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**REVUE DE LA FACULTÉ FORESTIÈRE
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DURABILITY OF LAMINATED RAILROAD TIES

Doç. Dr. Halûk H. ÜNLİGİL[1)]

Abstract

Pathological examinations which included soil-block tests (test fungi: *Lentinus lepideus and Gloeophyllum trabeum)* were made on borings taken in 1976 from the upper surfaces of 30 laminated crossties (uppermost lamination of yellow birch, others of jack pine) and from 9 controls (single piece jack pine), all treated with a creosote and petroleum-oil mixture, and in service since 1948 in two areas in Canada (North Bay, Ontario, and St-Lazare, Quebec).

The depth of preservative penetration generally exceeded 30-50 mm, the length of the borings. The two narrowest penetration zones (one 8, and the other 16 mm) were measured on borings from control ties. Preservative concentration on borings from laminated ties was visually assessed always as "medium" or "high", at least in the outer 12 mm portion. On the controls, however, preservative concentration was assessed as "low" in 7 out of 18 borings, the remainder being "medium" or "high".

In tests with a metal probe the borings from laminated ties were assessed in the yellow birch portions, and usually also in the jack pine portions, as "normal"; twenty percent of the controls, however, were assessed as "soft and weakened".

In microscopic examinations, none of the borings were found to be attacked by Basidiomycetes. Sporadic fungal hyphae were seen, but no evidence for fungal deterioration was observed, except for one of the control ties. Isolation attempts yielded moulds, wood staining fungi, and once a *Chaetomium* sp. (from a control tie). No Basidiomycetes were isolated.

1) Faculty of Forestry, University of Istanbul

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In the soil-block tests the borings from ties were generally more resistant to decay than those from untreated wood. Although in the assesment the borings from the laminated ties seemed to contain more preservative than the control ties, in soil-block tests they showed higher resistance only to *L. lepideus*. In tests eigth *G. trabeum* the opposite was observed. Outer portions (5.5-16.5 mm from the surface) of the laminated ties were highly resistant to fungal decay in tests both of the fungi used. For control ties this was true only in tests with *G. trabeum*. In their resistance to fungal decay, boring from the laminated ties in service in North Bay and in St-Lazare, (two locations of similar climate), were similar to each other. As expected, *L. lepideus*, a creosote resistant fungus, generally caused more decay on wood from ties than *G. trabeum*.

It appears that in the prediction of the remaining service life of the ties examined, fungal decay should be considered less important than factors such as mechanical wear due to traffic.

1. INTRODUCTION

As part of a long-term program at the Eastern Forest Products Laboratory on the improvement of wooden railroad ties, a co-operative study was originated in 1948 with Canadian Pacific Railways (CPR) on the development and performance evaluation of glued-laminated crossties (1, 2). A group of experimental ties, designated as "Glulam-ties", was produced in the Labotatory and put into service on main lines in two places: 1) North Bay, Ontario, and 2) St-Lazare, Quebec.

Since then the ties have been examined several times by the Laboratory staff to monitor their condition (checking, plate cutting, visual signs of biological deterioration, etc.). CPR carried out normal inspections independently and removed some of the ties from sevice, as they no longer met the specifications of the Company.

To help assess the residual sevice life the inspection carried out in 1976 included an examination of borings taken from the ties still in service. In this examination the borings were assessed for their pathological condition (degree of biological degradation) and for their resistance to fungal decay. The results of these examinations are presented in this paper. Other observations on the performance of these ties made during the 1976 inspection were presented by Krzyzewski (2).

2. MATERIALS AND METHODS

Laminated ties, (0.2 m x 0.2 m x 2.4 m; 16 for each test site) were produced from 5 or 7 horizontal laminations using phenol-resorcinol resin glue. The top lamination was 22 mm thick yellow birch (*Betula alleghaniensis* Britton); the other laminations were jack pine (*Pinus banksiana* Lamb.). The ties were incised on the top and bottom sides and treated, using the Rüping process, with a mixture of creosote (50 percent) and petroleum-oil to a retention of 130 kg/m^3 (Figure 1).

Control ties, (10 for Nort Bay and 16 for St.-Lazare), were of jack pine, and of the same size as the laminated ties. They were treated by CPR using the preservative and treatment process applied to the laminated ties (Figure 1). Krzyzewski (1, 2) has presented more detailed information of the performance of the ties and the traffic intensity on the lines (as well as the result of previous inspections).

