Night School 23: Topics on Industrial Building Design and Design of Non-building Structures

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Session 1 – Introduction and Code Provisions
June 16, 2020

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Course Description

Introduction and Code Provisions
June 16, 2020

This session introduces the course and reviews the standards and references applicable to industrial structures. The code and load requirements that need to be considered for the design of industrial structures will be reviewed. Emphasis on how these requirements compare to similar requirements for conventional structures will be presented

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Learning Objectives

- Introduce the topics that will be covered in the balance of the course.
- Review of standards and references applicable to industrial structures.
- Review of the code and load requirements that need to be considered for the design of industrial structures.
- Emphasize how these requirements compare to similar requirements for conventional structures.

Night School 23: Topics on Industrial Building Design and Design of Non-Building Structures

Session 1: Introduction and Code Provisions
June 16, 2020

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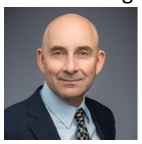


Smarter.
Stronger.
Steel.

SESSION 1 INTRODUCTION AND CODE PROVISIONS

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INTRODUCTION

SESSION 1 INTRODUCTION AND CODE PROVISIONS
SESSION 2 INDUSTRIAL BUILDINGS – PART 1
SESSION 3 INDUSTRIAL BUILDINGS – PART 2
SESSION 4 CRANE SUPPORTING STRUCTURES
SESSION 5 FATIGUE DESIGN FOR INDUSTRIAL STRUCTURES
SESSION 6 HIGH & LOW TEMPERATURE DESIGN FOR INDUSTRIAL STRUCTURES
SESSION 7 NON-BUILDING STRUCTURES –PART 1
SESSION 8 NON-BUILDING STRUCTURES –PART 2

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INTRODUCTION

The sessions cover different aspects of the structural design of steel framed industrial structures

Steel structures used for:
- storage
- food & beverage
- pharmaceutical
- automotive
- raw materials
- steel making
- foundries
- glass production…

Steel structures such as:
- warehouses
- crane buildings
- racks (high density storage)
- bins and hoppers
- structures supporting vibratory equipment
- conveyor support structures
- large ducts and plate structures…

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INTRODUCTION

The sessions cover different aspects of the structural design of steel framed industrial structures

Design Issues:
- developing design loads and performance criteria
- fatigue
- fracture
- thermal loads
- dynamic loads
- construction tolerances
- structure and member stability
- connection design and detail selection

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SESSION 1: INTRODUCTION & CODE PROVISIONS

LEARNING OBJECTIVES:
- Introduce the topics that will be covered in the balance of the course.
- Review of standards and references applicable to industrial structures.
- Review of the code and load requirements that need to be considered for the design of industrial structures with emphasis on how these requirements compare to similar requirements for conventional structures.

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INTRODUCTION

SESSION 1

- Refer to learning objectives

SESSION 2 INDUSTRIAL BUILDINGS – PART 1

- General presentation covering industrial buildings as a broad topic.
- Discussion of the design process and the structural engineer's role.

SESSION 3 INDUSTRIAL BUILDINGS – PART 2

- Discussion of structural analysis, design for stability, and unique design requirements for industrial structures.

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INTRODUCTION

SESSION 4 CRANE SUPPORTING STRUCTURES

- Design of light and heavy-duty high cycle crane support structures.

SESSION 5 FATIGUE DESIGN FOR INDUSTRIAL STRUCTURES

- A discussion of fatigue concepts, review of the AISC criteria, and applications in fatigue design.

SESSION 6 HIGH & LOW TEMPERATURE DESIGN FOR INDUSTRIAL STRUCTURES

- Temperature effects on welds, bolts, stability, and brittle fracture.

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INTRODUCTION

SESSION 7 NON-BUILDING STRUCTURES –PART 1

- Design issues related to pipe racks, machine supports, storage racks, piling design, and other non-building structures

SESSION 8 NON-BUILDING STRUCTURES –PART 2

- Plate structures, buckling, design of cylindrical shells, design of stiffeners.

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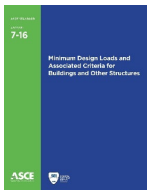
CODES & STANDARDS

General Requirements:

- Building Code: Local Jurisdiction
- IBC (2012, 2015, 2018…)
  ICC; International Code Council
- ASCE 7-16 for loads
  American Society of Civil Engineers



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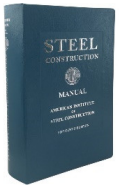
CODES & STANDARDS

General Requirements:

- AISC 360-16 or 341-16 for steel design
- AISC 303 (COSP) for fabrication and erection
- AISC 360 Chapter N for Special Inspections



American Institute of Steel Construction

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CODES, STANDARDS & REFERENCES

- AIST Guide for the Design and Construction of Mill Buildings (2020)
- Mill buildings: AISE Tech Report No. 13. (2003) Guide for the Design and Construction of Mill Buildings

