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US Army Corps
of Engineers

COMPUTER AIDED STRUCTURAL
ENGINEERING (CASE) PROJECT

INSTRUCTION REPORT ITL-92-3



CONCEPT DESIGN EXAMPLE, COMPUTER AIDED STRUCTURAL MODELING (CASM)

Report 3

SCHEME C

by

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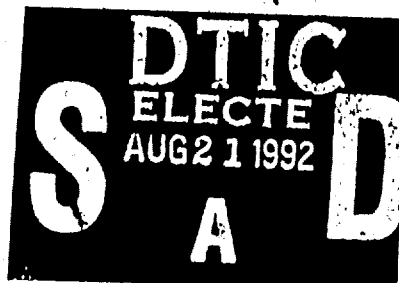
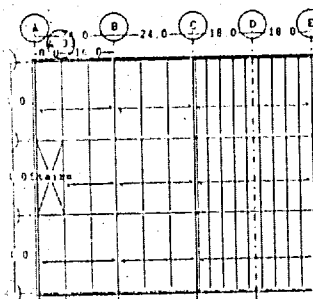
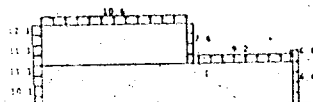
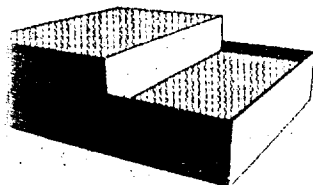
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DEPARTMENT OF THE ARMY

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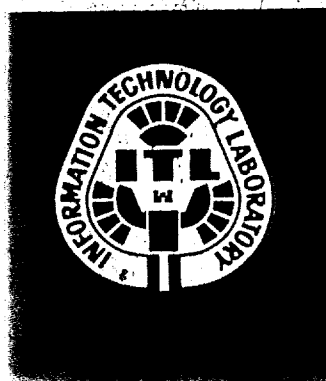
June 1992

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C

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

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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.

Funds for publication of this report were provided to ITL under the RDT&E Program and CASE Project.

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:

Mr. Dan Reynolds, US Army Engineer (USAE) District, Sacramento (Chairman)
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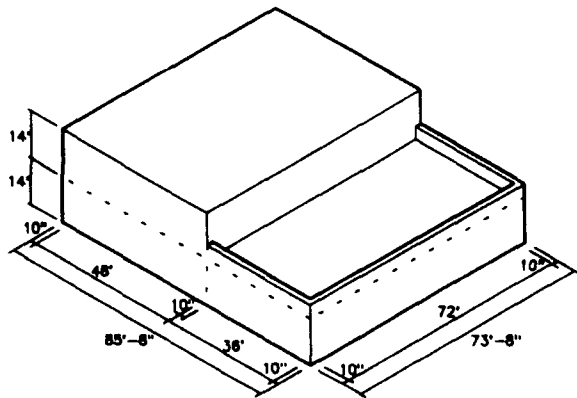
The computer program was written by Messrs. David Wickersheimer, Gene McDermott, and Carl Roth of Wickersheimer Engineers, Inc.

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:

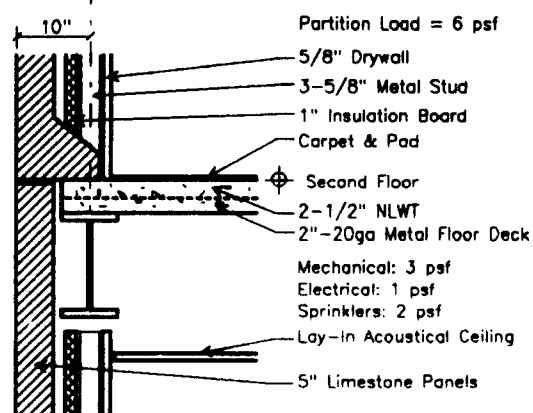
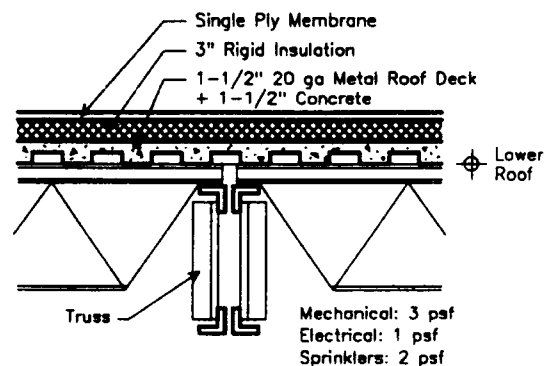
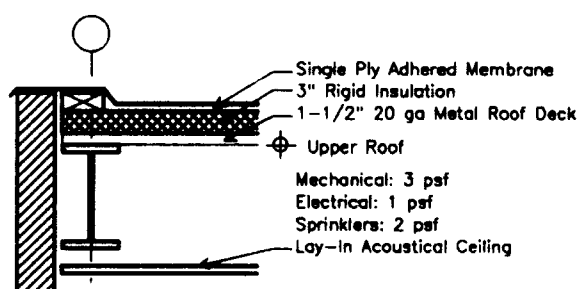
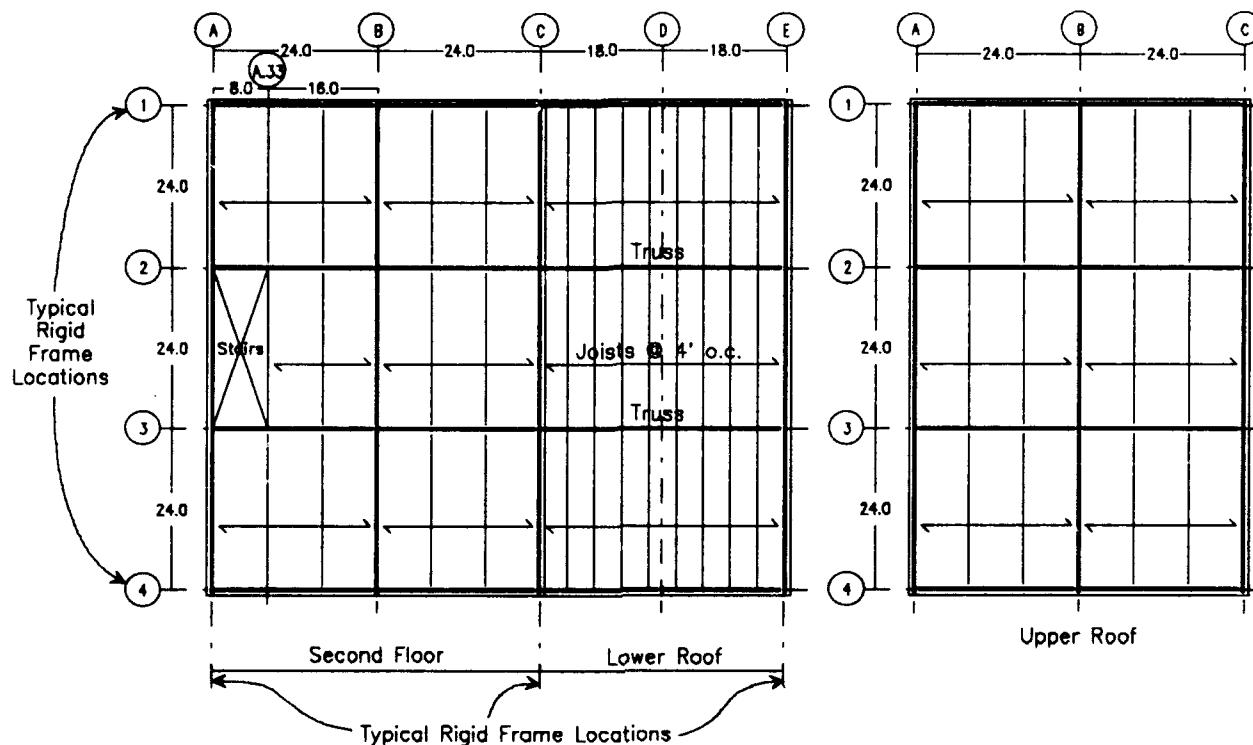
Scheme A: All steel, non-composite,
lateral load resistance = rigid frames.

Scheme B: All steel, composite,
lateral load resistance = X braced frames.

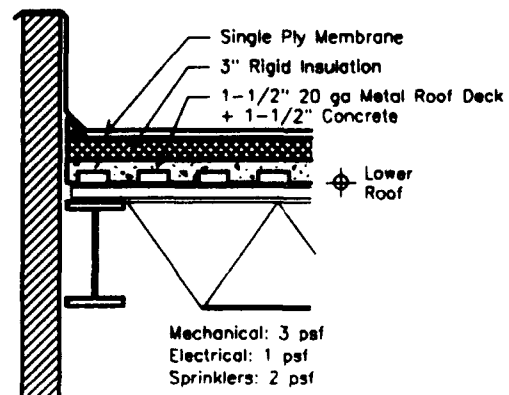
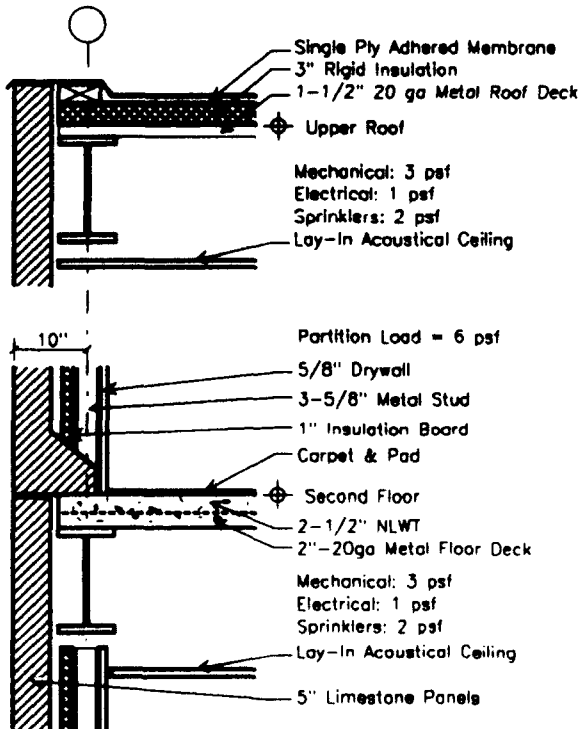
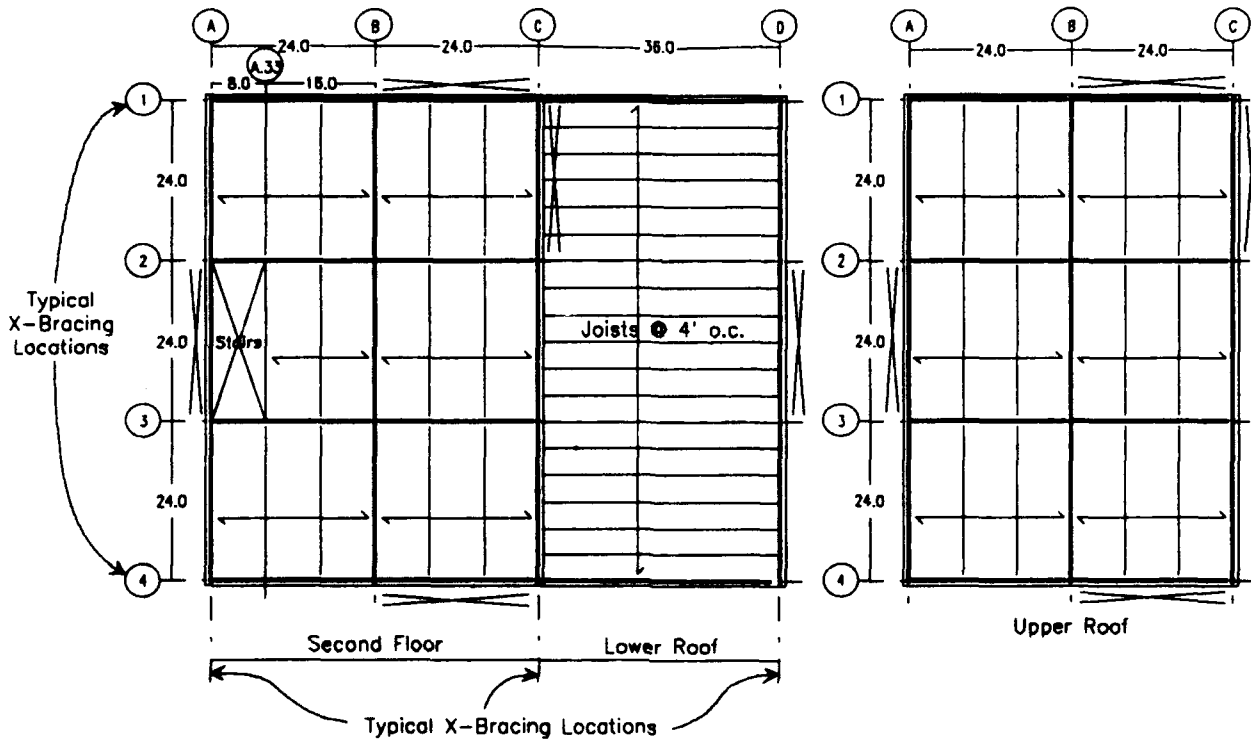
Scheme C: Monolithic concrete for two story portion, steel for lower roof portion,
lateral load resistance = shear walls.

Project Description

Scheme A

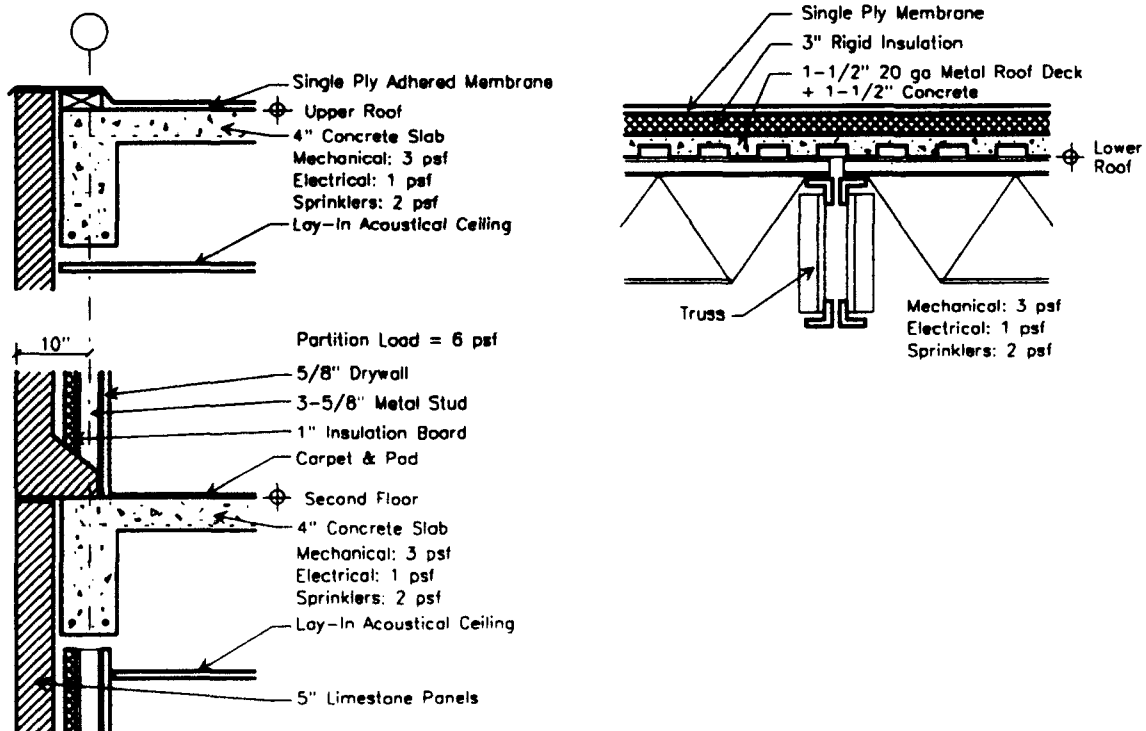
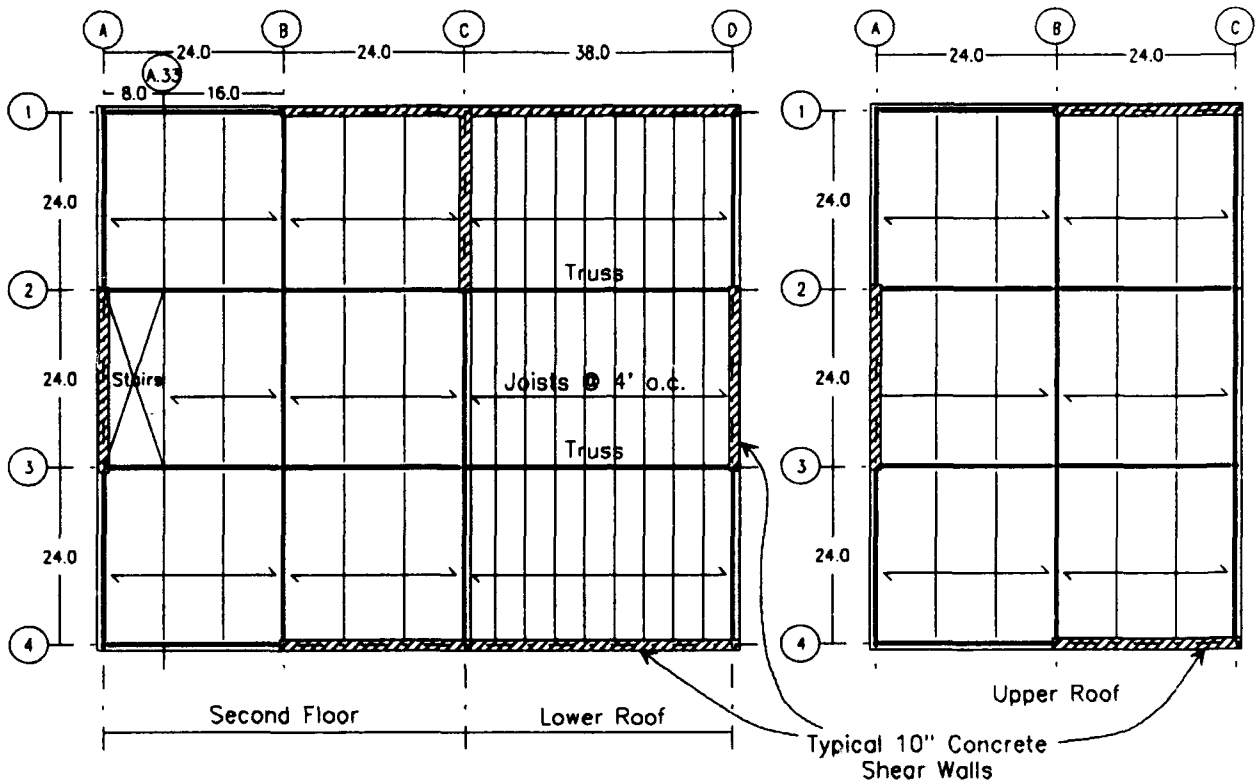


Scheme B



Project Description

Scheme C



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:

	Importance Category	Exposure Category
Snow:	I	C
Wind:	I	C
Seismic:	IV	

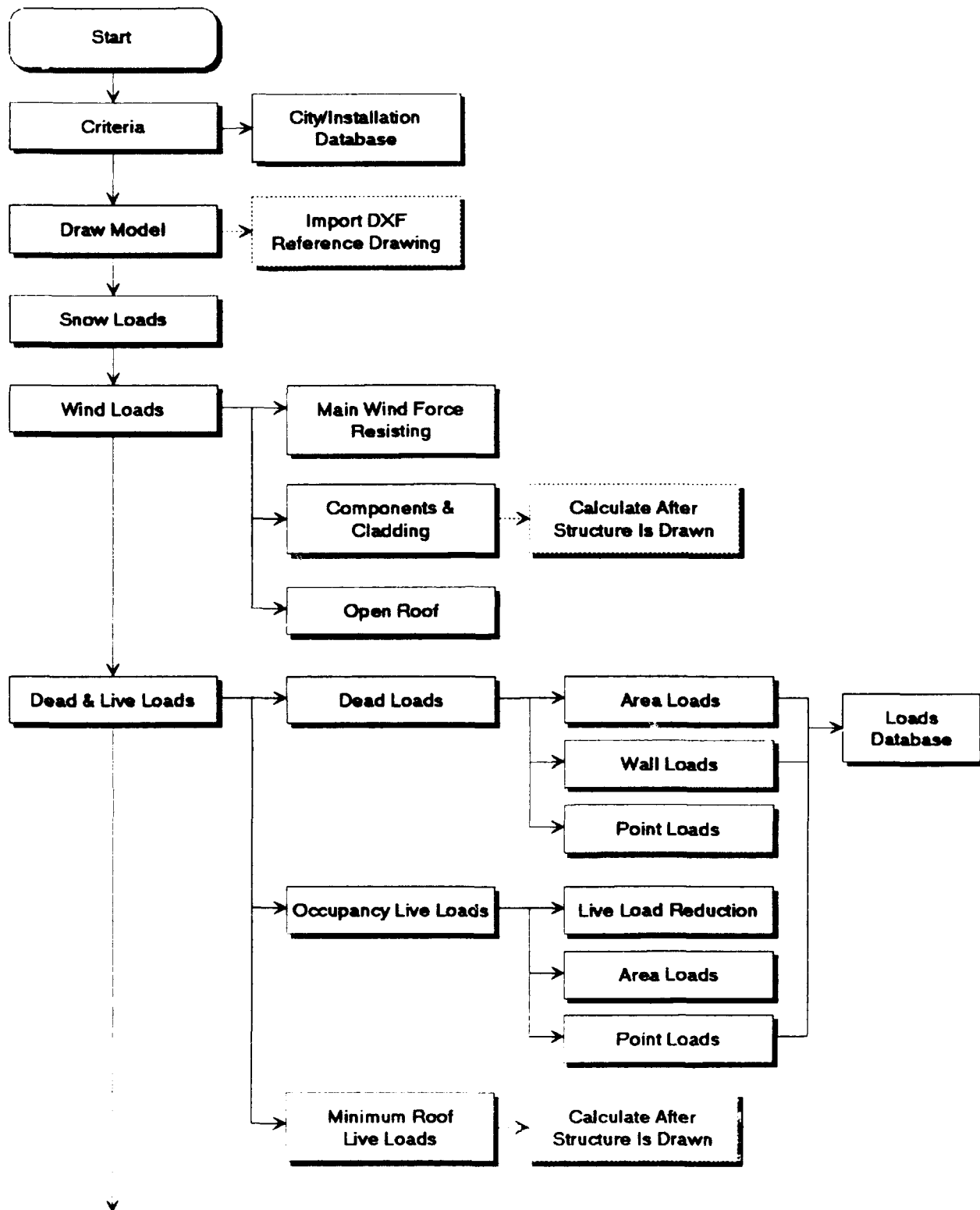
9. Material Assumptions:

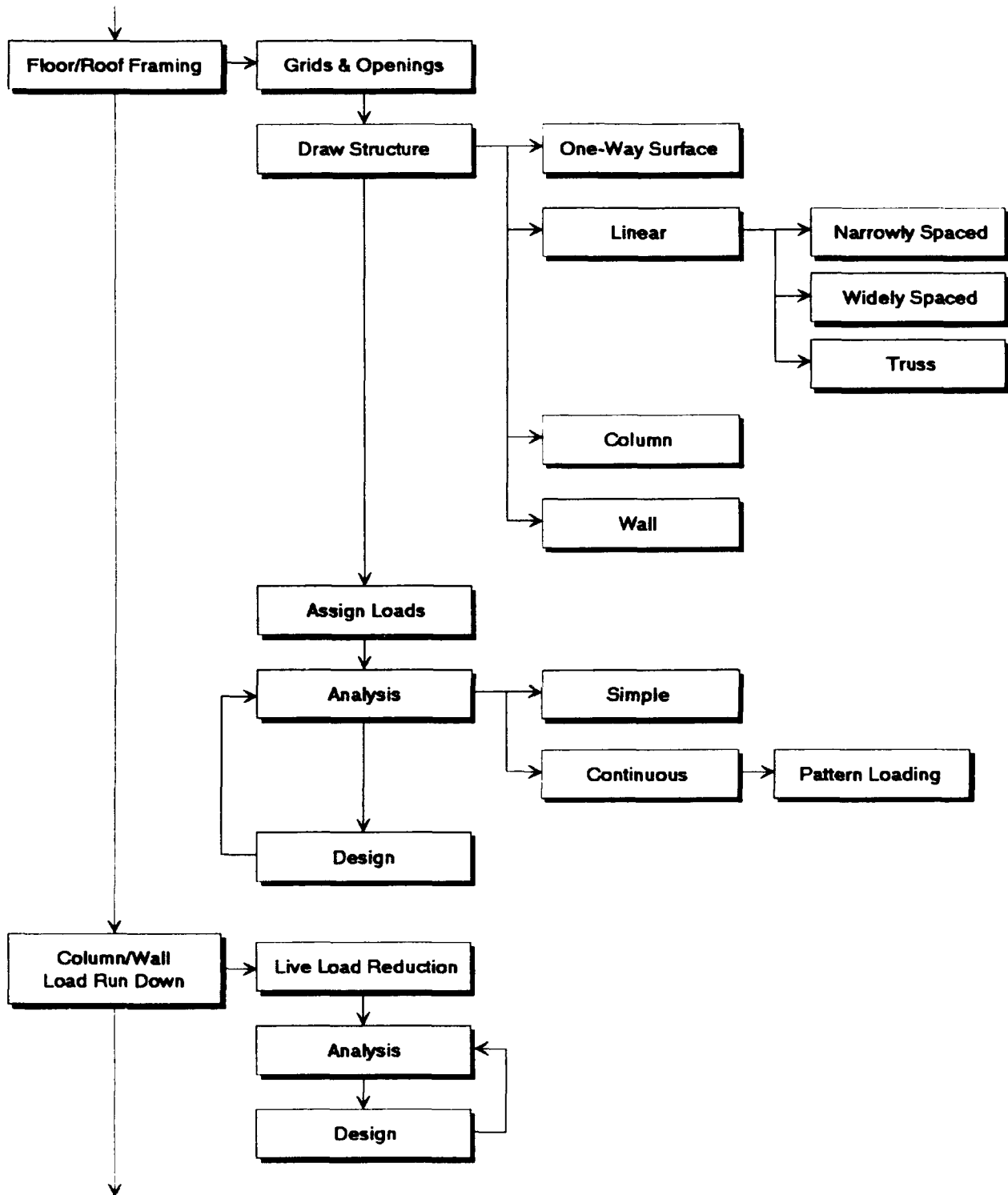
Concrete:	4,000 psi, NLWT
	Steel Reinforcing: Grade 60
Steel:	A36

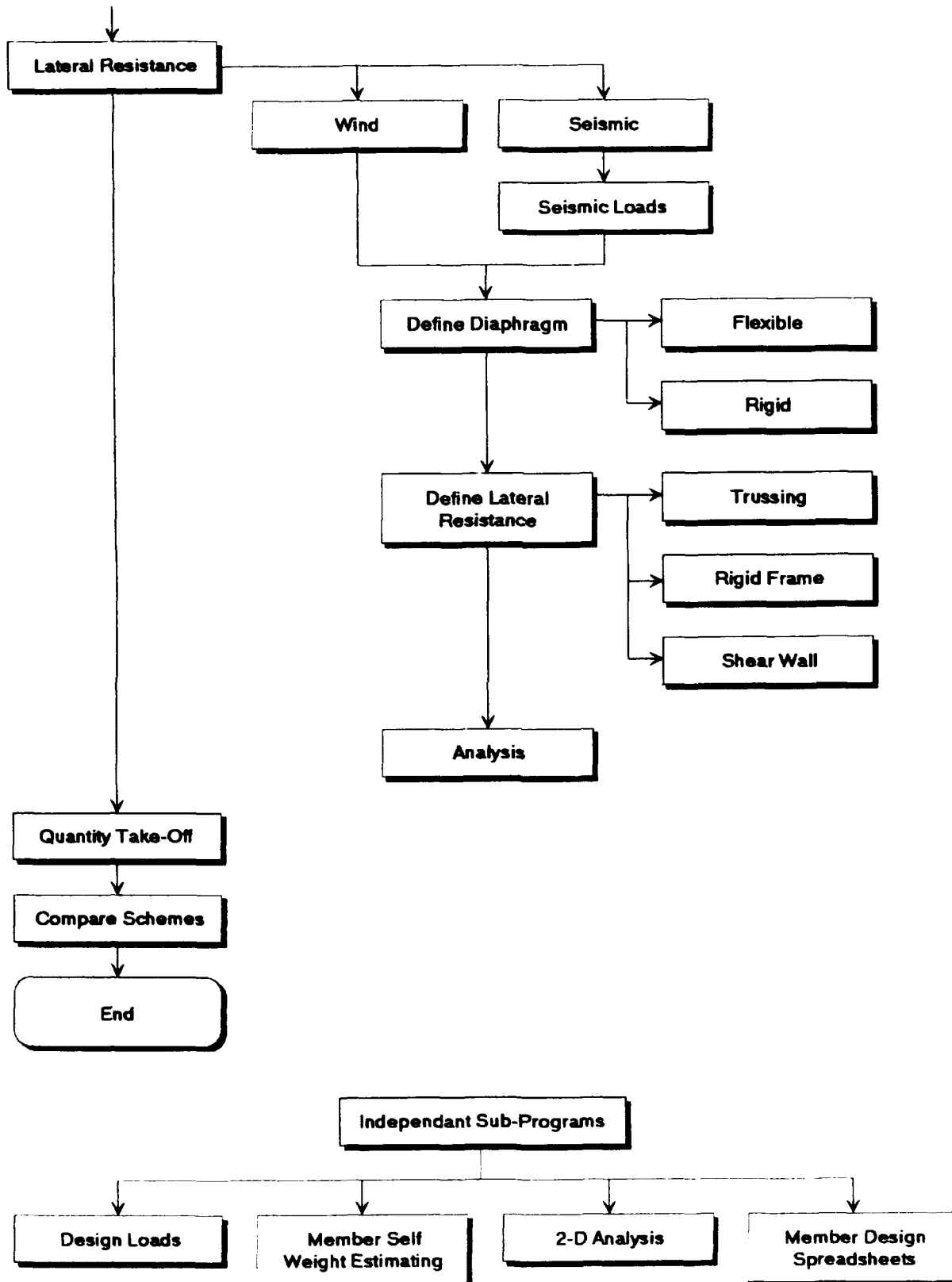
10. Fire resistance rating shall be achieved by a wet sprinkler system.



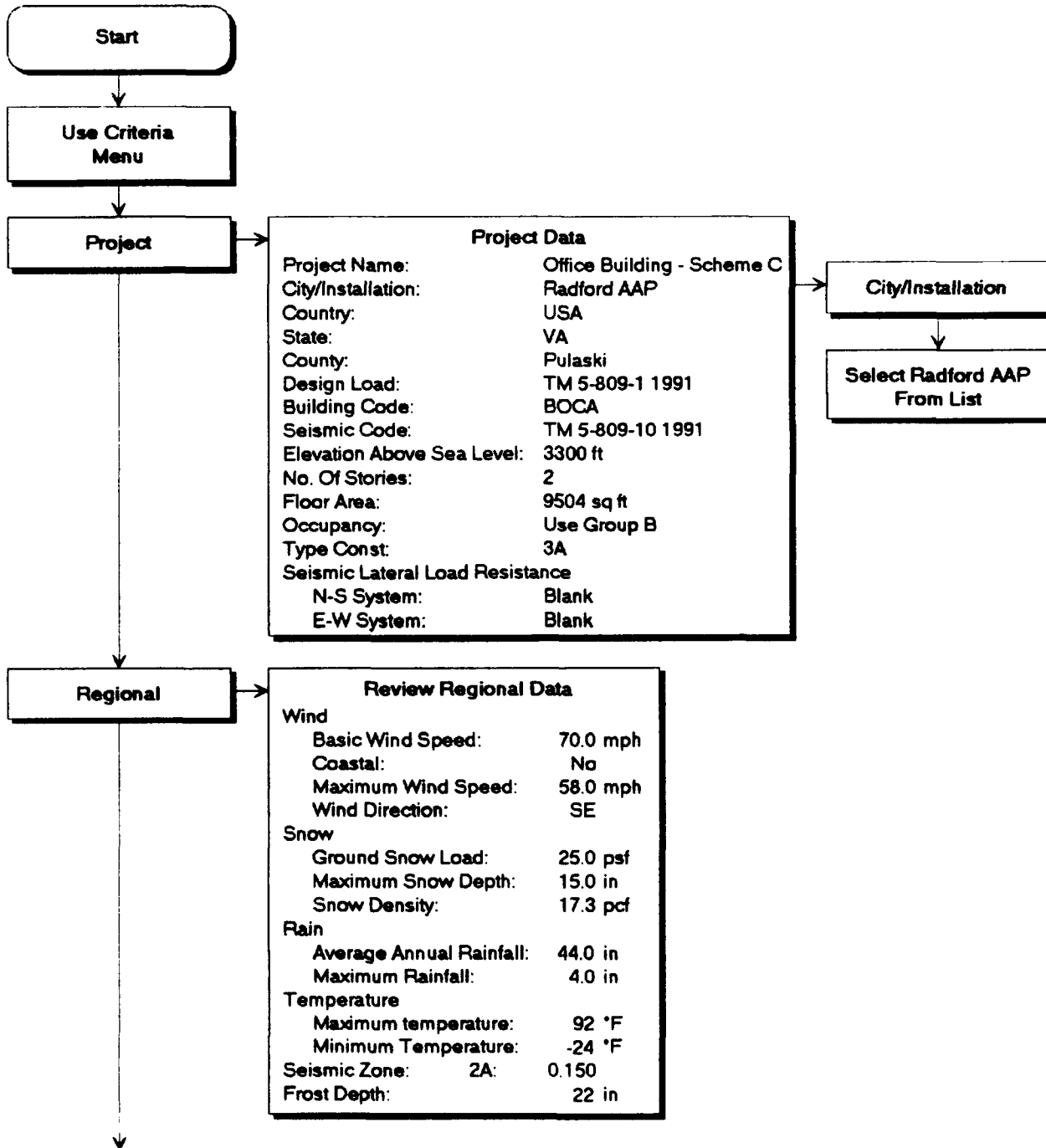
Computer Aided Structural Modeling

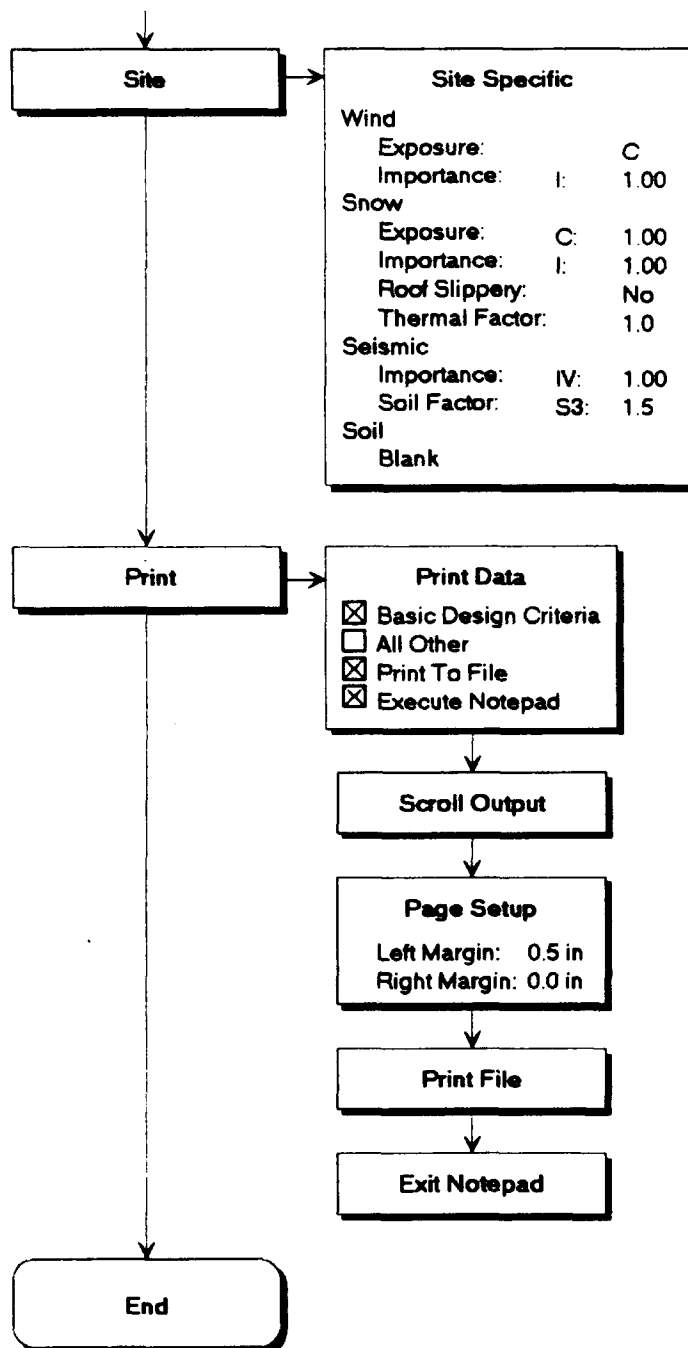






Criteria





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 :
 N-S Rw : 0
 E-W System :
 E-W Rw : 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

: 0.150

Frost Depth

: 22 in.

Site Specific Data

Wind

Exposure : C
 Importance : I : 1.00

Snow

Exposure : C : 1.00
 Importance : I : 1.00
 Roof Smooth : No
 Thermal Factor : 1.0

Seismic

Importance : IV : 1.00
 Soil Factor : S3 : 1.5

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.

Criteria

- 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

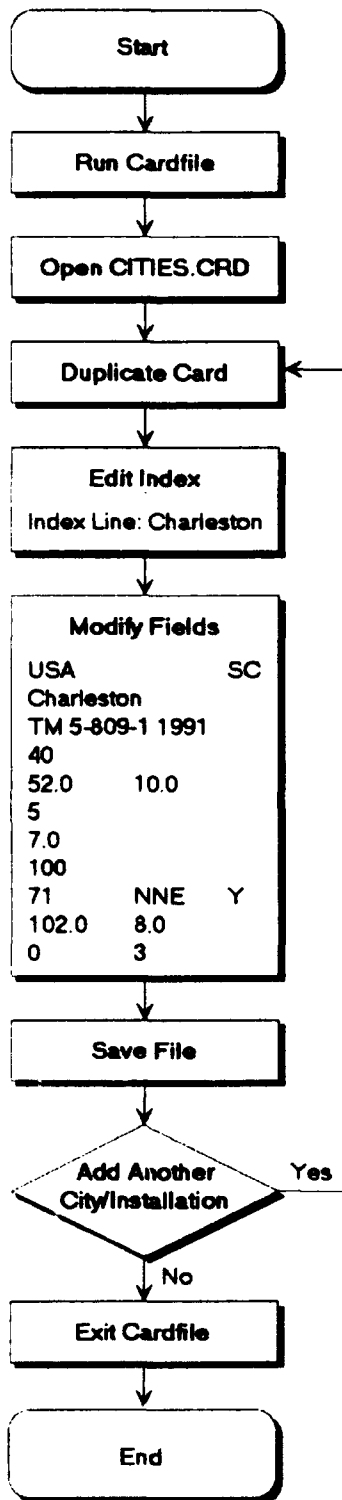
All Structures having occupancies or functions not listed above.

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



Fields		
Country		State
County		
Design Load		
Elevation (ft)		
Ave. Rain (in)	Max. Rain (in)	
Ground Snow Load (psf)		
Max. Snow Depth (in)		
Basic Wind Speed (mph)		
Max. Wind Speed (mph)	Wind Direction	Coastal (Y/N)
Max. Temp. (°F)	Min. Temp. (°F)	
Frost Depth (in)	Seismic Zone	

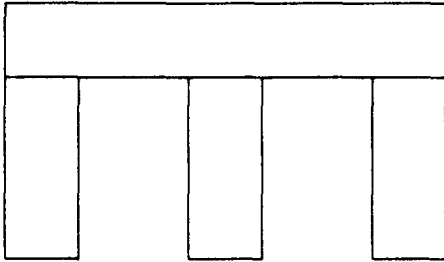


Modeling Philosophy

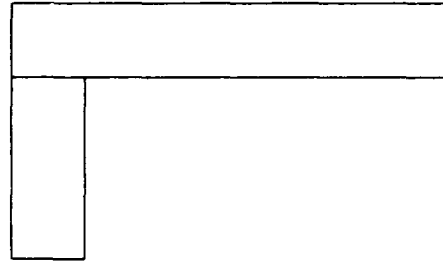
A. Simplify the geometric model

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

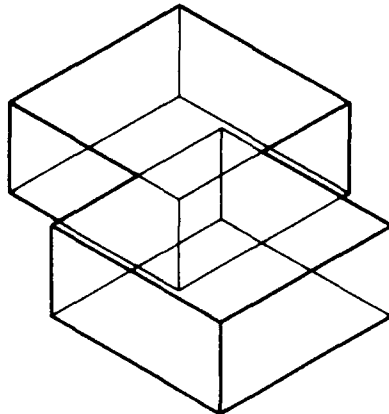
B. Make sure planes are in contact

A gap between adjoining shapes will make the surfaces exterior.

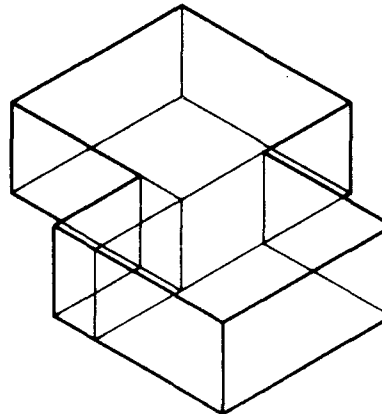
Use the Stack options to accurately place adjoining shapes.

