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EVALUATION OF TWO DIFFERENT WOOD TYPES IN TERMS OF DURABILITY AND TREATABILITY

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Keywords

Wood,
Bangkirai,
Iroko,
Durability,
Treatability.

Abstract

The selection of an appropriate wood type as a structural material mainly depends on the environmental conditions of a region, such as humidity and temperature. Besides, the availability of the material with a reasonable cost is another concern in the selection. In this study, replaceability of "bangkirai" type of wood with "iroko" type of wood is investigated in terms of durability and treatability. The need for this study is aroused from the lack of "bangkirai" wood to satisfy the necessary conditions aforementioned above in the construction of visitor's platform of Göbeklitepe Roof Canopy Structure. Göbeklitepe, which is known as the world's first temple, is located in 18 km distance to the city of Şanlıurfa, Turkey. A visitor's platform is planned to be built on this area in order to present the findings, the archaeological remains and the architecture to the society. The plank flooring material used on various parts of the visitor's platform of this roof canopy structure is specified as "bangkirai" type of wood in the technical specification of the project. This study aims to reveal if it is convenient and suitable to use "iroko" type of wood instead of "bangkirai" type of wood on the related parts of platform.

İKİ FARKLI AHŞAP TÜRÜNÜN DURABİLİTE VE EMPRENYE EDİLEBİLİRLİK AÇISINDAN DEĞERLENDİRİLMESİ

Anahtar Kelimeler

Ahşap,
Bangkirai,
İroko,
Durabilite,
Emprenye Edilebilirlik.

Öz

Yapısal malzeme olarak uygun bir ahşap türünün seçimi, öncelikle nem ve sıcaklık gibi bölgenin çevresel koşullarına bağlıdır. Bunun yanında, malzemenin ekonomik olarak bulunabilirliği de seçimi etkileyen bir diğer etmendir. Bu çalışmada, "iroko" türü bir ahşabın, "bangkirai" türü bir ahşap yerine kullanılıp kullanılamayacağı, durabilite ve emprenye edilebilirlik açısından irdelenmiştir. Bu çalışmaya, Göbeklitepe'de bulunan çatı kanopi yapısının ziyaretçi platformu kısmında kullanılan "bangkirai" ahşabının yukarıda bahsedilen şartları sağlama zorlukları bulunduğundan dolayı ihtiyaç duyulmuştur. Dünya'da en eski tapınağın keşfedildiği Göbeklitepe, Türkiye'nin Şanlıurfa şehrine 18 km mesafede bulunmaktadır. Bu bölgede, açığa çıkarılan bulguları, arkeolojik kalıntıları ve mimariyi topluma sunabilmek amacıyla bir ziyaretçi platformunun inşası planlanmıştır. Söz konusu çatı kanopi yapısında ziyaretçi platformunun çeşitli bölümlerinde kullanılan ahşap döşeme malzemesi, proje teknik şartnamesinde "bangkirai" türü ahşap olarak belirlenmiştir. Bu çalışma, platformun ilgili bölümlerinde "bangkirai" türünde ahşap malzeme yerine "iroko" türünde ahşabın kullanılmasının uygun olup olmadığının ortaya konmasını amaçlamaktadır.

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1. Introduction

The archaeological site of Göbeklitepe has listed in the “World Heritage List of the UNESCO” in 2018 (WHC, 2018). The location lies near the Orencik village in the north-east of the Şanlıurfa Province, Turkey (Fig. 1). The findings were first discovered by a survey of Chicago and Istanbul Universities in 1963. Current excavations started by Prof. Schmidt Klaus are ongoing since 1995 and collaborated by various researchers. The site has a history, which roots back to twelve thousand years. From its first discovery to the present time, archaeologists are enlightening civilised human history with developments and research in this area. It is believed by the researches that, many artefacts are waiting to be unearthed and discovered in this region (Peters et al., 2014). A roofing project with a canopy structure has been planned to protect the findings from the ultraviolet effects of the sun and to provide a platform for visitors on the archaeological site. The plank flooring material used on this platform is designed with “bangkirai” type of wood (Technical-Specification, 2017). However, the selection of this wood type is costly and questionable, considering the environmental conditions of the related region. Besides this, the “iroko” type of wood is a cheaper material which is known for its suitability for land conditions in the Turkish market. The equivalence and the replaceability of these types of wood species are evaluated in terms of “durability and treatability concepts” considering the environmental conditions which the related project will be applied.