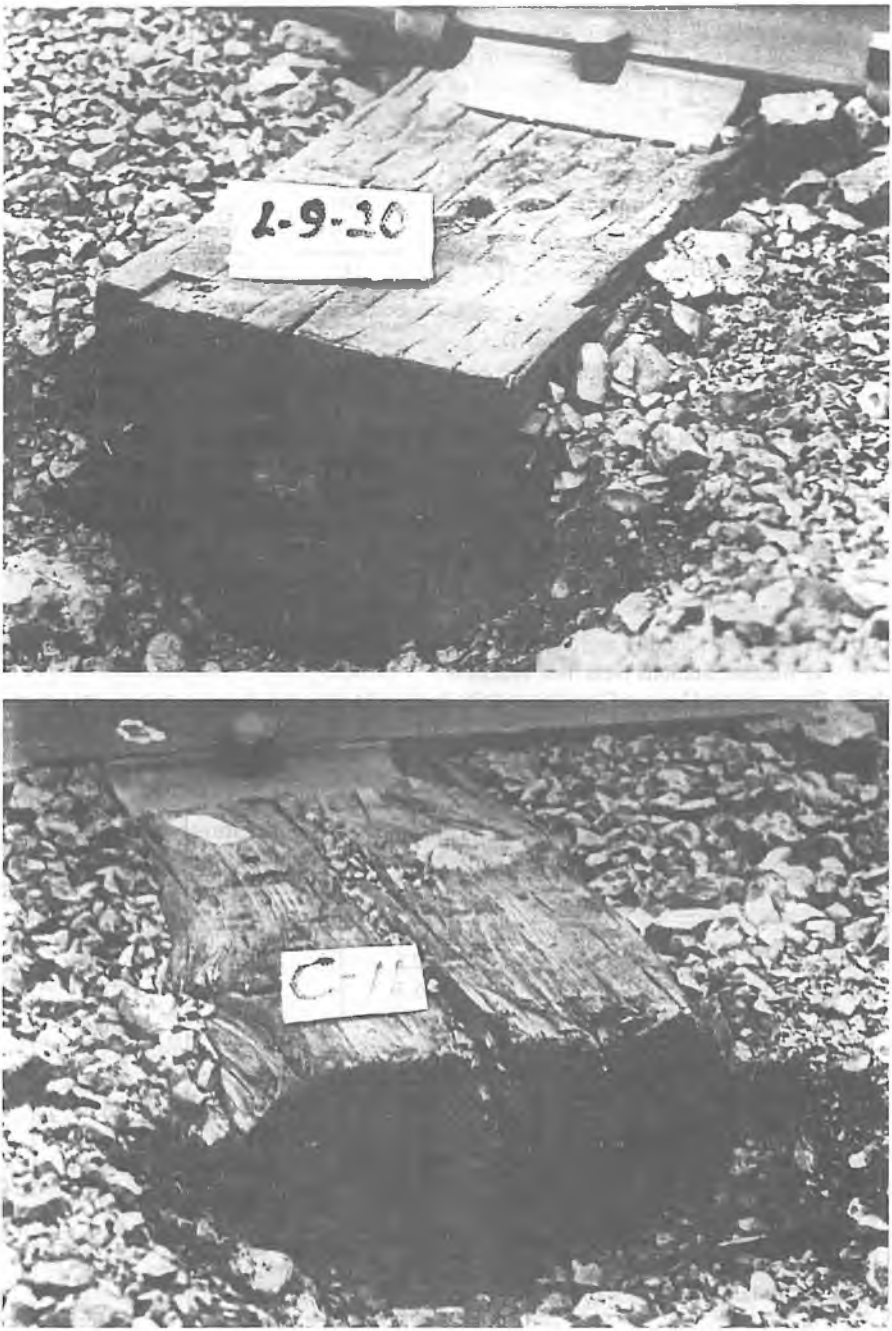

Figure 1: Ties examined in North-Bay. A typical laminated tie (above) and a control tie
Şekil 1: North Bay'da incelenen traversler. Tipik bir lamine travers (yukarda) ve bir kontrol traversi

Information on the long-term monthly averages of temperature and precipitation for North Bay and for the Dorval Airport, about 30 km from the St-Lazare test site, is given in Table 1. The number of ties originally put into service and of those still in service when examined was as follows:

		Ties put into service	Remaining ties (examined)
North Bay :	Laminated Ties	16	16
	Controls	10	5
St-Lazare :	Laminated Ties	16	14
	Controls	16	4

Borings taken from the examined ties were 11 mm in diameter and 30 to 50 mm long. They were taken from the approximate centre of the upper surface of the tie outside the rail, one from each end. After examining external surfaces and, in some cases, the ends of the ties by removing gravel, this area was chosen for core samples, because it represented well the general condition of the ties end caused the least damage from sampling.

Table 1: Long Term Monthly and Annual Averages for Temperature and Precipitation Recorded at Weather Stations Near Test Tracks(1)

Tablo 1: Traverslerin Hizmet Gördükleri Bölgelerdeki Meteoroloji İstasyonlarında Kaydedilmiş Uzun Süreye Ait Aylık ve Yıllık Sıcaklık ve Yağış Ortalamaları(1)

Month Ay	North Bay A		Dorval Airport(2)	
	Temperature Sıcaklık, °C	Precipitation Yağış, mm	Temperature Sıcaklık, °C	Precipitation Yağış, mm
Jan.	–12.8	172.8	–9.9	75.6
Feb.	–11.1	58.7	–8.8	71.0
Mar.	– 5.4	62.5	–2.3	70.9
Apr.	3.2	65.3	5.9	73.5
May.	10.1	73.0	12.8	67.2
June	15.8	86.1	18.5	83.0
July	18.3	102.2	21.2	85.0
Aug.	17.1	86.2	19.9	86.2
Sept.	12.4	115.8	15.3	79.7
Oct.	6.9	85.2	9.4	74.9
Nov.	– 0.8	92.5	2.3	86.5
Dec.	– 9.4	79.8	–6.6	87.1
Annual Means Yıllık Ortalamalar	3.7	81.7	6.5	78.4

(1) From Canadian Weather Review, Fisheries and Environment Canada, Atmospheric Environment, 1977, Vol. 15. No. 12.

(2) Dorval Airport is about 30 km east of St-Lazare.

(2) Dorval Havalimanı St-Lazare'nin 30 km doğusundadır.

A visuel examination was carried out on the borings to assess the colour and condition of wood on the preservative-free portion, if presend, and the concentration of preservative. The length of the boring and the depth of preservative was measured, and the strength of the wood assessed using the tip of a metal probe. The portions of the borings, shown in Figure-2, were examined microscopically for fungal hyphae, bacteria, and morphological evidence of biodeterioration. For mounting the sections, a glycerin-water mixture was used on creosoted wood and Amman's lactophenol with trypan blue on untreated wood.

