CONCEPT・DESIGN EXAMPLE, COMPUTER AIDED STRUCTURAL MODELING (CASM)

Report 3

SCHEME C

by

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Monolithic Concrete For Two Story Portion,
Steel For Lower Roof Portion,
Lateral Load Resistance = Shear Walls
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for

Scheme C

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Preface

This manual presents a detailed design example emphasizing major capabilities of the Computer Aided Structural Modeling (CASM) computer program which is a program designed to aid the structural engineer in the preliminary design and evaluation of structural building systems by the use of three-dimensional interactive graphics.

Funds for the development of this program were provided to the Information Technology Laboratory (ITL), US Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, by the Directorate of Military Programs, Headquarters, US Army Corps of Engineers (HQUSACE), under the Research, Development, Test, and Evaluation (RDT&E) program. The work was accomplished under Work Unit No. AT40-CA-001 entitled "CASE (Computer Aided Structural Engineering) Building Systems." The work was performed by members of Wickersheimer Engineers, Inc., of Champaign, IL, under Contract No. DACA39-86-C-0024.

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Specifications for the program were provided by members of the Building Systems Task Group of the CASE Project. The following were members of the task group during this phase of program development:

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Mr. Michael Pace, WES

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This report was written by Messrs. Wickersheimer, McDermott, and Roth and Mr. Michael E. Pace, Computer-Aided Engineering Division (CAED), ITL, WES.

The work was monitored at WES by Mr. Pace, under the general supervision of Mr. H. Wayne Jones, Chief, Scientific and Engineering Applications Center; and Dr. N. Radhakrishnan, Director, ITL. Mr. Charlie Gutberlet is the HQUSACE Technical Monitor.

During publication of this report, Dr. Robert W. Whalin was Director of WES. COL Leonard G. Hassell, EN, was Commander and Deputy Director.
Project Description

This 1 and 2 story project is to provide approximately 9,500 gross square feet of office space for one of two possible sites:

(a) Charleston, South Carolina
(b) Radford AAP, Virginia

Soil conditions are unknown at both sites.

The following project criteria has been established:

1. The 36' x 72' space on the first level shall be column free for open office planning.

2. The 48' x 72' first and second floor areas shall provide 24' square bays.

3. The first floor shall be a slab on grade with the tops of perimeter continuous wall footings set at 2'-6" below grade. Column footings will be isolated spread footings.

4. The second floor occupancy live loads located on the plan are:
   - Offices: 50 psf
   - File Storage: 150 psf
   - Corridor, Stair & Lobby: 100 psf

5. Structural framing schemes to be designed and compared shall be as follows:
   - Scheme A: All steel, non-composite, lateral load resistance = rigid frames.
   - Scheme B: All steel, composite, lateral load resistance = X braced frames.
   - Scheme C: Monolithic concrete for two story portion, steel for lower roof portion, lateral load resistance = shear walls.
Scheme A

Typical Rigid Frame Locations

Second Floor Lower Roof

Typical Rigid Frame Locations

Single Ply Membrane
3" Rigid Insulation
1-1/2" 20 ga Metal Roof Deck
Mechanical: 3 psf
Electrical: 1 psf
Sprinklers: 2 psf
Lay-In Acoustical Ceiling

Trusses

Single Ply Adhered Membrane
3" Rigid Insulation
1-1/2" 20 ga Metal Roof Deck
Mechanical: 3 psf
Electrical: 1 psf
Sprinklers: 2 psf
Lay-In Acoustical Ceiling

Second Floor

2-1/2" NLWT
2"-20ga Metal Floor Deck
Mechanical: 3 psf
Electrical: 1 psf
Sprinklers: 2 psf
Lay-In Acoustical Ceiling

5" Limestone Panels

10"

5/8" Drywall
3-5/8" Metal Stud
1" Insulation Board
Carpet & Pad

10"
Scheme B

Typical X-Bracing Locations

Second Floor
Lower Roof

Typical X-Bracing Locations

Single Ply Adhered Membrane
- 3" Rigid Insulation
- 1-1/2" 20 ga Metal Roof Deck
Upper Roof

Mechanical: 3 psf
Electrical: 1 psf
Sprinklers: 2 psf
Lay-In Acoustical Ceiling

Partition Load = 6 psf
5/8" Drywall
3-5/8" Metal Stud
1" Insulation Board
Carpet & Pad

Second Floor
- 2-1/2" NLWT
- 2"-20 ga Metal Floor Deck
Mechanical: 3 psf
Electrical: 1 psf
Sprinklers: 2 psf
Lay-In Acoustical Ceiling
5" Limestone Panels

Upper Roof

Single Ply Membrane
- 3" Rigid Insulation
- 1-1/2" 20 ga Metal Roof Deck + 1-1/2" Concrete

Mechanical: 3 psf
Electrical: 1 psf
Sprinklers: 2 psf
**Scheme C**

Second Floor Lower Roof

Typical 10" Concrete Shear Walls

- **Second Floor**
  - 4" Concrete Slab
  - Mechanical: 3 psf
  - Electrical: 1 psf
  - Sprinklers: 2 psf
  - Lay-In Acoustical Ceiling

- **Partition Load = 6 psf**
  - 5/8" Drywall
  - 3-5/8" Metal Stud
  - 1" Insulation Board
  - Carpet & Pad

- **5" Limestone Panels**

- **Upper Roof**
  - Single Ply Membrane
  - 3" Rigid Insulation
  - 1-1/2" 20 ga Metal Roof Deck
  + 1-1/2" Concrete

- **Mechanical**: 3 psf
- **Electrical**: 1 psf
- **Sprinklers**: 2 psf

- **Joists @ 4" o.c.**

- **Truss**
6. The typical exterior envelope consists of 5" limestone panels, 1" rigid insulation, 3-5/8" metal studs, and 5/8" drywall.

7. Window and door openings are uniformly distributed to all elevations.

8. Load Assumptions:

<table>
<thead>
<tr>
<th>Importance Category</th>
<th>Exposure Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow: I</td>
<td>C</td>
</tr>
<tr>
<td>Wind: I</td>
<td>C</td>
</tr>
<tr>
<td>Seismic: IV</td>
<td></td>
</tr>
</tbody>
</table>

9. Material Assumptions:

Concrete: 4,000 psi, NLWT
Steel Reinforcing: Grade 60
Steel: A36

10. Fire resistance rating shall be achieved by a wet sprinkler system.
Computer Aided Structural Modeling

Start

- Criteria
  - City/Installation Database
- Draw Model
  - Import DXF Reference Drawing
- Snow Loads
- Wind Loads
  - Main Wind Force Resisting
  - Components & Cladding
  - Open Roof
- Dead & Live Loads
  - Dead Loads
    - Area Loads
      - Wall Loads
      - Point Loads
    - Occupancy Live Loads
      - Live Load Reduction
      - Area Loads
      - Point Loads
  - Minimum Roof Live Loads
    - Calculate After Structure is Drawn
Computer Aided Structural Modeling

Lateral Resistance
  → Wind
  → Seismic

Seismic Loads

Define Diaphragm
  → Flexible
  → Rigid

Define Lateral Resistance
  → Trussing
  → Rigid Frame
  → Shear Wall

Analysis

Quantity Take-Off

Compare Schemes

End

Independant Sub-Programs

Design Loads

Member Self Weight Estimating

2-D Analysis

Member Design Spreadsheets
### Project Data

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Office Building - Scheme C</th>
</tr>
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<tr>
<td>City/Installation:</td>
<td>Radford AAP</td>
</tr>
<tr>
<td>Country:</td>
<td>USA</td>
</tr>
<tr>
<td>State:</td>
<td>VA</td>
</tr>
<tr>
<td>County:</td>
<td>Pulaski</td>
</tr>
<tr>
<td>Design Load:</td>
<td>TM 5-809-1 1991</td>
</tr>
<tr>
<td>Building Code:</td>
<td>BOCA</td>
</tr>
<tr>
<td>Seismic Code:</td>
<td>TM 5-809-10 1991</td>
</tr>
<tr>
<td>Elevation Above Sea Level:</td>
<td>3300 ft</td>
</tr>
<tr>
<td>No. Of Stories:</td>
<td>2</td>
</tr>
<tr>
<td>Floor Area:</td>
<td>9504 sq ft</td>
</tr>
<tr>
<td>Occupancy:</td>
<td>Use Group B</td>
</tr>
<tr>
<td>Type Const:</td>
<td>3A</td>
</tr>
<tr>
<td>Seismic Lateral Load Resistance:</td>
<td>Blank</td>
</tr>
<tr>
<td>N-S System:</td>
<td>Blank</td>
</tr>
<tr>
<td>E-W System:</td>
<td>Blank</td>
</tr>
</tbody>
</table>

### Regional Data

#### Wind
- Basic Wind Speed: 70.0 mph
- Coastal: No
- Maximum Wind Speed: 58.0 mph
- Wind Direction: SE

#### Snow
- Ground Snow Load: 25.0 psf
- Maximum Snow Depth: 15.0 in
- Snow Density: 17.3 pcf

#### Rain
- Average Annual Rainfall: 44.0 in
- Maximum Rainfall: 4.0 in

#### Temperature
- Maximum temperature: 92 °F
- Minimum Temperature: -24 °F

#### Seismic Zone
- 2A: 0.150

#### Frost Depth
- 22 in
Criteria

Site Specific

Wind
Exposure: C
Importance: I: 1.00

Snow
Exposure: C: 1.00
Importance: I: 1.00
Roof Slippery: No
Thermal Factor: 1.0

Seismic
Importance: IV: 1.00
Soil Factor: S3: 1.5

Soil
Blank

Print Data
- Basic Design Criteria
- All Other
- Print To File
- Execute Notepad

Scroll Output

Page Setup
Left Margin: 0.5 in
Right Margin: 0.0 in

Print File

Exit Notepad

End
Basic Design Criteria

Project Data

Project Name : Office Building - Scheme C
City/Installation : Radford AAP
Country : USA
State : VA
County : Pulaski
Design Load : TM 5-809-1 1991
Building Code : BOCA
Seismic Code : TM 5-809-10 1991
Elevation above sea level : 3300 ft.
No. of Stories : 2
Floor Area : 9504 sqft.
Occupancy : Use Group B
Type of Construction : 3A

Seismic Lateral Load Resistance
N-S System : 0
E-W System : 0

Regional Data

Wind
Basic Wind Speed : 70.0 mph
Coastal : No
Maximum Wind Speed : 58.0 mph
Wind Direction : SE

Snow
Ground Snow Load : 25.0 psf
Maximum Snow Depth : 15.0 in.
Snow Density : 17.3 pcf

Rain
Average Annual Rainfall : 44.0 in.
Maximum Rainfall : 4.0 in.

Temperature
Maximum Temperature : 92.0 deg F
Minimum Temperature : -24.0 deg F
Seismic Zone : 2A
Frost Depth : 22 in.

Site Specific Data

Wind
Exposure : C
Importance : I

Snow
Exposure : C
Importance : I
Roof Smooth : No
Thermal Factor : 1.0

Seismic
Importance : IV

Soil Factor : S3

Notes

Importance Factor for Snow and Wind:
I All buildings and structures except those listed below.
II Buildings and structures where primary occupancy is one in which
more than 300 people congregate in one area.
III Buildings and structures designated as essential facilities,
including, but not limited to:
   Hospital and other medical facilities having surgery or emergency
treatment areas.
   Fire or rescue and police stations.
   Primary communication facilities and disaster operation centers.
   Power stations and other utilities required in an emergency.
   Structures having critical national defense capabilities.
IV Buildings and structures that represent a low hazard to human life in the event of failure, such as agricultural buildings, certain temporary facilities, and minor storage facilities.

Wind Exposure Category:
Exposure C:
Open terrain with scattered obstructions having heights generally less than 30 ft.

Snow Exposure Category:
Exposure C:
Locations in which snow removal by wind cannot be relied on to reduce roof loads because of terrain, higher structures, or several trees nearby.
* The conditions discussed should be representative of those that are likely to exist during the life of the structure. Roofs that contain several large pieces of mechanical equipment or other obstructions do not qualify for siting category A.

Snow Thermal Factor:
Heated Structure.
* These conditions should be representative of those that are likely to exist during the life of the structure.

Importance Factor for Seismic:
I. Essential Facilities
Hospitals and other medical facilities having surgery and emergency treatment areas.
Fire and police stations.
Tanks or other structures containing, housing or supporting water or other fire-suppression materials or equipment required for the protection of essential or hazardous facilities, or special occupancy structures.
Emergency vehicle shelters and garages.
Structures and equipment in emergency preparedness centers.
Stand-by power generating equipment for essential facilities.
Structures and equipment in communication centers and other facilities required for emergency response.

II. Hazardous Facilities
Structures housing, supporting or containing sufficient quantities of toxic or explosive substances to be dangerous to the safety of the general public if released.

III. Special Occupancy Structure
Covered structures whose primary occupancy is public assembly - capacity more than 300 persons.
Buildings for schools (through secondary) or day-care centers - capacity more than 250 students.
Buildings for colleges or adult education schools - capacity more than 500 students.
Medical facilities with 50 or more resident incapacitated patients, but not included above.
Jails and detention facilities.
All structures with occupancy more than 5000 persons.
Structures and equipment in power generating stations and other public utility facilities not included above, and required for

IV. Standard Occupancy Structure
All Structures having occupancies or functions not listed above.

Seismic Soil Factor:
S3: A soil profile 70 feet or more in depth and containing more than 20 feet of soft to medium stiff clay but not more than 40 feet of soft clay.
The site factor shall be established from properly substantiated geotechnical data. In locations where the soil properties are not known in sufficient detail to determine the soil profile type, soil profile S3 shall be used. Soil profile S4 need not be assumed unless the Building Official determines that soil profile S4 may be present at the site, or in the event that soil profile S4 is established by geotechnical data.
City/Installation Database

Start

Run Cardfile

Open CITIES.CRD

Duplicate Card

Edit Index
Index Line: Charleston

Modify Fields
USA SC
Charleston
TM 5-809-1 1991
40
52.0 10.0
5
7.0
100
71 NNE Y
102.0 8.0
0 3

Save File

Add Another City/Installation
Yes

Exit Cardfile

End
Modeling Philosophy

A. Simplify the geometric model

For buildings with repetitive wings, only one wing needs to be modeled.

Insignificant portions such as chimneys, dormers, and small projections, should not be modeled.

Extra wings are not necessary

Simplified model

B. Make sure planes are in contact

A gap between adjoining shapes will make the surfaces exterior.

Use the Stack options to accurately place adjoining shapes.

C. Do not intersect shapes

When modeling parapet walls, make sure the corners do not intersect.

