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MAINTAINING THE INTEGRITY OF THE TRESTLE DECKING

Lt D. S. McKnight

July 1982

Final Report

Approved for public release; distribution unlimited.

AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
Kirtland Air Force Base, NM 87117

AFWL-TR-82-29

This final report was prepared by the Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico, under Job Order 12091301. Lieutenant Darren S. McKnight (NTMD) was the Laboratory Project Officer-in-Charge.

This technical report has been reviewed and is approved for publication.

Darren S. McKnight

DARREN S. MCKNIGHT
2d Lt, USAF
Project Officer

FOR THE COMMANDER

Gerald P. Chapman	Harold O. Spurlin
GERALD P. CHAPMAN	HAROLD O. SPURLIN
Lt Colonel, USAF	Colonel, USAF
Chief, Data & Instrumentation Branch	Chief, EMP Test Division

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This report examines methods of maintaining the integrity of the wood decking (top surface platform) of the TRESTLE Electromagnetic Pulse Simulator located at Kirtland AFB, New Mexico. Since the decking directly supports large aircraft during testing and is completely exposed to the weather its state is examined through a series of experiments which test the condition of the wood and coating, and moisture content levels in the wood. The decking is presently protected by a waterproof epoxy coating. This report looks at an alternative coating

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20. ABSTRACT (Continued)

called Miracote and examines possible modes of protection other than the use of coatings.

PREFACE

This report examines alternatives to maintaining the integrity of the decking on the TRESTLE simulator wood structure, and makes a recommendation as to which alternative is the best. This $60,000,000 test facility is an integral part of the Air Force's EMP Hardening Program, and as such, extra efforts should be made to maintain the capability of its wooden structure to simulate in-flight EMP conditions on large aircraft. For these reasons, the state of the decking and methods to protect it from environmental and operational hazards are studied in this report.

Many individuals, military and civilians, assisted in the writing of this report, but major contributions were made by Dr. Douglas H. Merkle, Applied Research Associates, Albuquerque, New Mexico, and Mr. John J. Ungvarsky, Air Force Weapons Laboratory, Programs Management Office, Kirtland AFB, New Mexico.

A

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ILLUSTRATIONS

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Conversion factors for U.S. customary*
to metric (SI) units of measurement.

To Convert From	To	Multiply By
Board Feet	cm^3	196.6
Feet	cm	30.48
Inch	cm	2.54
Miles/Hour	cm/s	44.70
Pound	kg	0.454
$Feet^2$	cm^2	929
$Pound/ft^3$	kg/cm^3	15.99

*English units are used predominantly in this report because this study deals with lumber and construction which still exclusively use these units. The table above shows conversions needed in this report to convert these English units to metric units.

I. INTRODUCTION

The TRESTLE is the world's largest, glued-laminated (glulam) timber structure. Six million board feet of specially treated Douglas fir from the West Coast region was used in its construction. TRESTLE, located on Kirtland Air Force Base, New Mexico, is divided into two main sections--the ramp and the test stand (Fig. 1).

> The test stand and ramp provide the TRESTLE Simulator with the capability to position the test article in a simulated in-flight condition during EMP testing operations.*

The structure was designed to withstand wind loads of 100 mph without an aircraft on it and 40 mph with an aircraft. The materials used to build TRESTLE were carefully picked according to cost, strength, and dielectric properties.

1. BACKGROUND

The TRESTLE wooden structure (ramp and test stand) cost 12 million dollars to build and is structurally well designed and built. There are, however, minor structural concerns which must be addressed to assure its continuing effective use for many years to come.

The decking directly supports the test article, operates as close to its design allowable as any other member,** and takes the worst beating of any part of the structure and, as such, the decking should be examined.

2. SCOPE

This report will specifically discuss the problems incurred with the platform's decking and makes specific recommendations for solving those problems and, thereby, insuring the integrity of TRESTLE's decking. Problems which have been incurred for years include warpage, expansion, and shrinkage of the deck planking. For TRESTLE to remain an effective simulation facility, these problems must be solved soon. Two different coatings have been used to prevent the deck's further deterioration. These coatings are tested and

*Integrated Electromagnetic Pulse Facilities Brochure, AFWL (NT), Kirtland AFB, NMex 87117, December 1979.
**Conversation with John Ungvarsky and Douglas Merkle on 8 April 1982.

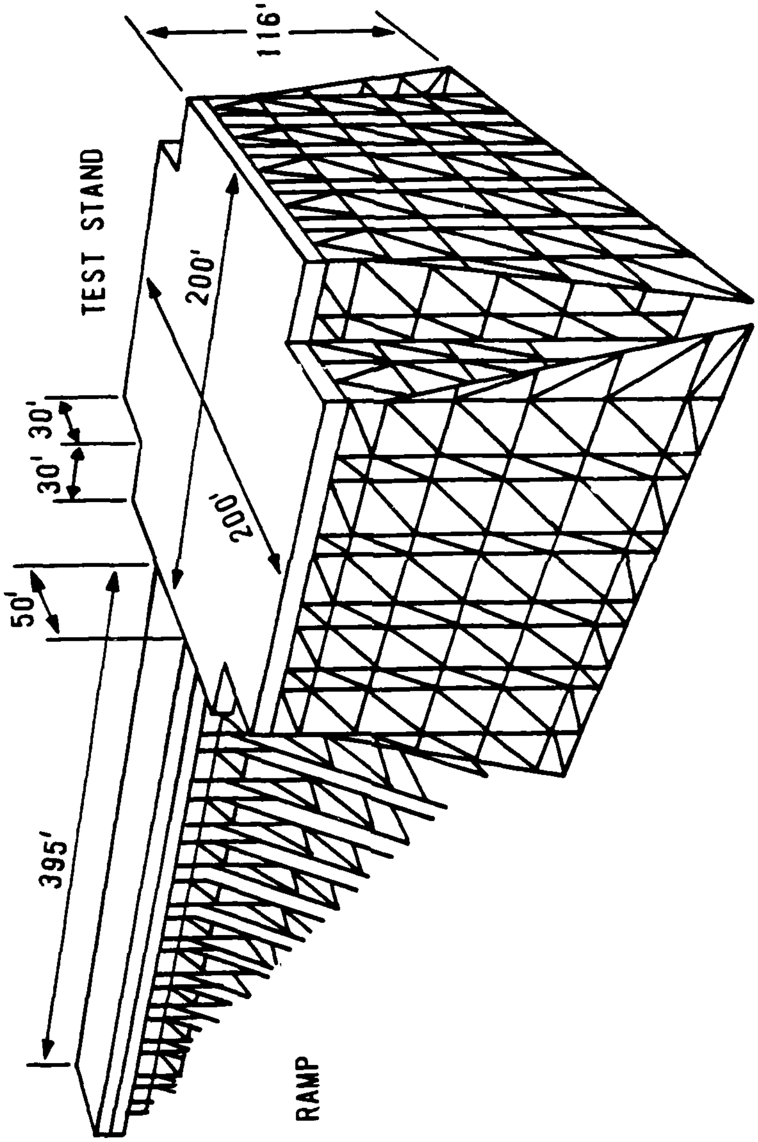

Figure 1. TRESTLE schematic.

evaluated to determine which is most effective in maintaining the decking's integrity. In addition, this report explores alternatives to deck coating and answers the following questions:

a. What type of coating is the most effective in maintaining the integrity of the decking?

b. How well will the bare-wood decking (if left uncoated) hold up to the weather and aging?

c. What is the most cost-effective, long-lasting option available now for maintaining the integrity of the decking?

These key questions are answered by analyzing the results of experiments and observations along with information gathered from professional organizations and technical writings.

II. THE DECK SYSTEM

The deck system consists of planking supported by longitudinal girders resting on column tops. Large cleats or yoke blocks are fastened to the sides of the columns and girders to prevent side thrust especially during wind loading and tire scrubbing. Distributor beams are attached to the underside of the planking between the girders to help distribute concentrated loads which are applied between the plank members. The planking is laid out as shown in Figure 2.

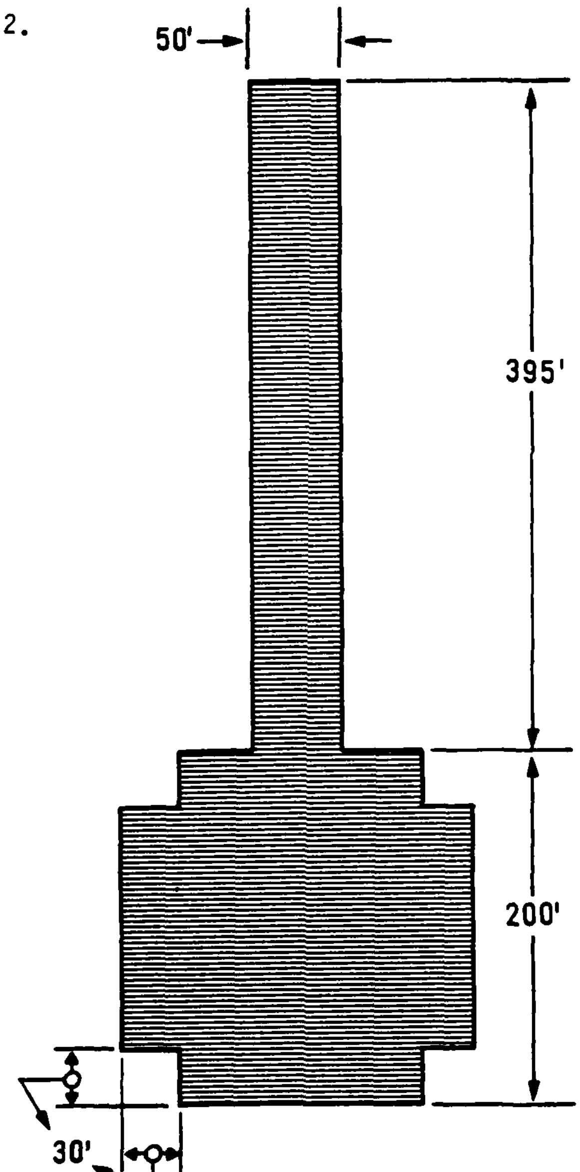

Figure 2. Top view of TRESTLE decking.