C. Do not intersect shapes

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



Incorrect

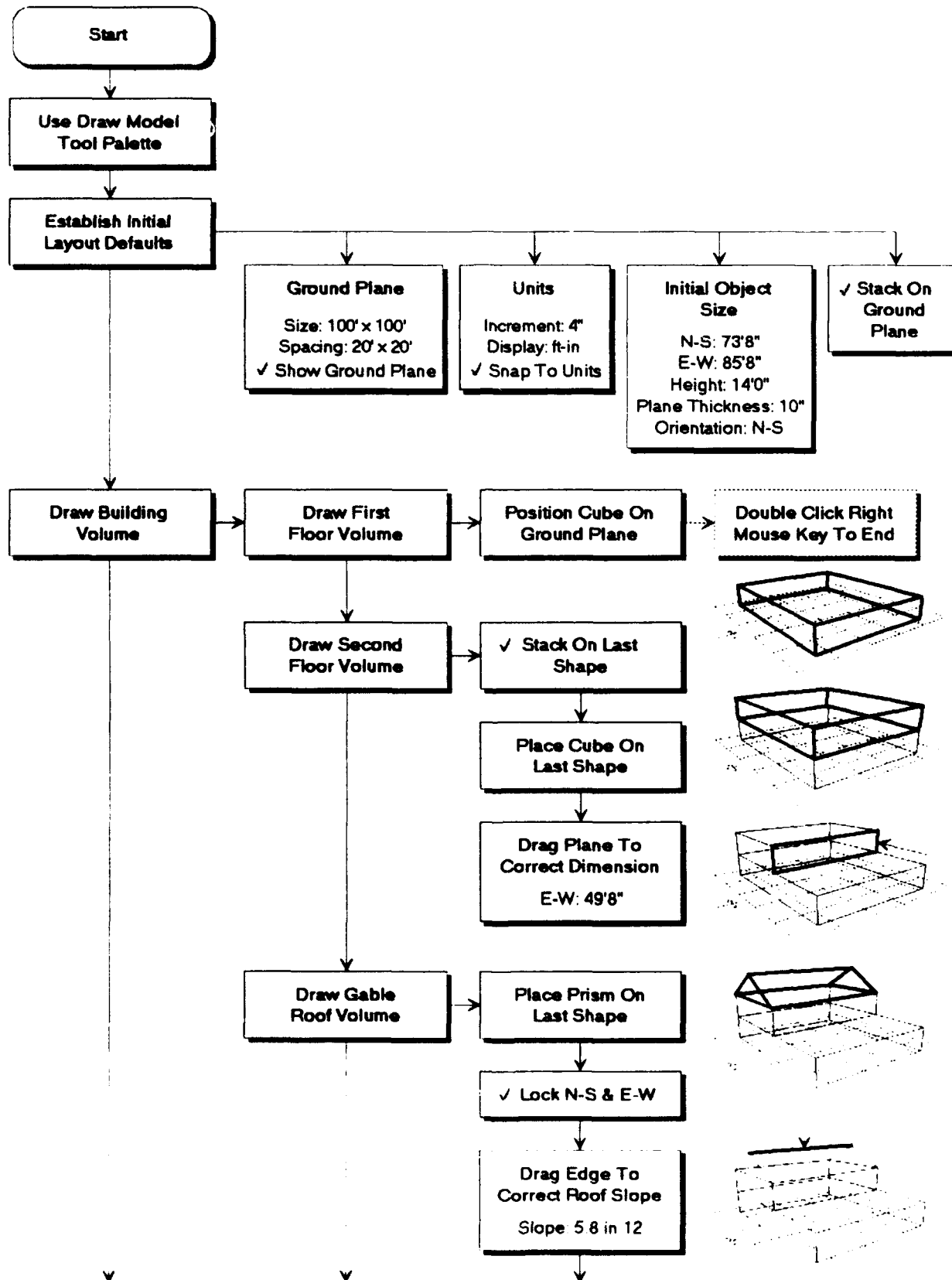


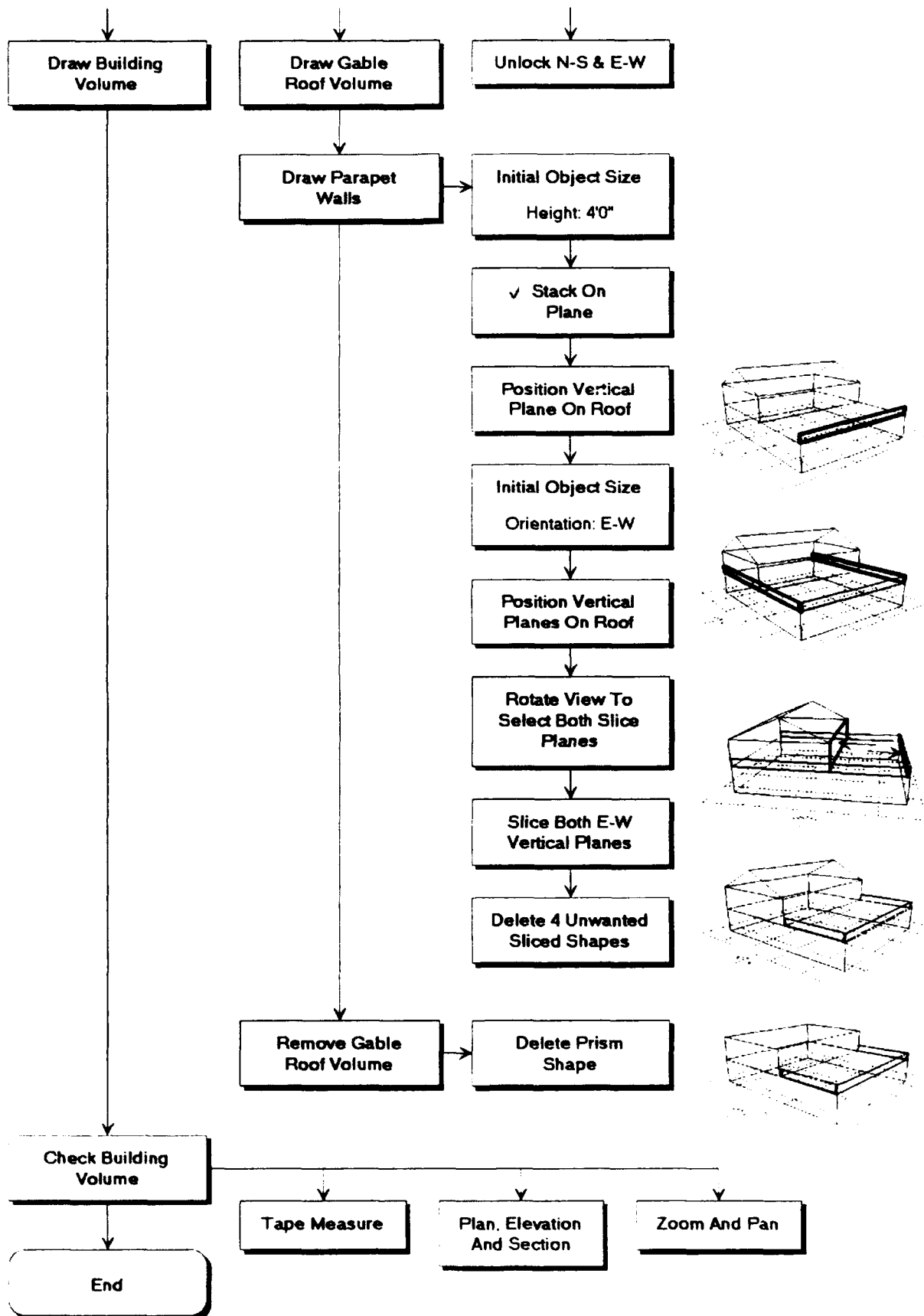
Correct

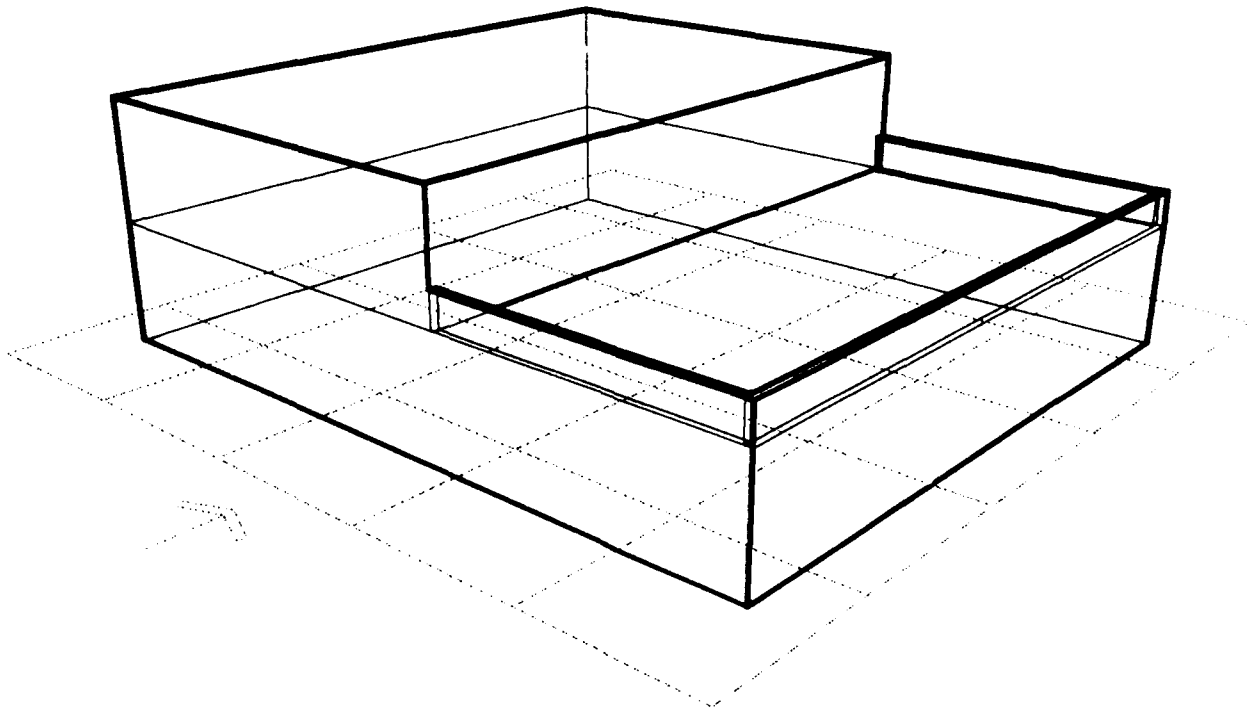
D. Verify the model

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

Draw Model

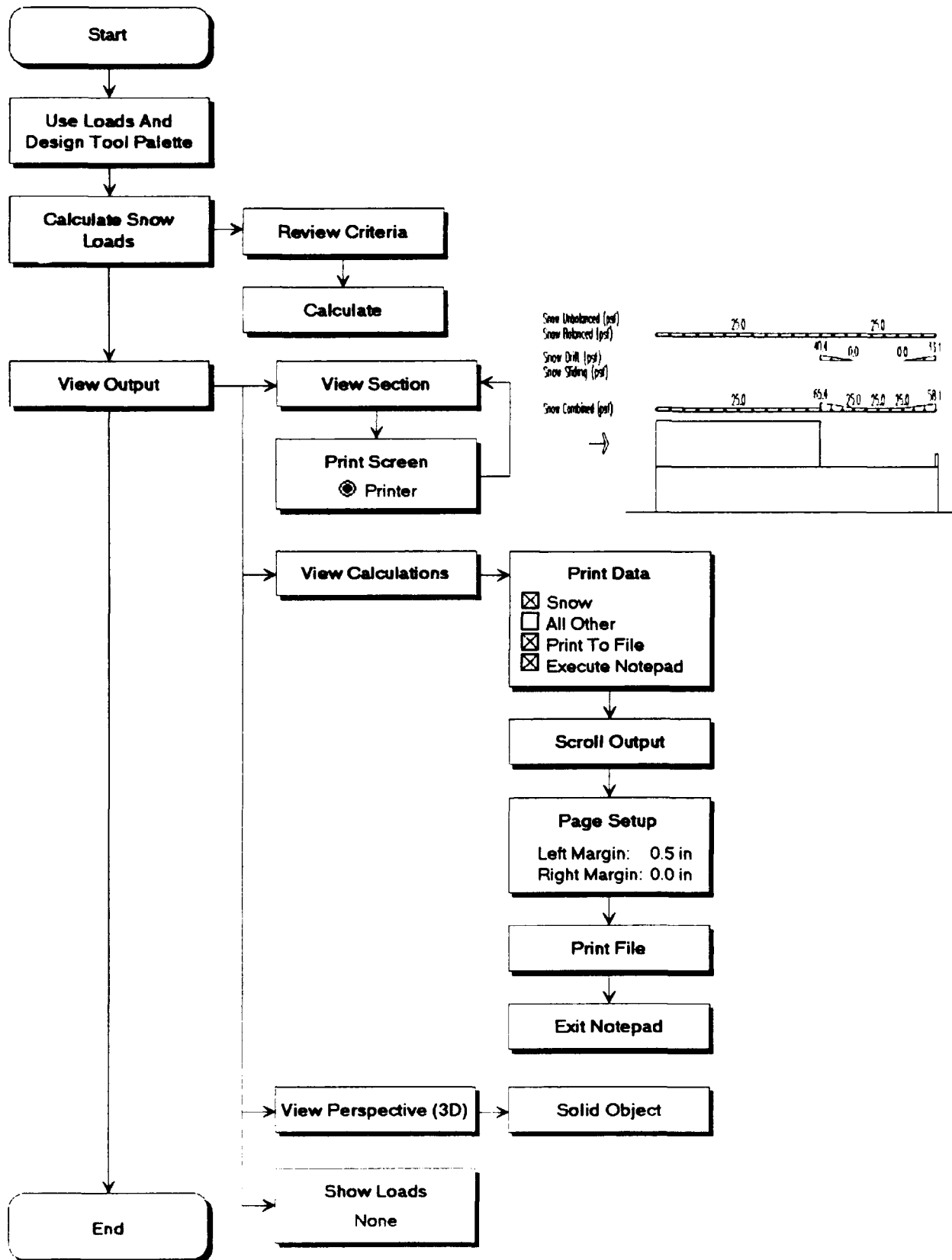








Snow Loads



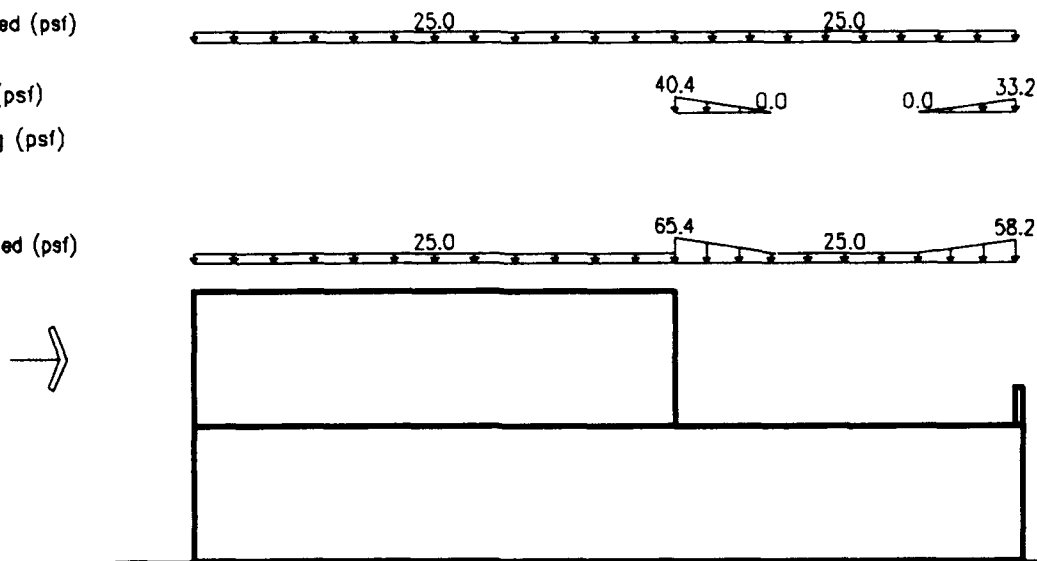
Snow Unbalanced (psf)

Snow Balanced (psf)

Snow Drift (psf)

Snow Sliding (psf)

Snow Combined (psf)



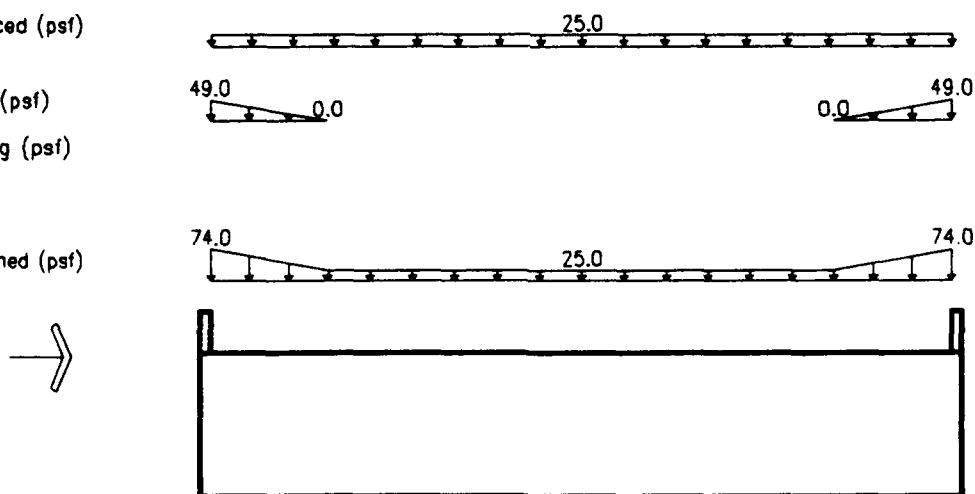
Snow Unbalanced (psf)

Snow Balanced (psf)

Snow Drift (psf)

Snow Sliding (psf)

Snow Combined (psf)



Snow Loads

Project : Office Building - Scheme C
Location : Radford AAP
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)
 $Pf = 0.7 \cdot Ce \cdot Ct \cdot I \cdot Pg$
Snow Exposure Category: C
 $Ce = 1.0$
Heated Structure.
 $Ct = 1.0$
Importance Category: I
 $I = 1.0$
 $Pg = 25.0 \text{ psf}$
 $Pf = 17.50 \text{ psf}$
Roof Slope: 0.00 in 12
Theta = 0 deg
Check minimum Pf where theta <= 15 deg
When $Pg > 20.0 \text{ psf}$, min $Pf = 20 \cdot I$
Min $Pf = 20.00 \text{ psf}$
Since theta < 1/2 in/ft, 5 psf rain-on-snow surcharge applies.