Incorrect

Correct

D. Verify the model

Use the Tape Measure command, zoom in on a plan, elevation and 3-D views to verify the model.
Use Draw Model Tool Palette

Establish Initial Layout Defaults

Ground Plane
Size: 100' x 100'
Spacing: 20' x 20'
✓ Show Ground Plane

Units
Increment: 4'
Display: ft-in
✓ Snap To Units

Initial Object Size
N-S: 73'8"
E-W: 85'8"
Height: 14'0"
Plane Thickness: 10"
Orientation: N-S

✓ Stack On Ground Plane

Draw Building Volume

Draw First Floor Volume
Position Cube On Ground Plane
Double Click Right Mouse Key To End

Draw Second Floor Volume
✓ Stack On Last Shape
Place Cube On Last Shape
Drag Plane To Correct Dimension
E-W: 49'8"

Draw Gable Roof Volume
Place Prism On Last Shape
✓ Lock N-S & E-W
Drag Edge To Correct Roof Slope
Slope 5 8 in 12
Snow Loads

Snow Unbalanced (psf)
Snow Balanced (psf)
Snow Drift (psf)
Snow Sliding (psf)
Snow Combined (psf)

Snow Unbalanced (psf)
Snow Balanced (psf)
Snow Drift (psf)
Snow Sliding (psf)
Snow Combined (psf)
Snow Loads

Project: Office Building - Scheme C
Location: Radford AAF
Design Load: TM 5-809-1 1991
Time: Sat Jan 25, 1992 5:40 PM

********************* Flat/Lean-To Roof Snow Load Design ********************

Flat Roof Snow Load (PF)
PF = 0.7 * Ce * Ct * I * Pg

Snow Exposure Category: C
Ce = 1.0

Heated Structure.
Ct = 1.0

Importance Category: I
I = 1.0

Pg = 25.0 psf

PF = 17.50 psf

Roof Slope: 0.00 in 12

Theta = 0 deg

Check minimum PF where theta <= 15 deg

When Pg > 20.0 psf, min PF = 20*1

Min PF = 20.00 psf

Since theta < 1/2 in/ft, 5 psf rain-on-snow surcharge applies.

+----------------+
| PF = 25.0 psf |
+----------------+

Sloped Roof Snow Load (Ps)

Ps = Cs * Pf
Roof Slippery: No

Cs = 1.00

+----------------+
| Ps = 25.0 psf |
+----------------+

********************* Drift Snow Load Design ********************

Pg = 25.0 psf

Snow Density = 17.25 psf
Ps = 20.00 psf (rain-on-snow surcharge not included)

hb = Ps/density
hb = 1.16 ft

Projection Height = 4.00 ft
hc = height-hb
hc = 2.84 ft

hc/hb = 2.45 >= 0.20 Therefore consider drift load.

Importance Category: I
I = 1.0

Snow Exposure Category: C
Ce = 1.0

Separation = 0.00 ft

lu = 35.17 ft
hd = 0.43 * lu^1/3 * (Pg+10)^1/4 - 1.5
ha = 1.93 ft

Width of drift: W = minimum of 4*hd or 4*hc >= 10 ft
w = 4*hd = 7.71 ft
w = 4*hc = 11.36 ft

+----------------+
| W = 10.00 ft |
+----------------+

hd = hd * (20-s)/20 = 1.93 ft
hd <= hc

Pd = hd * density
+----------------+
| Pd = 33.23 psf |
+----------------+
Snow Loads

****************************************** Drift Snow Load Design ******************************************

\[ P_g = 25.0 \text{ psf} \]
\[ \text{Snow Density} = 17.25 \text{ pcf} \]
\[ P_s = 20.00 \text{ psf (rain-on-snow surcharge not included)} \]
\[ h_b = P_s/\text{density} \]
\[ h_b = 1.16 \text{ ft} \]
\[ \text{Projection Height} = 4.00 \text{ ft} \]
\[ h_c = \text{height} - h_b \]
\[ h_c = 2.84 \text{ ft} \]
\[ h_c/h_b = 2.45 > 0.20 \] Therefore consider drift load.

Importance Category: I
\[ I = 1.0 \]

Snow Exposure Category: C
\[ C_e = 1.0 \]

Separation = 0.00 ft
\[ l_u = 72.00 \text{ ft} \]
\[ h_d = 0.43*l_u^{1/3}*(P_g+10)^{1/4}-1.5 \]
\[ h_d = 2.85 \text{ ft} \]

Width of drift: \[ W = \text{minimum of } 4*h_d \text{ or } 4*h_c \geq 10 \text{ ft} \]
\[ w = 4*h_d = 11.40 \text{ ft} \]
\[ w = 4*h_c = 11.36 \text{ ft} \]

hd = hd*(20-s)/20 = 2.85 ft
hd > hc, therefore \[ h_d = h_c = 2.84 \text{ ft} \]

\[ P_d = h_d*\text{density} \]
\[ P_d = 49.00 \text{ psf} \]

****************************************** Drift Snow Load Design ******************************************

\[ P_g = 25.0 \text{ psf} \]
\[ \text{Snow Density} = 17.25 \text{ pcf} \]
\[ P_s = 20.00 \text{ psf (rain-on-snow surcharge not included)} \]
\[ h_b = P_s/\text{density} \]
\[ h_b = 1.16 \text{ ft} \]
\[ \text{Projection Height} = 14.00 \text{ ft} \]
\[ h_c = \text{height} - h_b \]
\[ h_c = 12.84 \text{ ft} \]
\[ h_c/h_b = 11.08 > 0.20 \] Therefore consider drift load.

Importance Category: I
\[ I = 1.0 \]

Snow Exposure Category: C
\[ C_e = 1.0 \]

Separation = 0.00 ft
\[ l_u = 49.67 \text{ ft} \]
\[ h_d = 0.43*l_u^{1/3}*(P_g+10)^{1/4}-1.5 \]
\[ h_d = 2.34 \text{ ft} \]

Width of drift: \[ W = \text{minimum of } 4*h_d \text{ or } 4*h_c \geq 10 \text{ ft} \]
\[ w = 4*h_d = 9.38 \text{ ft} \]
\[ w = 4*h_c = 51.36 \text{ ft} \]

hd = hd*(20-s)/20 = 2.34 ft
hd <= hc

\[ P_d = h_d*\text{density} \]
\[ P_d = 40.44 \text{ psf} \]

****************************************** Drift Snow Load Design ******************************************
Wind Assumptions

Proportions For B/L & h/L

 Defaults: Height Ratio: 0.75
 Plan Ratio: 0.75

Building Height Maximum 60 Feet
Assumed for components and cladding
Main Wind Force Resisting Loads

1. Start
2. Use Loads And Design Tool Palette
3. Calculate Wind Loads
   - Review Criteria
     - % Opening Coefs: -0.25 & +0.25
     - Main Wind Force Resistance System
4. Calculate
5. View Output
6. View Calculations
7. Print Screen
   - Printer
8. View Calculations
9. Print Data
   - Wind
   - All Other
   - Print To File
   - Execute Notepad
10. Scroll Output
11. Page Setup
    - Left Margin: 0.5 in
    - Right Margin: 0.0 in
12. Print File
13. Exit Notepad
14. View Perspective (3D)
15. Solid Object
Main Wind Force Resisting Loads

View Output

Show Loads
- GCpi = 0
- GCpi Positive
- GCpi Negative
- B & L Assumptions
  - none

End
Main Wind Force Resisting Loads

Wind Load: GC\textsubscript{p}=C (psf)

Wind Load: GC\textsubscript{ci}=0 (psi)

Wind Load: GC\textsubscript{pi}=0 (psf)
Main Wind Force Resisting Loads

Project: Office Building - Scheme C
Location: Radford AAP
Design Load: TM 5-809-1 1991
Time: Sat Jan 25, 1992 5:46 PM

****************************************************************************** Wind Load - 1 ******************************************************************************

<table>
<thead>
<tr>
<th>Velocity (mph)</th>
<th>Importance</th>
<th>Exposure</th>
<th>Width (ft)</th>
<th>Length (ft)</th>
<th>Roof Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.0</td>
<td>1.00</td>
<td>C</td>
<td>36.0</td>
<td>73.7</td>
<td></td>
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</table>

Distance to ocean line >= 100 mi. h/d = 0.39 <= 5

****************************************************************************** Main Framing Pressures ******************************************************************************

Parallel to Ridge or Length

<table>
<thead>
<tr>
<th>Location</th>
<th>z or h (ft)</th>
<th>Gh (psf)</th>
<th>Kz (psf)</th>
<th>qz (psf)</th>
<th>Cp</th>
<th>External Pressure P (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windward Wall</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>parapet</td>
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<td>11.8</td>
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<tr>
<td>level 3</td>
<td>18.0</td>
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<td>0.84</td>
<td>10.5</td>
<td>0.80</td>
<td>11.1</td>
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<tr>
<td>level 2 - 3</td>
<td>16.0</td>
<td>1.32</td>
<td>0.82</td>
<td>10.3</td>
<td>0.80</td>
<td>10.9</td>
</tr>
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<td>level 1 - 2</td>
<td>7.0</td>
<td>1.32</td>
<td>0.80</td>
<td>10.0</td>
<td>0.80</td>
<td>10.6</td>
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<tr>
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<td>10.6</td>
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<tr>
<td>14.0</td>
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<tr>
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<td>Roof</td>
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<th>Exposure</th>
<th>Width (ft)</th>
<th>Length (ft)</th>
<th>Roof Type</th>
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</thead>
<tbody>
<tr>
<td>70.0</td>
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Distance to ocean line >= 100 mi. h/d = 0.56 <= 5

****************************************************************************** Main Framing Pressures ******************************************************************************

Parallel to Ridge or Length

<table>
<thead>
<tr>
<th>Location</th>
<th>z or h (ft)</th>
<th>Gh (psf)</th>
<th>Kz (psf)</th>
<th>qz (psf)</th>
<th>Cp</th>
<th>External Pressure P (psf)</th>
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</thead>
<tbody>
<tr>
<td>Windward Wall</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>level 3</td>
<td>28.0</td>
<td>1.26</td>
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<td>0.80</td>
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<td>10.0</td>
<td>0.80</td>
<td>10.1</td>
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<td>10.0</td>
<td>0.80</td>
<td>10.1</td>
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<tr>
<td>Leeward Wall</td>
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<td>28.0</td>
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</table>
### Main Wind Force Resisting Loads

<table>
<thead>
<tr>
<th>Velocity (mph)</th>
<th>Importance Factor</th>
<th>Exposure</th>
<th>Width Perpend. to Wind (ft)</th>
<th>Length Parallel to Wind (ft)</th>
<th>Roof Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.0</td>
<td>1.00</td>
<td>C</td>
<td>49.7</td>
<td>73.7</td>
<td></td>
</tr>
</tbody>
</table>

**Distance to ocean line >= 100 mi.**  
**h/d = 0.56 <= 5**

---

### Main Framing Pressures

#### Parallel to Ridge or Length

<table>
<thead>
<tr>
<th>Location</th>
<th>z or h (ft)</th>
<th>Gh (psf)</th>
<th>Kz (psf)</th>
<th>qz (psf)</th>
<th>Cp</th>
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<td>Windward Wall</td>
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<tr>
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<td>11.1</td>
</tr>
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<td>1.26</td>
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<td>10.0</td>
<td>0.80</td>
<td>10.1</td>
</tr>
<tr>
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<td>10.1</td>
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<tr>
<td>Roof</td>
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<td>0.96</td>
<td>12.0</td>
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<td>-10.6</td>
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<tr>
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<td>12.0</td>
<td>0.0</td>
<td>-3.0</td>
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### Wind Loads

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<th>z or h (ft)</th>
<th>Gh (psf)</th>
<th>Kz (psf)</th>
<th>qz (psf)</th>
<th>Cp</th>
<th>External Pressure P (psf)</th>
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<tr>
<td>Windward Wall</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>parapet</td>
<td>22.0</td>
<td>1.32</td>
<td>0.89</td>
<td>11.2</td>
<td>0.80</td>
<td>11.8</td>
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<td>10.3</td>
<td>0.80</td>
<td>10.9</td>
</tr>
<tr>
<td>level 1 - 2</td>
<td>7.0</td>
<td>1.32</td>
<td>0.80</td>
<td>10.0</td>
<td>0.80</td>
<td>10.6</td>
</tr>
<tr>
<td>level 1</td>
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<td>1.32</td>
<td>0.80</td>
<td>10.0</td>
<td>0.80</td>
<td>10.6</td>
</tr>
<tr>
<td>Leeward Wall</td>
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<td>10.0</td>
<td>-0.70</td>
<td>-9.2</td>
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<tr>
<td>Roof</td>
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<td>1.32</td>
<td>0.80</td>
<td>10.0</td>
<td>-0.70</td>
<td>-9.2</td>
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<tr>
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<td>10.0</td>
<td>0.0</td>
<td>-2.5</td>
<td>-2.5</td>
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**Distance to ocean line >= 100 mi.**  
**h/d = 0.39 <= 5**
### Main Wind Force Resisting Loads

#### Wind Load - 5

<table>
<thead>
<tr>
<th>Velocity (mph)</th>
<th>Importance Factor</th>
<th>Exposure to Wind</th>
<th>Width (ft)</th>
<th>Length (ft)</th>
<th>Roof Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.0</td>
<td>1.00</td>
<td>C</td>
<td>73.7</td>
<td>49.7</td>
<td></td>
</tr>
</tbody>
</table>

Distance to ocean line $\geq 100$ mi., $h/d = 0.56 \leq 5$

#### Main Framing Pressures

<table>
<thead>
<tr>
<th>Location</th>
<th>z or h (ft)</th>
<th>Gh (psf)</th>
<th>Kz</th>
<th>qz  (psf)</th>
<th>Cp</th>
<th>External Pressure P (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windward Wall</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>level 2</td>
<td>28.0</td>
<td>1.26</td>
<td>0.96</td>
<td>12.0</td>
<td>0.80</td>
<td>12.1 15.1 9.1</td>
</tr>
<tr>
<td>level 1 - 2</td>
<td>14.0</td>
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<td>0.80</td>
<td>10.0</td>
<td>0.80</td>
<td>10.1 13.1 7.1</td>
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<tr>
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<td>0.80</td>
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<td>0.80</td>
<td>10.1 13.1 7.1</td>
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<tr>
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<td>0.96</td>
<td>12.0</td>
<td></td>
<td>-3.0 3.0</td>
</tr>
</tbody>
</table>

Notes for main framing:
- Positive pressures act toward surfaces.
- Pressure or suction $P = qh^*Gh^*Cp^*gh^*(GCpi)$
Wind Components & Cladding Loads

Start

Use Loads And Design Tool Palette

View Perspective (3D)

Calculate Wind Loads

Review Criteria
% Opening Coef: -0.25 & +0.25
Components & Cladding

Calculate

Select Wall Plane

Tributary Area

<table>
<thead>
<tr>
<th>Horizontal</th>
<th>Vertical</th>
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<tbody>
<tr>
<td>Base Point: 00&quot; 00&quot;</td>
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<tr>
<td>Point 2: 40&quot; 140&quot;</td>
<td></td>
</tr>
<tr>
<td>Length: 40&quot; 140&quot;</td>
<td></td>
</tr>
</tbody>
</table>

F2 Key For Keyboard Input

Wind Components & Cladding

Add Opposite Side Of Roof
Name: Limestone Panel

Component Tributary Width
Yes, Use Code Provision

Cancel Defining Tributary Areas

Mouse: Double Click Right Mouse Key

View Output

View Section

Print Screen

Printer
Wind Components & Cladding Loads

View Output → View Calculations →

Print Data
- Wind
- All Other
- Print To File
- Execute Notepad

Scroll Output

Page Setup
Left Margin: 0.5 in
Right Margin: 0.0 in

Print File

Exit Notepad

View Perspective (3D) → Solid Object

Show Loads
- Components & Cladding
- Zone Areas
  - none

End
Wind Load: Components & Cladding (psf)