Association of Iron and Steel Technology

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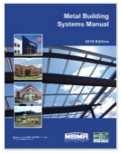
CODES, STANDARDS & REFERENCES

- MBMA Metal Building Systems Manual (2018)



Metal Building Manufacturers Association

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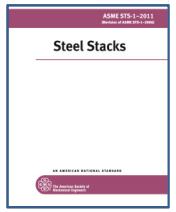
CODES, STANDARDS & REFERENCES

Steel Chimneys and Stacks:

- ASME STS-1 (2016)



American Society of Mechanical Engineers

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CODES, STANDARDS & REFERENCES

Petro Chem. & Industrial Tanks and Vessels (Fluid):

- API Standard 650 (13th ed.) Welded Tanks for Oil Storage
- API Standard 620 (12th ed.) Design and Construction of Large, Welded, Low-Pressure Storage Tanks

American Petroleum Institute

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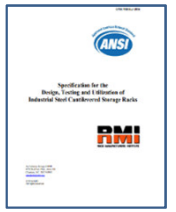
CODES, STANDARDS & REFERENCES

Steel Storage Racks:

- ANSI/RMI MH 16.1-2012 Specification for the Design Testing and Utilization of Industrial Steel Cantilevered Storage Racks

Rack Manufacturers Institute



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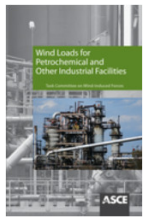
CODES, STANDARDS & REFERENCES

- Wind Loads for Petrochemical and Other Industrial Facilities (ASCE)

American Society of Civil Engineers

- Task Committee on Wind-Induced Forces of the Petrochemical Committee of Energy Division, ASCE



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CODES, STANDARDS & REFERENCES

- PIP STC01015 (2017) Structural Design Criteria

Process Industry Practices

- Federal Construction Council Technical Report No. 65 Expansion Joints in Buildings 1974;
National Academy of Sciences-National Research Council

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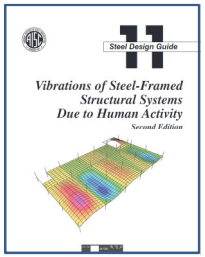
CODES, STANDARDS & REFERENCES

Vibration References:

- AISC Design Guide 11 Vibrations of Steel-Framed Structural Systems Due to Human Activity (2nd ed.)
- DIN 4150 -1 Prediction of Vibration Parameters
- DIN 4150 -2 Human Exposure to Vibration in Buildings
- DIN 4150-3 Effects on Structures
- ACI 351.3R-18 Report on Foundations for Dynamic Equipment



DIN

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CODES, STANDARDS & REFERENCES

Bins and Hoppers; Granular Materials (excluding agriculture):

- ACI 313-16 Design Specification for Concrete Silo and Stacking Tubes for Storing Granular Materials
- AS 3774 Australian Standard Loads on bulk solids containers
- Design of Steel Bins for Storage of Bulk Solids; Gaylord and Gaylord (1984)
- DIN standard 1055-6 Design Loads for Building; Loads in Silo Bins

DIN

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CODES, STANDARDS & REFERENCES

Cranes and Crane Support Structures:

- CISC Design Guide; Crane-Supporting Steel Structures, 3rd. Ed.
- AISC Design Guide 7 Industrial Building Design, 3rd. Ed.

Canadian Institute of Steel Construction
American Institute of Steel Construction

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CODES, STANDARDS & REFERENCES

Cranes:

- CMAA #70 Specifications for Top Running & Gantry Type Multiple Girder Electric Overhead Traveling Cranes
- CMAA #74 Specifications for Top Running & Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist

Crane Manufacturers Association of America

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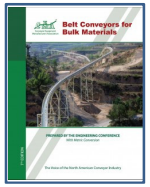
CODES, STANDARDS & REFERENCES

Conveyors

CEMA: Belt Conveyors for Bulk Materials 7th ed.

Conveyor Equipment Manufacturers Association



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CODES, STANDARDS & REFERENCES

Insurance Requirements:

Consult with the owner to determine their requirements

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LOAD REQUIREMENTS ASCE 7-16

D=Dead

D_i=weight of ice

E=earthquake load

F=load caused by fluids

F_a=flood load

H=lateral earth…bulk materials

L=Live load

Lr= Roof Live

N= Notional Load

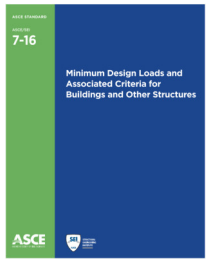
R= Rain Load

S=Snow

T= Self straining forces…thermal

W= wind load

W_i=wind on ice



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(D) DEAD LOADS

- Self weight of the structure
- Floor covering and partitions
- Roofing
- Building utilities
- Process piping / cable trays / small ducts
- Fixed in place equipment.