The deck planks are 15 in thick, 37.5 in wide and vary in length from 15 to 40 ft. The planks run east/west with the girders and distributor beams running north/south. An east/west cutaway of the decking (Fig. 3) shows the arrangement of the girders and distributor beams with the deck planking.

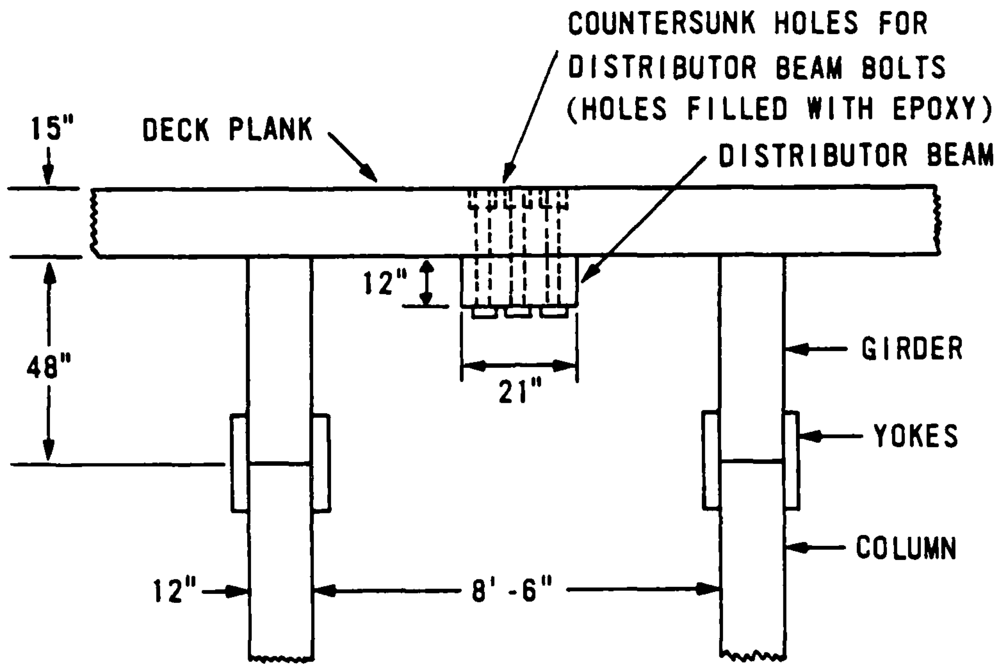

Figure 3. East/west cutaway of decking (looking north/south).

A north/south cutaway of the decking shows the 3/8 in edge gap which is kept between planks to allow for expansion and water runoff (Fig. 4).

The decking was coated with two types of epoxy in the Spring of 1979. The coating chosen, Epoxy 1170, produced by Adhesive Engineering Inc., was selected from the coatings available at the time (1974). Smooth epoxy was used on a 50 ft radius circle in the middle of the test stand to provide protection and a smooth surface for maneuvering an aircraft. The smooth surface lessens the side loading on the yokes which is created by the turning of a test article. The epoxy prevents the aircraft's tires from damaging the deck

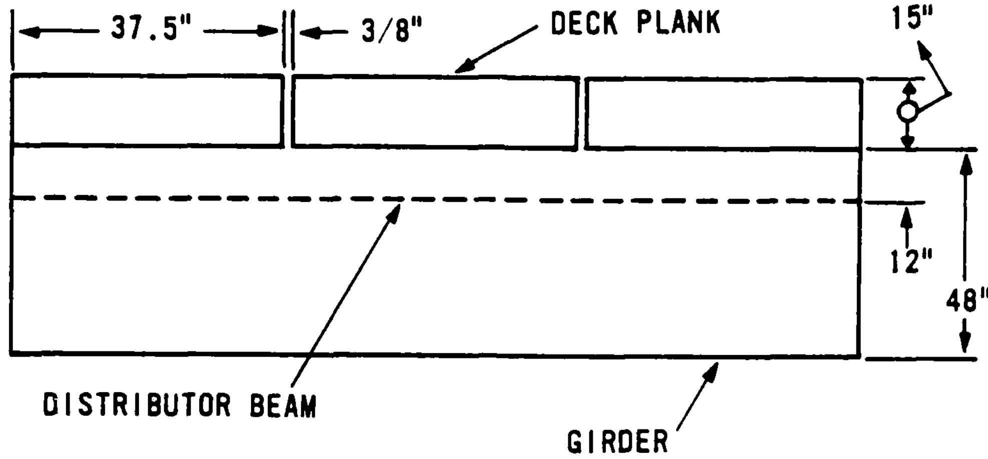

Figure 4. North/south cutaway of decking (looking east/west).

during maneuvering. Rough epoxy (epoxy mixed with silicon sand) was used on the remainder of the decking to provide a protective rough surface for people to walk on safely. In September 1980, a new coating (Miracote) was applied over the epoxy on a portion of the test stand. The performance and specifications of both of these coatings are covered herein.

Originally Epoxy 1170 was used to fill in the countersunk holes which resulted mainly from the installation of the distributor beams. Then its use was expanded to cover areas mentioned previously. Still another function for the coating is to prevent moisture cycling and weathering.

III. FACTORS THAT AFFECT WOOD

There are a number of factors that must be considered in analyzing the condition of the TRESTLE and maintaining its future integrity. The climate in which TRESTLE exists is a major factor in such analysis. There are many climatic conditions in Forest Product Laboratories' Wood Handbook (Ref. 1) that have been determined as important to outdoor wood structures, such as TRESTLE. Some of these factors are relevant to the TRESTLE decking analysis, while others are not. This section discusses the factors which must be taken into account and justifies the omission of other factors. In addition, other nonclimatic factors, such as the effect that aircraft tires have on the decking will be examined.

1. MOISTURE CONTENT

Moisture content of wood is defined as the ratio of weight of water in wood to the weight of oven dried wood (Ref. 2). The moisture content of wood affects a number of its properties including weight, dimension, and strength, and is directly related to the relative humidity and temperature of its surroundings in the absence of precipitation. This moisture content level is called the equilibrium moisture content (EMC). A chart from the Wood Handbook, shows the relationship between temperature/relative humidity and EMC (Table 1).

When it rains the moisture content level in wood can, and usually does, change drastically. These changes in moisture content, referred to as moisture cycling, cause warpage, expansion, shrinkage and cracking which are a result of direct exposure to water. Wood swells as the moisture content increases and shrinks as it decreases. The relationship between dimensional change and moisture content is linear up to the fiber saturation point (30 percent).* The fiber saturation point is defined as when the cell walls are completely saturated but no water exists in cell cavities (Ref. 1). This means that after the moisture content reaches 30 percent, the wood will not

*"Structural Performance Tests for TRESTLE Aircraft Support Structures," WJE No. 79128, Wiss, Janney, Elstner and Associates, Inc., Northbrook, Illinois, January 1980.

TABLE 1. EQUILIBRIUM MOISTURE CONTENTS

Temperature dry-bulb, °F.	Relative humidity, percent																			
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	98
30	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3	26.9
40	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.3	13.5	14.9	16.5	18.5	21.0	24.3	26.9
50	1.4	2.6	3.6	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.3	13.4	14.8	16.4	18.4	20.9	24.3	26.9
60	1.3	2.5	3.6	4.6	5.4	6.2	7.0	7.8	8.6	9.4	10.2	11.1	12.1	13.3	14.6	16.2	18.2	20.7	24.1	26.8
70	1.3	2.5	3.5	4.5	5.4	6.2	6.9	7.7	8.5	9.2	10.1	11.0	12.0	13.1	14.4	16.0	17.9	20.5	23.9	26.6
80	1.3	2.4	3.5	4.4	5.3	6.1	6.8	7.6	8.3	9.1	9.9	10.8	11.7	12.9	14.2	15.7	17.7	20.2	23.6	26.3
90	1.2	2.3	3.4	4.3	5.1	5.9	6.7	7.4	8.1	8.9	9.7	10.5	11.5	12.6	13.9	15.4	17.3	19.8	23.3	26.0
100	1.2	2.3	3.3	4.2	5.0	5.8	6.5	7.2	7.9	8.7	9.5	10.3	11.2	12.3	13.6	15.1	17.0	19.5	22.9	25.6
110	1.1	2.2	3.2	4.0	4.9	5.6	6.3	7.0	7.7	8.4	9.2	10.0	11.0	12.0	13.2	14.7	16.6	19.1	22.4	25.2
120	1.1	2.1	3.0	3.9	4.7	5.4	6.1	6.8	7.5	8.2	8.9	9.7	10.6	11.7	12.9	14.4	16.2	18.6	22.0	24.7
130	1.0	2.0	2.9	3.7	4.5	5.2	5.9	6.6	7.2	7.9	8.7	9.4	10.3	11.3	12.5	14.0	15.8	18.2	21.5	24.2
140	.9	1.9	2.8	3.6	4.3	5.0	5.7	6.3	7.0	7.7	8.4	9.1	10.0	11.0	12.1	13.6	15.3	17.7	21.0	23.7
150	.9	1.8	2.6	3.4	4.1	4.8	5.5	6.1	6.7	7.4	8.1	8.8	9.7	10.6	11.8	13.1	14.9	17.2	20.4	23.1
160	.8	1.6	2.4	3.2	3.9	4.6	5.2	5.8	6.4	7.1	7.8	8.5	9.3	10.3	11.4	12.7	14.4	16.7	19.9	22.5
170	.7	1.5	2.3	3.0	3.7	4.3	4.9	5.6	6.2	6.8	7.4	8.2	9.0	9.9	11.0	12.3	14.0	16.2	19.3	21.9
180	.7	1.4	2.1	2.8	3.5	4.1	4.7	5.3	5.9	6.5	7.1	7.8	8.6	9.5	10.5	11.8	13.5	15.7	18.7	21.3
190	.6	1.3	1.9	2.6	3.2	3.8	4.4	5.0	5.5	6.1	6.8	7.5	8.2	9.1	10.1	11.4	13.0	15.1	18.1	20.7
200	.5	1.1	1.7	2.4	3.0	3.5	4.1	4.6	5.2	5.8	6.4	7.1	7.8	8.7	9.7	10.9	12.5	14.6	17.5	20.0
210	.5	1.0	1.6	2.1	2.7	3.2	3.8	4.3	4.9	5.4	6.0	6.7	7.4	8.3	9.2	10.4	12.0	14.0	16.9	19.3

