RAS 10168

July 13, 2005

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	Docket No. 50-271
ENTERGY NUCLEAR VERMONT YANKEE, LLC and ENTERGY NUCLEAR OPERATIONS, INC.	)	ASLBP No. 04-832-02-OLA (Operating License Amendment)
(Vermont Yankee Nuclear Power Station)	)	

ENTERGY'S MOTION TO DISMISS AS MOOT, OR IN THE ALTERNATIVE, FOR SUMMARY DISPOSITION OF NEW ENGLAND COALITION CONTENTION 4

Applicants Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc. (collectively "Entergy") file this motion, pursuant to 10 C.F.R. §2.323 and the Atomic Safety and Licensing Board's ("Board") Memorandum and Order, LBP-04-28 (Nov. 22, 2004),[1] to seek dismissal of the New England Coalition's ("NEC") Contention 4 in this proceeding ("NEC Contention 4"). Dismissal of NEC Contention 4 is warranted because Entergy has completed the actions whose absence served as the basis for the contention. In the alternative, Entergy seeks summary disposition of the contention on the grounds that no genuine issue as to any material fact exists and Entergy is entitled to a decision as a matter of law. This motion is supported by a Statement of Material Facts as to which Entergy asserts there is no genuine dispute and the Declaration of George S. Thomas ("Thomas Declaration").

[1] Memorandum and Order, LBP-04-28, 60 NRC 548 (2004).

Template = SECY-041

SECY-02

I. STATEMENT OF FACTS

One of the contentions originally proposed by NEC was NEC Contention 4, which asserted that the extended power uprate ("EPU") for the Vermont Yankee Nuclear Power Station ("VY") should not be approved because "Entergy cannot assure seismic and structural integrity of the cooling towers under uprate conditions, in particular the Alternate Cooling System cell. At present the minimum appropriate structural analyses have apparently not been done."[2] Contrary to this assertion, appropriate analyses have now been performed.

The Vermont Yankee Alternate Cooling System ("ACS") provides an alternate means of cooling in the unlikely event that the service water pumps become unavailable. Thomas Declaration, para. 6.[3] The ACS utilizes only the north end cell (CT2-1) ("Alternate Cooling System cell") of the West Cooling Tower (Cooling Tower No. 2) for service water heat removal. *Id.* The Alternate Cooling System cell, as well as the adjoining cell (CT2-2), are Seismic Class I structures. Thomas Declaration, para. 7. The remaining nine cells in the West Cooling Tower and all eleven cells in the East Cooling Tower are Seismic Class II structures. *Id.*

At the prehearing conference held on October 21, 2004, Entergy counsel represented to the Board that Entergy was in the process of conducting an updated seismic and structural analysis of the portion of the cooling towers that contains the ACS, and by doing so the deficiency alleged by NEC was already being addressed. Tr. 331-32. Notwithstanding this representation, the Board admitted NEC Contention 4 into this proceeding. The contention reads:

> The license amendment should not be approved because Entergy cannot assure seismic and structural integrity of the cooling towers under uprate conditions, in particular the Alternate Cooling System

2 New England Coalition's Request for Hearing, Demonstration of Standing, Discussion of Scope of Proceeding and Contentions, dated August 30, 2004 at 11.

3 Exhibit 2 to the Thomas Declaration includes the body of the Seismic Calculation, but excludes the voluminous attachments to the calculation. The entire calculation, including all attachments, is contained in a compact disk included as Exhibit 3 to the Thomas Declaration.

> cell. At present the minimum appropriate structural analyses have apparently not been done.

LBP-04-28, 60 NRC at 580.

In explaining its decision to admit the contention, the Board stated as follows:

> And the fact that Entergy may intend to conduct such an analysis does not eliminate this genuine dispute, because Entergy could change its intent at any time unless, as NEC argues, it is required to perform the analysis.

Id. at 573.

Entergy has completed a new structural and seismic analysis of the cooling towers under EPU conditions that takes into account the cooling tower modifications performed as part of the upgrade for EPU operation. The new analysis is contained in the Seismic Calculation.

II. NEC CONTENTION 4 SHOULD BE DISMISSED AS MOOT

The admission of NEC Contention 4 was based solely on the fact that the seismic/structural analysis of the cooling towers had not yet been performed at the time the Board ruled on the admissibility of the contention. Such analysis has now been performed. The contention should therefore be dismissed as moot.

Dismissal of NEC Contention 4 at this point is consistent with the Board's previous actions. Subsequent to its admission of NEC Contention 4, the Board considered a request by another party, the Vermont Department of Public Service ("DPS"), to admit a proposed new contention, DPS Contention 6. DPS Contention 6 alleged that Entergy's EPU application was defective because it does not verify the assumption "that the reactor core isolation cooling (RCIC) system can be made operable in sufficient time to permit the operator to perform the required actions before core uncovery."[4] On January 11, 2005, the Board admitted DPS Contention 6. Memorandum and Order (Admitting Intervenor's New Contention) (Jan. 11, 2005). In admitting

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[4] Vermont Department of Public Service Request for Leave to File a New Contention (Oct. 18, 2004) at 1.

the contention, the Board analogized DPS Contention 6 to NEC Contention 4 and noted that "the contention is narrow" because the contention merely "challenges the absence of the verification, not its quality." *Id.* at 7. Thus, the Board stated that "when Entergy performs the verifications showing compliance, and duly submits them to NRC, this contention will be moot." *Id.*

Entergy performed the verification whose absence was raised as the basis for DPS Contention 6 and moved to dismiss the contention as moot or, alternatively, for summary disposition of the contention. The Board granted the motion and dismissed DPS Contention 6 as moot. Memorandum and Order (Granting Motion to Dismiss State Contention 6) (Mar. 15, 2005). The Board described the applicable Commission law as follows:

> The Commission has stated that "[w]here a contention alleges the omission of particular information or an issue from an application, and the information is later supplied by the applicant . . . the contention is moot." Duke Energy Corporation (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-28, 56 NRC 373, 383 (2002).

Id. at 4. This precedent, as applicable to DPS Contention 6, meant that "at such time when Entergy performs and submits its verification, this contention will be rendered moot. Duke, CLI-02-28, 56 NRC at 383." *Id.* at 5. Accordingly, the Board dismissed DPS Contention 6 as moot.

The same result should be reached on NEC Contention 4. Entergy has performed the structural and seismic calculation for the Alternate Cooling System cell and the adjacent cell. Thomas Declaration, para. 9 and Exhibits 2 and 3 thereto. NEC's contention is, therefore, moot, and should be dismissed.

III. ENTERGY IS ENTITLED TO SUMMARY DISPOSITION

Independently of the analysis in Section II above, summary disposition of NEC Contention 4 is appropriate pursuant to the Commission's adjudicatory rules.

A. Legal Standards for Summary Disposition

Commission regulations provide for summary disposition. Motions for summary disposition in a 10 C.F.R. Part 2, Subpart L, proceeding may be submitted up to 45 days before the commencement of a hearing, unless the presiding officer orders otherwise. 10 C.F.R. §2.1205(a).[5] In ruling on motions for summary disposition, the Board is to apply the standards for summary disposition set forth in subpart G of 10 C.F.R. Part 2. *Id.* §2.1205(c). The standards for summary disposition under Subpart G are set forth in 10 C.F.R. §2.710, which states that the "presiding officer shall render the decision sought if . . . there is no genuine issue as to any material fact and . . . the moving party is entitled to a decision as a matter of law." *Id.* §2.710(d)(2). Entergy satisfies the Commission's requirements for summary disposition of NEC Contention 4 because there is no genuine issue of disputed fact that would require a hearing and Entergy is entitled to a favorable decision as a matter of law.

NRC rules "long have allowed summary disposition in cases where there is no genuine issue as to any material fact and where the moving party is entitled to a decision as a matter of law." *Carolina Power & Light Co.* (Shearon Harris Nuclear Power Plant), CLI-01-11, 53 NRC 370, 384 (2001) (internal quotations omitted). Commission case law is clear that for there to be a genuine issue, "the factual record, considered in its entirety, must be enough in doubt so that there is a reason to hold a hearing to resolve the issue." *Cleveland Electric Illuminating Co.* (Perry Nuclear Power Plant, Units 1 and 2), LBP-83-46, 18 NRC 218, 223 (1983). Summary disposition "is a useful tool for resolving contentions that . . . are shown by undisputed facts to have nothing to commend them." *Private Fuel Storage, L.L.C.* (Independent Fuel Storage Installation), LBP-01-39, 54 NRC 497, 509 (2001). Lacking any genuine factual dispute, NEC Contention 4 clearly has "nothing to commend" it for further litigation in this proceeding.

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[5] In its Initial Scheduling Order, the Board set 30 days after the issuance by the Staff of the Safety Evaluation Report as the deadline for filing motions for summary disposition herein. Initial Scheduling Order (Feb. 1, 2005) at 3.

B. There Is No Factual Dispute Requiring Litigation

There remains no genuine issue as to any material fact relevant to NEC Contention 4. NEC's sole factual basis for the contention was that Entergy had failed to perform the requisite structural analyses for the ACS cell located in the West Cooling Tower. LBP-04-28, 60 NRC at 580. Contrary to the contention, Entergy has now performed those analyses and has determined that there is no need for structural modifications to the Alternate Cooling System cell or to the adjoining cell, and that the Alternate Cooling Cell and the cell adjacent to it are seismically adequate for the design basis loading conditions. Thomas Declaration, para. 11; Exhibit 2 thereto, Section 7 at 179. The factual bases underpinning NEC Contention 4 no longer present a genuine factual dispute requiring further litigation to resolve.

C. Entergy is Entitled to a Favorable Decision as a Matter of Law

There is nothing left to litigate with respect to NEC Contention 4 and there are no facts in controversy regarding the contention that could result in the denial of Entergy's application. The contention claimed that the verification had not taken place; now it has. Accordingly, Entergy is entitled to summary disposition of NEC Contention 4 as a matter of law.

IV. CONCLUSION

NEC's assertion that Entergy's license amendment request should be denied because "the minimum appropriate structural analyses have apparently not been done" has no factual basis, for analyses in question have been performed. NEC Contention 4, which is based solely on that factual assertion, is therefore moot. In any event, there is no genuine dispute of material fact remaining to litigate and Entergy is entitled to a decision as a matter of law.

CERTIFICATION

In accordance with 10 C.F.R. §2.323(b), counsel for Entergy has discussed this motion with counsel for the other parties in this proceeding in an attempt to resolve this issue.

Respectfully submitted,

Jay E. Silberg
Matias F. Travieso-Diaz
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Washington, DC 20037-1128
Tel. (202) 663-8063
Counsel for Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc.

Dated: July 13, 2005

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of ENTERGY NUCLEAR VERMONT YANKEE, LLC and ENTERGY NUCLEAR OPERATIONS, INC. (Vermont Yankee Nuclear Power Station)	))))))))	Docket No. 50-271 ASLBP No. 04-832-02-OLA (Operating License Amendment)

STATEMENT OF MATERIAL FACTS REGARDING NEC CONTENTION 4 ON WHICH NO GENUINE DISPUTE EXISTS

Applicants Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc. (collectively "Entergy") submit, in support of their motion for summary disposition of NEC Contention 4, that there is no genuine issue to be heard with respect to the following material facts.

1. On August 30, 2004, the New England Coalition ("NEC") sought admission, *inter alia*, of its Contention 4 ("NEC Contention 4"). New England Coalition's Request For Hearing, Demonstration of Standing, Discussion of Scope of Proceeding and Contentions, dated August 30, 2004 at 11.

2. In NEC Contention 4, NEC asserted that Entergy "cannot assure seismic and structural integrity of the cooling towers under uprate conditions, in particular the Alternate Cooling System cell. At present the minimum appropriate structural analyses have apparently not been done." *Id.*

3. The Vermont Yankee Alternate Cooling System ("ACS") provides an alternate means of cooling in the unlikely event that the service water pumps become unavailable. Declaration of George S. Thomas (Thomas Declaration), para. 6.

4. The ACS utilizes the north end cell (CT2-1) ("Alternate Cooling System cell") of the West eleven-cell cooling tower (Cooling Tower No. 2) for service water heat removal. *Id.*

5. The Alternate Cooling System cell, as well as the adjoining cell (CT2-2), are Seismic Class I structures. *Id.*, para. 7.

6. The remaining cells in the West and East cooling towers are Seismic Class II structures. *Id.*

7. The gravamen of NEC Contention 4 is that, before the extended power uprate ("EPU") is approved, which approval is the subject of the instant proceeding, Entergy should be required to perform seismic and structural analyses of the cooling towers under uprate conditions, in particular the Alternate Cooling System cell. Memorandum and Order, LBP-04-28, 60 NRC 543, 580 (2004).

8. Entergy has completed a new structural and seismic analysis of the cooling tower Seismic Class I cells under EPU conditions that takes into account the cooling tower modifications performed as part of the proposed uprate. Thomas Declaration, para. 9.

9. The new analysis is contained in the Seismic Calculation, which is attached as Exhibits 2 and 3 to the Thomas Declaration.

10. The Seismic Calculation includes structural and seismic analyses for the Alternate Cooling System cell and the adjacent cell. Thomas Declaration, para. 9 and Exhibit 2 thereto.

11. The Seismic Calculation shows that the cooling tower cell utilized for the Alternate Cooling Systems cell and the adjacent cell are seismically adequate for the design basis loading under EPU conditions. Thomas Declaration, para. 11 and Exhibit 2 thereto, Section 7 at 179.

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ENTERGY NUCLEAR VERMONT YANKEE, LLC and ENTERGY NUCLEAR OPERATIONS, INC.	)	ASLBP No. 04-832-02-OLA (Operating License Amendment)
(Vermont Yankee Nuclear Power Station)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of "Entergy's Motion to Dismiss as Moot, or in the Alternative, for Summary Disposition of New England Coalition Contention 4," "Statement of Material Facts Regarding NEC Contention 4 on Which no Genuine Dispute Exists," and "Declaration of George S. Thomas" were served on the persons listed below by deposit in the U.S. Mail, first class, postage prepaid, and where indicated by an asterisk by electronic mail, this 13th day of July, 2005.

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	)	Docket No. 50-271
ENTERGY NUCLEAR VERMONT YANKEE, LLC and ENTERGY NUCLEAR OPERATIONS, INC. (Vermont Yankee Nuclear Power Station)	)	ASLBP No. 04-832-02-OLA (Operating License Amendment)

DECLARATION OF GEORGE S. THOMAS

George S. Thomas states as follows under penalties of perjury:

I. Introduction

1. I am currently employed as Senior Project Manager by Entergy Nuclear Operations ("Entergy") at the Vermont Yankee Nuclear Power Station ("VY"). I am providing this declaration in support of Applicant's Motion to Dismiss as Moot, or in the Alternative, for Summary Disposition of New England Coalition's ("NEC") Contention 4 ("NEC Contention 4") in the above captioned proceeding regarding the proposed extended power uprate ("EPU") of VY.

2. My professional and educational experience is summarized in the *curriculum vitae* attached as Exhibit 1 to this declaration. Briefly summarized, I have 40 years of work experience in the field of nuclear energy, having held numerous management and technical positions during that period. I was involved with the design, operation and maintenance of the Vermont Yankee Cooling Towers both during the initial operation of the facility (1973-1977) and during the EPU Feasibility Study and EPU design evaluation (2002 to date).

3. I am the Project Manager of the VY Cooling Tower Upgrade Project and have overall responsibility for the engineering, procurement, design and testing of the cooling tower modifications, as well as for the performance of seismic and other analyses of the cooling towers.

4. In NEC Contention 4, as admitted,[1] NEC asserts that:

> The license amendment should not be approved because Entergy cannot assure seismic and structural integrity of the cooling towers under uprate conditions, in particular the Alternate Cooling System cell. At present the minimum appropriate structural analyses have apparently not been done.

5. In this declaration, I will address this contention and demonstrate it lacks technical or factual basis. In particular, I will 1) describe the changes that are being made to the cooling towers at VY[2] in support of EPU operations, and 2) demonstrate that these changes will not affect the structural and seismic integrity of the cooling towers or adversely affect the safety functions of the Alternate Cooling System ("ACS"), a system that utilizes one of the cooling towers cells.

II. <u>The Alternate Cooling System</u>

6. The VY ACS provides an alternate means of cooling in the unlikely event that the Service Water pumps become unavailable. The ACS consists of a cooling tower cell (the "Alternate Cooling System cell"), a cooling tower water deep basin (located under nine cells of the West Cooling Tower), Residual Heat Removal Service Water pumps and pump motor bearing coolers, Residual Heat Removal heat exchangers and pump coolers, Emergency Core Cooling System ("ECCS") room coolers (located in the Reactor Building), Emergency Diesel Generator heat exchangers (located in the Diesel Generator Rooms) and associated piping, valves and instrumentation. The ACS can also provide cooling for the Spent Fuel Pool. The Alternate Cooling System cell is the north end cell (CT2-1) of the West Cooling Tower (Cooling Tower No. 2). The NRC staff reviewed the design and performance capability of the Residual

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1 Memorandum and Order, LBP-04-28, 60 NRC 548, 580 (2004).

2 There are two cooling towers at VY, the West Cooling Tower and the East Cooling Tower. Each tower is comprised of eleven sections or "cells".

Heat Removal Service Water system when operating in the ACS mode and verified that the system design bases were in accordance with the licensing commitments and regulatory requirements. NRC Inspection Report 50-271/02-03 (July 22, 2002).

III. The Cooling Towers

7. The two cooling towers are located at the south end of the VY site. Each cooling tower contains two large pipes running along its length that distribute heated water from the plant condenser equally among the cells. The water drains down through plastic fill material to a basin underneath each tower, where it is collected and piped to the plant discharge structure. As the water falls through the fill, it is broken up into small droplets and is cooled by ambient air. An induced draft fan located on the top center of each cell draws air through the fill to obtain maximum cooling of the water. The Alternate Cooling System cell (CT2-1), the adjacent cell (CT2-2) and the Cooling Water Deep Basin in the West Cooling Tower are designed as Seismic Class I structures. The remaining cooling tower cells are designed as Seismic Class II structures.

8. The fans, motors, and gearboxes of all but one of the cooling tower cells have been increased from 125 horsepower to 200 horsepower. The only cell not being modified was the Alternate Cooling System cell, which presently has the capacity to meet EPU design requirements. In addition, the Electrical Distribution System for the cooling towers has been upgraded to handle the higher electrical current required by the larger fan motors.

IV. New Seismic and Structural Analyses

9. Entergy has performed a new structural and seismic analysis of the cooling tower Seismic Class I cells that takes into account the cooling tower upgrades. The new analysis is contained in Calculation No. 1356711-C-001, *Cooling Tower Seismic Calculation* (Rev. 1), performed by ABS Consulting and approved by Entergy on April 12, 2005, as VYC-2413, Rev. 0 ("Seismic Calculation"). A copy of the Seismic Calculation, minus attachments, is included as Exhibit 2 to this Declaration. A compact disk containing a copy of the entire calculation and attachments thereto is included as Exhibit 3.

10. The Seismic Calculation evaluates the cooling tower structure by modeling the main structural framing members as beam elements and applying the deadweight and mass of the

tower internals at member intersections (computer nodal locations). The models are analyzed for dead load, snow/ice load and seismic loading conditions. Dead load includes the weight of the cooling tower structure and equipment including the new 200 horsepower fans, motors, gearboxes and associated electrical cable. The snow/ice load is 40 pounds per square foot. The seismic loading condition is the design basis earthquake as described in Appendix A of the Vermont Yankee Updated Final Safety Analysis Report. The calculation conservatively assumes that the design snow/ice loads occur simultaneously with design summer temperature conditions, which results in a corresponding reduction in member strengths due to the high temperatures. Stresses calculated in the cooling tower structure are compared to the allowable loading of wood structures in accordance with the 1991 edition of the ANSI/NFPA "National Design Specification for Wood Construction" and the 1996 edition of the Cooling Tower Institute "Standard Specifications for the Design of Cooling Towers With Douglas Fir Lumber".

11. The Seismic Calculation demonstrates that there is no need for structural modifications to the Alternate Cooling System cell or the cell adjoining it, and that these two cells are seismically adequate for the design basis loading under EPU conditions. Also, and unrelated to NEC Contention 4, a separate calculation performed by ABS Consulting shows that the remaining cells in the West and East Cooling Towers are structurally adequate. Calculation No. 1356711- C-002, *Non Safety Cooling Tower Seismic Evaluation* (Rev. 0), performed by ABS Consulting and approved by Entergy on April 28, 2005, as VYC-2412, Rev. 0.

V. Summary

12. The claim in NEC Contention 4 is that Entergy has not performed the structural and seismic analyses necessary to assure the seismic and structural integrity of the cooling towers, and in particular the Alternate Cooling System cell, under EPU conditions. As discussed above, the Seismic Calculation contains the structural and seismic analyses sought by NEC, and demonstrates that the ACS and the Alternate Cooling System cell will retain their seismic and structural integrity under EPU conditions. Accordingly, the assertions in NEC Contention 4 are without factual basis because they have been addressed by the actions taken by Entergy.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on July 10, 2005.

George S. Thomas

EXHIBIT 1

George S. Thomas

Entergy Nuclear Operations, Inc.

PROFILE

Provided executive or line management leadership in numerous positions at nuclear-fueled electric generating facilities, all of which have demonstrated improved operating, economic and regulatory performance during his association with the facilities.

EXPERIENCE

ENTERGY NUCLEAR OPERATIONS **2000 to present**

Senior Project Manager – 2002 to present
Project Manager of a Power Uprate Feasibility Study during the transition phase of the Entergy purchase of the Vermont Yankee Nuclear Power Station. Responsible for numerous projects required to implement the Vermont Yankee Extended Power Uprate (EPU) Project, including obtaining ISO New England approval of project, project management of Cooling Tower Upgrade Project and managing EPU implementation.

Director of Engineering – 2000 to 2001
Responsible for engineering at James A. FitzPatrick Power Plant following Entergy purchase of the facility. Combined all site engineering functions into one organization. Significantly improved engineering performance as evidenced by plant performance indicators, NRC evaluations, and INPO ratings.

NEW YORK POWER AUTHORITY, **Lycoming, NY** **1998 to 2000**

Director of Engineering – 2000
Responsible for engineering at James A. FitzPatrick Plant since January 2000.

Manager, Design and Analysis Engineering - 1999 to 2000
Responsible for engineering design at James A. FitzPatrick Plant since January 1999.

Manager, Engineering Assurance - 1998
Assumed responsibility for Engineering Assurance at James A. FitzPatrick Plant during fourth quarter of 1998. Implemented Design Engineering Improvement Action Plan and assisted line management in improving engineering responsiveness and effectiveness during the Thirteenth Refueling Outage.

THOMAS CONSULTING SERVICES, **Moon Township, PA** **1996 to 1998**

Consultant – 1996 to 1998
Provided independent management consultant services for the energy industry. Assisted New York Power Authority to improve the engineering and management performance at the Indian Point 3 and FitzPatrick Power Plants (1997-1998).

DUQUESNE LIGHT COMPANY, **Shippingport, PA** **1990 to 1996**

Vice President, Nuclear Planning and Development – 1996
Responsible for management planning for Beaver Valley Power Station Units 1 and 2 and oversight of Duquesne Light Company's ownership interest in Perry Nuclear Power Plant. Chairman of Beaver Valley Offsite Review Committee and Member of Davis-Besse/Perry Nuclear Safety Review Committee.

Division Vice President, Nuclear Services -- 1993 to 1996
Responsible for the support services for Beaver Valley Power Station Units 1 and 2 at an annual budget in excess of $120 million. Areas of responsibility included engineering, licensing, quality assurance (1993-1994), information services, procurement, nuclear fuel, project management, training, emergency preparedness, administrative support and security. Reduced expenditures 30% over three years (1993-1995) while improving regulatory and operating performance. Member of Perry Nuclear Safety Review Committee (1994-1996).

General Manager, Corporate Nuclear Services -- 1991 to 1992
Responsible for engineering, licensing, procurement, nuclear fuel, project management, construction and administrative support for Beaver Valley Power Station Units 1 and 2.

General Manager, Special Projects -- 1990 to 1991
Responsible for development of a five year management plan for Beaver Valley Power Station Units 1 and 2.

THOMAS CONSULTING SERVICES, **Portsmouth, NH** **1989 to 1990**

Consultant -- 1989 to 1990
Provided independent consultant services for various contractors supporting the energy industry.

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE, **Seabrook, NH** **1980 to 1989**

Vice President, Nuclear *Production* -- *1982 to 1989*
Responsible for operation, startup and operational support of Seabrook Station. Assumed responsibility for all site activities in January, 1988. Managed an annual budget of approximately $80 million.

Nuclear Production Superintendent -- 1980 to 1982
Responsible for the Seabrook Station operating staff and associated corporate support. Developed plant programs, processes, budgets, accountabilities and management controls.

YANKEE ATOMIC ELECTRIC COMPANY, **Westborough, MA** **1977 to 1980**

Manager, Startup Test Group -- 1977 to 1980
Responsible for developing a new organization to manage the Seabrook Station initial startup test program. During this period, developed schedules, cost estimates, programs, plans and budgets.

VERMONT YANKEE NUCLEAR POWER CORPORATION, **Vernon, VT** **1973 to 1977**

Assistant Plant Superintendent -- 1973 to 1977
Responsible for the operation, maintenance and all on-site technical support of Vermont Yankee during both normal operation and refueling. During the period 1975 through 1977, Vermont Yankee had the highest cumulative capacity factor of any boiling water reactor in the United States. **Held a Senior Operator License for Vermont Yankee.**

OTHER EXPERIENCE

Other experience includes startup testing management for Vermont Yankee Power Station, project and design engineer for Babcock and Wilcox Company, and Senior Nuclear Test Engineer for submarine power plants at General Dynamics shipyards in Quincy, MA and Groton, CT.

EDUCATION/TRAINING

Masters in Business Administration, Robert Morris College (Pittsburgh, PA), 1996

Master of Science, Mechanical Engineering, Northeastern University (Boston, MA), 1982

Bachelor of Science, Mechanical Engineering, University of Massachusetts (Amherst, MA), 1965

Senior S5W Nuclear Test Engineer License, General Dynamics – Electric Boat, 1966

Senior Operator License, Vermont Yankee Nuclear Power Station, 1972

Advanced O&P Cause Analysis Training, Performance Improvement International, 1999

VYC-2413-Rev 0 [illegible] 5/4/05

EXHIBIT 2

Entergy	NUCLEAR MANAGEMENT MANUAL	QUALITY RELATED	ENN-DC-126	REV. 4
		INFORMATIONAL USE	~~PAGE 29 OF 57~~	

CALCULATION COVER PAGE

☐ IP-2 ☐ IP-3 ☐ JAF ☐ PNPS ☒ VY

Vender Calculation No. 1356711-C-001, Revision 1	This revision incorporates the following MERLIN DRNs or Minor Calc Changes: N/A	Cover Sheet for 2745 pages including Attachments
Title: Cooling Tower Seismic Evaluation		☒QR ☐NQR

Discipline: Mechanical/Structural Design Engineering | Design Basis Calculation? ☒Yes ☐No

This is calculation supersedes calculations:
1. No. EDAC-388-020.02, Rev. 0, 4/7/86, by EDAC, Title: "Dynamic Analysis of Custodis-Ecodyne Cooling Tower at the VYNPS (Cooling Tower No. E70-11960)
2. No. S7A-11960-H, Rev.0, 3/03/86, by Custodis-Ecodyne, Title: Calculations of Assessment & Modification

Modification No./Task No/ER No: ER 04-0705

☐ No software used
☐ Software used and filed separately (Include Computer Run Summary Sheet). If "YES', Code:
☒ Software used and filed with this calculation. If "YES', Code: SAP2000 Non-Linear Version 7.40

System No./Name: Circulating Water, Alternate Cooling System

Structure : Cooling Tower Cells CT-2-1 & CT-2-2

Component No./Name: CT-2-1& CT-2-2
(Attach additional pages if necessary)

Print/Sign

REV #	STATUS (Prel, Pend, A, V, S)	PREPARER	REVIEWER/ DESIGN VERIFIER	OTHER REVIEWER/ DESIGN VERIFIER	APPROVER	DATE
1	A (as-built)	ABS Consulting	[signature] James C. Fitzpatrick 4/12/05	N/A	[signature] S. D. Goodwin	4-12-05

VY CALCULATION DATABASE INPUT FORM

Place this form in the calculation package immediately following the Title page or CCN form.

1256711-C-001	1	N/A	N/A
Vendor Calculation/CCN Number	Revision Number	Vendor Calculation Number	Revision Number

Vendor Name: ABS Consulting PO Number: 4500533976 (9/8/04)
Originating Department: Design Engineering – Mechanical Structural
Critical References Impacted: ☒ UFSAR ☐ DBD ☐ Reload. "Check" the appropriate box if any critical document is identified in the tables below.
EMPAC Asset/Equipment ID Number(s): CT-2-1 & CT-2-2
EMPAC Asset/System ID Number(s): Circulation Water System , Alternate Cooling System
Keywords: Cooling Tower, Structural, Wood, Seismic, Power Uprate
For Revision/CCN only: Are deletions to General References, Design Input Documents or Design Output Documents required? ☐ Yes† ☒ No

Design Input Documents and General References - The following documents provide design input or supporting information to this calculation. (Refer to Appendix A, sections 3.2.7 and section 4)

Reference #	** DOC #	REV #	***Document Title (including Date, if applicable)	Significant Difference Review ††	**** Affected Program	Critical Reference (✓)
1			VY UFSAR, Updated as of 12-01-04.			
2			Cooling Tower Institute, CTI Code Tower "Standard Specifications for the Design of Cooling Towers With Douglas Fir Lumber," CTI Bulletin STD-114, October 1978.			
3			"Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment," Revision 3A corrected, Seismic Qualification Utility Group (SQUG), December 2001.			
4			SAP2000, Non-Linear Version 7.40, Copyright 1984 – 2000, Computers and Structures, Inc., Berkeley, California.			
5			ABS Consulting Nuclear Quality Assurance Manual (NQAM), Revision 7			
6			ABS Consulting, "NQA Procedure for Software Verification and Control", Procedure Number RCD-NQP-00-P03, Revision 1.			
7.1	5920-3326	7	Flour Products Dwg. Plan & Elevation 1170-1-7710			
7.2	5920-6451 Sheet 3 of 5	2	Transverse Section Additional Framing			
7.3			Longitudinal Section Framing Bent "C" Cells 1 and 2 Ecodyne Dwg. DR-1196013 Sheet 1 of 2, PDCR 86-02			
7.4			Longitudinal Section Framing Bent "B" Cells 1 and 2 Ecodyne DR-1196013 Sheet 2 of 2, PDCR 86-02			
7.5	5920-4600	4	Secondary Distribution System @ Cell No. 1			

7.6	5920-6840 Sheet 1 of 6	0	T-Bar Fill Inst'n 2 x 8 & 4 x 8 Config. Model 1170-1-7710			
7.7	5920-6840 Sheet 2 of 6	0	T-Bar Fill Inst'n 2 x 8 & 4 x 8 Config. Model 1170-1-7710			
7.8	5920-6840 Sheet 4 of 6	0	T-Bar Fill Inst'l Details and Notes			
7.9	5920-6452 Sheet 2 of 9	0	Companion Post Installation Details			
7.10	G-191731	2	Circulating Water Piping & Misc. Steel – Sh.2			
7.11	G-200357	7	Cooling Tower No. 2 – Foundation – MAS			
7.12	5920-3324	6	Anchor Bolt Setting 1170-1-7710			
7.13	5920-13331		New TPI drawing for ER-04-705 Plan View of Existing Fan Deck Layout			
7.14	5920-13330		New TPI drawing for ER-04-705 Transverse Section 1-1			
7.15	G-191374	13	Cooling Tower and Discharge Structure-Conduit, Grounding and Lighting Plan			
7.16	G191230	31	Yard Piping Plan – Sheet 1			
7.17	G191231	16	Yard Piping Plan – Sheet 2			
7.18			Material Fabrication Sketches for System #22, Service Water Yard Piping Grinnell Piping Spool Piece drawings AJ1230-1 through AJ1230-8			
8			ANSI/NFPA NDS-1991, "National Design Specification for Wood Construction," with NDS Supplement "Design Values for Wood Construction," 1991.			
9			AISC Manual of Steel Construction, 9th Edition			
10			ABS Calculation SAP2000-QA-001, "SAP2000 Version 7.4 Computer Program QA Verification," Revision 0, November 1, 2004.			
11			Cooling Tower Institute, CTI Code Tower "Standard Specifications for the Design of Cooling Towers With Douglas Fir Lumber," CTI Bulletin STD-114, Revision dated November 1996.			
12	S7A-11960-H	0	Custodis-Ecodyne Maintenance Services Division, "Vermont Yankee Nuclear Power Corporation, Job No. S7A-11960-H, Calculations of Assessment and Modification," dated January 1986.			
13	5920-4571	0	Vermont Yankee Document 5920-4571 R0, "Cooling Tower CT-2-1A Design Data 28 Sheets'", dated 11-25-1969. Job No. E70-11960, Prop. No. NY-CT-7110.3, by Fluor Products Company, Inc.			

14	EDAC-388-020.02,	0	Engineering Decision Analysis Company, Inc. (EDAC), EDAC-388-020.02, "Dynamic Seismic Analysis of the Custodis-Ecodyne Cooling Tower at VYNPS, (Cooling Tower NO. E70-11960)," April 7, 1986			
15	PDCR 86-02		VY PDCR 86-02, "Cooling Tower Seismic Modification," May 1986			
16			VY UFSAR Figures A.7-1 through A.7-14, Revision 5.			
17			Ebasco Specification 54-63, "Mechanical-Draft Cooling Tower," Revision 1, April23, 1969.			
18			American Plywood Association, "Plywood Design Specification," August 1986.			
19			US Army Corps of Engineers Standard ETL 1110-2-548, "Composite Materials for Civil Engineering and Design," March 31, 1997.			
20	VYC-2377	1	Entergy Calculation, "Raceway Supports for Cooling Tower Improvements,"			
21			NDS, "National Design Specification for Wood Construction Commentary," American Forest & Paper Association, 1997 Edition, with Addendum to the 1991 Commentary.			
22			NUREG/CR-0098, "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," N. M. Newmark Consulting Engineering Services for the U.S. Nuclear Regulatory Commission, May 1978.			
23			USNRC, NUREG-0800, Standard Review Plan, Section 3.8.4, "Other Seismic Category I Structures," Revision 1, July 1981.			
24			Bergen-Paterson Pipe Supports Catalog No. 82R			
25			Entergy Nuclear Operations Contract Order No. 4500533976, September 8, 2004.			
26			American Concrete Institute (ACI), "Code Requirements for Nuclear Safety Related Concrete Structures," ACI-349-90, March 1990.			