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(D) DEAD LOADS

Floor covering and partitions examples

- Acid Brick (Dairy brick) and sloped topping 25 to 50 psf
- Various process rooms can have full height masonry partitions with weights in excess of 1500 plf. resulting in an average partition load in excess of 50 psf.

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(D) PROCESS PIPING SUSPENDED

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(D, L_r) PROCESS PIPING EQUIPMENT

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(D) DEAD LOADS

SUMMARY

- Note all allowances on the structural drawings.
- Review load estimates with the process designers.
- Consider future process modifications and additions.

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(E) SEISMIC LOAD

ASCE 7-16

Seismic Base Shear V

$V = f(M, A, T, R, I_e)$

M=Mass

A=S_{DS}, S_{D1}=Design…acceleration…

T=Period

R= Response Modification Factor

I_e = Importance Factor

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(E) SEISMIC LOAD

Mass (ASCE 7-17 12.7.2)

- Include all permanent building dead load and the operating weight of fixed equipment.
- Stored materials. (L vs D)
  - storage…minimum 25% of the floor live load (CAUTION)
- Crane bridge and trolley weight.
- 20% of the uniform design snow load when the flat roof snow exceeds 30 psf.

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(E) SEISMIC LOAD

R= Response Modification Factor

Building Structure or Nonbuilding Structure?

ASCE 7-16 11.1.3

"Buildings whose purpose is to enclose equipment or machinery and whose occupants are engaged in maintenance or monitoring of that equipment, machinery, or associated processes shall be permitted to be classified as nonbuilding structures …"

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(E) SEISMIC LOAD

Table 15.4-1 Seismic Coefficients for Nonbuilding Structures Similar to Buildings

Building Frame Systems	Req.	R	Ω_o	C_d
Steel Special Conc. Br. Frames	AISC 341	6	2	5
Steel Ord. Conc. Br. Frames	AISC 341	3.25	2	3.25
With ht. increase	AISC 341	2.5	2	2.25
With unlimited ht.	AISC 360	1.5	1	1.5

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(E) SEISMIC LOAD

Table 15.4-1 Seismic Coefficients for Nonbuilding Structures Similar to Buildings

Moment Frame Systems	Req.	R	Ω_o	C_d
Steel Special Moment Frames	AISC 341	8	3	5.5
Steel Int. Moment Frames	AISC 341	4.5	3	4.0
With ht. increase	AISC 341	2.5	2	2.5
With unlimited ht.	AISC 341	1.5	1	1.5

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(E) SEISMIC LOAD

Table 15.4-1 Seismic Coefficients for Nonbuilding Structures Similar to Buildings

Moment Frame Systems	Req.	R	Ω_o	C_d
Steel Ordinary Moment Frames	AISC 341	3.5	3	3.0
With ht. increase	AISC 341	2.5	2	2.5
With unlimited ht.	AISC 360	1	1	1

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(E) SEISMIC LOAD

S_{DS}, S_{D1}=Design…acceleration…typically use the same maps and recurrence intervals used for Risk Category II structures.

T: Calculate the actual period of your structure. Do not use the approximate period equations. (15.4.4)

I_e = Importance Factor… Risk Category II structures

$$T = 2\pi \sqrt{\frac{\sum_{i=1}^{n} w_i \delta_i^2}{g \sum_{i=1}^{n} f_i \delta_i}}$$

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(E) SEISMIC LOAD

Drift Limit (15.4.5)

"The drift limit of section 12.12.1 need not apply to nonbuilding structures if a rational analysis indicates that they can be exceeded without adversely affecting structural stability or attached or interconnected components and elements such as walkways and piping. P-delta effects shall be considered…using the appropriate C_d value…"

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(L) LIVE LOADS

IBC 2018 → ASCE 7-16 → Table 4.3-1

Catwalks for maintenance access:	40 psf	300 lbs	(y/y)
Manufacturing / Light	125 psf	2,000 lbs.	(n/y)
Manufacturing / heavy	250 psf	3,000 lbs.	(n/y)
Stairs an exit ways	100 psf	300 lbs.	(y/y)
Storage Warehouses Light	125 psf		(n/y)
Storage warehouses Heavy	250 psf		(n/y)
Walkways and elevated Platforms	60 psf		(y/y)

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(L) AIST Table 3.1 (partial)

Casthouse casting floors	500 psf
Elevated platforms	200 psf
Blast Furnace top platforms	200 psf
Charging/furnace/casting floors	500 psf
Furnace/Ladle Repair platform	500 psf
Motor Room floor	1000 psf
Misc. walks access platforms	100 psf

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(L) LIVE LOADS

PROCESS PIPING & DUCTS

- Assume process pipes are full
- Refer to PIP document for detailed guidance
- Consider ducts and mains as ¼ depth filled with dust (evaluate wet and dry density)
- Supports for parallel mains and ducts on the same fan should be designed for one duct accidentally filled.
- Consider temperature changes differential or unbalanced internal pressure in the system.