Figure 1. Location of the region (Google Maps, 2018)

2. Literature Survey

The literature on this topic shows that there are similar studies done for different wood types considering environmental conditions, mechanical properties and the economic benefits where some of them include a comparison regarding “durability and treatability” concepts (Ali et al., 2011; Dourado et al., 2008; Palanti et al., 2015; Hagedorn et al., 2003 and Verma et al. 2014). These studies use the data collected from laboratory test results, different analysis methods and in-situ dependent observatory methods to compare the aforementioned properties of various wood types. The purpose of the study by Ali et al. (2011) is to assess the natural durability of five different wood types (muanga, metil, namuno, ncurri and ntholo) using laboratory and field test methods. Soft-, brown-, and white-rot fungi and termites are used in the laboratory tests. They concluded that “muanga”, “ncurri” and “ntholo” species are resistant to soft-, brown- and white-rot fungi and the termites. The soft rot fungi did the most harm on these species among the hazardous organisms used in the tests. It is also concluded that “metil" type of wood is not resistant to these hazards. Thus, the authors do not recommend these wood types for exterior use if untreated (Ali et al., 2011). Dourado et al. (2008) compared the fracture strength of the two wood types (maritime pine and Norwat spruce) used in the timber construction through three-point bending tests. Load-displacement curves are experimentally and analytically obtained by finite element analysis. The energy released by the crack propagation of these types are assessed, and strength comparison is made by assessing the cracks and fracture process zone (Dourado et al., 2008).

The purpose of another study by Palanti et al. (2015) is to evaluate the natural durability of different wood species against marine organisms in the Messina Strait. The aim is to determine the most durable wood type among the four tropical wood species for the replacement of wooden docks. The tested wood species are Bilinga/Opepe (Nauclea diderrichii Merril), Okan (Cylicodiscus gabunensis Taub (Harms), Demerara Greenheart (Ocota rodiaei Mez) and Azobé (Lophira alata Banks ex Gaertn), which are also currently used wood species for docks (EN-275, 1992). Combined with software for image acquisition called Nis D3.22, is used in the assessment. It is concluded from the experiment results that Bilinga and Okan can well replace the current utilisation of Azobé for wooden banking in the Sicilian Strait. The used software captured slight differences which cannot be perceived by the human eye in the assessment described in EN-275 (1992). The authors stated that the achieved differences, which did not appear in visual assessment connected with the wide nominal durability classes of EN-275 (1992) might affect the choice of wood species that are not convenient for their purpose. As a result, from an economic perspective, improving the assessment by image analysis can be significant (Palanti et al., 2015). Hagedorn et al. (2003) conducted a comparative study on the pyrolysis of three different wood species. It is concluded that inorganic salts have a strong influence on the temperature of pyrolysis and also on the product distribution. The authors stated that the differences in wood species are mainly due to the different thermochemical behaviour of lignin degradation and the first step of hemicellulose degradation. The paper by Verma et al. (2014) presents a study for the mechanical properties of bamboo to explore the possibility of its' usage as structural material instead of wood. Mechanical properties of bamboo laminae and their laminated bamboo epoxy composites were assessed under different loading conditions. It is concluded by the comparisons with woods that the average strength of bamboo laminae under different loading conditions is better than softwoods and comparable with hardwoods. The results show that bamboo can be used for fabrication of bamboo epoxy composites and bamboo epoxy composites can alternatively be used instead of wood and wood-based composites for structural purposes (Verma et al., 2014).

This study also presents a comparison between another type of wood species ‘‘bangkirai’’ and ‘‘iroko’’ with similar concepts based on the data provided in commonly used regulations. Similarly, with the papers aforementioned in this chapter, environmental conditions, mechanical properties and economic benefits are taken into consideration while assessing the replaceability of these species used on a real case. Furthermore, it is believed by the authors that experimental studies and field tests as presented in these papers will be worthwhile to verify and validate the conclusion about these two wood types as future work.

3. Environmental Conditions of the Location

Şanlıurfa Province has a mild, warm and temperate climate in general. The rain falls mostly in the winter, rarely in the summer in this region. The climate of this region can be classified as “Csa (Temperate-Dry Summer-Hot Summer)” according to the Köppen-Geiger climate classification system (Köppen, 1936; Geiger, 1954). The average temperature of the region is 18°C, and average rainfall is 477 mm. The climograph of the location is given in Fig. 2.