+-----+
| Pf = 25.00 psf |
+-----+

Sloped Roof Snow Load (Ps)
 $Ps = Cs \cdot Pf$
Roof Slippery: No
 $Cs = 1.00$

+-----+
| Ps = 25.00 psf |
+-----+

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

$Pg = 25.0 \text{ psf}$
Snow Density = 17.25 pcf
 $Ps = 20.00 \text{ psf}$ (rain-on-snow surcharge not included)
 $hb = Ps / \text{density}$
 $hb = 1.16 \text{ ft}$
Projection Height = 4.00 ft
 $hc = \text{height} - hb$
 $hc = 2.84 \text{ ft}$
 $hc/hb = 2.45 \geq 0.20$ Therefore consider drift load.
Importance Category: I
 $I = 1.0$

Snow Exposure Category: C
 $Ce = 1.0$
Separation = 0.00 ft
 $lu = 35.17 \text{ ft}$
 $hd = 0.43 \cdot lu^{1/3} \cdot (Pg + 10)^{1/4} - 1.5$
 $hd = 1.93 \text{ ft}$
Width of drift: $W = \text{minimum of } 4 \cdot hd \text{ or } 4 \cdot hc \geq 10 \text{ ft}$
 $w = 4 \cdot hd = 7.71 \text{ ft}$
 $w = 4 \cdot hc = 11.36 \text{ ft}$

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

$hd = hd \cdot (20 - s) / 20 = 1.93 \text{ ft}$
 $hd \leq hc$
 $Pd = hd \cdot \text{density}$

+-----+
| Pd = 33.23 psf |
+-----+

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

$P_g = 25.0 \text{ psf}$
 Snow Density = 17.25 pcf
 $P_s = 20.00 \text{ psf}$ (rain-on-snow surcharge not included)
 $h_b = P_s / \text{density}$
 $h_b = 1.16 \text{ ft}$
 Projection Height = 4.00 ft
 $h_c = \text{height} - h_b$
 $h_c = 2.84 \text{ ft}$
 $h_c / h_b = 2.45 \geq 0.20$ 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: $W = \text{minimum of } 4 * h_d \text{ or } 4 * h_c \geq 10 \text{ ft}$
 $w = 4 * h_d = 11.40 \text{ ft}$
 $w = 4 * h_c = 11.36 \text{ ft}$
 +-----+
 | $W = 11.36 \text{ ft}$ |
 +-----+

$h_d = h_d * (20 - s) / 20 = 2.85 \text{ ft}$
 $h_d > h_c$, 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 *****

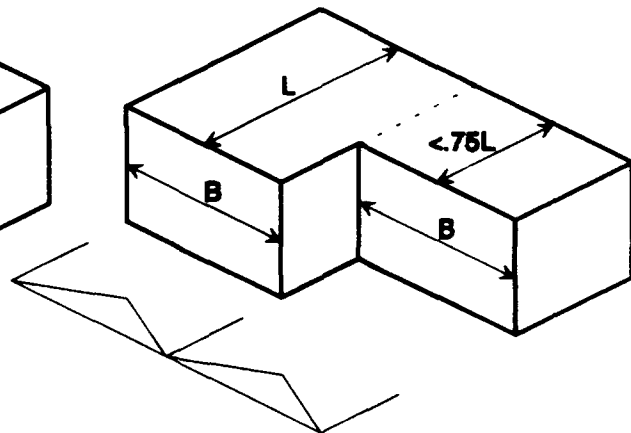
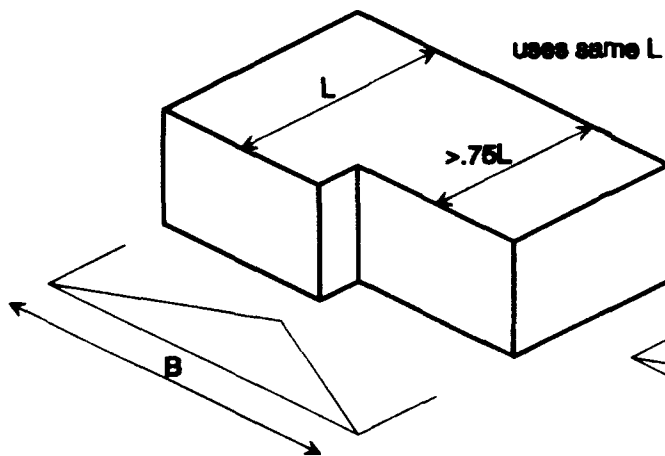
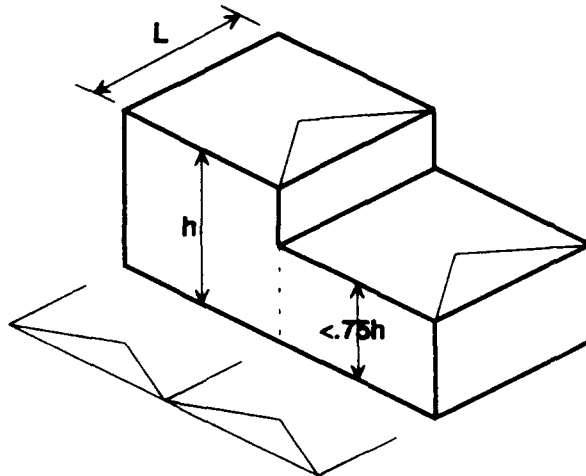
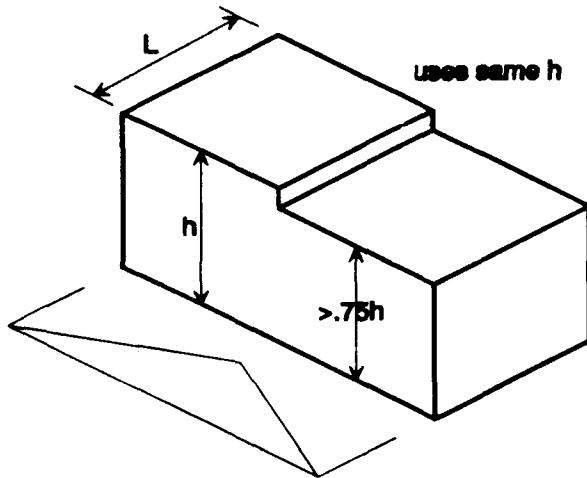
$P_g = 25.0 \text{ psf}$
 Snow Density = 17.25 pcf
 $P_s = 20.00 \text{ psf}$ (rain-on-snow surcharge not included)
 $h_b = P_s / \text{density}$
 $h_b = 1.16 \text{ ft}$
 Projection Height = 14.00 ft
 $h_c = \text{height} - h_b$
 $h_c = 12.84 \text{ ft}$
 $h_c / h_b = 11.08 \geq 0.20$ Therefore consider 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: $W = \text{minimum of } 4 * h_d \text{ or } 4 * h_c \geq 10 \text{ ft}$
 $w = 4 * h_d = 9.38 \text{ ft}$
 $w = 4 * h_c = 51.36 \text{ ft}$
 +-----+
 | $W = 10.00 \text{ ft}$ |
 +-----+

$h_d = h_d * (20 - s) / 20 = 2.34 \text{ ft}$
 $h_d \leq h_c$
 $P_d = h_d * \text{density}$
 +-----+
 | $P_d = 40.44 \text{ psf}$ |
 +-----+

Wind Assumptions

Proportions For B/L & h/L

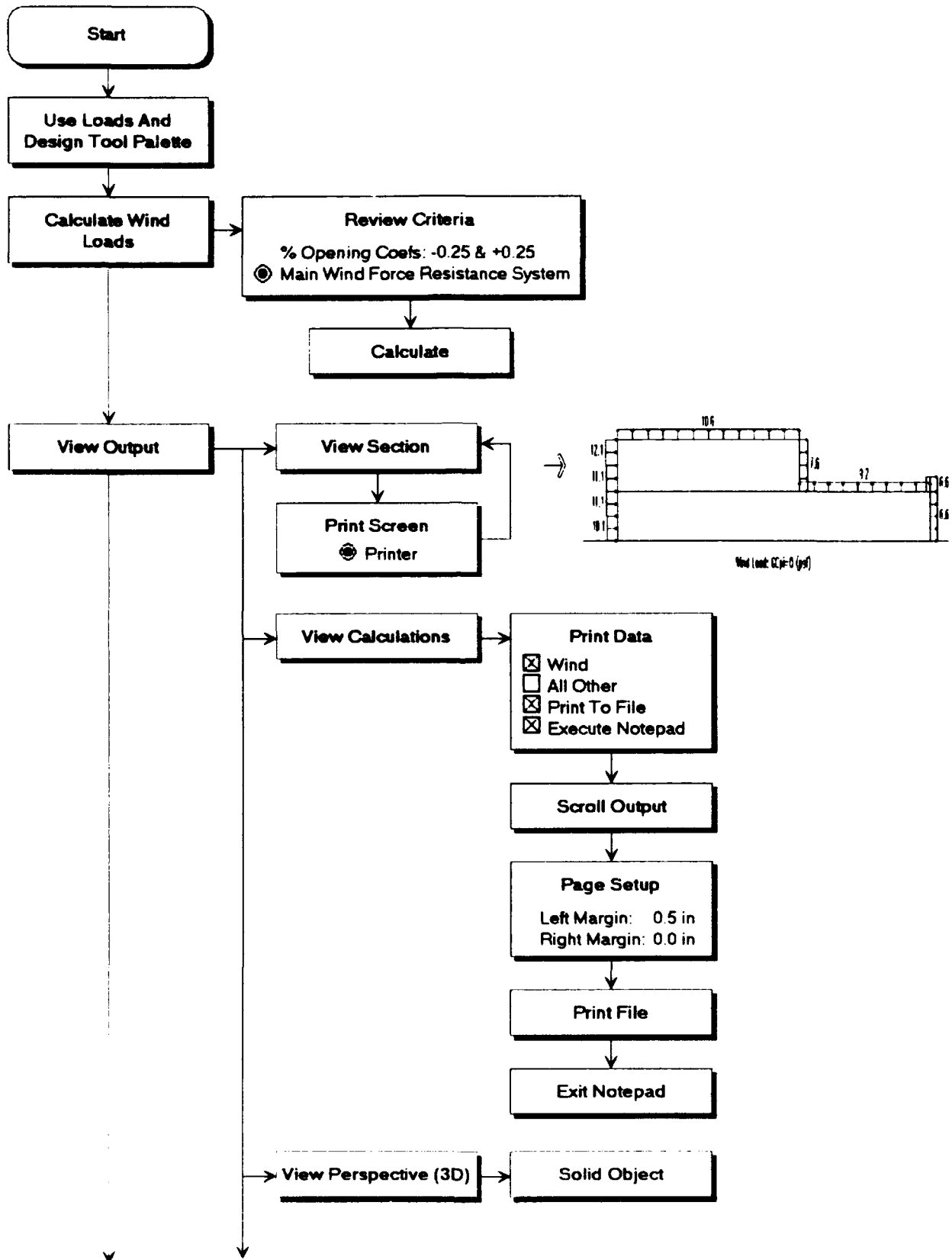
Defaults:	Height Ratio:	0.75
	Plan Ratio:	0.75



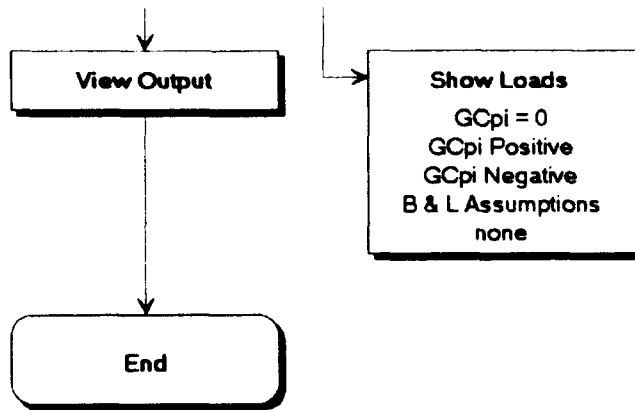
Building Height Maximum 60 Feet

Assumed for components and cladding

Main Wind Force Resisting Loads

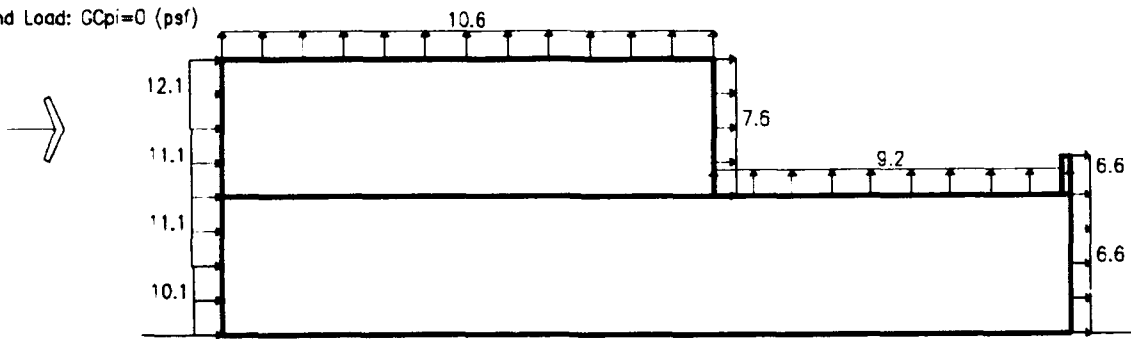


Main Wind Force Resisting Loads

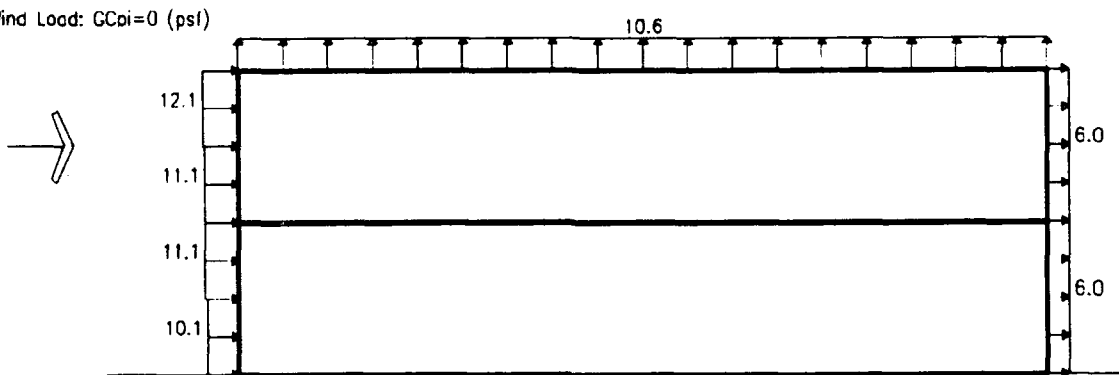


Main Wind Force Resisting Loads

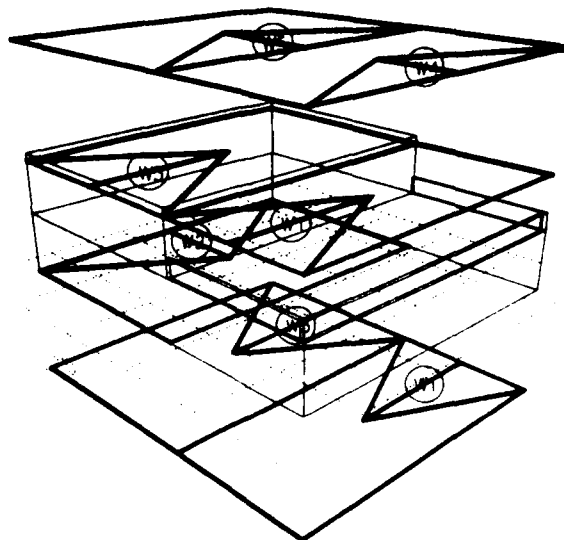
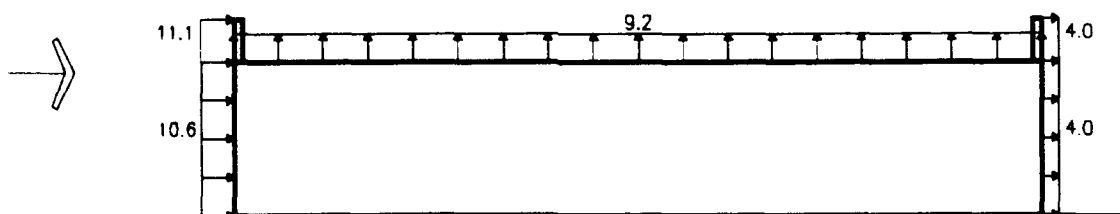
Wind Load: $GC_{pi}=0$ (psf)



Wind Load: $GC_{pi}=0$ (psf)



Wind Load: $GC_{pi}=0$ (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 *****

Velocity (mph)	Importance Factor	Exposure	Width Perpend. to Wind (ft)	Length Parallel to Wind (ft)	Roof Type
70.0	1.00	C	36.0	73.7	

Distance to ocean line ≥ 100 mi. $h/d = 0.39 \leq 5$

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

Parallel to Ridge or Length

Location	z or h (ft)	Gh	Kz	qz (psf)	Cp	External Pressure P (psf) GCpi=0 -0.25 0.25
Windward Wall						
parapet	22.0	1.32	0.89	11.2	0.80	11.8
level 3	18.0	1.32	0.84	10.5	0.80	11.1
level 2 - 3	16.0	1.32	0.82	10.3	0.80	10.9
level 1 - 2	7.0	1.32	0.80	10.0	0.80	10.6
level 1	0.0	1.32	0.80	10.0	0.80	10.6
Leeward Wall	14.0	1.32	0.80	10.0	-0.30	-4.0
Side Wall	14.0	1.32	0.80	10.0	-0.70	-9.2
Roof	14.0	1.32	0.80	10.0	-0.70	-9.2
Internal	14.0		0.80	10.0		0.0

***** Wind Load - 2 *****

Velocity (mph)	Importance Factor	Exposure	Width Perpend. to Wind (ft)	Length Parallel to Wind (ft)	Roof Type
70.0	1.00	C	73.7	49.7	

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

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

Parallel to Ridge or Length

Location	z or h (ft)	Gh	Kz	qz (psf)	Cp	External Pressure P (psf) GCpi=0 -0.25 0.25
Windward Wall						
level 3	28.0	1.26	0.96	12.0	0.80	12.1
level 2 - 3	21.0	1.26	0.88	11.0	0.80	11.1
level 1 - 2	7.0	1.26	0.80	10.0	0.80	10.1
level 1	0.0	1.26	0.80	10.0	0.80	10.1
Leeward Wall	28.0	1.26	0.96	12.0	-0.50	-7.6
Side Wall	28.0	1.26	0.96	12.0	-0.70	-10.6
Roof	28.0	1.26	0.96	12.0	-0.70	-10.6
Internal	28.0		0.96	12.0		0.0

Main Wind Force Resisting Loads

***** Wind Load - 3 *****

Velocity (mph)	Importance Factor	Exposure	Width Perpend. to Wind (ft)	Length Parallel to Wind (ft)	Roof Type
70.0	1.00	C	49.7	73.7	

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

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

Parallel to Ridge or Length

Location	z or h (ft)	Gh	Kz	qz (psf)	Cp	External Pressure P (psf) GCpi=0	-0.25	0.25
Windward Wall								
level 3	28.0	1.26	0.96	12.0	0.80	12.1	15.1	9.1
level 2 - 3	21.0	1.26	0.88	11.0	0.80	11.1	14.1	8.1
level 1 - 2	7.0	1.26	0.80	10.0	0.80	10.1	13.1	7.1
level 1	0.0	1.26	0.80	10.0	0.80	10.1	13.1	7.1
Leeward Wall	28.0	1.26	0.96	12.0	-0.40	-6.0	-3.0	-9.0
Side Wall	28.0	1.26	0.96	12.0	-0.70	-10.6	-7.6	-13.6
Roof	28.0	1.26	0.96	12.0	-0.70	-10.6	-7.6	-13.6
Internal	28.0		0.96	12.0		0.0	-3.0	3.0

***** Wind Load - 4 *****

Velocity (mph)	Importance Factor	Exposure	Width Perpend. to Wind (ft)	Length Parallel to Wind (ft)	Roof Type
70.0	1.00	C	73.7	36.0	

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

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

Parallel to Ridge or Length

Location	z or h (ft)	Gh	Kz	qz (psf)	Cp	External Pressure P (psf) GCpi=0	-0.25	0.25
Windward Wall								
parapet	22.0	1.32	0.89	11.2	0.80	11.8		
level 3	18.0	1.32	0.84	10.5	0.80	11.1	13.6	8.6
level 2 - 3	16.0	1.32	0.82	10.3	0.80	10.9	13.4	8.4
level 1 - 2	7.0	1.32	0.80	10.0	0.80	10.6	13.1	8.1
level 1	0.0	1.32	0.80	10.0	0.80	10.6	13.1	8.1
Leeward Wall	14.0	1.32	0.80	10.0	-0.50	-6.6	-4.1	-9.1
Side Wall	14.0	1.32	0.80	10.0	-0.70	-9.2	-6.7	-11.7
Roof	14.0	1.32	0.80	10.0	-0.70	-9.2	-6.7	-11.7
Internal	14.0		0.80	10.0		0.0	-2.5	2.5

Main Wind Force Resisting Loads

***** Wind Load - 5 *****

Velocity (mph)	Importance Factor	Exposure	Width Perpend. to Wind (ft)	Length Parallel to Wind (ft)	Roof Type
70.0	1.00	C	73.7	49.7	

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

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

Parallel to Ridge or Length

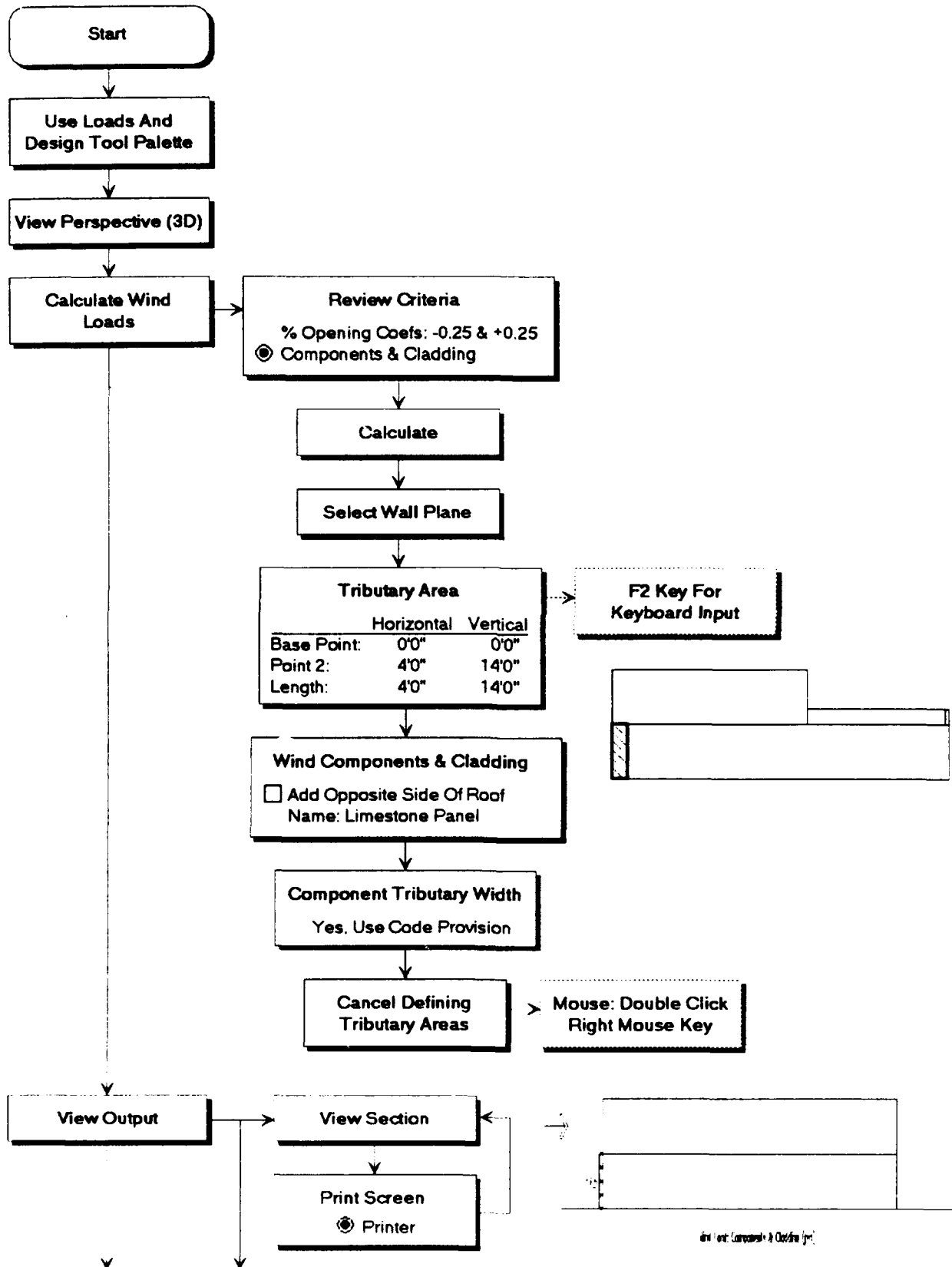
Location	z or h (ft)	Gh	Kz	qz (psf)	Cp	External Pressure GCpi=0	Pressure P (psf) -0.25 0.25
Windward Wall							
level 2	28.0	1.26	0.96	12.0	0.80	12.1	15.1 9.1
level 1 - 2	14.0	1.26	0.80	10.0	0.80	10.1	13.1 7.1
level 1	0.0	1.26	0.80	10.0	0.80	10.1	13.1 7.1
Leeward Wall	28.0	1.26	0.96	12.0	-0.50	-7.6	-4.6 -10.6
Side Wall	28.0	1.26	0.96	12.0	-0.70	-10.6	-7.6 -13.6
Roof	28.0	1.26	0.96	12.0	-0.70	-10.6	-7.6 -13.6
Internal	28.0		0.96	12.0		0.0	-3.0 3.0