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(L) LIVE LOADS – HANDRAILS, GUARDRAILS

IBC → ASCE 7-16 → Section 4.5.1

Handrail and guardrail systems lb. in any direction	200
on the handrail and top rail plf. in any direction	or 50
Infill components on a 1'x1' square.	50 lb.

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(L) LIVE LOADS – HANDRAILS, GUARDRAILS

IBC 1015.2 …along walking surfaces that are located more than 30” measured vertically… (exceptions)

OSHA 1910.28 …walking –working surface with an unprotected side or edge that is 4 feet or more above a lower level is protected…

1910.29(b)3 Guardrail	200 lb. downward or outward on the top rail
Midrails/components	150 lb. downward or outward at any point

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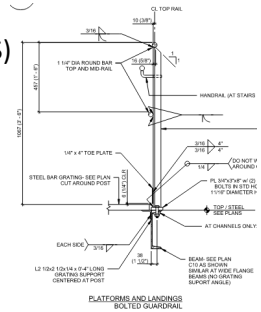
HANDRAILS, GUARDRAILS Configuration

IBC 1015.4 (areas not open to the public…within occupancies I-3, F, H, or S)

- 42” high
- 21” maximum sphere

OSHA 1910.29



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(L) LIVE LOADS – HANDRAILS, GUARDRAILS

Vehicle Barrier Systems: ASCE 7-16 Section 4.5.3

- 6,000 lbs. applied horizontally between 1’-6” and 2’-3” above the floor.
- Refer to AASHTO if trucks are allowed.

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(L) LIVE LOADS – FALL ARREST & LIFELINE ANCHORAGES

UBC ➡ ASCE 7-10 ➡ 4.6.5

Fall arrest and lifeline anchorages and structural elements that support these anchorages shall be designed for a live load of 3,100 lb. for each attached lifeline in every direction that a fall arrest load may be applied.

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(L) LIVE LOADS – FALL ARREST & LIFELINE ANCHORAGES

OSHA (1910.140(a)), 1910.140(c)(11)

- The employer must ensure that each horizontal lifeline:
- Is part of a complete personal fall arrest system that maintains a safety factor of at least two.
- (Anchorages) must be capable of supporting at least 5,000 pounds for each employee attached; or …
- Designed, installed, and used, under the supervision of qualified person, as part of a complete personal fall protection system that maintains a safety factor of at least two.
- Travel restraint lines must be capable of sustaining a tensile load of at least 5,000 pounds.

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(L) LIVE LOADS – FIXED LADDERS

UBC → ASCE 7-16 → 4.5.4

Concentrated Load	300 lb. for every	10’ of ladder ht.
Siderail Extensions	100 lb. in any	direction

OSHA:

Ladders are not to be loaded beyond the maximum intended load; The maximum intended load… includes the total load (weight and force) of the employee and all tools, equipment, and materials being carried

https://www.osha.gov/Publications/OSHA3903.pdf

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(L) CONVEYORS

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(L) CONVEYORS

Small short conveyors

- Often suspended from structure
- The conveyor support frame may be continuous from end to end and the belt tension will be resolved in the conveyor frame.
- Head and tail end equipment may be directly attached to the conveyor frame.

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(L) CONVEYORS

Large long (external) conveyors

- It is often not practical to resolve belt tensions in the conveyor frame.
- Confirm anchorage forces for belt tensions include start up effects.
- Typically include walkways on both sides for maintenance access
- Review thermal and seismic separation (conveyor frame vs. support frame)

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(H, L) BULK MATERIALS

Material Loads for Bins and Hoppers are a function of :

- (ϒ) Density
- (ϕ) Angle of internal friction
- (δ) Effective angle of internal friction
- (μ') Coefficient of friction against the bin
- (C_d) Overpressure

Use variable ranges of the material properties to create load combinations with maximum vertical pressure, lateral pressure and friction force.

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(H, L) BULK MATERIALS BINS & HOPPERS

Consider:

- Specify a thickness allowance for wear and/or exposure
- Specify AR plate or liners in areas of heavy wear
- Specify the bin will be maintained at atmospheric pressure

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(L) FORKLIFTS AND MOVABLE EQUIPMENT

IBC 2018 1607.7.4

Impact loads and fatigue loading shall be considered in the design of the supporting structure. For the purposes of design the vehicle and wheel loads shall be increased 30% to account for impact.

IBC 2018 1607.7.5

The maximum weight of vehicles allowed…shall be posted by the owner…

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(L) FORKLIFTS & MOVABLE EQUIPMENT AIST

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(L) FLOOR SUPPORTED EQUIPMENT

ASCE 7-16 4.6.3 Machinery

For the purpose of design, the weight of machinery and moving loads shall be increased as follows to allow for impact:

(1) light machinery, shaft- motor driven, 20 percent: and

(2) (2) reciprocating machinery or power-driven units, 50 percent. All percentages shall be increased where specified by the manufacturer.