Isolations of fungi from the borings were attempted within 3 d after the borings were taken from the ties. After surface sterilization, small pieces of the borings were put into culture tubes containing 2 percent malt-agar growth medium, and incubated at 27 °C.

Other portions of the borings (Figure 2) were exposed in soil-block tests to pure cultures of two fungi (wood-rotting Basidiomycetes) to examine their resistance to fungal attack. The materials and methods applied were as specified in the American Wood Preserves' Assosiation Standard M10-74 except for size of the wood specimens.

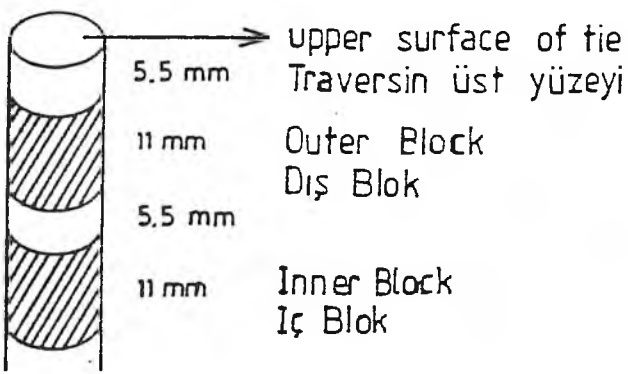

Figure 2: Portions of borings used for different examinations. White portions were used for microscopic examinations and culturing, striped portions for soil-block tests

Şekil 2: Burgu numunelerinde çeşitli incelemelerin yapıldığı bölümler. Çizgili bölümler soil-blok testlerinde, diğerleri mikroskopik incelemelerinde ve mantar izolasyonu çalışmalarında kullanılmıştır

The test fungi were *Gloeophyllum trabeum* (Pers. ex. Fr.) [*Lenzites trabea* Pers. ex. Fr.] (Madison 617), which is tolerant to phenolic compounds and occurs on hardwood as well as on softwoods, and *Lentinus lepideus* Fr. (Madison 534), which is known for its creosote tolerance and frequent occurrence on creosoted railway ties.

Jars used in the soil-block tests were cylindrical, of 225 cm^3 capacity, and each contained two test blocks. Before and after exposure to the fungi, the blocks were conditioned at 27±1 C and 70±2 percent relative humidity to an equilibrium moisture content (MC) of 13.4 percent. Part of the weight loss occurring during the incubation (12 weeks), especially that of the outer blocks, containing high concentrations of creosote, was probably due to factors other than the fungal decay of wood (evaporation and leaching of creosote during incubation and conditioning). No attempt was made to estimate the loss due to these factors.

Control blocks were produced from untreated yellow birch and jack pine sapwood using borings similar to those obtained from the ties.

The results of the soil-block tests were analysed statistically by Student's t-test and the unbalanced 2-way analysis of variance, followed by comparisons according to Scheffe's method.

3. RESULTS

Depth and concentration of preservative and colour of borings:

The depth of preservative penetration and assessed preservative concentrations are presented in Table-2 and Table-3. Depth of preservative usually exceeded the length of the borings (30-50 mm). Values less than 20 mm were measured on two borings, both from control ties: one from North Bay, other from St-Lazare. The concentration of preservative was assessed on laminated ties in the outer 20 mm usually as "high" or "moderate"; on controls, usually as "moderate" or "low".

The colour of the wood in the preservative-free portions, was assessed as "normal".

Strengt:

Strengt assessed on the borings from laminated ties of both test sites was "normal". From the controls, two borings out of 10 from North Bay, and two out of 8 from St-Lazare, ware assessed as "soft and weakened".

Microscopic Examinations:

Several borings from laminated and control ties were examined under the microscope from both test sites. On borings from the North Bay ties no fungal hyphae or morphological evidence for fungal degradation were observed. About one third of the St-Lazare ties examined were infected sporadically (simple septate hyphae); other borings were free of fungal infection. No fungi of the Basidiomycete class or evidence for cell-wall deterioration (bore holes, wall erosion, cavities) were observed, except for one of the controls.

Isolations:

In isolation attempts, no fungi of the Basidiomycete class were obtained. Fifteen isolation attempts were made from borings of control ties from North Bay. A *Cephalosporium* sp., probably the conidial stage of *Ceratocystis,* frequently associated with blue stain in wood, was the most common fungus and was isolated three times. *Aureobasidium pullulans* (De Barry) Arnaud, a ubiquitous, darkly pigmented staining fungus; *Chaetomium* sp., which causes soft-rot in favourable environments; and *Aspergillus* sp., (a mould) were isolated, each twice. *Trichoderma viride* Pers., *Monodictys glauca* (Cooke & Harkn.) Hughes, two other moulds, and a yeast were isolated, one each. Two unidentified non-sporulating fungi with hyaline hyphae were isolated, each once. One isolation attempt yielded no growth.

From borings of laminated ties from North Bay, 16 isolations attempts were made. *Trichoderma viride, Alternaria tenuissima* (Kunze ex Pers.) Wiltshire, *Scytalidium lignicola* Pesante, three cosmopolitan Hyphomycetes and a yeast were isolated, each twice. A *Cladosporium* sp., *Alternaria alternata* (Fr.) Kreissler, *Aureobasidium pollulans, Wardomyces inflatus* (Marchal) Hennebert, a *Cephalosporium* sp. and two other unidentified non-sporulating fungi (one with hyaline, the other with brown, hyphae) were isolated, each once. Three isolation attempts yielded no growth.