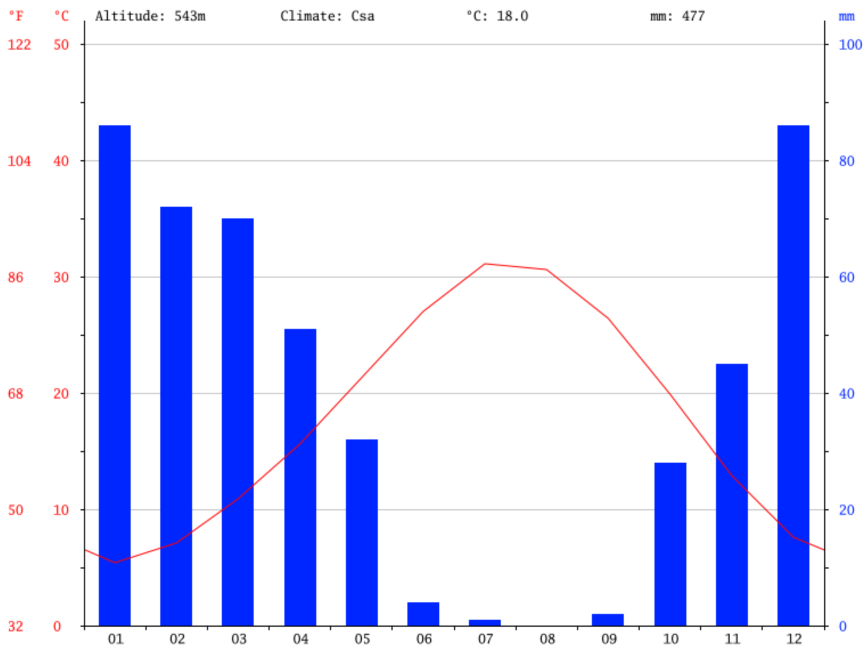

Figure 2. The climograph of Sanliurfa Province (Climate-Data, 2018).

The lowest precipitation level is measured in August according to this data. The peak level of the precipitation is reached in January with an average of 86 mm. The temperature graph of the location is given in Fig. 3.

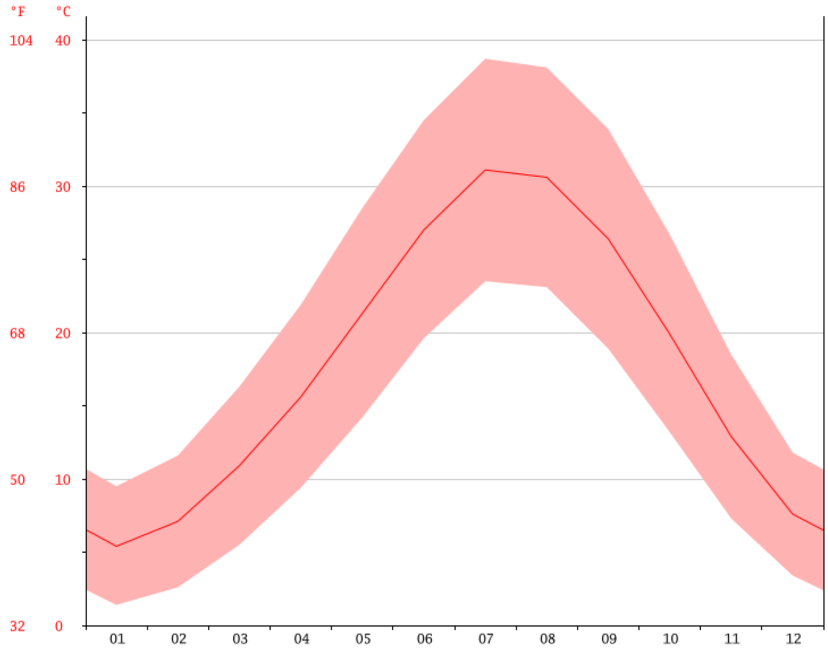

Figure 3. The temperature graph of Sanliurfa Province (Climate-Data, 2018).

The hottest month of the year is recorded as July with an average temperature of 31.1°C. The coldest month of the year is recorded as January with an average temperature of 5.4°C. The historical weather data of the location is given in Fig. 4.

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	5.4	7.1	10.9	15.6	21.3	27	31.1	30.6	26.4	19.9	12.9	7.6
Min. Temperature (°C)	1.4	2.6	5.5	9.4	14.2	19.6	23.5	23.1	18.9	13.2	7.3	3.4
Max. Temperature (°C)	9.5	11.6	16.3	21.9	28.5	34.5	38.7	38.1	33.9	26.7	18.5	11.8
Avg. Temperature (°F)	41.7	44.8	51.6	60.1	70.3	80.6	88.0	87.1	79.5	67.8	55.2	45.7
Min. Temperature (°F)	34.5	36.7	41.9	48.9	57.6	67.3	74.3	73.6	66.0	55.8	45.1	38.1
Max. Temperature (°F)	49.1	52.9	61.3	71.4	83.3	94.1	101.7	100.6	93.0	80.1	65.3	53.2
Precipitation / Rainfall (mm)	86	72	70	51	32	4	1	0	2	28	45	86

Figure 4. The historical weather data of Sanliurfa Province (Climate-Data, 2018).

The difference in precipitation is 86 mm between the wettest and driest months at this location. The annual temperature varies around 25.7°C according to this data. Wood materials are widely used on the outer parts of structures and can easily be affected by the environmental effects. The selection of appropriate wood material at the plank flooring for visitor's platform should be sufficient in terms of durability concerning these environmental conditions.

4. Description of the Roof Structure

The architectural and the structural design of the roof structure is carried out by "kleyer koblitz letzel freivogel gesellschaft von Architekten mbh" and "EiSat GmbH", respectively. The structure has an elliptical shape which consists of axes of the cable network, axes of membrane welds and rainwater drain pipe formations. Membrane welds' grid spacing varies between 1.82 m. and 3.00 m. Cable network grid spacing varies between 3.00 m. and 3.35 m. The structure has an irregular form which can be defined as concave inwards and outwards shell (crust) shape. The longitudinal cross-section consists of geometrical information about the axes representing main structural gridlines and elevations. The axes are generally having a spacing of 3.00 m. The elevation differs from +766.00 to +790.00 m. Fig. 5 and Fig. 6 shows the top view and the longitudinal cross-section drawings of the structure.