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(L) FLOOR SUPPORTED EQUIPMENT

ASCE 7-16 4.6.1 General

The live loads specified in Sections 4.3 through 4.5 shall be assumed to include adequate allowance for ordinary impact conditions. Provision shall be made in the structural design for uses and loads that involve unusual vibration and impact forces.

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(L) FLOOR SUPPORTED EQUIPMENT

ASCE 7-16 4.6.1 General

The live loads specified in Sections 4.3 through 4.5 shall be assumed to include adequate allowance for ordinary impact conditions. Provision shall be made in the structural design for uses and loads that involve unusual vibration and impact forces.

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(L) AIST VIBRATORY LOADING

Structures supporting rotating and vibrating equipment shall be deigned with due consideration of dynamic loads, the operating frequency of the equipment, the natural frequencies of the support structure and the potential for dynamic magnification and resonant response.

Details of static and dynamic loads generated by the equipment and any associated design criteria pertaining to the performance of the equipment should be provided by the equipment supplier.

The design of the structure shall also acknowledge potential fatigue concerns associated with the vibratory loading and potential concerns relative to human comfort for occupants of the structure.

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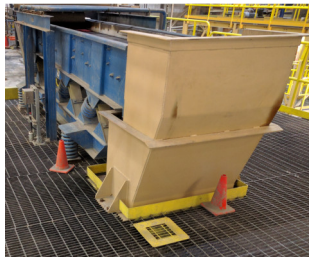
(L) AIST 2003 VIBRATORY LOADING / IMPACT FACTORS

Motors and similarly balanced rotating equipment
Vibrating screen supports
Pan feeder supports
Vibratory conveyors
Gyratory and jaw crushers
Forced or induced draft fans
Mold oscillators
Reciprocating compressors



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(L) VIBRATORY EQUIPMENT DYNAMIC ANALYSIS

Analysis Options:

1. Frequency Analysis

   Determine the natural frequencies and mode shapes of the primary modes of vibration and the modes close to the machines operating range.

   Acceptance criteria is stated as a ratio between the operating frequency and the natural frequency of the primary modes.

2. Forced Response

   Determine displacements, velocities, or accelerations as a function of time compare these to acceptance criteria, and design for the response.

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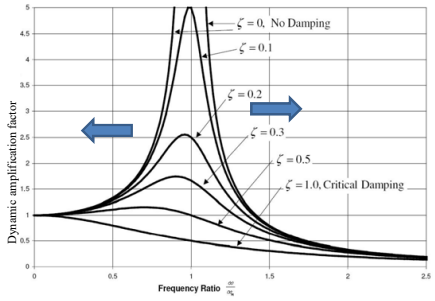
(L) FLOOR SUPPORTED EQUIPMENT



Frequency Analysis:

ω= natural frequency of a mode of vibration

ω_r= the forcing frequency

Typically criteria for primary modes:

$.5<\omega/\omega_r<1.5$

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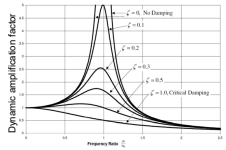
(L) FLOOR SUPPORTED EQUIPMENT



Damping Ratio

- Steel framed “building like” structures assumed ranges of damping can be in the range of 1 to 1.5%
- Steel framed towers may have less damping 0.15 to 0.5 %

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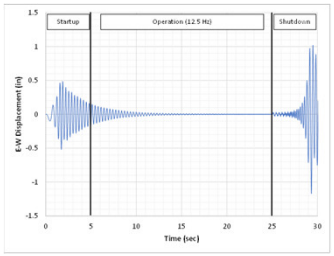
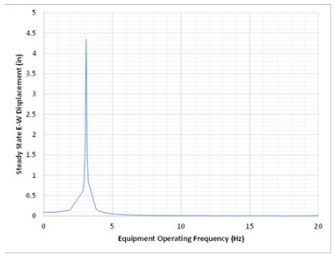
(L) FLOOR SUPPORTED EQUIPMENT





Forced Response Analysis

70

(L) FLOOR SUPPORTED EQUIPMENT

Vibratory equipment:

- Consider fatigue based on the results of your dynamic analysis. (Miner’s Rule)
- Consider independent framing to isolate the behavior
- Consider a static load case considering the equipment plugged with material

71

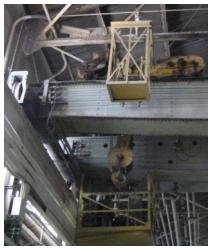
(L) BRIDGE CRANES

72

(L) BRIDGE CRANES

Get a crane data sheet for the crane or cranes proposed for the project.