Table 2: Depth of Penetration and Concentration of Preservative on Borings From Ties From North Bay[1]

Tablo 2: North Bay'da Hizmet Gören Traverslerden Alınan Artım Burgusu Örneklerinde Ölçülen Emprenye Maddesi İşleme Derinliği ve Konsantrasyonu[1]

Boring[1] Burgu Numunesi[1]		Preservative, Emprenye Maddesi		
		Depth of Penetration, mm[2] İşleme Derinliği, mm[2]	Concentration[3], Konsantrasyon[3]	
			Outer, Dış	Inner, İç
C5	N	8	(20)XXX	(4)X
	S	>45	(20)XXX	(25)X
C9	N	>46	XXX	XXX
	S	>30	XXX	XXX
C11	N	>45	(15)XX	(30)X
	S	>50	X	X
C13	N	>45	X	X
	S	>45	X	X
C2	N	>40	X	X
	S	>50	(15)XX	(35)X
L1	N	>42	(22)XXX	(20)X
	S	>45	(20)XXX	(25)X
L2-14	N	>50	(22)XXX	(28)XX
	S	>40	(22)XXX	(18)XX
L	N	>43	(22)XXX	(21)XX
	S	>22	XXX	XXX
L5	N	20	XXX	XXX
	S	>42	(16)XXX	(26)X
L7	N	>40	(22)XXX	(18)XX
	S	>45	XXX	XXX
L8	N	>48	(22)XXX	(26)X
	S	>40	(22)XXX	(18)XX
L9	N	>36	(22)XXX	(14)XX
	S	>38	(22)XXX	(16)XX
L10	N	>35	XXX	XXX
	S	>45	(15)XXX	(20)XX
L11	N	>40	XXX	XXX
	S	>45	XXX	XXX
L12	N	>46	(12)XXX	(34)X
	S	>41	XXX	XXX
L13	N	23	XXX	XXX
	S	>36	(22)XXX	(14)X
L24	N	>50	XXX	XXX
	S	>40	XXX	XXX
L6	N	>50	(22)XXX	(28)XX
	S	>45	(22)XXX	(23)XX
L4	S	>48	(22)XXX	(26)XX
L	S	>48	(22)XXX	(26)XX
L2-28	N	>46	(22)XXX	(24)X
	S	>33	(15)XXX	(18)XX

(1) Borings designated "C" were controls (jack pine); "L" were laminated ties. "N" indicates borings taken from the northern end of the tie; "S", boring taken from the southern end.

(1) C=kontrol (çam), L=lamine traversler, n=kuzey uçtan, S=güney uçtan, alınan burgu örnekleri.

(2) >=Depth of penetration exceeds the length of the boring.

(2) >=Emprenye maddesi işleme derinliği burgu örneği uzunluğunu geçiyor.

(3) Preservative concentration assessed as low (X), moderate (XX), and high (XXX). Numbers in brackets indicate the length of the borings to which the assessmant applies. No number is given when the assessment applies to the outer or inner half of the boring.

(3) (X)=Emprenye maddesi konsantrasyonu alçak, (XX)=orta, (XXX)=yüksek. Parentez içindeki numaralar derecelendirilen kısmın uzunluğunu göstermektedir. Bu numara yok ise takdir numunenin yarısı için geçerlidir.

Table 3: Depth of Penetration and Concentration of Preservative on Borings From Ties From St-Lazare(1)

Tablo 3: St-Lazare'de Hizmet Gören Traverstlerden Alınan Artım Burgusu Örneklerinde Ölçülen Emprenye Maddesi İşleme Deriliği ve Konsantrasyonu(1)

Boring Burgu Numunesi		Preservative, Emprenye Maddesi Depth of Penetration, mm İşleme Derinliği, mm	Concentration, Konsantrasyon Outer, Dış	Inner, İç
C1	N	32	(10)XXX	(22)XXX
	S	33	(10)XXX	(23)XX
C5	N	16	XX	XX
	S	20	XX	XX
C7	N	>33	(10)XXX	(23)XX
	S	34	X	X
C15	N	>50	X	X
	S	>40	X	X
L1	N	>30	XX	XX
	S	>23	XX	XX
L2	N	>39	XX	XX
	S	>45	XX	XX
L3	N	>45	XX	XX
	S	>50	XX	XX
L4	N	>43	XXX	XXX
	S	>45	(20)XX	(26)X
L5	N	>45	(30)XX	(35)X
	S	>45	(22)XX	(23)X
L6	N	>45	XXX	XXX
	S	>43	(22)XXX	(27)X
L7	N	30	XX	XX
	S	>50	XX	XX
L8	N	>45	(22)XXX	(23)XXX
	S	>40	(22)XXX	(18)XX
L9	N	>40	XXX	XXX
	S	>45	XX	XX
L10	N	>48	(20)XXX	(28)X
	S	>35	XXX	XXX
L11	N	>48	XXX	XX
	S	>42	XXX	XX
L12	N	>42	(22)XXX	(20)X
	S	>25	(16)XXX	(9)X
L15	N	>50	XXX	XXX
	S	>43	XXX	XXX
L16	N	>38	(22)XXX	(16)X
	S	>48	(22)XXX	(26)X

(1) For explanations refer to footnotes on Table 1.
(1) Açıklamalar için Tablo 1'deki dipnotlara bakınız.