(After Ref. 1)

expand anymore. Wood can be protected from moisture content changes by using protective coatings (Epoxy 1170 and Miracote in this case).

As the moisture content of wood increases, its strength decreases (Table 2). This is especially true if the higher moisture content is combined with temperatures above 160°F. New Mexico's climate does not provide high humidity and temperature simultaneously of the magnitude which would affect the strength of the wood.

TABLE 2. STATIC BENDING OF DOUGLAS FIR (COAST REGION) AT 70°F (Ref. 3)

Moisture Content	Modulus of Rupture (lb/in^2)	Fiber Stress at Proportional Limit (lb/in^2)	Modulus of Elasticity ($1000\ lb/in^2$)	Shear Modulus (1000 lb)
12	11,700	8,100	1,920	137
36	7,600	4,800	1,550	111

Because of dimensional changes and strength concerns, the moisture content of the decking must be closely monitored. A number of experiments will check closely the moisture content levels under various circumstances.

2. WEATHERING

Weathering is an important factor to consider for outside wood which has no protective coating. Weathering is

> "the mechanical or chemical disintegration and discoloration of the surface of wood caused by exposure to light, the action of dust and sand carried by winds, and the alternate shrinking and swelling of the surface fibers with the continual variation in moisture content brought by changes in the weather" (Ref 1).

For the purpose of this study weathering is important only if the alternative of no coating on the decking is examined or if a transparent coating (clear epoxy or varnish) is used. Under either of these conditions weathering would tend to amplify the problems created by changes in moisture content by increasing warpage, cracking, and a general deterioration of the wood. It should be emphasized here that the Albuquerque area, due to its climate (many sunny days) and its altitude, provides worse than normal ultraviolet (UV) radiation conditions. This UV radiation actually breaks down the cellular structure of wood.

Experiments with natural and artificial aging were conducted on samples of Douglas fir glulam lumber in 1974 (Ref. 4). The wood that was artificially aged 7 to 10 years showed marked deterioration of its structure due to weathering. One artificially aged sample literally fell apart after about 7.2 years of simulated aging (Ref. 4). The aging consisted of moisture cycling and UV radiation similar to that which TRESTLE experiences and, therefore, weathering should be considered in analyzing the decking.

3. DECAY

Wet (moisture content greater than 20 percent) conditions provide the most suitable environment for the growth of wood-destroying fungi and decay to occur. The dry climate of New Mexico is a natural safeguard to decay. In addition, the wood used for the decking was pressure-treated with the Celon process with a pentachlorophenol level of greater than 0.3 lb/ft^3 and closer to 0.5 lb/ft^3.* This type of treatment has proven effective in preventing decay in stake experiments which were conducted by the Forest Products Laboratory in Mississippi. In a stake experiment a treated wooden stake is put into the ground and checked periodically for failure due to decay and for pentachlorophenol retention. The results showed that under these conditions (a wooden stake constantly in moist soil which contains acids and salts naturally) failure due to decay may occur even when most of the pentachlorophenol remains in the test stake. The conditions for this stake experiment are much different than the conditions under which TRESTLE must exist but the results are still pertinent to the analysis of the decking since they show that any wood, no matter how it is treated, is a possible victim of decay as long as oxygen and sustained high moisture content levels are present.

*Discussion with Doug Stadelmann, January, 1982

4. TERMITES

Two types of termites attack wooden structures: subterranean and nonsubterranean. The subterranean termites present no problem to the TRESTLE decking since it is elevated over 100 ft aboveground. The nonsubterranean termites also present no problems because they are not found in this area of New Mexico. Local exterminators have never encountered a wood structure in this area treated with pentachlorophenol which has been infested with nonsubterranean termites. In addition, pentachlorophenol is very toxic to animals and insects. Consequently, termites need not be considered as a factor in analyzing how to maintain the integrity of TRESTLE's decking.

5. SCRUBBING OF TIRES

Large aircraft (e.g., a B-52) must be maneuvered on the test platform to orient them in various positions for testing. This maneuvering will result in the aircraft's tires scrubbing or rubbing the decking. The decking was proven capable of supporting the loads of expected test articles,* but strength and dimensional properties of the decking must be preserved to assure this fact in the future. Unprotected wood soon discolors due to UV radiation. This discoloration is a sign of deterioration of the cellulose fibers and of the lignin (the polymer which binds the cellulose fibers together). Without a good lignin binder, the wood fibers separate which results in flaking and chipping of the wood. For this reason, a large aircraft being pivoted on its wheels will cause more extensive deterioration of the upper layer of wood on the decking, if the wood is not protected. This factor must be taken into account in the decking analysis.

6. CONCLUSION

The most important factor to the integrity of deckings is the moisture content and moisture cycling. Weather, decay and tire scrubbing are of lesser importance. Termites are not a concern in this study.

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*Conversation with John Ungvarsky, 5 March 1982.

IV. ANALYSIS RESULTS

To conclude that one coating is better than another is difficult and subjective. This becomes evident when discussing the appearance of the epoxy and Miracote coatings on the test platform. Some people feel that the epoxy-coated wood is holding up better than the Miracote-coated wood, while others feel the opposite is true.

An objective method of measuring the performance of the two coatings must be developed. There are a number of factors which must be taken into account in this type of evaluation:

1. The number and size of the cracks in the decking and coating.

2. The number of times that delamination of deck planks has occurred.

3. Extent of warpage (edge gap which is needed, disappears); this indirectly refers to moisture content and moisture cycling.

4. The maintenance history of the coatings.

By using these four factors as criteria, a more objective judgment may be made as to the performance of Epoxy 1170 and Miracote. Performance here implies durability and ability of the coating to keep the planking as close to its original state as possible. Experiments concerning the moisture content of the decking have also been performed to provide an additional objective criterion. It should be noted again that moisture cycling of the decking is what causes cracking, warping, and delamination of the decking.

The epoxy on the decking has cracked, flaked, and chipped off in a number of areas; in many places actually leaving bare wood. These imperfections in the coating provide areas where moisture can enter the wood and where the wood can become weathered which amplifies the problems of the deck planks expanding, shrinking, and cracking. These problems accentuated the problem of the edge gap having to be resawn which has had to be done three times. In fact, the edge gap had to be resawn before the original application of the epoxy. The resawing is essential since wood does not return to its original dry dimensions after it has undergone moisture cycling, it only recovers partially. If the edge gap is not resawn the water cannot run off as easily and internal stresses on the tops of the planks cause them to buckle. Internal stresses are also a direct result of moisture gradients alone. This expansion of the planks is more prominent on the top lamination resulting in a crowned appearance of the planks. The plank appears crowned because the moisture content of the wood is higher near the middle of the plank than near the edge gaps (Fig. 5). This crowned nature has actually aided in the runoff of water from the decking as long as the edge gap remains.

Two other problems which are a direct result of the changing dimensions of the wood are: (1) delamination and (2) severe cracking (interior wood fibers can be seen). Delamination is caused when the glue between laminations or the wood itself, usually adjacent to the glue line, fails. This occurs as a result of the wood changing dimensions and the moisture affecting the glue.* When delamination occurs the area must be cleaned out and prepared for the gluing of a new piece of wood in the place of the old laminations. This has occurred about 24 times at a total cost of about $12,000 to the Air Force.** A better coating might decrease these maintenance costs.

Severe cracking (Fig. 6) has occurred in some areas. When surface cracks that are large enough to crack the coating developed, and a new coating is not applied immediately, water collects in these cracks. Absorption of this water causes it to further expand and crack, resulting in still more absorption, expansion, and cracking. In addition, when the wood expands it initially closes the crack and makes it more difficult for it to dry. If this problem is ignored, it could (and may) cause major structural problems by changing the decking's characteristics. Minor cracking and aging are expected and accounted for in determining the platform strength. Prompt maintenance and repair of these cracks will prevent severe cracking and extend the useful life of TRESTLE immeasurably. The severe cracking is a major concern that could greatly reduce the decking's strength.