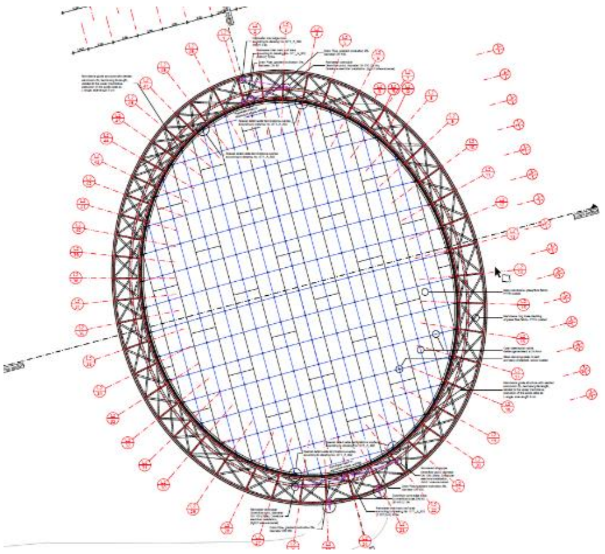

Figure 5. Top view of the roof structure (Arge, 2014).

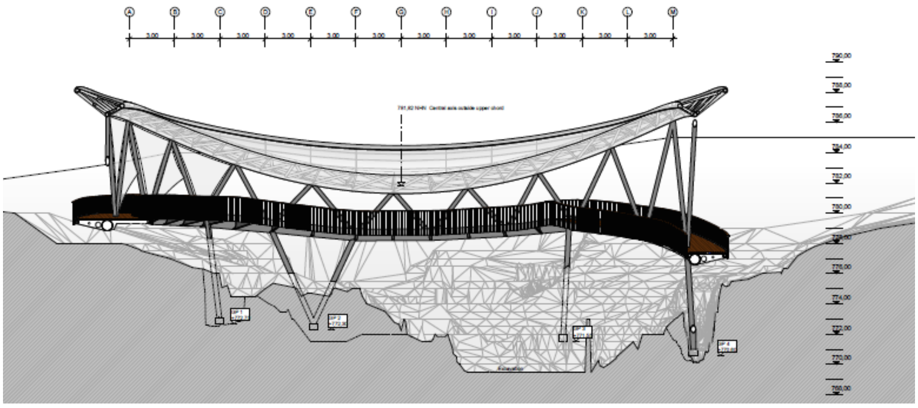

Figure 6. Longitudinal cross-section of the roof structure (Arge, 2014).

The visitor's platform of the structure has an elliptical shape with the dimensions of 43.5 m and 51.5 m in orthogonal directions. The plan of the visitor's platform consists of the formation of plank flooring and wooden handrails, the slope, and locations of the rainwater and the drainage pipes and the boundaries of weather protection screens. It is noted that wooden parts of the visitor's platform are planned to be built with "bangkirai" wood. The primary material of the weather protection screen is glass fiber fabric. Fig. 7 shows the plan of the visitor's platform and the details of weather protection screen.

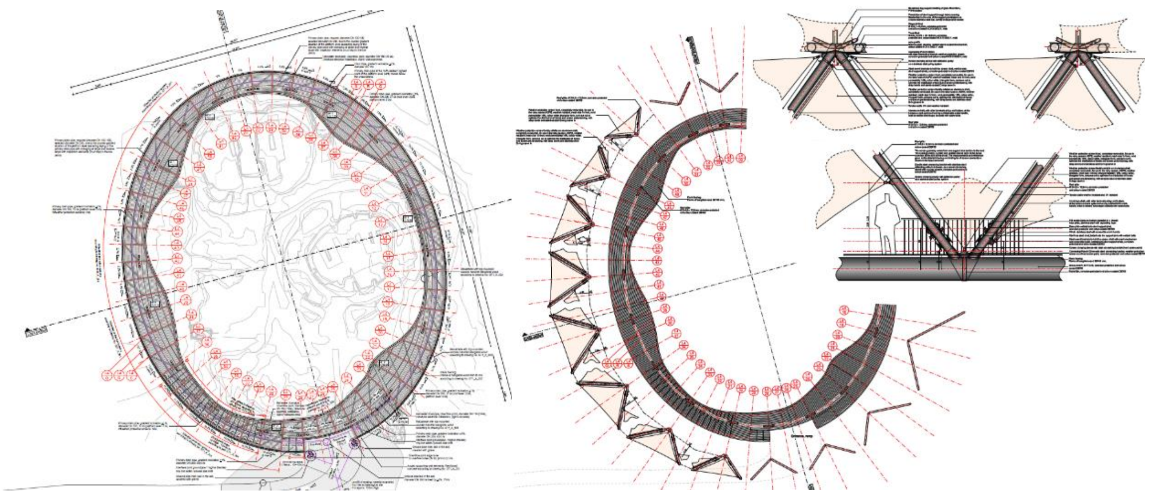

Figure 7. The plan of the visitor's platform and the details of the weather protection screen (Arge, 2014).