Ten isolation attemts were made from borings of control ties from St-Lazare. An unidentified fungus with brown simple septate hyphae was isolated three times. A *Phialophora* sp., common on cellulosic materials, was isolated twice. A *Penicillium* sp. (common mould); *Scytalidium lignicola*, a *Histoplasma* sp., and an unidentified non-sporulating fungus with simple septate gray hyphae were isolated each once.

From borings of laminated ties from St-Lazare 15 isoalation attempts were made. *Penicillium* spp. were isolated nine times. Yeasts and unidentified non-sporulating fungi with hyaline simple septate hyphae were isolated three times. A *Cephalosporium* sp., *Alternaria alternata* and an unidentified non-sporulating fungus with gray simple septate hyphae were isolated, each once.

Table 4: Weight Losses (Arithmetic Means ± Standard Deviations) Obtained in Soil-Block Tests With Specimens From Laminated Ties(1)

Tablo 4: Lamine Traverslerden Alınan Artım Burgusu Numunelerinin Soil-Blok Testlerinde Uğradığı Ağırlık Kaybı (Aritmetik Ortalama ± Standart Sapma)(1)

Test Fungus Test Mantarı	Block(2) Blok(2)	North Bay		St-Lazare	
		No of Blocks Blok adedi No	Weight loss s.d. Ağırlık kaybı s.s. %	No of Blocks Blok adedi No	Weight loss s.d. Ağırlık kaybı s.s. %
L. lepideus	Lo	8	10.09 ± 9.04	11	14.73 ± 14.45
L. lepideus	Li	7	47.15 ± 6.86	6	46.77 ± 9.80
G. trabeum	Lo	12	12.82 ± 11.79	13	13.82 ± 10.63
G. trabeum	Li	9	33.74 ± 22.00	11	28.58 ± 20.30

(1) Based on weight at 13.4 percent MC.
(1) Yüzde 13.4 oranında rutubet baz alınmıştır.
(2) Lo: outer blocks; Li: inner blocks.
(2) Lo: dış bloklar; Li: iç bloklar.

Soil-block Tests

The results obtained from specimens of laminated ties are presented in Table-4 for comparison between exposure sites. The differences between the corresponding blocks of the two sites were small and in Student's t-test not significant (results from control ties were not included in the table because the numbers of specimens were insufficient).

The results from all test blocks (combining corresponding groups from both exposure sites) are presented in Figure-3 and the significance of the differences in Figure-4.

In tests with *L. lepideus*, untreated blocks of pine lost 66.6 ± 0.3 percent (mean ± standard error of the mean); birch blocks lost 68.7 ± 1.1 percent. Generally, blocks from ties were less severely decayed then untreated blocks. Blocks from laminated ties decayed less than those from control ties; blocks from outer portions of the ties (closer to the surface) decayed less than blocks from inner portions.

In tests with *G. trabeum*, untreated blocks of pine lost 71.6 ± 0.3 percent; birch blocks lost 75.4 ± 0.3 percent. Generally blocks from ties were less severely decayed than untreaeted blocks. Blocks from laminated ties decayed more than blocks from control ties; blocks from outer portions of the ties decayed less than blocks from inner portions.

G. trabeum, compared with L. lepideus, caused slightly more decay on non-treated controls, but generally less on blocks from ties.