Design Output Documents - This calculation provides output to the following documents. (Refer to Appendix A, section 5)

* Reference #	** DOC #	REV #	Document Title (including Date, if applicable)	**** Affected Program	†††Critical Reference (✓)
	ER 04-0705	2	Cooling Tower Upgrade	N/A	

* Reference # -	Assigned by preparer to identify the reference in the body of the calculation.
** Doc # -	Identifying number on the document, if any (e.g., 5920-0264, G191172, VYC-1286)
*** Document Title -	List the specific documentation in this column. "See attached list" is not acceptable. Design Input/Output Documents should identify the specific design input document used in the calculation or the specific document affected by the calculation and not simply reference the document (e.g., VYDC, MM) that the calculation was written to support. If a DBD is used as a general reference, include the most current interim change number after the title.
**** Affected Program -	List the affected program or the program that reference is related to or part of.
†	If "yes," attach a copy of "VY Calculation Data" marked-up to reflect deletion (See Section 3.1.8 for Revision and 5.2.3.18 for CCNs).
††	If the listed input is a calculation listed in the calculation database that is not a calculation of record (see definition), place a check mark in this space to indicate completion of the required significant difference review. (see Appendix A, section 4.1.4.4.3). Otherwise, enter "N/A."
†††	If the reference is UFSAR, DBD or Reload (IASD or OPL), check Critical Reference column and check UFSAR, DBD or Reload, as appropriate, on this form (above).

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CALCULATION COVER SHEET

Calculation No.	1356711-C-001
Project:	Entergy Vermont Yankee
Calculation Title:	Cooling Tower Seismic Evaluation
References:	See Section 6 of this calculation
Attachments:	See Table of Contents

Total Number of Pages (Including Cover Sheet): 2745

Revision Number	Approval Date	Description of Revision	Originator	Checker	Approver
0	03/23/2005	Original Issue	R.D. Augustine	J.L. White	P.D. Baughman
1	04/052005	Revised fan thrust loads. Clarified text per Entergy comments.	R.D. Augustine	J.L. White	P.D. Baughman

Table of Contents

ATTACHMENTS (2563 pages)		
Attachment A	Vermont Yankee UFSAR Cooling Tower Figures	7 pages
Attachment B	Cooling Tower Loading Design Input	15 pages
Attachment C	Vermont Yankee Ground Response Spectra	2 pages
Attachment D	Base Reaction Forces	6 pages

Attachment E	Computer Models – Members, Nodes Element Descriptions, Loadings and Mode Shapes	253 pages
Attachment F	Bent A – Dead Load Model	
Attach. F-1	Computer Input Echo	42 pages
Attach. F-2	Analysis Execution Log	2 page
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Attachment G	Bent A – Seismic Model	
Attach. G-1	Computer Input Echo	30 pages
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Attachment H	Bent B – Dead Load Model	
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Attach. H-2	Analysis Execution Log	2 pages
Attach. H-3	Computer Output	168 pages
Attachment I	Bent B – Seismic Model	
Attach. I-1	Computer Input Echo	41 pages
Attach. I-2	Analysis Execution Log	3 pages
Attach. I-3	Computer Output	130 pages
Attachment J	Bent C – Dead Load Model	
Attach. J-1	No Triangle Load Input Echo	60 pages
Attach. J-2	No Triangle Load Execution Log	2 pages
Attach. J-3	No Triangle Load Output	197 pages
Attachment K	Bent C – Seismic Model	
Attach. K-1	Computer Input Echo	41 pages
Attach. K-2	Analysis Execution Log	3 pages
Attach. K-3	Computer Output	107 pages

TABLE OF REVISIONS

Revision Number	Description of Revision	Issue Date
0	Initial Issue	March 23, 2005
1	Incorporates Entergy Comments	April 4, 2005

1. INTRODUCTION

The Vermont Yankee Alternate Cooling System is a safety-related system whose safety function is to provide an alternate means of cooling in the unlikely event that the service water pumps become inoperable. The Alternate Cooling System utilizes the north end cell (CT2-1) of the west eleven-cell cooling tower (Cooling Tower No. 2) for service water heat removal. The north end cell, as well as the adjoining cell (CT2-2), are seismic Class I structures. The remaining cells 3 through 11 are non-safety-related Class II structures. Cells 3 through 11 are structurally separated from cells 1 and 2 by cut-away ties designed to isolate the safety related cells from the non-safety-related portion of the structure.

The VY cooling towers are braced wood frame structures constructed of treated wood with bolted and steel bracket type connections. The towers are of modular construction with 11 cells in the longitudinal direction. Each module is typically 42 ft. wide by 42 ft. long in plan by 42 ft. 6 in. from the top of the concrete perimeter pad to the top of the fan deck, and 56 ft. 7 in. to the top of the fan stack. The tower is constructed of timber columns, beams, girders and diagonal bracing. The wood frames support cooling fans, fan motor, circulating water distribution piping and various components at the top of the towers. A concrete cooling water basin constructed below grade supports the tower frames.

Modifications to the cooling towers are required as part of power uprate. The modifications consist of removing and replacing the existing fans, motors and gearboxes and adding new cable trays. The replacement components weigh more than the original components, and the thrust loads from the replacement fans are greater than the original thrust loads. The cooling towers require re-analysis to verify the adequacy of the modifications.

2. PURPOSE

The purpose of this calculation is to evaluate the main structural framing members of the modified cooling tower cells CT2-1 and CT2-2 (Cooling Tower No. 2, cells 1 and 2) for dead load and seismic loading conditions. The cooling tower cells to be seismically analyzed include additional weights and loads from the power uprate modifications.

Only cells CT2-1 and CT2-2 are evaluated in this calculation. The remaining non-safety-related cells, 3 through 11, are separated from cells 1 and 2 by break-away joints and are not addressed in this calculation. Only CT2-1 is required to be operational following an earthquake. CT2-2 is included in the analysis so its effect on CT2-1 is accounted for.

Cell CT2-1 is evaluated for the increased loads of the new fans and motors, but new fans and motors will not be installed as part of the power upgrade. The analysis envelopes the existing equipment mounted in cell CT2-1. Also, since the analysis uses a conservative loading for CT2-1 (uses bigger fan loading) any asymmetric effects from different fan ratings in CT2-1 and CT2-2 are bounded.

This work is being performed under Entergy Nuclear Operations Contract Order No. 4500533976, September 8, 2004 (Reference 25).

3. METHODOLOGY

The cooling towers are shown on the drawings listed in Reference 7. The cooling towers were originally designed and analyzed in Reference 13. Cooling tower maintenance and analysis considerations required additional analysis to be performed in 1986. Dynamic (response spectrum) seismic analysis of the cooling towers was performed in Reference 14. This analysis concluded that modifications were required. The modifications were designed and analyzed in Reference 12, and installed under PDCR 86-02 (Reference 15). A description of the dynamic analysis from Reference 14 is included in UFSAR Section A.7 (Reference 1). The computer models are shown in UFSAR Figures A.7-1 through A.7-14 (Reference 16, included in this calculation as Attachment A).

The methodology for this calculation is to perform a response spectrum seismic analysis of the cooling tower cells including the additional loads from the power uprate modifications. The models and analysis methods are consistent with those described in the UFSAR (Ref. 1 and 16), except analysis criteria have been updated where required.

Current plans (as of the date of this calculation) for power uprate include providing new fans, motors and gearboxes for all cooling tower cells except for cell CT2-1. This calculation is conservatively performed assuming the fan, motor and gearbox modifications are applicable to all cells including CT2-1. This will allow the changes to be made in the future (if required) without re-analyzing the structure.

The cooling towers are symmetrical about the longitudinal centerline (refer to page A1) except for the loading of the cable trays, secondary distribution system piping, and the fan motors. Cooling tower cells CT2-1 and CT2-2 are evaluated using three longitudinal models (Bents A, B and C) and three transverse models (Main, End and Partition).

The longitudinal and transverse bents are analyzed separately as 2-D models since the cooling tower construction lacks any horizontal floor diaphragms. The only floor diaphragm is at the top level but the cement board and plywood deck was judged inadequate to ensure diaphragm action given the large openings of the fan stacks. For each typical bent, the maximum loading applicable to any bent is used, considering the full range of fan/motor weights and operating modes (i.e., number of cells in use). Asymmetric loads from differing fan/motor weights, operating modes and dead loads will result in lower loads on individual bents and are thus bounded by this analysis.

Each cooling tower has four A bents, two B bents and two C bents in the longitudinal direction. Bent B on the west side of the tower governs since it receives fan motor and support frame loads. Bent C on the west side of the tower governs since it receives fan motor and cable tray loads. The load applied to the Bent A model envelopes the loads applied to all four A type bents. This is conservative since the dead load of the fan only applies to two of the A bents, and these bents are not actually loaded by the T-bar fill.

The transverse main bent structural model includes member sizes from the main bents in cell CT2-1. The loads on the main bents in cell CT2-1 govern because of the weight of the secondary distribution piping. Differences between the main bent members in cells CT2-1 and CT2-2 are evaluated separately. The transverse wall end of cell CT2-1 (wall no. 3) is modeled. The partition bent at wall no. 4 (wall between cells CT2-1 and CT2-2) is modeled since it receives load from both cells. The partition bent at wall no. 5 is not modeled as it is outside the zone of influence for cell CT2-1 and does not receive load from two cells.

This calculation evaluates the cooling towers by modeling the main structural framing members as beam elements and applying the deadweight and mass of all internals at member intersections (computer nodal locations). The models are evaluated for dead load, snow/ice load and seismic loading conditions.

This calculation is a conservative enveloping evaluation of both the summer and winter conditions occurring simultaneously. The maximum snow loads are being taken at the same time as the maximum (summer) operating temperatures. Corresponding reductions in member strengths due to high temperature are conservatively used for loading combinations that include snow loads.

The transverse bents are modeled as 2-D trusses because all loads are applied at the joints. The longitudinal bents have loads applied at intermediate points on the columns and are therefore modeled as 2-D frames. All diagonal bracing and horizontal members are modeled with pinned ends. Columns are modeled as pin-ended in the transverse truss models (except at selected locations in the hot basin where there are no diagonal braces) and continuous in the longitudinal frame models. All connections to the concrete foundation are modeled as pinned end supports. The longitudinal bent models include constraints between adjacent nodes where wood blocking exists (at the top just below the deck and along the length of the hot basin). The transverse truss models contain very small lateral springs for the dead load analysis to provide numerical stability in the absence of the diagonal bracing and partition wall shear panels.

The T-bar fill loads are conservatively distributed at node points located at anchor points of the T-bar fill wire mesh support grid. This is conservative since the support grid has a low horizontal frequency relative to the cooling tower structure. The T-bar fill mass includes water in transit which will not be driven by acceleration of the structure. A large portion of the mass of the T-bar fill could be de-coupled from the model due to the low support frequency and water in transit. The horizontal members at the nodal locations in the models are included only for calculating distribution of T-bar fill.

The models are analyzed using the Vermont Yankee design basis earthquake from Appendix A of the UFSAR (included as Attachment C). The curves in Attachment C have a peak ground acceleration of 0.07g, corresponding to the operating basis earthquake (OBE). Horizontal seismic input for this analysis is the maximum hypothetical earthquake (MHE) equal to two times the OBE (PGA of 0.14g). The vertical acceleration in the analysis is equal to 0.093 or 2/3 of the rigid range horizontal ground spectrum.

A damping ratio of 5 percent of critical damping is used in the analysis for the MHE. This type of wood framed structure has significant damping since the bolted connections absorb energy due to friction and slippage inherent in the connections and support points. NUREG/CR-0098 (Reference 22) provides seismic criteria for re-evaluating structures in older nuclear power plants. NUREG/CR-0098 recommends using 5 to 7 percent damping for bolted wood structures designed to a stress level of ½ yield point (i.e. OBE stress levels), and 10 to 15 percent damping for bolted wood structures designed to yield point stress levels (i.e. MHE stress levels). A damping ratio of 5 percent for the MHE is conservative since it is the lower bound value recommended for OBE in NUREG/CR-0098.

The cooling tower is evaluated using the finite element computer program SAP2000, Version 7.40 (Reference 4). The program is verified and certified for use on QA projects in accordance with the ABS Consulting Quality Assurance Manual (Reference 5) and Procedure NQP-03 (Reference 6). Documentation of the program verification is contained in Reference 10.

The models are analyzed for the vertical and horizontal earthquake in the plane of the model acting simultaneously. The vertical earthquake is evaluated statically with a seismic loading of 0.093 of the weight along the height of the columns. Structural response from the horizontal and vertical earthquake components are combined using the square root of the sum of the squares (SRSS) method. Modal response is combined using the CQC method to account for closely spaced modes. Modes are calculated up to 33 Hz with residual mass correction applied for participating mass above 33 Hz. The residual mass correction option is chosen within the SAP2000 computer program (Reference 4).

The analysis considers the following loading combination based on the UFSAR (Reference 1):

D + L + E

Where:

D = the dead load of structure and equipment plus any other permanent loads

L = 40 psf snow/ice load

E = Seismic load resulting from the maximum hypothetical earthquake, with a peak ground acceleration of 0.14g.

The allowable loading for the wood structure is determined in accordance with the 1991 edition of the NDS (Reference 8) and the 1996 edition of the Cooling Tower Institute (CTI) Standard Specification for the Design of Cooling Towers With Douglas Fir Lumber (Reference 11). The tower is constructed using treated Douglas Fir lumber. The allowable load calculations account for load duration, operating moisture level, operating temperature, member size and unbraced compression lengths. The load duration factor is taken as 0.9 for dead, 1.15 for snow/ice and 1.6 for earthquake load cases per NDS Table 2.3.2 (Ref. 8). A buckling length coefficient (Ke) of 0.8 is used for columns and 1.0 for bracing per NDS Table G1 (Ref. 8), unless otherwise noted in the body of the calculation (for isolated conditions).

The 1.6 load duration factor for earthquake load combinations is based on 10-minutes duration of load. This is conservative since the duration of strong motion in large earthquakes does not exceed 30 to 40 seconds, based on seismic experience data (Reference 3). A more realistic duration factor of up to 1.9 could be used for the MHE based on NDS Appendix B, Figure B1.

Allowable loads on connections are increased by 1.33 for earthquake loads using Reference 9. This is conservative since an increase of 1.6 could be used based on SRP Section 3.8.4 (Reference 23).

The allowable loads on the base anchor bolts are calculated in accordance with Section C.4 of Reference 3. The allowable bolt stress is equal to 1.7 times the working stress design allowable stress in Part 1 of AISC (Reference 9). The 1.7 increase factor is based on the standard increase in Part 2 of AISC. Reductions for embedment and edge distance are based on shear cone theory from Appendix B of ACI 349 (Reference 26).

4. DESIGN INPUT

Design input and sources of information are described below.

- The as-built details of the cooling towers are shown on the drawings listed in Reference 7.
- The bent models from the Vermont Yankee UFSAR (Reference 1) shown in Attachment A are used in this analysis. These models include all the structural members (beams, columns and bracing) that are stressed under the applied dead, ice/snow and seismic loading.
- The weight (mass) of the following items are included in the model (weights from Attachment B unless noted):
  - Top fan deck weight consists of 3/8" thick flat cement board (4.3 psf wet – sheet B4), 1 1/8" thick plywood and 2 x 6 pressure treated Douglas Fir joists 2' on center (weights determined from References 9 and 18)
  - Depth of water in the hot water basin under normal operating conditions – 8.75" deep (46 psf – sheet B4)
  - Weight of water in transit is based on a design flow of 17.5 GPM per square foot (Sheet B3). Weight of water in transit including weight of T-bar fill and supports is taken as 1.88 pcf for 4 x 8 T-Bar Fill from Sheet B4. Weight of water in transit, T-bar fill and supports for 2 x 8 T-bar fill is calculated as 2.53 pcf based on Sheets B4, B5 and Ref. 7.8.
  - Louver Wall consisting of 3/8" thick flat Cement Asbestos Board (6'-0" long) (112 lbs – sheet B4)
  - Drift Eliminators (2.5 psf wet – sheet B4)
  - Partition Wall – firewall with two 1/2" thick C.A.B. Flats (11.8 psf wet – sheet B4)
  - End Wall – firewall with one 3/8" thick Corrugated C.A.B. (5.0 psf wet sheet B4)
  - Cable Tray weight is defined as 60 lbs/ft per Reference 20.
  - Secondary distribution system piping configuration is based on Reference 7.5.
  - Wood framing member self-weight is calculated in the computer model and included in the analysis.
  - The weight of the fiberglass fan stack is calculated based on the details on sheet B15.

- The weights of the mechanical components (from sheet B7) are listed as follows. These weights include the change in weight due to power uprate modifications:

Fan Weight	2070	lbs.
Fan Thrust	2454	lbs.
Gear Reducer	2125	lbs.
Gear Adapting Steel	250	lbs.
Driveshaft	75	lbs.
Motor	2000	lbs.
Motor Adapting Steel	125	lbs.

- The weight of the fan stack is calculated based on the configuration on Drawing 5920-13330 (Reference 7.14).
- The fan thrust load is from Drawing 5920-13330 (Reference 7.14).
- The circulating water distribution system piping is 60" diameter fiberglass pipe per Ebasco Specification 54-63 (Reference 17).
- The snow and ice load applied to the top deck area is 40 psf per Ebasco Specification 54-63 (Reference 17).
- The allowable load on the wood members is determined in accordance with References 8 and 11. The modulus of elasticity (E) and allowable load is determined using Douglas Fir No. 1 lumber (sheets B2 and B7).
- The design temperatures for calculating the allowable load on the wood members are as follows (from sheet B7):

Plenum Area	100.3F
Fill Area – top third of tower	115F
Fill Area – middle third of tower	107.5F
Fill Area – bottom third near deep basin	100F

- The allowable loads for connections are taken from sheet 13 of Reference 12.

5. ASSUMPTIONS

Assumptions are as follows:

- The weight of the circulating water distribution header is calculated assuming 60" OD fiberglass pipe with a wall thickness of 1/2". The density of the fiberglass material is assumed to be 120 pcf based on Reference 19.
- The concrete strength of the cooling tower foundation basin is assumed to be 3000 psi based on the notes on Drawing. G-200357 (Ref. 7.11). This is used for determining the allowable anchor bolt loads. This assumption is conservative since the value on the drawing is the minimum design strength (actual strength at the time the concrete is placed is normally much greater than the minimum design strength) and concrete strength increases with time.
- The moisture condition of all wood members is assumed saturated. This is conservative since not all members are continuously exposed to water.
- Lumber sizes are assumed to be equal to the minimum dry dressed size in accordance with NDS Supplement (Ref. 8) Table 1A.
- It is assumed that all lumber is capable of supporting the full design capacities based on ongoing inspection and replacement regime in place at VY (see sheet B7).
- The weight of the secondary distribution pipe in cell CT2-1 does not include the weight of water since the pipe is assumed to be normally empty (see Ref. 7.5). This system has to be activated manually by opening a manual valve. The weight of the empty pipe is determined assuming STD schedule wall thickness.
- The density of Douglas fir is assumed to be a minimum of 32 pcf from Reference 9 page 6-8.
- The density of the fan stack fiberglass is assumed to be 120 pcf based on Reference 19 (included in Attachment B) and Reference 27.

There are no unsubstantiated assumptions that require additional verification.

6. CALCULATIONS

The following sections of this calculation will determine the individual nodal weights and masses and will also document the results of the analysis. For each model, summaries are provided documenting the resulting loads from both the dead load and seismic load cases. These resulting loads are then compared with the allowable loads determined by References 8 and 11.

6.1 BENT MODELS

The bents are modeled as beam elements using the models from the Vermont Yankee UFSAR as shown in Attachment A. In addition, various modification drawings (Reference 7) are used to reflect the "as-built" cooling tower frames. Attachment E contains copies of the models with dimensions, load locations and nodal numbering shown.

6.2 MODEL LOADING

The cooling towers are subject to various dead loads that are detailed in the following sections. These include the following:

1. New Fans and Motors
2. Fan Support Steel
3. Top Cover Fan Deck (Including Snow Load)
4. New Cable Tray
5. Manifold Pipe
6. Hot Water Basin
7. T-Bar Fill and Water in Transit
8. Partition and End Wall Cladding
9. Triangular Wall Self Weight
10. Louver Wall
11. Drift Eliminators
12. Fiberglass Fan Stack
13. Secondary Distribution Piping

The dead loads and masses are distributed to framing member intersection points based on the spans to the next joint both in and out of the plane of the model.

Section 6.2.1 will determine the nodal loading for each joint location on the model. Section 6.2.2 will determine and combine the individual nodal loads and masses.

6.2.1 Dead Load and Mass Distribution

6.2.1.1 New Fans and Motors

The following fan and motor loads are from sheet B6.

Fan Weight	2070	lbs.
Fan Thrust	2454	lbs.
Gear Reducer	2125	lbs.
Gear Adapting Steel	250	lbs.
Driveshaft	75	lbs.
Motor	2000	lbs.
Motor Adapting Steel	125	lbs.

Divide driveshaft weight between fan and motor.

Apply to Fan:	6,937	lbs.
Apply to Motor:	2,163	lbs.

The fans are located at the centerline of the cooling towers between two A Bents and two MAIN Bents. This will spread the load to 4 Bent A and MAIN nodes on the top level.

Fan loading per node = fan wt / 4 =	1,734	lbs.	Bent A nodes P4, P5, P11 and P12
Fan mass per node = (fan loading -thrust)/ (4*g) =	2.9002	(lb*sec^2/in)	Main bent nodes P5 and P6

The motors are located near the centerline of the cooling towers between bents B and C and between two MAIN Bents. The motors are located approximately 2 feet from the B bent and 4 feet from the C bent resulting in 2/3 of the weight and mass on two B bents and 1/3 on two C bents.

The B-Line Main nodes will see 2/3 of the load and the C-Line Main nodes will see 1/3 of the load and

(2/3) Motor loading per node = (2/3) wt / 2 bents =	721	lbs.	B bent nodes P4, P5, P11 and P12
(2/3) Motor mass per node = (2/3) wt / (2*g) =	1.8655	(lb*sec^2/in)	Main bent node P8 (B-line motor)
(1/3) Motor loading per node = (1/3) wt / 2 bents=	360	lbs.	C bent nodes P4, P5, P11 and P12
(1/3) Motor mass per node = (1/3) wt / (2*g) =	0.9328	(lb*sec^2/in)	Main bent node P9 (C-line moter)

6.2.1.2 Fan Support Steel

The fan and motor are bolted to W 5x16 cross members which, in turn, are bolted to steel W6x15 members which are bolted to the wooden tower. The cross members are 6 feet long (from bent to bent) and the long frame members are 24 feet long (4 bent span).

The resulting weight taken by the 4 columns under the fan is:

Cross Members:	= (2)*(6 feet)*(16 lb/ft)/(4 col) =	48	lbs.	Main bent nodes P5 and P6 (fan)
	= (2)*(6 feet)*(16 lb/ft)/(4 col)*(2/3) =	32	lbs.	Main bent node P8 (B-line motor)
	= (2)*(6 feet)*(16 lb/ft)/(4 col)*(1/3) =	16	lbs.	Main bent node P9 (C-line moter)
	= (2)*(6 feet)*(16 lb/ft)/(4 col) =	48	lbs.	A bent nodes P4, P5, P11 and P12
	= (2)*(6 feet)*(16 lb/ft)/(4 col)*(2/3) =	32	lbs.	B bent nodes P4, P5, P11 and P12
	= (2)*(6 feet)*(16 lb/ft)/(4 col)*(1/3) =	16	lbs.	C bent nodes P4, P5, P11 and P12

Long Members: The MAIN bent top nodes will support 6 feet of the long frame steel

=(6 feet)*(15 lb/ft) =	90	lbs.	Main bent nodes P5 and P6 (fan)
=(6 feet)*(15 lb/ft) =	90	lbs.	Main bent nodes P8 and P9 (motor)
=(6 feet)*(15 lb/ft) =	90	lbs.	A bent nodes P4, P5, P11 and P12
=(6 feet)*(15 lb/ft) =	90	lbs.	B bent nodes P4, P5, P11 and P12
=(3 feet)*(15 lb/ft) =	45	lbs.	C bent nodes P4, P5, P11 and P12

6.2.1.3 Top Cover Fan Deck (Including Snow Load)

The load on the top deck of the towers is from the 3/8" cement board, 1-1/8" thick marine plywood, 2x6 floor joists on 24-inch centers and a 40 psf snow load.

The top cover is 3/8" thick cement board which, per sht B4, weighs 4.3 psf wet.

Per Ref. 18, 1-1/8" marine plywood weighs 3.3 psf.

Per Ref. 9, Doug Fir wood weighs 32 pcf. The floor joists result in an area weight of

Area of 2x6 =	(1.5*5.5)	8.25	in^2
located on 24-inch centers results in		4.125	in^2 per horiz. foot
Joist weight = 32 pcf * area * 1 foot =		0.917	psf

Per Ref. 1, the snow load = 40 psf

Total top cover wet weight = 48.52 psf. The weight will be applied to level P in the model.

End Bent

	In-Plane Spacing per Node (in)	Out-Of-Plane Spacing (in)	Area Supported (ft^2)	Weight (lb)	Mass per node (lb*sec^2/in)
End Node	36	36	9.0	437	1.1300
Interior Node	72	36	18.0	873	2.2601

Main and Partition Bents

	In-Plane Spacing per Node (in)	Out-Of-Plane Spacing (in)	Area Supported (ft^2)	Weight (lb)	Mass per node (lb*sec^2/in)
End Node	36	72	18.0	873	2.2601
Interior Node	72	72	36.0	1747	4.5202

Bent C

	In-Plane Spacing per Node (in)	Out-Of-Plane Spacing (in)	Area Supported (ft^2)	Weight (lb)	Mass per node (lb*sec^2/in)
End Node	36	131	32.8	1589	4.1121
Interior Node	72	131	65.5	3178	8.2242

Top Cover Fan Deck (Including Snow Load) (Continued)

Bents A and B

	In-Plane Spacing per Node (in)	Out-Of-Plane Spacing (in)	Area Supported (ft^2)	Weight (lb)	Mass per node (lb*sec^2/in)
End Node	36	72	18.0	873	2.2601
Interior Node	72	72	36.0	1747	4.5202

On the top level of the towers, the fan stacks are located over 31-foot diameter openings in the top deck. These openings will limit the number of nodes which will see top cover load.

Bent C

Bent C is not affected by the fan stack opening so the top cover load will apply to all P level nodes.

Bent B

For Bent B, nodes P1, P2, P7, P8, P9, P14 and P15 will see the full top cover load as they are not affected by the fan stack opening.
Nodes P3, P6, P10 and P13 will see approximately 7/8 of the top cover load as they are affected by the fan stack opening.
Nodes P4, P5, P11 and P12 will see approximately 5/8 of the top cover load as they are affected by the fan stack opening.

Node P3, P6, P10 and P13 =	1528	lbs.
Node P4, P5, P11 and P12 =	1092	lbs.

Bent A

For Bent A, nodes P1, P8 and P15 will see the full top cover load as they are not affected by the fan stack opening. P1 is an end node and P8 and P15 are interior nodes.
Nodes P2, P7, P9 and P14 will see approximately 7/8 of the top cover load as they are affected by the fan stack opening.
Nodes P3, P6, P10 and P13 will see approximately 1/4 of the top cover load as they are affected by the fan stack opening.

Node P2, P7, P9 and P14 =	1528	lbs.
Node P3, P6, P10 and P13 =	437	lbs.

Top Cover Fan Deck (Including Snow Load) (Continued)

End Bent

The END bent is not affected by the fan stack opening so the top cover load applies to all P level nodes.

Main Bent

For the MAIN bent, nodes P1, P2, P9 and P10 will see the full top cover load as they are not affected by the fan stack opening.
Nodes P3 and P8 will see approximately 5/8 of the top cover load as they are affected by the fan stack opening.

Node P3 and P8 = 1092 lbs.

Partition Bent

The PARTITION bent is not affected by the fan stack opening so the top cover load will apply to all P level nodes.

6.2.1.4 New Cable Tray

The tray weight is 60 lb/ft. It is routed the length of the towers 3'-10" west of Bent C per drawing G191374 (Ref. 7.15).

BENT C

Row	In Plane Spacing per Node (in)	Cable Tray weight per node (lb)	Mass per node (lb*sec^2/in)	
End Node	36	180	0.4658	Bent C node P1
Interior Node	72	360	0.9317	Bent C nodes P2-P15

MAIN AND PARTITION BENT

Row	Out of Plane Spacing per Node (in)	Cable Tray weight per node (lb)	Mass per node (lb*sec^2/in)	
Interior Node	72	360		

The cable tray is located approximately mid-way between nodes P9 and P10.

Load per node = 1/2*tray load = 180 0.4658 Nodes P9 and P10

END BENT

Row	Out of Plane Spacing per Node (in)	Cable Tray weight per node (lb)	Mass per node (lb*sec^2/in)	
End Node	36	90	0.2329	Nodes P9 and P10

In addition to the uniform load along bent C, the END bent along column 9 will see a point loads from the cable tray running up the end of the tower. The cable is cable tied to the tray and the tray is attach to the bent at each horizontal structural member. This results in a nodal load based on the horizontal membe spacing and a tray weight of 60 lb/ft.

New Cable Tray (Continued)

Row	Elevation (in)	Vert Span per Level (in)	Cable Tray Load (lb)	Mass per node (lb*sec^2/in)	
End Bent - all levels present					
F	195				
G	243	48	240	0.6211	END bent node G9, MAIN Bent 2FIL1
H	291	48	240	0.6211	END bent node H9, MAIN Bent H1
I	339	48	240	0.6211	END bent node I9, MAIN Bent 3FIL1
J	387	48	240	0.6211	END bent node J9, MAIN Bent J1
K	435	48	240	0.6211	END bent node K9, MAIN Bent 4FIL1
L	483	48	240	0.6211	END bent node L9, MAIN Bent L1
M	531	40.71875	204	0.5269	END bent node M9, MAIN Bent M1
N	564.4375	61.5	308	0.7958	END bent node N9, MAIN Bent 5FIL1
P	654	44.78125	224	0.5795	END bent node P9, MAIN Bent P1

e P9 loading = tray weight plus riser weight =	314	lbs.
Bent C Node P1 supports riser also =	90	lbs.

6.2.1.5 Manifold Pipe

The weight of the circulating water distribution header is calculated assuming 60" OD fiberglass pipe with a wall thickness of 1/2".

The density of the fiberglass material is 120 pcf per Reference 19.

<u>Determine pipe weight per foot:</u>

OD =	60	in	thick =	0.5	in
			ID =	59	in

pipe area/ft =	PI * (OD^2 - ID^2) / 4 =	93.46	in^2 / ft
pipe weight =	A * (12 *in) *fiberglass density =	78	lb / ft
water area/ft =	PI * (ID^2) / 4 =	2733.97	in^2 / ft
water weight / ft =	A * (12 *in) * water density =	1185	lb / ft
	Total pipe + water weight =	1263	lb / ft

For the interior nodes, the support spacing for the pipe is 72 inches.
For the end nodes, the support spacing for the pipe is 36 inches.

Interior Nodal Load = (total weight per foot) * (6 feet) =	7576	lb / node
End Nodal Load = (total weight per foot) * (3 feet) =	3788	lb / node

<u>End Bent Nodal Loading:</u>

Load on nodes N2 N3, N8 and N9 = (end nodal load) / 2 =	1894	lb / node
Load on nodes N2 N3, N8 and N9 = (end nodal mass) / 2 =	4.9014	lb *sec^2 / in

<u>Main and Partition Bent Nodal Loading:</u>

Load on nodes N2 N3, N8 and N9 = (interior nodal load) / 2 =	3788	lb / node
Load on nodes N2 N3, N8 and N9 = (interior nodal mass) / 2 =	9.8028	lb *sec^2 / in

---

The manifold pipe loads Bents B and C on model level N, Elev. 564". Bent A does not support the manifold pipe.

Interior Nodal Load = (total weight per foot) * (6 feet) =	7576	lb / node
End Nodal Load = (total weight per foot) * (3 feet) =	3788	lb / node

<u>Bents B and C</u>

Load on nodes (interior nodal load) / 2 =	3788	lb / node
Mass on nodes = (interior nodal mass) / 2 =	9.8028	lb *sec^2 / in
Load on nodes (end nodal load) / 2 =	1894	lb / node
Mass on nodes = (end nodal mass) / 2 =	4.9014	lb *sec^2 / in

6.2.1.6 Hot Water Basin

Per sheet B4, the weight of the water in the Hot Basin is defined as 46 psf.
This is based on a depth of 8-3/4" for normal operating conditions.

Use water weight = 46 psf

Longitudinal Direction, Loads on Bents B and C

The load is distributed in the longitudinal direction between two sets of in-plane nodes. The nodes for Bent B will see 1/4 of the of the total hot basin load and Bent C will take the other 3/4.

Bent Nodes	In-Plane Spacing per Node (in)	Out-of-Plane Spacing (in)	Area Supported (ft^2)	Weight (lb)	Mass per node (lb*sec^2/in)
Bent C					
end nodes	36	108	27.0	1242	3.2143
interior nodes	72	108	54.0	2484	6.4286
Bent B					
end nodes	36	36	9.0	414	1.0714
interior nodes	72	36	18.0	828	2.1429

Transverse Direction, Load on End, Main and Partition Bents

The load is distributed in the transverse direction between three sets of in-plane nodes. The exterior nodes will see 1/2 of the of the total hot basin load and the interior node will take the other 1/2.