As shown in Figure 6, a severe crack could eventually separate a plank into two or more smaller planks. The reduced strength area includes only a

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*The glue used, phenol resorsonal, is a waterproof glue but its effectiveness can be degraded by moisture over a period of time.

**From conversation with TRESTLE maintenance contractor, Austin Littell, 8 Feb 82.

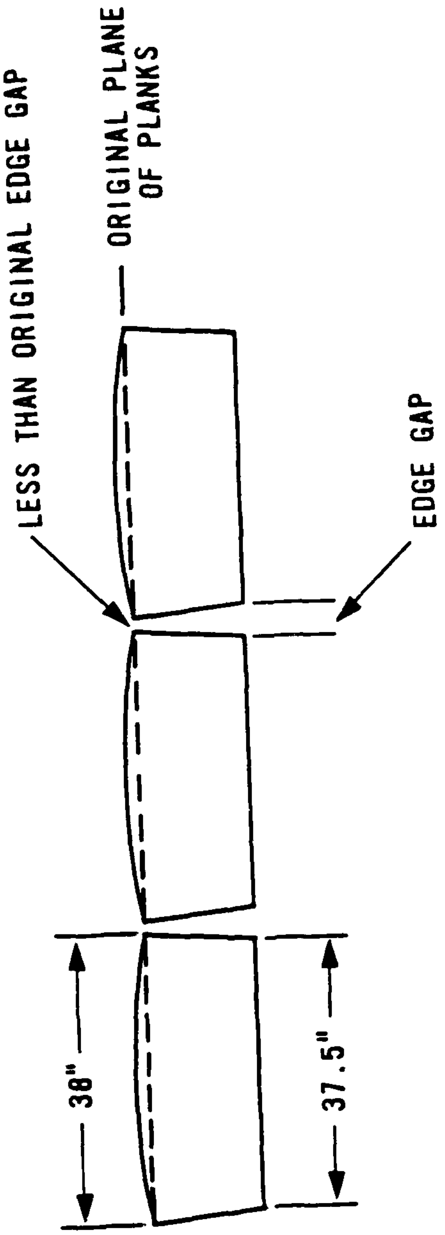

Figure 5. Representation of plank crowning.

portion of the remaining cross section. The variation of the moisture content with depth is an unknown factor which needs to be investigated by an additional study. The depth of the increased moisture content is minimized since glue lines every 1 5/8 in helps to prevent the seepage of moisture. As a result, the higher moisture content levels of the upper laminations in contrast to the drier lower laminations cause high shear between these laminations.

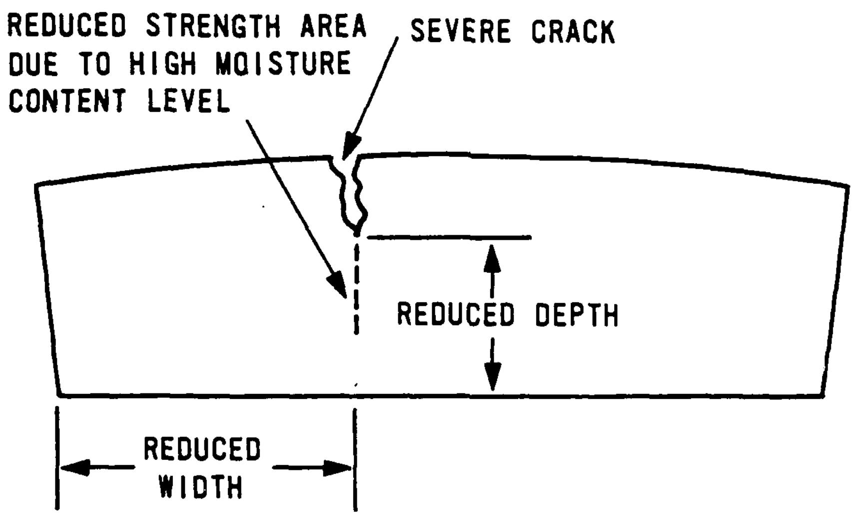

Figure 6. Severe crack - worst case.

Plank separation may result from a severe crack alone or from a large crack which is ripped open (dotted line in Fig. 7) when loaded. The possibility of this rip occurring is increased because where the depth is reduced, the strength of the wood is also reduced, due to the higher moisture content (Table 2). Readings taken on TRESTLE show that the moisture content varies across the cross section of the plank. It is higher on the top and lower on the underside of the planks. In fact, the underside of the planks showed moisture content levels of less than 7 percent. These readings were taken as part of Experiment 1A. These two factors, reduced strength and reduced dimensions, make this area a candidate for failure in horizontal tension (shear)* which would cause one plank to act as two. This phenomena actually occurred in tests conducted on TRESTLE deck planks at the Portland Cement Laboratories in Skokie, Illinois.** The width of the deck planks is an important number in calculating the deck strength. If a severe crack causes one deck plank to act as two planks at half the width, then each of the two new deck planks are at best half as strong as the original one. This is a worst case analysis, but entirely possible, if nothing is done to alter the problems.

It should be noted at this point that the distributor beams were added to the TRESTLE to prevent plank separation, caused by horizontal tension. This is a direct result of combined bending and torsion due to undistributed loading. The builders and designers of TRESTLE feared that as the weight of the aircraft was shifted from one plank to another there was the possibility of one of the planks becoming separated into two. Fig'ire 7 shows what theoretically could happen.

The first plank is loaded unsymmetrically which results in combined bending and torsion on this plank. It is the horizontal tension due to torsion which causes separation. This fracture results because the cross grain tensile strength of the wood is quite low. The distributor beams were added to help prevent this from happening. If the distributor beams are present and intact, the possibility of failure due to horizontal tension is nonexistent. For this reason a study concerning the maintenance of the distributor beams should be done as an addition to this study.

The two problems, severe cracking and horizontal tension, are similar and both safeguarded against by the installation of distributor beams, but at this time the condition of the distributor beams is unknown.

Part of the decking had Miracote applied over the original epoxy coating in September 1980. It is this section which will be compared to a nearby portion of which was coated with epoxy in May 1979. By using the four criterion previously established, a preliminary, limited comparison between Miracote and Epoxy 1170 can be made.

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*Failure in shear is caused when the load is parallel to the face on which failure occurs.
**From a conversation with John Ungvarsky, 5 March 1982.

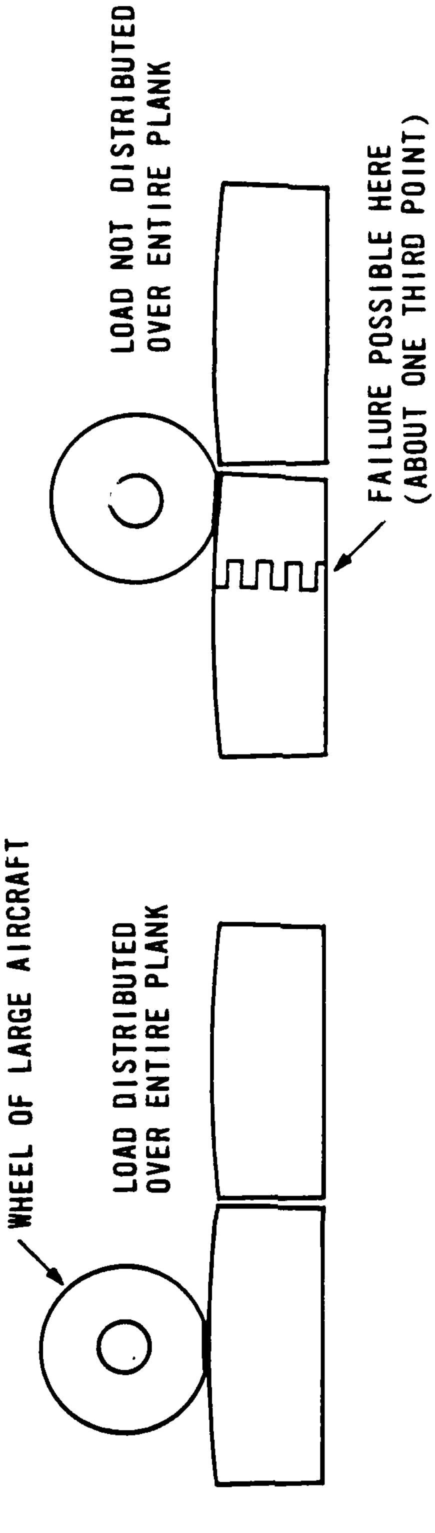


Figure 7. Reason for distributor beams.

Table 3 gives performance comparisons between epoxy only coatings, and Miracote over epoxy coatings. These results show that the area where Miracote was applied over the epoxy was in better condition than the other area. One reason for this was that the Miracote was applied a year after the epoxy. Therefore, the Miracote covered area should be in better condition. On the other hand, the Miracote was applied over the already deteriorating epoxy and this could amplify the existing problems.

TABLE 3. COATING PERFORMANCE COMPARISON (23 FEB 82)

	Miracote Over Epoxy	Epoxy
Number and size of cracks	12 minor cracks[a] for a total length of 48 ft	15 minor cracks for a total length of 54 ft, one 8 ft long severe crack[b] and 5 percent of the wood was bare
Number of times that delamination has occurred	Zero	Zero in area compared to Miracote but a total of 24 times over the entire decking
Amount of warpage (edge gap)	Same as epoxy; level was the same and edge gaps were the same	--------
Maintenance history of coatings	Never had to be reapplied	Had to be reapplied in a number of places

[a]Minor crack = separation in the coating.