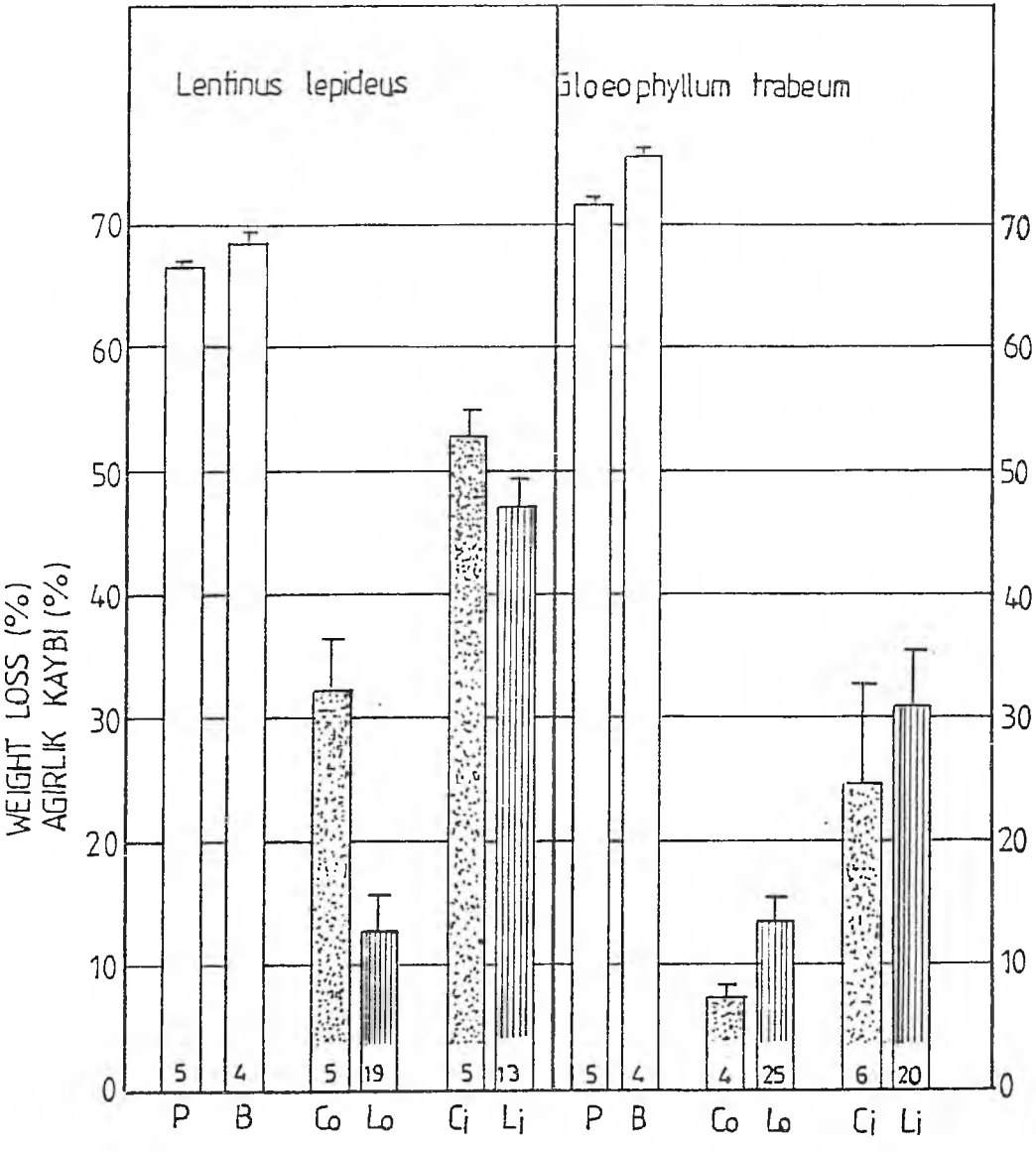

Figure 3: Weight losses (based on weight at 13.4 percent MC) obtained in soil-block tests: Arithmetic means and standard error of the means (vertical bars). Numbers of blocks in each group is indicated in the columns. Included are blocks from North Bay as well as from St-Lasare.: P-Pine sapwood; B-Yellow birch (both non-treated); Co and Ci- outer and inner blocs from control ties; Lo and Li- outer and inner blocks from laminated ties

Şekil 3: Soil-blok testlerinde belirlenen ağırlık kayıpları (% 13.4 rutubet miktarı temel alınmıştır). Aritmetik ortalamalar ve ortalamaların standart hataları. Test gruplarındaki örnek adetleri sütunların içinde gösterilmiştir. Travers grupları içinde hem North Bay hem de St-Lazare örnekleri bulunmaktadır. P=çam diri odunu; B=Sarı huş (emprenye edilmemiş örnekler); Co ve Ci=kontrol traverslerinin dış ve iç blokları; Lo ve Li=lamine traverslerin dış ve iç blokları

		Lentinus lepideus						Gloeophyllum trabeum					
		P	B	C_o	L_o	C_i	L_i	P	B	C_o	L_o	C_i	L_i
Lentinus lepideus	P				XXX					XXX	XXX	XXX	XXX
	B				XXX					XXX	XXX	XXX	XXX
	C_o							XX	XX				
	L_o	XXX	XXX			XXX	XXX	XXX	XXX				X
	C_i				XXX					XXX	XXX		
	L_i				XXX					XXX	XXX		
Gloeophyllum trabeum	P			XX	XXX					XXX	XXX	XXX	XXX
	B			XX	XXX					XXX	XXX	XXX	XXX
	C_o	XXX	XXX			XXX	XXX	XXX	XXX				
	L_o	XXX	XXX			XXX	XXX	XXX	XXX				XX
	C_i	XXX	XXX					XXX	XXX				
	L_i	XXX	XXX		X			XXX	XXX		XX		

Figure 4: p-values for comparisons of the results of the soil-block tests presented in Figure 3. XXX=p<0.01; XX=p<0.05; X=p<0.1. For the meaning of the letters refer to Figure 3

Şekil 4: Şekil 3'de verilen soil-blok testlerinin sonuçları arasındaki farkların güven düzeyleri (p-değerleri). XXX=p<0.01; XX=p<0.05; X=p<0.1. Harflerin anlamı için Şekil 3'e bakınız

4. CONCLUSIONS

In general (assuming that the borings adequately represented the ties), the laminated ties, as well as the control ties, were essentially free of fungal decay and still satisfactorily protected against fungal deterioration by residual preservative. Fungal deterioration will probably not be a primary factor in the termination of serviece life of the ties examined. In the assesment (prediction) of the remaining service life, other factors, such as mechanical damage due to traffic, have to be the main consideration.

Considering that after 28 years of service only 2 out of 32 laminated ties were discarded, and the results of the present examinations, it is to be expected that their service life will exceed 40 years. Since laminations also permit the use of smaller row material, and in parts of the ties exposed to lower level of stress, cheaper grades, it can be assumed that the use of laminated ties will extend.

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LAMİNE DEMİRYOLU TRAVERSLERİNİN ÇÜRÜMEYE DAYANIKLILIĞI

Doç. Dr. Haluk H. ÜNLİGİL

Kısa Özet

Orta Kanada'da North Bay ve St. Lazare'de 1948 yılında hizmete girmiş olan horizontal lâmine demiryolu traverslerinden 1976 yılında alınan artım burgusu numunelerinde soil-blok testlerini içeren patolojik incelemeler yapılmıştır. Lâminatların fenol-resorsinol reçinesi ile yapıştırılması sonucu üretilen traversler, maden kömürü katranı kreozotu (% 50) ile petrol yağı karışımı bir emprenye maddesiyle 130 kg/m3 absorbsiyon düzeyinde emprenye edilmişlerdir.