	In-Plane Spacing per Node (in)	Out-Of-Plane Spacing (in)	Area Supported (ft^2)	Weight (lb)	Mass per node (lb*sec^2/in)
End Bent					
exterior node	36	36	9.0	414	1.0714
interior node	72	36	18.0	828	2.1429
Main and Partition Bents					
exterior node	36	72	18.0	828	2.1429
interior node	72	72	36.0	1656	4.2857

6.2.1.7 T-Bar Fill and Water in Transit

This section of the calculation will determine the T-Bar fill in the tower. The fill weight wil be distributed along the horizontal members at the fill wire anchor locations. The weight will be distributed to horizontal framing members along model levels E, G, I, K and N. It is assumed the fill wires are not attached to the framing members at levels F, H, J, L or M based on the drawing details. Each wire anchor location will take 1/2 of the load from each of the next tie locations in the horizontal in-plane direction and 1/2 of the load to the next horizontal framing member out of-plane. In addition, the wire location will take 1/2 of the l to the above and below horizontal members. The T-bar installation configuration is shown in References 7.6, 7.7 and 7.8.

2x8 Fill Density (pcf)	4x8 Fill Density (pcf)	Center wire Fill Density
2.53	1.88	2.205

The nodes for the models are shown on the following sheets:

Bent A	Sheets E7-E20	End Bent	Sheets E140-E152
Bent B	Sheets E42-E54	Main Bent	Sheets E180-E192
Bent C	Sheets E81-E97	Partition Bent	Sheets E226-E238

Main and Partition Bents

Level	Level Elev. (in)	Vertical Spacing (in)	Tributary Wire Length (in)	Tributary In-Plane Spacing (in)	Tributary Out-of-Plane Spacing (in)	Volume per Anchor (ft^3)	Using 2x8 Fill Density (lbs)	Using 4x8 Fill Density (lbs)	Using Average Density (lbs)
E	162.25	40.375	41.72	24	72	41.72	106	78	
E outer	162.25	40.375	41.72	14	72	24.34	62		
E center	162.25	40.375	41.72	24	72	41.72			92
G	243	88.375	91.33	24	72	91.33	231	172	
G outer	243	88.375	91.33	14	72	53.27	135		
G center	243	88.375	91.33	24	72	91.33			201
I	339	96	99.21	24	72	99.21	251	187	
I outer	339	96	99.21	14	72	57.87	146		
I center	339	96	99.21	24	72	99.21			219
K	435	112.72	116.49	24	72	116.49	295	219	
K outer	435	112.72	116.49	14	72	67.95	172		
K center	435	112.72	116.49	24	72	116.49			257
N	564.4375	64.72	66.88	24	72	66.88	169	126	
N outer	564.4375	64.72	66.88	14	72	39.01	99		
N center	564.4375	64.72	66.88	24	72	66.88			147

T-Bar Fill and Water in Transit (Continued)

End Bent

Level	Level Elev.	Vertical Spacing	Tributary Wire Length	Tributary In-Plane Spacing	Tributary Out-of-Plane Spacing	Volume per Anchor	Using 2x8 Fill Density	Using 4x8 Fill Density	Using Average Density
	(in)	(in)	(in)	(in)	(in)	(ft^3)	(lbs)	(lbs)	(lbs)
E	162.25	40.375	41.72	24	36	20.86	53	39	
E outer	162.25	40.375	41.72	14	36	12.17	31		
E center	162.25	40.375	41.72	24	36	20.86			46
G	243	88.375	91.33	24	36	45.66	116	86	
G outer	243	88.375	91.33	14	36	26.64	67		
G center	243	88.375	91.33	24	36	45.66			101
I	339	96	99.21	24	36	49.60	125	93	
I outer	339	96	99.21	14	36	28.94	73		
I center	339	96	99.21	24	36	49.60			109
K	435	112.72	116.49	24	36	58.24	147	109	
K outer	435	112.72	116.49	14	36	33.97	86		
K center	435	112.72	116.49	24	36	58.24			128
N	564.4375	64.72	66.88	24	36	33.44	85	63	
N outer	564.4375	64.72	66.88	14	36	19.51	49		
N center	564.4375	64.72	66.88	24	36	33.44			74

T-Bar Fill and Water in Transit (Continued)

BENTS A, B and C

To determine the T-bar fill loading on the longitudinal bents A, B and C the nodal loads from the fill wire hanger locations will be accounted for.

LEVEL N The load from each of the transverse bent nodes N1A, N1B and N1C will be applied to the longitudinal bent C at the N level.

	END	MAIN	PARTITION
Loads: N1A =	49	99	99
N1B =	85	169	169
N1C =	74	147	147
Bent C load =	208	415	415

The load from nodes N2A, N2B and N2C will be applied to bents C and B.

	END	MAIN	PARTITION
Loads: N2A =	74	147	147
N2B =	63	126	126
N2C =	63	126	126
Bent C load from N2A=	67	134	134
Bent B load from N2A=	7	13	13
Bent C load from N2B=	36	73	73
Bent B load from N2B=	27	53	53
Bent C load from N2C=	15	31	31
Bent B load from N2C=	48	95	95
Bent C load =	119	237	237
Bent B load =	81	162	162
Summation Bent C Load =	326	653	653
Summation Bent B Load =	81	162	162
	Long. Bent Node 5FIL1	Long. Bent Node 5FIL2-7 and 5FIL9-14	Long. Bent Node 5FIL8 and 5FIL15

6.46 24 24 17.54

LENGTH = 72

T-Bar Fill and Water in Transit (Continued)

LEVEL K The load from each of the transverse bent nodes K1A and K1B will be applied to the longitudinal bent C at the K level.

	END	MAIN	PARTITION
Loads: K1A =	86	172	172
K1B =	147	295	295
Bent C load =	233	467	467

The load from nodes K2A, K2B and K2C will be applied to bents C and B.

	END	MAIN	PARTITION
Loads: K2A =	128	257	257
K2B =	128	257	257
K2C =	109	219	219
Bent C load from K2A=	99	198	198
Bent B load from K2A=	29	59	59
Bent C load from K2B=	56	113	113
Bent B load from K2B=	72	144	144
Bent C load from K2C=	11	23	23
Bent B load from K2C=	98	196	196
Bent C load =	167	334	334
Bent B load =	200	399	399

16.46	24	24	7.54
	LENGTH =	72	

The load from node K3A will be applied to bents B and A.

	END	MAIN	PARTITION
Loads: K3A =	109	219	219
Bent B load from K3A=	84	169	169
Bent A load from K3A=	25	50	50
Summation Bent C Load =	400	800	800
Summation Bent B Load =	284	568	568
Summation Bent A Load =	25	50	50

16.46	55.54	0	0
	LENGTH =	72	

Long. Bent Node 4FIL1	Long. Bent Node 4FIL2-7 and 4FIL9-14	Long. Bent Node 4FIL8 and 4FIL15

T-Bar Fill and Water in Transit (Continued)

LEVEL I The load from the transverse bent nodes I1A will be applied to the longitudinal bent C at the I level.

	END	MAIN	PARTITION
Loads: I1A =	73	146	146
Bent C load =	73	146	146

The load from nodes I2A, I2B and I2C will be applied to bents C and B.

	END	MAIN	PARTITION
Loads: I2A =	125	251	251
I2B =	109	219	219
I2C =	109	219	219
Bent C load from I2A=	98	197	197
Bent B load from I2A=	27	54	54
Bent C load from I2B=	49	99	99
Bent B load from I2B=	60	120	120
Bent C load from I2C=	13	26	26
Bent B load from I2C=	96	193	193
Bent C load =	161	322	322
Bent B load =	183	367	367

15.49	24	24	8.51

LENGTH = 72

T-Bar Fill and Water in Transit (Continued)

The load from nodes I3A and I3B will be applied to bents B and A.

	END	MAIN	PARTITION
Loads: I3A =	93	187	187
I3B =	93	187	187
Bent B load from I3A=	73	146	146
Bent A load from I3A=	20	40	40
Bent B load from I3B=	42	84	84
Bent A load from I3B=	51	102	102
Bent B load =	115	231	231
Bent A load =	71	142	142
Summation Bent C Load =	234	468	468
Summation Bent B Load =	299	597	597
Summation Bent A Load =	71	142	142
	Long. Bent Node 3FIL1	Long. Bent Node 3FIL2-7 and 3FIL9-14	Long. Bent Node 3FIL8 and 3FIL15

15.49	24	24	8.51

LENGTH = 72

T-Bar Fill and Water in Transit (Continued)

LEVEL G The load from the transverse bent nodes G1A will be applied to the longitudinal bents at the G level.

The load from nodes G2A, G2B and G2C will be applied to bents C and B.

	END	MAIN	PARTITION
Loads: G2A =	67	135	135
G2B =	116	231	231
G2C =	101	201	201
Bent C load from G2A=	53	107	107
Bent B load from G2A=	14	28	28
Bent C load from G2B=	53	106	106
Bent B load from G2B=	63	125	125
Bent C load from G2C=	13	25	25
Bent B load from G2C=	88	176	176
Bent C load =	119	238	238
Bent B load =	165	329	329

15 24 24 9

LENGTH = 72

The load from nodes G3A, G3B and G3C will be applied to bents B and A.

	END	MAIN	PARTITION
Loads: G3A =	101	201	201
G3B =	86	172	172
G3C =	86	172	172
Bent B load from G3A=	80	159	159
Bent A load from G3A=	21	42	42
Bent B load from G3B=	39	79	79
Bent A load from G3B=	47	93	93
Bent B load from G3C=	11	21	21
Bent A load from G3C=	75	150	150
Bent B load =	130	260	260
Bent A load =	143	285	285

15 24 24 9

LENGTH = 72

Summation Bent C Load =	119	238	238
Summation Bent B Load =	295	589	589
Summation Bent A Load =	143	285	285
	Long. Bent Node 2FIL1	Long. Bent Node 2FIL2-7 and 2FIL9-14	Long. Bent Node 2FIL8 and 2FIL15

T-Bar Fill and Water in Transit (Continued)

LEVEL E The load from the transverse bent nodes E2A and E2B will be applied to the longitudinal bents at the E level.

The load from nodes E2A and E2B will be applied to bents C and B.

	END	MAIN	PARTITION				
Loads: E2A =	31	62	62	36	24	10	0
E2B =	53	106	106		LENGTH =	70	
Bent B load from E2A=	15	30	30				
Bent A load from E2A=	16	32	32				
Bent B load from E2B=	8	15	15				
Bent A load from E2B=	45	90	90				
Bent C load =	22	45	45				
Bent B load =	61	122	122				

The load from nodes E3A, E3B and E3C will be applied to bents B and A.

	END	MAIN	PARTITION				
Loads: E3A =	46	92	92	12	24	24	12
E3B =	46	92	92				
E3C =	39	78	78		LENGTH =	72	
Bent B load from E3A=	38	77	77				
Bent A load from E3A=	8	15	15				
Bent B load from E3B=	23	46	46				
Bent A load from E3B=	23	46	46				
Bent B load from E3C=	7	13	13				
Bent A load from E3C=	33	65	65				
Bent B load =	68	136	136				
Bent A load =	63	127	127				

T-Bar Fill and Water in Transit (Continued)

The load from node E4A will be applied to TWO Bent A nodes.

	END	MAIN	PARTITION
Loads: E4A =	39	78	78
Bent A load from E4A=	33	65	65
Bent A load from E4A=	7	13	13
Bent A load =	33	65	65
Summation Bent C Load =	22	45	45
Summation Bent B Load =	129	258	258
Summation Bent A Load =	96	192	192
	Long. Bent Node 1FIL1	Long. Bent Node 1FIL2-7 and 1FIL9-14	Long. Bent Node 1FIL8 and 1FIL15

12 24 36 0

LENGTH = 72

6.2.1.8 Partition and End Wall Cladding

The partition and end wall bents will take all of the wall weight in the transverse direction. There is no cladding on the Main Bents.

The end wall is constructed of 3/8" corrugated C.A.B. Per sheet B4, the wet weight is 5.0 psf.

Per sheet B4, the partition wall is constructed of 2 layers of 1/2" corrugated C.A.B. The wet weight is defined as 11.8 psf.

	Elevation (in)	Vert Span per Level (in)	Horiz Spacing per Node (in)	End Wall square footage per node (ft^2)	End Wall weight per node (lb)	Mass per node (lb*sec^2/in)
	End Bent					
D end	146.5	7.875	36	1.969	9.8	0.0255
D interior	146.5	7.875	72	3.938	19.7	0.0510
E end	162.25	24.25	36	6.063	30.3	0.0784
E interior	162.25	24.25	72	12.125	60.6	0.1569
F end	195	40.375	36	10.094	50.5	0.1306
F interior	195	40.375	72	20.188	100.9	0.2612
G end	243	48	36	12.000	60.0	0.1553
G interior	243	48	72	24.000	120.0	0.3106
H end	291	48	36	12.000	60.0	0.1553
H interior	291	48	72	24.000	120.0	0.3106
I end	339	48	36	12.000	60.0	0.1553
I interior	339	48	72	24.000	120.0	0.3106
J end	387	48	36	12.000	60.0	0.1553
J interior	387	48	72	24.000	120.0	0.3106
K end	435	48	36	12.000	60.0	0.1553
K interior	435	48	72	24.000	120.0	0.3106
L end	483	48	36	12.000	60.0	0.1553
L interior	483	48	72	24.000	120.0	0.3106
M end	531	40.719	36	10.180	50.9	0.1317
M interior	531	40.719	72	20.359	101.8	0.2634
N end	564.4375	55	36	13.750	68.8	0.1779
N interior	564.4375	55	72	27.500	137.5	0.3558
O end	641	44.78125	36	11.195	56.0	0.1449
O interior	641	44.78125	72	22.391	112.0	0.2897
P end	654	6.500	36	1.625	8.1	0.0210
P interior	654	6.500	72	3.250	16.3	0.0421

Partition and End Wall Cladding (Continued)

Row	Elevation (in)	Vert Span per Level (in)	Horiz Spacing per Node (in)	End Wall square footage per node (ft^2)	End Wall weight per node (lb)	Mass per node (lb*sec^2/in)
	End Bent with Levels F, H, J, L, N and O redistributed					
D end	146.5	7.875	36	1.969	9.8	0.0255
D interior	146.5	7.875	72	3.938	19.7	0.0510
E end	162.25	48.25	36	12.063	60.3	0.1561
E interior	162.25	48.25	72	24.125	120.6	0.3122
G end	243	88.375	36	22.094	110.5	0.2859
G interior	243	88.375	72	44.188	220.9	0.5718
I end	339	96	36	24.000	120.0	0.3106
I interior	339	96	72	48.000	240.0	0.6211
K end	435	96	36	24.000	120.0	0.3106
K interior	435	96	72	48.000	240.0	0.6211
M end	531	109.5	36	27.375	136.9	0.3542
M interior	531	109.500	72	54.750	273.8	0.7085
P end	654	61.500	36	15.375	76.9	0.1990
P interior	654	61.500	72	30.750	153.8	0.3979

Partition and End Wall Cladding (Continued)

Row	Elevation (in)	Vert Span per Level (in)	Horiz Spacing per Node (in)	Partition Wall square footage per node (ft^2)	Partition Wall weight per node (lb)	Mass per node (lb*sec^2/in)
	Partition Bents					
E end	162.25	16.375	36	4.094	48.3	0.1250
E interior	162.25	16.375	72	8.188	96.6	0.2500
F end	195	40.375	36	10.094	119.1	0.3082
F interior	195	40.375	72	20.188	238.2	0.6165
G end	243	48	36	12.000	141.6	0.3665
G interior	243	48	72	24.000	283.2	0.7329
H end	291	48	36	12.000	141.6	0.3665
H interior	291	48	72	24.000	283.2	0.7329
I end	339	48	36	12.000	141.6	0.3665
I interior	339	48	72	24.000	283.2	0.7329
J end	387	48	36	12.000	141.6	0.3665
J interior	387	48	72	24.000	283.2	0.7329
K end	435	48	36	12.000	141.6	0.3665
K interior	435	48	72	24.000	283.2	0.7329
L end	483	48	36	12.000	141.6	0.3665
L interior	483	48	72	24.000	283.2	0.7329
M end	531	40.719	36	10.180	120.1	0.3109
M interior	531	40.719	72	20.359	240.2	0.6217
N end (3/4 area)	564.4375	55	36	13.750	121.7	0.3149
N interior	564.4375	55	72	27.500	324.5	0.8398
O end	641	44.78125	36	11.195	132.1	0.3419
O interior	641	44.78125	72	22.391	264.2	0.6838
P end	654	6.500	36	1.625	19.2	0.0496
P interior	654	6.500	72	3.250	38.4	0.0992

Partition and End Wall Cladding (Continued)

Partition Bents with Level O redistributed

Row	Elevation (in)	Vert Span per Level (in)	Horiz Spacing per Node (in)	Partition Wall square footage per node (ft^2)	Partition Wall weight per node (lb)	Mass per node (lb*sec^2/in)
E end	162.25	16.375	36	4.094	48.3	0.1250
E interior	162.25	16.375	72	8.188	96.6	0.2500
F end	195	40.375	36	10.094	119.1	0.3082
F interior	195	40.375	72	20.188	238.2	0.6165
G end	243	48	36	12.000	141.6	0.3665
G interior	243	48	72	24.000	283.2	0.7329
H end	291	48	36	12.000	141.6	0.3665
H interior	291	48	72	24.000	283.2	0.7329
I end	339	48	36	12.000	141.6	0.3665
I interior	339	48	72	24.000	283.2	0.7329
J end	387	48	36	12.000	141.6	0.3665
J interior	387	48	72	24.000	283.2	0.7329
K end	435	48	36	12.000	141.6	0.3665
K interior	435	48	72	24.000	283.2	0.7329
L end	483	48	36	12.000	141.6	0.3665
L interior	483	48	72	24.000	283.2	0.7329
M end	531	40.719	36	10.180	120.1	0.3109
M interior	531	40.719	72	20.359	240.2	0.6217
N end	564.4375	61.5	36	15.375	181.4	0.4695
N interior	564.4375	61.5	72	30.750	362.9	0.9391
P end	654	44.781	36	11.195	132.1	0.3419
P interior	654	44.781	72	22.391	264.2	0.6838

Partition and End Wall Cladding (Continued)

Row	Elevation (in)	Vert Span per Level (in)	Horiz Spacing per Node (in)	Partition Wall square footage per node (ft^2)	Partition Wall weight per node (lb)	Mass per node (lb*sec^2/in)
Partition Bents with levels F, H, J, L, N, and O redistributed						
E end	162.25	40.375	36	10.094	119.1	0.3082
E interior	162.25	40.375	72	20.188	238.2	0.6165
G end	243	88.375	36	22.094	260.7	0.6747
G interior	243	88.375	72	44.188	521.4	1.3494
I end	339	96	36	24.000	283.2	0.7329
I interior	339	96	72	48.000	566.4	1.4658
K end	435	96	36	24.000	283.2	0.7329
K interior	435	96	72	48.000	566.4	1.4658
M end	531	109.5	36	27.375	323.0	0.8360
M interior	531	109.500	72	54.750	646.1	1.6720
P end	654	61.500	36	15.375	181.4	0.4695
P interior	654	61.500	72	30.750	362.9	0.9391

Partition and End Wall Cladding (Continued)

Row	Elevation (in)	Vert Span per Level (in)	Horiz Spacing per Node (in)	Partition Wall square footage per node (ft^2)	Partition Wall weight per node (lb)	Mass per node (lb*sec^2/in)
Partition Bents including Level O and with levels F, H, J, L, and N redistributed						
E end	162.25	40.375	36	10.094	119.1	0.3082
E interior	162.25	40.375	72	20.188	238.2	0.6165
G end	243	88.375	36	22.094	260.7	0.6747
G interior	243	88.375	72	44.188	521.4	1.3494
I end	339	96	36	24.000	283.2	0.7329
I interior	339	96	72	48.000	566.4	1.4658
K end	435	96	36	24.000	283.2	0.7329
K interior	435	96	72	48.000	566.4	1.4658
M end	531	103	36	25.750	303.9	0.7864
M interior	531	103.000	72	51.500	607.7	1.5727
O end	641	61.5	36	15.375	181.4	0.4695
O interior	641	61.500	72	30.750	362.9	0.9391
P end	654	6.500	36	1.625	19.2	0.0496
P interior	654	6.500	72	3.250	38.4	0.0992

Partition and End Wall Cladding (Continued)

BENT A

Bents A will see end and partition loads on column lines 1, 8 and 15.

BENT A	Elevation (in)	Vertical Spacing (in)	Tributary Out-of-Plane Spacing (in)	Area per Node (ft^2)	End Wall Weight Per Node (lb)	Partition Wall Weight Per Node (lb)
A	not attached					
B	not attached					
C	122.5	48.25	72	24.125		285
D	144	37.5	72	18.75	94	
E	not attached					
F	219	85.5	72	42.75	214	504
G	not attached					
H	315	96	72	48	240	566
I	not attached					
J	411	96	72	48	240	566
K	not attached					
L	507	72	72	36	180	425
M	555	73.5	72	36.75	184	434
P	654	49.5	72	24.75	124	292

note: Use Level C for the partition wall but not end wall.

Partition and End Wall Cladding (Continued)

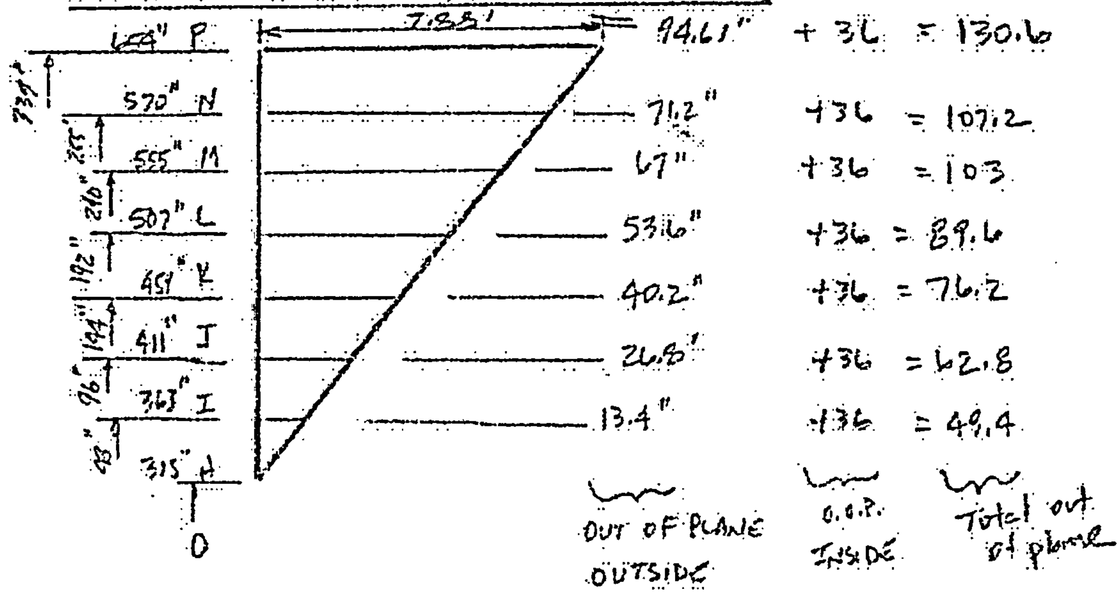
BENT B

Bent B will see end and partition loads on column lines 1, 8 and 15.

BENT B	Elevation (in)	Vertical Spacing (in)	Tributary Out-of-Plane Spacing (in)	Area per Node (ft^2)	End Wall Weight Per Node (lb)	Partition Wall Weight Per Node (lb)
A	not attached					
B	not attached					
C	not attached					
D	144	13.375	72	6.6875	33	79
E	170.75	37.5	72	18.75	94	221
F	219	48.125	72	24.0625	120	284
G	267	48	72	24	120	283
H	315	48	72	24	120	283
I	363	48	72	24	120	283
J	411	48	72	24	120	283
K	459	48	72	24	120	283
L	507	48	72	24	120	283
M	555	31.5	72	15.75	79	186
N	570	49.5	72	24.75	124	292
P	654	42	72	21	105	248

Partition and End Wall Cladding (Continued)

BENT C - END & PARTITION WALLS



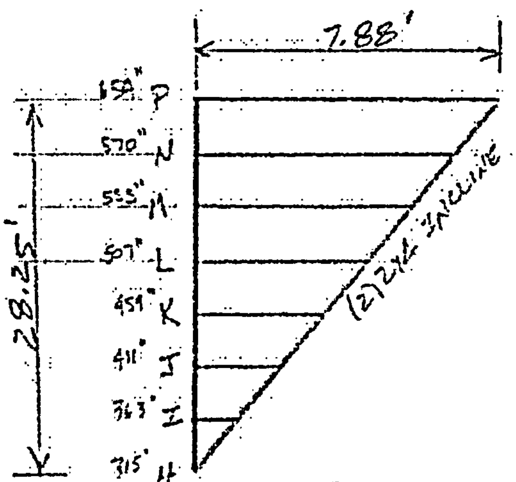
BENT C	Elevation (in)	Vertical Spacing (in)	Tributary Out-of-Plane Spacing END (in)	Tributary Out-of-Plane Spacing PARTITION (in)
A	not attached			
B	not attached			
C	not attached			
D	144	37.5	36	36
E	not attached			
F	219	61.5	36	36
G	267	48	36	36
H	315	48	36	36
I	363	48	49.4	49.4
J	411	48	62.8	62.8
K	459	48	76.2	76.2
L	507	48	89.6	89.6
M	555	31.5	103	103
N	570	49.5	107.2	
P	654	42	130.6	

Partition and End Wall Cladding (Continued)

BENT C	Area per Node END	Area per Node PARTITION	End Wall Weight Per Node	Partition Wall Weight Per Node
	(ft^2)	(ft^2)	(lb)	(lb)
A				
B				
C				
D	9	9	47	111
E				
F	15	15	77	181
G	12	12	60	142
H	12	12	60	142
I	16	16	82	194
J	21	21	105	247
K	25	25	127	300
L	30	30	149	352
M	23	23	113	266
N	37		184	
P	38		190	

6.2.1.9 Triangular Wall Self Weight

Determine the self-weight of the framing members compromising the triangular wall section outside of Bent C.



use density = 35#/FT³

HORIZ LENGTH	TYPE	WT PER FT (lb/FT)	HORIZ WT. (lb)	INCLINE WT	TOTAL WT.
94.61"	(2)2x6	4#/FT	32#	6#	38#
71.2"	(2)2x6	4#/FT	24#	13#	37#
67"	(2)2x4	3#/FT	22#	13#	35#
53.6"	(2)2x4	3#/FT	18#	13#	31#
40.2"	(2)2x4	3#/FT	13#	13#	26#
26.8"	(2)2x4	3#/FT	7#	13#	20#
13.4"	(2)2x4	3#/FT	3#	6#	9#

INCLINE WT $= (3\#/FT)(28.25^2 + 7.88^2)^{1/2} = 88\#$

Apply incline wt at 7 nodes, $= \frac{88}{7} = 13\#/\text{node}$

6.2.1.10 Louver Wall

Per sheet B4, the louver blades weigh 112 lbs. each. The blades are 6'-0" long (column to column). There are 14 rows of blades covering the height of the tower. Therefore the load per square foot is determined as follows:

The louvers are mounted on the outside of the cooling tower's sloped walls.

Height of sloped wall = SQRT(7'10.625" ^2 + (654-291)^2) =	375.1	inches
Height of straight wall = 291-146.5 =	144.5	inches
Total Wall Height =	519.6	inches
Total wall area covered by the louvers per column section = (wall height) * 6 feet =	259.82	ft^2
Weight of 14 louver blades = 14 * 112 =	1568	lbs.
Louver wall loading = weight / area =	6.04	psf

The brace angle is as follows:

$$\text{atan}\left(\frac{94.625}{654-291}\right) = 0.255 \text{ rad}$$

The brace is offset at 0.255 radians = 14.6 degrees

Louver Wall (Continued)

Row	Elevation (in)	Vert Span per Level (in)	In Plane Spacing per Node (in)	Louver Wall square footage per node (ft^2)	Louver Wall weight per node (lb)	Mass per node (lb*sec^2/in)
End Bent						
D end	146.5	7.875	36	1.969	12	0.0307
E end	162.25	24.25	36	6.063	37	0.0947
F end	195	40.375	36	10.094	61	0.1577
G end	243	48	36	12.000	72	0.1874
H end	291	48.802	36	12.201	74	0.1906
I end	339	49.604	36	12.401	75	0.1937
J end	387	49.604	36	12.401	75	0.1937
K end	435	49.604	36	12.401	75	0.1937
L end	483	49.604	36	12.401	75	0.1937
M end	531	42.079	36	10.520	63	0.1643
N end	564.4375	63.555	36	15.889	96	0.2482
P end	654	46.278	36	11.569	70	0.1807

Row	Elevation (in)	Vert Span per Level (in)	In Plane Spacing per Node (in)	Louver Wall square footage per node (ft^2)	Louver Wall weight per node (lb)	Mass per node (lb*sec^2/in)
Main and Partition Bents						
D end	146.5	7.875	72	3.938	24	0.0615
E end	162.25	24.25	72	12.125	73	0.1894
F end	195	40.375	72	20.188	122	0.3153
G end	243	48	72	24.000	145	0.3748
H end	291	68.209	72	34.105	206	0.5327
I end	339	49.604	72	24.802	150	0.3874
J end	387	49.604	72	24.802	150	0.3874
K end	435	49.604	72	24.802	150	0.3874
L end	483	49.604	72	24.802	150	0.3874
M end	531	42.079	72	21.040	127	0.3286
N end	564.4375	63.555	72	31.778	192	0.4963
P end	654	46.278	72	23.139	140	0.3614

Louver Wall (Continued)

Row	Elevation (in)	Vert Span per Level (in)	In Plane Spacing per Node (in)	Louver Wall square footage per node (ft^2)	Louver Wall weight per node (lb)	Mass per node (lb*sec^2/in)
	Bent C					
D end	144	37.5	36	9.375	57	0.1464
D interior	144	37.5	72	18.750	113	0.2929
F end	219	61.5	36	15.375	93	0.2401
F interior	219	61.5	72	30.750	186	0.4803
G end	267	48	36	12.000	72	0.1874
G interior	267	48	72	24.000	145	0.3748
H end	315	48	36	12.000	72	0.1874
H interior	315	48	72	24.000	145	0.3748
I end	363	48	36	12.000	72	0.1874
I interior	363	48	72	24.000	145	0.3748
J end	411	48	36	12.000	72	0.1874
J interior	411	48	72	24.000	145	0.3748
K end	459	48	36	12.000	72	0.1874
K interior	459	48	72	24.000	145	0.3748
L end	507	48	36	12.000	72	0.1874
L interior	507	48	72	24.000	145	0.3748
M end	555	31.5	36	7.875	48	0.1230
M interior	555	31.5	72	15.750	95	0.2460
N end	570	39	36	9.750	59	0.1523
N interior	570	39	72	19.500	118	0.3046
O end	633	42	36	10.500	63	0.1640
O interior	633	42	72	21.000	127	0.3280
P end	654	10.5	36	2.625	16	0.0410
P interior	654	10.5	72	5.250	32	0.0820

Note: Slope of louver wall has negligible effect on weight of wall.

Louver Wall (Continued)

Row	Elevation (in)	Vert Span per Level (in)	In Plane Spacing per Node (in)	Louver Wall square footage per node (ft^2)	Louver Wall weight per node (lb)	Mass per node (lb*sec^2/in)
Bent C with level O redistributed						
D end	144	37.5	36	9.375	57	0.1464
D interior	144	37.5	72	18.750	113	0.2929
F end	219	61.5	36	15.375	93	0.2401
F interior	219	61.5	72	30.750	186	0.4803
G end	267	48	36	12.000	72	0.1874
G interior	267	48	72	24.000	145	0.3748
H end	315	48	36	12.000	72	0.1874
H interior	315	48	72	24.000	145	0.3748
I end	363	48	36	12.000	72	0.1874
I interior	363	48	72	24.000	145	0.3748
J end	411	48	36	12.000	72	0.1874
J interior	411	48	72	24.000	145	0.3748
K end	459	48	36	12.000	72	0.1874
K interior	459	48	72	24.000	145	0.3748
L end	507	48	36	12.000	72	0.1874
L interior	507	48	72	24.000	145	0.3748
M end	555	31.5	36	7.875	48	0.1230
M interior	555	31.5	72	15.750	95	0.2460
N end	570	49.5	36	12.375	75	0.1933
N interior	570	49.5	72	24.750	149	0.3866
P end	654	42	36	10.500	63	0.1640
P interior	654	42	72	21.000	127	0.3280

6.2.1.11 Drift Eliminators

The nodes for the models are shown on the following sheets:

Bent A	Sheets E7-E20	End Bent	Sheets E140-E152
Bent B	Sheets E42-E54	Main Bent	Sheets E180-E192
Bent C	Sheets E81-E97	Partition Bent	Sheets E226-E238

The drift eliminator is anchored to the cooling tower transverse bents at levels E, G, I, K and M. In Att. B the drift eliminator weight is defined as 2.5 psf. Distribute the DE weight to the bent by proportioning the weight by the area of DE near the node.

END Bent

Node	Level Elev. (in)	Vertical Spacing (in)	Tributary DE Length (in)	Tributary Out-of-Plane Spacing (in)	FT^2 per node (ft^3)	DE Weight (lbs)	
E4B, E6A	162.25	40.375	41.72	36	10.43	26	
G4A, G6A	243	88.375	91.33	36	22.83	57	
I3C, I4A, I6A, I7A	339	96	99.21	36	24.80	62	(Note: 1/2 of load to each level I node.)
K3B, K7A	435	112.72	116.49	36	29.12	73	
M3A, M7A	564.4375	64.72	66.88	36	16.72	42	

Drift Eliminators (Continued)

MAIN and PARTITION Bents

Level	Level Elev. (in)	Vertical Spacing (in)	Tributary DE Length (in)	Tributary Out-of-Plane Spacing (in)	FT^2 per node (ft^3)	DE Weight (lbs)	
C	122.5	19.875	20.54				
E4B, E6A	162.25	60.25	62.26	72	31.13	78	
G4A, G6A	243	88.375	91.33	72	45.66	114	
I3C, I4A, I6A, I7A	339	96	99.21	72	49.60	124	(Note: 1/2 of load to each level I node.)
K3B, K7A	435	112.72	116.49	72	58.24	146	
M3A, M7A	564.4375	64.72	66.88	72	33.44	84	

Drift Eliminators (Continued)

BENTS A and B

DE locations on the transverse bents will be accounted for to determine the DE loading on longitudinal bents A and B.