[b]Severe crack = interior wood fibers can be seen.

V. EXPERIMENTS

1. OVERVIEW

Three moisture content experiments were conducted for this study These experiments were done at three different locations; (a) TRESTLE, (b) a storage area located near the TRESTLE site, and (c) the F-16 test platform located just north of TRESTLE. At each location moisture content readings were taken over a 4-month period. Each of these experiments is described in more detail after the TRESTLE Decking Experiments Form (which is used for each experiment to organize the data) is explained fully.

a. TRESTLE Decking Experiments Form. Figure 8 shows the form used to record the data obtained during the TRESTLE decking experiments. The top of the form identifies the particular experiment involved, the date of the experiment, and the conditions (temperature, dew point, and relative humidity*) under which the experiment was conducted. Space is provided at the bottom for the moisture content measurements and comments. The diagrams are used to show the particular experiment configuration involved. Included are the experiment sites and points where the moisture content readings are taken. These points (1 through 18) are described further in Appendix A. This form provides quick, thorough, and consistent data acquisition for the three experiments.

2. EXPERIMENT 1A--TRESTLE

This experiment was devised to ascertain the present state of the TRESTLE decking and to compare the effectiveness of Epoxy 1170 and Miracote. Ample measurements at each of these five test areas have been made over a 4-month period to be able to confidently calculate an average moisture content for the decking.

Test Area 1 is an area where Miracote was applied over epoxy. Test Area 4 is a bare spot where the epoxy has chipped off. Test Areas 2, 3, and 5 are

*The weather service available near TRESTLE only supplies the temperature and dew point so the relative humidity must be calculated from these values for each experiment form. The procedure for this conversion is in Appendix E.

TRESTLE Decking Experiments Form

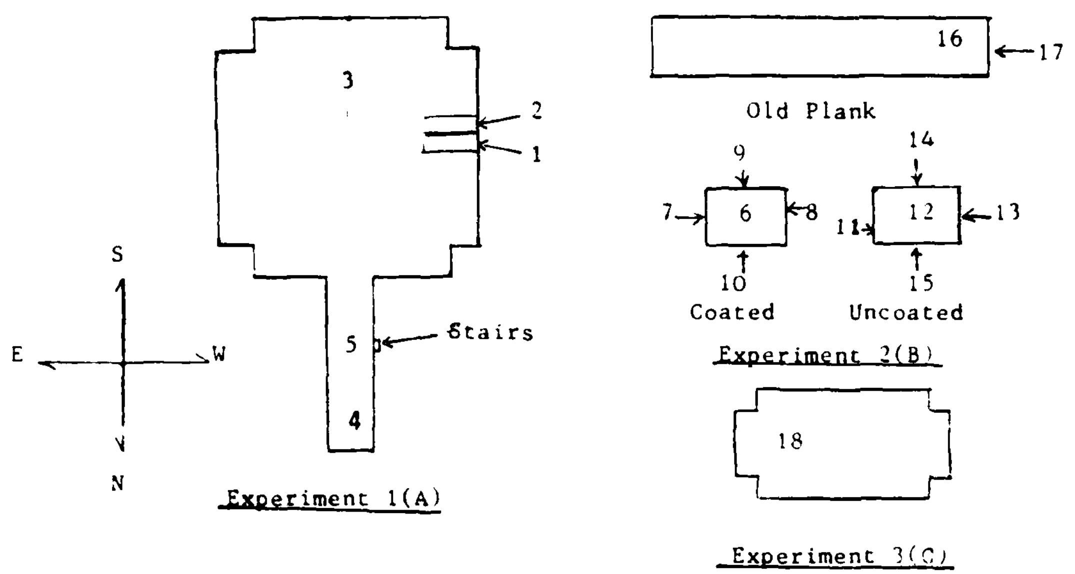
Experiment:

Date:

Temperature:

Dew Point:

Relative Humidity:



Moisture Content Readings:____

COMMENTS:

Figure 8. Form for recording decking experiment data.

all regions where the epoxy is still intact. By comparing the moisture content readings between various test areas, this experiment will answer the following questions:

a. Does Miracote work better than Epoxy 1170 to keep moisture out of the wood?

b. Do coatings actually hold the moisture in the wood more than they keep it out?

c. What is the moisture content of the decking at various places?

During this experiment, 200 moisture content readings were taken at 71 test areas on the platform decking. This gridwork was used as a means to verify the accuracy of the readings taken periodically at the five test areas of interest. The gridwork of these 71 test areas and the readings taken at each area are located in Appendix F.

3. EXPERIMENT 2B--BLOCK EXPERIMENT

To assess the performance of Miracote another parallel experiment was performed. Two blocks (2 ft x 1 ft x 1 ft) of Douglas fir glulam lumber were placed side by side at an outside storage area near TRESTLE. One block was coated on all sides with Miracote while the other was left bare. The two blocks were placed 3/8-in apart to simulate an edge gap on the platform decking of TRESTLE. The appearance and moisture content of these two blocks were observed, measured, and compared over a period of time. In addition, a deck plank was observed that was left uncoated and outside in the weather since TRESTLE was built. The condition of this plank indicates how the TRESTLE decking would have looked if it had been left uncoated and unprotected. Comparison of the two blocks and the uncoated deck plank should answer the following questions:

a. Does the decking require some type of coating?

b. Does Miracote keep moisture out of the wood?

c. Is the moisture content higher in the edge gaps compared to the exposed areas of the decking?

4. EXPERIMENT 3C--F-16 TEST PLATFORM

A special test stand was built for the F-16 aircraft using Southern Pine. Southern Pine is similar to the wood used to build TRESTLE. This stand (considerably smaller than TRESTLE) was coated with Miracote over the original coating, Epoxy 1170. Moisture content readings were taken at various test areas on the stand's decking. This experiment should answer the following question: How well did coatings prevent dimensional changes (warpage, shrinkage, etc.) in the wood due to moisture cycling?

5. RESULTS

The moisture content readings obtained from the three experiments (including gridwork) are summarized in Table 4. The experiments were conducted over a 4-month period (December 1981 through March 1982). The gridwork (over 200 measurements) was accomplished on 17 February 1982.

TABLE 4. AVERAGE MOISTURE CONTENT VALUES

	Ave Moist Cont (No Crack)(%)	Ave Moist Cont (Crack)(%)	Ave EMC(%)
EXPERIMENTS			
TRESTLE	15.3	25.5	8
COATED BLOCK	10.7	----	8
UNCOATED BLOCK	12.3	----	8
F-16 PLATFORM	11.0	----	8
GRIDWORK			
TRESTLE RAMP	22.9	32.3	10
TRESTLE TEST PLATFORM	15.7	29.5	10
TRESTLE TOTAL	17.3	30.1	10

Table 5 reveals some interesting facts about the climate in the Albuquerque area. The table shows that although there historically is not much precipitation during the December through March period, the equilibrium moisture content level is higher than during other periods throughout the year. This table shows that conditions change greatly throughout the year.

This drastic climatic variance must be taken into account when analyzing the data obtained during these experiments.

TABLE 5. ALBUQUERQUE CLIMATE

Month	Average Temp (°F)	Aver Rel Humidity (%)	Average Precip (in)	Average EMC (%)
Jan	35	42	0.4	8
Feb	40	36	0.4	7
Mar	46	28	0.5	6
Apr	55	22	0.5	5
May	65	20	0.8	4.5
Jun	75	19	0.6	4
Jul	78	28	1.2	5.5
Aug	76	32	1.3	6.5
Sep	70	29	1.0	6
Oct	58	31	0.8	6
Nov	44	35	0.4	7
Dec	37	42	0.5	8

Table 5 describes the average climate for the TRESTLE but Table 6 shows the actual rainfall encountered during the course of testing. It can be seen that the actual rainfall was less than normal for this time period.

TABLE 6. ACTUAL RAINFALL (FROM 1 DEC - 5 MAR)*

Date	Amount of precipitation (in)
Dec (total)	-0-
1 Jan	0.04
2 Jan	Trace
11 Jan	0.05
12 Jan	0.17
13 Jan	0.02
29 Jan	0.03
30 Jan	0.01
Jan (total)	-0.32-
1 Feb	0.08
3 Feb	Trace
5 Feb	Trace
8 Feb	Trace
10 Feb	Trace
11 Feb	0.10
14 Feb	Trace
18 Feb	Trace
24 Feb	Trace
25 Feb	0.02
Feb (total)	-0.20-
2 Mar	0.17
3 Mar	Trace
5 Mar	0.06

*Information obtained from Base Operations at KAFB, NMex.