Sonuçlar, bu traverslerin mantar çürüklüğünden tamamen ari olduğunu, kalan emprenye maddesi miktarının traversleri mantar zararlarına karşı yeteri derecede korumaya devam ettiğini ve bu traverslerden beklenen hizmet süresinin tahmininde mantar çürümesinin mekanik zararlar gibi faktörlerden daha az önemli sayılması gerektiğini göstermiştir. Bu sonuçlar ve hizmet süresinin uzun olacağının belirlenmesi –28 yıllık hizmet süresinde 32 travers sadece 2 adet fire vermiştir– gözönüne alındığında lamine traverslerin kullanım miktarının artması beklenmelidir.

ÖZET

Çalışma, fenol-resorsinol reçinesi kullanılarak üretilen ve 1948 yılında Orta Kanada'da North Bay ve St. Lazare bölgelerinde hizmete konulan bir seri demiryolu traversinin patolojik durumunun incelenerek kalan hizmet sürelerinin tahmininde mantar çürüklüğünün rolünü meydana çıkarmak amacıyla 1976 yılında sözkonusu traverslerden artım burgusu ile alınan numunelerde yapılmıştır.

Traverslerin hizmet gördüğü North Bay ve St. Lazare'nin 30 km doğusundaki Dorval Hava Alanı meteoroloji istasyonlarının uzun süreye ait aylık sıcaklık ve yağış kayıtları Tablo 1'de verilmiştir (Tablo ve şekiller İngilizce metin içinde verilmiştir).

Traversler 0.2 x 0.2 x 2.4 m boyutlarındadır ve 5-7 adet yatay lâmineden üretilmişlerdir. En üstteki laminasyon 22 mm kalınlığında olup yoğunluğu oldukça yüksek (0.45-0.60 g/cm^3, taze; 0.55-0.71 g/cm^3, tam kuru) ve oldukça sert sayılan ve diğer amaçlar yanında demiryolu traversi üretiminde tercihen kullanılan sarı huş, *Betula alleghaniensis* Britton, diğer laminasyonları ise orta derecede yoğun (0.40 g/cm^3, taze; 0.45 g/cm^3, tam kuru), orta derecede yumuşak, kerestesi budaklı olan ve genelde ancak kaba inşaata elverişli sayılan "Jack pine", *Pinus banksiana* Lamb'-dan, üretilmişlerdir. Traversler, üst ve alt yüzeyleri "incising"(*) işlemine tabi tutulduktan sonra, Rüping metoduna göre maden kömürü katranı kreozotu (%50) ve petrol yağı karışımı ile 130 kg/m^3 absorbsiyon düzeyinde emprenye edilmişlerdir (Şekil 1). Kontrol amacıyla aynı boyutlarda ve biçimde, emprenye işlemi yapılmış, masif Jack pine traversleri de aynı bölge ve hatta hizmete konulmuştur (Şekil 1). İncelemenin yapıldığı 1976 yılında, hizmete konulan 32 lamine traversten 30 tanesinin, 26 kontrol traversinden de sadece 9 tanesinin hizmete devam ettiği görülmüş, diğerleri hattın sahibi Canadian Pacifik demiryolu şirketi tarafından kalite yetersizliği nedeniyle hizmetten çıkarılmıştır. İncelemeler hizmete devam eden traverslerden alınan 11 mm çapında ve 30-50 mm uzunluğundaki artım burgusu numunelerinde yapılmıştır. Numuneler, traverslerin her iki ucundan ve ray yatağının dışında kalan alanın orta noktasından alınmıştır.

Bu numunelerin çeşitli bölümlerinde hangi incelemelerin yapıldığı Şekil 2'de gösterilmiştir.

Sonuçlar, emprenye maddesi nüfuz derinliğinin hem lamine traverslerde hem de kontrol traverslerinde numune uzunluğunu geçtiğini, biri 8, diğeri 16 mm'lik en düşük derinliklerin kontrol traverslerinde bulunduğunu göstermiştir (Tablo 2 ve Tablo 3).

Görsel değerlendirmeler, lâmine traverslerden alınan numunelerin 12 mm'lik dış kısımlarının daima "yüksek", ya da "orta" derecede, kontrollardan alınan 18 numuneden 7 tanesinin dış kısımlarının "düşük", kalan 11 tanesinin dış kısımlarının "orta" veya "yüksek" derecede emprenye maddesi içerdiğini göstermiştir.

Bıçak ucu ile yapılan direnç testlerinde lâmine traversleri numunelerinin dış taraflardaki huş laminatı içeren kısımları daima, çam laminatı içeren kısımları genellikle, "esnek", kontrol numunelerinin % 20'si ise "gevrek" olarak değerlendirilmiştir.

Mikroskopla yapılan incelemeler, traverslerin odun çürüten mantarların en önemlilerini içeren Basidiomycetes sınıfı üyelerinin saldırısına uğramadığını göstermiştir. Az miktarda mantar küfü görülmüşse de, kontrol traverslerinden alınan tek bir numune hariç, mantar degradasyonu belirtilerine rastlanmıştır.

Artım burgularının alınmasından sonra % 2'lik malt-agar besin ortamı kullanılarak 3 gün süre ile yapılan mantar izolasyon denemeleri sonucu kontrol traverslerinden birer adet *Cephalosporium* sp., *Aureobasidium pullulans* (De Barry) Arnaud, *Aspergillus* sp., *Trichoderma viride* Pers., *Monodictys glauca* (Cooke & Harkn) Hughes, *Phialophora* sp., *Penicillum* sp., *Scytalidium lignicola* Pesante, *Histoplasma* sp., 4 adet teşhis edilmemiş diğer Fungi Imperfecti ve bir adet uygun ortamlarda "yumuşak çürüklük" yapma yeteneğinde olan *Chaetomium* sp., izole edilmiştir.

