information in wooden structure evaluation (Fakopp Enterprise, 2010).

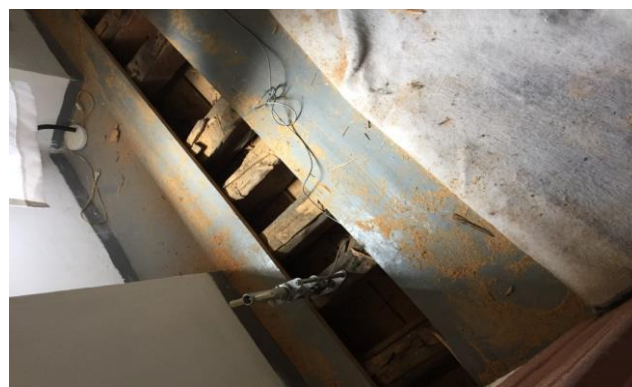


Figure 2. The beams in Santa Maria Church were tested using screw withdrawal resistance meter.

## RESULTS AND DISCUSSION

**Resistograph:** The wooden beams in 15 rooms of the Santa Maria Church were evaluated by Resistograph in order to determine the internal defects and deteriorations (Figure 3). Some of the Resistograph outputs obtained are given in Figure 4. As shown in the outputs, the higher peaks show the solid zone whereas the lower peaks indicate the decay, cracks, splits or deteriorated zones. The explanation of the Resistograph outputs was given on the outputs for each beam tested.

The results showed that beams in (Figure 4a) had partial damage, rot, cracks/voids in the interior. Rot/insect damage and the onset of rot were detected in the inner parts of the beam examined. As shown in the shaded area in (Figure 4b), intensive internal cracks with rot insect damage were detected in the inner parts of the beam. The obtained results from Resistograph testing verified the visual inspection observation. As a result of the

investigations carried out with the Resistograph device, it was determined that some of the beams had partial damage, while some of them had severe damage/cracks/decay. However, some of the beams recommended to be changed as a result of the findings obtained from both visual inspections and examinations made with non-destructive test devices.

**Screw withdrawal resistance results:** The wooden beams in 15 rooms of the Santa Maria Church were evaluated by Screw withdrawal resistance meter in order to determine screw withdrawal resistance, modulus of rupture (MOR) and shear resistance. Screw withdrawal resistance, MOR and shear resistance of the beams are given in Table 1.



Figure 3. Evaluation of the beams by Resistograph.