The width of the platform varies between 2 m and 4 m. The height of the handrails is 1.50 m. UPE120 and UPE140 profiles are used as supports for planks. Ø 711 mm profiles are used as main girders, and 244.5/10 mm profiles are used as edge beams. Diagonal braces are as QRO 120/8 mm profiles. Wooden parts of the handrails are formed with 14x4 mm sections. Handrails are placed with a spacing of 0.132 m. Planks of "bangkirai" wood 30/145 mm sections are used as plank flooring. It is noted that; planks are grooved from the top and corrugated from the bottom. The spacing of 10 and 20 mm is left between the planks in transverse and longitudinal directions, respectively. The longitudinal sides of planks are grooved with springs made of curved aluminium sections in order to drain the rainwater. The total length of a plank is given as around 2.70 m having pin support conditions. The planks of "bangkirai" wood with dimensions of 30/124 mm are used as the risers. Where the platform is inclined, the dimensions of these planks are increased to 30/145. Fig. 8 shows the typical details of the visitor's platform.

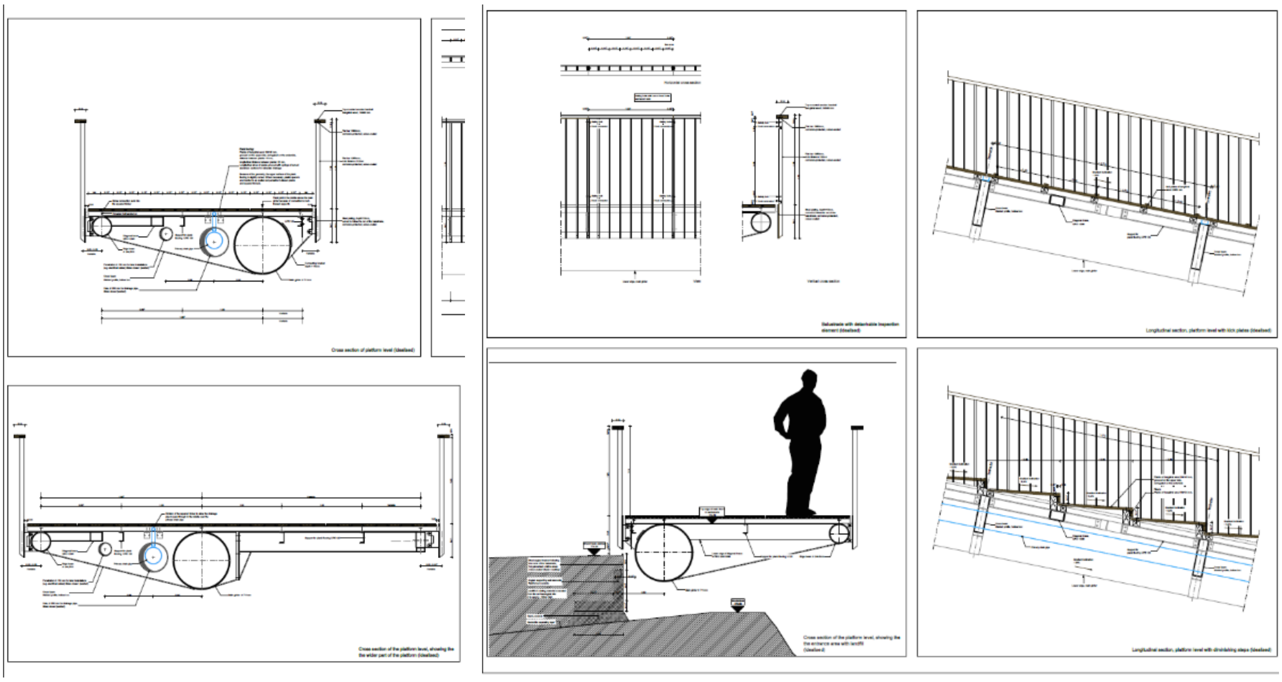

Figure 8. The typical details of the visitor's platform (Arge, 2014).

5. Investigation of Standards

Mainly three different standards, namely EN-350 (2016), EN-335 (2013) and EN-460 (1994) are investigated to evaluate the wood types used on the visitor's platform of the structure. Some concepts related to these standards are given under this chapter.

5.1. EN-350 (2016)

This standard gives guidance on methods for determining and classifying the durability of wood and wood-based materials against biological wood-destroying agents. The methods can be applied either to individual wood species, batches of wood and processed wood-based materials, including heat-treated, preservative-treated wood and modified wood. However, this standard is not intended to replace testing of the efficacy of biocides. The wood-destroying agents considered in this standard are; wood-decay fungi (basidiomycete and soft-rot fungi), beetles capable of attacking dry wood, termites, marine organisms capable of attacking wood in service. Data on the biological durability of selected wood species considered of economic importance in European countries are presented in Annex B (informative), which also provides information relating to their geographical origin, density, sapwood width and treatability.