At Level M (transverse model Elev. 531) the DE weight is applied to the transverse models at node M3A. This load will be divided between Bents A and B.

Dist. M3A from A	Dist. M3A from B
48	24

Load on M3A =	84	lbs.	
Load on Bent A nodes =	28	lbs.	Nodes (DE2-15). Load on DE1 is 1/2 that on DE2
Load on Bent B nodes =	56	lbs.	Nodes (DE2-15). Load on DE1 is 1/2 that on DE2

At Level K (transverse model Elev. 435) the DE weight is applied to the transverse models at node K3B. This load will be divided between Bents A and B.

Dist. K3B from A	Dist. K3B from B
26.5732	45.4268

Load on K3B =	146	lbs.	
Load on Bent A nodes =	92	lbs.	Nodes (4FIL2-15). Load on 4FIL1 is 1/2 that on 4FIL2
Load on Bent B nodes =	54	lbs.	Nodes (4FIL2-15). Load on 4FIL1 is 1/2 that on 4FIL2

DE weight is applied at Level I (transverse model Elev. 339) to the transverse models at nodes I3C and I4A. This load will be applied to a single A Bent.

Load on I3C and I4A =	124	lbs.	
Load on Bent A nodes =	124	lbs.	Nodes (3FIL2-15). Load on 3FIL1 is 1/2 that on 3FIL2

At Level G (transverse model Elev. 243) the DE weight is applied to the transverse models at node G4A. This load will be divided between two A bents.

Dist. G4A from A	Dist. G4A from A
46	26

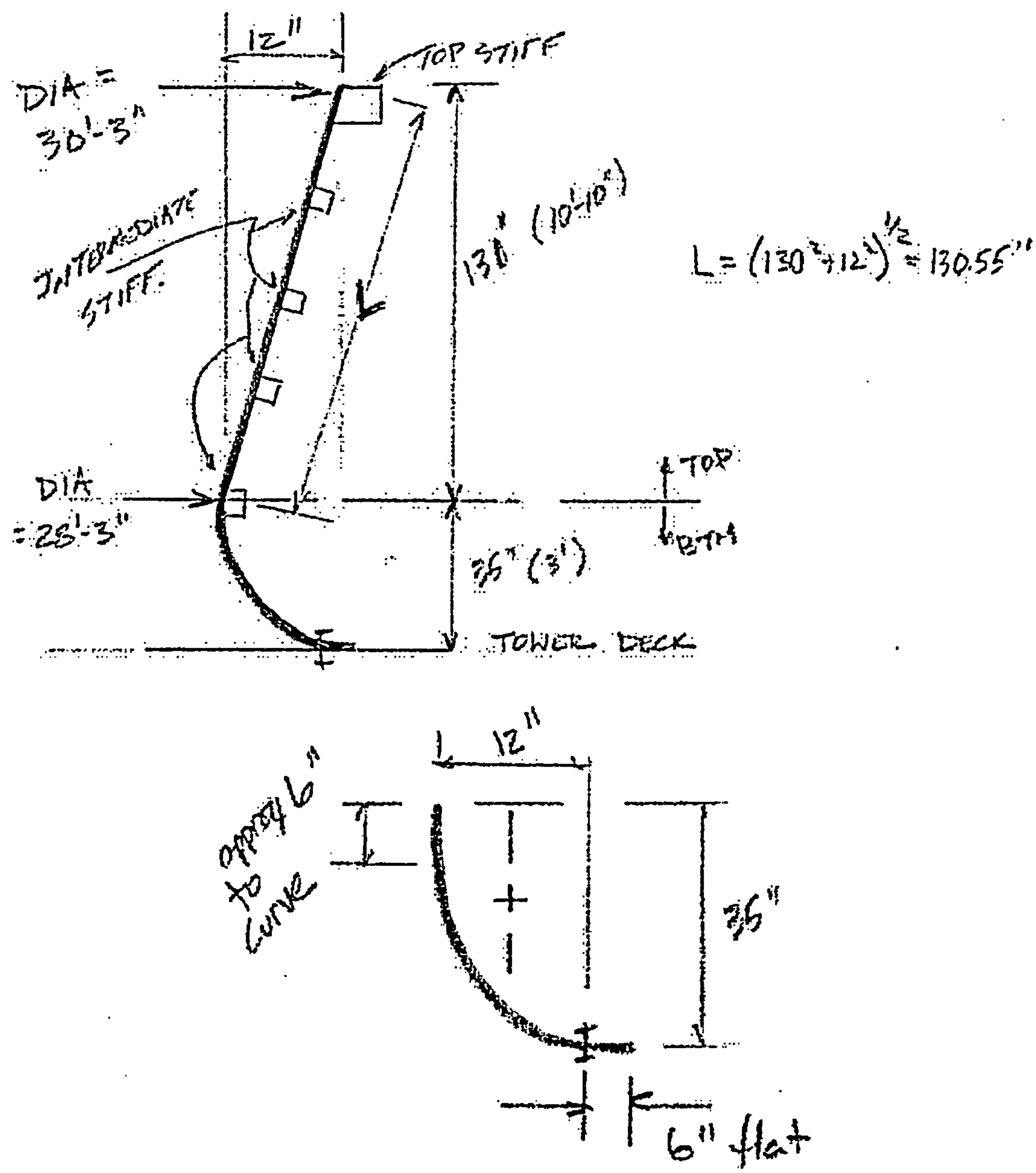
Load on K3B =	57	lbs.	
Load on Bent A nodes =	21	lbs.	Nodes (2FIL2-15). Load on 2FIL1 is 1/2 that on 2FIL2
Load on Bent A nodes =	36	lbs.	Nodes (2FIL2-15). Load on 2FIL1 is 1/2 that on 2FIL2

Use 36 lbs. as controlling.

6.2.1.12 Fiberglass Fan Stack

Determine weight of the fan stack:

The physical details and configuration of the CT2-1 fan stack were documented and are shown on sheet B15.



The approximate median diameter is $Stack\_dia\_median := 29 \cdot ft + 3 \cdot in$

The approximate diameter is $Stack\_dia\_top := 30 \cdot ft + 3 \cdot in$ $\quad$ $stack\_thk := 0.25 \cdot in$

$TOP\_length := \sqrt{(130 \cdot in)^2 + (12 \cdot in)^2}$ $\quad$ $TOP\_length = 10.879\ ft$

$BTM\_curve\_length := \frac{2 \cdot \pi}{4} \cdot \sqrt{\frac{(36 \cdot in)^2 + (12 \cdot in)^2}{2}}$ $\quad$ $BTM\_curve\_length = 42.149\ in$

$BTM\_length := (BTM\_curve\_length) + (6 \cdot in)$ $\quad$ $BTM\_length = 48.149\ in$

$Shell\_eff\_length := (TOP\_length) + (BTM\_length)$ $\quad$ $Shell\_eff\_length = 14.892\ ft$

Determine Volume of Fiberglass in Stack:

$Shell\_volume := \pi \cdot (stack\_thk) \cdot (Shell\_eff\_length) \cdot (Stack\_dia\_median)$ $\quad$ $Shell\_volume = 28.5\ ft^3$

Determine Volume of Intermediate Stiffeners in Stack:

$side\_length := \sqrt{(1 \cdot in)^2 + (2.75 \cdot in)^2}$ $\quad$ $side\_length = 2.9\ in$

$Int\_rib\_volume := [(2) \cdot (side\_length) + (2.5 \cdot in)] \cdot (stack\_thk) \cdot (Stack\_dia\_median) \cdot (\pi) \cdot (4 \cdot ribs)$

$Int\_rib\_volume = 5.33\ ft^3$

Determine Volume of Top Stiffener in Stack:

The approximate diameter to the center of the top stiffener rib is 6 inches beyond the top diameter.

$Top\_stiff\_dia := (Stack\_dia\_top) + (6 \cdot in)$

$TOP\_stiff\_volume := [(2) \cdot (6 \cdot in) + (6.5 \cdot in)] \cdot (stack\_thk) \cdot (Top\_stiff\_dia) \cdot (\pi) \cdot (1 \cdot ribs)$

$TOP\_stiff\_volume = 3.103\ ft^3$

Determine Volume of Vertical Stiffeners in Stack:

The 18 stack segments are secured together at each vertical seam by a 3-3/4"x3/8" thick plate bolted to the next segment.

$vert\_stiff\_thk := 0.375 \cdot in$ $vert\_stiff\_width := 3.75 \cdot in$

$vert\_stiff\_volume := (18 \cdot segments) \cdot (2 \cdot ribs) \cdot (Shell\_eff\_length) \cdot (vert\_stiff\_thk) \cdot (vert\_stiff\_width)$

$vert\_stiff\_volume = 5.24\ ft^3$

TOTAL SHELL VOLUME:

$Total\_stack\_volume := (Shell\_volume) + (Int\_rib\_volume) + (TOP\_stiff\_volume) + (vert\_stiff\_volume)$

$Total\_stack\_volume = 42.18\ ft^3$

TOTAL SHELL WEIGHT: $Fiberglass\_density := 120 \cdot \frac{lb}{ft^3}$ (References 19 and 27)

$Total\_stack\_weight := (Total\_stack\_volume) \cdot (Fiberglass\_density)$

$Total\_stack\_weight = 5061\ lb$ use 5100 lbs to account for nuts and bolts.

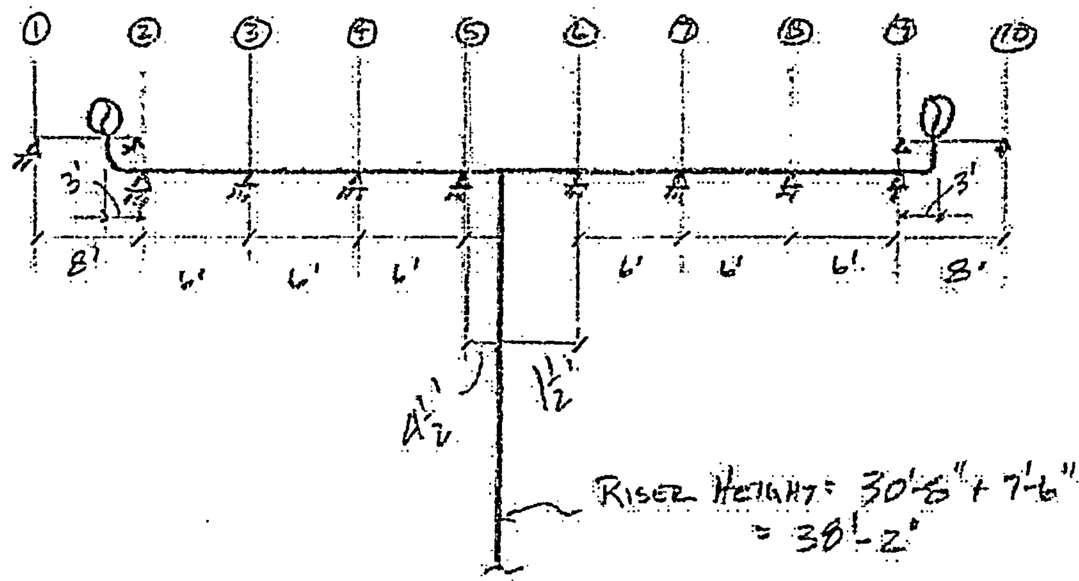
The fan stack layout is shown on drawing 5920-13331 (Ref. 7.13). From this it is seen that the fan stack loading is taken by approximately 12 columns.

Fan stack load per column = 5100/12 = 425 lbs.

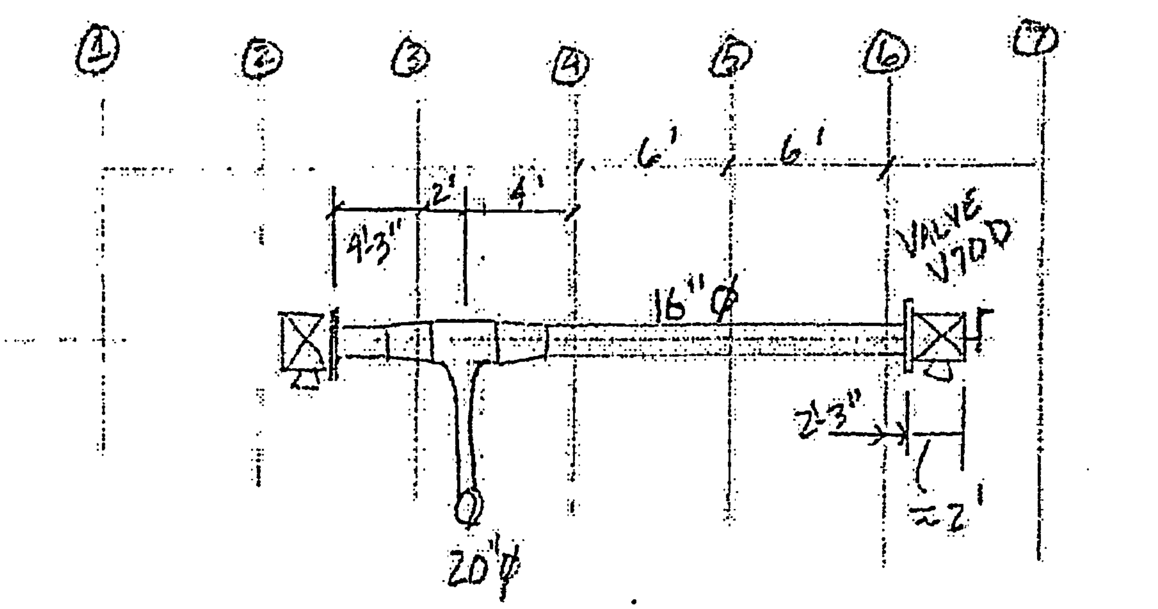
This weight will be applied to MAIN bent nodes P3 and P8 and to A bent nodes P2, P7, P9 and P14. and Bent B nodes P3 to P6 and P10 to P13.

6.2.1.13 Secondary Distribution Piping

MAIN BENT - SECONDARY DIST. PIPE



BENT C - SECONDARY DIST. PIPE



Secondary Distribution Piping (Continued)

The routing for the Secondary Distribution System piping is shown in References 7.5, 7.16 and 7.17. It rises from the ground 14'-0" south of the north end of Cell 1 18-inches from model column line 5 and 54-inches from 6. This riser is approximately 2'-0" south of a MAIN bent. It rises 38'-2" to a tee (approximate model Elev. 514.5"). From there it splits east and west 22'-6" and 25'-6" (model dimensions 58.625" and 634.625") to another tee rises 4'-6" (approximate model Elev. 590") and runs north and south.

The pipe is 20" diameter STD SCH pipe based on References 7.16 through 7.18. This cooling system will not be in use when the cooling tower is operating using the manifold pipe. The loading condition of the manifold pipe full is worse than the secondary pipe full.

Determine loading using empty secondary distribution piping.

The weight of 20-inch dia empty pipe = 80 lb/ft. Per Ref 24, wt = 78.6 lb/ft, use 80.
The weight of 16-inch dia empty pipe = 65 lb/ft. Per Ref 24, wt = 62.58 lb/ft, use 65.

MAIN BENT

The riser is supported at the bottom and by the branch piping at the top of the riser. Determine load on branch piping.

Riser weight on branch = 1/2*(38'-2")*(weight) = 1527 lbs. This load is taken by the supports on model column lines 5 and 6.

Load on model nodes. All load is applied to model level M.

	Pipe Run = 6' (20" dia)	Pipe Run = 3' (20" dia)	Transition Weight (lb)(see Bent C) 1204	Riser Weight (lb) 1527	Nodal Weight	1/3 Nodal Weight	2/3 Nodal Weight
M1			602		602	201	401
M2		240	602		842	281	561
M3	480				480	160	320
M4	480				480	160	320
M5	480			382	862	287	574
M6	480			1145	1625	542	1083
M7	480				480	160	320
M8	480				480	160	320
M9		240	602		842	281	561
M10			602		602	201	401

The riser and branch above is located between 2 MAIN bents. The weight will be distributed by approximately 1/3 being taken by the bent which supports the motor and 2/3 by a bent that does not support the motor.

Secondary Distribution Piping (Continued)

BENT C

Nodes N3 and N4 Load: The weight of pipe on Node N3 is comprised of a horiz. E-W pipe run, a horiz. N-S pipe run, a 90 degree elbow and the riser to the centerline of the N-S run.

Horiz EW Pipe Run	weight = (6'/2)-30")*pipe weight =	40	lbs
Horiz NS Pipe Run	weight = 3 ft*pipe weight =	240	lbs
	R = 30" L = PI*D/4=	3.93	ft
90 degree elbow	weight = length * pipe weight =	314	lbs
Vertical Run	weight = ((4.5 ft) - 30")* pipe weight =	160	lbs
N-S Run	weight = (4 ft)*(20" dia)+(2 ft)*(16" dia) =	450	lbs
	TOTAL WEIGHT =	1204	lbs

This total weight is divided between nodes N3 and N4.

N3 = 2/3*total =	803	lbs
N4 = 1/3*total =	401	lbs

Node N3 will also see load due to the 16" piping between N3 and N2.

Pipe and Valve	weight = 4.25 ft*16" pipe weight =	276.25	lbs	(accounts for valve V70D)

Node N4 will also see load due to the 16" piping between N4 and N5.

Pipe weight = 3 ft*16" pipe weight =	195	lbs
N3 Total Load =	1079	lbs
N4 Total Load =	596	lbs

Node N5 Load:

Pipe weight = 6 ft*16" pipe weight =	390	lbs

Node N6 Load:

Pipe and Valve	weight = (3 ft+4.25 ft)*16" pipe weight =	471	lbs	(accounts for valve V70A)

N5 Total Load =	390	lbs
N6 Total Load =	471	lbs

Secondary Distribution Piping (Continued)

<u>BENTS A and B</u> The riser feeding the tower is located 14'-0" from the north end of the tower and is located 18" from the center of a column between two BENT A columns.

Riser weight on one BENT A = (4.5/6)*(1/2)*(38'-2")*(weight) + (6 ft trib)*&weight) = 1625 lbs

This load is split between BENT A nodes DE3 and DE4

BENT A node DE3 Total Load = 1083 lbs
BENT A node DE4 Total Load = 542 lbs

BENT B is loaded by the piping passing through it. BENT B will only see load from a 6 ft tributary length.

Pipe weight weight = (6 ft)*pipe weight = 480 lbs

BENT B node DE3 Total Load = 320 lbs
BENT B node DE4 Total Load = 160 lbs

6.2.2 Applied Loads and Masses

6.2.2.1 Bent A Applied Loads and Masses

Bent A Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
C8	285	0.7367			285	0.7367
C15	285	0.7367			285	0.7367

Bent A Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
D1	94	0.2426			94	0.2426

Bent A Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
F1	214	0.5532			214	0.5532
F8	504	1.3055			504	1.3055
F15	504	1.3055			504	1.3055

Bent A Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
H1	240	0.6211			240	0.6211
H8	566	1.4658			566	1.4658
H15	566	1.4658			566	1.4658

Bent A Applied Loads and Masses (Continued)

Bent A Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
J1	240	0.6211			240	0.6211
J8	566	1.4658			566	1.4658
J15	566	1.4658			566	1.4658

Bent A Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
L1	180	0.4658			180	0.4658
L8	425	1.0994			425	1.0994
L15	425	1.0994			425	1.0994

Bent A Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
M1	184	0.4755			184	0.4755
M8	434	1.1223			434	1.1223
M15	434	1.1223			434	1.1223

Bent A Applied Loads and Masses (Continued)

Bent A Node	Fan, Stack and Motor Weight (lb)	Fan, Stack and Motor Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Top Cover Weight (lb)	Top Cover Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
P1			124	0.3203	873	2.2601	997	2.5804
P2	425	1.0999			1528	3.9552	1953	5.0551
P3					437	1.1300	437	1.1300
P4	1872	3.2573					1872	3.2573
P5	1872	3.2573					1872	3.2573
P6					437	1.1300	437	1.1300
P7	425	1.0999			1528	3.9552	1953	5.0551
P8			292	0.7558	1747	4.5202	2039	5.2760
P9	425	1.0999			1528	3.9552	1953	5.0551
P10					437	1.1300	437	1.1300
P11	1872	3.2573					1872	3.2573
P12	1872	3.2573					1872	3.2573
P13					437	1.1300	437	1.1300
P14	425	1.0999			1528	3.9552	1953	5.0551
P15			292	0.7558	1747	4.5202	2039	5.2760

Bent A Applied Loads and Masses (Continued)

Bent A Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
1FIL1			96	0.2485	96	0.2485
1FIL2			192	0.4971	192	0.4971
1FIL3			192	0.4971	192	0.4971
1FIL4			192	0.4971	192	0.4971
1FIL5			192	0.4971	192	0.4971
1FIL6			192	0.4971	192	0.4971
1FIL7			192	0.4971	192	0.4971
1FIL8			192	0.4971	192	0.4971
1FIL9			192	0.4971	192	0.4971
1FIL10			192	0.4971	192	0.4971
1FIL11			192	0.4971	192	0.4971
1FIL12			192	0.4971	192	0.4971
1FIL13			192	0.4971	192	0.4971
1FIL14			192	0.4971	192	0.4971
1FIL15			192	0.4971	192	0.4971
2FIL1	18	0.0472	143	0.3690	161	0.4162
2FIL2	36	0.0944	285	0.7381	322	0.8325
2FIL3	36	0.0944	285	0.7381	322	0.8325
2FIL4	36	0.0944	285	0.7381	322	0.8325
2FIL5	36	0.0944	285	0.7381	322	0.8325
2FIL6	36	0.0944	285	0.7381	322	0.8325
2FIL7	36	0.0944	285	0.7381	322	0.8325
2FIL8	36	0.0944	285	0.7381	322	0.8325
2FIL9	36	0.0944	285	0.7381	322	0.8325
2FIL10	36	0.0944	285	0.7381	322	0.8325
2FIL11	36	0.0944	285	0.7381	322	0.8325
2FIL12	36	0.0944	285	0.7381	322	0.8325
2FIL13	36	0.0944	285	0.7381	322	0.8325
2FIL14	36	0.0944	285	0.7381	322	0.8325
2FIL15	36	0.0944	285	0.7381	322	0.8325
3FIL1	62	0.1605	71	0.1843	133	0.3448
3FIL2	124	0.3209	142	0.3686	266	0.6895
3FIL3	124	0.3209	142	0.3686	266	0.6895
3FIL4	124	0.3209	142	0.3686	266	0.6895
3FIL5	124	0.3209	142	0.3686	266	0.6895
3FIL6	124	0.3209	142	0.3686	266	0.6895
3FIL7	124	0.3209	142	0.3686	266	0.6895
3FIL8	124	0.3209	142	0.3686	266	0.6895
3FIL9	124	0.3209	142	0.3686	266	0.6895
3FIL10	124	0.3209	142	0.3686	266	0.6895
3FIL11	124	0.3209	142	0.3686	266	0.6895
3FIL12	124	0.3209	142	0.3686	266	0.6895
3FIL13	124	0.3209	142	0.3686	266	0.6895
3FIL14	124	0.3209	142	0.3686	266	0.6895
3FIL15	124	0.3209	142	0.3686	266	0.6895

Bent A Applied Loads and Masses (Continued)

Bent A Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
4FIL1	46	0.1189	25	0.0648	71	0.1837
4FIL2	92	0.2378	50	0.1296	142	0.3673
4FIL3	92	0.2378	50	0.1296	142	0.3673
4FIL4	92	0.2378	50	0.1296	142	0.3673
4FIL5	92	0.2378	50	0.1296	142	0.3673
4FIL6	92	0.2378	50	0.1296	142	0.3673
4FIL7	92	0.2378	50	0.1296	142	0.3673
4FIL8	92	0.2378	50	0.1296	142	0.3673
4FIL9	92	0.2378	50	0.1296	142	0.3673
4FIL10	92	0.2378	50	0.1296	142	0.3673
4FIL11	92	0.2378	50	0.1296	142	0.3673
4FIL12	92	0.2378	50	0.1296	142	0.3673
4FIL13	92	0.2378	50	0.1296	142	0.3673
4FIL14	92	0.2378	50	0.1296	142	0.3673
4FIL15	92	0.2378	50	0.1296	142	0.3673

Bent A Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
DE1	14	0.0361			14	0.0361
DE2	28	0.0721			28	0.0721
DE3	28	0.0721	1083	2.8037	1111	2.8758
DE4	28	0.0721	542	1.4018	570	1.4739
DE5	28	0.0721			28	0.0721
DE6	28	0.0721			28	0.0721
DE7	28	0.0721			28	0.0721
DE8	28	0.0721			28	0.0721
DE9	28	0.0721			28	0.0721
DE10	28	0.0721			28	0.0721
DE11	28	0.0721			28	0.0721
DE12	28	0.0721			28	0.0721
DE13	28	0.0721			28	0.0721
DE14	28	0.0721			28	0.0721
DE15	28	0.0721			28	0.0721

6.2.2.2 Bent B Applied Loads and Masses

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
D1	33	0.0865	33	0.0865
D8	79	0.2042	79	0.2042
D15	79	0.2042	79	0.2042

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
E1	94	0.2426	94	0.2426
E8	221	0.5726	221	0.5726
E15	221	0.5726	221	0.5726

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
F1	120	0.3114	120	0.3114
F8	284	0.7348	284	0.7348
F15	284	0.7348	284	0.7348

Bent B Applied Loads and Masses (Continued)

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
G1	120	0.3106	120	0.3106
G8	283	0.7329	283	0.7329
G15	283	0.7329	283	0.7329

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
H1	120	0.3106	120	0.3106
H8	283	0.7329	283	0.7329
H15	283	0.7329	283	0.7329

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
I1	120	0.3106	120	0.3106
I8	283	0.7329	283	0.7329
I15	283	0.7329	283	0.7329

Bent B Applied Loads and Masses (Continued)

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
J1	120	0.3106	120	0.3106
J8	283	0.7329	283	0.7329
J15	283	0.7329	283	0.7329

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
K1	120	0.3106	120	0.3106
K8	283	0.7329	283	0.7329
K15	283	0.7329	283	0.7329

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
L1	120	0.3106	120	0.3106
L8	283	0.7329	283	0.7329
L15	283	0.7329	283	0.7329

Bent B Applied Loads and Masses (Continued)

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
M1	79	0.2038	79	0.2038
M8	186	0.4810	186	0.4810
M15	186	0.4810	186	0.4810

Bent B Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Hot Basin Weight (lb)	Hot Basin Mass (lb*sec^2/in)	Manifold Pipe Weight (lb)	Manifold Pipe Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
N1	124	0.3203	414	1.0714	1894	4.9014	2432	6.2931
N2			828	2.1429	3788	9.8028	4616	11.9457
N3			828	2.1429	3788	9.8028	4616	11.9457
N4			828	2.1429	3788	9.8028	4616	11.9457
N5			828	2.1429	3788	9.8028	4616	11.9457
N6			828	2.1429	3788	9.8028	4616	11.9457
N7			828	2.1429	3788	9.8028	4616	11.9457
N8	292	0.7558	828	2.1429	3788	9.8028	4908	12.7015
N9			828	2.1429	3788	9.8028	4616	11.9457
N10			828	2.1429	3788	9.8028	4616	11.9457
N11			828	2.1429	3788	9.8028	4616	11.9457
N12			828	2.1429	3788	9.8028	4616	11.9457
N13			828	2.1429	3788	9.8028	4616	11.9457
N14			828	2.1429	3788	9.8028	4616	11.9457
N15	292	0.7558	828	2.1429	3788	9.8028	4908	12.7015

Bent B Applied Loads and Masses (Continued)

Bent B Node	Fan, Stack and Motor Weight (lb)	Fan, Stack and Motor Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Top Cover Weight (lb)	Top Cover Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
P1			105	0.2717	873	2.2601	978	2.5318
P2					1747	4.5202	1747	4.5202
P3	425	1.0999			1528	3.9552	1953	5.0551
P4	1268	3.2811			1092	2.8251	2359	6.1063
P5	1268	3.2811			1092	2.8251	2359	6.1063
P6	425	1.0999			1528	3.9552	1953	5.0551
P7					1747	4.5202	1747	4.5202
P8			248	0.6413	1747	4.5202	1994	5.1615
P9					1747	4.5202	1747	4.5202
P10	425	1.0999			1528	3.9552	1953	5.0551
P11	1268	3.2811			1092	2.8251	2359	6.1063
P12	1268	3.2811			1092	2.8251	2359	6.1063
P13	425	1.0999			1528	3.9552	1953	5.0551
P14					1747	4.5202	1747	4.5202
P15			248	0.6413	1747	4.5202	1994	5.1615

Bent B Applied Loads and Masses (Continued)

Bent B Node	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
1FIL1	129	0.3337	129	0.3337
1FIL2	258	0.6674	258	0.6674
1FIL3	258	0.6674	258	0.6674
1FIL4	258	0.6674	258	0.6674
1FIL5	258	0.6674	258	0.6674
1FIL6	258	0.6674	258	0.6674
1FIL7	258	0.6674	258	0.6674
1FIL8	258	0.6674	258	0.6674
1FIL9	258	0.6674	258	0.6674
1FIL10	258	0.6674	258	0.6674
1FIL11	258	0.6674	258	0.6674
1FIL12	258	0.6674	258	0.6674
1FIL13	258	0.6674	258	0.6674
1FIL14	258	0.6674	258	0.6674
1FIL15	258	0.6674	258	0.6674
2FIL1	295	0.7622	295	0.7622
2FIL2	589	1.5244	589	1.5244
2FIL3	589	1.5244	589	1.5244
2FIL4	589	1.5244	589	1.5244
2FIL5	589	1.5244	589	1.5244
2FIL6	589	1.5244	589	1.5244
2FIL7	589	1.5244	589	1.5244
2FIL8	589	1.5244	589	1.5244
2FIL9	589	1.5244	589	1.5244
2FIL10	589	1.5244	589	1.5244
2FIL11	589	1.5244	589	1.5244
2FIL12	589	1.5244	589	1.5244
2FIL13	589	1.5244	589	1.5244
2FIL14	589	1.5244	589	1.5244
2FIL15	589	1.5244	589	1.5244
3FIL1	299	0.7731	299	0.7731
3FIL2	597	1.5463	597	1.5463
3FIL3	597	1.5463	597	1.5463
3FIL4	597	1.5463	597	1.5463
3FIL5	597	1.5463	597	1.5463
3FIL6	597	1.5463	597	1.5463
3FIL7	597	1.5463	597	1.5463
3FIL8	597	1.5463	597	1.5463
3FIL9	597	1.5463	597	1.5463
3FIL10	597	1.5463	597	1.5463
3FIL11	597	1.5463	597	1.5463
3FIL12	597	1.5463	597	1.5463
3FIL13	597	1.5463	597	1.5463
3FIL14	597	1.5463	597	1.5463
3FIL15	597	1.5463	597	1.5463

Bent B Applied Loads and Masses (Continued)

Bent B Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
4FIL1	27	0.0695	284	0.7350	311	0.8046
4FIL2	54	0.1391	568	1.4701	622	1.6092
4FIL3	54	0.1391	568	1.4701	622	1.6092
4FIL4	54	0.1391	568	1.4701	622	1.6092
4FIL5	54	0.1391	568	1.4701	622	1.6092
4FIL6	54	0.1391	568	1.4701	622	1.6092
4FIL7	54	0.1391	568	1.4701	622	1.6092
4FIL8	54	0.1391	568	1.4701	622	1.6092
4FIL9	54	0.1391	568	1.4701	622	1.6092
4FIL10	54	0.1391	568	1.4701	622	1.6092
4FIL11	54	0.1391	568	1.4701	622	1.6092
4FIL12	54	0.1391	568	1.4701	622	1.6092
4FIL13	54	0.1391	568	1.4701	622	1.6092
4FIL14	54	0.1391	568	1.4701	622	1.6092
4FIL15	54	0.1391	568	1.4701	622	1.6092
5FIL1			81	0.2090	81	0.2090
5FIL2			162	0.4180	162	0.4180
5FIL3			162	0.4180	162	0.4180
5FIL4			162	0.4180	162	0.4180
5FIL5			162	0.4180	162	0.4180
5FIL6			162	0.4180	162	0.4180
5FIL7			162	0.4180	162	0.4180
5FIL8			162	0.4180	162	0.4180
5FIL9			162	0.4180	162	0.4180
5FIL10			162	0.4180	162	0.4180
5FIL11			162	0.4180	162	0.4180
5FIL12			162	0.4180	162	0.4180
5FIL13			162	0.4180	162	0.4180
5FIL14			162	0.4180	162	0.4180
5FIL15			162	0.4180	162	0.4180

Bent B Applied Loads and Masses (Continued)

Bent B Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
DE1	28	0.0721			28	0.0721
DE2	56	0.1442			56	0.1442
DE3	56	0.1442	320	0.8282	376	0.9724
DE4	56	0.1442	160	0.4141	216	0.5583
DE5	56	0.1442			56	0.1442
DE6	56	0.1442			56	0.1442
DE7	56	0.1442			56	0.1442
DE8	56	0.1442			56	0.1442
DE9	56	0.1442			56	0.1442
DE10	56	0.1442			56	0.1442
DE11	56	0.1442			56	0.1442
DE12	56	0.1442			56	0.1442
DE13	56	0.1442			56	0.1442
DE14	56	0.1442			56	0.1442
DE15	56	0.1442			56	0.1442