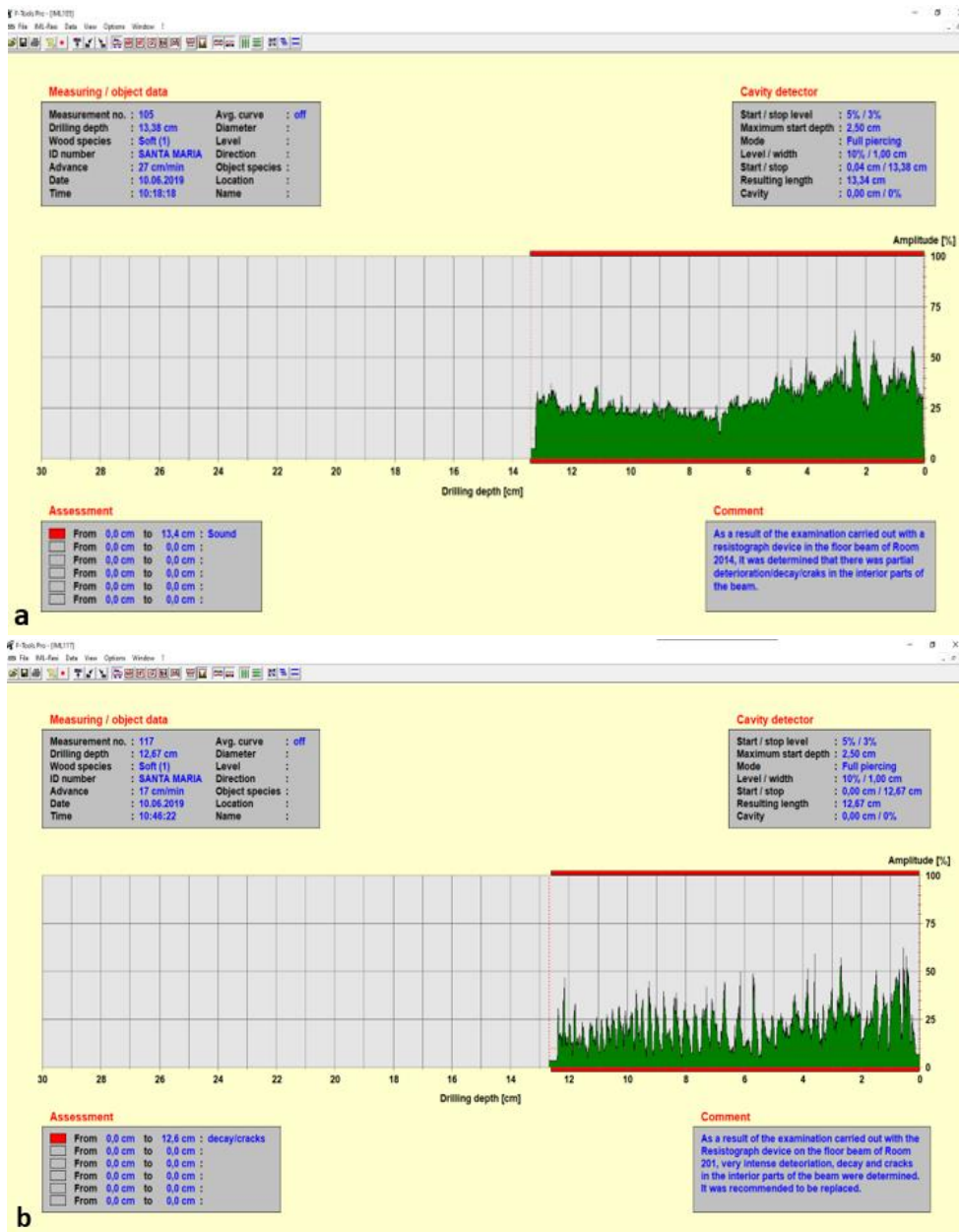


Figure 4. Some Resistograph output of the beam.

Screw withdrawal resistance values of the beams in the wooden structures examined in this study were ranged from 1.18 to 2.18 kN. According to the results, it was found that the beams in the room 103 and 113 had the highest shear resistance, MOR and screw withdrawal resistance. The lowest results were obtained from the beams in rooms located in the second floor of the church where the water pipeline was broken and beams got soaked with water.

**Table 1.** Screw withdrawal resistance meter results.

Room no	Screw withd. res. kN	MOR MPa	Shear resistance MPa
102	1,84	61	622
102	1,80	60	613
103	2,08	70	676
103	1,62	54	574
104	1,94	65	644
105	1,98	66	653
105	1,37	45	516
105	1,46	48	536
106	1,25	41	490
106	1,43	48	531
111	1,67	56	584
111	1,73	58	597
111	1,90	63	635
112	1,64	54	576
112	2,07	69	673
112	2,06	69	670
113	2,18	73	698
113	1,74	58	601
201	2,01	67	661
201	1,85	62	624
202	1,65	55	580
203	1,23	41	485
203	1,39	46	521
204	1,29	43	498
204	1,68	56	587
204	1,55	52	558
205	1,38	46	519
205	1,61	54	571
210	1,18	39	475
210	1,74	58	600
213	1,57	52	561
214	1,51	50	549

The screw withdrawal resistance, bending and shear strengths of the beams were calculated thanks to the data obtained with the non-destructive test device and it was determined that the strength properties of the beams had the lowest resistance properties in this structure in the resistance classes specified in the EN 338 standard. Although these beams still had enough strength properties, it might be recommended to replace them considering the fatigue resistance due to the service life.

## CONCLUSION

1. As a result of the investigations carried out with the Resistograph device, it was determined that some

of the beams had partial damage, while some of them had severe damage/cracks/decay.

2. Generally, the mechanical strength properties of the beams examined fell into D35 and D70 classes according to EN 338 standard and it is still possible to use them. However, some of the beams recommended to be changed as a result of the findings obtained from both visual inspections and examinations made with nondestructive test device.

3. The screw withdrawal resistance, bending and shear strengths of the beams were calculated thanks to the data obtained with the nondestructive test device and it was determined that the strength properties of the beams in rooms 106, 203 and 204 had the lowest resistance properties in this structure in the resistance classes specified in the EN 338 standard. Although these beams still had enough strength properties, it might be recommended to replace them considering the fatigue resistance due to the service life.

4. Decay and insect damage were detected on some of the wooden elements in the attic.

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