- Rated Capacity
- Bridge Weight
- Trolley Weight
- Wheel Spacing & Loads
- Bumper forces
- Service Classification
- Clearance dimensions



73

(L) BRIDGE CRANES - Continued

For "*light* occupancies" determine impact, lateral, and longitudinal loads based on the building code, IBC 2018:

Impact for cranes increase wheel loads :

- Monorails (powered) 25%
- Cab or remotely operated bridge cranes 25%
- Pendant operated bridge cranes (powered) 10%
- Bridge or monorail cranes with hand geared bridge, trolley and hoist 0%

74

(L) BRIDGE CRANES - Continued

Building code; IBC 2018:

Lateral Loads:

- 20% of the sum of the rated capacity and weight of the hoist and trolley

Longitudinal Loads:

- 10% of the maximum wheel loads

75

(L) BRIDGE CRANES – AIST

CRANE	VERTICAL IMPACT %	LATERAL LOAD %	TRACTIVE FORCE %
MILL & LADLE	25	40	20
CLAMSHELL & MAGNET*, SOAKING PIT,STRIPPING	25	100	20
MOTOR ROOM	20	30	20
STACKER	25	200	20

TABLE 3.2 PARTIAL LIST

76

(L) BRIDGE CRANES - Continued

Life Cycle / CMAA Crane Classifications:

- Class A (Standby or infrequent service) ex. Power plants
- Class B (Light service) 2 to 5 lifts per hour typically well below rated capacity
- Class C (Moderate Service) 5 to 10 lifts per hour averaging below 50% of the rated capacity
- Class D (Heavy Service) loads approaching 50% of the rated capacity are handled constantly

77

(L) BRIDGE CRANES - Continued

Life Cycle / CMAA Crane Classifications:

- Class E (Severe Service) handling loads approaching the rated capacity are handled constantly twenty or more lifts per hour at or near rated capacity.
- Class F (Continuous Severe Service) handling loads approaching rated capacity under severe service conditions throughout its life.

78

(T) SELF - STRAINING FORCES

Thermal (Climate)

- Typically controlled by with expansion joints

Joint spacing is determined by:

- Experience
- Use of limits in standards or references
- Application of the Federal Construction Council Technical Report No. 65 Expansion Joints in Buildings
- Results of a formal analysis

79

(T) SELF - STRAINING FORCES

AIST “Guide for the Design and Construction of Mill Buildings”

Transverse Expansion Joints

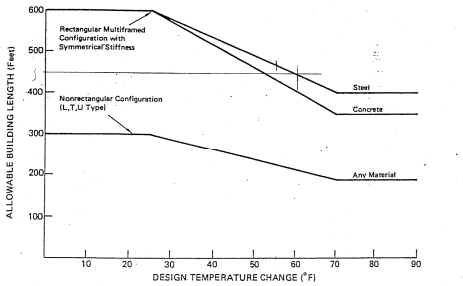
- “In furnace buildings and similar structures … internal temperature fluctuations can be significant …400 ft. intervals
- In other parts of the mill facilities where temperature fluctuations are not as pronounced 500 ft.

Longitudinal Expansion Joints

- If the width exceeds 500 feet or 5 aisles

80

(T) FCC TECH. REPORT NO. 65 EXPANSION JOINTS IN BUILDINGS



81

(T) SPACING OF EXPANSION JOINTS

Adjustments to Figure 1

1. If the building will be heated and will have pinned column bases, use the maximum length.
2. If the building will be air conditioned as well as heated, increase the maximum length by 15% (provided the environmental control system will run continuously).
3. If the building is unheated, (not conditioned) decrease the maximum length by 33%

82

(T) SELF - STRAINING FORCES

Adjustments to Figure 1

4. If the building will have fixed base column bases , decrease the maximum length by 15%.
5. If the building will have substantially greater stiffness against lateral displacements at one end of the plan dimension decrease the maximum length by 25%.

If more than one of these design conditions prevail, the percentile factor to be applied is the algebraic sum of the adjustment factors of all the various applicable conditions.

83

(T) SELF - STRAINING FORCES

Design Temperature T

$$T = T_w - T_m \quad \text{or} \quad T_m - T_c$$

T_w= (warm) The temperature exceeded, on the average, only 1 % of the time during the summer in the building locality.

T_c= (cold) The temperature equaled or exceeded, on the average, 99 % of the time during the winter in the building locality.

Tm = (mean) mean construction season temperature. The contiguous period in a year during which the minimum daily temperature equals or exceeds 32 deg F.

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(T) SELF - STRAINING FORCES

Thermal: Example solution:

- 70 degree or greater design temperature (400 ft. base length)
- Not conditioned- industrial structure (-33%)
- Pinned bases, braces at one end (-25%)

Joint spacing: 400(1-.25-.33)=168 ≈170 feet

Comparison:

- Conditioned- heating and cooling (+15%)
- Pinned bases, braces symmetrical (0%)

Joint spacing: 400(1+.15)=460 feet

85

(T) SELF - STRAINING FORCES

Analysis: Load Combinations ASCE 7-16 C2.3.4

STRENGTH DESIGN

1.2D + 1.2 T +.5 L

1.2D + 1.6 L + 1.0 T

ALLOWABLE STRENGTH DESIGN

1.0 D + 1.0 T

1.0 D +.785(L + T)

These combinations are not all inclusive.