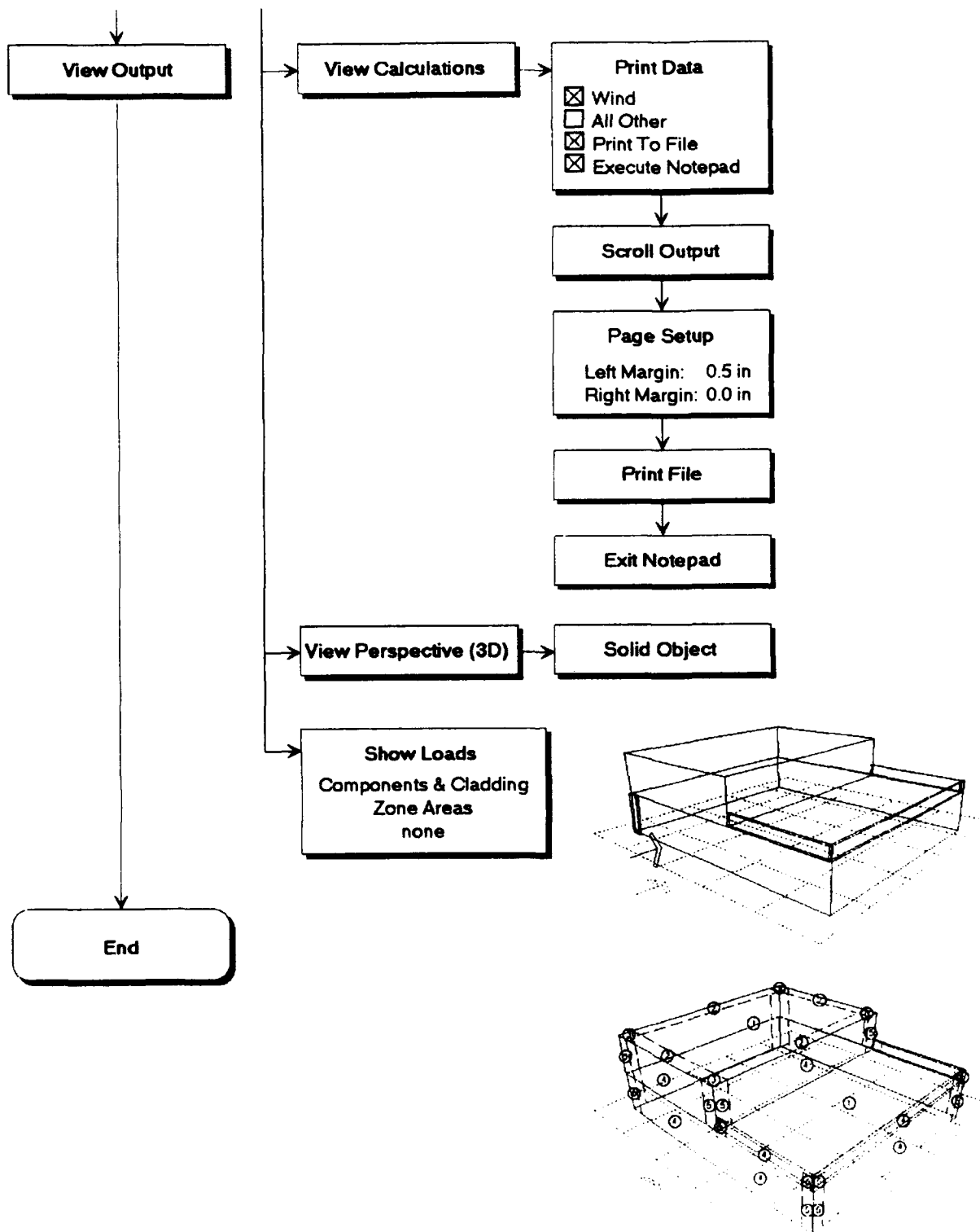
Notes for main framing:

Positive pressures act toward surfaces.

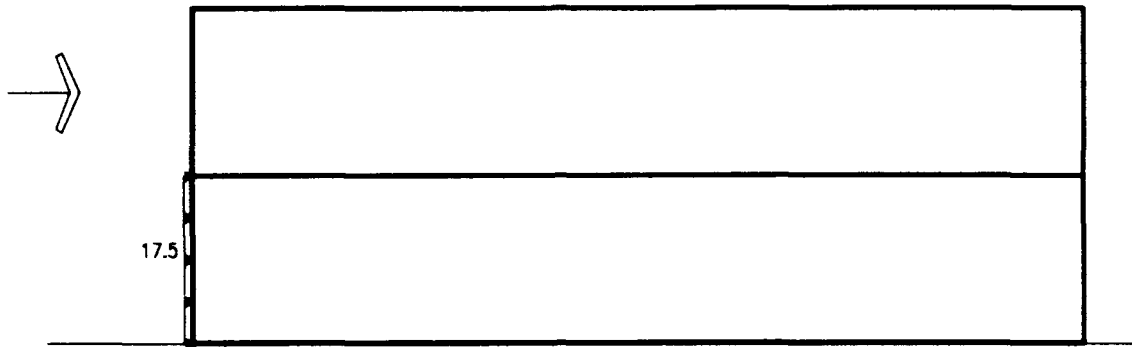
Pressure or suction = $P = qh \cdot Gh \cdot Cp - qh \cdot (GCpi)$

Wind Components & Cladding Loads

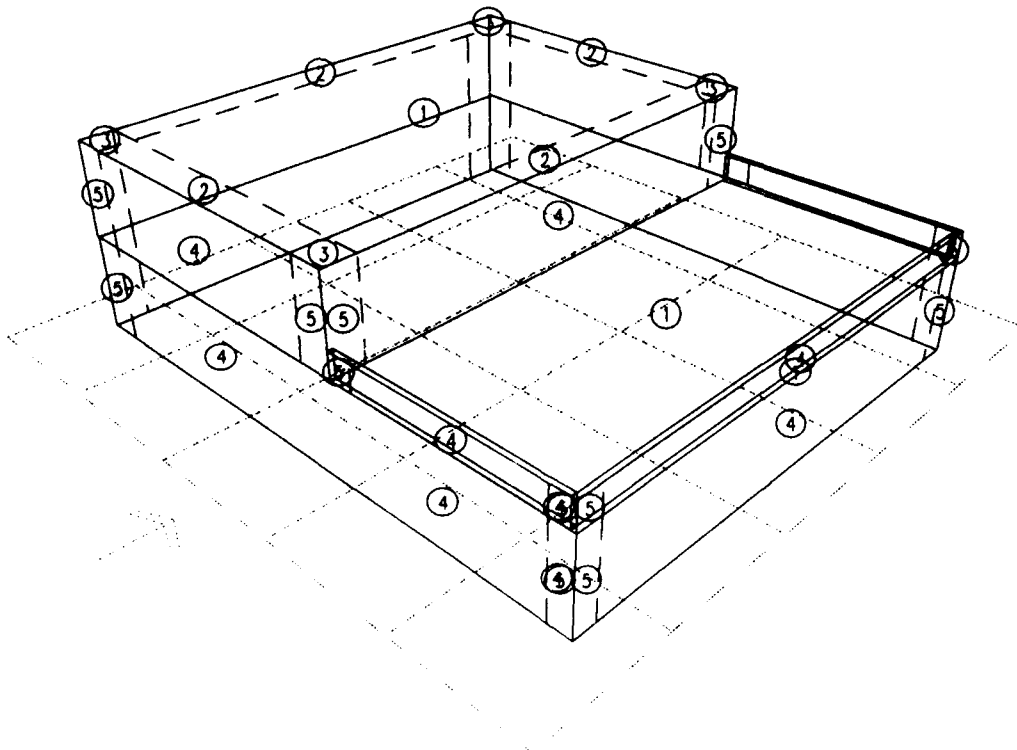
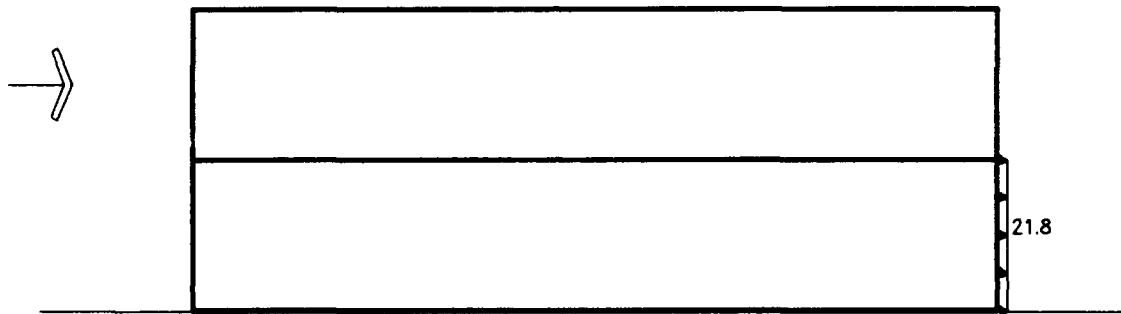




Wind Load: Components & Cladding (psf)



Wind Load: Components & Cladding (psf)



Wind Components & Cladding Loads

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

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

Velocity (mph)	Importance Factor	Exposure	Width Perpend. to Wind (ft)	Length Parallel to Wind (ft)	Roof Type
70.0	1.00	C	49.7	73.7	

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

Height (ft)	Kh	qh (psf)	GCpi
28.0	0.96	12.0	-0.25 0.25

Height <= 60 ft

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

Tributary Area (sf)	-----Walls-----							
	Windward				Leeward			
	Zone 4 middles		Zone 5 corners		Zone 4 middles		Zone 5 corners	
	GCp	P	GCp	P	GCp	P	GCp	P
Internal	-3.0		-3.0		3.0		3.0	
Limestone Panel	4.67 ft x 14.00 ft	**						
65.3	1.21	17.5	1.21	17.5	-1.31	-18.7	-1.57	-21.8
a = 5.0 ft								

Notes for components and cladding:

P = qh(GCp)-qh(GCpi)

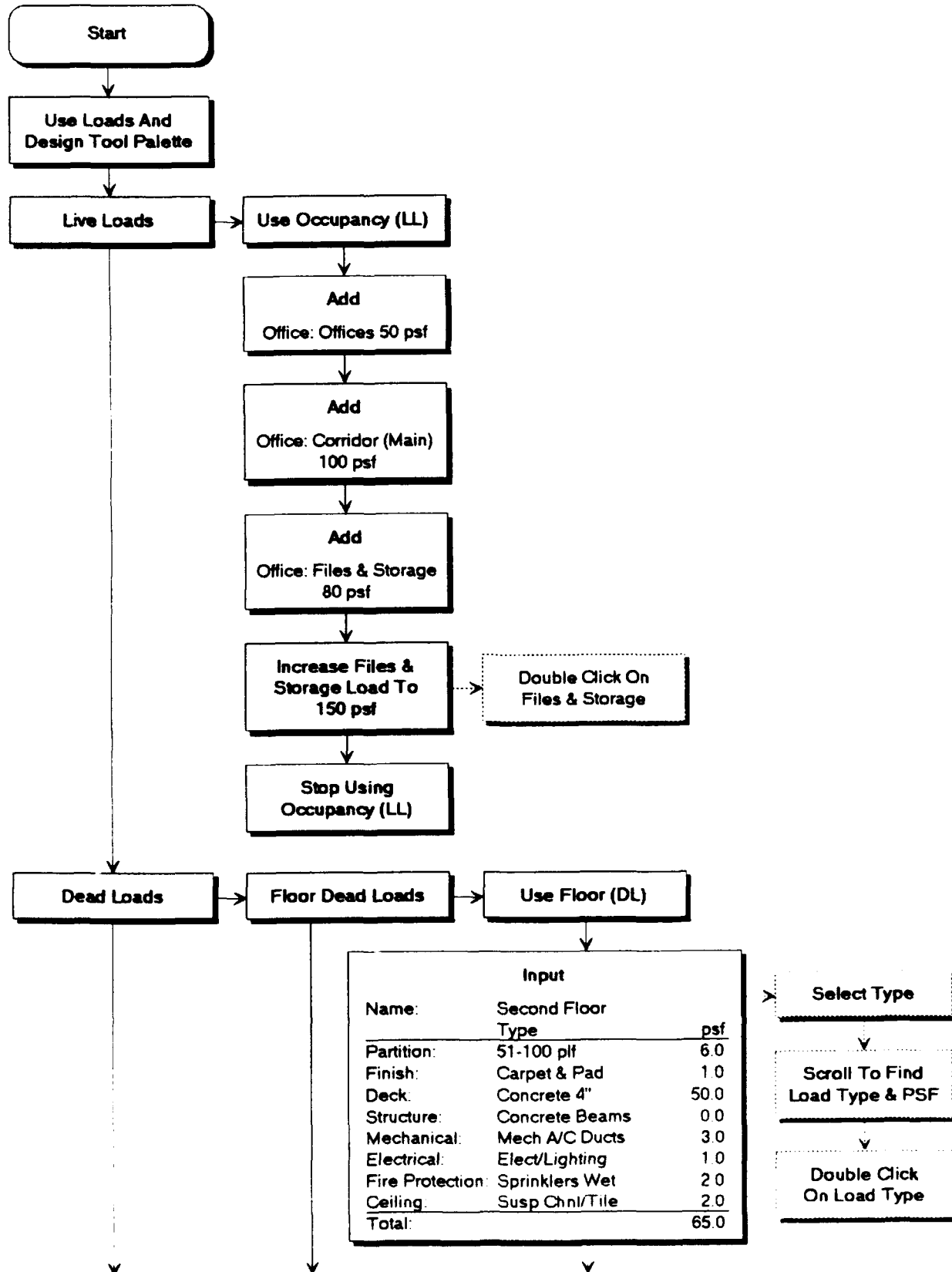
Internal pressures have been included in above values.

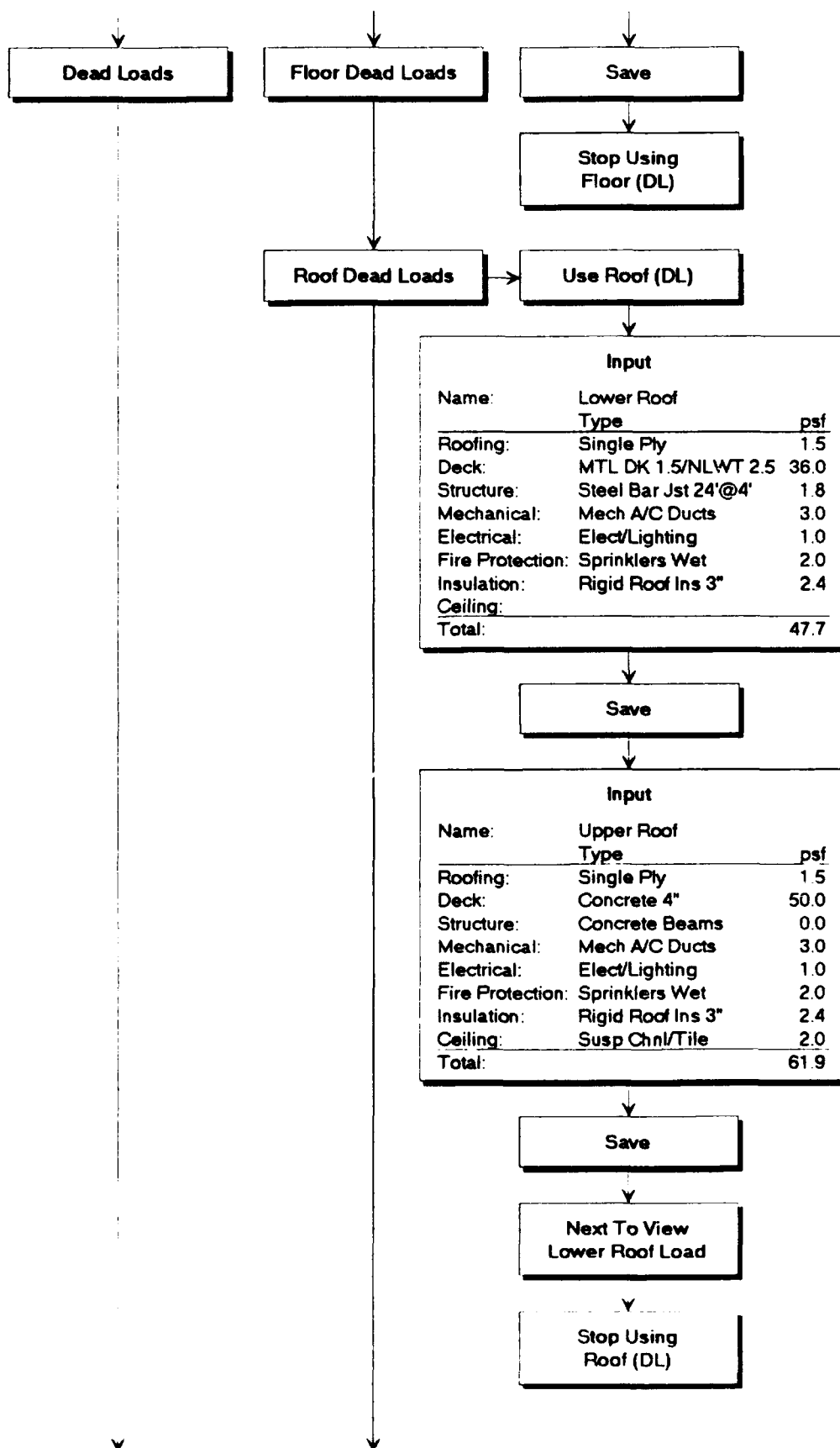
* For roof overhangs: algebraically add this pressure to the above values. P = qh(GCp) = 0.8qh

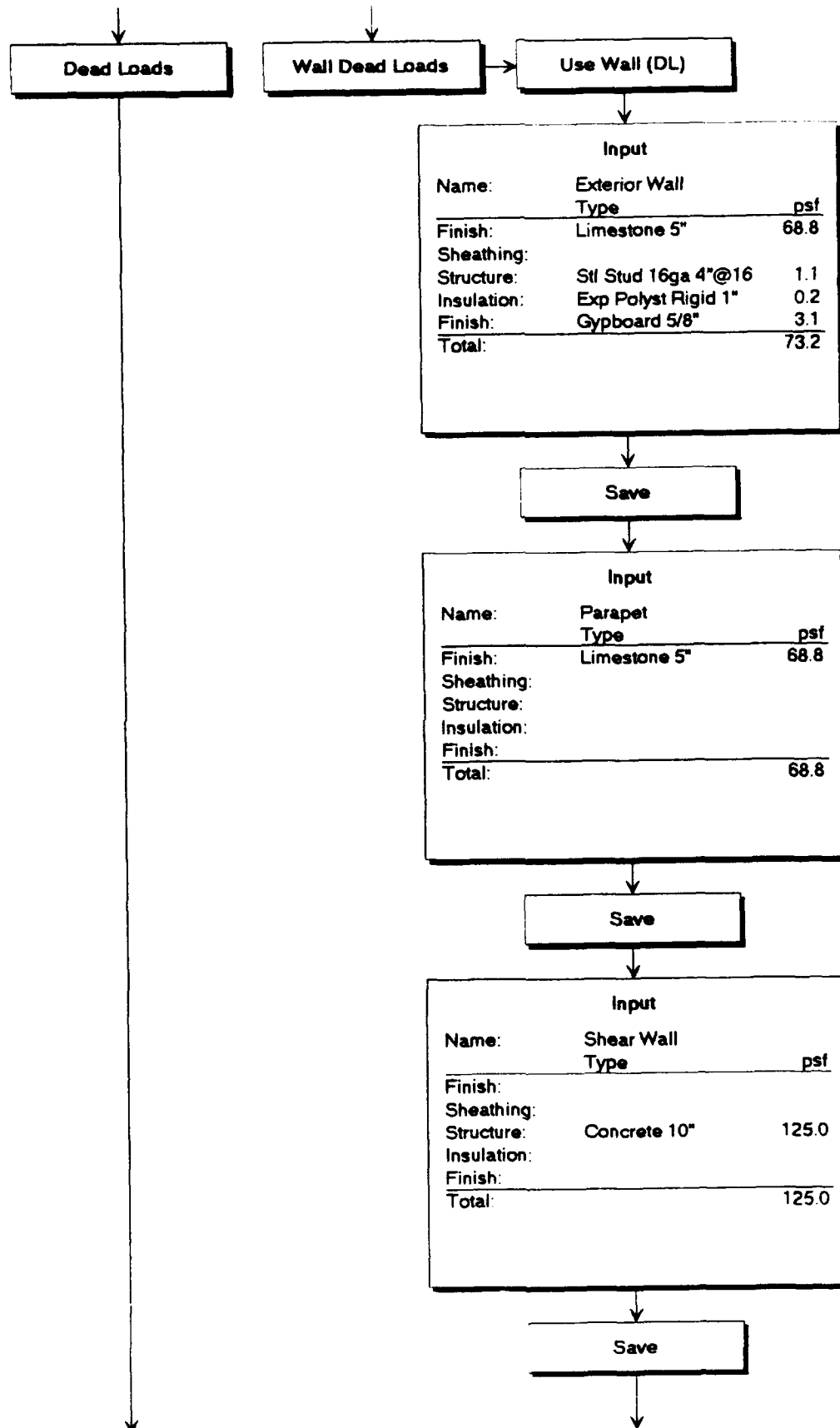
To comply with TM 5-809-1, wall external pressures have not been reduced 10% per ASCE figure 3, note 3.