6.2.2.3 Bent C Applied Loads and Masses

Bent C Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
D1	47	0.1213	57	0.1464	103	0.2677
D2			113	0.2929	113	0.2929
D3			113	0.2929	113	0.2929
D4			113	0.2929	113	0.2929
D5			113	0.2929	113	0.2929
D6			113	0.2929	113	0.2929
D7			113	0.2929	113	0.2929
D8	111	0.2863	113	0.2929	224	0.5791
D9			113	0.2929	113	0.2929
D10			113	0.2929	113	0.2929
D11			113	0.2929	113	0.2929
D12			113	0.2929	113	0.2929
D13			113	0.2929	113	0.2929
D14			113	0.2929	113	0.2929
D15	111	0.2863	113	0.2929	224	0.5791

Bent C Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
F1	77	0.1990	93	0.2401	170	0.4391
F2			186	0.4803	186	0.4803
F3			186	0.4803	186	0.4803
F4			186	0.4803	186	0.4803
F5			186	0.4803	186	0.4803
F6			186	0.4803	186	0.4803
F7			186	0.4803	186	0.4803
F8	181	0.4695	186	0.4803	367	0.9498
F9			186	0.4803	186	0.4803
F10			186	0.4803	186	0.4803
F11			186	0.4803	186	0.4803
F12			186	0.4803	186	0.4803
F13			186	0.4803	186	0.4803
F14			186	0.4803	186	0.4803
F15	181	0.4695	186	0.4803	367	0.9498

Bent C Applied Loads and Masses (Continued)

Bent C Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
G1	60	0.1553	72	0.1874	132	0.3427
G2			145	0.3748	145	0.3748
G3			145	0.3748	145	0.3748
G4			145	0.3748	145	0.3748
G5			145	0.3748	145	0.3748
G6			145	0.3748	145	0.3748
G7			145	0.3748	145	0.3748
G8	142	0.3665	145	0.3748	286	0.7413
G9			145	0.3748	145	0.3748
G10			145	0.3748	145	0.3748
G11			145	0.3748	145	0.3748
G12			145	0.3748	145	0.3748
G13			145	0.3748	145	0.3748
G14			145	0.3748	145	0.3748
G15	142	0.3665	145	0.3748	286	0.7413

Bent C Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
H1	60	0.1553	72	0.1874	240	0.6211	372	0.9638
H2			145	0.3748			145	0.3748
H3			145	0.3748			145	0.3748
H4			145	0.3748			145	0.3748
H5			145	0.3748			145	0.3748
H6			145	0.3748			145	0.3748
H7			145	0.3748			145	0.3748
H8	142	0.3665	145	0.3748			286	0.7413
H9			145	0.3748			145	0.3748
H10			145	0.3748			145	0.3748
H11			145	0.3748			145	0.3748
H12			145	0.3748			145	0.3748
H13			145	0.3748			145	0.3748
H14			145	0.3748			145	0.3748
H15	142	0.3665	145	0.3748			286	0.7413

Bent C Applied Loads and Masses (Continued)

Bent C Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Triangular Wall Self Weight (lb)	Triangular Wall Self Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
I1	82	0.2131	72	0.1874	9	0.0233	164	0.4238
I2			145	0.3748	9	0.0233	154	0.3981
I3			145	0.3748	9	0.0233	154	0.3981
I4			145	0.3748	9	0.0233	154	0.3981
I5			145	0.3748	9	0.0233	154	0.3981
I6			145	0.3748	9	0.0233	154	0.3981
I7			145	0.3748	9	0.0233	154	0.3981
I8	194	0.5029	145	0.3748	9	0.0233	348	0.9010
I9			145	0.3748	9	0.0233	154	0.3981
I10			145	0.3748	9	0.0233	154	0.3981
I11			145	0.3748	9	0.0233	154	0.3981
I12			145	0.3748	9	0.0233	154	0.3981
I13			145	0.3748	9	0.0233	154	0.3981
I14			145	0.3748	9	0.0233	154	0.3981
I15	194	0.5029	145	0.3748	9	0.0233	348	0.9010

Bent C Applied Loads and Masses (Continued)

Bent C Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Triangular Wall Self Weight (lb)
J1	105	0.2709	72	0.1874	20
J2			145	0.3748	20
J3			145	0.3748	20
J4			145	0.3748	20
J5			145	0.3748	20
J6			145	0.3748	20
J7			145	0.3748	20
J8	247	0.6393	145	0.3748	20
J9			145	0.3748	20
J10			145	0.3748	20
J11			145	0.3748	20
J12			145	0.3748	20
J13			145	0.3748	20
J14			145	0.3748	20
J15	247	0.6393	145	0.3748	20

Bent C Node	Triangular Wall Self Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
J1	0.0518	240	0.6211	437	1.1312
J2	0.0518			165	0.4266
J3	0.0518			165	0.4266
J4	0.0518			165	0.4266
J5	0.0518			165	0.4266
J6	0.0518			165	0.4266
J7	0.0518			165	0.4266
J8	0.0518			412	1.0659
J9	0.0518			165	0.4266
J10	0.0518			165	0.4266
J11	0.0518			165	0.4266
J12	0.0518			165	0.4266
J13	0.0518			165	0.4266
J14	0.0518			165	0.4266
J15	0.0518			412	1.0659

Bent C Applied Loads and Masses (Continued)

Bent C Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Triangular Wall Self Weight (lb)	Triangular Wall Self Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
K1	127	0.3287	72	0.1874	26	0.0673	225	0.5834
K2			145	0.3748	26	0.0673	171	0.4421
K3			145	0.3748	26	0.0673	171	0.4421
K4			145	0.3748	26	0.0673	171	0.4421
K5			145	0.3748	26	0.0673	171	0.4421
K6			145	0.3748	26	0.0673	171	0.4421
K7			145	0.3748	26	0.0673	171	0.4421
K8	300	0.7757	145	0.3748	26	0.0673	471	1.2178
K9			145	0.3748	26	0.0673	171	0.4421
K10			145	0.3748	26	0.0673	171	0.4421
K11			145	0.3748	26	0.0673	171	0.4421
K12			145	0.3748	26	0.0673	171	0.4421
K13			145	0.3748	26	0.0673	171	0.4421
K14			145	0.3748	26	0.0673	171	0.4421
K15	300	0.7757	145	0.3748	26	0.0673	471	1.2178

Bent C Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Triangular Wall Self Weight (lb)
L1	149	0.3865	72	0.1874	31
L2			145	0.3748	31
L3			145	0.3748	31
L4			145	0.3748	31
L5			145	0.3748	31
L6			145	0.3748	31
L7			145	0.3748	31
L8	352	0.9121	145	0.3748	31
L9			145	0.3748	31
L10			145	0.3748	31
L11			145	0.3748	31
L12			145	0.3748	31
L13			145	0.3748	31
L14			145	0.3748	31
L15	352	0.9121	145	0.3748	31

Bent C Applied Loads and Masses (Continued)

Bent C Node	Triangular Wall Self Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
L1	0.0802	240	0.6211	493	1.2752
L2	0.0802			176	0.4551
L3	0.0802			176	0.4551
L4	0.0802			176	0.4551
L5	0.0802			176	0.4551
L6	0.0802			176	0.4551
L7	0.0802			176	0.4551
L8	0.0802			528	1.3672
L9	0.0802			176	0.4551
L10	0.0802			176	0.4551
L11	0.0802			176	0.4551
L12	0.0802			176	0.4551
L13	0.0802			176	0.4551
L14	0.0802			176	0.4551
L15	0.0802			528	1.3672

Bent C Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)
M1	113	0.2916	48	0.1230
M2			95	0.2460
M3			95	0.2460
M4			95	0.2460
M5			95	0.2460
M6			95	0.2460
M7			95	0.2460
M8	266	0.6881	95	0.2460
M9			95	0.2460
M10			95	0.2460
M11			95	0.2460
M12			95	0.2460
M13			95	0.2460
M14			95	0.2460
M15	266	0.6881	95	0.2460

Bent C Applied Loads and Masses (Continued)

Bent C Node	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Triangular Wall Self Weight (lb)	Triangular Wall Self Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
	204	0.5269				
M1			35	0.0906	399	1.0320
M2			35	0.0906	130	0.3366
M3			35	0.0906	130	0.3366
M4			35	0.0906	130	0.3366
M5			35	0.0906	130	0.3366
M6			35	0.0906	130	0.3366
M7			35	0.0906	130	0.3366
M8			35	0.0906	396	1.0246
M9			35	0.0906	130	0.3366
M10			35	0.0906	130	0.3366
M11			35	0.0906	130	0.3366
M12			35	0.0906	130	0.3366
M13			35	0.0906	130	0.3366
M14			35	0.0906	130	0.3366
M15			35	0.0906	396	1.0246

Bent C Applied Loads and Masses (Continued)

Bent C Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Hot Basin Weight (lb)	Hot Basin Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)	Manifold Pipe Weight (lb)	Manifold Pipe Mass (lb*sec^2/in)
N1	184	0.4768	1242	3.2143			1894	4.9014
N2			2484	6.4286			3788	9.8028
N3			2484	6.4286	1079	2.7925	3788	9.8028
N4			2484	6.4286	596	1.5434	3788	9.8028
N5			2484	6.4286	390	1.0093	3788	9.8028
N6			2484	6.4286	471	1.2196	3788	9.8028
N7			2484	6.4286			3788	9.8028
N8			2484	6.4286			3788	9.8028
N9			2484	6.4286			3788	9.8028
N10			2484	6.4286			3788	9.8028
N11			2484	6.4286			3788	9.8028
N12			2484	6.4286			3788	9.8028
N13			2484	6.4286			3788	9.8028
N14			2484	6.4286			3788	9.8028
N15			2484	6.4286			3788	9.8028

Bent C Node	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Triangular Wall Self Weight (lb)	Triangular Wall Self Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
N1	59	0.1523	37	0.0958	3416	8.8406
N2	149	0.3866	37	0.0958	6458	16.7137
N3	149	0.3866	37	0.0958	7537	19.5062
N4	149	0.3866	37	0.0958	7055	18.2572
N5	149	0.3866	37	0.0958	6848	17.7230
N6	149	0.3866	37	0.0958	6929	17.9333
N7	118	0.3046	37	0.0958	6427	16.6317
N8	149	0.3866	37	0.0958	6458	16.7137
N9	118	0.3046	37	0.0958	6427	16.6317
N10	149	0.3866	37	0.0958	6458	16.7137
N11	149	0.3866	37	0.0958	6458	16.7137
N12	149	0.3866	37	0.0958	6458	16.7137
N13	149	0.3866	37	0.0958	6458	16.7137
N14	149	0.3866	37	0.0958	6458	16.7137
N15	149	0.3866	37	0.0958	6458	16.7137

Bent C Applied Loads and Masses (Continued)

Bent C Node	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
O1	63	0.1640	63	0.1640
O7	127	0.3280	127	0.3280
O9	127	0.3280	127	0.3280
O15	127	0.3280	127	0.3280

Bent C Node	Fan, Stack and Motor Weight (lb)	Fan, Stack and Motor Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Top Cover Weight (lb)	Top Cover Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)
P1			190	0.4929	1589	4.1121	16	0.0410
P2					3178	8.2242	127	0.3280
P3					3178	8.2242	127	0.3280
P4	421	1.0906			3178	8.2242	127	0.3280
P5	421	1.0906			3178	8.2242	127	0.3280
P6					3178	8.2242	127	0.3280
P7					3178	8.2242	32	0.0820
P8					3178	8.2242	127	0.3280
P9					3178	8.2242	32	0.0820
P10					3178	8.2242	127	0.3280
P11	421	1.0906			3178	8.2242	127	0.3280
P12	421	1.0906			3178	8.2242	127	0.3280
P13					3178	8.2242	127	0.3280
P14					3178	8.2242	127	0.3280
P15					3178	8.2242	16	0.0410

Bent C Applied Loads and Masses (Continued

Bent C Node	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Triangular Wall Self Weight (lb)	Triangular Wall Self Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
P1	270	0.6988	38	0.0983	2103	5.4431
P2	360	0.9317	38	0.0983	3703	9.5822
P3	360	0.9317	38	0.0983	3703	9.5822
P4	360	0.9317	38	0.0983	4124	10.6729
P5	360	0.9317	38	0.0983	4124	10.6729
P6	360	0.9317	38	0.0983	3703	9.5822
P7	360	0.9317	38	0.0983	3608	9.3362
P8	360	0.9317	38	0.0983	3703	9.5822
P9	360	0.9317	38	0.0983	3608	9.3362
P10	360	0.9317	38	0.0983	3703	9.5822
P11	360	0.9317	38	0.0983	4124	10.6729
P12	360	0.9317	38	0.0983	4124	10.6729
P13	360	0.9317	38	0.0983	3703	9.5822
P14	360	0.9317	38	0.0983	3703	9.5822
P15	360	0.9317	38	0.0983	3592	9.2952

Bent C Applied Loads and Masses (Continued)

Bent C Node	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
1FIL1	22	0.0582			22	0.0582
1FIL2	45	0.1164			45	0.1164
1FIL3	45	0.1164			45	0.1164
1FIL4	45	0.1164			45	0.1164
1FIL5	45	0.1164			45	0.1164
1FIL6	45	0.1164			45	0.1164
1FIL7	45	0.1164			45	0.1164
1FIL8	45	0.1164			45	0.1164
1FIL9	45	0.1164			45	0.1164
1FIL10	45	0.1164			45	0.1164
1FIL11	45	0.1164			45	0.1164
1FIL12	45	0.1164			45	0.1164
1FIL13	45	0.1164			45	0.1164
1FIL14	45	0.1164			45	0.1164
1FIL15	45	0.1164			45	0.1164
2FIL1	119	0.3077	240	0.6211	359	0.9288
2FIL2	238	0.6154			238	0.6154
2FIL3	238	0.6154			238	0.6154
2FIL4	238	0.6154			238	0.6154
2FIL5	238	0.6154			238	0.6154
2FIL6	238	0.6154			238	0.6154
2FIL7	238	0.6154			238	0.6154
2FIL8	238	0.6154			238	0.6154
2FIL9	238	0.6154			238	0.6154
2FIL10	238	0.6154			238	0.6154
2FIL11	238	0.6154			238	0.6154
2FIL12	238	0.6154			238	0.6154
2FIL13	238	0.6154			238	0.6154
2FIL14	238	0.6154			238	0.6154
2FIL15	238	0.6154			238	0.6154
3FIL1	234	0.6056	240	0.6211	474	1.2268
3FIL2	468	1.2113			468	1.2113
3FIL3	468	1.2113			468	1.2113
3FIL4	468	1.2113			468	1.2113
3FIL5	468	1.2113			468	1.2113
3FIL6	468	1.2113			468	1.2113
3FIL7	468	1.2113			468	1.2113
3FIL8	468	1.2113			468	1.2113
3FIL9	468	1.2113			468	1.2113
3FIL10	468	1.2113			468	1.2113
3FIL11	468	1.2113			468	1.2113
3FIL12	468	1.2113			468	1.2113
3FIL13	468	1.2113			468	1.2113
3FIL14	468	1.2113			468	1.2113
3FIL15	468	1.2113			468	1.2113

Bent C Applied Loads and Masses (Continued)

Bent C Node	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
4FIL1	400	1.0355	240	0.6211	640	1.6566
4FIL2	800	2.0709			800	2.0709
4FIL3	800	2.0709			800	2.0709
4FIL4	800	2.0709			800	2.0709
4FIL5	800	2.0709			800	2.0709
4FIL6	800	2.0709			800	2.0709
4FIL7	800	2.0709			800	2.0709
4FIL8	800	2.0709			800	2.0709
4FIL9	800	2.0709			800	2.0709
4FIL10	800	2.0709			800	2.0709
4FIL11	800	2.0709			800	2.0709
4FIL12	800	2.0709			800	2.0709
4FIL13	800	2.0709			800	2.0709
4FIL14	800	2.0709			800	2.0709
4FIL15	800	2.0709			800	2.0709
5FIL1	326	0.8447	308	0.7958	634	1.6405
5FIL2	653	1.6895			653	1.6895
5FIL3	653	1.6895			653	1.6895
5FIL4	653	1.6895			653	1.6895
5FIL5	653	1.6895			653	1.6895
5FIL6	653	1.6895			653	1.6895
5FIL7	653	1.6895			653	1.6895
5FIL8	653	1.6895			653	1.6895
5FIL9	653	1.6895			653	1.6895
5FIL10	653	1.6895			653	1.6895
5FIL11	653	1.6895			653	1.6895
5FIL12	653	1.6895			653	1.6895
5FIL13	653	1.6895			653	1.6895
5FIL14	653	1.6895			653	1.6895
5FIL15	653	1.6895			653	1.6895

6.2.2.4 Bent C Triangular Wall Redistribution

The preceding pages developed the seismic model with all sloped wall mass applied on top of a single C bent line columns. This section will revise the dead load in the sloped wall section. This load change will only apply to the dead load model and will not redistribute the mass for the seismic model.

Redistribute the dead weight of the T-bar fill, top cover loading, end walls, partition walls, hot basin, cable tray and the louver wall in the triangular area to the top of the double 4x4 members companion posts (Level G in Bent C model):

Bent C	Original DL Model						Amount In Angular Wall				
Node	T-Bar	Top Cover	Hot Basin	Cable Tray	Louver Wall	Node	T-Bar	Top Cover	Hot Basin	Cable Tray	Louver Wall
3FIL1	234					3FIL1	37				
3FIL2-15	468					3FIL2-15	73				
4FIL1	400					4FIL1	117				
4FIL2-15	800					4FIL2-15	233				
5FIL1	326					5FIL1	104				
5FIL2-15	653					5FIL2-15	208				
P1		1589		180		P1		576		90	
P2-15		3178		360		P2-15		1152		180	
N1			1242			N1			414		
N2-N15			2484			N2-N15			828		
H1					72	H1					72
H2-H15					145	H2-H15					145
I1					72	I1					72
I2-I15					145	I2-I15					145
J1					72	J1					72
J2-J15					145	J2-J15					145
K1					72	K1					72
K2-K15					145	K2-K15					145
L1					72	L1					72
L2-L15					145	L2-L15					145
M1					48	M1					48
M2-M15					95	M2-M15					95
N1					59	N1					59
N2-N6					149	N2-N6					149
N7					118	N7					118
N8					149	N8					149
N9					118	N9					118
N10-N15					149	N10-N15					149
O1					63	O1					63
O7, O9, O15					127	O7, O9, O15					127
P1					16	P1					16
P2-P6					127	P2-P6					127
P7					32	P7					32
P8					127	P8					127
P9					32	P9					32
P10-P14					127	P10-P14					127
P15					16	P15					16

Resultant New Dead Loads for Use in Bent C DL Model

Node	T-Bar	Top Cover	Hot Basin	Cable Tray	Louver Wall
3FIL1	197				
3FIL2-15	395				
4FIL1	283				
4FIL2-15	567				
5FIL1	222				
5FIL2-15	445				
P1		1013		90	
P2-15		2026		180	
N1			828		
N2-N15			1656		
H1					
H2-H15					
I1					
I2-I15					
J1					
J2-J15					
K1					
K2-K15					
L1					
L2-L15					
M1					
M2-M15					
N1					
N2-N6					
N7					
N8					
N9					
N10-N15					
O1					
O7, O9, O15					
P1					
P2-P6					
P7					
P8					
P9					
P10-P14					
P15					

Amount to be added to Level G at the top of the companion posts.

Node	T-Bar	Top Cover	Hot Basin	Cable Tray	Louver Wall
3FIL1	37				
3FIL2-15	73				
4FIL1	117				
4FIL2-15	233				
5FIL1	104				
5FIL2-15	208				
P1		576		90	
P2-15		1152		180	
N1			414		
N2-N15			828		
H1					72
H2-H15					145
I1					72
I2-I15					145
J1					72
J2-J15					145
K1					72
K2-K15					145
L1					72
L2-L15					145
M1					48
M2-M15					95
N1					59
N2-N6					149
N7					118
N8					149
N9					118
N10-N15					149
O1					63
O7, O9, O15					127
P1					16
P2-P6					127
P7					32
P8					127
P9					32
P10-P14					127
P15					16

Node			Node			Node		
H1	1885	lbs.	H7	3770	lbs.	H13	3770	lbs.
H2	3770	lbs.	H8	3770	lbs.	H14	3770	lbs.
H3	3770	lbs.	H9	3770	lbs.	H15	3786	lbs.
H4	3770	lbs.	H10	3770	lbs.			
H5	3770	lbs.	H11	3770	lbs.			
H6	3770	lbs.	H12	3770	lbs.			

6.2.2.5 End Bent Applied Loads and Masses

End Bent	Drift Eliminator Weight	Drift Eliminator Mass	End and Partition Wall Weight	End and Partition Wall Mass	T Bar Fill Weight	T Bar Fill Mass	Louver Wall Weight	Louver Wall Mass	Total Dead Load	Total Mass
Node	(lb)	(lb*sec^2/in)	(lb)	(lb*sec^2/in)	(lb)	(lb*sec^2/in)	(lb)	(lb*sec^2/in)	(lb)	(lb*sec^2/in)
D2			10	0.0255			12	0.0307	22	0.0562
D3			20	0.0510					20	0.0510
D4			20	0.0510					20	0.0510
D5			20	0.0510					20	0.0510
D6			20	0.0510					20	0.0510
D7			20	0.0510					20	0.0510
D8			20	0.0510					20	0.0510
D9			10	0.0255			12	0.0307	22	0.0562
E2			30	0.0784			37	0.0947	67	0.1731
E2A					31	0.0797			31	0.0797
E2B					53	0.1366			53	0.1366
E3			61	0.1569					61	0.1569
E3A					46	0.1190			46	0.1190
E3B					46	0.1190			46	0.1190
E3C					39	0.1015			39	0.1015
E4			121	0.3122					121	0.3122
E4A					39	0.1015			39	0.1015
E4B	26	0.0675							26	0.0675
E5			121	0.3122					121	0.3122
E6			121	0.3122					121	0.3122
E6A	26	0.0675							26	0.0675
E6B					39	0.1015			39	0.1015
E7			121	0.3122					121	0.3122
E7A					39	0.1015			39	0.1015
E7B					46	0.1190			46	0.1190
E7C					46	0.1190			46	0.1190
E8			61	0.1569					61	0.1569
E8A					53	0.1366			53	0.1366
E8B					31	0.0797			31	0.0797
E9			30	0.0784			37	0.0947	67	0.1731

End Bent Applied Loads and Masses (Continued)

End Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)
F2			50	0.1306		
F3			101	0.2612		
F8			101	0.2612		
F9			50	0.1306		
G2			60	0.1553		
G2A					67	0.1744
G2B					116	0.2990
G2C					101	0.2606
G3			120	0.3106		
G3A					101	0.2606
G3B					86	0.2222
G3C					86	0.2222
G4			221	0.5718		
G4A	57	0.1477				
G5			221	0.5718		
G6			221	0.5718		
G6A	57	0.1477				
G7			221	0.5718		
G7A					86	0.2222
G7B					86	0.2222
G7C					101	0.2606
G8			120	0.3106		
G8A					101	0.2606
G8B					116	0.2990
G8C					67	0.1744
G9			60	0.1553		

End Bent Applied Loads and Masses (Continued)

End Bent Node	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
F2	61	0.1577			111	0.2883
F3					101	0.2612
F8					101	0.2612
F9	61	0.1577			111	0.2883
G2	72	0.1874			132	0.3427
G2A					67	0.1744
G2B					116	0.2990
G2C					101	0.2606
G3					120	0.3106
G3A					101	0.2606
G3B					86	0.2222
G3C					86	0.2222
G4					221	0.5718
G4A					57	0.1477
G5					221	0.5718
G6					221	0.5718
G6A					57	0.1477
G7					221	0.5718
G7A					86	0.2222
G7B					86	0.2222
G7C					101	0.2606
G8					120	0.3106
G8A					101	0.2606
G8B					116	0.2990
G8C					67	0.1744
G9	72	0.1874	240	0.6211	372	0.9638

End Bent Applied Loads and Masses (Continued)

End Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)
H2			60	0.1553		
H3			120	0.3106		
H8			120	0.3106		
H9			60	0.1553		
I1			60	0.1553		
I1A					73	0.1895
I2			120	0.3106		
I2A					125	0.3248
I2B					109	0.2831
I2C					109	0.2831
I3			120	0.3106		
I3A					93	0.2413
I3B					93	0.2413
I3C	31	0.0802				
I4			240	0.6211		
I4A	31	0.0802				
I5			240	0.6211		
I6			240	0.6211		
I6A	31	0.0802				
I7			240	0.6211		
I7A	31	0.0802				
I7B					93	0.2413
I7C					93	0.2413
I8			120	0.3106		
I8A					109	0.2831
I8B					109	0.2831
I8C					125	0.3248
I9			120	0.3106		
I9A					73	0.1895
I10			60	0.1553		

End Bent Applied Loads and Masses (Continued)

End Bent Node	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
H2	74	0.1906			134	0.3458
H3					120	0.3106
H8					120	0.3106
H9	74	0.1906	240	0.6211	374	0.9670
I1	75	0.1937			135	0.3490
I1A					73	0.1895
I2					120	0.3106
I2A					125	0.3248
I2B					109	0.2831
I2C					109	0.2831
I3					120	0.3106
I3A					93	0.2413
I3B					93	0.2413
I3C					31	0.0802
I4					240	0.6211
I4A					31	0.0802
I5					240	0.6211
I6					240	0.6211
I6A					31	0.0802
I7					240	0.6211
I7A					31	0.0802
I7B					93	0.2413
I7C					93	0.2413
I8					120	0.3106
I8A					109	0.2831
I8B					109	0.2831
I8C					125	0.3248
I9			240	0.6211	360	0.9317
I9A					73	0.1895
I10	75	0.1937			135	0.3490

End Bent Applied Loads and Masses (Continued)

End Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)
J1			60	0.1553
J2			120	0.3106
J3			120	0.3106
J8			120	0.3106
J9			120	0.3106
J10			60	0.1553
K1			60	0.1553
K1A				
K1B				
K2			120	0.3106
K2A				
K2B				
K2C				
K3			120	0.3106
K3A				
K3B	73	0.1884		
K4			240	0.6211
K5			240	0.6211
K6			240	0.6211
K7			240	0.6211
K7A	73	0.1884		
K7B				
K8			120	0.3106
K8A				
K8B				
K8C				
K9			120	0.3106
K9A				
K9B				
K10			60	0.1553

End Bent Applied Loads and Masses (Continued)

End Bent Node	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
J1			75	0.1937			135	0.3490
J2							120	0.3106
J3							120	0.3106
J8							120	0.3106
J9					240	0.6211	360	0.9317
J10			75	0.1937			135	0.3490
K1			75	0.1937			135	0.3490
K1A	86	0.2225					86	0.2225
K1B	147	0.3814					147	0.3814
K2							120	0.3106
K2A	128	0.3324					128	0.3324
K2B	128	0.3324					128	0.3324
K2C	109	0.2834					109	0.2834
K3							120	0.3106
K3A	109	0.2834					109	0.2834
K3B							73	0.1884
K4							240	0.6211
K5							240	0.6211
K6							240	0.6211
K7							240	0.6211
K7A							73	0.1884
K7B	109	0.2834					109	0.2834
K8							120	0.3106
K8A	109	0.2834					109	0.2834
K8B	128	0.3324					128	0.3324
K8C	128	0.3324					128	0.3324
K9					240	0.6211	360	0.9317
K9A	147	0.3814					147	0.3814
K9B	86	0.2225					86	0.2225
K10			75	0.1937			135	0.3490

End Bent Applied Loads and Masses (Continued)

End Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
L1			60	0.1553	75	0.1937			135	0.3490
L2			120	0.3106					120	0.3106
L3			120	0.3106					120	0.3106
L8			120	0.3106					120	0.3106
L9			120	0.3106			240	0.6211	360	0.9317
L10			60	0.1553	75	0.1937			135	0.3490
M1			51	0.1317	63	0.1643			114	0.2960
M2			102	0.2634					102	0.2634
M3			102	0.2634					102	0.2634
M3A	42	0.1082							42	0.1082
M4			274	0.7085					274	0.7085
M5			274	0.7085					274	0.7085
M6			274	0.7085					274	0.7085
M7			274	0.7085					274	0.7085
M7A	42	0.1082							42	0.1082
M8			102	0.2634					102	0.2634
M9			102	0.2634			204	0.5269	305	0.7903
M10			51	0.1317	63	0.1643			114	0.2960

End Bent Applied Loads and Masses (Continued)

End Bent Node	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Hot Basin Weight (lb)	Hot Basin Mass (lb*sec^2/in)	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Top Cover Weight (lb)	Top Cover Mass (lb*sec^2/in)
N1	77	0.1990	414	1.0714				
N1A					49	0.1277		
N1B					85	0.2190		
N1C					74	0.1908		
N2	154	0.3979	828	2.1429				
N2A					74	0.1908		
N2B					63	0.1627		
N2C					63	0.1627		
N3	154	0.3979	414	1.0714				
N8	154	0.3979	414	1.0714				
N8A					63	0.1627		
N8B					63	0.1627		
N8C					74	0.1908		
N9	154	0.3979	828	2.1429				
N9A					74	0.1908		
N9B					85	0.2190		
N9C					49	0.1277		
N10	77	0.1990	414	1.0714				
O4	112	0.2897						
O7	112	0.2897						
P1	56	0.1449					437	1.1300
P2	112	0.2897					873	2.2601
P3	112	0.2897					873	2.2601
P4	16	0.0421					873	2.2601
P5	112	0.2897					873	2.2601
P6	112	0.2897					873	2.2601
P7	16	0.0421					873	2.2601
P8	112	0.2897					873	2.2601
P9	112	0.2897					873	2.2601
P10	56	0.1449					437	1.1300

End Bent Applied Loads and Masses (Continued)

End Bent Node	Manifold Pipe Weight (lb)	Manifold Pipe Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
N1			96	0.2482			587	1.5185
N1A							49	0.1277
N1B							85	0.2190
N1C							74	0.1908
N2	1894	4.9014					2876	7.4422
N2A							74	0.1908
N2B							63	0.1627
N2C							63	0.1627
N3	1894	4.9014					2462	6.3708
N8	1894	4.9014					2462	6.3708
N8A							63	0.1627
N8B							63	0.1627
N8C							74	0.1908
N9	1894	4.9014			308	0.7958	3183	8.2380
N9A							74	0.1908
N9B							85	0.2190
N9C							49	0.1277
N10			96	0.2482			587	1.5185
O4							112	0.2897
O7							112	0.2897
P1			70	0.1807			562	1.4556
P2							985	2.5498
P3							985	2.5498
P4							890	2.3021
P5							985	2.5498
P6							985	2.5498
P7							890	2.3021
P8							985	2.5498
P9					314	0.2329	1299	2.7827
P10			70	0.1807	90	0.2329	652	1.6885

6.2.2.6 Main Bent Applied Loads and Masses

Main Bent Node	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
D2	24	0.0615	24	0.0615
D9	24	0.0615	24	0.0615

Main Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
E2					73	0.1894	73	0.1894
E2A			62	0.1594			62	0.1594
E2B			106	0.2732			106	0.2732
E3								
E3A			92	0.2381			92	0.2381
E3B			92	0.2381			92	0.2381
E3C			78	0.2030			78	0.2030
E4								
E4A			78	0.2030			78	0.2030
E4B	78	0.2014					78	0.2014
E5								
E6								
E6A	78	0.2014					78	0.2014
E6B			78	0.2030			78	0.2030
E7								
E7A			78	0.2030			78	0.2030
E7B			92	0.2381			92	0.2381
E7C			92	0.2381			92	0.2381
E8								
E8A			106	0.2732			106	0.2732
E8B			62	0.1594			62	0.1594
E9					73	0.1894	73	0.1894
F2					122	0.3153	122	0.3153
F3								
F8								
F9					122	0.3153	122	0.3153

Main Bent Applied Loads and Masses (Continued)

Main Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
G2					145	0.3748	145	0.3748
G2A			135	0.3488			135	0.3488
G2B			231	0.5980			231	0.5980
G2C			201	0.5212			201	0.5212
G3								
G3A			201	0.5212			201	0.5212
G3B			172	0.4443			172	0.4443
G3C			172	0.4443			172	0.4443
G4								
G4A	114	0.2954					114	0.2954
G5								
G6								
G6A	114	0.2954					114	0.2954
G7								
G7A			172	0.4443			172	0.4443
G7B			172	0.4443			172	0.4443
G7C			201	0.5212			201	0.5212
G8								
G8A			201	0.5212			201	0.5212
G8B			231	0.5980			231	0.5980
G8C			135	0.3488			135	0.3488
G9					145	0.3748	145	0.3748
H2					206	0.5327	206	0.5327
H3								
H8								
H9					206	0.5327	206	0.5327

Main Bent Applied Loads and Masses (Continued)

Main Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
I1					150	0.3874	150	0.3874
I1A			146	0.3789			146	0.3789
I2								
I2A			251	0.6496			251	0.6496
I2B			219	0.5661			219	0.5661
I2C			219	0.5661			219	0.5661
I3								
I3A			187	0.4827			187	0.4827
I3B			187	0.4827			187	0.4827
I3C	62	0.1605					62	0.1605
I4								
I4A	62	0.1605					62	0.1605
I5								
I6								
I6A	62	0.1605					62	0.1605
I7								
I7A	62	0.1605					62	0.1605
I7B			187	0.4827			187	0.4827
I7C			187	0.4827			187	0.4827
I8								
I8A			219	0.5661			219	0.5661
I8B			219	0.5661			219	0.5661
I8C			251	0.6496			251	0.6496
I9								
I9A			146	0.3789			146	0.3789
I10					150	0.3874	150	0.3874
J1					150	0.3874	150	0.3874
J10					150	0.3874	150	0.3874

Main Bent Applied Loads and Masses (Continued)

Main Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
K1			150	0.3874			150	0.3874
K1A					172	0.4449	172	0.4449
K1B					295	0.7627	295	0.7627
K2A					257	0.6647	257	0.6647
K2B					257	0.6647	257	0.6647
K2C					219	0.5668	219	0.5668
K3A					219	0.5668	219	0.5668
K3B	146	0.3768					146	0.3768
K7A	146	0.3768					146	0.3768
K7B					219	0.5668	219	0.5668
K8A					219	0.5668	219	0.5668
K8B					257	0.6647	257	0.6647
K8C					257	0.6647	257	0.6647
K9A					295	0.7627	295	0.7627
K9B					172	0.4449	172	0.4449
K10			150	0.3874			150	0.3874