- 17.5 psi
- 21.8 psi

Wind Components & Cladding Loads
Wind Components & Cladding Loads

Project: Office Building - Scheme C
Location: Radford AAF
Design Load: TM 5-809-1 1991
Time: Sat Jan 25, 1992 5:49 PM

***************************************************************************** Wind Load ****************************************************************************

<table>
<thead>
<tr>
<th>Velocity</th>
<th>Importance</th>
<th>Exposure</th>
<th>Width</th>
<th>Length</th>
<th>Roof Type</th>
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<tbody>
<tr>
<td>(mph)</td>
<td>Factor</td>
<td>to Wind</td>
<td>Perpend.</td>
<td>Parallel</td>
<td>to Wind</td>
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<tr>
<td>----------</td>
<td>------------</td>
<td>---------</td>
<td>---------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>70.0</td>
<td>1.00</td>
<td>C</td>
<td>49.7</td>
<td>73.7</td>
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</tr>
</tbody>
</table>

Distance to ocean line >= 100 mi.  h/d = 0.56 <= 5

<table>
<thead>
<tr>
<th>Height</th>
<th>Kh</th>
<th>qh</th>
<th>GCpi</th>
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</thead>
<tbody>
<tr>
<td>(ft)</td>
<td>(psf)</td>
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Height <= 60 ft

***************************************************************************** Component/Cladding Pressures (psf) *****************************************************************************

<table>
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<tr>
<th>Tributary Area (sf)</th>
<th>Windward</th>
<th>Leeward</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wall</td>
<td>Wall</td>
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<tr>
<td></td>
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<td>corners</td>
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<tr>
<td></td>
<td>middles</td>
<td>middles</td>
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<tr>
<td></td>
<td>GCP</td>
<td>GCP</td>
</tr>
<tr>
<td>Internal</td>
<td>-3.0</td>
<td>-3.0</td>
</tr>
<tr>
<td>Limestone Panel 4.67 ft x 14.00 ft **</td>
<td>1.21</td>
<td>17.5</td>
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<tr>
<td>a = 5.0 ft</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes for components and cladding:

P = qh(GCP) - qh(GCpi)

Internal pressures have been included in above values.
* For roof overhangs: algebraically add this pressure to the above values. P = qh(GCP) = 0.8qh

To comply with TM 5-809-1, wall external pressures have not been reduced 10% per ASCE figure 3, note 3.
** For a rectangular tributary area, the width of the area need not be less than one-third the length of the area.
Dead & Live Loads

Start

Use Loads And Design Tool Palette

Live Loads

Use Occupancy (LL)

Add
Office: Offices 50 psf

Add
Office: Corridor (Main) 100 psf

Add
Office: Files & Storage 80 psf

Increase Files & Storage Load To 150 psf

Stop Using Occupancy (LL)

Dead Loads

Floor Dead Loads

Use Floor (DL)

Input

<table>
<thead>
<tr>
<th>Name</th>
<th>Second Floor Type</th>
<th>psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partition:</td>
<td>51-100 psf</td>
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<tr>
<td>Finish:</td>
<td>Carpet &amp; Pad</td>
<td>1.0</td>
</tr>
<tr>
<td>Deck:</td>
<td>Concrete 4''</td>
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<tr>
<td>Structure:</td>
<td>Concrete Beams</td>
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<td>Mechanical:</td>
<td>Mech A/C Ducts</td>
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<tr>
<td>Electrical:</td>
<td>Elect/Lighting</td>
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</tbody>
</table>

Select Type

Scroll To Find
Load Type & PSF

Double Click On Load Type

41
Dead & Live Loads

Dead Loads → Floor Dead Loads → Save → Stop Using Floor (DL) → Roof Dead Loads → Use Roof (DL) → Input

Input

Name: Lower Roof
Type: psf
Roofing: Single Ply 1.5
Deck: MTL DK 1.5/NLWT 2.5 36.0
Structure: Steel Bar Jst 24'@4' 1.8
Mechanical: Mech A/C Ducts 3.0
Electrical: Elect/Lighting 1.0
Fire Protection: Sprinklers Wet 2.0
Insulation: Rigid Roof Ins 3" 2.4
Ceiling: Total: 47.7

Save

Input

Name: Upper Roof
Type: psf
Roofing: Single Ply 1.5
Deck: Concrete 4" 50.0
Structure: Concrete Beams 0.0
Mechanical: Mech A/C Ducts 3.0
Electrical: Elect/Lighting 1.0
Fire Protection: Sprinklers Wet 2.0
Insulation: Rigid Roof Ins 3" 2.4
Ceiling: Total: 61.9

Save

Next To View

Lower Roof Load

Stop Using Roof (DL)
Dead Loads

Wall Dead Loads

Use Wall (DL)

**Dead Loads**

**Wall Dead Loads**

**Use Wall (DL)**

**Input**

Name: Exterior Wall
Type: 
Finish: Limestone 5" 68.8
Sheathing: 
Structure: Stl Stud 16ga 4"@16 1.1
Insulation: Exp Polyst Rigid 1" 0.2
Finish: Gypboard 5/8" 3.1
Total: 73.2

Save

**Input**

Name: Parapet
Type: 
Finish: Limestone 5" 68.8
Sheathing: 
Structure: 
Insulation: 
Finish: 
Total: 68.8

Save

**Input**

Name: Shear Wall
Type: 
Finish: 
Sheathing: 
Structure: Concrete 10" 125.0
Insulation: 
Finish: 
Total: 125.0

Save
Dead & Live Loads

Dead Loads → Wall Dead Loads → Next To View Exterior Wall Load → Stop Using Wall (DL) →

Print → Print Data
- Loads
- All Other
- Print To File
- Execute Notepad →

Scroll Output →

Page Setup
- Left Margin: 0.5 in
- Right Margin: 0.0 in →

Print File →

Exit Notepad →

End
**Dead & Live Loads**

**Floor Dead Loads**

<table>
<thead>
<tr>
<th>Name</th>
<th>Second Floor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td><strong>psf</strong></td>
</tr>
<tr>
<td>Partition</td>
<td>51-100 pif</td>
</tr>
<tr>
<td>Finish</td>
<td>Carpet &amp; Pad</td>
</tr>
<tr>
<td>Deck</td>
<td>Concrete NLMT 4&quot;</td>
</tr>
<tr>
<td>Structure</td>
<td>Concrete Beams</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Mech A/C Ducts</td>
</tr>
<tr>
<td>Electrical</td>
<td>Elect/Lighting</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>Sprinklers Wet</td>
</tr>
<tr>
<td>Ceiling</td>
<td>Susp Chnl/Tile</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Roof Dead Loads**

<table>
<thead>
<tr>
<th>Name</th>
<th>Lower Roof</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td><strong>psf</strong></td>
</tr>
<tr>
<td>Roofing</td>
<td>Single Ply</td>
</tr>
<tr>
<td>Deck</td>
<td>MIL DK 1.5/NLMT 2.5</td>
</tr>
<tr>
<td>Structure</td>
<td>Steel Bar Jst 24*84'</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Mech A/C Ducts</td>
</tr>
<tr>
<td>Electrical</td>
<td>Elect/Lighting</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>Sprinklers Wet</td>
</tr>
<tr>
<td>Insulation</td>
<td>Rigid Roof Ins 3&quot;</td>
</tr>
<tr>
<td>Ceiling</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Upper Roof</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td><strong>psf</strong></td>
</tr>
<tr>
<td>Roofing</td>
<td>Single Ply</td>
</tr>
<tr>
<td>Deck</td>
<td>Concrete NLMT 4&quot;</td>
</tr>
<tr>
<td>Structure</td>
<td>Concrete Beams</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Mech A/C Ducts</td>
</tr>
<tr>
<td>Electrical</td>
<td>Elect/Lighting</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>Sprinklers Wet</td>
</tr>
<tr>
<td>Insulation</td>
<td>Rigid Roof Ins 3&quot;</td>
</tr>
<tr>
<td>Ceiling</td>
<td>Susp Chnl/Tile</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Wall Dead Loads**

<table>
<thead>
<tr>
<th>Name</th>
<th>Exterior Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td><strong>psf</strong></td>
</tr>
<tr>
<td>Finish</td>
<td>Limestone 5&quot;</td>
</tr>
<tr>
<td>Sheathing</td>
<td></td>
</tr>
<tr>
<td>Structure</td>
<td>Stl Stud 16ga 4&quot;x16</td>
</tr>
<tr>
<td>Insulation</td>
<td>Exp Polysty Rigid 1&quot;</td>
</tr>
<tr>
<td>Finish</td>
<td>Gypsum 5/8&quot;</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>
Dead & Live Loads

Name: Parapet

<table>
<thead>
<tr>
<th>Type</th>
<th>psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish: Limestone 5&quot;</td>
<td>68.8</td>
</tr>
<tr>
<td>Sheathing</td>
<td>0.0</td>
</tr>
<tr>
<td>Structure</td>
<td>0.0</td>
</tr>
<tr>
<td>Insulation</td>
<td>0.0</td>
</tr>
<tr>
<td>Finish</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Total: 68.8

Name: Shear Wall

<table>
<thead>
<tr>
<th>Type</th>
<th>psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish</td>
<td>0.0</td>
</tr>
<tr>
<td>Sheathing</td>
<td>0.0</td>
</tr>
<tr>
<td>Structure: Concrete 10&quot;</td>
<td>125.0</td>
</tr>
<tr>
<td>Insulation</td>
<td>0.0</td>
</tr>
<tr>
<td>Finish</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Total: 125.0

Occupancy Live Loads

<table>
<thead>
<tr>
<th>Name</th>
<th>psf</th>
</tr>
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<tbody>
<tr>
<td>Office: Offices</td>
<td>50</td>
</tr>
<tr>
<td>Office: Corridor (main)</td>
<td>100</td>
</tr>
<tr>
<td>Office: Files &amp; Storage</td>
<td>150a</td>
</tr>
</tbody>
</table>

a. Variable design load. Increase may be necessary.

Notes:

Uniformly distributed live loads for supporting members; i.e., two-way slab, beam, girder or columns having an influence area of 400 sq ft or more may be reduced with: \( L = L_o \times [0.25 + (15/\sqrt{A_i})] \)

The reduced design live load will not be less than 50% of the unit live load for members supporting one floor, nor less than 40% of the unit live load for members supporting two or more floors.

Exceptions: For live loads less than 100 psf, no reduction is permitted for members supporting floor(s) in the following areas:

- Public assembly
- Garages [except where 2 or more floors are supported]
- One-way slab floor

For live loads greater than 100 psf and for garages used for passenger cars only, no reduction is permitted for members supporting one floor; however, where two or more floors are supported, a 20% reduction is permitted.
Minimum Roof Live Load

Start

Use Loads & Design Tool Palette

Select Second Floor/ Lower Roof Horizontal Structural Plane

Calculate Minimum Roof Live Load

Minimum Roof (LL)
- Add Opposite Roof

Tributary Area

Horizontal Vertical
Base Point: 62'10" 24'10"
Point 2: 66'10" 48'10"
Length: 40" 24'0"

Cancel Minimum Roof (LL)

View Output

View Section

Print Screen
- Printer

View Calculations

Print Data
- Min. Roof LL
- All Other
- Print To File
- Execute Notepad

Scroll Output

Page Setup
- Left Margin: 0.5 in
- Right Margin: 0.0 in
Minimum Roof Live Load

- View Output
  - View Calculations
    - Print File
      - Exit Notepad
    - View Perspective (3D)
      - Solid Object
    - Show Loads
      - None
  - End
Minimum Roof Live Load

Project: Office Building - Scheme C
Location: Radford AAP
Design Load: TM 5-809-1 1991
Time: Sat Jan 25, 1992 6:16 PM

************************** Minimum Roof Live Load (Lr) **************************

Tributary area (At): 96 sf
Roof slope (F): 0.00 in 12

\[ Lr = 20 \times R1 \times R2 \geq 12 \]
\[ At \leq 200 \quad R1 = 1.00 \]
\[ F \leq 4 \quad R2 = 1.00 \]
\[ Lr = 20.00 \text{ psf} \]

Minimum Lr = 12 psf

Check minimum roof live load, Lr, against minimum snow design loads.

Additionally, for the design of secondary members such as roof decking and rafters, a concentrated live load with 250 lbs uniformly distributed over an area of 2 feet square (4 sqft) will be included. The concentrated load will be located so as to produce the maximum stress in the member.
Start

Run Notepad

Open LOADS.DAT

Scroll To Location In File

Add New Item

Save File

Add Another Item

Yes

No

Exit Notepad

End

Insert A Single Tab Character Between The Text And The Load
**Draw Grid & Openings**

1. **Start**
2. **Use Draw Structure Tool Palette**
3. **Define Structural Grid**
   - Select Second Floor/Lower Roof Horizontal Structural Plane
   - Structural Plane Information
     - Name: Second Floor/Lower Roof
   - Close Structural Plane Information Dialog Window
4. **Define Grid**
   - N-S Spacing: 24'0" E-W Spacing: 24'0"
   - Perimeter Offset: 10"
5. **Delete Grid Lines D & E**
6. **Delete Grid Lines**
   - Select Grid Line E Then D
   - Double Click Right Mouse Key To End Deleting Grid Lines
Draw Openings

Add Opening

<table>
<thead>
<tr>
<th>Horizontal</th>
<th>Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Point</td>
<td>10&quot; 24'10&quot;</td>
</tr>
<tr>
<td>Point 2</td>
<td>8'10&quot; 48'10&quot;</td>
</tr>
<tr>
<td>Length</td>
<td>8'0&quot; 24'0&quot;</td>
</tr>
</tbody>
</table>

Opening
Name: Stairs
☐ Continuous

F2 Key For Keyboard Input
Structure Hierarchy

Surface/Deck
(horizontal)

1 way
2 way
(not activated)

Linear
(horizonal)

Narrowly Spaced
(joists)

Widely Spaced
(beams)

Surface
(vertical)
(planar)

uniform loads

Linear
(vertical)

concentrated loads

places uniform loads on girders

places concentrated loads on girders

x = 4'

> 4'
Start
Use Draw Structure Tool Palette
Draw Upper Roof Framing
Select Upper Roof Horizontal Structural Plane
Structural Plane Information
  Name: Upper Roof
Close Structural Plane Information Dialog Window
Draw Linear Beams On All Grid Lines
Draw Third Point Beams In Bay A1-B2
Linear: Widely Spaced
Select Handle On Grid A1-B1
Select Handle On Grid A2-B2
Double Click Right Mouse Key To End Defining Area
Save Linear Elements
  Orientation: N-S
  Number Of Elements: 2
Draw One-Way Surface In Bay A1-B2
Surface: One-Way
Draw Structure