Increases in moisture content levels due to the EMC cannot be prevented, but changes in the levels due to precipitation may be almost entirely eliminated if the waterproof coatings remain intact.* All of these factors were considered in determining the results of each of the three experiments and answering the questions asked.

a. TRESTLE Readings--Experiment 1A. Both of the coatings tested, Epoxy 1170 and Miracote, are waterproof and both keep moisture out of the wood as well as the other as long as they are intact.** Comparison of the data obtained from Test Areas 1 and 2 (no cracks in these areas) shows this. The average for Test Area 1 (Miracote over epoxy) was 14 percent and the average for Test Area 2 was 15 percent. The data showed that the coatings actually held the moisture in the decking and caused the moisture content levels to be higher. This is shown by the fact that the moisture content is lower near the edge gaps and higher at the middle of the planks. This result is partially due to the fact that drying is a diffusion phenomenon and, therefore, the moisture content would be slightly higher near the middle of the plank even if there was no coating. The two readings at points on the underside of the decking averaged 6.75 percent. This low reading average indicates that moisture content readings obtained from on top of the decking do not represent the average for the entire plank, especially since glue lines every 1 5/8 in act as natural barriers to moisture penetration. The average moisture content level for Test Area 4 (where the epoxy was chipped off the wood) was 12 percent. The average for the rest of the areas was about 16 percent. In the areas where cracks occurred in the epoxy and Miracote, the moisture content levels were much higher, averaging at 25 percent. Although the cracks readily allow water to enter the wood, it takes much longer for the water to leave the cracks because of the sealing effect of the coating. Miracote is better at preventing this moisture retention because it has a level of water vapor transmission. Water vapor transmissivity means that water vapor can pass through the coating to some extent while it remains impervious to liquid water. Table 7 summarizes all of the moisture content readings obtained in Experiment 1A.

*This is explained in the results obtained from the F-16 experiment.
**This conclusion is based on the results from this experiment only. The results obtained from Experiment 3C will clarify this statement.

TABLE 7. EXPERIMENT 1A MOISTURE CONTENT READINGS

		1		2		3		4		5	
Date	EMC %	NC	C	NC	C	NC	C	NC	C	NC	C
16 Dec	4.6	9.9	19.7	--	12.1	11.8	15.7	13.5	--	11.5	--
4 Jan	4.6	11.2	29.0	11.7	30.5	13.1	22.9	11.8	--	16.0	22.5
6 Jan	4.6	14.8	21.6	12.0	22.5	13.5	22.5	10.7	--	17.5	22.9
8 Jan	13.5	10.0	17.5	11.2	18.5	10.5	14.5	10.5	--	16.4	16.4
11 Jan	11.3	19.5	26.5	27.5	20.0	14.2	18.5	13.2	--	15.5	36.5
12 Jan	13.5	20.1	28.5	20.5	28.5	22.0	31.5	21.0	--	20.2	28.5
15 Jan	10.0	21.0	23.0	23.0	25.5	18.0	26.0	11.0	--	21.0	25.0
18 Jan	7.1	12.0	31.0	13.5	28.0	15.0	23.5	12.0	--	18.5	28.0
20 Jan	4.5	13.5	30.0	14.5	31.0	13.0	28.0	13.0	--	25.5	27.5
25 Jan	8.5	14.0	26.0	14.0	24.0	13.5	29.5	11.0	--	23.5	25.0
27 Jan	6.0	13.0	20.0	12.0	18.5	18.0	21.0	13.0	--	18.0	19.0
1 Feb	11.3	15.5	26.0	18.5	29.5	22.5	25.0	13.0	--	25.0	25.0
8 Feb	7.0	15.5	28.5	17.5	33.5	--	--	12.5	--	17.5	34.5
17 Feb	9.0	12.5	30.5	13.5	28.5	14.5	25.5	12.5	--	26.5	37.5
26 Feb	13.5	14.0	22.0	15.0	32.0	12.0	20.0	13.5	--	21.0	35.0
3 Mar	11.3	13.5	16.0	18.5	26.5	14.5	26.0	12.5	--	16.0	24.5

Note: An adjustment for temperature has been added into these values.

b. Block Experiment--Experiment 2B. In the experiment conducted with uncoated and coated blocks, the bare block has already shown effects (after only 4 mo.) of weathering and increased moisture content. The average moisture content for the uncoated block is 12.3 percent and for the coated block 10.7 percent. This shows that the Miracote is effective in keeping the moisture content of the wood low. This experiment also hinted that the edge gap does not cause the wood to retain moisture longer. This is shown by the fact that the areas of the two wood blocks that were placed 3/8 in apart did not have higher moisture content levels than the remaining faces. In addition to these block experiments, others were made on the edge gaps of the TRESTLE's decking to determine if the gaps contributed to the decreased moisture content levels since the edge gaps are not coated. If the edge gap allows more moisture to enter the wood, the moisture content level should be higher near the gap and decrease closer to the center of this plank. However, actual test results proved different. The moisture content levels were higher near the middle of the planks than at the edge gaps. This is a result of the wood near the edge gap being affected more by the atmosphere and that the equilibrium moisture content is usually between 6 and 14 percent. The moisture content of the wood near the middle of the plank also changes much more slowly. Table 8 summarizes all of the moisture content readings obtained in Experiment 2B.

TABLE 8. EXPERIMENT 2B MOISTURE CONTENT READINGS

Date	EMC (%)	COATED BLOCK (%)	UNCOATED BLOCK (%)	OLD PLANK (%)
18 Dec	4.6	9.3	9.7	11.5
4 Jan	4.6	9.5	11.1	14.5
6 Jan	4.6	8.9	9.5	--
11 Jan	11.3	9.2	11.5	20.5
12 Jan	13.5	21.5	26.5	28.5
15 Jan	10.0	11.0	12.3	15.0
18 Jan	9.1	10.2	12.5	18.5
20 Jan	4.5	10.6	11.9	16.5
25 Jan	8.5	11.0	12.5	15.5
17 Feb	6.3	10.5	11.3	9.5

Note: An adjustment for temperature has been added into these values.

c. F-16 Test Platform--Experiment 3C. The coatings have performed well on the F-16 test platform. The platform was coated in October of 1980 and no observable cracks have formed as of March 1982. The average moisture content (11 percent) of the F-16 platform is much lower than that of TRESTLE. The moisture content range on the F-16 test platform varied from 10 to 13 percent while on the TRESTLE, the readings have ranged from 8 to 45 percent. The F-16 platform's decking planks are made of Southern Pine, arranged vertically and smaller than the TRESTLE deck planks, while TRESTLE's decking is made of

Douglas fir and the planks are arranged horizontally. These differences may be part of the reason for the discrepancy in moisture content levels. It is these differences and changes in moisture content that cause dimensional changes in wood; i.e., warpage, shrinkage, expansion.

Table 9 summarizes all the moisture content readings obtained in Experiment 3C.

TABLE 9. EXPERIMENT 3C MOISTURE CONTENT READINGS

Date	EMC (%)	F-16 Test Platform (%)
8 Jan	4.6	11.3
4 Jan	11.3	11.0
12 Jan	13.5	10.2
18 Jan	7.1	10.7
20 Jan	4.5	11.7
25 Jan	9.0	12.5
1 Feb	8.5	11.25
10 Feb	6.7	12.5
17 Feb	6.3	11.5
23 Feb	11.0	11.3
26 Feb	13.5	8.5
3 Mar	11.3	12.5

Note: An adjustment for temperature has been added into these values.

VI. WHICH COATING IS THE BEST

1. INTRODUCTION

Four factors must be considered in deciding which coating is best: (a) effectiveness of keeping moisture out of wood, (b) lifespan, (c) cost, and (d) ease of application. These four factors will be evaluated by looking at the results of experiments and performance to date. When the TRESTLE was built, Epoxy 1170 was chosen from a wide field of coatings as the best overall coating available. Since that time Miracote has become available, so in essence by comparing Miracote and Epoxy 1170, Miracote is actually being compared to a large number of coatings. It would be wasteful to start from a complete field of coatings at this time.

The effectiveness of a coating to keep moisture out of wood was examined in the three experiments conducted for this test. In Experiment 1A, the results show that where either coating was intact the moisture content did not vary appreciably and the average moisture content was about 16 percent. Where cracks in the coating were present the moisture content was much higher, averaging about 25 percent. Both of these values were higher for the results from the gridwork, 17 and 30 percent, respectively.

2. LIFESPAN AND KEEPING MOISTURE OUT OF WOOD

The lifespan of a coating is partially based on its ability to keep moisture out of the wood. When the coating cracks and allows moisture to enter the wood, its functional lifespan has ended. Miracote has the edge in this category since it has some elasticity (6 percent) while epoxy has no elastic qualities at all. Six percent elasticity means that Miracote can be stretched 6 percent of its original length without cracks appearing, whereas Epoxy 1170 will crack if even the slightest stretching is attempted (0 percent elasticity). Due to the elastic quality of Miracote, fewer cracks will form on the decking when it is used. At this point the maintenance required to keep the coating intact must be taken into account. Again, this would be less for the Miracote since it would crack less. The ultimate lifespan of the coatings depend on usage, weather conditions and maintenance. Miracote has the edge in this category due to its better elasticity.

3. COST

The cost of the coatings is an important factor in deciding which one to use. Table 10 summarizes the cost of the Epoxy 1170 and Miracote as of February 1982.

TABLE 10. COMPARISON OF COATING COST

	Miracote	Epoxy (1170)
Cost of Coating to Coat Entire Decking[a]	\$23,000 (2 coats)	\$34,500 (1 coat)

[a]The area of the ramp and test platform is 56,150 sq ft. Prices were obtained from the Miracote distributor in Albuquerque.

The labor to apply either coating is approximately \$25,000, which does not include the cost for stripping the epoxy from the decking (this should be done before the application of either coating).

4. EASE OF APPLICATION AND DIELECTRIC PROPERTIES

Epoxy has a shelf life of 1 year while Miracote can be stored indefinitely as long as it is not subjected to a freeze. The shelf life of Epoxy 1170 has caused problems with application. When the shelf life is exceeded, the epoxy does not set properly and must be removed. This problem does not occur when using Miracote. Both coatings are applied in a similar manner. Miracote has a dielectric constant of 5.24 while the epoxy's is about 5.