Main Bent Applied Loads and Masses (Continued)

Main Bent Node	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
L1	150	0.3874	150	0.3874
L10	150	0.3874	150	0.3874

Main Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	Hot Basin Weight (lb)	Hot Basin Mass (lb*sec^2/in)	Secondary Dist. Piping Weight (lb)	Secondary Dist. Piping Mass (lb*sec^2/in)
M1					401	1.0388
M2					561	1.4529
M3					320	0.8282
M3A	84	0.2164				
M4					320	0.8282
M5					574	1.4867
M6					1083	2.8037
M7					320	0.8282
M7A	84	0.2164				
M8					320	0.8282
M9					561	1.4529
M10					401	1.0388
N1			828	2.1429		
N1A						
N1B						
N1C						
N2			1656	4.2857		
N2A						
N2B						
N2C						
N3			828	2.1429		
N8			828	2.1429		
N8A						
N8B						
N8C						
N9			1656	4.2857		
N9A						
N9B						
N9C						
N10			828	2.1429		

Main Bent Applied Loads and Masses (Continued)

Main Bent Node	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Manifold Pipe Weight (lb)	Manifold Pipe Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
M1					127	0.3286	528	1.3674
M2							561	1.4529
M3							320	0.8282
M3A							84	0.2164
M4							320	0.8282
M5							574	1.4867
M6							1083	2.8037
M7							320	0.8282
M7A							84	0.2164
M8							320	0.8282
M9							561	1.4529
M10					127	0.3286	528	1.3674
N1					192	0.4963	1020	2.6392
N1A	99	0.2554					99	0.2554
N1B	169	0.4379					169	0.4379
N1C	147	0.3817					147	0.3817
N2			3788	9.8028			5444	14.0886
N2A	147	0.3817					147	0.3817
N2B	126	0.3254					126	0.3254
N2C	126	0.3254					126	0.3254
N3			3788	9.8028			4616	11.9457
N8			3788	9.8028			4616	11.9457
N8A	126	0.3254					126	0.3254
N8B	126	0.3254					126	0.3254
N8C	147	0.3817					147	0.3817
N9			3788	9.8028			5444	14.0886
N9A	147	0.3817					147	0.3817
N9B	169	0.4379					169	0.4379
N9C	99	0.2554					99	0.2554
N10					192	0.4963	1020	2.6392

Main Bent Applied Loads and Masses (Continued)

Main Bent	Fan, Stack and Motor Weight (lb)	Fan, Stack and Motor Mass (lb*sec^2/in)	Top Cover Weight (lb)	Top Cover Mass (lb*sec^2/in)
P1			873	2.2601
P2			1747	4.5202
P3	425	1.0999	1092	2.8251
P4				
P5	1872	3.2573		
P6	1872	3.2573		
P7				
P8	1268	3.2811	1092	2.8251
P9	466	1.2071	1747	4.5202
P10			873	2.2601

Main Bent	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
P1	140	0.3614			1013	2.6215
P2					1747	4.5202
P3					1517	3.9250
P4						
P5					1872	3.2573
P6					1872	3.2573
P7						
P8					2359	6.1063
P9			180	0.4658	2393	6.1931
P10	140	0.3614	180	0.4658	1193	3.0873

6.2.2.7 Partition Bent Applied Loads and Masses

Partition Bent Node	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
D2	24	0.0615	24	0.0615
D9	24	0.0615	24	0.0615

Partition Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)
E2			48	0.1250
E2A				
E2B				
E3			97	0.2500
E3A				
E3B				
E3C				
E4			238	0.6165
E4A				
E4B	78	0.2014		
E5			238	0.6165
E6			238	0.6165
E6A	78	0.2014		
E6B				
E7			238	0.6165
E7A				
E7B				
E7C				
E8			97	0.2500
E8A				
E8B				
E9			48	0.1250
F2			119	0.3082
F3			238	0.6165
F8			238	0.6165
F9			119	0.3082

Partition Bent Applied Loads and Masses (Continued)

Partition Bent Node	T Bar Fill Weight (lb)	T Bar Fill Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
E2			73	0.1894	121	0.3144
E2A	62	0.1594			62	0.1594
E2B	106	0.2732			106	0.2732
E3					97	0.2500
E3A	92	0.2381			92	0.2381
E3B	92	0.2381			92	0.2381
E3C	78	0.2030			78	0.2030
E4					238	0.6165
E4A	78	0.2030			78	0.2030
E4B					78	0.2014
E5					238	0.6165
E6					238	0.6165
E6A					78	0.2014
E6B	78	0.2030			78	0.2030
E7					238	0.6165
E7A	78	0.2030			78	0.2030
E7B	92	0.2381			92	0.2381
E7C	92	0.2381			92	0.2381
E8					97	0.2500
E8A	106	0.2732			106	0.2732
E8B	62	0.1594			62	0.1594
E9			73	0.1894	121	0.3144
F2			122	0.3153	241	0.6235
F3					238	0.6165
F8					238	0.6165
F9			122	0.3153	241	0.6235

Partition Bent Applied Loads and Masses (Continued)

Partition Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	T Bar Fill Weight (lb)
G2			142	0.3665	
G2A					135
G2B					231
G2C					201
G3			283	0.7329	
G3A					201
G3B					172
G3C					172
G4			521	1.3494	
G4A	114	0.2954			
G5			521	1.3494	
G6			521	1.3494	
G6A	114	0.2954			
G7			521	1.3494	
G7A					172
G7B					172
G7C					201
G8			283	0.7329	
G8A					201
G8B					231
G8C					135
G9			142	0.3665	
H2			142	0.3665	
H3			283	0.7329	
H8			283	0.7329	
H9			142	0.3665	

Partition Bent Applied Loads and Masses (Continued)

Partition Bent Node	T Bar Fill Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
G2		145	0.3748	286	0.7413
G2A	0.3488			135	0.3488
G2B	0.5980			231	0.5980
G2C	0.5212			201	0.5212
G3				283	0.7329
G3A	0.5212			201	0.5212
G3B	0.4443			172	0.4443
G3C	0.4443			172	0.4443
G4				521	1.3494
G4A				114	0.2954
G5				521	1.3494
G6				521	1.3494
G6A				114	0.2954
G7				521	1.3494
G7A	0.4443			172	0.4443
G7B	0.4443			172	0.4443
G7C	0.5212			201	0.5212
G8				283	0.7329
G8A	0.5212			201	0.5212
G8B	0.5980			231	0.5980
G8C	0.3488			135	0.3488
G9		145	0.3748	286	0.7413
H2		206	0.5327	347	0.8991
H3				283	0.7329
H8				283	0.7329
H9		206	0.5327	347	0.8991

Partition Bent Applied Loads and Masses (Continued)

Partition Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	T Bar Fill Weight (lb)
I1					
I1A					146
I2			142	0.3665	
I2A					251
I2B					219
I2C					219
I3			283	0.7329	
I3A					187
I3B					187
I3C	62	0.1605			
I4			566	1.4658	
I4A	62	0.1605			
I5			566	1.4658	
I6			566	1.4658	
I6A	62	0.1605			
I7			566	1.4658	
I7A	62	0.1605			
I7B					187
I7C					187
I8			283	0.7329	
I8A					219
I8B					219
I8C					251
I9			142	0.3665	
I9A					146
I10					
J1					
J2			283	0.7329	
J3			283	0.7329	
J8			283	0.7329	
J9			283	0.7329	
J10					

Partition Bent Applied Loads and Masses (Continued)

Partition Bent Node	T Bar Fill Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
I1		150	0.3874	150	0.3874
I1A	0.3789			146	0.3789
I2				142	0.3665
I2A	0.6496			251	0.6496
I2B	0.5661			219	0.5661
I2C	0.5661			219	0.5661
I3				283	0.7329
I3A	0.4827			187	0.4827
I3B	0.4827			187	0.4827
I3C				62	0.1605
I4				566	1.4658
I4A				62	0.1605
I5				566	1.4658
I6				566	1.4658
I6A				62	0.1605
I7				566	1.4658
I7A				62	0.1605
I7B	0.4827			187	0.4827
I7C	0.4827			187	0.4827
I8				283	0.7329
I8A	0.5661			219	0.5661
I8B	0.5661			219	0.5661
I8C	0.6496			251	0.6496
I9				142	0.3665
I9A	0.3789			146	0.3789
I10		150	0.3874	150	0.3874
J1		150	0.3874	150	0.3874
J2				283	0.7329
J3				283	0.7329
J8				283	0.7329
J9				283	0.7329
J10		150	0.3874	150	0.3874

Partition Bent Applied Loads and Masses (Continued)

Partition Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	T Bar Fill Weight (lb)
K1					
K1A					172
K1B					295
K2			283	0.7329	
K2A					257
K2B					257
K2C					219
K3			283	0.7329	
K3A					219
K3B	146	0.3768			
K4			566	1.4658	
K5			566	1.4658	
K6			566	1.4658	
K7			566	1.4658	
K7A	146	0.3768			
K7B					219
K8			283	0.7329	
K8A					219
K8B					257
K8C					257
K9			283	0.7329	
K9A					295
K9B					172
K10					
L1					
L2			283	0.7329	
L3			283	0.7329	
L8			283	0.7329	
L9			283	0.7329	
L10					

Partition Bent Applied Loads and Masses (Continued)

Partition Bent Node	T Bar Fill Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
K1		150	0.3874	150	0.3874
K1A	0.4449			172	0.4449
K1B	0.7627			295	0.7627
K2				283	0.7329
K2A	0.6647			257	0.6647
K2B	0.6647			257	0.6647
K2C	0.5668			219	0.5668
K3				283	0.7329
K3A	0.5668			219	0.5668
K3B				146	0.3768
K4				566	1.4658
K5				566	1.4658
K6				566	1.4658
K7				566	1.4658
K7A				146	0.3768
K7B	0.5668			219	0.5668
K8				283	0.7329
K8A	0.5668			219	0.5668
K8B	0.6647			257	0.6647
K8C	0.6647			257	0.6647
K9				283	0.7329
K9A	0.7627			295	0.7627
K9B	0.4449			172	0.4449
K10		150	0.3874	150	0.3874
L1		150	0.3874	150	0.3874
L2				283	0.7329
L3				283	0.7329
L8				283	0.7329
L9				283	0.7329
L10		150	0.3874	150	0.3874

Partition Bent Applied Loads and Masses (Continued)

Partition Bent Node	Drift Eliminator Weight (lb)	Drift Eliminator Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)	End and Partition Wall Mass (lb*sec^2/in)	Hot Basin Weight (lb)	Hot Basin Mass (lb*sec^2/in)	T Bar Fill Weight (lb)
M1			120	0.3109			
M2			240	0.6217			
M3			240	0.6217			
M3A	84	0.2164					
M4			646	1.6720			
M5			646	1.6720			
M6			646	1.6720			
M7			646	1.6720			
M7A	84	0.2164					
M8			240	0.6217			
M9			240	0.6217			
M10			120	0.3109			
N1					828	2.1429	
N1A							99
N1B							169
N1C							147
N2					1656	4.2857	
N2A							147
N2B							126
N2C							126
N3			122	0.3149	828	2.1429	
N8			122	0.3149	828	2.1429	
N8A							126
N8B							126
N8C							147
N9					1656	4.2857	
N9A							147
N9B							169
N9C							99
N10					828	2.1429	

Partition Bent Applied Loads and Masses (Continued)

Partition Bent Node	T Bar Fill Mass (lb*sec^2/in)	Manifold Pipe Weight (lb)	Manifold Pipe Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
M1				127	0.3286	247	0.6395
M2						240	0.6217
M3						240	0.6217
M3A						84	0.2164
M4						646	1.6720
M5						646	1.6720
M6						646	1.6720
M7						646	1.6720
M7A						84	0.2164
M8						240	0.6217
M9						240	0.6217
M10				127	0.3286	247	0.6395
N1				192	0.4963	1020	2.6392
N1A	0.2554					99	0.2554
N1B	0.4379					169	0.4379
N1C	0.3817					147	0.3817
N2		3788	9.8028			5444	14.0886
N2A	0.3817					147	0.3817
N2B	0.3254					126	0.3254
N2C	0.3254					126	0.3254
N3		3788	9.8028			4738	12.2606
N8		3788	9.8028			4738	12.2606
N8A	0.3254					126	0.3254
N8B	0.3254					126	0.3254
N8C	0.3817					147	0.3817
N9		3788	9.8028			5444	14.0886
N9A	0.3817					147	0.3817
N9B	0.4379					169	0.4379
N9C	0.2554					99	0.2554
N10				192	0.4963	1020	2.6392

Partition Bent Applied Loads and Masses (Continued)

Partition Bent Node	Top Cover Weight (lb)	Top Cover Mass (lb*sec^2/in)	Louver Wall Weight (lb)	Louver Wall Mass (lb*sec^2/in)	End and Partition Wall Weight (lb)
P1	873	2.2601	140	0.3614	
P2	1747	4.5202			
P3	1747	4.5202			181
P4	1747	4.5202			363
P5	1747	4.5202			363
P6	1747	4.5202			363
P7	1747	4.5202			363
P8	1747	4.5202			181
P9	1747	4.5202			
P10	873	2.2601	140	0.3614	

Partition Bent Node	End and Partition Wall Mass (lb*sec^2/in)	Cable Tray Weight (lb)	Cable Tray Mass (lb*sec^2/in)	Total Dead Load (lb)	Total Mass (lb*sec^2/in)
P1				1013	2.6215
P2				1747	4.5202
P3	0.4695			1928	4.9897
P4	0.9391			2109	5.4592
P5	0.9391			2109	5.4592
P6	0.9391			2109	5.4592
P7	0.9391			2109	5.4592
P8	0.4695			1928	4.9897
P9		180	0.4658	1927	4.9860
P10		180	0.4658	1193	3.0873

6.3 ALLOWABLE LOADS

The allowable loads for the cooling tower wooden members are determined in accordance with References 2, 8 and 11.

6.3.1 Allowable Compression Stress:

From Table 2.3.1 of Reference 8, find the allowable compressive stress is determined by applying adjustment factors to a non-factored allowable compressive stress.

$$F_C' = (F_C)*(C_D)*(C_M)*(C_t)*(C_F)*(C_P)$$

Where: F_C' = factored allowable compressive stress parallel to the grain

F_C = non-factored allowable compressive stress paralle to the grain

C_D = load duration factor

C_M = wet service factor

C_t = temperature factor

C_F = size factor

C_P = column stability factor

- From page B7, find the wood allowable loads are to be based on Douglas Fir #1 grade lumber. From Table 114-A, Reference 11, find the following allowable compressive stress:

  $$F_C = 1377 * psi \quad (\text{with } C_D = 0.9)$$

  Per note 3 of Table 114-A, Reference 11, the allowable compressive stress above has been adjusted for a 50 year load duration ($C_D = 0.9$).
- From Table 2.3.2, Reference 8, find the load duration factor, C_D, = 1.0 for live load and 0.9 for dead load. Therefore the unadjusted allowable compressive stress = (1377 psi) / (0.9) = 1530 psi.
- From Table 114-D, Reference 11, find the wet service factor, C_M, = 0.80 for compression parallel to the grain for saturated wood. The cooling tower wood wet service is defined as saturated on sheet B7.
- From Table 114-D, Reference 11, find the wet service factor, C_M, = 0.90 for the modulus of elasticity for saturated wood. The cooling tower wood wet service is defined as saturated on sheet B7.

- From sheet B7, find the following temperature profile for the cooling tower structure:

Design Loads

a. Design Temperatures for calculation of wood allowable loads.

Plenum Area: 100.3F

Fill Area - top third of tower: 115.F (model Z < approx. 654" and > 380")

Fill Area - middle third of tower: 107.5F (model Z < approx. 380" and > 190")

Fill Area – bottom third near deep basin: 100.F (model Z < approx. 190")

From Table 114-C, Reference 11, find the following temperature correction factors, C_t:

	Temperature °F					
	90	100	107.5	110	115	130
Modulus of Elasticity (Table Values)	0.96			0.93		0.91
Modulus of Elasticity Interpolated Values		0.945	0.934		0.925	
Compression parallel to grain (Table Values)	0.87			0.76		0.64
Compression parallel to grain, Interpolated Values		0.815	0.774		0.73	

- From Table 114-B, Reference 11, find the following size adjustment factors, C_F,

Width	Compression Parallel to Grain (F c)
(2", 3" and 4")	1.15
5"	1.10
6	1.10
8	1.05
10	1.00
12	1.00
14	0.90

- From Section 3.3.3.1 of Reference 8, the beam stability factor, C_L, is 1.0 for the 4x4's as the depth does not exceed the breadth, and it is1.0 for the 2x8's as the member is laterally supported per Sections 3.3.3.2 and 4.4.1.
- From Section 3.7 of Reference 8, the column stability factor, C_P, is determined as follows:

$$C_P = \frac{1+\left(\frac{F_{cE}}{F_{comp}}\right)}{2\cdot c} - \sqrt{\left[\frac{1+\left(\frac{F_{cE}}{F_{comp}}\right)}{2\cdot c}\right]^2 - \left(\frac{\frac{F_{cE}}{F_{comp}}}{c}\right)}$$

Where: F_{comp} = tabulated compression design value multiplied by all applicable adjustment factors except C_P. A temperature reduction factor for each highest level is used in the tables following:

$$F_{cE} = \frac{(K_{cE})\cdot(E)}{\left(\frac{l_e}{d}\right)^2}$$

; from Section 3.7.1.3, Reference 8, the slenderness ratio, le/d, shall be the larger of the two lateral support spans adjusted by the appropriate buckling length coefficient, Ke, from Appendix G, Reference 8.

From Table 114A, Ref. 11, E = 1.7 x 10^6 psi for No. 1 Douglas Fir with a 50 year load duration and dry service conditions. This value is adjusted as follows:

E = 1.7 x 10^6 psi *(0.9) * (0.945) = 1445850 psi (0.945 is temp. adjustment factor for the bottom third)

(0.9 is moisture correction factor)

K_{cE} = 0.3 for visually graded lumber

C = 0.8 for sawn lumber

The ratio, l/d, will vary for the bottom compression members due to bracing locations. Determine the allowable compressive loads for various brace spacing lengths. Per Section 3.7.1.4, Reference 8, the ratio, l/d, is limited to 50.

6.3.2 Allowable Bending Stress:

From Table 2.3.1 of Reference 8, find the allowable bending stress is determined by applying adjustment factors to a non-factored allowable bending stress.

$$F_b' = (F_b)*(C_D)*(C_M)*(C_t)*(C_L)*(C_F)*(C_{fu})*(C_r)*(C_f)$$

Where: F_c' = factored allowable bending stress

F_b = non-factored allowable bending stress

C_D = load duration factor

C_M = wet service factor

C_t = temperature factor

C_L = beam stability factor

C_F = size factor

C_{fu} = flat use factor

C_r = repetitive member factor

C_f = form factor

- From page B7, find the wood allowable loads are to be based on Douglas Fir No. 1 grade lumber. From Table 114-A, Reference 11, find the following allowable bending stress:

  $$F_b = 950 * psi \quad (\text{with } C_D = 0.9)$$

  Per note 3 of Table 114-A, Reference 11, the allowable compressive stress above has been adjusted for a 50 year load duration (C_D = 0.9).

- From Table 2.3.2, Reference 8, find the load duration factor, C_D = 1.0 for live load and 0.9 for dead load. Therefore the unadjusted allowable bending stress = (950 psi) / (0.9) = 1056 psi.
- From Table 114-D, Reference 11, find the wet service factor, C_M = 0.85 for bending stress for saturated wood. The cooling tower wood in-service condition is defined as saturated on sheet B7.
- From Table 114-C, Reference 11, find the following temperature correction factors for bending, C_t:

	Temperature °F					
	90	100	107.5	110	115	130
Bending (Table values)	0.87			0.76		0.64
Interpolated Values		0.815	0.774		0.73	

- From Section 3.3.3.1 of Reference 8, the beam stability factor, C_L, is 1.0 for the 4x4's as the depth does not exceed the breadth.
- From Table 114-B, Reference 11, the size adjustment factor, C_F is 1.5 for the 4x4's.
- Per Table 4A of Reference 8, the flat use factor C_{fu} = 1.0 as the load is applied to the normal face of the lumber. For out of plane loading (seismic) the flat use factor = 1.0 for the 4x4's.
- Per Section 4.3.4 of Reference 8, the cooling tower column and diagonal brace members are not defined as "Repetitive Members" and the factor, $C_r = 1.0$
- Per Section 2.3.8 of Reference 8, as the cooling tower members are not loaded on their diagonal (diamond section), the form factor, $C_f = 1.0$

6.3.3 Allowable Tension Stress:

The allowable tension stress is required for the seismic load on the bracing. From Table 2.3.1 of Reference 8, find the allowable tension stress is determined by applying adjustment factors to a non-factored allowable tension stress.

$$F'_t = (F_t)*(C_D)*(C_M)*(C_t)*(C_F)$$

Where: F'_t = factored allowable tensile stress parallel to the grain

F_t = non-factored allowable tensile stress parallel to the grain

C_D = load duration factor

C_M = wet service factor

C_t = temperature factor

C_F = size factor

- From page B7, find the wood allowable loads are to be based on Douglas Fir #1 grade lumber. From Table 114-A, Reference 11, find the following allowable tension stress:

  $$F_C = 641 * psi \quad (\text{with } C_D = 0.9)$$

  Per note 3 of Table 114-A, Reference 11, the allowable tension stress above has been adjusted for a 50 year load duration (C_D = 0.9).

- From Table 2.3.2, Reference 8, find the load duration factor, C_D = 1.0 for live load, 0.9 for dead load, and 1.6 for earthquake loads. Therefore the unadjusted allowable tension stress = (641 psi) / (0.9) = 712 psi.
- From Table 114-D, Reference 11, find the wet service factor, C_M = 1.0 for tension stress for saturated wood. The cooling tower wood wet service is defined as saturated on sheet B7.
- From Table 114-C, Reference 11, find the following temperature correction factors for tension parallel to grain, C_t:

	Temperature °F					
	90	100	107.5	110	115	130
Tension Parallel to Grain	0.96			0.93		0.91
Interpolated Values	.	0.945	0.934		0.925	

- From Table 114-B, Reference 11, the size adjustment factor for tension, C_F is 1.5 for the 4x4's and 4 x 6's (width taken as 3.5" max).

Determine Value for Kce for Bracing for MHE Earthquake:

Calculate the value of Kce for bracing subjected to the MHE earthquake using Section 3.7.1.5 of Reference 21. The 1.66 FS value in equation CA3.7-1 is for OBE level earthquake. Adjust this value to 1.33 for MHE earthquake.

$COV_E := 0.25$ — Coefficient of variation for machine and visually graded lumber from Ref. 11, Appendix F Table F-1.

$FS := 1.33$ — Factor of safety for MHE earthquake.

$$K_{ce} := (1 - 1.645 \cdot COV_E) \cdot \left[\frac{(0.822) \cdot (1.03)}{(FS)}\right]$$ Equation CA3.7-1, Ref. 21.

$K_{ce} = 0.375$

6.3.4 Determine Allowable Compression and Bending Loads:

As there are 3 different temperature areas in the fill area of the cooling tower, determine the allowable compression and bending loads for each of the three regions. The regions are defined as follows:

Compression Parallel to Grain:

- Top Third - temperature correction factor for compression parallel to grain= 0.73
- Mid Third - temperature correction factor compression parallel to grain = 0.774
- Bottom Third - temperature correction factor compression parallel to grain = 0.815

Tension Parallel to Grain:

- Top Third - temperature correction factor for tension parallel to grain= 0.925
- Mid Third - temperature correction factor tension parallel to grain = 0.934
- Bottom Third - temperature correction factor tension parallel to grain = 0.945

The plenum area is the same as the bottom third.

See the following sheets for the computed allowable stress values:

DEAD LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 4 Column Members with Ke = 0.8:

			Stress Factors	E Factors	Bending Stress Factors	Bending Stress Factors
KcE =	0.3	load duration factor =	0.9	N/A	0.9	
c =	0.8	moisture factor =	0.80	0.90	0.85	
		temp. factor =	0.730	0.925	0.730	(4x4 and 4x6)
		size factor =	1.15	N/A		1.5

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1415250 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 925 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	5	6	6.67	7	7.08	7.17	7.67	7.83	8	8.42	8.75	9.5	10
l/d ratio using d = 3.5" and ke = 0.8	10.1	11.0	13.7	16.5	18.3	19.2	19.4	19.7	21.0	21.5	21.9	23.1	24.0	26.1	27.4
Fce	4198	3527	2257	1568	1270	1152	1125	1099	960	920	882	797	737	625	564
(Fce / Fcomp)	4.539	3.814	2.441	1.695	1.373	1.245	1.216	1.188	1.038	0.995	0.954	0.861	0.797	0.676	0.610
Cp	0.950	0.939	0.896	0.837	0.788	0.761	0.754	0.747	0.704	0.689	0.674	0.637	0.608	0.545	0.506

DEAD LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 4 Column Members with Ke = 0.8:

Allowable dead load compressive stress (psi) for members located in the upper 1/3 of the structure.

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.42	8.75	9.5	10
$F_{allow\_comp\,(psi)}$ =	878	868	829	774	729	704	697	691	651	637	624	589	562	504	468

Allowable Dead Load Compressive Load on a 4x4 member:

	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.42	8.75	9.5	10
P_{allow} (lbs) =	10759	10634	10151	9480	8925	8621	8542	8463	7973	7806	7639	7221	6890	6178	5736

SNOW LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 4 Column Members with Ke = 0.8:

			Stress Factors	E Factors
KcE =	0.3	load duration factor =	1.15	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.730	0.925
		size factor =	1.15	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1415250 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1182 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.417	8.75	9.5	10
l/d ratio using d = 3.5" and ke = 0.8	10.1	11.0	13.7	16.5	18.3	19.2	19.4	19.7	21.0	21.5	21.9	23.1	24.0	26.1	27.4
Fce	4198	3527	2257	1568	1270	1152	1125	1099	960	920	882	797	737	625	564
(Fce / Fcomp)	3.552	2.985	1.910	1.327	1.075	0.975	0.952	0.930	0.813	0.778	0.746	0.674	0.624	0.529	0.478
Cp	0.933	0.918	0.859	0.779	0.715	0.682	0.674	0.665	0.615	0.599	0.583	0.544	0.515	0.454	0.418

SNOW LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 4 Column Members with Ke = 0.8:

Allowable snow load compressive stress (psi) for members located in the upper 1/3 of the structure.

Brace spacing length in feet:	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.417	8.75	9.5	10
$F_{allow\_comp\ (psi)}$ =	1103	1085	1016	920	845	806	796	786	727	708	689	643	608	536	494

Allowable Dead plus Snow Load Compressive Load on a 4x4 member:

Brace spacing length in feet:	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.417	8.75	9.5	10
P_{allow} (lbs) =	13512	13294	12441	11272	10354	9873	9753	9631	8909	8673	8441	7878	7450	6569	6046

SESIMC LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 4 Column Members with Ke = 0.8:

			Stress Factors	E Factors
KcE =	0.3	load duration factor =	1.6	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.730	0.925
		size factor =	1.15	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1415250 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1644 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	5	6	6.67	7	7.08	7.17	92 7.67	7.83	8	8.417	8.75	9.5	10
l/d ratio using d = 3.5" and ke = 0.8	10.1	11.0	13.7	16.5	18.3	19.2	19.4	19.7	21.0	21.5	21.9	23.1	24.0	26.1	27.4
Fce	4198	3527	2257	1568	1270	1152	1125	1099	960	920	882	797	737	625	564
(Fce / Fcomp)	2.553	2.145	1.373	0.954	0.772	0.701	0.684	0.668	0.584	0.559	0.536	0.485	0.448	0.380	0.343
Cp	0.902	0.878	0.788	0.674	0.596	0.559	0.550	0.541	0.490	0.474	0.459	0.423	0.396	0.344	0.314

SESIMC LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 4 Column Members with Kc = 0.8:

Allowable seismic compressive stress (psi) for members located in the upper 1/3 of the structure.

Allowable Seismic Load Compressive Load on a 4x4 member:

Brace spacing length in feet:	3.67	4	5	6	6.67	7	7.08	7.17	7.67	7.83	8	8.417	8.75	9.5	10
$F_{allow\_comp\ (psi)}$ =	1482	1444	1295	1109	980	919	904	889	805	779	754	695	652	566	517
P_{allow} (lbs) =	18158	17688	15867	13580	12008	11256	11074	10893	9867	9546	9237	8513	7982	6932	6332

DEAD LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 4 Brace Members with Ke = 1.0:

			Stress Factors	E Factors
KcE =	0.3	load duration factor =	0.9	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.730	0.925
		size factor =	1.15	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1415250 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 925 psi

d = 3.5 inches

	Brace spacing length in feet:													
	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.75	9.5	10
l/d ratio using d = 3.5" and ke = 1.0.	12.6	13.7	17.1	20.6	22.9	24.0	24.3	24.6	26.9	27.4	28.9	30.0	32.6	34.3
Fce	2686	2257	1445	1003	813	737	720	703	589	564	510	472	400	361
(Fce / Fcomp)	2.905	2.441	1.562	1.085	0.879	0.797	0.778	0.760	0.636	0.610	0.551	0.510	0.433	0.391
Cp	0.916	0.896	0.819	0.718	0.645	0.608	0.599	0.590	0.522	0.506	0.469	0.441	0.385	0.352

DEAD LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 4 Brace Members with Ke = 1.0:

Allowable dead load compressive stress (psi) for members located in the upper 1/3 of the structure.

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.75	9.5	10
$F_{allow\_comp\ (psi)}$ =	847	829	758	664	596	562	554	546	483	468	433	408	356	326

Allowable Dead Load Compressive Load on a 4x4 member:

	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.75	9.5	10
P_{allow} (lbs) =	10374	10151	9282	8138	7304	6890	6789	6687	5917	5736	5309	4992	4358	3990

SEISMIC LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 4 Brace Members with Ke = 1.0:

			Stress Factors	E Factors
KcE =	0.38	load duration factor =	1.6	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.730	0.925
		size factor =	1.15	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1415250 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1644 psi

d = 3.5 inches

	Brace spacing length in feet:							86 in	94 in		101 in			
	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.75	9.5	10
l/d ratio using d = 3.5" and ke = 1.0	12.6	13.7	17.1	20.6	22.9	24.0	24.3	24.6	26.9	27.4	28.9	30.0	32.6	34.3
Fce	3403	2859	1830	1271	1029	934	912	891	746	715	646	598	507	457
(Fce / Fcomp)	2.070	1.739	1.113	0.773	0.626	0.568	0.555	0.542	0.453	0.435	0.393	0.363	0.308	0.278
Cp	0.873	0.842	0.727	0.597	0.516	0.480	0.471	0.462	0.400	0.386	0.354	0.331	0.286	0.260

SEISMIC LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 4 Brace Members with Ke = 1.0:

Allowable seismic compressive stress (psi) for members located in the upper 1/3 of the structure.

Brace spacing length in feet:	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.75	9.5	10
$F_{allow\_comp\,(psi)}$ =	1435	1384	1195	981	848	788	774	760	658	635	582	544	469	427

Allowable seismic Compressive Load on a 4x4 member:

Brace spacing length in feet:	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.75	9.5	10
P_{allow} (lbs) =	17577	16957	14635	12015	10393	9658	9483	9311	8058	7778	7130	6662	5750	5236

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 6 Brace Members with Ke = 1.0:

SEISMIC LOAD DURATION FACTOR = 1.60

			Stress Factors	E Factors
KcE =	0.3	load duration factor =	1.6	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.730	0.925
		size factor =	1.10	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1415250 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1573 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.75	9.5	10
l/d ratio using d = 3.5" and ke = 1.0.	12.6	13.7	17.1	20.6	22.9	24.0	24.3	24.6	26.9	27.4	28.9	30.0	32.6	34.3
Fce	2686	2257	1445	1003	813	737	720	703	589	564	510	472	400	361
(Fce / Fcomp)	1.708	1.435	0.919	0.638	0.517	0.469	0.458	0.447	0.374	0.359	0.324	0.300	0.254	0.230
Cp	0.838	0.799	0.661	0.523	0.445	0.411	0.403	0.395	0.339	0.327	0.299	0.278	0.239	0.218

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – TOP THIRD

4 x 6 Brace Members with Ke = 1.0:

Allowable seismic load compressive stress (psi) for members located in the upper 1/3 of the structure.

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.75	9.5	10
$F_{allow\_comp\,(psi)}$ =	1318	1257	1039	823	700	647	634	622	534	514	470	438	377	342

Allowable Seismic Load Compressive Load on a 4x6 member:

	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.75	9.5	10
P_{allow} (lbs) =	25380	24194	20009	15838	13480	12450	12209	11971	10275	9901	9044	8430	7248	6586

ALLOWABLE BENDING STRESSES AND LOADS (DEAD LOAD AND SEISMIC) – TOP THIRD

All Members:

Bending Allowable Stresses:
Allowable bending is adjusted by, load duration, wet service, temperature, beam stability, size factor, flat use factor, repetitice member factor, curvature factor and form factors.