5.2. EN-335 (2013)

This standard gives general definitions of use classes for different service situations and is relevant to solid wood and wood-based products and gives information on the biological agents that can attack wood and wood-based products in defined situations. The differences between the use classes mentioned in the standard are based on differences in environmental exposures that can make the wood or wood-based products susceptible to biological deterioration. EN 1995-1-1 (2004) defines a set of three service classes which are relevant to a designer when assigning strength values and calculating deformations for timber elements to be used in construction. These service classes are determined by the wood moisture content corresponding to the humidity and temperature, which are expected to prevail in service. The wood moisture content is also an essential factor in biological durability, but the system of service classes in EN 1995-1-1 (2004) and the system of use classes in this standard differ in their considerations of the effects of this moisture, and individual classes do not directly align with one another. Table 1 gives guidance on the possible corresponding use classes for each of the service classes. Service class definitions in EN 1995-1-1 (2004) and use class definitions in this standard should be consulted to ensure correct classification. The attention of users is drawn to the need to avoid misinterpretation of any numbering system using classes for timber that cannot correspond precisely to the European use classes defined in EN 335 (2013). Specifiers need to work with both systems when designing load-bearing structures.

Table 1. Service classes and their possible corresponding use classes (EN-335, 2013).

SERVICE CLASS ACCORDING TO EN 1995-1-1	POSSIBLE CORRESPONDING USE CLASS ACCORDING TO EN 335:2012
1	Use class 1
2	Use class 1 Use class 2 if the component is in a situation where it could be subjected to occasional wetting caused by e.g. condensation
3	Use class 2 Use class 3 or higher if used externally

If the use class or intended use conditions of a component cannot be accurately determined, or when different parts of the same component are deemed to be in different use classes, decisions should be taken concerning the more severe of the possible use classes. In situations where wood components out of ground contact may permanently accumulate water due to their design, or where deposits of dirt, soil, leaves etc. for a more extended period can be expected, it may be necessary to consider that these situations are equivalent to contact with the ground or fresh water. In interior use situations where high wetting conditions are to be expected, it may be necessary to assign a more severe use class.

5.3. EN-460 (1994)

This Standard gives guidance on the selection of wood species based on their natural durability to attack by wood-destroying organisms for use as solid wood or as glued laminated timber (glulam) in the hazard classes defined in EN 335-1 (2013). This standard does not consider the durability characteristics of the glue used in glued laminated timber. The natural durability of a wood species should be considered separately for each wood-destroying organism. In practice supplies of sawn timber may include sapwood as well as heartwood. If the proportion of sapwood present is such that its loss would have adverse implications for the performance of the component, or if the sapwood and heartwood cannot be distinguished, the durability of the whole component should be regarded as equivalent to that of the sapwood. In addition to the natural durability, there are other factors that influence performance which should also be taken into consideration in the selection of a wood species and the decision whether or not it should be treated with a preservative. For instance, wood with low permeability may acquire lower moisture contents under intermittent wetting conditions, compared to more permeable species, and will, therefore, have a reduced risk of fungal attack under such service conditions. An indication of propensity to take up moisture may be obtained from the treatability classification of different wood species. Hence timbers having a particular natural durability classification for wood-destroying fungi and with a treatability classification of 3 or 4 may achieve an increased service life in out of ground contact conditions (hazard class 2 or hazard class 3) compared to the wood of similar durability classification but with a treatability classification of 1 or 2. General service situations and hazard classes are given in Table 2.

Table 2. General service situations and hazard classes (EN-460, 1994).

HAZARD CLASSES	GENERAL SERVICE SITUATIONS
1	Above ground, covered (dry)
2	Above ground, covered (risk of wetting)
3	Above ground, not covered
4	In contact with the ground or fresh water
5	In salt water

6. Investigation of Wood Types

Properties and characteristics of the two wood types (bangkirai and iroko) are presented in this chapter. The data is collected from "TROPIX 7 cirad / the main technological characteristics of 245 tropical wood species" database prepared by "BioWooEB Research Unit (Biomass, Wood, Energy, Bioproducts)" (BioWooEB, 2012).

6.1. Descriptions and Properties

The family of "bangkirai" wood is "dipterocarpaceae (angiosperm)", and the scientific names are "shorea glauca, shorea laevis and shorea spp.". The family of "iroko" wood is "moraceae (angiosperm)", and the scientific names are "milicia excelsa and milicia regia." Wood and log descriptions of the two wood types are given in Table 3. Physical, mechanical and acoustic properties of these wood types are presented in Table 4.

Table 3. Wood and log descriptions of "bangkirai" and "iroko" wood types (BioWooEB, 2012).