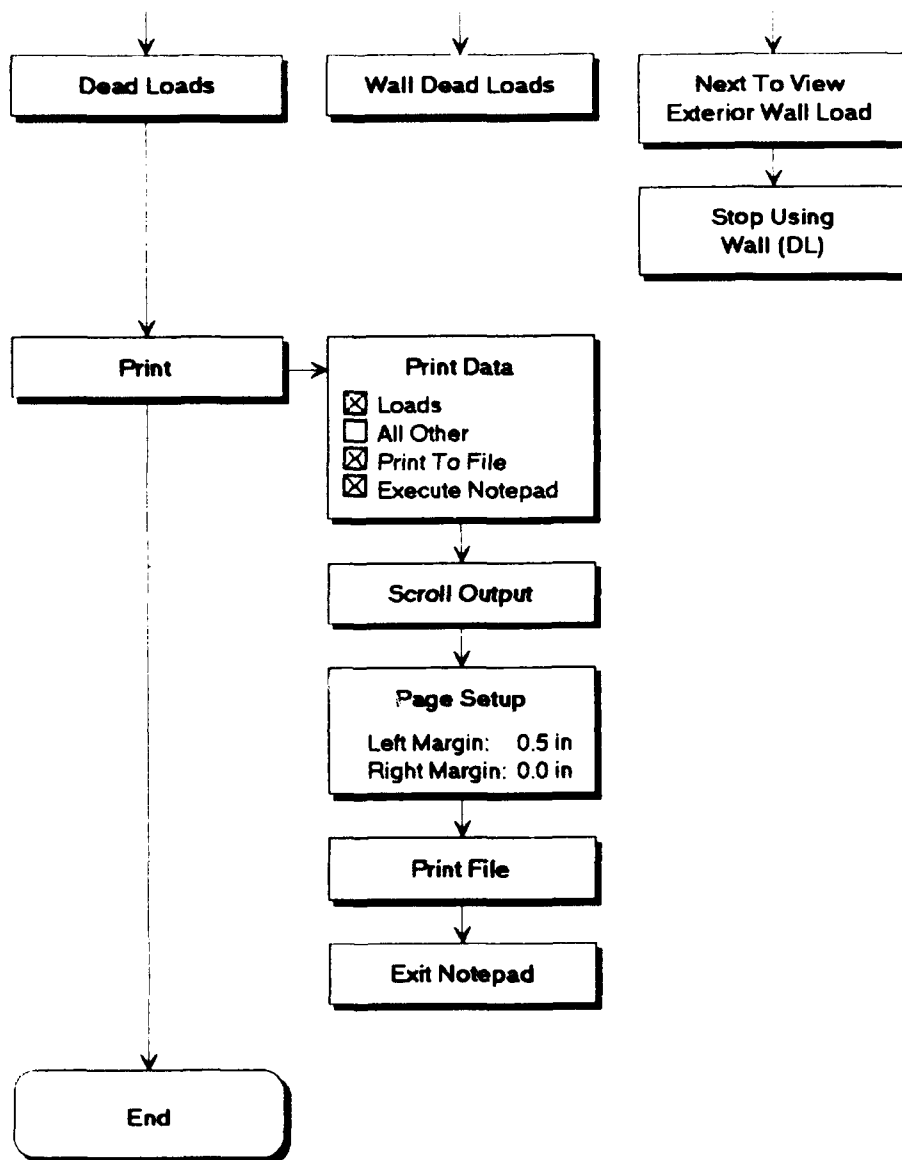
** For a rectangular tributary area, the width of the area need not be less than one-third the length of the area.

Dead & Live Loads









Loads

Floor Dead Loads

Name	: Second Floor	
	Type	psf
Partition	: 51-100 plf	6.0
Finish	: Carpet & Pad	1.0
Deck	: Concrete NLWT 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
Ceiling	: Susp Chnl/Tile	2.0
Total	:	65.0

Roof Dead Loads

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	:	0.0
Total	:	47.7

Name	: Upper Roof	
	Type	psf
Roofing	: Single Ply	1.5
Deck	: Concrete NLWT 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	: Susp Chnl/Tile	2.0
Total	:	61.9

Wall Dead Loads

Name	: Exterior Wall	
	Type	psf
Finish	: Limestone 5"	68.8
Sheathing	:	0.0
Structure	: Stl Stud 16ga 4"@16	1.1
Insulation	: Exp Polysty Rigid 1"	0.2
Finish	: Gypboard 5/8"	3.1
Total	:	73.2

Dead & Live Loads

Name : Parapet

	Type	psf
Finish	: Limestone 5"	68.8
Sheathing	:	0.0
Structure	:	0.0
Insulation	:	0.0
Finish	:	0.0
Total	:	68.8

Name : Shear Wall

	Type	psf
Finish	:	0.0
Sheathing	:	0.0
Structure	: Concrete 10"	125.0
Insulation	:	0.0
Finish	:	0.0
Total	:	125.0

Occupancy Live Loads

Name	psf
Office: Offices	50
Office: Corridor (main)	100
Office: Files & Storage	150a

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: $L = L_o \{0.25 + (15/\sqrt{A_i})\}$

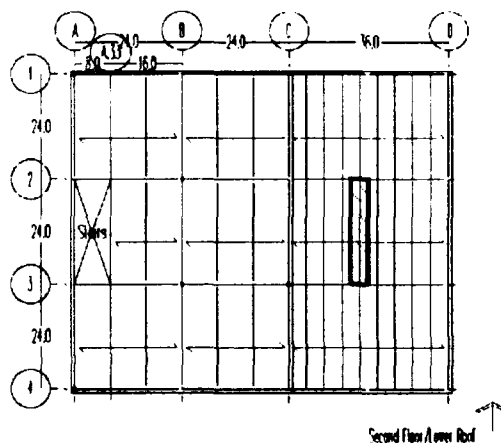
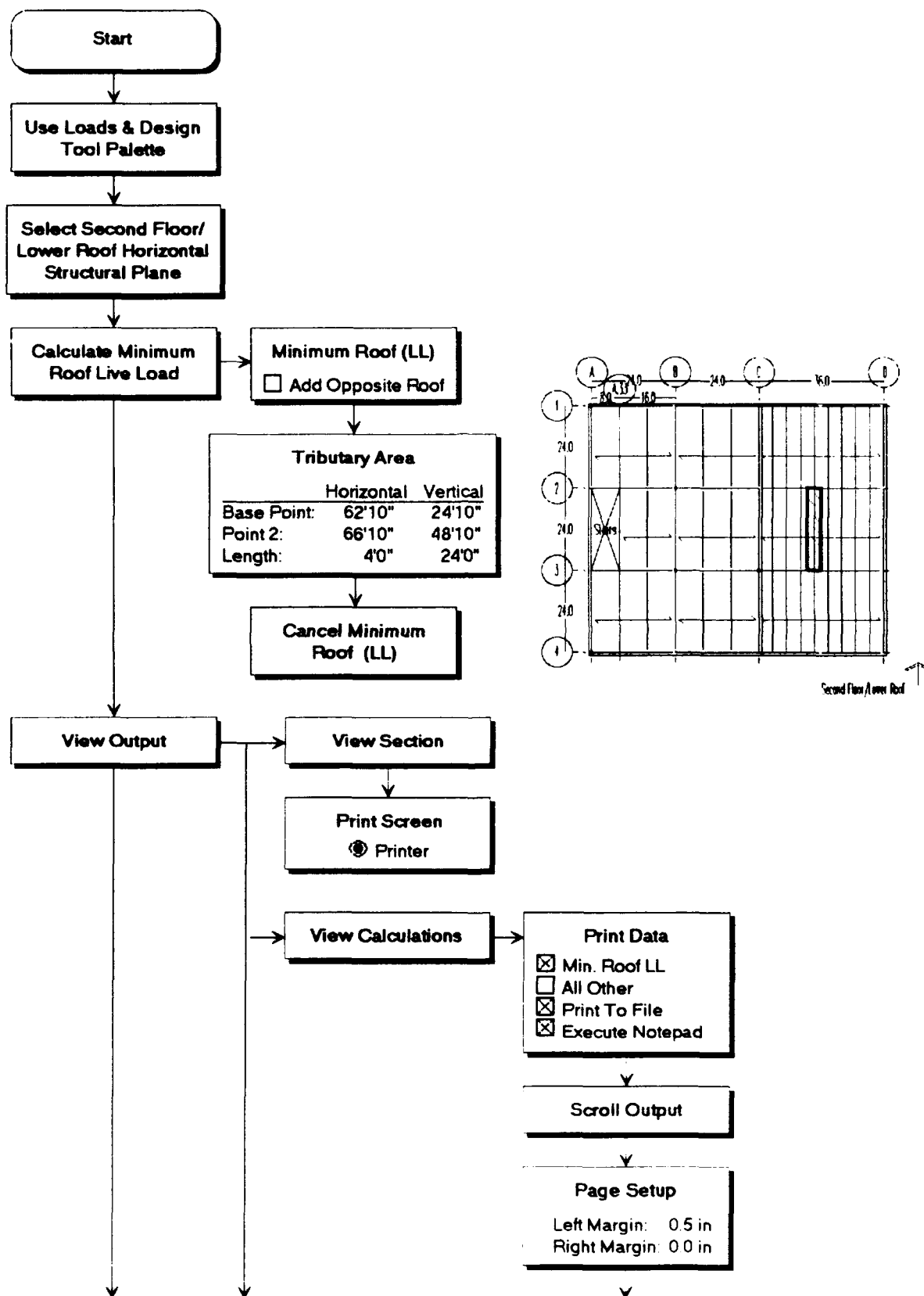
The reduced design live load will not be less than 50% of the unit live load for members supporting one floor, nor less than 40% of the unit live load for members supporting two or more floors.

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

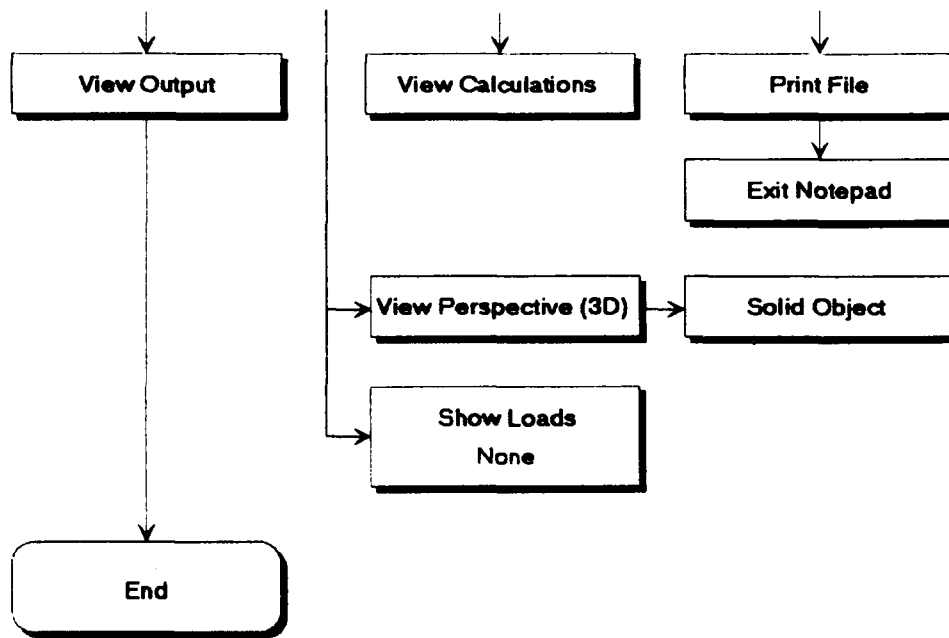
- public assembly
- garages [except where 2 or more floors are supported]
- one-way slab floor

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



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

$L_r = 20 \cdot R_1 \cdot R_2 \geq 12$
 At ≤ 200 $R_1 = 1.00$
 F ≤ 4 $R_2 = 1.00$
 $L_r = 20.00$ psf
 minimum $L_r = 12$ psf

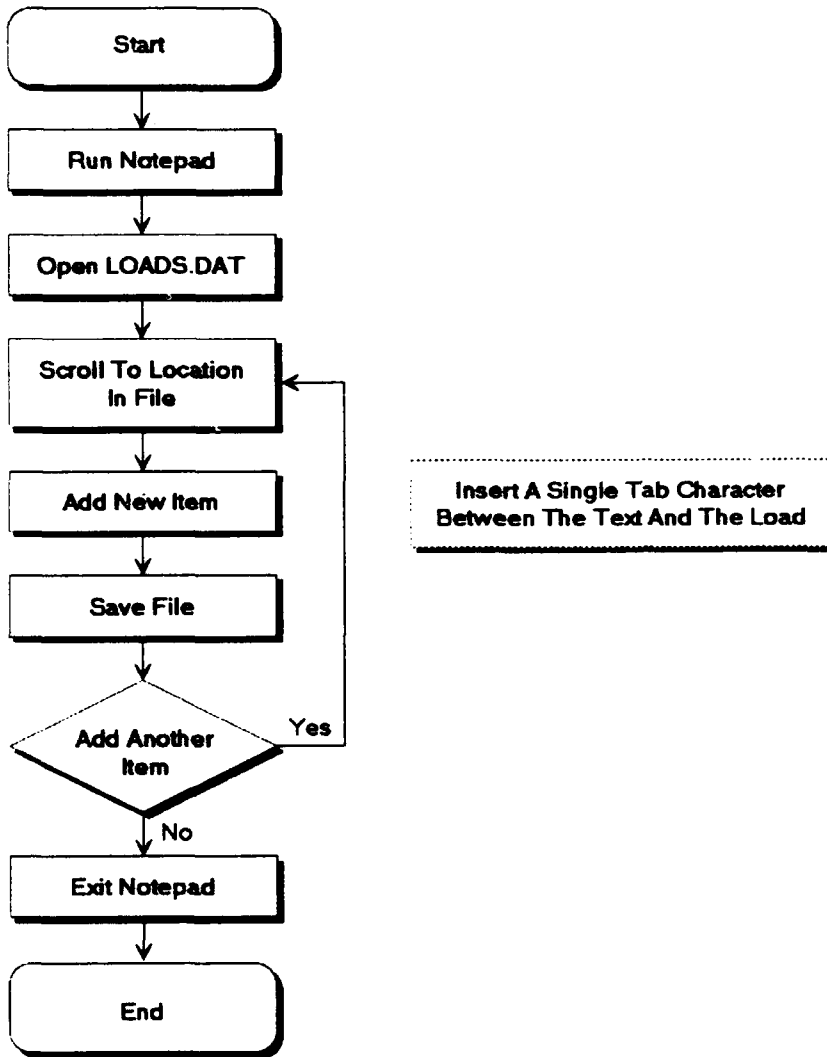
```

+-----+
|      Lr = 20.00 psf      |
+-----+
  
```

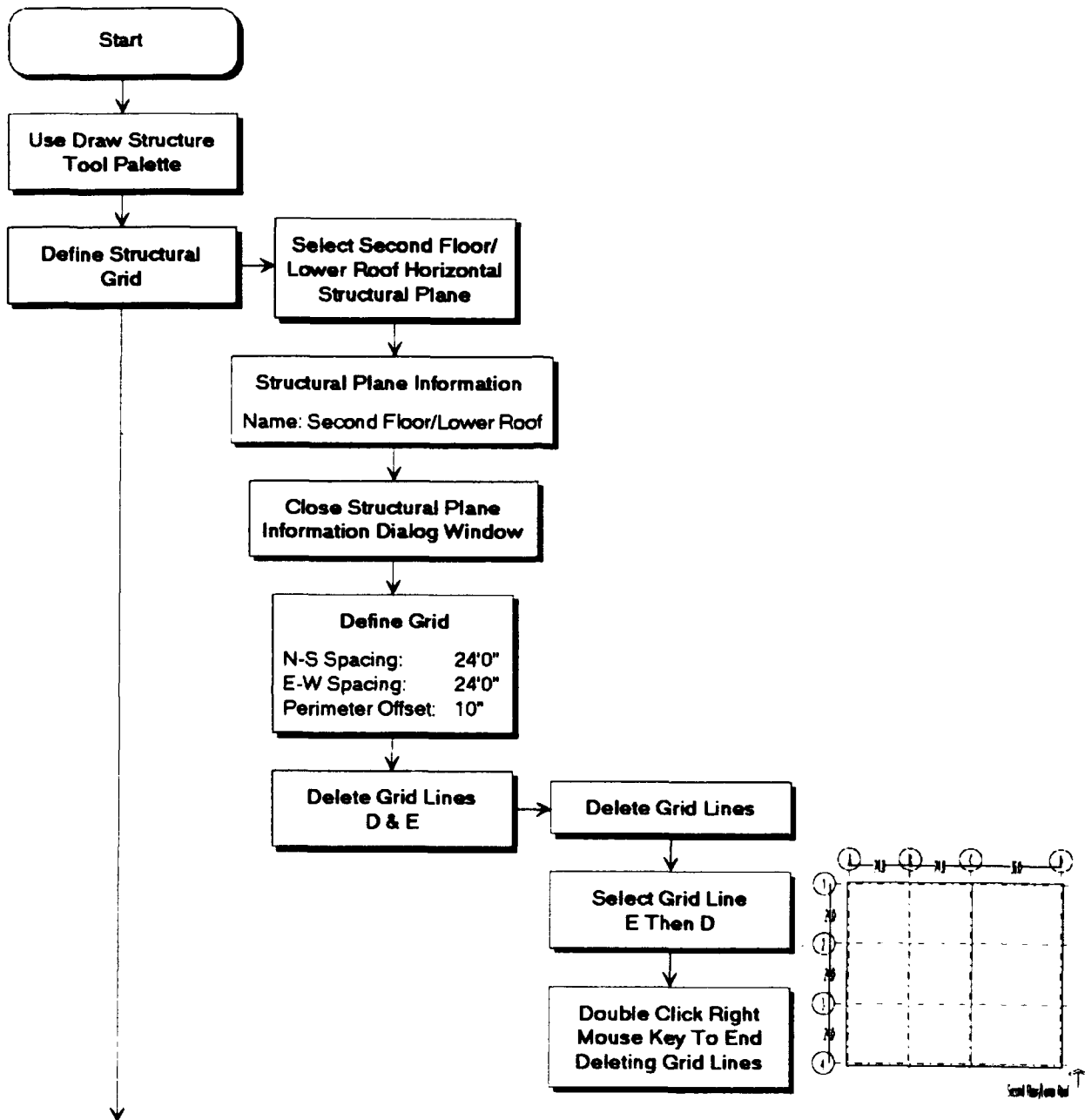
Check minimum roof live load, L_r , against minimum snow design loads.