1. Draw Upper Roof framing
2. Draw Surface in Bay A1-B2
4. Select Handle On Grid Line B1-B2
5. Double Click Right Mouse Key To End Defining Area
6. Save Surface Element Orientation: E-W
7. Copy Beams & One-Way Surface To Other Bays
8. Copy Structure
9. Select Third Point Beams
10. Select One-Way Surface
11. Double Click Right Mouse Key To End Selecting Structure
12. Select Grid Location A1 As The Base Point
13. Paste Structure
14. Select Grid Locations B1, A2, B2, A3, B3
15. Double Click Right Mouse Key To End
Draw Upper Roof framing → Delete Beams → Delete Structure → Select Beams B1-C1, C1-C2, A2-A3, B4-C4 → Double Click Right Mouse Key To End → Draw Walls → Wall 2 Grid Points → Select B1 & C1 → Save Wall Elements (Orientation: E-W, Start Height: 14', End Height: 14', Thickness: 10') → All Floors → Assign Dead Load Shear Wall → Repeat For C1-C2, A2-A3, B4-C4 → Draw Columns → Column One Grid Intersection → Select A1, B2, B3, C3, A4 → Double Click Right Mouse Key To End → Save Column Elements (Orientation: N-S, All Floors)
Draw Structure

- Draw Second Floor/ Lower Roof Framing
  - Select Second Floor/ Lower Roof Horizontal Structural Plane
    - Draw Linear Beams On All Grid Lines
      - Delete Beams At Grids C2-D2, C3-D3, And Over Walls
        - Draw Third Point Beams And One-Way Surface In Bays A1-B2, B1-C2, B2-C3, A3-B4, B3-C4
          - Paste Structure
            - Select Grid Locations A1, B1, B2, A3, B3
              - Double Click Right Mouse Key To End
                - Draw Third Point Beams In Bay A2-B3
                  - Linear: Widely Spaced
Draw Second Floor/ Lower Roof Framing

Draw Third Point Beams in Bay A2-B3

Select Handle On Grid B2-B3

Select Handle On Grid A2-A3

Double Click Right Mouse Key To End Defining Area

Save Linear Elements
Orientation: N-S
Number Of Elements: 2

Select Handle On Grid A.33.2-A.33.3

Select Handle On Grid Line B2-B3

Double Click Right Mouse Key To End Defining Area

Save Surface Element Orientation: E-W

Surface: One-Way

Draw Joists In Bay C1-D2

Linear: Narrowly Spaced

Select Handle On Grid C1-D1

Select Handle On Grid C2-D2
Draw Structure

- Draw Second Floor/ Lower Roof Framing
- Copy Joists & One-Way Surface To Other Bays
- Paste Structure
  - Select Grid Locations C2, C3
  - Double Click Right Mouse Key To End
  - Draw Trusses
  - Linear Truss-Custom
    - Select Grid Location C2-D2
    - Double Click Right Mouse Key To End Defining Area
    - Save Linear Elements Orientation: E-W
    - Truss-Custom
      - Include Opposite Side Of Roof
      - Depth Of Support: 3'
      - Scissors Height: 0'
      - Repeat For Grid Location C3-D3

- Lower Hoot Framing One-Way Surface To Other Bays
Draw Structure

- Draw Second Floor/Lower Roof Framing
  - Draw Walls
    - Wall 2 Grid Points
      - Select C1 & D1
        - Save Wall Elements
          - Orientation: N-S
          - Start Height: 14'
          - End Height: 14'
          - Thickness: 10'
          - All Floors
          - Assign Dead Load
          - Shear Wall
            - Repeat For D2-D3, C4-D4
  - View Structure
    - Perspective (3D)
      - Transparent Object
        - Show Structure

End
Assign Wall Loads Philosophy

This approach saves memory
Assign Loads

Start

Use Loads & Design Tool Palette

Assign Live Loads

Select Second Floor/ Lower Roof Horizontal Structural Plane

Use Occupancy (LL)

Highlight: Office 50 psf

Assign Offices 50 psf

<table>
<thead>
<tr>
<th>Base Point</th>
<th>Horizontal</th>
<th>Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>24'10&quot;</td>
<td>10&quot;</td>
<td></td>
</tr>
<tr>
<td>48'10&quot;</td>
<td>72'10&quot;</td>
<td></td>
</tr>
<tr>
<td>240&quot;</td>
<td>720&quot;</td>
<td></td>
</tr>
</tbody>
</table>

Length: 24'0" 240"

Highlight: Corridor (main) 100 psf

Assign Corridor (main) 100 psf

<table>
<thead>
<tr>
<th>Base Point</th>
<th>Horizontal</th>
<th>Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>8'10&quot;</td>
<td>24'10&quot;</td>
<td></td>
</tr>
<tr>
<td>24'10&quot;</td>
<td>48'10&quot;</td>
<td></td>
</tr>
<tr>
<td>160&quot;</td>
<td>240&quot;</td>
<td></td>
</tr>
</tbody>
</table>

Length: 160" 240"

Highlight: Files & Storage 150 psf
Assign Loads

Assign Live Loads

Assign Files & Storage 150 psf

Base Point: 10" 10"
Point 2: 24'10" 24'10"
Length: 24'0" 24'0"

Stop Using Occupancy (LL)

Assign Dead Loads

Assign Floor Loads

Use Floor (DL)

Assign Second Floor Load

Horizontal Vertical
Base Point: 10" 10"
Point 2: 48'10" 24'10"
Length: 48'0" 24'0"

Assign Second Floor Load

Horizontal Vertical
Base Point: 8'10" 24'10"
Point 2: 48'10" 48'10"
Length: 40'0" 24'0"

Assign Second Floor Load

Horizontal Vertical
Base Point: 10" 48'10"
Point 2: 48'10" 72'10"
Length: 36'0" 72'0"

Stop Using Floor (DL)

Assign Roof Loads

Use Roof (DL)

Assign Lower Roof Load

Horizontal Vertical
Base Point: 48'10" 10"
Point 2: 84'10" 72'10"
Length: 36'0" 72'0"

Stop Using Roof (DL)

Next Button To View Lower Roof
Assign Loads

Assign Dead Loads

Assign Parapet Wall Loads

Assign Shear Wall Load
- Assign All Floors
  - Horizontal Vertical
  - Base Point: 48'10" 72'10"
  - Point 2: 84'10" 72'10"
  - Length: 360° 0°

Next Button To View Shear Wall

Wall Height
- Start: 40"
- End: 40"

Assign Shear Wall Load
- Assign All Floors
  - Horizontal Vertical
  - Base Point: 49'10" 10"
  - Point 2: 84'10" 10"
  - Length: 360° 0°

Wall Height
- Start: 40"
- End: 40"

Assign Shear Wall Load
- Assign All Floors
  - Horizontal Vertical
  - Base Point: 84'10" 24'10"
  - Point 2: 84'10" 48'10"
  - Length: 0° 240°

Wall Height
- Start: 40"
- End: 40"

Stop Using Wall (DL)
Assign Loads

Assign Dead Loads

Assign Upper Roof Loads

Select Upper Roof Horizontal Structural Plane

Use Roof (DL)

Assign Upper Roof Load

Next Button To View Upper Roof

Assign All Floors

Horizontal Vertical

Base Point: 10° 10°
Point 2: 48'10" 72'10"
Length: 46'0" 72'0"

Stop Using Roof (DL)

Assign Ground Floor Wall Loads

Assign Ground Floor Horizontal Structural Plane

Select Ground Floor Horizontal Structural Plane

Structural Plane Information

Name: Ground Floor

Close Structural Plane Information Dialog Window

Use Wall (DL)

Assign Exterior Wall Load

Next Button To View Exterior Wall

Assign All Floors

Horizontal Vertical

Base Point: 84'10" 10°
Point 2: 84'10" 24'10"
Length: 0'0" 24'0"

Wall Height

Start: 14'0"
End: 14'0"
Assign Loads

Assign Dead Loads

Assign Ground Floor Wall Loads

Assign Exterior Wall Load

- Assign All Floors
- Horizontal
- Vertical
- Base Point: 64'10" 48'10"
- Point 2: 84'10" 72'10"
- Length: 0'0" 24'0"

Wall Height
- Start: 14'0"
- End: 14'0"

Stop Using Wall (DL)

View Loads

Show Loads
- None

End
Assign Loads

Second Floor/Lower Roof
Assign Loads

- Upper Roof

- Exterior Wall

- Shed Wall

- Exterior Wall

- Ground Floor
**Analysis & Design Philosophy**

**Preliminary Analysis**

A. Select:  
* Material  
* Load Combination  
  - (Live Load Reduction)  
* Element To Analyze

B. Review:  
* Attributes  
* Guidelines

C. Connectivity

D. Self Weight Estimate  
* Guidelines

E. Analysis  
* Review Loads  
* Connectivity  
* Analysis Output
  - $I = 1$  
  - $E = 1$  
  - $A = 1000$

F. Re-Analysis (with real properties)
## Preliminary Design

* Maximum V's, M's, R's, etc. sent to Excel

<table>
<thead>
<tr>
<th>Title</th>
<th>Connectivity</th>
<th>Dimensions</th>
<th>Allowable Stresses</th>
<th>Allowable Deflections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loads</td>
<td>M</td>
<td>V</td>
<td>Required: I &amp; S</td>
<td></td>
</tr>
</tbody>
</table>

### Spreadsheets

- Connectivity
- Dimensions
- Allowable Stresses
- Allowable Deflections

### Choices & Options Table

### Selection

Sent back to CASM
Surface Element Analysis

- Start
  - Use Loads & Design Tool Palette
    - Select Upper Roof Horizontal Structural Plane
      - Material Concrete
        - Load Combination 1.4D + 1.7S
          - Use Load Combination
            - Set Factors
              - Dead: 1.4
              - Snow: 1.7
          - OK Button To Close Dialog Window
            - Highlight 1.4D + 1.7S
  - Select Element To Analyze & Design
    - Surface One-Way C.I.P. Slab
      - Select A One-Way Surface Element
        - Review Element Attributes & Guidelines
Surface Element Analysis

Preliminary Analysis

Use Preliminary

Analysis
Units: Feet & Pounds
☐ Use Actual Properties
☐ DL=Deck+Self Weight

Decking Analysis
Number Of Spans: 3
Distance From Edge: 12'
Starting Span Number: 1
☒ Include Superimposed Dead Load

Analysis
Analysis File Name: Optional
Yes, The Loads & Connectivity Are Correct

View Shear, Moment & Deflection Diagrams

Excel Data
☒ Execute Excel

End
Concrete Slab Design

Start

Review Material Properties & Depth Limit

Trial Slab Depth
☐ Send Member Size To CASM

Select Rebar Sizes

Review Calculations & Selections

Use Scratch Pad To Explore Support Conditions, Span, And Loading Alternatives

Select Slab Depth & Rebar Size

Print Spreadsheet

Return To Preliminary

Trial Slab Depth
☑ Send Member Size To CASM

Print Spreadsheet

Return To CASM

Restore CASM

Double Click On CASM Icon

Cancel Selected Element

End
Concrete Slab Selection

CONCRETE SLAB PRELIMINARY SELECTION

<table>
<thead>
<tr>
<th>Project: Office Building - Scheme C</th>
<th>Date: Feb 26, 1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location: Radford AAP</td>
<td>Engr:</td>
</tr>
</tbody>
</table>

CASM Load & Analysis Data:

<table>
<thead>
<tr>
<th>Method: Analysis</th>
<th>Load Combination: 1.4D + 1.7S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member ID:</td>
<td>Factored Moments (k-ft) Fact. Reactions</td>
</tr>
<tr>
<td>Connectivity:</td>
<td>Left</td>
</tr>
<tr>
<td>Beam (Left)</td>
<td>Dead</td>
</tr>
<tr>
<td>Beam (Right)</td>
<td>Dead</td>
</tr>
<tr>
<td>Slab Span:</td>
<td>8.0 ft</td>
</tr>
<tr>
<td>Trib Width=</td>
<td>12.0 in</td>
</tr>
<tr>
<td>Depth Limit=</td>
<td>8.0 in. max</td>
</tr>
<tr>
<td>Concrete F'c=</td>
<td>4.0 ksi</td>
</tr>
<tr>
<td>Concrete Wt=</td>
<td>145 pcf</td>
</tr>
<tr>
<td>Steel Fy=</td>
<td>60.0 ksi</td>
</tr>
</tbody>
</table>

CASM Preliminary Slab Thickness/Values:

<table>
<thead>
<tr>
<th>ACI Preliminary Dimensions:</th>
<th>Design Data:</th>
<th>Rebar Ratios:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACI Depth: L/ 28.0 = 3.4 in</td>
<td>Bending phi((\phi)) = 0.90</td>
<td>(p_{\text{max}}) = 2.14%</td>
</tr>
<tr>
<td>Trial Depth= 4.00 in</td>
<td>Span= 3</td>
<td>beta((\beta)) = 0.85</td>
</tr>
<tr>
<td>Cover: Top= 0.75 in</td>
<td>Btm= 0.75 in</td>
<td>m= 17.6</td>
</tr>
<tr>
<td>(d'= 1.00) in</td>
<td>(d= 3.00) in</td>
<td>(R_u = 581) psi</td>
</tr>
</tbody>
</table>

CASM Preliminary Slab Reinforcement:

<table>
<thead>
<tr>
<th>Left end</th>
<th>Midspan</th>
<th>Right end</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mu (kfr)</td>
<td>0.83</td>
<td>1.74</td>
</tr>
<tr>
<td>Ru (psi)</td>
<td>102</td>
<td>215</td>
</tr>
<tr>
<td>Req(d) p (%)</td>
<td>0.19</td>
<td>0.37</td>
</tr>
<tr>
<td>Req(d) As (sq in.)</td>
<td>0.07</td>
<td>0.13</td>
</tr>
<tr>
<td>Shear Capacity:</td>
<td>(\epsilon V_c = 3.9) k</td>
<td></td>
</tr>
<tr>
<td>Shrinkage/Temp Reinforcement</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Rqd As=</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Selected Bar Size:</td>
<td>#3</td>
<td></td>
</tr>
<tr>
<td>Selected Spacing:</td>
<td>18 in</td>
<td></td>
</tr>
<tr>
<td>As (sq in/ft)=</td>
<td>0.13</td>
<td></td>
</tr>
</tbody>
</table>

4. slab Quantities:

| Depth= 4.00 in | Conc Vol= 0.012 cy/sf | Rebar Wgt = 0.0005 tons/sf |

Notes:
1. ACI 318-89 Strength Design used for sizing member.
Narrowly Spaced Element Analysis

Start

Use Loads & Design Tool Palette

Select Second Floor/Lower Roof Horizontal Structural Plane

Material Steel

Load Combination D + S

Use Load Combination

Set Factors
Dead: 1.0
Snow: 1.0

Add

OK Button To Close Dialog Window

Highlight D+S In List

Select Element To Analyze & Design

Linear Narrowly Spaced Open-Web Joist-K

Select A Narrowly Spaced Element Near A Corner

Review Element Attributes & Guidelines
Narrowly Spaced Element Analysis

Preliminary Analysis → Use Preliminary

Analysis
Units: Feet & Pounds
☐ Use Actual Properties
☐ DL=Deck+Self Weight

Connectivity
Left: Hinge
Right: Roller

Self Weight
Estimated Self Weight: 0.0

Analysis
Analysis File Name: Optional
Yes, The Loads & Connectivity Are Correct

View Shear, Moment & Deflection Diagrams

Excel Data
☐ Execute Excel

End
Narrowly Spaced Element Analysis

1.00 Dead (plf)

1.00 Superimposed Dead (plf)

1.00 Snow (plf)

Moment (lb-ft)

