

2004 ARCHITECTURAL ENGINEERING THESIS
GLUED-LAMINATED TIMBER
ARCHITECTURAL REDESIGN



**COUNTRY MUSIC HALL
OF FAME AND MUSEUM**

NASHVILLE, TENNESSEE

PENNSYLVANIA STATE UNIVERSITY
ARCHITECTURAL STRUCTURAL ENGINEERING
SPRING 2004

Date: 4/2/2004

Authored By:

David L. Clark II

Consultant:

Dr. L. F. Geschwindner Jr.



COUNTRY MUSIC HALL OF FAME AND MUSEUM

222 Fifth Avenue South & Demonbreun ? Nashville ? Tennessee ? 37203

General

- ◆ 40,000 square-foot exhibit
- ◆ 11,000-square-foot conservatory
- ◆ 5,500 square-foot museum shop
- ◆ 2-story Archive and Library
- ◆ Ford Theater
- ◆ Full service restaurant
- ◆ XM Radio studio

Structural System

- ◆ 3 Buildings: Hall of Fame, Museum, & Conservatory
- ◆ Museum is a Steel Composite Structure
- ◆ Maximum Live Load: 350PSF for Records & Archives
- ◆ Diagonal & Chevron Bracing for Lateral Loads
- ◆ The Hall of Fame building and Cadillac Fin are architectural concrete with intentional oversized columns inside to give grandness
- ◆ Repetitive Forms Used for Symmetry
- ◆ Foundation Piers Range From 6'-24' Due to Variations in Bedrock Depth

Mechanical

- ◆ Field Assembled, Draw-Through, Variable/Constant Volume System
- ◆ 6 Zoned Air Handling Units (137,410 CFM)
- ◆ 15% Min O.A. & 100% Maximum O.A.
- ◆ 100% Min O.A. for the Conservatory
- ◆ 4-Electric Humidifiers (200-400 lb/hr) to protect Exhibits and Hall of Fame

- ◆ 550,500 BTU/HR Preheat Coil to control inconsistent temperature variations in the glass-enclosed Conservatory
- ◆ 123,000 Gallon Hot Water Heater
- ◆ Pre- & Post Filters (35% & 95%, respectively)



Architecture

Conservatory

- ◆ The heavy steel frame is inspired by the railroads and bridges that connected the small towns where country music came to life.
- ◆ A symbolic steam follows the descending monumental stair represents the streams of the Appalachia and into the Mississippi Delta.

Museum

- ◆ The form of the museum inspires the country stores that feature large façades and signage but are really intimate spaces where people come to socialize and exchange information.
- ◆ The musical reference of the giant keyboard formed by the series of vertical windows positioned like ebony keys across the dominant, curved front façade.
- ◆ The tail fin of a '57 Chevy is inspired in the dramatic end of the concrete wall that rises above the street corner.

Hall of Fame

- ◆ The cylindrical shape is based on the water towers that nourished steam engines and grain silos dotting rural landscapes.
- ◆ A replica of the WSM tower pierces the rotunda roof.
- ◆ Four concentric circles representing the 78-, 45- and 33-rpm records and the compact disc create that stair stepping roof.

Construction

- ◆ Pre Construction December 1995
- ◆ Construction June 1999
- ◆ Finish May 2001
- ◆ Total Cost: \$37,000,000

Electrical

- ◆ 3 Phase, 4 Wire, 277/480 Volts Wye & 120/208 Volts Wye
- ◆ 277/480 Volt Emergency Standby Engine Generator
- ◆ Illuminations: Incandescent, T8 Fluorescents, Cold Cathodes, Halogens, Metal Halides, & Neon

OWNER: COUNTRY MUSIC FOUNDATION

ARCHITECT: TUCK-HINTON ARCHITECTS

STRUCTURAL: EMC STRUCTURAL ENGINEERS

MEP: I.C. THOMASSON

CM: AM CONSTRUCTORS



DAVID L. CLARK II
STRUCTURAL EMPHASIS



A c k n o w l e d g m e n t s

I would like to thank my project sponsor, facility, and outside consultants for providing resources and the opportunity to use this building for my senior thesis project.

Mr. Seab Tuck III, *Tuck-Hinton Architects*

410 Elm Street; Nashville, TN 37203

Mr. Terry Scholes, *E.M.C. Structural Engineers PC*

4525 Trousdale Drive; Nashville, TN 37204

Mr. John Madole, *A&M Constructors*

1409 4th Avenue North; Nashville, TN 37208

Ms. Beth Davenport, *I. C. Thomasson Associates*

2950 Kraft Drive, Nashville, TN 37204

Mr. Todd Doutrich, *Rigidply Rafters, Inc.*

701 East Linden St, Richland, PA 17087

AE & ABE Faculty

Prof. Louis F. Geschwindner Jr.