86

(T) THERMAL

87

LOAD REQUIREMENTS ASCE 7-16

D=Dead

D_i=weight of ice

E=earthquake load

F=load caused by fluids

F_a=flood load

H=lateral earth…bulk materials.

L=Live load

Lr= Roof Live

N= Notional Load

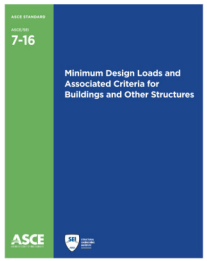
R= Rain Load

S=Snow

T= Self-straining forces…thermal

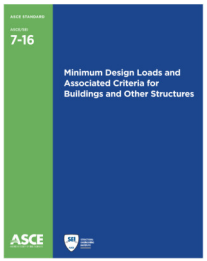
W= wind load

W_i=wind on ice



88

LOAD COMBINATIONS ASCE 7-16

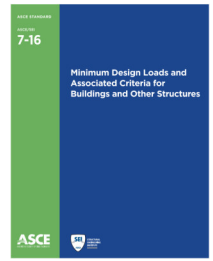


STRENGTH DESIGN

1. 1.4D
2. 1.2D+1.6L+.5(L_r or S or R)
3. 1.2D+1.6 (L_r or S or R)+L+.5W
4. 1.2D+1.0W+L+.5(L_r or S or R)
5. .9D+1.0W
6. 1.2D+E_v+E_h+L+.2S 1.2D+E_v+E_{mh}+L+.2S
7. .9D-E_v+E_h+L+.2S .9D-E_v+E_{mh}+L+.2S

89

LOAD COMBINATIONS ASCE 7-16



ALLOWABLE STRESS DESIGN

1. D
2. D + L
3. D + L_r
4. D+.75L+.75(L_r or S or R)
5. D+.6W
6. D+.75 L+.75(.6W)+.75(L_r or S or R)
7. .6 D+.6W
8. D+.7 E_v+.7 E_h D+.7 E_v+.7 E_{mh}
9. D+.525 E_v+.525 E_h+.75 L+.75 S D+.525 E_v+.525 E_{mh}+.75 L+.75 S
10. .6 D-.7E_v+.7E_h .6 D-.7E_v+.7E_{mh}

90

SESSION 1: SUMMARY

Developing the structural loads and structural performance criteria in a process intensive project requires a coordinated effort between the structural engineer and the process designers.

- Cranes: Rated Capacity, Type, Impact Factor, Lateral & Longitudinal Loads, Class
- Vibratory Equipment: reactions to the structure, operating frequency and performance requirements
- Bulk Storage: Material density, and properties
- Conveyors: Belt tension loads, drive equipment

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SESSION 1: SUMMARY

DOCUMENTION

List and record all process load requirements used during the design.

List all process load requirements on the structural drawings

92

SESSION 1: INTRODUCTION & CODE PROVISIONS

Thank you!

AISC | Questions?

Individual Session Registrants

PDH Certificates

- You will receive an email on how to report attendance from: registration@aisc.org.
- Be on the lookout: Check your spam filter! Check your junk folder!
- Completely fill out online form. Don't forget to check the boxes next to each attendee's name!

Individual Session Registrants

PDH Certificates

- Reporting site (URL will be provided in the forthcoming email).
- Username: Same as AISC website username.
- Password: Same as AISC website password.

Individual Session Registrants

PDH Certificates

- Accommodations for Work-From-Home situations:
- AISC will provide the list of attendees from your company to report attendance. These are the only individuals that you should report for attending this session.
- The lists will be send out within 3 business days.

8-Session Registrants

PDH Certificates

One certificate will be issued at the conclusion of all 8 sessions.

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8-Session Registrants

Access to the quiz

Information for accessing the quiz will be emailed to you by Thursday. It will contain a link to access the quiz. EMAIL COMES FROM NIGHTSCHOOL@AISC.ORG.

Quiz and attendance records

Posted Thursday mornings. www.aisc.org/nightschool -- Click on Current Course Details.

Reasons for quiz

- EEU – You must take all quizzes and the final exam to receive EEU.
- PDHs – If you watch a recorded session, you must pass quiz for PDHs.
- REINFORCEMENT – Reinforce what you learn tonight. Get more out of the course.

Note: If you attend the live presentation, you do not have to take the quizzes to receive PDHs

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8-Session Registrants

Access to the recording

Information for accessing the recording will be emailed to you by Thursday. The recording will be available for four weeks. (For 8-session registrants only.) EMAIL COMES FROM NIGHTSCHOOL@AISC.ORG.