5. CONCLUSION

By using the results of the experiments and the performances of the coatings to date, it is concluded that at this time the best coating to use on the decking is Miracote. Miracote is an inexpensive, elastic, waterproof acrylic which is easy to store. The use of Miracote with a comprehensive maintenance plan will provide adequate protection to maintain the integrity of the decking for many years, but alternatives to coating should also be examined.

VII. ALTERNATIVES TO COATING

1. INTRODUCTION

Not to use a coating on the decking would make it imperative to create alternative systems to provide (a) a smooth, tough area in the middle of the test platform for aircraft maneuvering and (b) a device to prevent weathering on the rest of the platform.

2. SMOOTH TOUGH AREA FOR AIRCRAFT MANEUVERING

Two groups of options have been suggested as alternatives in providing a smooth tough surface for the aircraft maneuvering. First, a portable, durable, long lasting, reusable, smooth surface could be used. Second, a nondurable, nonreusable surface could be used. The area for an individual surface need not exceed 25 sq ft. This area is the maximum area of any wheel pattern of aircraft which might be tested on the TRESTLE.

a. The original idea for a durable surface was a set of Teflon plates large enough for the aircraft to be turned on but small enough to be removed before pulsing. Plates of Teflon which are 2 ft^2 and 1 in thick would cost $571.20 a piece.

b. In researching the feasibility of Teflon as a smooth tough surface a superior product was found. Ultra High Molecular Weight (UHMW) polyethylene is stronger, smoother, and almost ten times cheaper than Teflon. This material comes in 4 by 10 ft sheets in varying thicknesses. The 1-in thickness costs $15.00/$ft^2$. In addition, the dielectric constant of UHMW is 2.3 at 1 KHz.* This low value of dielectric constant would allow these sheets to remain on the platform during pulsing.

c. A nonreusable surface may be provided by the use of plywood sheets. An aircraft could be towed onto these sheets and then turned. (Splintering into the tires may be a problem.) Plywood is inexpensive with 4 by 8 ft sheets of 3/8-in thickness ranging from $6.00 to $13.50.**

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*Information about Teflon and UHMW was obtained from an Albuquerque plastic distributor during a phone conversation on 23 February 1982.
**Prices obtained from Albuquerque lumber stores, February 1982.

3. PROTECTIVE DEVICE TO PREVENT WEATHERING

If the deck is left uncovered it will deteriorate due to exposure to the sun and moisture content changes. Consequently, a durable, waterproof covering must be devised to protect the decking when tests are not being conducted. A local distributor of protective coverings identified three types and provided information about each.* One of the cheapest types of coverings is polypropolene. It is .197 in thick with a rip-stop feature which prevents a small rip from becoming large under normal operations (truckers use this type of covering to cover loads temporarily when traveling). The next type of covering is canvas. Canvas is simply specially treated cotton which has no rip-stop feature. Canvas is more expensive and heavier than polypropalene. The third type is vinyl tarp. It has the rip-stop feature and is used for long-term covering purposes. It is the heaviest, strongest, and most expensive covering available. Table 11 compares the costs and weights of the amount of each covering needed to cover the entire 56,150 ft of decking.

TABLE 11. PROTECTIVE COVERINGS

	Polypropolene	Canvas	Vinyl Tarp
Price	\$7,300 (13¢/ft^2)	\$19,650 (35¢/ft^2)	\$30,900 (55¢/ft^2)
Weight	1,950 lbs (5 oz/yd^2)	4,680 lbs (12 oz/sq^2)	7,020 lbs (18 oz/yd^2)

In the Spring of 1979, two canvas tarps were used temporarily to cover part of the ramp while the deck was being prepared for the application of coating. The tarps (approximately 50 ft by 100 ft) were cumbersome and dangerous. It took six workers to move the tarps. Wind flowing through the edge gap necessitated the use of sandbags at 10 ft intervals to hold down the tarps. Once during the implacing of a tarp, a worker was thrown about 12 ft when the wind

*Information was obtained from a telephone conversation with a saleslady of Radar Test and Awning on 10 February 1982.

blew the tarp up from the decking. After a few days of use, it was concluded that the tarps would be destroyed beyond repair after a few weeks so they were removed.* In addition to these observations, the local distributor for the protective coverings said it would be impossible to cover an area the size of the decking with one continuous covering. The slightest wind would cause whipping of the cover, which would assuredly cause failure in even the best of coverings. To protect the decking, the tarp would have to be placed on the decking in pieces with a series of overlapping joints. In this arrangement it would be possible for the water to run under the covering and wet the decking. This situation would not be acceptable.

4. CONCLUSION

The look at alternatives to coating was very limited but some conclusions are obvious. First, these alternatives would be cumbersome, expensive, and their effectiveness questionable. It may be concluded at this point that the application of coatings is the most effective way to maintain the integrity of the decking.

*From conversation with John Ungvarsky, 5 March 1982.

VIII. ADVERSE EFFECTS ON ELECTROMAGNETIC FIELD

This report has directly examined how to maintain the structural integrity of the TRESTLE deck by looking at a number of factors. One of the most important factors, the moisture content of the decking, also has a possible effect on the ability of the TRESTLE to simulate airborne effects of an electromagnetic pulse (EMP) on a test article.

Original analysis examining the effects of the wooden test structure on the degradation and propagation of the EMP were completed in 1977 (Ref. 5). These documents investigated the effects of a theoretical dielectric slab (the decking) on an EMP. An important assumption in this analysis was the value for the dielectric constant used for the wood. The highest dielectric constant (worst case) assumed was 10 for a frequency of 1 MHz and a moisture content of less than 5 percent. The dielectric constant of wood increases as moisture content increases and frequency decreases. The range of moisture contents present on the decking are given in the results of Experiment 2A and the range of frequencies over which the TRESTLE pulser operates well is 300 KHz to 30 MHz. By using this data and Reference 6, Table 12 was formulated to represent ranges of dielectric constants. It should be noted that low values of dielectric constants are the most desirable.

TABLE 12. DIELECTRIC CONSTANT[a] VERSUS MOISTURE CONTENT AND FREQUENCY (AT 77°F)

FREQUENCY	50 MHz	3.3	5.0	6.2	7.8	43
	10 MHz	3.7	5.5	7.0	8.9	44
	1 MHz	4.1	6.1	8.7	12.3	53
	100 MHz	4.3	6.8	11.7	19.0	83
		5.4	11.8	16.4	23.3	Soaked (130)
		MOISTURE CONTENT (PERCENT)				

[a]The dielectric constants in the table are averages of radial, tangential, and longitudinal measurements.

As the moisture content goes above 15 percent the dielectric constant begins to increase above 10 and because of this the capability of keeping the moisture content of the decking low (less than 15 percent) is very important.

IX. CONCLUSION

This study examined the decking on the TRESTLE test platform to determine how to best maintain the decking to insure its effective use in the future. It was found that coating the deck with Miracote is the best way to maintain the deck's integrity.

Alternatives to coating (covering TRESTLE with canvas, vinyl, or polypropalene) are expensive and unproven for this specific application. The old epoxy and Miracote coatings must be stripped off the decking, weak glue-laminations replaced, the decking permitted to reach EMC, and the deck recoated with Miracote. The removal of the epoxy is recommended due to its present condition of chipping and peeling. A maintenance plan must be established that insures frequent checking (monthly) of the coating's condition and reapplication of Miracote on any crack or surface flaw.

The reasons for these recommendations are (1) present structural concerns, (2) concerns with dielectric properties and, (3) cost.

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4. Natural and Artificial Aging Comparison of Various Dielectric Materials to be Used at the TRESTLE Site, SDRL 34, WBS 3.3.2, BDM/A-97-74-TR, BDM Corp., Albuquerque, New Mexico, July 1974.

5. Latham, R. W., Atlas Memos, "Reflection from an Array of Dielectric Posts," Sensor and Simulation Notes, Note 80, Northrop Corporate Laboratories, Pasadena, Calif, June 1973.

6. Dielectric Properties of Wood and Hardboard: Variation with Temperature, Frequency, Moisture Content and Grain Orientation, FPL 245, U.S. Department of Agriculture, Madison, WI, 1975.

APPENDIX A
SPECIFICATIONS FOR MOISTURE CONTENT READING DEVICE

The moisture content reading device used in all the experiments has the following description:

Model RC-2, D
S/N 6046
Government Property Number 02687

Made By: Delmhorst Instrument Co.
Boonton, NJ

Power Supply:	two 9-V batteries
Electrode:	2-prong, 26E
Dimensions:	8.25-in x 7.0-in x 3.75-in
Weight:	approximately 3 lbs

APPENDIX B

PROCEDURE FOR TAKING MOISTURE CONTENT READINGS

When taking a moisture content reading, certain precautions must be observed:

1. Do not take moisture content readings when the temperature is below 30°F because the prongs will break off easily.

2. Change prongs when paint gets scraped off to insure that the readings are accurate. When the prongs lose their insulation, the reading is taken from the meter reading, not the corrected reading.

3. Never leave the instrument on any longer than absolutely necessary, to preserve the life of the batteries.

4. Additional calibrations should be made periodically (once a week) to check the accuracy of the device. A 22 MΩ resistor coupled between the two prongs should give a reading of 14.5 percent (±0.5 percent) if the instrument is working properly.

The following procedures should be taken for each moisture content reading to be taken:

1. Calibrate the instrument to X, then to Y, and again to X.

2. Switch the instrument to Moisture Content.

3. Place the two prongs along the grain of the wood. Make sure the prongs are perpendicular to the wood.

4. Drive the prongs into the wood until the wood is 1/4 in from the prongs' attachment.

5. Do not record a reading until the needle has stabilized.

Note: The reading on the instrument's dial refers to the top row of numbers on the table attached to the clear face, but the moisture content is the value on the lowest row.