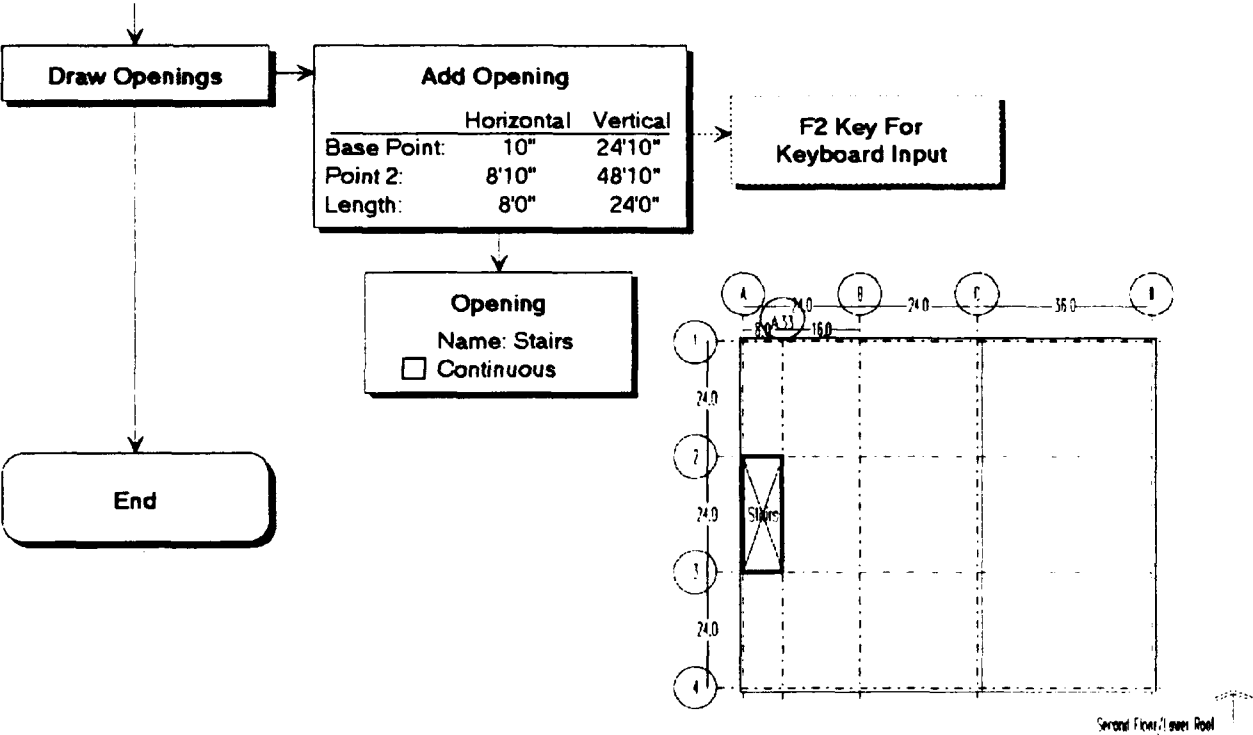
Additionally, for the design of secondary members such as roof decking and rafters, a concentrated live load with 250 lbs uniformly distributed over an area of 2 feet square (4 sqft) will be included. The concentrated load will be located so as to produce the maximum stress in the member.

Loads Database



Draw Grid & Openings

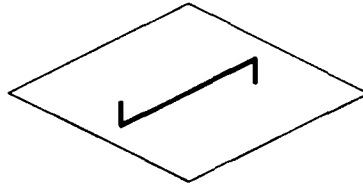




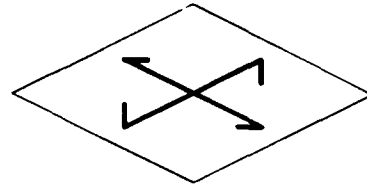
Draw Structure Philosophy

Structure Hierarchy

Surface/Deck
(horizontal)



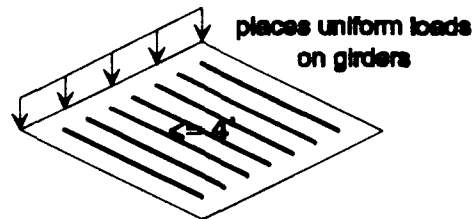
1 way



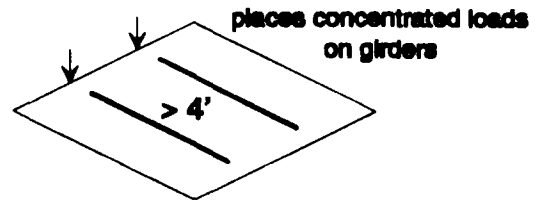
2 way
(not activated)

Linear
(horizontal)

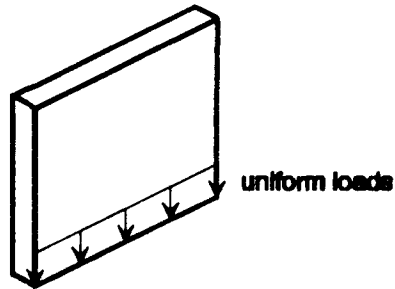
Narrowly Spaced
(joists)



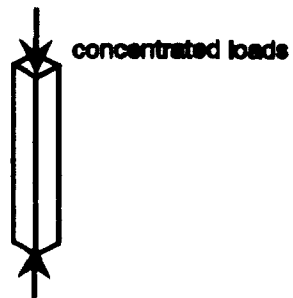
Widely Spaced
(beams)



Surface
(vertical)
(planar)

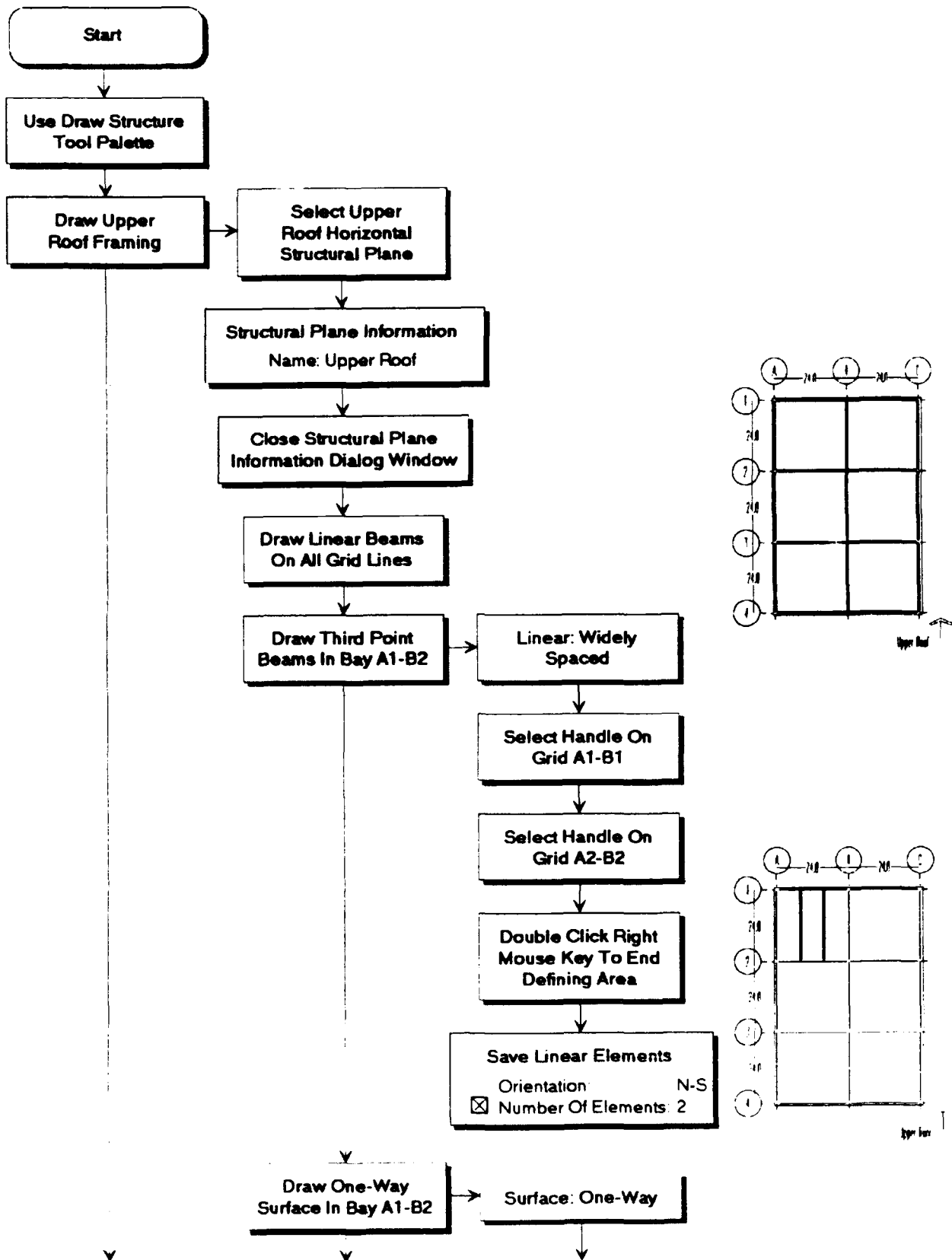


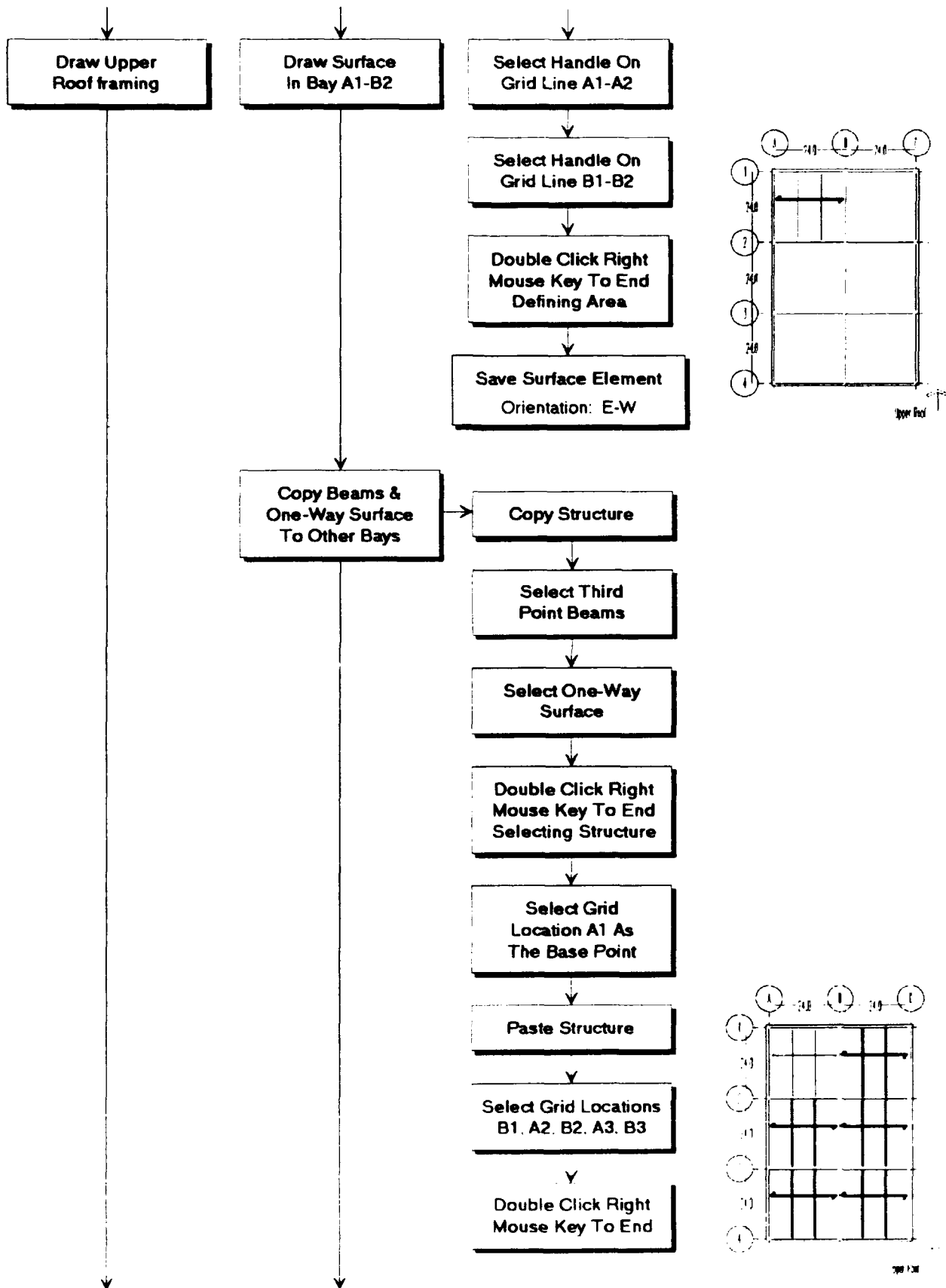
Linear
(vertical)