PROPERTIES	BANGKIRAI WOOD	IROKO WOOD
Color:	yellow-brown	yellow-brown
Sapwood:	not clearly demarcated	clearly demarcated
Texture:	medium	coarse
Grain:	straight or interlocked	interlocked
Interlocked grain:	slight	slight
Diameter:	from 70 to 90 cm	from 80 to 100 cm
Thickness of sapwood:	from 2 to 8 cm	from 5 to 10 cm
Floats:	no	no
Log durability:	good	moderate
		(treatment recommended)

Table 4. Physical, mechanical and acoustic properties of "bangkirai" and "iroko" wood types (BioWooEB, 2012).

PROPERTIES	BANGKIRAI WOOD	IROKO WOOD
Specific gravity*:	0.91	0.64
Monnin hardness*:	7.3	4.1
Coefficient of volumetric shrinkage:	0.68%	0.44%
Total tangential shrinkage (TS):	9.5%	5.4%
Total radial shrinkage (RS):	4.2%	3.5%
TS/RS ratio:	2.3	1.5
Fiber saturation point:	23%	23%
Stability:	moderately stable	moderately stable
Crushing strength*:	85 MPa	54 MPa
Static bending strength*:	150 MPa	87 MPa
Modulus of elasticity:	22940 MPa	12840 MPa
Musical quality factor:	116.8 measured at 2689 Hz	126.8 measured at 2527 Hz
The data presented in this table represent mean values *: at 12% moisture content, with 1 MPa = 1 N/mm^2		

When the log durability of the two wood types is compared, "bangkirai" type of wood is classified as "good" and "Iroko" type of wood is classified as "moderate". In case of usage of "iroko" type of wood, treatment is recommended concerning the log durability. The main differences between the two types are about strength values. "Bangkirai" wood has higher crushing and static bending strength values like 36% and 42%. The modulus of elasticity of "bangkirai" wood is %44 higher than "iroko" wood. The stability of the two materials is classified as "moderately stable". By these facts, it is recommended to decrease the span length of the planks to the half where this material is planned to be used on the related wooden parts of the structure. The decrease of span lengths can be ensured by attaching additional supports at the previous midspans of the plank flooring. It is believed that the differences shown in the other descriptions given in Table 3 and Table 4 do not strongly affect the selection of "iroko" instead of "bangkirai" type in terms of durability and treatability concepts.

6.2. Durability and Treatability

The classification of "bangkirai" and "iroko" wood on the natural durability and treatability characteristics and properties are given in Table 5. Fungi and termite resistance refers to end-uses under temperate climate. Except for special comments on sapwood, natural durability is based on mature heartwood. Sapwood must always be considered as non-durable against wood degrading agents. E.N. Std.s refers to Euro Norm Standards. It is indicated in the same document that in case of risk of temporary and permanent humidification, neither "bangkirai" nor "iroko" wood types do not require any preservative treatment. Only "bangkirai" type of wood requires an appropriate preservative treatment against dry wood borer attacks. "Iroko" type is durable against this kind of attacks. The durability and treatability characteristics of "bangkirai" and "iroko" wood types, according to EN-350 (2016) standard are given in Table 6. "Bangkirai" and "iroko" woods are marked in red and blue rectangles, respectively.

Table 5. Natural durability and treatability of "bangkirai" and "iroko" wood (BioWooEB, 2012).

PROPERTIES	BANGKIRAI WOOD	IROKO WOOD
Fungi*:	class 2 – durable	class 1-2 – very durable to durable
Dry wood borers:	heartwood durable but sapwood not clearly demarcated	durable – sapwood demarcated (risk limited to sapwood)
Termites*:	class D – durable	class D – durable
Treatability*:	class 4 – not permeable	class 4 – not permeable
Use class ensured by natural durability:	class 4 – in ground or fresh water contact	class 3 – not in ground contact, outside
Species covering the use class 5:	yes	no

***according to E.N. Standards.**
Note: These species are listed in the European standard NF EN 350-2. The data presented in this table represent mean values.
Bangkirai: The possible presence of few demarcated sapwood in sawnwood may have an influence on the expected durability. Only Shorea laevis has a good enough natural durability to allow end-uses under use class 5 (end-uses in marine environment or in brackish water). It is due to its high specific gravity and high silica content. According to the European standard NF EN 335, performance length might be modified by the intensity of end-use exposition.
Iroko: The heartwood does not cover the use class 4 required for end-uses in contact with permanent humidity (example: contact with ground). On the other hand, if the constructive system is well-drained, without water trap, this species can be used outside without any treatment. Heartwood is hardly permeable to preservative products. This species naturally covers the use class 5 (end-uses in marine environment or in brackish water) due to its high specific gravity and hardness. According to the European standard NF EN 335, performance length might be modified by the intensity of end-use exposition.

Table 6. The durability of heartwood and treatability of softwood species (BioWooEB, 2012).