Deflection

Total Combined Load
**Narrowly Spaced Element Analysis**

---

### INPUT

**Office Building - Scheme C -- Dead load**

| NUMBER OF ELEMENTS | = 10 |
| NUMBER OF NODES | = 11 |
| NUMBER OF MATERIALS | = 5 |
| NUMBER OF ELASTIC SUPPORT TYPES | = 0 |

**Material Types**

<table>
<thead>
<tr>
<th>UNIT</th>
<th>INCHE, POONCH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ROCK</strong></td>
<td><strong>POSITION</strong></td>
</tr>
<tr>
<td>1</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

**Member Properties**

| 1 | 1000.0000 | 0.0000 | 0.0000 |

### SUMMARY OF IN-PLAN LOADS

**Positive In-Plan and Converse In-Plan**

<table>
<thead>
<tr>
<th>UNIT</th>
<th>FPONCH, POONCH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LOAD LOAD NO.</strong></td>
<td><strong>STARTING NODE</strong></td>
</tr>
<tr>
<td>1</td>
<td>2.00</td>
</tr>
</tbody>
</table>

### JOINT DATA

**UNIT** | **PONCH, POONCH**
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>JOIN</strong></td>
<td><strong>PONCH, POONCH</strong></td>
</tr>
<tr>
<td>1</td>
<td>15.00</td>
</tr>
<tr>
<td>2</td>
<td>28.00</td>
</tr>
<tr>
<td>3</td>
<td>37.00</td>
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<tr>
<td>4</td>
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</tr>
<tr>
<td>5</td>
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</tr>
<tr>
<td>6</td>
<td>12.00</td>
</tr>
<tr>
<td>7</td>
<td>8.00</td>
</tr>
<tr>
<td>8</td>
<td>24.00</td>
</tr>
<tr>
<td>9</td>
<td>22.00</td>
</tr>
<tr>
<td>10</td>
<td>15.00</td>
</tr>
<tr>
<td>11</td>
<td>17.00</td>
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</table>

### JOINT DISPLACEMENTS

**UNIT** | **PONCH, POONCH**
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>JOINT</strong></td>
<td><strong>PONCH, POONCH</strong></td>
</tr>
<tr>
<td>1</td>
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</tr>
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<tr>
<td>10</td>
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</tr>
<tr>
<td>11</td>
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### APPLIED JOINT LOADS AND SUPPORT REACTIONS

**UNIT** | **PONCH, POONCH**
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>JOINT</strong></td>
<td><strong>PONCH, POONCH</strong></td>
</tr>
<tr>
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<tr>
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**$\text{PROBLEM COMPLETED}$**

---

**OUTPUT**

---

**2-D Frame Analysis Program**

---

**Input**

**Office Building - Scheme C -- Dead load**
Narrowly Spaced Element Analysis

**Narrowly Spaced Element Analysis**

**NUMBER OF ELEMENTS** = 10
**NUMBER OF Nodal Points** = 11
**NUMBER OF MATERIALS** = 1
**NUMBER OF ELEMENT TYPES** = 1
**NUMBER OF ELASTIC SUPPORT TYPES** = 0
**NUMBER OF FIXED END FORCING TYPES** = 1

**NUMBER OF MATERIALS, POSITIONS**

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Unit</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

**NUMBER OF NODAL POINTS, POSITIONS**

<table>
<thead>
<tr>
<th>Node Number</th>
<th>X Position</th>
<th>Y Position</th>
<th>Z Position</th>
</tr>
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<tbody>
<tr>
<td>1</td>
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**NUMBER OF JOINTS**

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Joint Stiffness 1</th>
<th>Joint Stiffness 2</th>
<th>Joint Stiffness 3</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
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**JOINT DISPLACEMENTS**

<table>
<thead>
<tr>
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<th>Joint Displacement 1</th>
<th>Joint Displacement 2</th>
<th>Joint Displacement 3</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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**JOINT ROTATIONS**

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<th>Joint Rotation 1</th>
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<tbody>
<tr>
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**JOINT LOADS**

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<thead>
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<tr>
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**JOINT MOMENTS**

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<thead>
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<tbody>
<tr>
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<td>0.000</td>
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**JOINT FORCES**

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Joint Force 1</th>
<th>Joint Force 2</th>
<th>Joint Force 3</th>
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<tbody>
<tr>
<td>1</td>
<td>0.000</td>
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<tr>
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**APPLIED JOINT LOADS AND MOMENTS**

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<th>Applied Load 3</th>
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<tr>
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</tbody>
</table>

**COMMENTS**

- **Two Dimensional Frame Analysis Program**
- **Input**

Office Building - Scheme C -- Snow Load

**NUMBER OF ELEMENTS** = 10
**NUMBER OF NODAL POINTS** = 11
**NUMBER OF MATERIALS** = 1
**NUMBER OF ELEMENT TYPES** = 1
**NUMBER OF ELASTIC SUPPORT TYPES** = 0
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**NUMBER OF MATERIALS, POSITIONS**

<table>
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<tr>
<th>Material Type</th>
<th>Unit</th>
<th>Number</th>
</tr>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Node Number</th>
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<th>Y Position</th>
<th>Z Position</th>
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<tbody>
<tr>
<td>1</td>
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<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Joint Stiffness 1</th>
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<th>Joint Stiffness 3</th>
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**JOINT DISPLACEMENTS**

<table>
<thead>
<tr>
<th>Joint Number</th>
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<th>Joint Displacement 2</th>
<th>Joint Displacement 3</th>
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<tbody>
<tr>
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**JOINT ROTATIONS**

<table>
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<th>Joint Rotation 2</th>
<th>Joint Rotation 3</th>
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<tbody>
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**JOINT LOADS**

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<tbody>
<tr>
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<tr>
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**JOINT MOMENTS**

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Joint Moment 1</th>
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<th>Joint Moment 3</th>
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</thead>
<tbody>
<tr>
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<td>0.000</td>
<td>0.000</td>
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**JOINT FORCES**

<table>
<thead>
<tr>
<th>Joint Number</th>
<th>Joint Force 1</th>
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<th>Joint Force 3</th>
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<tbody>
<tr>
<td>1</td>
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<tr>
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</tbody>
</table>

**COMMENTS**

- **Two Dimensional Frame Analysis Program**
- **Input**

Office Building - Scheme C -- Snow Load
### Narrowly Spaced Element Analysis

#### Fixed End Forces in Local Coordinates

<table>
<thead>
<tr>
<th>Node</th>
<th>X Force</th>
<th>Y Force</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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#### Joint Data

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<tr>
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<th>Normal Coordinators</th>
<th>Elastic Moment</th>
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<tbody>
<tr>
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#### Member Data

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<thead>
<tr>
<th>Section</th>
<th>Left</th>
<th>Right</th>
<th>P.S.F.</th>
<th>P.S.L</th>
<th>Stiff</th>
<th>Carryover</th>
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<tbody>
<tr>
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<td>1</td>
<td>1</td>
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</tbody>
</table>

#### Joint Displacements

<table>
<thead>
<tr>
<th>Joint</th>
<th>X-Displacement</th>
<th>Y-Displacement</th>
<th>Z-Displacement</th>
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<tbody>
<tr>
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#### Member Ends

<table>
<thead>
<tr>
<th>Section</th>
<th>Left</th>
<th>Right</th>
<th>X</th>
<th>Y</th>
<th>Moment</th>
</tr>
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<tbody>
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<td>0.000</td>
<td>0.000</td>
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</tbody>
</table>
Steel Open-Web Joist Design

Start

Review Depth Limits & Deflection Limits

Review Calculations & Selections

Use Scratch Pad To Explore Span, Spacing, And Loading Alternatives

Select Member

Print Spreadsheet

Return To Preliminary

Select Member

Send Member Size To CASM

Print Spreadsheet

Return To CASM

Restore CASM

Double Click On CASM Icon

Cancel Selected Element

End
## Open-Web Joist Design

### Barjoist Selection

**Steel Bar Joist Preliminary Selection**

**Project:** Office Building - Scheme C  
**Location:** Radford AAP  
**Date:** Feb 26, 1992  
**Engr:**

#### CASM Load & Analysis Data:

<table>
<thead>
<tr>
<th>Method</th>
<th>Analysis</th>
<th>Load Combination: <strong>D + S</strong></th>
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</table>

<table>
<thead>
<tr>
<th>Member ID:</th>
<th>Connection:</th>
<th>Load Type</th>
<th>Factored Moment (ft-lb)</th>
<th>Factored Reaction (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinge (Left)</td>
<td>Roller (Right)</td>
<td>Dead</td>
<td>518</td>
<td>86</td>
</tr>
<tr>
<td>Span:</td>
<td>24.0 ft</td>
<td>Sup Dead</td>
<td>13,219</td>
<td>2,203</td>
</tr>
<tr>
<td>Spacing:</td>
<td>48.0 in</td>
<td>Live</td>
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<td></td>
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<td>Depth Limit:</td>
<td>24.0 in. max</td>
<td>Lmin Roof</td>
<td></td>
<td></td>
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<tr>
<td>Fy:</td>
<td>36.0 ksi</td>
<td>Snow</td>
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<tr>
<td>Fb:</td>
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<td>Wind</td>
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<table>
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<th>Mid (lb)</th>
<th>Right (lb)</th>
</tr>
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<tbody>
<tr>
<td>Roller (Right)</td>
<td>86</td>
<td></td>
<td>86</td>
</tr>
<tr>
<td>Sup Dead</td>
<td>13,219</td>
<td>2,203</td>
<td>2,203</td>
</tr>
<tr>
<td>Live</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snow</td>
<td>13,451</td>
<td>2,200</td>
<td>2,527</td>
</tr>
<tr>
<td>Wind</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Summary | 27,189 | 4,489 | 4,816 |

<table>
<thead>
<tr>
<th>Live Def</th>
<th>L/360 = 0.80 in</th>
<th>Moment (EUL)</th>
<th>Reaction (EUL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Def</td>
<td>L/240 = 1.20 in</td>
<td>Total</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ld</td>
<td>Ld</td>
</tr>
<tr>
<td></td>
<td></td>
<td>378 pif</td>
<td>401 pif</td>
</tr>
<tr>
<td></td>
<td></td>
<td>187 pif</td>
<td>211 pif</td>
</tr>
</tbody>
</table>

### CASM Joist Selection Table: (Joist capacities)

<table>
<thead>
<tr>
<th>Joist Size</th>
<th>Spacing (in)</th>
<th>Total Ld (pif)</th>
<th>Live Ld (pif)</th>
<th>Mmax (ft-lb)</th>
<th>Rmax (lb)</th>
<th>Live Ld Def (in)</th>
<th>Total Ld Def (in)</th>
<th>Joist Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>20K4</td>
<td>48.0</td>
<td>430</td>
<td>353</td>
<td>30,960</td>
<td>5,160</td>
<td>0.48</td>
<td>0.92</td>
<td>1.9</td>
</tr>
<tr>
<td>18K5</td>
<td>48.0</td>
<td>434</td>
<td>318</td>
<td>31,248</td>
<td>5,208</td>
<td>0.54</td>
<td>1.03</td>
<td>1.9</td>
</tr>
<tr>
<td>22K4</td>
<td>48.0</td>
<td>475</td>
<td>431</td>
<td>34,200</td>
<td>5,700</td>
<td>0.40</td>
<td>0.76</td>
<td>2.0</td>
</tr>
<tr>
<td>16K6</td>
<td>48.0</td>
<td>418</td>
<td>269</td>
<td>30,096</td>
<td>5,016</td>
<td>0.63</td>
<td>1.21</td>
<td>2.0</td>
</tr>
</tbody>
</table>

### CASM Bar Joist Selection:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wgt (tons):</td>
<td>0.09</td>
<td>Mmax:</td>
<td>30,960</td>
<td>Rmax:</td>
<td>5,160</td>
<td>TL def:</td>
<td>0.92 in</td>
<td>LL def:</td>
<td>0.48 in</td>
</tr>
</tbody>
</table>

### Notes:

1. Bar joist selections based on 1988 SJI Load Tables.  
   Edit spreadsheet stajstk.xls to revise selection table.
2. Approximate moment of inertia of the joist in inches^4 is:  
   \[ I_j = 26.767 \times (WLL)^3 \times (10^{-6}) \]  
   where WLL = Live Load value in table;  
   where L = Span - 0.33 in feet
Widely Spaced Element Analysis: Continuous Beam

Start

Use Loads & Design Tool Palette

Select Second Floor/ Lower Roof Horizontal Structural Plane

Material Concrete

Load Combination 1.4D + 1.7L

Pattern Occupancy

Live Load

Use Load Combination

Set Factors

Dead: 1.4
Live: 1.7

Add

OK Button To Close Dialog Window

Highlight 1.4D + 1.7L in List

Select Element To Analyze & Design

Linear Widely Spaced Beam-C.I.P.