Temperature (°F)	Correction (%)
30	+2
50	+1
70	0
90	-1

Note: Temperature will affect the readings slightly and these corrections must be incorporated into each reading.

APPENDIX C
PRECISE DEFINITION OF TEST POINT

Test Area

1. This section of the decking is coated with Miracote over Epoxy 1170. The Miracote was applied in September 1980 over the epoxy as an experiment. It is approximately in the middle of the west side of the decking. Readings are taken at various points along this section (3 ft by 20 ft).

2. This test area is immediately adjacent to Test Area 1 and has the same dimensions. This section of the decking is coated only with epoxy which was applied in the spring of 1979.

3. This test area (2 ft by 2 ft) is located on the centerline of the decking 75 ft from the south edge of the decking.

4. This test area is 181 ft from the north end of the test ramp near the centerline of the ramp. The area is about 3 in by 16 in and is a bare spot where the epoxy cracked and came off the decking.

5. This test area is 212 ft from the north end of the ramp (adjacent to the stairs) on the centerline of the ramp. The test area is approximately a 2 ft by 2 ft area.

6-10. These test areas represent faces of the Miracote-coated block. Test Area 6 is the top of the block and Test Areas 7, 8, 9, 10 are the east, west, north, and south faces, respectively. Test Area 8 is only 3/8 in away from the uncoated block.

11-15. These test areas represent faces of the uncoated block. Test Area 12 is the top of the block and Test Areas 11, 13, 14, 15 are the east, west, north, and south faces, respectively. Test Area 11 is only 3/8 in away from the coated block (Test Area 8).

16-17. These test areas are located on an original deck plank which was not used on the decking when it was originally built. Test Area 16 is the top of the plank while Test Area 17 is the end of the plank.

18. Test Area 18 is a 3 ft by 3 ft area in the middle of the F-16 test platform.

APPENDIX D
HOW TO COMPUTE RELATIVE HUMIDITY

TABLE D1. RELATIVE HUMIDITY TABLE

TEMPERATURE													
80	4	5	7	8	11	13	16	20	24	29	35	42	50
75	5	6	8	10	12	15	19	23	28	34	41	50	59
70	6	8	10	12	15	18	22	27	33	41	49	59	71
65	7	9	11	14	17	21	26	33	40	48	58	70	84
60	9	11	14	17	21	26	32	39	48	57	70	84	100
55	10	13	16	20	25	31	38	48	57	69	84	100	
50	12	15	20	24	30	37	46	56	68	83	100		
45	15	19	24	30	36	45	55	68	83	100			
40	18	23	28	35	44	55	67	82	100				
35	22	28	35	43	54	66	81	100					
30	27	34	43	53	66	81	100						
25	33	42	52	65	81	100							
20	41	52	65	80	100								
15	51	64	80	100									
10	63	80	100										
	0	5	10	15	20	25	30	35	40	45	50	55	60

DEW POINT (°F)
(WET BULB)

This table was tabulated using a Psychrometric Calculator provided by Kirtland Air Force Base's Base Operations. Below is some information on the calculator:

Model - ML-429/UM
Stock Number - 6685-399-7998
Order Number - 7192-PP-59
Made For - Signal Corps, U.S. Army
Made By - Seaview Electric Company
Avon, New Jersey

APPENDIX E
AWS CLIMATIC BRIEF

AWS CLIMATIC BRIEF	Albuquerque-Sunport/Kirtland AFB, NMex
Prepared by ETAC (Jul 71)	PERIOD: 1939-70 ELEVATION: 5362 ft

MONTH	TEMPERATURE (°F)				PRECIPITATION (in)		WIND (KT)		MEAN		
	Extreme Maximum	Mean Daily Maximum	Mean Daily Minimum	Extreme Minimum	Mean Total	Mean Snowfall	Mean Speed	Extreme (Fastest) Speed (Mile)	Relative Humidity (%) 0400	Relative Humidity (%) 1300	Dew Point (°F)
JAN	68	46	24	-7	0.4	2	7	53	65	42	19
FEB	72	52	28	-4	0.4	2	8	59	61	36	20
MAR	80	59	33	9	0.5	2	9	70	53	28	19
APR	89	69	42	20	0.5	#	9	63	46	22	23
MAY	97	78	52	28	0.8	#	9	63	44	20	30
JUN	102	89	61	43	0.6	0	9	71	41	19	36
JUL	104	91	66	54	1.2	0	8	59	57	28	50
AUG	99	88	64	52	1.3	0	7	53	63	32	52
SEP	96	82	58	37	1.0	#	7	54	55	29	42
OCT	87	71	45	25	0.8	#	7	57	57	31	33
NOV	74	56	31	10	0.4	1	7	50	61	35	24
DEC	72	48	26	3	0.5	3	6	78	65	42	20
ANN	104	69	44	-7	8.4	10	8	78	56	30	31
EYR	28	30	30	28	30	31	31	31	25	25	25

Source: Base Operations, Kirtland AFB, NMex

APPENDIX F
GRIDWORK

Table F1 lists the moisture content measurements taken at each of the 71 test areas shown in Figure F1. Each value represents the average of between one and three actual measurements.

TABLE F1. GRIDWORK MOISTURE CONTENT READINGS

Time	Area	No Crack	Crack	Time	Area	No Crack	Crack
0830	1	24	26		37	15	27
	2	14	33		38	14	29
	3	17	29		39	22	26
	4	2[illegible]	33		40	15	30
	5	24	45		41	14	20
	6	22	24		42	13	28
	7	15	33		43	14	34
	8	30	33		44	12	31
	9	32	25		45	10	19
	10	22	36		46	12	25
	11	32	39		47	12	30
	12	17	34		48	25	31
	13	19	16	1000	49	14	32
	14	18	38		50	11	24
	15	16	29		51	19	26
0900	16	27	20		52	17	36
	17	21	29		53	13	32
	18	21	27		54	17	20
	19	11	32		55	10	25
	20	18	35		56	16	50
	21	11	36		57	12	30
	22	18	27		58	12	33
	23	11	33		59	12	27
0930	24	14	27		60	15	17
	25	14	33		61	13	24
	26	18	30		62	19	30
	27	14	21		63	16	18
	28	18	31		64	12	32
	29	13	35		65	15	24
	30	12	21		66	13	38
	31	14	26		67	13	22
	32	10	22		68	11	27
	33	16	34		69	12	30
	34	19	28		70	12	36
	35	13	23	1037	71	15	27
	36	21	40				

At test areas 5, 9, and 56 moisture content measurements were taken that went well above 40 percent. It should be noted that the moisture content reading device does not function well over the 40 percent level.

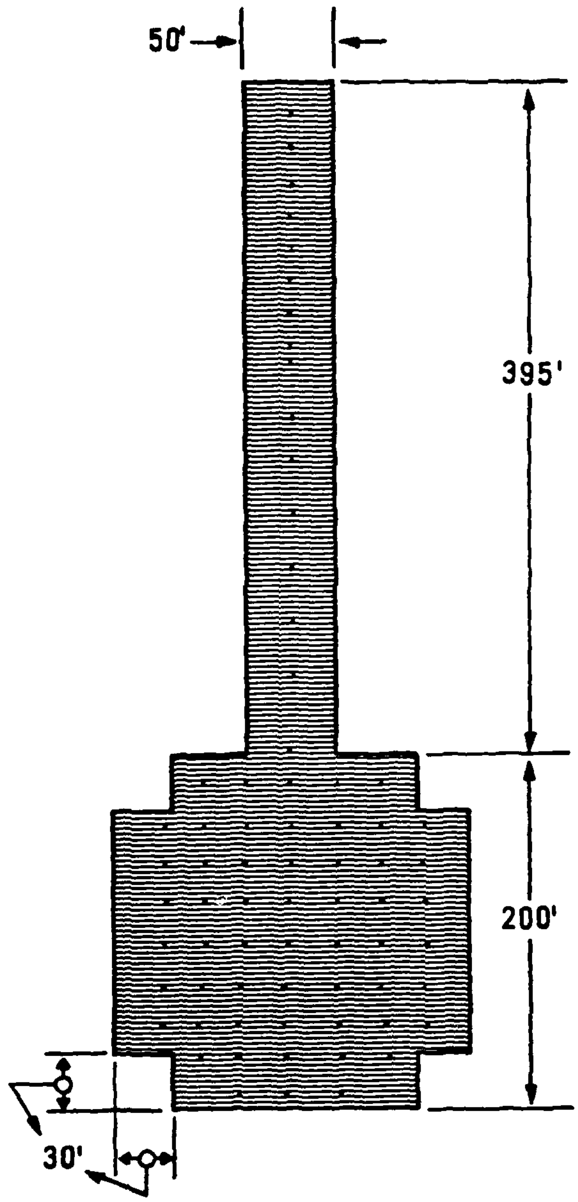

Figure F1. Gridwork

Table F2 shows the en ·onmental conditions which existed during the testing for the gridwork.

TABLE F2. ENVIRONMENTAL CONDITIONS

Time	EMC (%)	Temperature (°F)	Dew Point (°F)	Relative Humidity (%)
0800	11	40	29	60
0900	9	43	29	48
1000	10	45	30	55
1100	9	49	29	46

These conditions result in an average EMC of about 10 percent.

DATE

ILME