Distinguish Prof. Harvey B. Manbeck

Mr. Walter G. M. Schneider III

Mr. M. Kevin Parfitt

Dr. Richard G. Mistrick

And all other supporting faculty and staff

COUNTRY MUSIC HALL OF FAME AND MUSEUM



*"A Bass Clef,
a Cadillac fin, and
an Old Country Church"*



T a b l e o f C o n t e n t s

Executive Summary.....	v
1.0 Building Overview.....	1
1.1 Building Codes	1
1.2 Structure.....	1
1.2.1 Museum	2
1.2.2 Conservatory.....	5
1.2.3 Hall of Fame	5
2.0 Depth Structural Proposal.....	8
2.1 Building Codes	8
2.2 Hall of Fame.....	9
2.3 Conservatory	10
2.4 Museum.....	10
2.5 Roofs	12
2.6 Decking.....	12
3.0 Breadth Disciplinary Proposal	14
3.1 Construction Management.....	14
3.2 Lighting	14
3.3 Mechanical.....	14
3.4 Architectural	14
4.0 Glued-Laminated Overview.....	15
4.1 Grades and Combinations	15
4.2 Adhesives.....	16
5.0 Design Loads	17
5.1 Load Combinations.....	17
5.2 In-plane Loads	17
5.2.1 Long-term Loads.....	17
5.2.2 Floor Short-term loads	18
5.2.3 Roof Short-term loads.....	19
5.3 Out-of-plane Loads	20
5.3.1 Wind Loads.....	20



5.3.2 Seismic	20
5.4 Creep.....	20
5.5 Camber	21
5.6 Fire Safing.....	21
6.0 Structural Design	22
6.1 Manufacturer..	22
6.1 Third Floor Cantilever Truss	22
6.2 Third Floor Archive/Library Girders.....	25
6.3 Fourth Floor Girders	27
6.4 Roof Trusses.....	29
6.5 F.I.R.P.	29
6.5 Columns.....	31
6.6 Hall of Fame Roof	31
7.0 Timber Connections.....	32
7.1 Beam Saddle	32
7.2 Beam Face Hanger Connection.....	32
7.3 U-Brackets	32
7.4 Beam Connection to Continuous Column.....	33
7.5 Timber Rings & Shear Plates	33
7.6 Double Gusset Plates.....	33
8.0 Cost Analysis & Comparison	35
8.1 Steel Deduction.....	35
8.2 Glue-Laminated Timber Addition	35
9.0 Day Lighting Cost/Benefit Analysis.....	36
9.1 Glazing Types	36
9.2 Savings.....	36
9.3 Sizing	36
10.0 Thermal Ice Storage Units.....	38
10.1 Recommendation	38
10.2 About the Technology.....	38
10.3 Materials	38
10.4 Case Study.....	39
11.0 Architectural	41
Appendices.....	42
Bio-Sketch	58



L i s t o f F i g u r e s

1.1 Museum at Night.....	1
1.2 Concrete Façade	2
1.3 Typical Caisson & Grade Beam w/ Front Façade Wall.....	3
1.4 Conservatory Roof Connection	3
1.5 Museum Connection into Front Façade.....	3
1.6 Museum’s Lateral Braced Frames (9 & 19 Upper, 10 & 20 Lower)	4
1.7 Caisson & Grade Beam w/ Outer Drum Wall.....	5
1.8 HOF First Floor Structural Layout	5
1.9 HOF Second Floor Structural Layout.....	6
1.10 Section View of Second Floor Structure	6
1.11 Roof Frame.....	7
2.1 Hall of Fame	9
2.2 Conservatory.....	10
2.3 Exterior of Museum	10
2.4 Interior of the Museum from the 3rd Floor.....	10
2.5 Proposed cantilever	12
2.6 Arch Bridge.....	12
2.7 Tongue & Groove Decking	13
2.8 Laminated Roof Decking.....	13
4.1 24F-V4 Lay-up	16
6.1 Third Floor Cantilever Design.....	22
6.2 Third Floor Archive/Library Girder	25
6.3 Fourth Floor Girders.....	27
6.4 Mon-Sloped Truss J8 & J	30
6.5 Mon-Sloped Truss J8 & J-Segmented for Shipment.....	30
6.6 Hall of Fame Stair Stepping Roof	31
7.1 Beam Saddle Detail.....	32
7.2 Beam Face Hanger Detail	32
7.3 Beam Connection to Continuous Column Detail.....	33
7.4 Timber Ring	34
7.5 Shear Plate.....	34
11.1 The Use of Heavy Timber Trusses	41
11.2 The Use of Glued-Laminated Beams.....	41



List of Tables

2.1 Code Assessment between SBC 1994 & IBC 2000 for.....	9
A-III. Type IV Heavy Timber Construction	
5.1 Load Types & Durations	17
5.2 Deflection Limitations for Use Where Increased Floor Stiffness is Desired.....	18
6.1 Design Results: 3rd Floor Cantilever w/ Curved Knee Braces	24
6.2 Design Results: Archive/Library Girder.....	26
6.3 Deflection Results: Archive/Library Girder	26
6.4 Design Results: 4th Floor Girder w/ Overhang.....	28
6.5 Deflection Results: 4th Floor Girder w/ Overhang	28
8.1 Steel Deduction Costs.....	35
8.2 Glue-laminated Cost Addition	35
9.1 Types of Glazing for use in Skylights.....	36
10.1 First Cost Comparison for Ice Thermal Storage Systems	39