Select Widely Spaced Element B3-B4

Review Element Attributes & Guidelines
Preliminary Analysis → Use Preliminary

Analysis
Units: Feet & Kips
☐ Use Actual Properties
☐ DL=Deck+Self Weight

Connectivity
Left: Continuous Column
Right: Continuous Column
Adjacent Spans:
Left: 2
Right: 0

Column Connectivity
Above: Fixed
Height: 14'
Below: Fixed
Height: 14'

Connectivity
Continuous Column

Column Connectivity
Above: Fixed
Height: 14'
Below: Fixed
Height: 14'

Connectivity
Continuous Column
Widely Spaced Element Analysis: Continuous Beam

- Preliminary Analysis
  - Self Weight
    - Guidelines
      - Concrete Beam Estimated Self Weight
        - Continuous Exterior Spa., $t = 4'$, $h-t = 16'$, $b = 10'$
        - NLWT @ 150 pcf
      - Close Self Weight Guidelines Dialog Window
    - Self Weight
      - Estimated Self Weight: 166.7 plf
      - Update Area Structure Loads
      - Add Self Weight
    - Yes, Draw Pattern Live Loads
      - Analysis
        - Analysis File Name: Optional
        - Yes, The Loads & Connectivity Are Correct
      - View Shear, Moment & Deflection Diagrams
      - Excel Data
        - Execute Excel

- End
Widely Spaced Element Analysis: Continuous Beam

1.40 Dead (klf)

1.40 Superimposed Dead (klf)

1.70 Live (klf)

Alternate Spans 1

Alternate Spans 2

Two Adjacent Spans 1

Two Adjacent Spans 2

All Spans
Widely Spaced Element Analysis: Continuous Beam

Shear (k)

Moment (kft)

Deflection

Total Combined Load -- Envelope
Concrete Beam Design

Start

Review Material Properties & Beam Configuration

Trial Beam Size
☐ Send Member Size To CASM

Select Rebar Sizes

Review Calculations & Selections

Use Scratch Pad To Explore Support Conditions, Span, Spacing, And Loading Alternatives

☐ Select Member

☐ Print Spreadsheet

Return To Preliminary

Trial Beam Size
☒ Send Member Size To CASM

Print Spreadsheet

Return To CASM

Restore CASM

Double Click On CASM Icon

Cancel Selected Element

End
Concrete Beam Design

CONCRETE BEAM PRELIMINARY SELECTION

Project: Office Building - Scheme C
Location: Radford AAP
Date: Feb 28, 1992

CASM Load & Analysis Data:

Method: Analysis
Load Combination: 1.4D + 1.7L

Member ID: Connectivity: Column (Left) Factored Moments (k-ft) Fact. Reactions

Column (Right) Dead 12.2 6.3 8.8 2.9 2.7
Beam Span 24.0 ft Sup Dead 38.1 19.7 27.4 9.2 8.3
Trih Width 8.0 ft Live 69.3 37.3 56.1 17.0 16.2
Depth Limit 36.0 in. max Lmin Roof
Concrete Fc 4.0 ksi Snow
Concrete Wt 145 pcf Wind

CASM Analysis Data:

Load Type Left Mid Right Left(k) Right(k)
Member ID: Factored Moments (k-ft)

Load Combination: 1.4D + 1.7L

CASM Preliminary Beam Design:

Beam Configuration: Effective Width bE = 72.0 in Rebar Ratios:

ACI Preliminary Dimensions: T-Beam Data:

Rectangular

Effective Width bE = 72.0 in

Rebar Ratios:

Design Data: Bending phi(e) = 0.90 beta(6) = 0.85 m = 17.6 Ru = 581 psi

CASM Preliminary Beam Sizes and Reinforcing:

Beam Size Left end Midspan Right end Shear Rebar Volume Weight
b x h As ϕMn As ϕMn As ϕMn Layers Layer Design Layers Layer Design Layers Layer Design
11 x 14 2.90 120 1.35 63 2.09 92 #3 @ 5 0.95 0.16
10 x 16 2.32 120 1.12 63 1.71 92 #3 @ 6 0.99 0.16
11 x 18 1.90 120 0.95 63 1.43 92 #3 @ 7 1.22 0.20
12 x 20 1.63 120 0.83 63 1.24 92 #3 @ 8 1.48 0.24
13 x 22 1.43 120 0.74 63 1.09 92 #3 @ 9 1.77 0.29

CASM Preliminary Beam Design:

Beam Configuration: Trial Depth h = 16.0 in Cover Top = 1.5 in d = 13.5 in
Trial Width b = 10.0 in Cover Btm = 1.5 in d' = 2.5 in

Bending Reinforcement:

Reinforcement: Layers Reqd Design Layers Reqd Design Layers Reqd Design
Mu (kft) 120 123 63 75 92 123
Ru (psi) 875 883 463 527 675 883
p (%) 1.61 1.74 0.85 0.96 1.24 1.74
As (eq in) 2.17 2.37 1.15 1.32 1.68 2.37

Select Rebar: 1 3 - #8 1 4 - #5 1 4 - #6

Shear Reinforcement:

Select Rebar: 1 3 - #6 1 3 - #8 1

Rebar Option: 1 3 - #8 1 4 - #5 1 4 - #6
Shear

Reinforcement: Left End Right End Design Values:

Vu: 29.2 kips 27.1 kips phi(e) = 0.85
Reqd ϕVs: 14.7 kips 12.6 kips cVc = 14.5 k
Size&Spacing: #3 @ 6 in #3 @ 6 in 1/2A = 7.3 k

Properties and Quantities for Concrete Beam/Girder:

Dimensions (b x h): 10 x 16
Volume: 1.0 c.y.
Weight: 0.16 klf
Rebar Wt = .18 tons

Notes:
1. Concrete beam/girder volume and weight does not include slab volume and weight.
2. ACI 318-89 Strength Design used for sizing member.
Start

Use Loads & Design Tool Palette

Select Second Floor/ Lower Roof Horizontal Structural Plane

Material Steel

Load Combination D + S

Use Load Combination

Set Factors
Dead: 1.0
Snow: 1.0

Add

OK Button To Close Dialog Window

Highlight D+S In List

Select Element To Analyze & Design

Linear Truss-Custom

Select A Truss

Review Element Attributes & Guidelines

Preliminary Analysis

Use Preliminary

Truss Element Analysis
Truss Element Analysis

Preliminary Analysis

Analysis
Units: Feet & Kips
☐ Use Actual Properties
☐ DL=Deck+Self Weight

Connectivity
Left: Hinge
Right: Roller

Truss - Custom
Pratt
Top Chord Panels: 9
Depth At Supports: 3'
Scissors Height: 0'

Try Other Configurations

Self Weight

Guidelines
Find Estimate For 36' Span & Flat Pitch
Close Self Weight Guidelines Dialog Window

Self Weight
Estimated Self Weight: 96 plf
☐ Update Area Structure Loads
☐ Add Self Weight

Analysis
Analysis File Name: Optional
Yes, The Loads & Connectivity Are Correct

View Axial, Reactions & Deflection Diagrams

Cancel Linear Element

End
Truss Element Analysis

1.00 Dead (kif)

1.00 Superimposed Dead (kif)

1.00 Snow (kif)
Truss Element Analysis

Total Combined Load — Axial (k)

Total Combined Load — Deflection

Total Combined Load — Reactions (k)
**Column Load Run Down**

1. **Start**
2. Use Loads & Design Tool Palette
3. Material Concrete
4. Load Combination 1.4D + 1.7L + 1.7S
5. Use Load Combination
   - Set Factors
     - Dead: 1.4
     - Live: 1.7
     - Snow: 1.7
   - Add
   - OK Button To Close Dialog Window
   - Highlight 1.4D + 1.7L + 1.7S
7. Live Load Reduction
8. Occupancy (LL)
   - ☑ Apply Live Load Reduction
9. Select Element To Analyze & Design
10. Column Rectangular
11. Select Column B3
12. Review Element Attributes & Guidelines
Column Load Run Down

1. Live Load Reduction
2. Occupancy (LL)
   - Apply Live Load Reduction
3. End
Column Load Run Down
<table>
<thead>
<tr>
<th>Column Load Run Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tributary Area Weight DL LLR LLR S TL Sum DL Sum LLR Sum S Sum TL</td>
</tr>
<tr>
<td>712.1 61.7 0.0 0.0 30.3 92.0</td>
</tr>
<tr>
<td>1.5 63.2 0.0 30.3 93.4</td>
</tr>
<tr>
<td>685.6 80.0 79.2 0.0 159.2</td>
</tr>
<tr>
<td>1.5 144.6 79.2 30.3 254.1</td>
</tr>
</tbody>
</table>

Note: Tributary area includes 15% increase to account for concrete continuity at first interior column.

Column B-3 Load Run Down (k)
Column Load Run Down

Project: Office Building - Scheme C
Location: Radford AAP
Design Load: TM 5-809-1 1991
Time: Sun Jan 26, 1992 7:38 PM

**************************************** Live Load Reduction ****************************************

Second Floor/Lower Roof
Office: Offices (Lo) : 50.0 psf
Tributary area (TA) : 576.0 sf
Area of influence (Ai) = 4*TA for columns.
Ai = 2304.0 sf
Ai = 400.0 sf
Lo <= 100.0 psf
L = Lo*[0.25+15/sqrt(Ai)]
L = 28.1 psf
Member supports only one floor.
L >= 0.5*Lo
0.5*Lo = 25.0 psf
!-----------------------------
| L = 28.13 psf |
!-----------------------------

**************************************** Live Load Reduction ****************************************

Second Floor/Lower Roof
Office: Corridor (main) (Lo) : 100.0 psf
Tributary area (TA) : 576.0 sf
Area of influence (Ai) = 4*TA for columns.
Ai = 2304.0 sf
Ai = 400.0 sf
Lo <= 100.0 psf
L = Lo*[0.25+15/sqrt(Ai)]
L = 56.3 psf
Member supports only one floor.
L >= 0.5*Lo
0.5*Lo = 50.0 psf
!-----------------------------
| L = 56.25 psf |
!-----------------------------

**************************************** Live Load Reduction ****************************************

Second Floor/Lower Roof
Office: Files & Storage (Lo) : 150.0 psf
Tributary area (TA) : 576.0 sf
Area of influence (Ai) = 4*TA for columns.
Ai = 2304.0 sf
Ai = 400.0 sf
Lo <= 100.0 psf
Member supports only one floor.
No live load reduction taken.
L = Lo
!-----------------------------
| L = 150.00 psf |
!-----------------------------
Concrete Column Design

Start

Review Material Strength & Design Data

Review Load & Analysis Data

Review Selection For Level 1

Select Member
☐ Send Member Size To CASM

Review Selection For Level 2

Select Member
☐ Send Member Size To CASM

Print Spreadsheet

Return To CASM

Restore CASM

Cancel Selected Column

End

Use Scratch Pad To Explore Length, And Loading Alternatives

Select Member

Print Spreadsheet

Return To Preliminary

Double Click On CASM Icon
## Concrete Column Preliminary Selection

### CASM Load & Analysis Data:

<table>
<thead>
<tr>
<th>Method: Analysis</th>
<th>Load Combination: $1.4D + 1.7L + \text{Gonc F}'c = 4.0$ ksi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member ID: B-3</td>
<td>Size Limit= 16.0 in. max Fy= 60.0 ksi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Level</th>
<th>Fc (in$^2$)</th>
<th>b (in)</th>
<th>p (%)</th>
<th>Ast (in$^2$)</th>
<th>Rebar &amp; Size</th>
<th>Pu (kip)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Roof</td>
<td>6</td>
<td>576</td>
<td>63.2</td>
<td>30.3</td>
<td>93.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second Floor/Ld</td>
<td>1</td>
<td>576</td>
<td>144.6</td>
<td>30.3</td>
<td>254.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### CASM Column Selection Table

<table>
<thead>
<tr>
<th>Column Data:</th>
<th>Calculated Values:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Level: 2</td>
<td></td>
</tr>
<tr>
<td>Column Shape: Square</td>
<td></td>
</tr>
<tr>
<td>Reinf. Ratio: 1.5 %</td>
<td></td>
</tr>
<tr>
<td>Ties: Tied 5</td>
<td></td>
</tr>
<tr>
<td>Fire Rating: 1 Hour(s)</td>
<td></td>
</tr>
<tr>
<td>Estimated Ave. 3</td>
<td></td>
</tr>
<tr>
<td>Beam Depth: 20.0 in.</td>
<td></td>
</tr>
<tr>
<td>Concrete Wgt: 145pcf</td>
<td></td>
</tr>
</tbody>
</table>

### CASM Column Design Data:

<table>
<thead>
<tr>
<th>Level</th>
<th>b (in)</th>
<th>Ag (in$^2$)</th>
<th>Rebar &amp; Size</th>
<th>Ast (in$^2$)</th>
<th>p (%)</th>
<th>Pu (kip)</th>
<th>Reqd Pu</th>
<th>Pc (kip)</th>
<th>Tie &amp; Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Roof - 2 11</td>
<td>121</td>
<td>4-#4</td>
<td>0.80</td>
<td>0.7</td>
<td>256</td>
<td>93</td>
<td>#3@8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r/Lower Roof - 1</td>
<td>11</td>
<td>121</td>
<td>4-#6</td>
<td>1.76</td>
<td>1.5</td>
<td>254</td>
<td>#3@11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. Initial column size based on larger of:
   a. Size based on axial load $Ag = Pn/(0.8*(0.85f'c + p*(fy-0.85f'c)))$
   b. Size based on fire resistance rating.
   c. Size assuming $k=1.0$ and neglecting effects of slenderness by solving for $b$:
      - first story $- - - - - - - lu/b <= 10$
      - above first story $- - lu/b <= 14$

2. Slenderness is considered when selecting a column size less than the calculated value.
Lateral Resistance Philosophy

**Steps Required**

1. Create building volume
2. Define a structural grid
3. Layout structural framing on ALL levels
4. Assign gravity load on ALL levels
   Calculate wind and/or seismic loads
5. Select a load combination including wind or seismic loads
6. Define N-S & E-W vertical resistance system
   - **Options:**
     1. Unbraced Frames
     2. Braced Frames
        a. Trussing
        b. Shear Walls
7. Define horizontal diaphragm systems
   - All flexible
   - All rigid
   - Floors rigid & roof flexible
Lateral Resistance Philosophy

**Flexible Diaphragms**

Simple Beam Model (tributary area)

![Diagram of simple beam model with P/4, P/2, and P/4 lengths and P force applied.]

*No Torsion*

Continuous Beam Model

![Diagram of continuous beam model with 3/16 P, 5/8 P, and 3/16 P lengths and P force applied.]

**Rigid Diaphragms**

Symmetrical

![Diagram of symmetrical rigid diaphragm with 4 P, 2 P, and 4 P forces applied.]

\( Torsion \) (even accidental minimum required)

Non-Symmetrical

![Diagram of non-symmetrical rigid diaphragm with .5 P, .25 P, and .25 P forces applied.]

\( M = P \cdot e \)
Monolithic Perpendicular Shear Wall

For N-S orientation:

- Align the wall perpendicular to the north-south axis.
- Ensure the centroidal axes align correctly.

For E-W orientation:

- Align the wall perpendicular to the east-west axis.
- Ensure the centroidal axes align correctly.

**Lateral Resistance Philosophy**
Define Lateral Resistance

Start

Use Draw Structure Tool Palette

Select Second Floor/ Lower Roof Horizontal Structural Plane

Define Second Floor/ Lower Roof Diaphragm Type

Diaphragm Guidelines

Lateral Horizontal Rigid Diaphragm

Define N-S Lateral Resistance

Define Location

Vertical Define Location

Select Wall On Grid Line A

Repeat For Grid Lines C & D

Define E-W Lateral Resistance

Define Location

Vertical Define Location

Select Wall On Grid Line 1

Repeat For Grid Line 4
Define Lateral Resistance

1. Define Upper Roof Diaphragm Type
2. Select Upper Roof Horizontal Structural Plane
3. Lateral Horizontal Rigid Diaphragm
4. Display Lateral Resistance Locations
5. Show Structure
   - NS Lateral Resistance
   - EW Lateral Resistance
6. End
Define Lateral Resistance

Rigid Diaphragm

Second Floor/Lower Roof
Wind Lateral Analysis

Start

Use Loads & Design Tool Palette

Load Combination 0.9D + 1.3W

Use Load Combination

Set Factors
Dead: 0.9
Wind: 1.3

Add

OK Button To Close Dialog Window

Highlight 0.9D+1.3W

Select Second Floor/ Lower Roof Horizontal Structural Plane

Lateral Analysis

Use Lateral Resistance Design

Select NS-1

Analysis
Units: Feet & Kips
☐ Use Actual Properties
☐ DL=Deck+Self Weight
Wind Lateral Analysis

Lateral Analysis

Wind Load Options
- Wind Direction: South
- When 2 Wind Loads: Max. Suction
- Wind Load: GCpi = 0

Rigid Horizontal Diaphragm Calculations
- File Name: Rigidout.txt
- Consider Perpendicular Wall...