N°	Scientific name	Code acc. to EN 135 56	Common name	Origin	Density/ kg/m³ at 12 % MC	Durability of heartwood				Treatability		Sap wood width	
						Fungi	Beetles	Termites	Marine borers	Heart wood	Sap wood		Additional data / information when available
	R. albiflora Marc.-Berti *R. retusa* Marc.-Berti												
111	*Rhodognaphalon* spp. *R. brevicuspe* Roberty *R. schumannianum* Robyns	RHXX	X: Kondroti	W/E Africa	470–480–490	5	D	S	S	1	1	b	
112	*Sextonia rubra* van der Werff (also *Sextonia rubra*)	OCRB	X: Louro vermelho O: Red Louro	S America	600–620–650	2	D	D	D	4	2	m	
113	*Shorea* spp. subgen. *Eushorea* *S. glauca* King *S. laevis* Ridl. *S. maxwelliana* King *S. superba* Symington	SHBL	X: Yellow Balau O: Bangkirai	SE Asia	700–930–1150	2	D	D	D	4	1–2	s	Not resistant to termites under lab conditions
85	*Mezilaurus* spp. *M. itauba* Taub. *M. navalium* Taub.	MZXX	X: Itauba	S America	800–850–950	1	D	D	D	4	n/a	s	
86	*Micropholis* spp. *M. gardnerianum* Pierre *M. melinoniana* Pierre *M. venulosa* Pierre	MPWW	X: Curupixa F: Balata blanc	S America	650–750–850	4	S	S-M	S	2	n/a		
87	*Milicia* spp. *M. excelsa* C. C. Berg *M. regia* C. C. Berg	MIXX	X: Iroko O: Kambala	W/E Africa	630–650–670	1–2	D	D	D	4	1	m	Sapwood not resistant to *Lyctus* Not resistant to termites under lab conditions

Investigations and results according to durability and treatability, are summarised as follows:

- Fungi (according to E.N. standards): "Bangkirai" type of wood is classified as "class 2 – durable". "Iroko" type of wood is classified as "class 1-2 - very durable to durable". Thus, "iroko" type of wood can be used instead of "bangkirai" type of wood with respect to the durability to Fungi.
- Termites (according to E.N. standards): Both of the "bangkirai" and "iroko" type of woods are classified as "class D – durable". Thus, "iroko" type of wood can be used instead of "bangkirai" type of wood with respect to the durability to Termites.
- Beetles (according to E.N. standards): Both of the "bangkirai" and "iroko" type of woods are classified as "class D – durable". Thus, "iroko" type of wood can be used instead of "bangkirai" type of wood with respect to the durability to Beetles.
- Marine borers (according to E.N. standards): Both of the "bangkirai" and "iroko" type of woods are classified as "class D – durable". Thus, "iroko" type of wood can be used instead of "bangkirai" type of wood with respect to the durability to Marine borers.
- Treatability (according to E.N. standards): Both of the "bangkirai" and "iroko" type of woods are classified as "class 4 – not permeable". Thus, "iroko" type of wood can be used instead of "bangkirai" type of wood with respect to the treatability.
- Use class ensured by natural durability: "Bangkirai" type of wood is classified as "class 4 – in ground or fresh water contact". "Iroko" type of wood is classified as "class 3 – not in ground contact, outside". The related parts of the structure are not in contact with the ground, directly. These parts are locally exposed to fresh water. The drainage system is sufficient to evacuate fresh water to avoid the accumulation of water on the related parts of the visitor's platform. Thus, "iroko" type of wood can be used instead of "bangkirai" type of wood with respect to the natural durability considering the location of the parts of the structure that this material will be used.

7. Conclusion

The type of plank flooring material used on various parts of visitor's platform was investigated within the scope of this study for the roof canopy structure planned to be built on Göbeklitepe Project located in Şanlıurfa, Southeastern Anatolia, Turkey. The aim is to answer that is it convenient and suitable to use "iroko" type of wood instead of "bangkirai" type of wood on the related parts of the visitor's platform for environmental conditions, economic reasons and availability in the related region. The investigations and evaluation were done only for "durability and treatability" concepts. The results of the investigations and evaluation show that both of the wood types have sufficient durability against fungi, termites, beetles and marine borers. Both of the wood types are classified as "class 4 – not permeable" which satisfies the euro norms about treatability. Since the visitor's platform of the structure is not directly in contact with water, "iroko" wood's natural durability class (class 4-not in ground contact, outside) is acceptable considering the location of plank flooring and efficiency of the drainage system to avoid water accumulation on the planks. The log durability of "bangkirai" type of wood is classified as "good". However, the log durability of "Iroko" type of wood is classified as "moderate". Thus, if the "iroko" type of wood will be used instead of "bangkirai" type of wood, treatment is recommended with respect to the log durability. It is also recommended that the span length should be decreased to its half where this material is planned to be used on the related wooden parts of the structure by attaching additional supports at the previous midspan. Therefore, it is concluded that "iroko" type of wood can be used instead of "bangkirai" type of wood as the plank flooring material used on various parts of visitor's platform for Göbeklitepe Canopy Project. This suitability is only valid for the "durability and treatability" concepts considering the recommendations given and by the validity of conditions provided in this study.

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Conflict of Interest

No conflict of interest was declared by the author.

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