Lâmine traverslerden birer adet *T. viride, Alternaria tenuissima* (Kunze ex. Pers.) Witshire, *S. lignicola* 3 adet kozmopolit Hyphomycet, birer adet *Cladosporium* sp., *Alternaria alternata* (Fr.) Kreissler, *A. pullulans, Wardomyces inflatus* (Marchal) Hennebert, *Cephalosporium* sp, ve 3 adet teşhis edilmemiş, spor oluşturmayan mantar ve çeşitli *Penicillium* spp., izole edilmiştir.

American Wood Preserves' Association M10-74 Standardına göre, test mantarı olarak kreozota ve karışımlarında kreozot bulunan emprenye maddelerine yüksek tolerans gösteren *Lentinus lepideus* Fr. (Madison 534) ile fenolik ve arsenik bileşiklerine toleransı yüksek olan *Gloeophyllum trabeum* (Pers. ex. Fr.) Murr. = [*Lenzites trabea* Pers. ex. Fr.] (Madison 617) mantarları kullanıla-

(*) incising = emprenye maddesinin daha derine ve daha yeknesak nüfuzu için malzemenin lateral yüzeylerinde mekanik yoldan yarıklar açma işlemi.

rak, test uygulanan traverslerin burgu numunelerinden kesilen bolklarda ve karşılaştırma amacıyla aynı biçimdeki emprenye edilmemiş huş ve çam numunelerinde yapılan soil-blok testlerinin sonuçları Tablo 4 ile Şekil 3'te verilmiştir.

Soil-blok testlerinin sonuçlarına göre lamine traverslerin hizmet süresi bakımından önemli olan üst yüzeylerine yakın kısımları –yüzeyden 5.5-16.5 mm– her iki test mantarına karşı yüksek direnç göstermişlerdir (Bu değerlendirmede, numunelerde belirlenen ağırlık kaybının bir kısmının, 12 haftalık inkubasyon süresince kreozot ve petrol yağının buharlaşma veya yıkanma gibi çürüme dışındaki faktörlerin etkilerine atfedilmesi gerekmektedir. Bu tür kayıpların özellikle emprenye maddesi konsantrasyonu yüksek olan dış numunelerde yüksek olacağı kesin olup testlerde bu kayıplar belirlenmemiştir). Kontrol traverslerin aynı noktadan alınan numuneleri ise sadece *G. trabeum*'a karşı yüksek direnç göstermişlerdir.

Görsel değerlendirmeler, lamine traverslerden alınan burgu numunelerinin, kontrol numunelerine kıyasla, daha fazla emprenye maddesi içerdiği izlenimini vermiş ise de Soil-Blok testleri bunların sadece *L. lepideus*'a karşı kontrollardan daha dayanıklı, *G. trabeum*'a karşı ise daha az dayanıklı olduğunu göstermiştir.

Beklendiği üzere emprenye edilmemiş numuneler, emprenye edilmiş numunelere –bunlardan huş, *L. lepideus* testinde % 69, *G. trabeum* testinde % 75; çam *L. lepideus* testinde % 67, *G. trabeum* testinde % 72 ağırlık kaybına uğramıştır– kıyasla çok daha düşük direnç göstermişlerdir. Aynı şekilde beklendiği üzere traverslerden alınan emprenye edilmiş numunelerin *L. lepideus*'a, *G. trabeum*'a kıyasen daha düşük direnç gösterdikleri görülmüştür.

Nort Bay ve St. Lazare'de hizmet görmekte olan lâmine traverslerden alınan burgu numunelerinin mantar çürüklüğüne olan dayanıklılıkları (Tablo 4) iklim bakımından pek farklı olmayan (North Bay genellikle 3°C kadar daha soğuk) bu iki bölgede birbirine benzemektedir.

Artım burgusu ile alınan numune sayısının traversleri yeteri derecede temsil ettiği kabul edildiğinde, lâmine traverslerde hemen hemen hiç mantar çürüklüğü olmadığı belirlenmiştir. Soil-blok testleri de, traverslerin içerdikleri emprenye maddesinin bunları mantar çürümesine karşı yeteri derecede korumakta olduğunu göstermiştir.

Araştırma, traverslerin hizmet sürelerinin belirlenmesinde mantar çürümesinin önemli bir rolü olmadığını ve bu sürenin tahmininde özellikle yoğun trafik sonucu oluşan mekanik zararlar gibi diğer faktörlere öncelik verilmesi gerektiğini ortaya koymuştur.

Test uygulanan 32 lâmine traversin 28 yıllık hizmet süresinde sadece 2 adet fire vermiş olması ve bu incelemenin sonuçları, bu traverslerden 40 yılı aşacak bir ortalama hizmet süresi beklenmesi gerektiğini göstermektedir.

Travers seçiminde lâminasyonun temin ettiği bütün diğer avantajlar da (az stres gören lâminasyonlarda daha düşük kaliteli malzemenin kullanılabilmesi, budak gibi doğal malzeme sakıncalarının ve kuruma çatlaklarının azaltılması ve daha küçük veya standart kereste boyutlarındaki hammaddenin üretimde kullanılabilmesi vb.) gözönünde tutulduğunda lâmine traverslerin kullanım miktarlarının artması beklenmelidir.

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