View Loads

View Output

Print Data
- Rigid Diaphragm
- All Other
- Print To File
- Execute Notepad

Scroll Output

Page Setup
- Left Margin: 0.5 in
- Right Margin: 0.0 in

Print File

End

Exit Notepad
Wind Lateral Analysis

1.30 Wind (kft) -- NS-1 -- 46%, 31%

0.90 Superimposed Dead (kft)
Wind Lateral Analysis

Project: Office Building - Scheme C
Location: Radford AAF
Time: Sun Jan 26, 1992 8:15 PM

*************** Rigid Horizontal Diaphragm Calculations ***************

NS-1

<table>
<thead>
<tr>
<th>Name</th>
<th>t</th>
<th>l</th>
<th>Area</th>
<th>Arm</th>
<th>Area</th>
<th>Arm</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-1</td>
<td>0.83</td>
<td>24.00</td>
<td>20.0</td>
<td>12.00</td>
<td>240</td>
<td>0.00</td>
<td>0</td>
</tr>
</tbody>
</table>

Centroid = \( \frac{\text{sum(Moment)\ Area}}{\text{sum(Area)}} \)

NS Centroid: 12.00 ft  EW Centroid: 0.00 ft
Av: 20.00 sqft

Moment of Inertia

<table>
<thead>
<tr>
<th>Name</th>
<th>b</th>
<th>h</th>
<th>Area</th>
<th>d</th>
<th>Ad^2</th>
<th>I+Ad^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-1</td>
<td>0.83</td>
<td>24.00</td>
<td>960</td>
<td>20.0</td>
<td>0.00</td>
<td>0</td>
</tr>
</tbody>
</table>

Centroid: 12.00 ft  EW Centroid: 0.00 ft
Av: 20.00 sqft

Deflection: 0.254 in  Height: 14.0 ft
Total Deflection: 0.254 in

NS-2

<table>
<thead>
<tr>
<th>Name</th>
<th>t</th>
<th>l</th>
<th>Area</th>
<th>Arm</th>
<th>Area</th>
<th>Arm</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-2</td>
<td>0.83</td>
<td>24.42</td>
<td>20.3</td>
<td>12.21</td>
<td>248</td>
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<td>0</td>
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<tr>
<td>EW-1</td>
<td>0.83</td>
<td>5.00</td>
<td>4.2</td>
<td>24.00</td>
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<td>-12</td>
</tr>
<tr>
<td>EW-2</td>
<td>0.83</td>
<td>5.00</td>
<td>4.2</td>
<td>24.00</td>
<td>100</td>
<td>-2.92</td>
<td>-12</td>
</tr>
</tbody>
</table>

Centroid = \( \frac{\text{sum(Moment)\ Area}}{\text{sum(Area)}} \)

NS Centroid: 15.63 ft  EW Centroid: 0.00 ft
Av: 20.35 sqft
### Moment of Inertia

<table>
<thead>
<tr>
<th>Name</th>
<th>b (ft)</th>
<th>h (ft)</th>
<th>12 Area (ft^2)</th>
<th>d (ft)</th>
<th>Ad^2 (ft^4)</th>
<th>I+Ad^2 (ft^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS-2</td>
<td>0.83</td>
<td>24.42</td>
<td>1011</td>
<td>20.3</td>
<td>-3.43</td>
<td>239</td>
</tr>
<tr>
<td>EW-1</td>
<td>5.00</td>
<td>0.83</td>
<td>0</td>
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<td>8.37</td>
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<tr>
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<td>0.83</td>
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<td>292</td>
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<tr>
<td>Sum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1833</td>
</tr>
</tbody>
</table>

Deflection: 0.214 in Height: 14.0 ft
Total Deflection: 0.214 in

### Level Height: 20.0 ft

### Centroidal Axis

<table>
<thead>
<tr>
<th>Name</th>
<th>t (ft)</th>
<th>l (ft)</th>
<th>Area (ft^2)</th>
<th>Arm (ft)</th>
<th>NS NS Moment (ft^-3)</th>
<th>EW EW Moment (ft^-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS-2</td>
<td>0.83</td>
<td>24.42</td>
<td>1011</td>
<td>20.3</td>
<td>12.21</td>
<td>248</td>
</tr>
<tr>
<td>EW-1</td>
<td>0.83</td>
<td>5.00</td>
<td>4.2</td>
<td>24.00</td>
<td>100</td>
<td>-2.92</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td></td>
<td>24.5</td>
<td>348</td>
<td>-12</td>
<td></td>
</tr>
</tbody>
</table>

Centroid = sum(MomentArea)/sum(Area)
NS Centroid: 14.21 ft EW Centroid: -0.50 ft
Av: 20.35 sqft

### Moment of Inertia

<table>
<thead>
<tr>
<th>Name</th>
<th>b (ft)</th>
<th>h (ft)</th>
<th>12 Area (ft^2)</th>
<th>d (ft)</th>
<th>Ad^2 (ft^4)</th>
<th>I+Ad^2 (ft^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS-2</td>
<td>0.83</td>
<td>24.42</td>
<td>1011</td>
<td>20.3</td>
<td>-2.00</td>
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<tr>
<td>EW-1</td>
<td>5.00</td>
<td>0.83</td>
<td>0</td>
<td>4.2</td>
<td>9.79</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1492</td>
</tr>
</tbody>
</table>

Deflection: 0.223 in Height: 14.0 ft
Total Deflection: 0.437 in

### Level Height: 14.0 ft

### Centroidal Axis

<table>
<thead>
<tr>
<th>Name</th>
<th>t (ft)</th>
<th>l (ft)</th>
<th>Area (ft^2)</th>
<th>Arm (ft)</th>
<th>NS NS Moment (ft^-3)</th>
<th>EW EW Moment (ft^-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS-3</td>
<td>0.83</td>
<td>24.00</td>
<td>20.0</td>
<td>12.00</td>
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<td>Sum</td>
<td></td>
<td></td>
<td>20.0</td>
<td>240</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Centroid = sum(MomentArea)/sum(Area)
NS Centroid: 12.00 ft EW Centroid: 0.00 ft
Av: 20.00 sqft
### Moment of Inertia

<table>
<thead>
<tr>
<th>Name</th>
<th>b (ft)</th>
<th>h (ft)</th>
<th>Area (ft^2)</th>
<th>d (ft)</th>
<th>Ad^2 (ft^4)</th>
<th>I + Ad^2 (ft^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS-3</td>
<td>0.83</td>
<td>24.00</td>
<td>960</td>
<td>20.0</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>960</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>960</td>
</tr>
</tbody>
</table>

Deflection : 0.254 in  Height : 14.0 ft
Total Deflection : 0.254 in

---

**NS-3**

Level Height : 14.0 ft

**Centroidal Axis**

<table>
<thead>
<tr>
<th>Name</th>
<th>t (ft)</th>
<th>l (ft)</th>
<th>Area (ft^2)</th>
<th>NS Arm (ft)</th>
<th>NS Moment Area (ft^4)</th>
<th>EN Arm (ft)</th>
<th>EN Moment Area (ft^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW-1</td>
<td>0.83</td>
<td>60.00</td>
<td>50.0</td>
<td>0.00</td>
<td>0</td>
<td>30.0</td>
<td>1500</td>
</tr>
<tr>
<td>NS-2</td>
<td>0.83</td>
<td>5.00</td>
<td>4.2</td>
<td>-2.92</td>
<td>-12</td>
<td>24.0</td>
<td>100</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td></td>
<td>54.2</td>
<td>-12</td>
<td></td>
<td>1600</td>
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</tr>
</tbody>
</table>

Centroid = \( \frac{\text{sum(MomentArea)}}{\text{sum(Area)}} \)

NS Centroid : -0.22 ft  EW Centroid : 29.54 ft
Av : 50.00 sqft

### Moment of Inertia

<table>
<thead>
<tr>
<th>Name</th>
<th>b (ft)</th>
<th>h (ft)</th>
<th>Area (ft^2)</th>
<th>d (ft)</th>
<th>Ad^2 (ft^4)</th>
<th>I + Ad^2 (ft^4)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.83</td>
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<tr>
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<td>15139</td>
</tr>
</tbody>
</table>

Deflection : 0.075 in  Height : 14.0 ft
Total Deflection : 0.075 in

---

**NS-2**

Level Height : 28.0 ft

**Centroidal Axis**

<table>
<thead>
<tr>
<th>Name</th>
<th>t (ft)</th>
<th>l (ft)</th>
<th>Area (ft^2)</th>
<th>NS Arm (ft)</th>
<th>NS Moment Area (ft^4)</th>
<th>EN Arm (ft)</th>
<th>EN Moment Area (ft^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW-1</td>
<td>0.83</td>
<td>24.42</td>
<td>20.3</td>
<td>0.00</td>
<td>0</td>
<td>12.21</td>
<td>248</td>
</tr>
<tr>
<td>NS-2</td>
<td>0.83</td>
<td>5.00</td>
<td>4.2</td>
<td>-2.92</td>
<td>-12</td>
<td>24.0</td>
<td>100</td>
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<tr>
<td>Sum</td>
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<td></td>
<td>24.5</td>
<td>-12</td>
<td></td>
<td>348</td>
<td></td>
</tr>
</tbody>
</table>

Centroid = \( \frac{\text{sum(MomentArea)}}{\text{sum(Area)}} \)

NS Centroid : -0.50 ft  EW Centroid : 14.21 ft
Av : 29.35 sqft
Wind Lateral Analysis

**Moment of Inertia**
\[ bh^3/12 \]

<table>
<thead>
<tr>
<th>Name</th>
<th>b</th>
<th>h</th>
<th>Area</th>
<th>d</th>
<th>Ad^2</th>
<th>I+Ad^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW-1</td>
<td>0.83</td>
<td>24.42</td>
<td>1011</td>
<td>0</td>
<td>4.2</td>
<td>9.79</td>
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<tr>
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<td>0.83</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Deflection**: 0.223 in  
**Height**: 14.0 ft  
**Total Deflection**: 0.298 in

---

**Level Height: 14.0 ft**

**Centroidal Axis**

<table>
<thead>
<tr>
<th>Name</th>
<th>t</th>
<th>l</th>
<th>Area</th>
<th>Arm</th>
<th>Area</th>
<th>Arm</th>
<th>Area</th>
<th>Arm</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW-2</td>
<td>0.83</td>
<td>60.00</td>
<td>50.0</td>
<td>0.00</td>
<td>30.00</td>
<td>1500</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Centroid**

**NS Centroid**: 0.00 ft  
**EW Centroid**: 30.00 ft  
**Av**: 50.00 sqft

---

**Moment of Inertia**
\[ bh^3/12 \]

<table>
<thead>
<tr>
<th>Name</th>
<th>b</th>
<th>h</th>
<th>Area</th>
<th>d</th>
<th>Ad^2</th>
<th>I+Ad^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW-2</td>
<td>0.83</td>
<td>60.00</td>
<td>1500</td>
<td>50.0</td>
<td>0.00</td>
<td>1500</td>
</tr>
</tbody>
</table>

**Sum**

**Deflection**: 0.075 in  
**Height**: 14.0 ft  
**Total Deflection**: 0.075 in

---

**Level Height: 28.0 ft**

**Centroidal Axis**

<table>
<thead>
<tr>
<th>Name</th>
<th>t</th>
<th>l</th>
<th>Area</th>
<th>Arm</th>
<th>Area</th>
<th>Arm</th>
<th>Area</th>
<th>Arm</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW-2</td>
<td>0.83</td>
<td>24.00</td>
<td>20.0</td>
<td>0.00</td>
<td>12.00</td>
<td>240</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Centroid**

**NS Centroid**: 0.00 ft  
**EW Centroid**: 12.00 ft  
**Av**: 20.00 sqft
### Wind Lateral Analysis

#### Moment of Inertia

<table>
<thead>
<tr>
<th>Name</th>
<th>b (ft)</th>
<th>h (ft)</th>
<th>12</th>
<th>Area d (ft²)</th>
<th>Ad² (ft⁴)</th>
<th>I+Ad² (ft⁴)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW-2</td>
<td>0.83</td>
<td>24.00</td>
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<td>20.00</td>
<td>0</td>
<td>960</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deflection: 0.254 in  
Height: 14.0 ft  
Total Deflection: 0.329 in

#### Center of Rigidity

<table>
<thead>
<tr>
<th>Name</th>
<th>h (ft)</th>
<th>I (ft⁴)</th>
<th>Av Deflection</th>
<th>Rigidity R/ x R*x</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS-1</td>
<td>14.0</td>
<td>960</td>
<td>20 0.254</td>
<td>3.931 31.34% 3.276</td>
</tr>
<tr>
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<td>14.0</td>
<td>1833</td>
<td>20 0.214</td>
<td>4.682 37.33% 228.63</td>
</tr>
<tr>
<td>NS-3</td>
<td>14.0</td>
<td>960</td>
<td>20 0.254</td>
<td>3.931 31.34% 333.467</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
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<td></td>
<td></td>
<td>12.544 565.376</td>
</tr>
</tbody>
</table>

Centroid from lower left = sum(R*x)/sum(R) : 45.07 ft  
Center of mass from lower left : 39.07 ft  
Eccentricity (e) : 6.00 ft  
Maximum dimension : 85.67 ft  
\( e_{min} = 0.05\times\text{max. dimension} \) : 4.28 ft  
Eccentricity (e) used for torsional analysis : 6.00 ft

<table>
<thead>
<tr>
<th>Name</th>
<th>h (ft)</th>
<th>I (ft⁴)</th>
<th>Av Deflection</th>
<th>Rigidity R/ x R*x</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS-1</td>
<td>28.0</td>
<td>960</td>
<td>20 0.509</td>
<td>1.965 46.19% 1.638</td>
</tr>
<tr>
<td>NS-2</td>
<td>28.0</td>
<td>1492</td>
<td>20 0.437</td>
<td>2.290 53.61% 110.691</td>
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<tr>
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<td>28.0</td>
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<td>0 0</td>
<td>0.000 0.00% 0.000</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
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<td></td>
<td></td>
<td>4.255 112.329</td>
</tr>
</tbody>
</table>

Centroid from lower left = sum(R*x)/sum(R) : 26.40 ft  
Center of mass from lower left : 24.11 ft  
Eccentricity (e) : 2.29 ft  
Maximum dimension : 85.67 ft  
\( e_{min} = 0.05\times\text{max. dimension} \) : 4.28 ft  
Eccentricity (e) used for torsional analysis : 4.28 ft

<table>
<thead>
<tr>
<th>Name</th>
<th>h (ft)</th>
<th>I (ft⁴)</th>
<th>Av Deflection</th>
<th>Rigidity R/ x R*x</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW-1</td>
<td>14.0</td>
<td>15139</td>
<td>50 0.075</td>
<td>13.327 50.02% 72.6</td>
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<tr>
<td>EW-2</td>
<td>14.0</td>
<td>15000</td>
<td>50 0.075</td>
<td>13.319 49.98% 11.099</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
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<td></td>
<td></td>
<td>26.646 978.768</td>
</tr>
</tbody>
</table>