Defined allowable bending stress = 950 psi. in Table 114-A, Reference 11. This includes a load duration factor = 0.9.

unadjusted bending stress = allowable bending stress / load duration factor of 0.9
unadjusted bending stress = 1056 psi

Beam stability factor = 1.0
Flat use factor = 1.0
Repetitive member factor = 1.0
Form factor = 1.0

Per Table 2.3.1 of Reference 8, the revised allowable bending stress =
Fb * (load duration factor)*(moisture factor)*(temp. factor)*(beam stabilityfactor)*(size factor)*(flat use factor) *(repetitive member factor)*(form factor)

	Members 4x4	Members 4x6	
Dead Load Allowable Bending Stress (psi) =	884	884	
Seismic Allowable Bending Stress (psi) =	1572	1572	(1.60/0.9) * DL allowable
Snow Load Allowable Bending Stress (psi) =	1130	1130	(1.15/0.9) * DL allowable

Section modulus for 4x4 = 7.146 in^3
Section modulus for 4x6 = 17.65 in^3
Section modulus for 2x8 = 13.14 in^3
Section modulus for 2x4 = 3.063 in^3

Allowable Bending Moments (lb*in)

	4x4	4x6
Dead Load =	6319	15606
Seismic Load =	11233	27745
Snow Load =	8074	19941

DEAD LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – MIDDLE THIRD

4 x 4 Column Members with Kc = 0.8:

			Stress Factors	E Factors	Bending Stress Factors	Bending Stress Factors
KcE =	0.3	load duration factor =	0.9	N/A	0.9	
c =	0.8	moisture factor =	0.80	0.90	0.85	(4x4 and 4x6)
		temp. factor =	0.774	0.934	0.774	
		size factor =	1.15	N/A		1.5

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1429020 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 981 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	86 7.17	92 7.67	94 7.83	8	8.417	8.5	8.75	10
l/d ratio using d = 3.5" and ke = 0.8	10.1	11.0	13.7	16.5	18.3	19.2	19.4	19.7	21.0	21.5	21.9	23.1	23.3	24.0	27.4
Fce	4238	3562	2279	1583	1282	1163	1136	1109	969	929	890	804	789	744	570
(Fce / Fcomp)	4.323	3.632	2.325	1.614	1.308	1.186	1.158	1.132	0.989	0.947	0.908	0.820	0.804	0.759	0.581
Cp	0.947	0.935	0.890	0.827	0.775	0.746	0.739	0.732	0.687	0.672	0.657	0.619	0.612	0.590	0.488

DEAD LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – MIDDLE THIRD

4 x 4 Column Members with Ke = 0.8:

Allowable dead load compressive stress (psi) for members located in the mid 1/3 of the structure.

Brace spacing length in feet:	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.417	8.5	8.75	10
$F_{allow\_comp\,(psi)}$ =	928	917	872	810	760	732	725	718	674	659	644	607	600	578	479

Allowable Dead Load Compressive Load on a 4x4 member:

P_{allow} (lbs) =	11374	11233	10686	9928	9306	8966	8879	8791	8253	8071	7889	7436	7347	7082	5863

DEAD PLUS SNOW ALLOWABLE COMPRESSION STRESSES AND LOADS – MIDDLE THIRD

4 x 4 Column Members with Ke = 0.8:

			Stress Factors	E Factors
KcE =	0.3	load duration factor =	1.15	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.774	0.934
		size factor =	1.15	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1429020 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1253 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.417	8.5	8.75	10
l/d ratio using d = 3.5" and ke = 0.8	10.1	11.0	13.7	16.5	18.3	19.2	19.4	19.7	21.0	21.5	21.9	23.1	23.3	24.0	27.4
Fce	4238	3562	2279	1583	1282	1163	1136	1109	969	929	890	804	789	744	570
(Fce / Fcomp)	3.383	2.843	1.819	1.263	1.023	0.928	0.907	0.886	0.774	0.741	0.711	0.642	0.630	0.594	0.455
Cp	0.930	0.913	0.851	0.765	0.699	0.665	0.656	0.648	0.597	0.581	0.564	0.526	0.518	0.496	0.401

DEAD PLUS SNOW ALLOWABLE COMPRESSION STRESSES AND LOADS – MIDDLE THIRD

4 x 4 Column Members with Ke = 0.8:

Allowable dead plus snow load compressive stress (psi) for members located in the mid 1/3 of the structure.

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.417	8.5	8.75	10
$F_{allow\_comp\,(psi)}$ =	1165	1145	1066	959	876	833	822	811	748	727	707	659	649	622	503

Allowable Dead plus Snow Load Compressive Load on a 4x4 member:

	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.417	8.5	8.75	10
P_{allow} (lbs) =	14267	14020	13055	11742	10727	10202	10071	9939	9162	8910	8662	8067	7952	7617	6156

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – M IDDLE THIRD

4 x 4 Column Members with Ke = 0.8:

SEISMIC LOAD DURATION FACTOR = 1.60

			Stress Factors	E Factors
KcE =	0.3	load duration factor =	1.6	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.774	0.934
		size factor =	1.15	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1429020 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1743 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.417	8.5	8.75	10
l/d ratio using d = 3.5" and ke = 0.8	10.1	11.0	13.7	16.5	18.3	19.2	19.4	19.7	21.0	21.5	21.9	23.1	23.3	24.0	27.4
Fce	4238	3562	2279	1583	1282	1163	1136	1109	969	929	890	804	789	744	570
(Fce / Fcomp)	2.431	2.043	1.308	0.908	0.736	0.667	0.652	0.636	0.556	0.533	0.511	0.461	0.452	0.427	0.327
Cp	0.896	0.871	0.775	0.657	0.578	0.540	0.531	0.522	0.472	0.456	0.441	0.406	0.399	0.380	0.301

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – M IDDLE THIRD

4 x 4 Column Members with Ke = 0.8:

Allowable seismic compressive stress (psi) for members located in the mid 1/3 of the structure.

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.417	8.5	8.75	10
$F_{allow\_comp\ (psi)}$ =	1561	1518	1350	1145	1007	942	926	910	823	795	769	708	696	663	525

Allowable seismic Compressive Load on a 4x4 member:

	3.67	4	5	6	6.667	7	7.08	7.17	7.67	7.83	8	8.417	8.5	8.75	10
P_{allow} (lbs) =	19124	18592	16543	14024	12334	11535	11343	11153	10076	9742	9420	8669	8528	8121	6427

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – M IDDLE THIRD

4 x 4 Brace Members with Ke = 1.0:

			Stress Factors	E Factors
KcE =	0.38	load duration factor =	1.6	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.774	0.934
		size factor =	1.15	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1429020 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1743 psi

d = 3.5 inches

Brace spacing length in feet:

									94		101	102	105	
	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.5	8.75	10
l/d ratio using d = 3.5" and ke = 1.0	12.6	13.7	17.1	20.6	22.9	24.0	24.3	24.6	26.9	27.4	28.9	29.1	30.0	34.3
Fce	3436	2887	1848	1283	1039	943	921	899	753	722	652	639	603	462
(Fce / Fcomp)	1.971	1.656	1.060	0.736	0.596	0.541	0.528	0.516	0.432	0.414	0.374	0.367	0.346	0.265
Cp	0.865	0.832	0.711	0.578	0.498	0.462	0.453	0.445	0.384	0.370	0.339	0.333	0.317	0.249

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – M IDDLE THIRD

4 x 4 Brace Members with Ke = 1.0:

Allowable seismic compressive stress (psi) for members located in the mid 1/3 of the structure.

	Brace spacing length in feet:													
	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.5	8.75	10
$F_{allow\_comp\ (psi)}$ =	1507	1450	1239	1007	868	805	790	775	669	646	591	581	552	433

Allowable seismic Compressive Load on a 4x4 member:

P_{allow} (lbs) =	18467	17767	15177	12340	10627	9858	9676	9497	8200	7911	7244	7120	6764	5308

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – M IDDLE THIRD

4 x 6 Brace Members with Ke = 1.0:

			Stress Factors	E Factors
KcE =	0.3	load duration factor =	1.6	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.774	0.934
		size factor =	1.10	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1429020 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1667 psi

d = 3.5 inches

Brace spacing length in feet:											101			
	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.5	8.75	10
l/d ratio using d = 3.5" and ke = 1.0.	12.6	13.7	17.1	20.6	22.9	24.0	24.3	24.6	26.9	27.4	28.9	29.1	30.0	34.3
Fce	2713	2279	1459	1013	821	744	727	710	594	570	515	505	476	365
(Fce / Fcomp)	1.627	1.367	0.875	0.608	0.492	0.446	0.436	0.426	0.356	0.342	0.309	0.303	0.286	0.219
Cp	0.828	0.787	0.643	0.505	0.428	0.395	0.387	0.379	0.325	0.313	0.286	0.281	0.266	0.208

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – M IDDLE THIRD

4 x 6 Brace Members with Ke = 1.0:

Allowable seismic load compressive stress (psi) for members located in the upper 1/3 of the structure.

Brace spacing length in feet:

	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.5	8.75	10
$F_{allow\_comp\ (psi)}$ =	1381	1312	1072	842	714	658	645	633	542	522	477	468	444	347

Allowable Seismic Load Compressive Load on a 4x6 member:

	3.67	4	5	6	6.667	7	7.08	7.17	7.83	8	8.417	8.5	8.75	10
P_{allow} (lbs) =	26584	25251	20642	16200	13739	12674	12424	12179	10436	10053	9176	9013	8549	6670

ALLOWABLE BENDING STRESSES AND LOADS (DEAD LOAD AND SEISMIC)- MIDDLE THIRD

All Members:

Bending Allowable Stresses:
Allowable bending is adjusted by, load duration, wet service, temperature, beam stability, size factor, flat use factor, repetitice mewmber factor, curvature factor and form factor.

Defined allowable bending stress = 950 psi. in Table 114-A, Reference 11. This includes a load duration factor = 0.9.

unadjusted bending stress = allowable bending stress / load duration factor = 0.9
unadjusted bending stress = 1056 psi

Beam stability factor =	1.0
Flat use factor =	1.0
Repetitive member factor =	1.0
Form factor =	1.0

Per Table 2.3.1 of Reference 8, the revised allowable bending stress =
Fb * (load duration factor)*(moisture factor)*(temp. factor)*(beam stabilityfactor)*(size factor)*(flat use factor) *(repetitive member factor)*(form factor)

	Members 4x4	Members 4x6	
Dead Load Allowable Bending Stress (psi) =	938	938	
Seismic Allowable Bending Stress (psi) =	1667	1667	(1.60/0.9) * DL allowable
Snow Load Allowable Bending Stress (psi) =	1198	1198	(1.15/0.9) * DL allowable

Section modulus for 4x4 =	7.146	in^3
Section modulus for 4x6 =	17.65	in^3
Section modulus for 2x8 =	13.14	in^3
Section modulus for 2x4 =	3.063	in^3

Allowable Bending Moments (lb*in)

	4x4	4x6
Dead Load =	6699	16547
Seismic Load =	11910	29417
Snow Load =	8560	21143

DEAD LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – BOTTOM THIRD

4 x 4 Column Members with Ke = 0.8:

			Stress Factors	E Factors	Bending Stress Factors	Bending Stress Factors
KcE =	0.3	load duration factor =	0.9	N/A	0.9	
c =	0.8	moisture factor =	0.80	0.90	0.85	(4x4 and 4x6)
		temp. factor =	0.815	0.945	0.815	
		size factor =	1.15	N/A		1.5

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1445850 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1032 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.5	8.75	9	10	12.5
l/d ratio using d = 3.5" and ke = 0.8	10.1	11.0	13.0	13.7	15.1	16.5	19.2	19.4	21.0	21.5	21.9	23.3	24.0	24.7	27.4	34.3
Fce	4288	3603	2555	2306	1906	1602	1177	1149	981	940	901	798	753	712	577	369
(Fce / Fcomp)	4.154	3.490	2.475	2.234	1.846	1.551	1.140	1.113	0.950	0.910	0.873	0.773	0.729	0.689	0.558	0.357
Cp	0.944	0.932	0.898	0.884	0.853	0.818	0.734	0.727	0.673	0.658	0.642	0.597	0.574	0.553	0.473	0.326

DEAD LOAD ALLOWABLE COMPRESSION STRESSES AND LOADS – BOTTOM THIRD

4 x 4 Column Members with Kc = 0.8:

Allowable dead load compressive stress (psi) for members located in the lower 1/3 of the structure.

Brace spacing length in feet:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.5	8.75	9	10	12.5
$F_{allow\_comp\ (psi)}$ =	975	962	927	913	881	844	758	750	695	679	663	616	593	571	489	336

Allowable Dead Load Compressive Load on a 4x4 member:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.5	8.75	9	10	12.5
P_{allow} (lbs) =	11945	11789	11355	11183	10792	10342	9285	9191	8512	8316	8121	7545	7264	6991	5987	4122

DEAD PLUS SNOW ALLOWABLE COMPRESSION STRESSES AND LOADS – BOTTOM THIRD

4 x 4 Column Members with Ke = 0.8:

			Stress Factors	E Factors
KcE =	0.3	load duration factor =	1.15	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.815	0.945
		size factor =	1.15	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1445850 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1319 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.5	8.75	9	10	12.5
l/d ratio using d = 3.5" and ke = 0.8	10.1	11.0	13.0	13.7	15.1	16.5	19.2	19.4	21.0	21.5	21.9	23.3	24.0	24.7	27.4	34.3
Fce	4288	3603	2555	2306	1906	1602	1177	1149	981	940	901	798	753	712	577	369
(Fce / Fcomp)	3.251	2.731	1.937	1.748	1.445	1.214	0.892	0.871	0.744	0.712	0.683	0.605	0.571	0.540	0.437	0.280
Cp	0.926	0.909	0.862	0.843	0.801	0.753	0.650	0.642	0.582	0.565	0.549	0.503	0.481	0.461	0.388	0.261

DEAD PLUS SNOW ALLOWABLE COMPRESSION STRESSES AND LOADS – BOTTOM THIRD

4 x 4 Column Members with Kc = 0.8:

Allowable dead plus snow load compressive stress (psi) for members located in the lower 1/3 of the structure.

Brace spacing length in feet:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.5	8.75	9	10	12.5
$F_{allow\_comp\,(psi)}$ =	1222	1200	1137	1112	1056	994	858	846	767	746	724	664	635	608	512	345

Allowable Dead plus Snow Load Compressive Load on a 4x4 member:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.5	8.75	9	10	12.5
P_{allow} (lbs) =	14968	14695	13928	13623	12942	12177	10508	10367	9401	9135	8874	8130	7780	7447	6268	4222

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – BOTTOM THIRD

4 x 4 Column Members with Ke = 0.8:

			Stress Factors	E Factors
KcE =	0.3	load duration factor =	1.6	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.815	0.945
		size factor =	1.15	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1445850 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1836 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.5	8.75	9	10	12.5
l/d ratio using d = 3.5" and ke = 0.8	10.1	11.0	13.0	13.7	15.1	16.5	19.2	19.4	21.0	21.5	21.9	23.3	24.0	24.7	27.4	34.3
Fce	4288	3603	2555	2306	1906	1602	1177	1149	981	940	901	798	753	712	577	369
(Fce / Fcomp)	2.336	1.963	1.392	1.256	1.038	0.873	0.641	0.626	0.534	0.512	0.491	0.435	0.410	0.388	0.314	0.201
Cp	0.890	0.864	0.791	0.763	0.704	0.642	0.525	0.516	0.457	0.442	0.427	0.386	0.368	0.350	0.290	0.192

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – BOTTOM THIRD

4 x 4 Column Members with Ke = 0.8:

Allowable seismic compressive stress (psi) for members located in the lower 1/3 of the structure.

Brace spacing length in feet:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.5	8.75	9	10	12.5
$F_{allow\_comp\ (psi)}$ =	1634	1586	1453	1401	1292	1179	964	947	839	811	784	709	675	643	533	352

Allowable seismic Compressive Load on a 4x4 member:

P_{allow} (lbs) =	20020	19430	17796	17167	15826	14438	11804	11603	10283	9937	9604	8683	8264	7871	6529	4315

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – BOTTOM THIRD

4 x 4 Brace Members with Ke = 1.0:

			Stress Factors	E Factors
KcE =	0.38	load duration factor =	1.6	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.815	0.945
		size factor =	1.15	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1445850 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1836 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.417	8.75	9	10
l/d ratio using d = 3.5" and ke = 1.0	12.6	13.7	16.3	17.1	18.9	20.6	24.0	24.3	26.3	26.9	27.4	28.9	30.0	30.9	34.3
Fce	3476	2921	2072	1870	1545	1298	954	932	795	762	730	660	610	577	467
(Fce / Fcomp)	1.894	1.591	1.129	1.019	0.842	0.707	0.520	0.508	0.433	0.415	0.398	0.359	0.333	0.314	0.255
Cp	0.858	0.823	0.731	0.697	0.629	0.563	0.447	0.439	0.385	0.371	0.358	0.328	0.306	0.291	0.240

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – BOTTOM THIRD

4 x 4 Brace Members with Kc = 1.0:

Allowable seismic compressive stress (psi) for members located in the lower 1/3 of the structure.

Brace spacing length in feet:	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.417	8.75	9	10
$F_{allow\_comp\ (psi)}$ =	1575	1511	1342	1280	1154	1033	821	806	707	681	657	601	561	533	440

Allowable seismic Compressive Load on a 4x4 member:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.417	8.75	9	10
P_{allow} (lbs) =	19290	18515	16438	15679	14138	12650	10057	9869	8657	8346	8049	7365	6873	6533	5386

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – BOTTOM THIRD

4 x 6 Brace Members with Ke = 1.0:

			Stress Factors	E Factors
KcE =	0.3	load duration factor =	1.6	N/A
c =	0.8	moisture factor =	0.80	0.90
		temp. factor =	0.815	0.945
		size factor =	1.10	N/A

unadjusted E = 1700000 psi
adjusted E = 1.7E6 psi * moisture factor * temperature factor
adjusted E = 1445850 psi

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor
Fcomp = 1756 psi

d = 3.5 inches

Brace spacing length in feet:

	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.417	8.75	9	10
l/d ratio using d = 3.5" and ke = 1.0	12.6	13.7	16.3	17.1	18.9	20.6	24.0	24.3	26.3	26.9	27.4	28.9	30.0	30.9	34.3
Fce	2745	2306	1635	1476	1220	1025	753	736	628	601	577	521	482	456	369
(Fce / Fcomp)	1.563	1.314	0.931	0.841	0.695	0.584	0.429	0.419	0.358	0.343	0.328	0.297	0.275	0.259	0.210
Cp	0.819	0.776	0.666	0.628	0.556	0.490	0.382	0.374	0.326	0.314	0.302	0.276	0.257	0.244	0.200

SEISMIC ALLOWABLE COMPRESSION STRESSES AND LOADS – BOTTOM THIRD

4 x 6 Brace Members with Ke = 1.0:

Allowable seismic load compressive stress (psi) for members located in the lower 1/3 of the structure.

Brace spacing length in feet:	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.417	8.75	9	10
$F_{allow\_comp\ (psi)}$ =	1439	1362	1169	1103	976	860	670	657	572	551	531	484	451	428	351

Allowable Seismic Load Compressive Load on a 4x6 member:

Brace spacing length in feet:	3.67	4	4.75	5	5.5	6	7.00	7.083	7.67	7.83	8	8.417	8.75	9	10
P_{allow} (lbs) =	27695	26226	22508	21234	18782	16553	12903	12646	11019	10606	10214	9318	8678	8238	6765

ALLOWABLE BENDING STRESSES AND LOADS (DEAD LOAD AND SEISMIC)- BOTTOM THIRD

All Members:

Bending Allowable Stresses:
Allowable bending is adjusted by, load duration, wet service, temperature, beam stability, size factor, flat use factor, repetitice mewmber factor, curvature factor and form factor.

Defined allowable bending stress = 950 psi. in Table 114-A, Reference 11. This includes a load duration factor = 0.9.

unadjusted bending stress = allowable bending stress / load duration factor = 0.9
unadjusted bending stress = 1056 psi

Beam stability factor = 1.0
Flat use factor = 1.0
Repetitive member factor = 1.0
Form factor = 1.0

Per Table 2.3.1 of Reference 8, the revised allowable bending stress =
Fb * (load duration factor)*(moisture factor)*(temp. factor)*(beam stability factor)*(size factor)*(flat use factor) *(repetitive member factor)*(form factor)

	Members 4x4	Members 4x6	
Dead Load Allowable Bending Stress (psi) =	987	987	
Seismic Allowable Bending Stress (psi) =	1755	1755	(1.60/0.9) * DL allowable
Snow Load Allowable Bending Stress (psi) =	1261	1261	(1.15/0.9) * DL allowable

Section modulus for 4x4 = 7.146 in^3
Section modulus for 4x6 = 17.65 in^3
Section modulus for 2x8 = 13.14 in^3
Section modulus for 2x4 = 3.063 in^3

Allowable Bending Moments (lb*in)

	4x4	4x6
Dead Load =	7054	17424
Seismic Load =	12541	30975
Snow Load =	9014	22263

TAPERED BOTTOM OF COMPANION POSTS

The installation of the companion posts required the tapering of the bottom section per sheet 35 of Reference 13. For these posts, the compression area transferring the load is 3-1/2" x 4-1/2". This section of post (only at bottom of the columns) is not subject to the column stability reduction factor. The allowable load for the columns at the base of the companion posts is as follows:

DEAD and SEISMIC LOAD (Posts are located in bottom third)

	Stress Factors
load duration factor =	0.9
moisture factor =	0.80
temp. factor =	0.815
size factor =	1.15

Fcomp = 1530 psi * load duration factor * moisture factor * temperature factor * size factor

Fcomp = 1032 psi

Base area = 3.5" x 4.5" = 15.75 in^2

Allowable Dead load = A * stress allow = 16261 lbs.

Allowable Seismic load = A * stress allow = 28909 lbs.

Seismic load = DL * (1.6 / 0.9)

6.4 RESULTS

Computer output files in Attachments F through Q provide the analysis results including modal response and member forces for each model.

Attachment R shows the member lengths and resulting allowable loads.

Member forces for each bent are extracted from the output files and summarized in Attachment S. Member interaction ratios are also calculated and summarized in Attachment S.

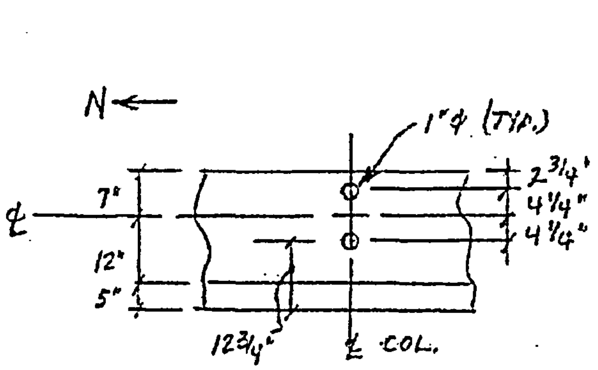
From inspection of Attachment S, interaction ratios for all members are 1.0 or less, showing that the cooling tower members in the analysis meet the acceptance criteria.

6.4.1 Base Reaction Forces

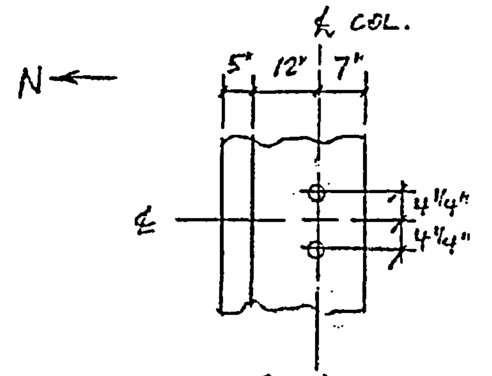
Base reaction forces are summarized in the tables in Attachment D. Plots of the base reaction forces are included in Attachment E. The base anchorage is checked in the following pages.

Check Base Anchor Bolts

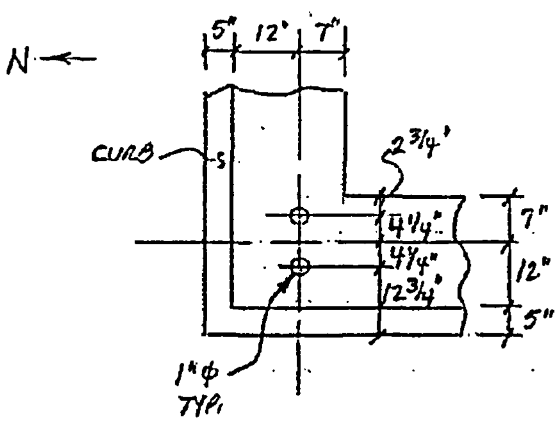
Determine anchor bolt capacity using Appendix C of the GIP (Ref. 3). The foundation support details and base anchorage are shown in References 7.11 and 7.12. The bolts are 1" diameter cast in place J-bolts, with 21" minimum embedment and 3 1/2" leg. The concrete strength is conservatively assumed to be 3000 psi based on Ref. 7.11. Some of the bolts have shear plates to help transfer shear, as shown in the details on Ref. 7.11. These plates are conservatively neglected in the shear allowable calculations. The following configurations apply to the columns that have bracing and that will experience shear loads due to earthquake loading.



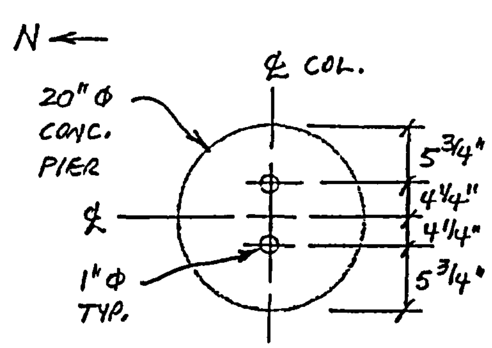
PLAN - WEST SIDE PERIMETER WALL (EAST SIDE OPP. HAND)



PLAN NORTH SIDE PERIMETER WALL



PLAN - CORNER OF PERIMETER WALL



PLAN INTERIOR CONC. PIERS

Reductions for Embedment Length (GIP Section C.4.2):

A capacity reduction factor is not required for shear per GIP Section C.4.2.

$L_{actual} := 21 \cdot in$ Embedment length

$D := 1 \cdot in$ Bolt diameter

$$RL_p := \frac{L_{actual} + 20 \cdot D}{62.5 \cdot D}$$

$RL_p = 0.656$ Pullout capacity reduction factor for cast-in-place J-bolt with 90^0 hook

Reductions for Edge Distance (GIP Section C.4.4 and C.3.4):

The east and west side perimeter walls have one bolt with 2.75" edge distance in the east or west directions. Since this is less than 4D, the bolt is assumed ineffective for E-W loading. The other bolt is fully effective for E-W loading since the edge distance in both directions is greater than 8.75". By inspection of the other details reductions are required for 7" and 5.75". All bolts are effective for N-S loading.

$E_1 := 7 \cdot in$ $E_2 := 5.75 \cdot in$

$D := 1.0 \cdot in$

$$RE_{s7\_in} := 0.0131 \cdot \left(\frac{E_1}{D}\right)^2$$

$RE_{s7\_in} = 0.64$ Shear capacity reduction factor for 7" edge distance.

$$RE_{s5.75\_in} := 0.0131 \cdot \left(\frac{E_2}{D}\right)^2$$

$RE_{s5.75\_in} = 0.43$ Shear capacity reduction factor for 5-3/4" edge distance.

The following values are obtained from GIP Table C.4-1 for 1" J-bolts in 3500 psi concrete:

$P_{nom\_1} := 26.69 \cdot kip$ — Nominal tension capacity of 1" cast-in-place J-bolt with 90^0 hook.

$V_{nom\_1} := 13.35 \cdot kip$ — Nominal shear capacity of 1" cast-in-place J-bolt with 90^0 hook.

$L_{min\_1} := 54.5 \cdot in$ — Minimum embedment for 1" cast-in-place J-bolt.

$S_{min\_1} := 3 \cdot in$ — Minimum spacing for 1" cast-in-place J-bolt.

$E_{min\_1} := 8.75 \cdot in$ — Minimum edge distance for 1" cast-in-place J-bolt.

By inspection of the anchor bolt details, reductions are not required for spacing. Reductions are required for concrete strength and embedment for all of the bolts, and edge distance for some of the bolts.

Reductions for Concrete Strength (GIP Section C.4.5):

$f_c := 3000 \cdot psi$

$$RF_p := \sqrt{\frac{f_c}{3500}}$$

$RF_p = 0.926$ — Pullout reduction factor for J-bolts for concrete strengt

$RF_s := RF_p$

$RF_s = 0.926$ — Shear reduction factor for J-bolts for concrete strength

$L := L_{actual}$

$r := \frac{2 \cdot L + D}{2}$

$r = 21.5\ in$

$A_{e\_nom} := 0.96 \cdot \frac{\pi}{4} \cdot (2 \cdot L + D)^2$

$A_{e\_nom} = 1394.11\ in^2$

$\alpha_1 := \frac{2 \cdot E_1}{2 \cdot L + D}$ $\alpha_2 := \frac{2 \cdot E_2}{2 \cdot L + D}$

$\alpha_1 = 0.33$ $\alpha_2 = 0.27$

$\theta_1 := 2 \cdot acos(\alpha_1)$ $\theta_2 := 2 \cdot acos(\alpha_2)$

$\theta_1 = 2.48$ $\theta_2 = 2.6$

$A_{e\_red\_7\_in} := \pi \cdot r^2 - \frac{1}{2} \cdot \left(r^2 \cdot \theta_1 - 2 \cdot r \cdot E_1 \cdot \sin\left(\frac{\theta_1}{2}\right)\right)$

$A_{e\_red\_7\_in} = 1021.69\ in^2$

$A_{e\_red\_5.75\_in} := \pi \cdot r^2 - \frac{1}{2} \cdot \left(r^2 \cdot \theta_2 - 2 \cdot r \cdot E_2 \cdot \sin\left(\frac{\theta_2}{2}\right)\right)$

$A_{e\_red\_5.75\_in} = 970.37\ in^2$

$RE_{p\_7\_in} := \frac{A_{e\_red\_7\_in}}{A_{e\_nom}}$ $RE_{p\_5.75\_in} := \frac{A_{e\_red\_5.75\_in}}{A_{e\_nom}}$

$RE_{p\_7\_in} = 0.733$ — Pullout capacity reduction factor for 7" edge distance.

$RE_{p\_5.75\_in} = 0.696$ — Pullout capacity reduction factor for 5.75" edge distance.

Shear Allowables:

Determine shear allowable for the east and west side perimeter wall connections. A reduction is required for concrete strength. This connection is assumed to have one bolt fully effective in the east west direction, and two bolts fully effective in the north south direction:

$$V_{allow\_EW\_walls\_EW\_direction} := V_{nom\_1} \cdot RF_s \cdot 1 \cdot bolt$$

$$V_{allow\_EW\_walls\_EW\_direction} = 12360\,lb$$

$$V_{allow\_EW\_walls\_NS\_direction} := V_{nom\_1} \cdot RF_s \cdot 2 \cdot bolt$$

$$V_{allow\_EW\_walls\_NS\_direction} = 24719\,lb$$

Determine shear allowable for north side perimeter wall connections. Reductions are required for concrete strength and edge distance. Each bolt has a reduction for 7" edge distance:

$$V_{allow\_north\_wall} := V_{nom\_1} \cdot RF_s \cdot 2 \cdot bolt \cdot RE_{s7\_in}$$

$$V_{allow\_north\_wall} = 15867\,lb$$

Determine shear allowable for perimeter wall corner connections. No reductions are required for edge distance. A reduction is required for concrete strength:

$$V_{allow\_corner\_wall} := V_{nom\_1} \cdot RF_s \cdot 2 \cdot bolt$$

$$V_{allow\_corner\_wall} = 24719\,lb$$

Determine shear allowable for interior column pier connections. Reductions are required for concrete strength and edge distance. Each bolt has a reduction for 5.75" edge distance:

$$V_{allow\_piers} := V_{nom\_1} \cdot RF_s \cdot 2 \cdot bolt \cdot RE_{s5.75\_in}$$

$$V_{allow\_piers} = 10706\,lb$$

Pullout Allowables:

Determine pullout allowable for the east and west side perimeter wall connections. This connection is assumed to have only one bolt fully effective in tension since the other bolt has less than 4D edge distance. Reductions are required for concrete strength and embedment length:

$$P_{allow\_EW\_walls} := P_{nom\_1} \cdot RF_p \cdot RL_p \cdot 1bolt$$

$$P_{allow\_EW\_walls} = 16210\,lb$$

Determine pullout allowable for north side perimeter wall connections. Reductions are required for concrete strength, embedment length and edge distance. Each bolt has a reduction for 7" edge distance:

$$P_{allow\_north\_wall} := P_{nom\_1} \cdot RF_p \cdot RL_p \cdot RE_{p\_7\_in} \cdot 2 \cdot bolt$$

$$P_{allow\_north\_wall} = 23759\,lb$$

Determine pullout allowable for perimeter wall corner connections. Reductions are required for concrete strength and embedment length. No reductions are required for edge distance:

$$P_{allow\_corner\_wall} := P_{nom\_1} \cdot RF_p \cdot RL_p \cdot 2 \cdot bolt$$

$$P_{allow\_corner\_wall} = 32420\,lb$$

Determine pullout allowable for interior column pier connections. Reductions are required for concrete strength, embedment length and edge distance. Each bolt has a reduction for 5.75" edge distance:

$$P_{allow\_piers} := P_{nom\_1} \cdot RF_p \cdot RL_p \cdot RE_{p\_5.75\_in} \cdot 2 \cdot bolt$$

$$P_{allow\_piers} = 22566\,lb$$

Determine Allowables for Bent B Connections Anchored with Hilti Bolts:

From review of References 7.11, 7.12, and page 37 of Reference 12, two of the Bent B columns with bracing are specified to be anchored with two 1" dia. Hilti Kwik Bolts with 4.5" minimum embedment. The shear allowable for this type of connection is calculated in Ref. 12 to be as follows:

$$V_{allow\_Hilti} := 13000 \cdot lb$$

The pullout capacity is not calculated in Ref. 12 because there is no net tension on these columns.