PDHs via recording

If you watch a recorded session, you must take *and pass* the quiz for PDHs.

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Night School Resources

Find all your handouts, quizzes and quiz scores, recording access, and attendance information all in one place!

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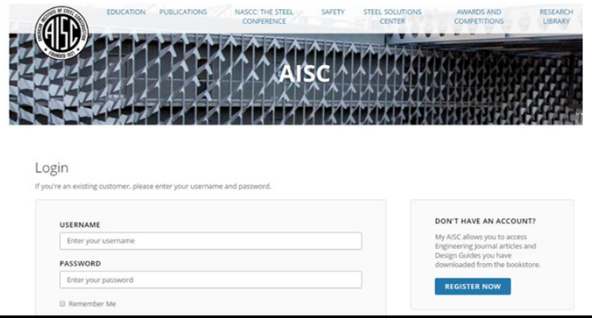
8-Session Registrants

Night School Resources

Go to www.aisc.org and sign in.



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8-Session Registrants

Night School Resources

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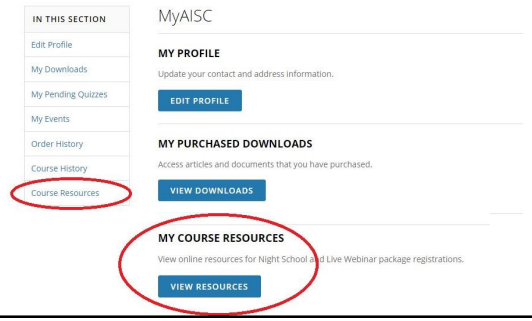

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Night School Resources

Course Resources

Event	Start Date
NS 13 8-Session Package-Night School 13 - Design of Industrial Buildings	1/30/2017 7:00:00 PM
NS 14 8-Session Package-Night School 14 - Fundamentals of Stability	6/5/2017 7:00:00 PM

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Night School Resources

Night School 13: Design of Industrial Buildings

8-SESSION PACKAGE RESOURCES

Event	Date	Handouts	Video	Quiz	Attendance
NS13 - Design Criteria	1/30/2017 7:00:00 PM	Handouts	View Passcode: NS13DSN	Pass Score: 80	Pending
NS13 - Economic Considerations	2/6/2017 7:00:00 PM	Handouts	Available 02/08/2017 5pm EST	Available 02/08/2017 5pm EST	Pending
NS13 - Lateral Load Systems and Details	2/13/2017 7:00:00 PM	Handouts	Available 02/15/2017 5pm EST	Available 02/15/2017 5pm EST	Pending
NS13 - Preliminary Design Procedures	2/27/2017 7:00:00 PM	Handouts	Available 03/01/2017 5pm EST	Available 03/01/2017 5pm EST	Pending
NS13 - Crane Girder Design and Frame Analysis	3/6/2017 7:00:00 PM	Handouts	Available 03/08/2017 5pm EST	Available 03/08/2017 5pm EST	Pending
NS13 - Frame Member and Connection Design	3/13/2017 7:00:00 PM	Handouts	Available 03/15/2017 5pm EST	Available 03/15/2017 5pm EST	Pending
NS13 - Transfer Crane Girder & Longitudinal Bldg Bracing Dsn	3/27/2017 7:00:00 PM	Handouts	Available 03/29/2017 5pm EST	Available 03/29/2017 5pm EST	Pending

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Night School Resources

- Weekly "quiz and recording" email.
- Weekly updates of the master quiz and attendance record, found at www.aisc.org/nightschool23. Scroll down to Quiz and Attendance records.
  - Updated on Thursday mornings.

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8-Session Registrants

Night School Resources

- Webinar connection information
  - Reminder email sent out Tuesday mornings
- Links to handouts also found here

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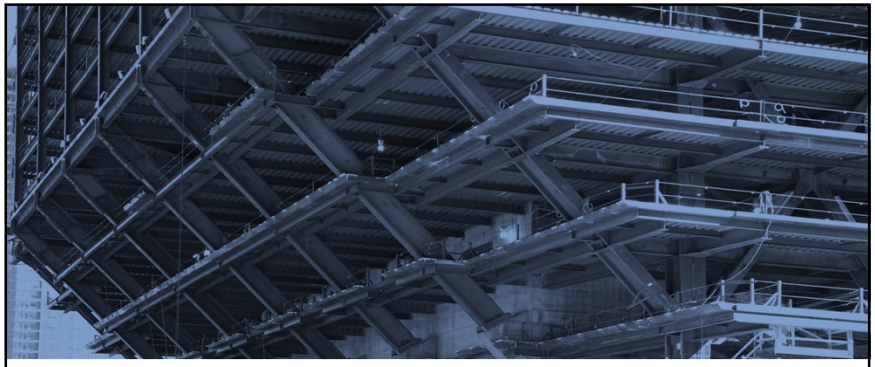

AISC | Thank you

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