Centroid from lower left = sum(R*x)/sum(R) : 36.73 ft  
Center of mass from lower left : 16.53 ft  
Eccentricity (e) : 0.20 ft  
Maximum dimension : 73.67 ft  
\( e_{min} = 0.05\times\text{max. dimension} \) : 3.68 ft  
Eccentricity (e) used for torsional analysis : 3.68 ft
## Wind Lateral Analysis

<table>
<thead>
<tr>
<th>Name</th>
<th>h</th>
<th>I</th>
<th>Av</th>
<th>Deflection Rigidity</th>
<th>R/ x</th>
<th>R*x</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(ft)</td>
<td>(ft^4)</td>
<td>(ft^2)</td>
<td>(in)</td>
<td>sum(R)</td>
<td>(ft)</td>
</tr>
<tr>
<td>EW-3</td>
<td>28.0</td>
<td>1492</td>
<td>20</td>
<td>0.298</td>
<td>3.354</td>
<td>52.50%</td>
</tr>
<tr>
<td>EW-4</td>
<td>28.0</td>
<td>960</td>
<td>20</td>
<td>0.329</td>
<td>3.035</td>
<td>47.50%</td>
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</tbody>
</table>

**Sum**
- sum(R) = 6.389 ft
- sum(R*x) = 245.162 ft

- Centroid from lower left: \( \frac{\text{sum}(R*x)}{\text{sum}(R)} \) = 38.37 ft
- Center of mass from lower left: 36.11 ft
- Eccentricity (\( e \)): 2.26 ft
- Maximum dimension: 73.67 ft
- \( e_{\text{min}} = 0.05 \times \text{max. dimension} \): 3.68 ft
- Eccentricity (\( e \)) used for torsional analysis: 3.68 ft

### Assumptions used:
- \( E_m = 144,000 \) ksf
- \( Ev = 0.4 \times E_m = 57,600 \) ksf
- All wall thicknesses are equal.
- Deflections calculated by applying a 1,000 kip load.
- Interstory shear wall deflection is calculated based on cantilever action. Deflection at a level is obtained by summing each story's cantilever deflection from grade.
- Deflection = \( \frac{F(h^3)}{3 \times E_m I} + \frac{1.2 \times F \times h}{A \times E_v} \)
  \( h = \) floor to floor height

### Deflection Calculation

#### Name | h | Rigidity | dx | R*dx | R*dx*dx | R*dx/r sum(R*dx*dx)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>MS-1</td>
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<td>3.931</td>
<td>44.2</td>
<td>173.899</td>
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<tr>
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<td>17.606</td>
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<td>14.0</td>
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<td>156.292</td>
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<td>35.9</td>
<td>478.133</td>
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<td>0.00990</td>
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<tr>
<td>EW-2</td>
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<td>13.319</td>
<td>35.9</td>
<td>478.133</td>
<td>17164.481</td>
<td>0.00990</td>
</tr>
</tbody>
</table>

**Sum**
- 48291.982

#### Name | h | Rigidity | dx | R*dx | R*dx*dx | R*dx/r sum(R*dx*dx)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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<td>50.243</td>
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<tr>
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<td>15.4</td>
<td>0.000</td>
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<td>37.5</td>
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**Sum**
- 10533.242

### Shear Distribution
- \( F_v = \frac{V \times R}{\text{sum}(R)} \)

### Torsional Moment
- \( M_t = V \times e \)

### Torsional Component
- \( F_t = \frac{M_t \times R \times dx}{\text{sum}(R \times dx \times dx)} \)

### Total Shear to Element
- \( F_{\text{total}} = F_v + F_t \)
Seismic Loads

Start

Use Loads & Design Tool Palette

Load Combination D+E

Use Load Combination

Set Factors
Dead: 1.0
Seismic: 1.0

Add

OK Button To Close Dialog Window

Highlight D+E In List

Calculate Seismic Loads

Review Criteria

Select Lateral Force Resisting System As B.3.a

View Spectral Plots

Spectral Plots
\( C_f = 0.020 \) For All Other Buildings

View Base Shear Spectrum (ZC)

Print Screen

View Design Base Shear Coefficient Spectrum (ZC/Rw)
Seismic Loads

Zone : 2A  \( Z = 0.150 \)
Soil Factor : S3  \( S = 1.5 \)
\( C_t = 0.020 \)
\( h_n = 28.0 \text{ ft} \)

\[ F = C_t (h_n - 3/4) \]
\[ C = 1.25 \times S/(T-2/3) \]

Base Shear Spectrum

Design Base Shear Coefficient Spectrum

147
Seismic Loads

Project: Office Building - Scheme C  
Location: Radford AAP  
Seismic Code: TM 5-809-10 1991  
Time: Sun Jan 26, 1992 8:14 PM

Seismic Analysis

3. Upper Roof: 350.4 k  
2. Second Floor/Lower Roof: 700.9 k  
Total Building Weight (W): 1051.3 k

Zone: 2A; Z = 0.150  
Importance Category: IV; I = 1.00  
Soil Factor: SS; S = 1.5  
System: B3a; Rw = 8  

\[ C = 2.5 \]  
\[ C/Rw = 0.344 > 0.075 \]  
\[ W = 1051.3 \text{k} \]  
\[ V = Z*I*C*W/Rw \]  
\[ V = 54.2 \text{k} \]  
\[ T < 0.7 \text{sec} \]

<table>
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<tr>
<th>Level</th>
<th>Floor to</th>
<th>h</th>
<th>w</th>
<th>( w*h )</th>
<th>( w*h/)</th>
<th>F</th>
<th>V</th>
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</thead>
<tbody>
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<table>
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<th>( w*h/)</th>
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148
Seismic Loads

Project: Office Building - Scheme C
Location: Redford AAP
Time: Sun Jan 26, 1992 8:14 PM

************************* Center Of Mass *************************

<table>
<thead>
<tr>
<th>Name</th>
<th>Weight (k)</th>
<th>NS (ft)</th>
<th>NS*Weight (kft)</th>
<th>EW (ft)</th>
<th>EW*Weight (kft)</th>
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<td>0.8</td>
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<td>12.8</td>
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<td>90.6</td>
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Sum: 350.4 12652.1 8447.7

N-S Center Of Mass: 36.11 ft
E-W Center Of Mass: 24.11 ft

Second Floor/Lower Roof -- 14.00 ft

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<thead>
<tr>
<th>Name</th>
<th>Weight (k)</th>
<th>NS (ft)</th>
<th>NS*Weight (kft)</th>
<th>EW (ft)</th>
<th>EW*Weight (kft)</th>
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<td>24.8</td>
<td>90.6</td>
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</table>

Sum: 700.9 25605.3 27382.6

N-S Center Of Mass: 36.53 ft
E-W Center Of Mass: 39.07 ft
Seismic Lateral Analysis

Start

Use Loads & Design
Tool Palette

Load Combination
0.9D + 1.5E

Use Load Combination

Set Factors
Dead: 0.9
Seismic: 1.5

Add

OK Button To Close
Dialog Window

Highlight
0.9D + 1.5E

Select Second Floor/
Lower Roof Horizontal
Structural Plane

Lateral Analysis

Use Lateral
Resistance Design

Select NS-1

Analysis
Units: Feet & Kips
☐ Use Actual Properties
☐ DL=Deck+Self Weight
Seismic Lateral Analysis

Lateral Analysis

Rigid Horizontal Diaphragm Calculations
File Name: Rigidout.txt
☑ Consider Perpendicular Wall...

View Loads

Seismic Lateral Resistance Locations
File Name: Latseis.txt

View Output

Print Data
☑ Seismic Resistance
☑ Rigid Diaphragm
☐ All Other
☐ Print To File
☑ Execute Notepad

Scroll Output

Page Setup
Left Margin: 0.5 in
Right Margin: 0.0 in

Print File

Exit Notepad

End
Seismic Lateral Analysis

1.50 Seismic (kif) -- NS-1 -- 46%, 31%

0.90 Superimposed Dead (kif)
Seismic Lateral Analysis

0.90 Doed (kif)
### Seismic Lateral Analysis

**Project**: Office Building - Scheme C  
**Location**: Radford AAP  
**Seismic Code**: TM 5-809-10 1991  
**Time**: Sun Jan 26, 1992 8:16 PM

********** Seismic Lateral Resistance Locations **********

<table>
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<th>NS-1 -- 46%, 31%</th>
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<td>3</td>
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<tr>
<td>2</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Sum</td>
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<table>
<thead>
<tr>
<th>NS-2 -- 54%, 37%</th>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Sum</td>
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<table>
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</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Sum</td>
</tr>
</tbody>
</table>
Quantity Take-Off Philosophy

3 Considerations

1. One typical interior bay (exterior side bay, corner bay)

2. One typical floor level and roof level

3. The entire building structural system

Estimated weights are not used for quantity take-offs

Elements designed by Excel spreadsheets are used

Use Modify Design and Copy Design to manually enter element sizes

Calculated square footage can be overridden
Quantity Take-Off

Start

Use Loads & Design Tool Palette

Select Second Floor/ Lower Roof Horizontal Structural Plane

Design All Elements To Include In Quantity Take-Off

Design Surface Elements

Use Modify Design

Select A Surface Element On The Second Floor

Design

Material: Concrete
Description: 4" Slab
Weight: 145.0 pcf
Reinforcing Weight: 1.04 psf
Depth: 4.0 in

Use Copy Design

Select Surface With Properties

Select All Other Surface Elements On The Second Floor

Double Click Right Mouse Key To End Copying Designs

Design Beam Elements

Use Copy Design
Design All Elements To Include In Quantity Take-Off

Design Beam Elements

Select Beam With Properties

Select All Other Beams

Double Click Right Mouse Key To End Copying Designs

Design Column Elements

Use Copy Design

Select Column With Properties

Select Other Columns

Double Click Right Mouse Key To End Copying Designs

Design Wall Elements

Use Modify Design

Select A Wall Element On The Second Floor

Design
Material: Concrete
Description: 10" Concrete
Weight: 1450 pcf
Reinforcing Weight: 20 psf

Use Copy Design

Select Wall With Properties
**Project:** Office Building - Scheme C  
**Location:** Radford AAP  
**Time:** Sun Jan 26, 1992 8:20 PM

########################### Quantity Take-off ###########################

**Second Floor/Lower Roof**

Plan Area: 72.0 ft x 48.0 ft: 3456.0 sqft

**CONCRETE: Narrowly Spaced Elements**

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<th>(ft)</th>
<th>(pcf)</th>
<th>(plf)</th>
<th>(lbs)</th>
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<th>(lbs)</th>
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</table>

Sum: 0 0 0 0 0

Concrete Cubic Yards: 0.0  
Weight Per Square Foot: 0.0 psf  
Reinforcing Total Weight: 0.0 tons  
Weight Per Square Foot: 0.0 psf

**CONCRETE: Widely Spaced Elements**

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<th>(ft)</th>
<th>(pcf)</th>
<th>(plf)</th>
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<th>(lbs)</th>
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Sum: 96667 9000

Concrete Cubic Yards: 24.7  
Weight Per Square Foot: 28.0 psf  
Reinforcing Total Weight: 4.5 tons  
Weight Per Square Foot: 2.6 psf

**CONCRETE: Surface Elements**

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Sum: 157760 3395

Concrete Cubic Yards: 40.3  
Reinforcing Total Weight: 1.7 tons
### CONCRETE: Column Elements

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<th>Length (ft)</th>
<th>Weight (pcf)</th>
<th>Weight (lbs)</th>
<th>Conc No.</th>
<th>Conc Weight (lbs)</th>
<th>Total Weight (lbs)</th>
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<tbody>
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<td>5</td>
<td>8529</td>
<td>560</td>
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</table>

Concrete Cubic Yards: 2.2
Weight Per Square Foot: 2.5 psf
Reinforcing Total Weight: 0.3 tons
Weight Per Square Foot: 0.2 psf

### CONCRETE: Wall Elements

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Sum: 162400

Concrete Cubic Yards: 41.5

### Reinforcing Total Weight: 1.3 tons
Concluding Remarks

Schemes A, B and C were developed to permit exploration and instruction of the broadest possible range of CASM capabilities. The schemes should not be viewed as completely logical structural framing solutions to the given design parameters, nor as necessarily economical. Each of the three schemes contain a variety of elements, which if properly combined and interchanged might produce "real" schemes for consideration at a 35% review.

Examples of unlikely components assembled in schemes A, B and C include: (1) concrete as a decking for the low roof, (2) custom made trusses for the low roof framing, (3) prefabricated limestone wall panels mixed with cast-in-place concrete shear walls, and (4) non-composite steel beam framing for the second floor.

A logical steel framed beam/column solution for "real" consideration would include open web steel joists spanning 48 feet for the upper roof to eliminate a central column in the second floor space. The lower roof would be framed with 36 foot span open web steel joists (without inclusion of custom trusses) as in scheme B. Both roofs would be sheathed with a metal roof deck without concrete and both would become flexible diaphragms. The second floor would be framed with composite steel beams as in scheme B and remain a rigid diaphragm. Two lateral load resistance system options could be compared. One scheme could include a moment resistant frame approach similar to scheme A, while a second approach might incorporate trussing similar to scheme B. The non-loadbearing exterior envelope is open to a variety of possibilities. The Architects will likely dictate the aesthetic expression. The foundation system would be a combination of isolated and linear spread footings.

A third logical solution would be a masonry bearing wall system to support the steel open-web joist roof planes described above. The second floor plane might be constructed of pre-cast pre-stressed hollow cored planks, which would also bear on the walls and a central steel girder line. Some of these walls could become shear walls for lateral load resistance. Thus the exterior envelope and the interior partition provide a structural function, eliminating costly moment connections and columns within the exterior wall layout. Footings are now all linear spread footings with only one isolated footing.

It is unlikely that a reinforced concrete frame would present an economical solution for a 1-2 story office building.

The structural engineers that become proficient with the use of CASM will be able to explore many other ideas to arrive at the most structurally efficient and economical solution for this hypothetical project.
Concluding Remarks

Scheme 1: Moment connections for lateral load resistance

Scheme 2: Trussing for lateral load resistance
Scheme 3: Shear walls for lateral load resistance

8" CMU walls can be used as shear walls
# Concept Design Example Computer Aided Structural Modeling (CASM); Report 3, Scheme C

## Authors
- David Wickersheimer, Gene McDermott, Carl Roth, and Michael Pace

## Performing Organization Name(s) and Address(es)
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## Abstract
This is one in a series of three manuals designed to instruct in the use of the Computer Aided Structural Modeling (CASM) computer program. The manuals are composed of flowcharts which show step-by-step procedures for executing a broad range of CASM capabilities. CASM is a computer program designed to aid the structural engineer in the preliminary design and evaluation of structural building systems by the use of three-dimensional (3-D) interactive graphics. This manual contains one of three different framing schemes for the same 1-2 story office building. The examples contain a complete range of capabilities to permit framing comparisons, including 3-D geometry modeling, criteria specifications, development of loads (snow, wind, seismic, dead, and live), drawing structural elements, preliminary analysis and design of structural elements, and quantity take-offs.
14. (Concluded).

Building systems
Computer Aided Structural Engineering Modeling (CASE)
Computer programs
Preliminary structural design
Structural modeling
Three-dimensional graphics
Three-dimensional loads
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