Summary of Base Anchorage Allowable Loads (per Connection)

Allowable Shear (per Connection):

$V_{allow\_EW\_walls\_EW\_direction} = 12360\,lb$ $\quad$ $V_{allow\_corner\_wall} = 24719\,lb$

$V_{allow\_EW\_walls\_NS\_direction} = 24719\,lb$ $\quad$ $V_{allow\_piers} = 10706\,lb$

$V_{allow\_north\_wall} = 15867\,lb$ $\quad$ $V_{allow\_Hilti} = 13000\,lb$

Allowable Pullout (per Connection):

$P_{allow\_EW\_walls} = 16210\,lb$ $\quad$ $P_{allow\_corner\_wall} = 32420\,lb$

$P_{allow\_north\_wall} = 23759\,lb$ $\quad$ $P_{allow\_piers} = 22566\,lb$

Determine Minimum Allowable Load per Connection:

$V_{allow\_min} := V_{allow\_piers}$

$V_{allow\_min} = 10706\,lb$

$P_{allow\_min} := P_{allow\_EW\_walls}$

$P_{allow\_min} = 16210\,lb$

Compare Reactions with Allowables:

From review of the "Reaction Summary" sheets in Attachment D, the maximum shear load is from Bent C and is 12,573 lbs in the N-S direction, and the maximum net uplift load is from Bent B. The second highest shear load is from Bent B = 8,390 lbs.

$V_{applied\_max\_NS} := 12573 \cdot lb$	<	$V_{allow\_EW\_walls\_NS\_direction} = 24719\,lb$	OK
$V_{applied\_max\_other} := 8390 \cdot lb$	<	$V_{allow\_min} = 10706\,lb$	OK
$P\_applied\_max := 6156 \cdot lb$	<	$P_{allow\_min} = 16210\,lb$	OK

Conclusion: All base anchorage connections are adequate using enveloping analysis.

6.4.2 Bracing Check for Tension Loads

The loading in the bracing is reversible, thus all braces are subjected to tension and compression parallel to the grain. The following pages checks the tension allowable loads and compares them with the compression allowable loads to show that tension does not govern.

Allowable Tension Load in the Bracing

Determine the allowable tension load in the major bracing members, and compare with the allowable compression load to determine which one governs. Adjustment factors are per the previous section.

$F_t := 641 \cdot psi$ — Allowable tension stress for Douglas Fir No. 1 from Table 114-A, Ref. 11, adjusted for dead load duration factor of 0.9.

$C_{D\_dead} := 0.9$ — Load duration factor for dead load

$C_{D\_seismic} := 1.6$ — Load duration factor for seismic load.

$C_M := 1.0$ — Wet service factor, tension parallel to grain.

$C_{t\_top} := 0.925$ — Temperature correction factor at 115 ^{0} for top third of structure, tension parallel to grain.

$C_{t\_middle} := 0.934$ — Temperature correction factor at 107.5 ^{0} for middle third of structure, tension parallel to grain.

$C_{t\_bottom} := 0.945$ — Temperature correction factor at 100 ^{0} for bottom third of structure, tension parallel to grain.

$C_F := 1.5$ — Size adjustment factor for tension parallel to grain for bracing.

$$F_{t\_adjusted\_top\_seismic} := \frac{F_t \cdot C_{D\_seismic} \cdot C_M \cdot C_{t\_top} \cdot C_F}{C_{D\_dead}}$$

$$F_{t\_adjusted\_top\_seismic} = 1581\,psi$$

$$F_{t\_adjusted\_middle\_seismic} := \frac{F_t \cdot C_{D\_seismic} \cdot C_M \cdot C_{t\_middle} \cdot C_F}{C_{D\_dead}}$$

$$F_{t\_adjusted\_middle\_seismic} = 1597\,psi$$

$$F_{t\_adjusted\_bottom\_seismic} := \frac{F_t \cdot C_{D\_seismic} \cdot C_M \cdot C_{t\_bottom} \cdot C_F}{C_{D\_dead}}$$

$$F_{t\_adjusted\_bottom\_seismic} = 1615\,psi$$

Determine the allowable load on each brace type. Connection bolts are 1/2" diameter based on Ref. 12, Sheet 22.

$$Dia\_bolt := 0.5 \cdot in$$

$$A\_net\_4x4 := (3.5 \cdot in) \cdot (3.5 \cdot in) - (Dia\_bolt) \cdot (3.5 \cdot in)$$

$$A\_net\_4x4 = 10.5\,in^2$$

Net area of 4 x 4 brace.

$$A\_net\_4x6 := (3.5 \cdot in) \cdot (4.5 \cdot in) - (Dia\_bolt) \cdot (3.5 \cdot in)$$

$$A\_net\_4x6 = 14\,in^2$$

Net area of 4 x 6 brace, with 6" dimension in plane.

$$P_{t\_seismic\_capacity\_4x4\_top} := F_{t\_adjusted\_top\_seismic} \cdot A\_net\_4x4$$

$$P_{t\_seismic\_capacity\_4x4\_top} = 16602\,lb$$

$$P_{t\_seismic\_capacity\_4x4\_middle} := F_{t\_adjusted\_middle\_seismic} \cdot A\_net\_4x4$$

$$P_{t\_seismic\_capacity\_4x4\_middle} = 16763\,lb$$

$$P_{t\_seismic\_capacity\_4x4\_bottom} := F_{t\_adjusted\_bottom\_seismic} \cdot A\_net\_4x4$$

$$P_{t\_seismic\_capacity\_4x4\_bottom} = 16961\,lb$$

$$P_{t\_seismic\_capacity\_4x6\_top} := F_{t\_adjusted\_top\_seismic} \cdot A\_net\_4x6$$

$$P_{t\_seismic\_capacity\_4x6\_top} = 22136\,lb$$

$P_{t\_seismic\_capacity\_4x6\_middle} := F_{t\_adjusted\_middle\_seismic} \cdot A\_net\_4x6$

$P_{t\_seismic\_capacity\_4x6\_middle} = 22351\ lb$

$P_{t\_seismic\_capacity\_4x6\_bottom} := F_{t\_adjusted\_bottom\_seismic} \cdot A\_net\_4x6$

$P_{t\_seismic\_capacity\_4x6\_bottom} = 22614\ lb$

Summary of Allowable Seismic Load Capacity for Bracing - Tension Parallel to Grain

4x4 Braces:

$P_{t\_seismic\_capacity\_4x4\_top} = 16602\ lb$

$P_{t\_seismic\_capacity\_4x4\_middle} = 16763\ lb$

$P_{t\_seismic\_capacity\_4x4\_bottom} = 16961\ lb$

4x6 Braces:

$P_{t\_seismic\_capacity\_4x6\_top} = 22136\ lb$

$P_{t\_seismic\_capacity\_4x6\_middle} = 22351\ lb$

$P_{t\_seismic\_capacity\_4x6\_bottom} = 22614\ lb$

Summary of Allowable Seismic Load Capacity for Bracing - Compression Parallel to Grain:

From review of the "Seismic Allowable Compression Stresses and Loads" tables for the 4 x 4 and 4 x 6 braces ($K_e = 1.0$), the following values are taken for bracing with 5' lengths:

4x4 Braces:

$P_{C\_seismic\_capacity\_4x4\_top} := 14635 \cdot lb$

$P_{C\_seismic\_capacity\_4x4\_middle} := 15177 \cdot lb$

$P_{C\_seismic\_capacity\_4x4\_bottom} := 15679 \cdot lb$

4x6 Braces:

$P_{C\_seismic\_capacity\_4x6\_top} := 20009 \cdot lb$

$P_{C\_seismic\_capacity\_4x6\_middle} := 20642 \cdot lb$

$P_{C\_seismic\_capacity\_4x6\_bottom} := 21234 \cdot lb$

Compare Tension Capacity to Compression Capacity:

4x4 Braces:

$P_{t\_seismic\_capacity\_4x4\_top} = 16602\ lb \quad > \quad P_{C\_seismic\_capacity\_4x4\_top} = 14635\ lb$

$P_{t\_seismic\_capacity\_4x4\_middle} = 16763\,lb$ > $P_{C\_seismic\_capacity\_4x4\_middle} = 15177\,lb$

$P_{t\_seismic\_capacity\_4x4\_bottom} = 16961\,lb$ > $P_{C\_seismic\_capacity\_4x4\_bottom} = 15679\,lb$

4x6 Braces:

$P_{t\_seismic\_capacity\_4x6\_top} = 22136\,lb$ > $P_{C\_seismic\_capacity\_4x6\_top} = 20009\,lb$

$P_{t\_seismic\_capacity\_4x6\_middle} = 22351\,lb$ > $P_{C\_seismic\_capacity\_4x6\_middle} = 20642\,lb$

$P_{t\_seismic\_capacity\_4x6\_bottom} = 22614\,lb$ > $P_{C\_seismic\_capacity\_4x6\_bottom} = 21234\,lb$

Conclusion: Tension capacity exceeds compression capacity for all 4 x 4 and 4 x 6 braces that are 5' or more in length. All 4 x 4 and 4 x 6 braces are longer than 5' based on review of the computer models. Since compression capacity decreases as member lengths increase, and tension strength does not change with member length, tension will not govern for any of the braces.

Check Bracing in Main Bents of Cell No. CT2-2:

The structural members in the main bents for cell no. CT2-2 are the same as the members in the main bents for cell no. CT2-1 except the bottom bracing members in CT2-2 are 4 x 4 instead of 4 x 6 members (based on review of Reference 13 sheets 2A and 3). This applies to members 42, 88, 182, and 218 in the main bent model (see Attachment E). Check the 4 x 4 members in the main bents in cell no. CT2-2:

Loads on Members 42, 88, 182 and 218 from Attachment S sheet S32:

$Member\_42_{seismic} := 7315 \cdot lb$ $\qquad Member\_88_{seismic} := 7215 \cdot lb$

$Member\_218_{seismic} := 7317 \cdot lb$ $\qquad Member\_182_{seismic} := 7229 \cdot lb$

All members are 101" long from Attachment R sheets R17 and R18. Members 88 and 182 are in the middle third temperature range, and members 42 and 218 are in the bottom third temperature range. Allowable loads for members 42 and 218 are given on sheet 140, and allowable loads for members 88 and 182 are given on sheet 151:

$Allowable_{seismic\_4x4\_mid\_101in} := 7244$

$Allowable_{seismic\_4x4\_bot\_101in} := 7365$

Compare applied loads to allowables:

$Member\_42_{seismic} = 7315\,lb \quad < \quad Allowable_{seismic\_4x4\_bot\_101in} = 7365$

$Member\_218_{seismic} = 7317\,lb \quad < \quad Allowable_{seismic\_4x4\_bot\_101in} = 7365$

$Member\_88_{seismic} = 7215\,lb \quad < \quad Allowable_{seismic\_4x4\_mid\_101in} = 7244$

$Member\_182_{seismic} = 7229\,lb \quad < \quad Allowable_{seismic\_4x4\_mid\_101in} = 7244$

Conclusion: All members are adequate. Main bent for cell no. CT2-2 is adequate

Note: The secondary distribution piping is not on tower CT2-2, only CT2-1. The above check is conservative as the brace loads account for the secondary piping load of CT2-1.

6.4.3 Brace Connections

The type of brace end connections are identified in the following documents:

Main Bent – sheets 2A and 3 (55 and 56), Reference 12 –types #1019, 1021, 2001, 2007, 2008, 2010, 2017 and 2024

End Bent – sheet 4A (58), Reference 12 –types #1019, 1021, 2110, 2121 and 2117.

Partition Bent – sheet 6A (61), Reference 12 –types #1018, 1019, 1021, 2001, 2010, 2012, 2017, 2020, 2021 and 2024.

Bent A – sheet 7 (74), Reference 12 and sheet 7 Reference 13–types #1019, 1020, 1023, 2001, 2002, 2007, 2008, 2011, 2017, 2021 and 2024

Bent B –Reference 7.4 –types #1019, 1020, 1021, 1023, 2001, 2002, 2007, 2008, 2012, 2017, 2021, 2024, 2034 and 2236.

Bent C – sheets 9B and 19 (34), Reference 12 –The 4 x 4 braces have the following connection types: 2010, 2021, 2024, 2034, 2035 and 2236. Note that connection 2110 for the top 4 x 4 braces of the truss was removed and replaced with 2010 and 2236 per sheet 19 (34) of Ref. 12. The 4 x 6 braces have the following connection types # 1019, 1023, 2007, 2017, 2018, 2021,2024 and 2035.

The brace loads for the seismic load case are compared with the allowable loads on the following pages. Note that the governing connection is listed (i.e., the connection that has the lowest allowable capacity) for cases that have more than one connection part listed. This occurs for the connections at the base of the columns, and for the differences in the Main Bent connections between cells CT1-1 and CT1-2 (refer to sheets 2A (55) and 3 (56) of Reference 12).

The allowable brace joint loads are found on sheet 13 (24) of Reference 12. The loads given in Ref. 12 for Redwood are increased by 1/3 for Douglas Fir (per the heading at the top of sheet 13 (24) of Reference 12). The allowable loads are shown below. The allowable loads are increased by 1.33 for seismic per Reference 9:

Joint Type	Douglas Fir Allowable Load (lbs.)	Seismic Allowable Load (lbs.)
1018 (Use 1019)	11970	15920
1019	11970	15920
1020	16226	21581
1021	10161	13514
1023 (Use 1022)	16598	22076
2001	10108	13444
2002	10108	13444
2007	10108	13444
2008	6052	8048
2010	6052	8048
2011	8698	11569
2012	6052	8048
2013	8698	11569
2017	16226	21581
2018	16226	21581
2020	16226	21581
2021	16226	21581
2024	10108	13444
2034 (Use 2024)	10108	13444
2035 (Use 2021)	16226	21581
2101	7022	9340
2110	4203	5590
2117	10534	14010
2120	10534	14010
2121	10534	14010
2124	7022	9340
2236 (Use 2010)	6052	8048

FRAME	LOAD	Axial Load	Connection Type	Connection Type	Seismic Allow Load	Seismic Allow Load	Connection Adequate?
BENT A	FRAME ELEMENT FORCES						
14	HORIZ	4531	1020	2024	21581	21581	OK
20	HORIZ	1202	2011	2024	11569	11569	OK
39	HORIZ	4040	2001	2024	13444	13444	OK
43	HORIZ	1342	2024	2024	13444	13444	OK
64	HORIZ	3213	2001	2002	13444	13444	OK
66	HORIZ	2525	2002	2024	13444	13444	OK
88	HORIZ	2858	2001	2002	13444	13444	OK
90	HORIZ	2841	2002	2024	13444	13444	OK
111	HORIZ	3391	2001	2017	13444	13444	OK
115	HORIZ	2012	2024	2024	13444	13444	OK
134	HORIZ	2716	2017	2021	21581	21581	OK
140	HORIZ	2360	2013	2024	11569	11569	OK
157	HORIZ	2101	1019	2002	15920	15920	OK
159	HORIZ	1970	2002	2021	13444	13444	OK
166	HORIZ	2491	2013	2024	11569	11569	OK
182	HORIZ	2259	1019	2002	15920	15920	OK
184	HORIZ	2438	2002	2021	13444	13444	OK
190	HORIZ	2312	2024	2024	13444	13444	OK
209	HORIZ	2738	2017	2021	21581	21581	OK
213	HORIZ	2687	2001	2024	13444	13444	OK
234	HORIZ	2613	2002	2017	13444	13444	OK
236	HORIZ	2882	2001	2002	13444	13444	OK
258	HORIZ	2646	2002	2017	13444	13444	OK
260	HORIZ	2769	2001	2002	13444	13444	OK
281	HORIZ	2848	2017	2021	21581	21581	OK
285	HORIZ	2370	2001	2024	13444	13444	OK
304	HORIZ	2380	2001	2021	13444	13444	OK
310	HORIZ	1549	2008	2024	8048	8048	OK
327	HORIZ	2275	1019	2001	15920	15920	OK
335	HORIZ	1437	2008	2011	8048	8048	OK

FRAME	LOAD	Axial Load	Connection Type	Connection Type	Seismic Allow Load	Seismic Allow Load	Connection Adequate?
BENT B	FRAME ELEMENT FORCES						
20	HORIZ	11985	1020	2021	21581	21581	OK
28	HORIZ	4305	2024	2034	13444	13444	OK
31	HORIZ	1211	2236	2236	8048	8048	OK
57	HORIZ	8610	2017	2021	21581	21581	OK
65	HORIZ	5174	2001	2024	13444	13444	OK
67	HORIZ	1887	2024	2034	13444	13444	OK
89	HORIZ	6545	2007	2017	13444	13444	OK
92	HORIZ	6057	2001	2007	13444	13444	OK
101	HORIZ	5254	2002	2024	13444	13444	OK
106	HORIZ	4832	2001	2007	13444	13444	OK
109	HORIZ	7792	2002	2007	13444	13444	OK
133	HORIZ	5598	2001	2001	13444	13444	OK
136	HORIZ	5922	2001	2002	13444	13444	OK
139	HORIZ	6519	2002	2024	13444	13444	OK
165	HORIZ	5147	2001	2001	13444	13444	OK
168	HORIZ	7458	2001	2001	13444	13444	OK
175	HORIZ	5740	2024	2034	13444	13444	OK
198	HORIZ	3953	2001	2024	13444	13444	OK
201	HORIZ	6104	2001	2001	13444	13444	OK
214	HORIZ	1811	2012	2236	8048	8048	OK
235	HORIZ	4249	1021	2007	13514	13514	OK
236	HORIZ	4566	2007	2024	13444	13444	OK
238	HORIZ	5037	2001	2002	13444	13444	OK
250	HORIZ	3949	2012	2236	8048	8048	OK
252	HORIZ	4566	1019	2007	15920	15920	OK
253	HORIZ	4249	2002	2007	13444	13444	OK
272	HORIZ	4476	1019	2007	15920	15920	OK
273	HORIZ	3650	2002	2007	13444	13444	OK
275	HORIZ	4768	2002	2008	13444	13444	OK
285	HORIZ	6788	2024	2034	13444	13444	OK
289	HORIZ	3650	1019	2007	15920	15920	OK
290	HORIZ	4476	2001	2007	13444	13444	OK
310	HORIZ	3542	2001	2008	13444	13444	OK
313	HORIZ	5572	2001	2008	13444	13444	OK
323	HORIZ	6669	2001	2024	13444	13444	OK
349	HORIZ	4970	2001	2008	13444	13444	OK

FRAME	LOAD	Axial Load	Connection Type	Connection Type	Seismic Allow Load	Seismic Allow Load	Connection Adequate?
BENT B	FRAME ELEMENT FORCES						
352	HORIZ	5574	2001	2002	13444	13444	OK
355	HORIZ	6683	2001	2002	13444	13444	OK
380	HORIZ	4409	2001	2007	13444	13444	OK
382	HORIZ	6449	2002	2007	13444	13444	OK
389	HORIZ	6027	2001	2002	13444	13444	OK
396	HORIZ	5165	2001	2007	13444	13444	OK
398	HORIZ	5688	2001	2007	13444	13444	OK
420	HORIZ	5708	2001	2008	13444	13444	OK
425	HORIZ	4766	2001	2001	13444	13444	OK
428	HORIZ	5301	2001	2024	13444	13444	OK
452	HORIZ	4603	2001	2008	13444	13444	OK
464	HORIZ	5243	2001	2024	13444	13444	OK
466	HORIZ	2775	2024	2034	13444	13444	OK
488	HORIZ	4651	1021	2001	13514	13514	OK
499	HORIZ	4169	2024	2034	13444	13444	OK
502	HORIZ	1304	2236	2236	8048	8048	OK

FRAME	LOAD	Axial Load	Connection Type	Connection Type	Seismic Allow Load	Seismic Allow Load	Connection Adequate?
BENT C	FRAME ELEMENT FORCES						
12	HORIZ	9853	1019	2021	15920	15920	OK
22	HORIZ	4462	2236	2010	8048	8048	OK
36	HORIZ	10967	2021	2017	21581	21581	OK
45	HORIZ	10336	2035	2021	21581	21581	OK
62	HORIZ	11913	2017	2018	21581	21581	OK
65	HORIZ	11327	2021	2018	21581	21581	OK
82	HORIZ	10234	2018	2017	21581	21581	OK
83	HORIZ	6797	2035	2017	21581	21581	OK
87	HORIZ	8253	2017	2018	21581	21581	OK
95	HORIZ	6860	2017	2017	21581	21581	OK
96	HORIZ	10187	2017	2021	21581	21581	OK
109	HORIZ	8704	2017	2021	21581	21581	OK
112	HORIZ	9722	2017	2017	21581	21581	OK
117	HORIZ	9446	2021	2035	21581	21581	OK
131	HORIZ	8254	1019	2021	15920	15920	OK
133	HORIZ	10185	2017	2021	21581	21581	OK
144	HORIZ	3725	2236	2010	8048	8048	OK
157	HORIZ	8971	1023	2021	22076	22076	OK
178	HORIZ	9164	1023	2021	22076	22076	OK
200	HORIZ	8469	1023	2021	22076	22076	OK
203	HORIZ	10237	2017	2021	21581	21581	OK
214	HORIZ	3742	2236	2010	8048	8048	OK
227	HORIZ	8868	2017	2021	21581	21581	OK
230	HORIZ	11081	2017	2017	21581	21581	OK
235	HORIZ	8346	2024	2034	13444	13444	OK
249	HORIZ	8792	2017	2007	21581	21581	OK
250	HORIZ	9908	2007	2024	13444	13444	OK
254	HORIZ	7720	2017	2018	21581	21581	OK
262	HORIZ	9959	2007	2018	13444	13444	OK
263	HORIZ	8735	2007	2024	13444	13444	OK
277	HORIZ	11667	2017	2018	21581	21581	OK
280	HORIZ	9700	2018	2024	21581	21581	OK
283	HORIZ	4103	2024	2034	13444	13444	OK
299	HORIZ	11288	2017	2021	21581	21581	OK
308	HORIZ	8945	2024	2034	13444	13444	OK
322	HORIZ	9978	1019	2021	15920	15920	OK
332	HORIZ	4689	2010	2236	8048	8048	OK

FRAME	LOAD	Axial Load	Connection Type	Connection Type	Seismic Allow Load	Seismic Allow Load	Connection Adequate?
END BENT	FRAME ELEMENT FORCES						
44	HORIZ	5902	1019	2117	15920	15920	OK
84	HORIZ	5599	2117	2117	14010	14010	OK
105	HORIZ	5288	2117	2117	14010	14010	OK
108	HORIZ	1957	2110	2121	5590	5590	OK
119	HORIZ	4887	2117	2117	14010	14010	OK
120	HORIZ	4838	2117	2121	14010	14010	OK
127	HORIZ	4842	2117	2117	14010	14010	OK
128	HORIZ	4883	2117	2121	14010	14010	OK
138	HORIZ	5281	2117	2117	14010	14010	OK
141	HORIZ	1963	2110	2121	5590	5590	OK
159	HORIZ	5616	2117	2117	14010	14010	OK
192	HORIZ	5911	1019	2117	15920	15920	OK
MAIN BENT	FRAME ELEMENT FORCES						
42	HORIZ	7315	1019	2001	15920	15920	OK
88	HORIZ	7215	2001	2001	13444	13444	OK
114	HORIZ	7089	2001	2001	13444	13444	OK
117	HORIZ	2010	2010	2008	8048	8048	OK
130	HORIZ	6979	2001	2007	13444	13444	OK
131	HORIZ	6965	2007	2008	13444	13444	OK
140	HORIZ	6967	2001	2007	13444	13444	OK
141	HORIZ	6977	2007	2008	13444	13444	OK
155	HORIZ	7088	2001	2001	13444	13444	OK
158	HORIZ	2039	2010	2008	8048	8048	OK
182	HORIZ	7229	2001	2001	13444	13444	OK
218	HORIZ	7317	2001	1019	13444	13444	OK

FRAME	LOAD	Axial Load	Connection Type	Connection Type	Seismic Allow Load	Seismic Allow Load	Connection Adequate?
PARTITION BENT		FRAME ELEMENT FORCES					
30	HORIZ	7757	1018	2001	15920	15920	OK
60	HORIZ	1013	1019	2024	15920	15920	OK
66	HORIZ	7464	2001	2020	13444	13444	OK
70	HORIZ	1037	2010	2012	8048	8048	OK
83	HORIZ	1378	2001	2024	13444	13444	OK
87	HORIZ	1260	2001	2020	13444	13444	OK
89	HORIZ	8297	2017	2020	21581	21581	OK
92	HORIZ	2013	2012	2021	8048	8048	OK
102	HORIZ	1374	2007	2001	13444	13444	OK
103	HORIZ	1372	2007	2001	13444	13444	OK
104	HORIZ	7959	2017	2017	21581	21581	OK
105	HORIZ	7950	2017	2021	21581	21581	OK
114	HORIZ	1374	2001	2007	13444	13444	OK
115	HORIZ	1373	2001	2007	13444	13444	OK
116	HORIZ	7954	2017	2017	21581	21581	OK
117	HORIZ	7955	2017	2021	21581	21581	OK
127	HORIZ	1378	2001	2024	13444	13444	OK
131	HORIZ	1259	2001	2020	13444	13444	OK
133	HORIZ	8292	2017	2020	21581	21581	OK
136	HORIZ	2021	2021	2012	21581	21581	OK
148	HORIZ	1012	1019	2024	15920	15920	OK
154	HORIZ	7461	2001	2024	13444	13444	OK
158	HORIZ	1042	2010	2012	8048	8048	OK
178	HORIZ	7758	1018	2001	15920	15920	OK

6.4.4 Sloped Wall Member Check

Evaluate the sloped 4x4 members of the transverse bents by extracting the loads and comparing to the allowable loads, which were determined previously. The longest sloped wall member is the top one and it is approximately 92-inches long and is located in the top third of the structure. Conservatively use an 8-foot unbraced length and the allowable load for a 4x4 brace in the top third of the structure.

END Bent:

Max Horiz. seismic load =	168	lbs. for Member	226
Max. Vertical Seis. = 0.093 * DL =	218	lbs. for Member	226
Max DL =	2340	lbs. for Member	226

Combined Load = SRSS Seis + DL = 2615 lbs.

MAIN Bent:

Max Horiz. seismic load =	294	lbs. for Member	252
Max. Vertical Seis. = 0.093 * DL =	385	lbs. for Member	252
Max DL =	4144	lbs. for Member	252

Combined Load = SRSS Seis + DL = 4629 lbs.

PARTITION Bent:

Max Horiz. seismic load =	295	lbs. for Member	205
Max. Vertical Seis. = 0.093 * DL =	358	lbs. for Member	205
Max DL =	3854	lbs. for Member	205

Combined Load = SRSS Seis + DL = 4318 lbs.

From Section 6.3.4 above, find the following allowable axial compressive load for a 4x4 member, 96 inches long and located in the top third of the structure with ke = 1.0,

Allowable seismic axial load = 7778 lbs.

Allowable dead axial load = 5736 lbs.

All of the sloped wall members are adequate.

7. SUMMARY AND CONCLUSIONS

The cooling towers at Vermont Yankee are undergoing modifications for power uprate. These modifications consist of removing and replacing the existing fans and motors and adding new cable trays. Cells CT2-1 and CT2-2 of the west cooling tower are designated as Seismic Class 1 structures and require a seismic evaluation for the power uprate changes.

This calculation documents the response spectrum seismic analysis of the main structural framing members of modified cooling tower cells CT2-1 and CT2-2.

The evaluation consists of modeling the structural framing members as beam elements, determining the forces and masses distributed to the models, and evaluating the models for dead, snow/ice and seismic loadings. The tower is analyzed using three 2-D longitudinal models (Bents A, B and C), and three 2-D transverse models (Main, End and Partition).

The models are analyzed using the Vermont Yankee design basis earthquake from Appendix A of the UFSAR (Attachment C) as seismic input. Horizontal seismic input for this analysis is the maximum hypothetical earthquake (MHE) equal to two times the OBE (PGA of 0.14g). The vertical acceleration is equal to 0.093 or 2/3 of the rigid range horizontal ground spectrum. The models are analyzed using 5% damping.

The allowable loading for the wood structure is determined in accordance with the 1991 edition of the NDS (Reference 8) and the 1996 edition of the Cooling Tower Institute (CTI) Standard Specification for the Design of Cooling Towers With Douglas Fir Lumber (Reference 11).

The results of the analysis show that cooling tower cells CT2-1 and CT2-2 are seismically adequate for the applied loading conditions. All member interaction ratios are 1.0 or less, all connections have adequate capacity, and base anchorage is also adequate.

Attachment E shows the computer models and base reaction results. Computer output files in Attachments F through Q provide the analysis results including modal response and member forces for each model. Member forces for each bent are extracted from the computer output files and summarized in Attachment S. Member interaction ratios are calculated and summarized in Attachment S.

No assumptions require verification to validate the conclusions reached in this calculation.

8. REFERENCES

1. VY UFSAR, Updated as of 12-01-04.
2. Cooling Tower Institute, CTI Code Tower "Standard Specifications for the Design of Cooling Towers With Douglas Fir Lumber," CTI Bulletin STD-114, October 1978.
3. "Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment," Revision 3A corrected, Seismic Qualification Utility Group (SQUG), December 2001.
4. SAP2000, Non-Linear Version 7.40, Copyright 1984 – 2000, Computers and Structures, Inc., Berkeley, California.
5. ABS Consulting Nuclear Quality Assurance Manual (NQAM), Revision 7.
6. ABS Consulting, "NQA Procedure for Software Verification and Control", Procedure Number RCD-NQP-00-P03, Revision 1.
7. Reference Drawings:

Ref. No.	Drawing Author	Drawing Number	Rev	Drawing Title
7.1	Flour Products Company, Inc.	5920-3326	-	Plan & Elevation 1170-1-7710
7.2	Flour Products Company, Inc.	5920-6451 Sheet 3 of 5	-	Transverse Section Additional Framing
7.3	Custodis-Ecodyne	DR-1196013 Sheet 1 of 2	B	Longitudinal Section Framing Bent "C" Cells 1 and 2
7.4	Custodis-Ecodyne	DR-1196013 Sheet 2 of 2	B	Longitudinal Section Framing Bent "B" Cells 1 and 2
7.5	Flour Products Company, Inc.	5920-4600	R3	Secondary Distribution System @ Cell No. 1
7.6	Custodis-Ecodyne	5920-6840 Sheet 1 of 6	0	T-Bar Fill Inst'n 2 x 8 & 4 x 8 Config. Model 1170-1-7710
7.7	Custodis-Ecodyne	5920-6840 Sheet 2 of 6	0	T-Bar Fill Inst'n 2 x 8 & 4 x 8 Config. Model 1170-1-7710
7.8	Custodis-Ecodyne	5920-6840 Sheet 4 of 6	0	T-Bar Fill Inst'l Details and Notes
7.9	Custodis-Ecodyne	5920-6452 Sheet 2 of 9	0	Companion Post Installation Details

Ref. No.	Drawing Author	Drawing Number	Rev	Drawing Title
7.10	Ebasco	G-191731	2	Circulating Water Piping & Misc. Steel – Sh.2
7.11	Ebasco	G-200357	-	Cooling Tower No. 2 – Foundation - MAS
7.12	Flour Products Company, Inc.	5920-3324	-	Anchor Bolt Setting 1170-1-7710
7.13	Tower Performance, Inc	5920-13331	-	Plan View of Existing Fan Deck Layout
7.14	Tower Performance, Inc	5920-13330	-	Transverse Section 1-1
7.15	Entergy Nuclear VY	G-191374	13	Cooling Tower and Discharge Structure-Conduit, Grounding and Lighting Plan
7.16	Entergy Nuclear VY	G191230	31	Yard Piping Plan – Sheet 1
7.17	Entergy Nuclear VY	G191231	16	Yard Piping Plan – Sheet 2
7.18	Ebasco	AJ1230-1 through AJ1230-8	4-1970	Material Fabrication Sketches for System #22, Service Water Yard Piping

8. ANSI/NFPA NDS-1991, "National Design Specification for Wood Construction," with NDS Supplement "Design Values for Wood Construction," 1991.
9. AISC Manual of Steel Construction, 9th Edition
10. ABS Calculation SAP2000-QA-001, "SAP2000 Version 7.4 Computer Program QA Verification," Revision 0, November 1, 2004.
11. Cooling Tower Institute, CTI Code Tower "Standard Specifications for the Design of Cooling Towers With Douglas Fir Lumber," CTI Bulletin STD-114, Revision dated November 1996.
12. Custodis-Ecodyne Maintenance Services Division, "Vermont Yankee Nuclear Power Corporation, Job No. 57A-11960-H, Calculations of Assessment and Modification," dated January 1986.
13. Vermont Yankee Document 5920-4571 R0, "Cooling Tower CT-2-1A Design Data 28 Sheets'", dated 11-25-1969. Job No. E70-11960, Prop. No. NY-CT-7110.3, by Fluor Products Company, Inc.

14. Engineering Decision Analysis Company, Inc. (EDAC), EDAC-388-020.02, "Dynamic Seismic Analysis of the Custodis-Ecodyne Cooling Tower at the Vermont Yankee Nuclear Power Station (Cooling Tower N0. E70-11960)," April 7, 1986.
15. VY PDCR 86-02, "Cooling Tower Seismic Modification," May 1986.
16. VY UFSAR Figures A.7-1 through A.7-14, Revision 5.
17. Ebasco Specification 54-63, "Mechanical-Draft Cooling Tower," Revision 1, April23, 1969.
18. American Plywood Association, "Plywood Design Specification," August 1986.
19. US Army Corps of Engineers Standard ETL 1110-2-548, "Composite Materials for Civil Engineering and Design," March 31, 1997.
20. Entergy Calculation VYC-2377, "Raceway Supports for Cooling Tower Improvements," Revision 1.
21. NDS, "National Design Specification for Wood Construction Commentary," American Forest & Paper Association, 1997 Edition, with Addendum to the 1991 Commentary.
22. NUREG/CR-0098, "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," N. M. Newmark Consulting Engineering Services for the U.S. Nuclear Regulatory Commission, May 1978.
23. USNRC, NUREG-0800, Standard Review Plan, Section 3.8.4, "Other Seismic Category I Structures," Revision 1, July 1981.
24. Bergen-Paterson Pipe Supports Catalog No. 82R
25. Entergy Nuclear Operations Contract Order No. 4500533976, September 8, 2004.
26. American Concrete Institute (ACI), "Code Requirements for Nuclear Safety Related Concrete Structures," ACI-349-90, March 1990.
27. E-mail correspondence from Jim Fitzpatrick of Entergy Nuclear VY to Jim White of ABS Consulting, Subject: "Fiberglass Density Verification," March 22, 2005, 1:44 P.M.