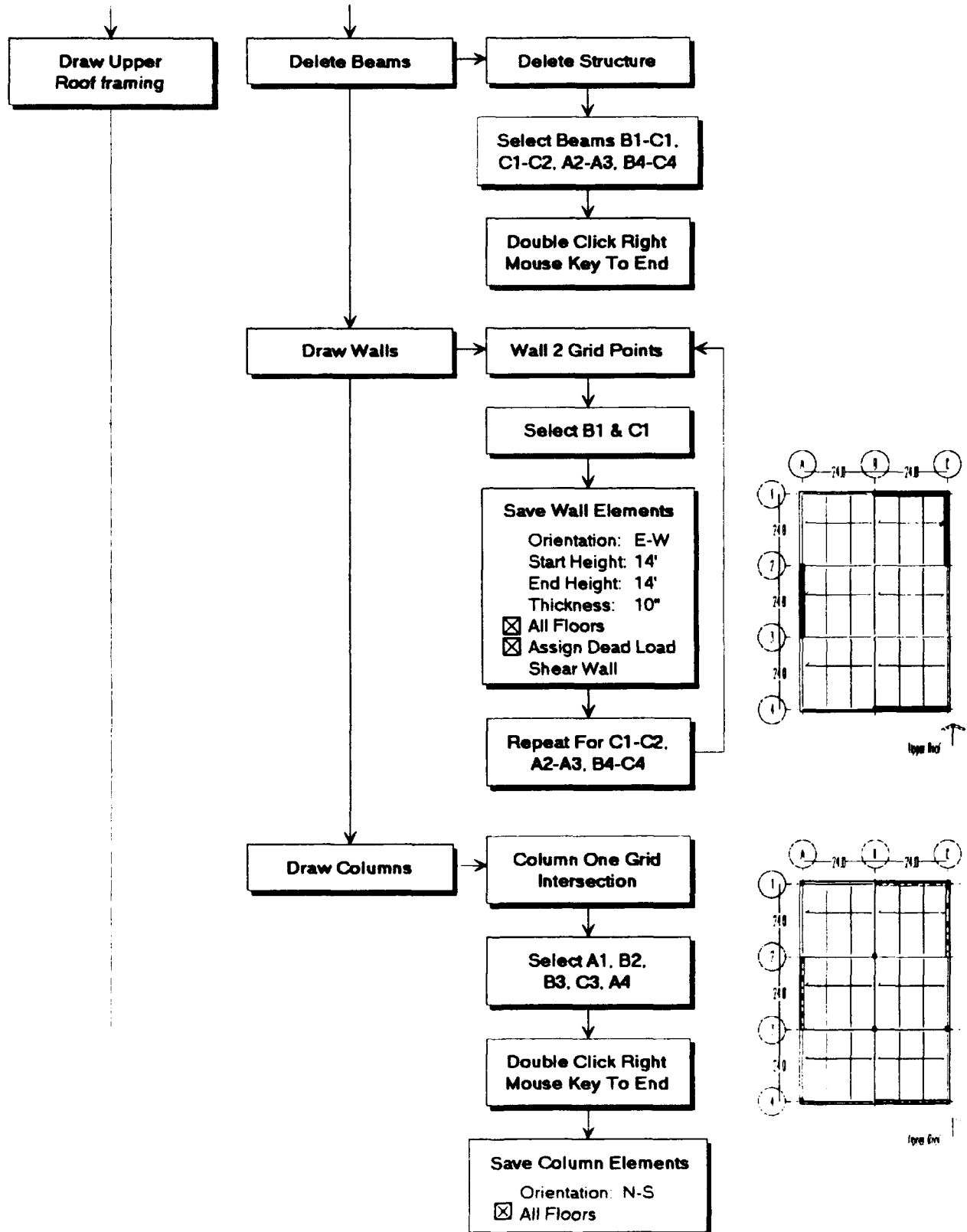




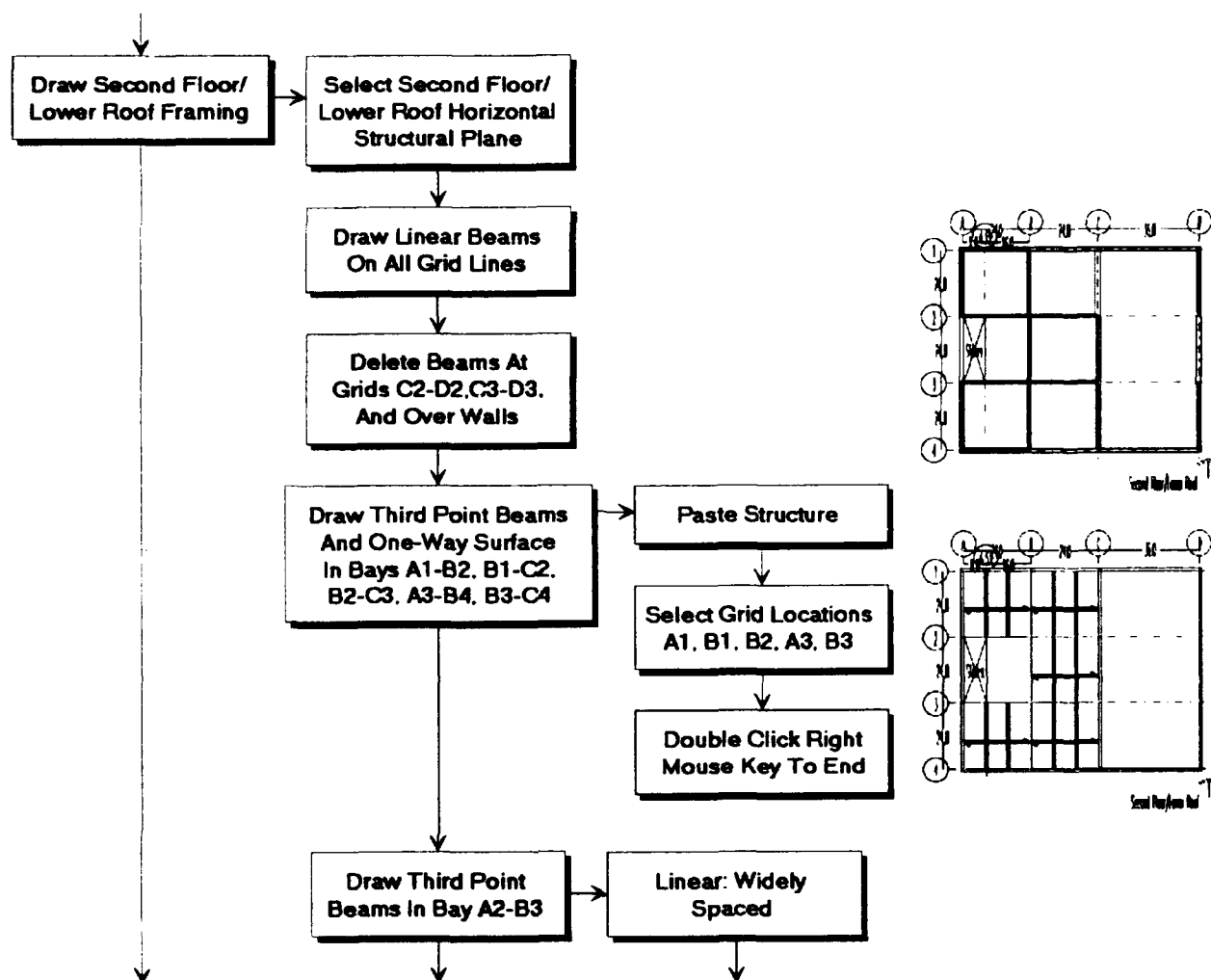
Draw Structure

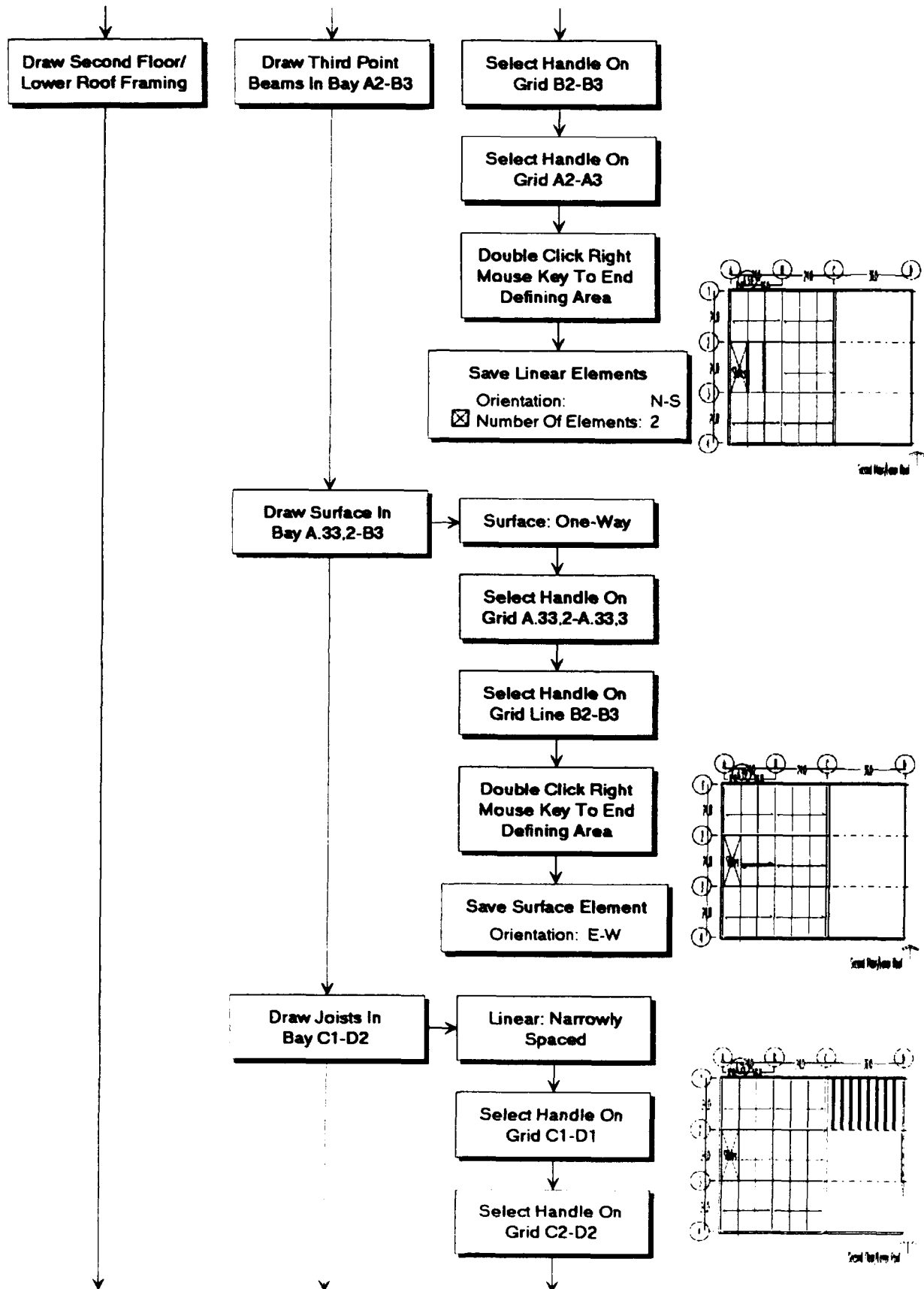




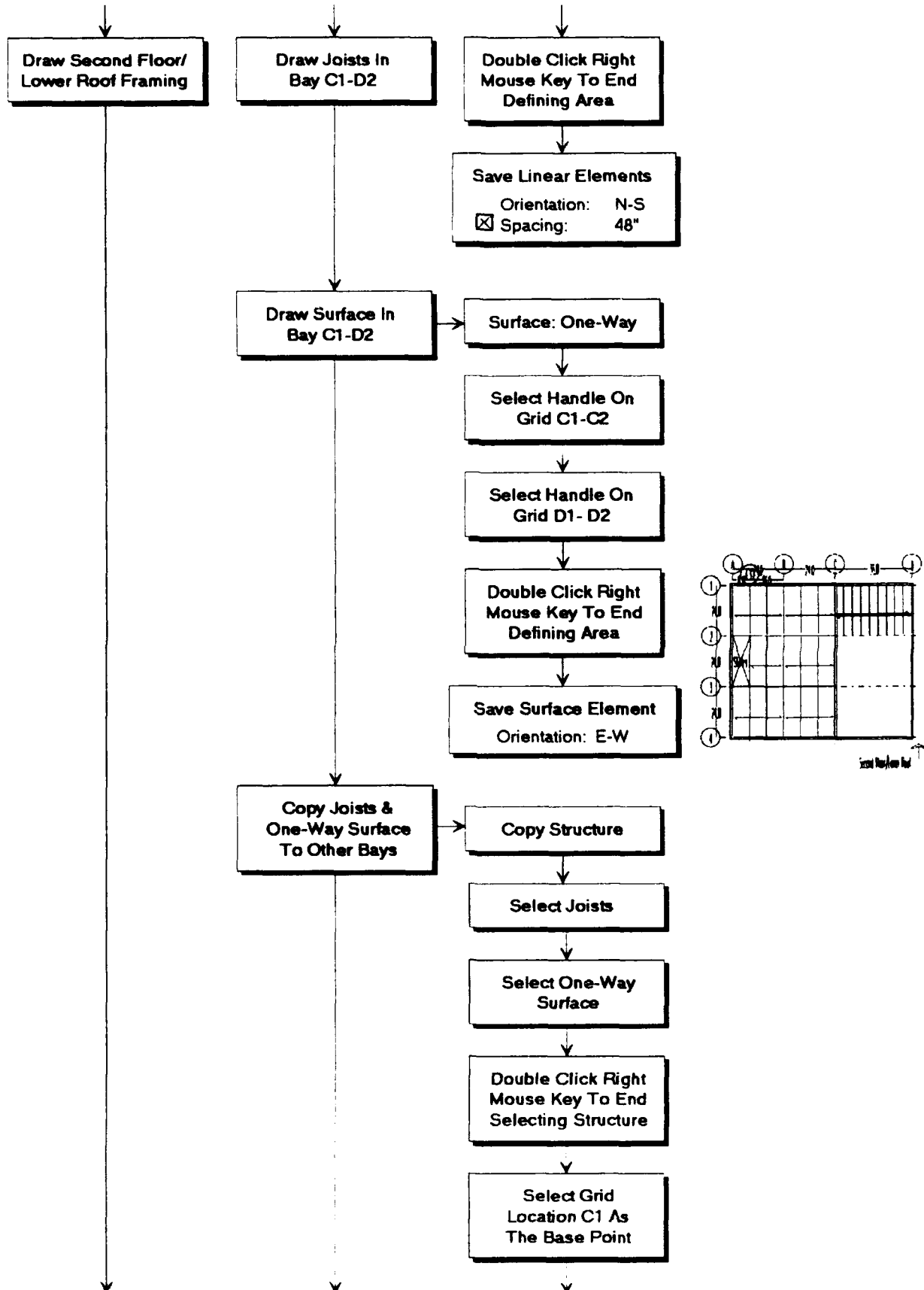


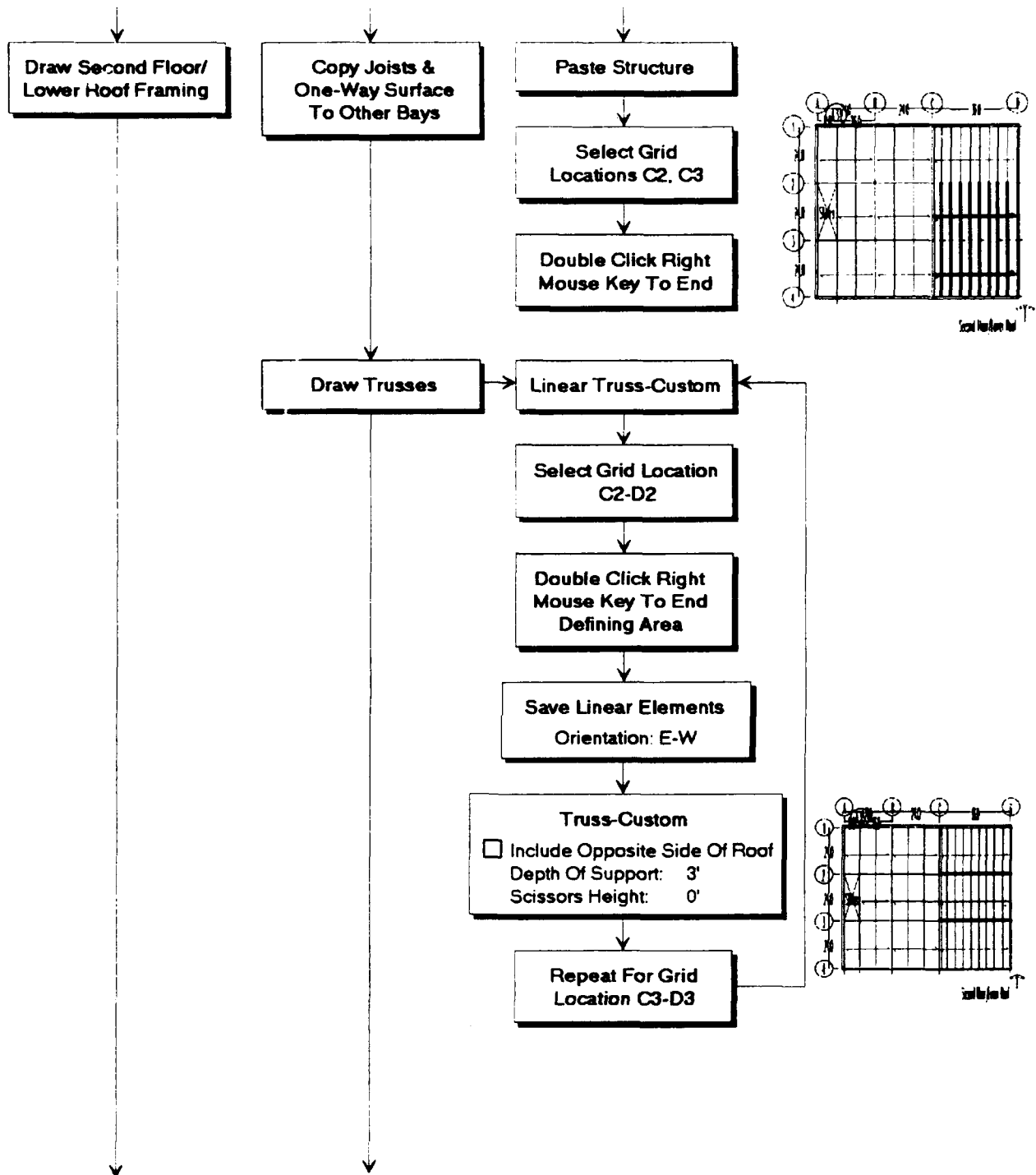
Draw Structure



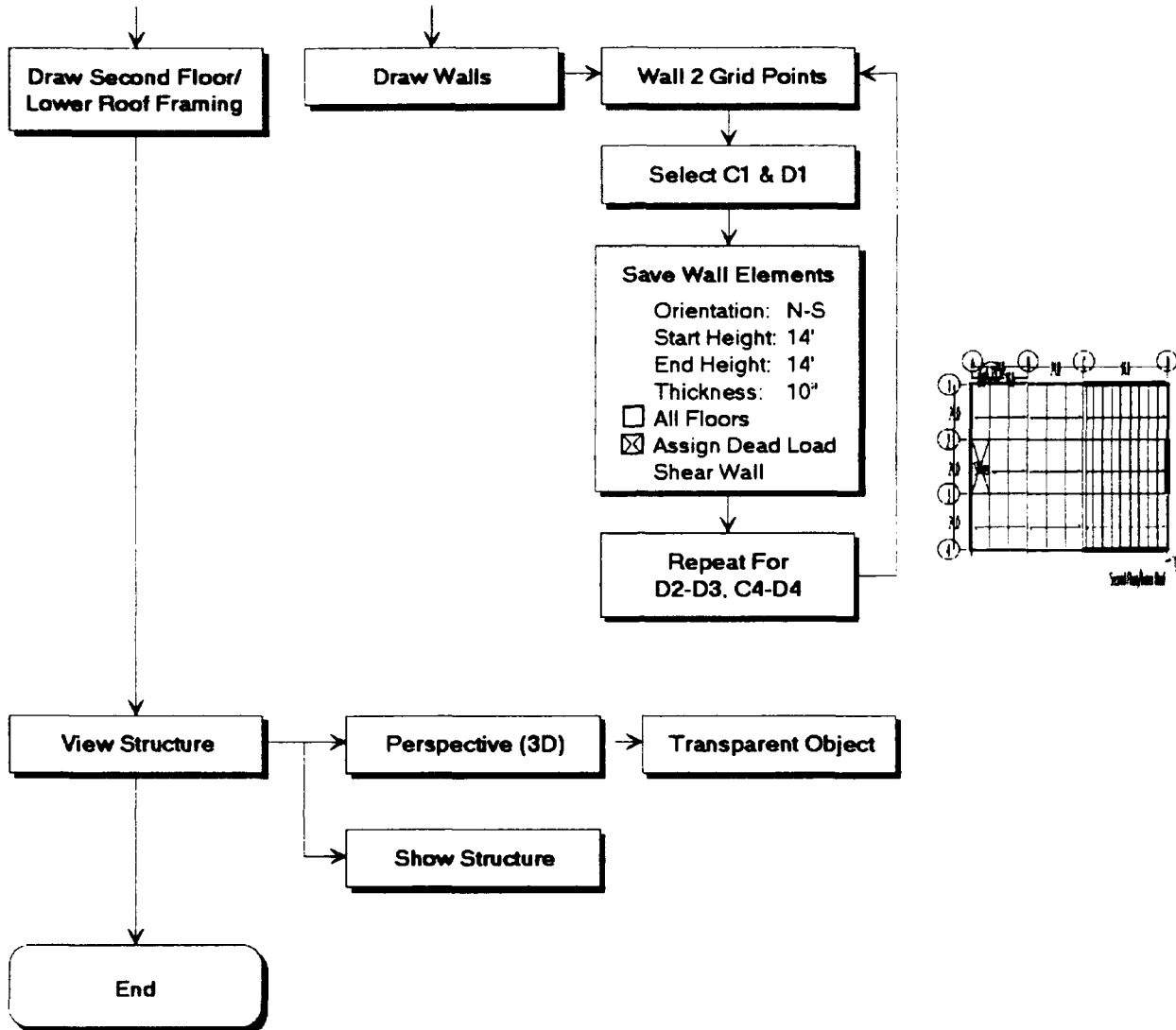


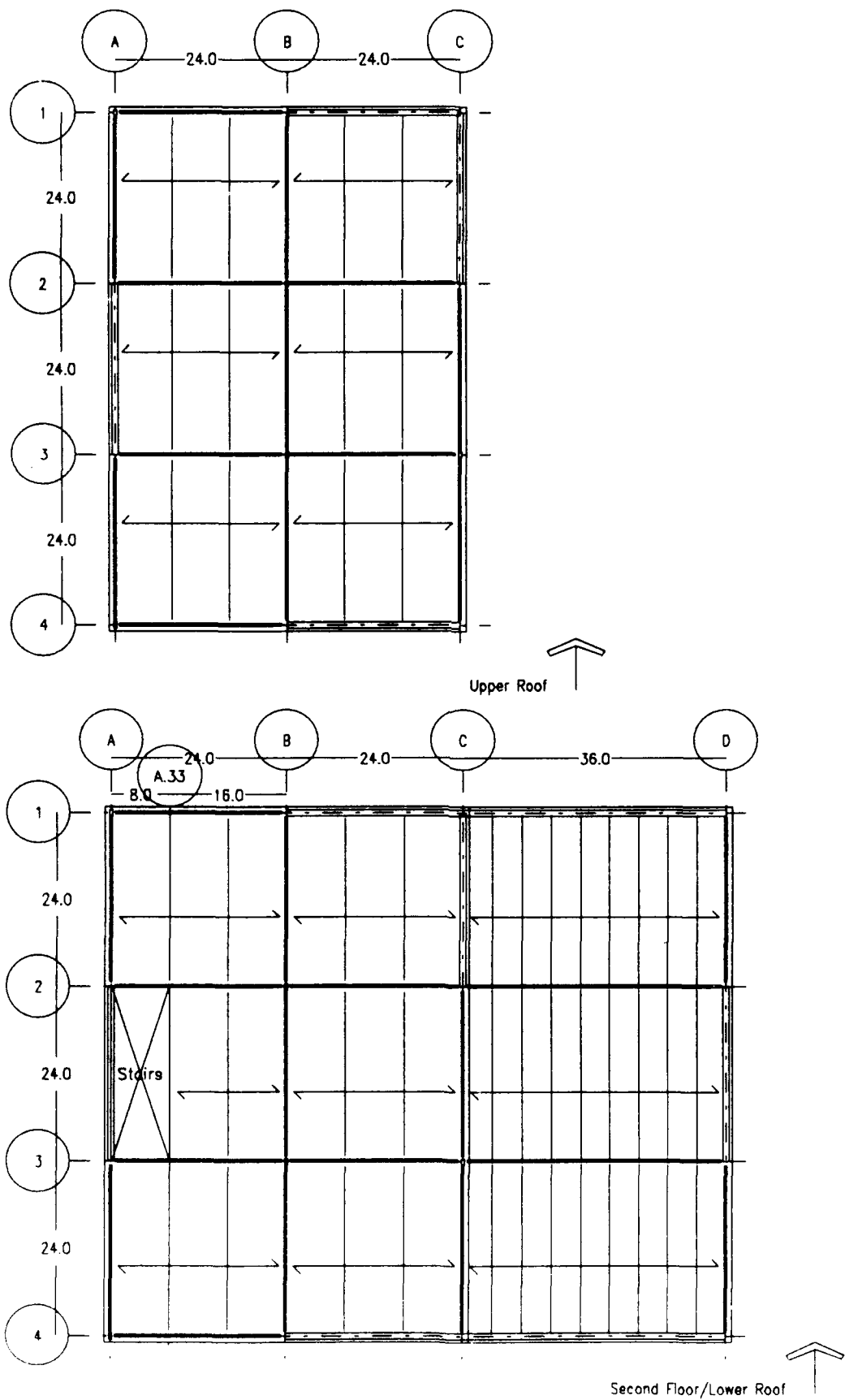
Draw Structure

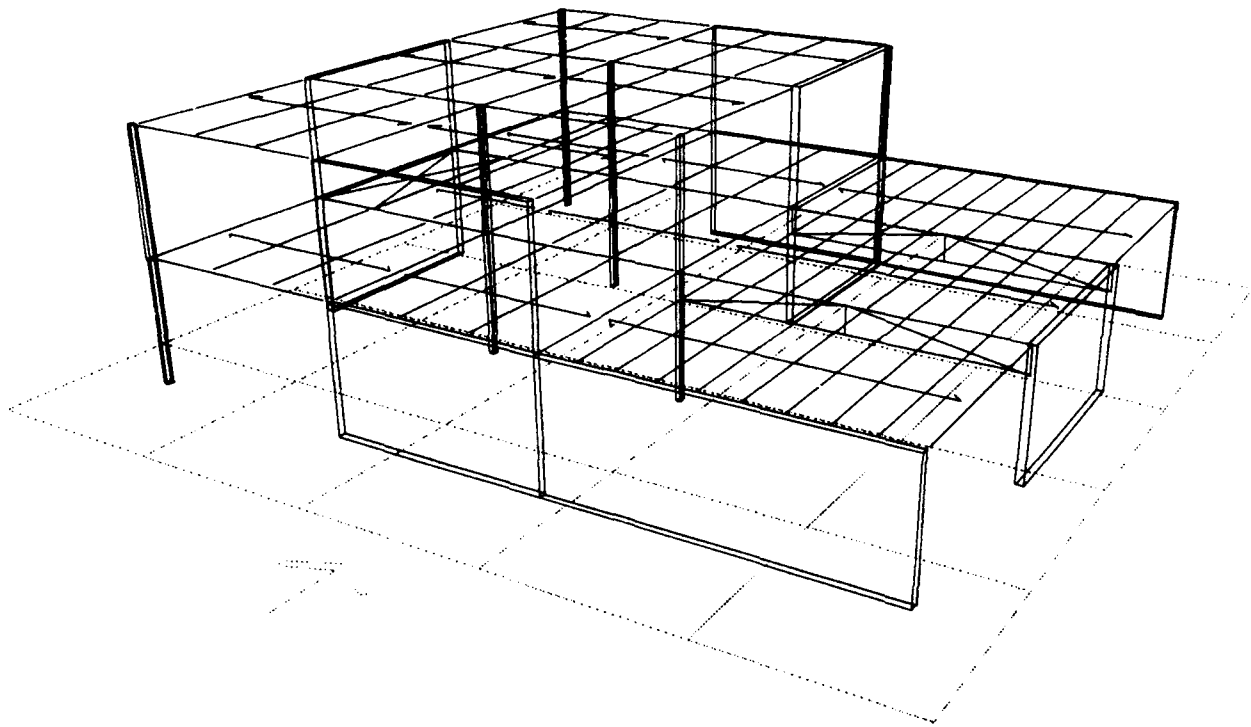




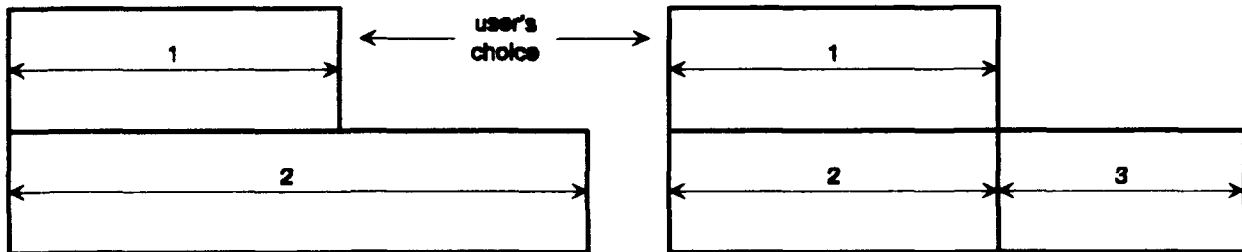
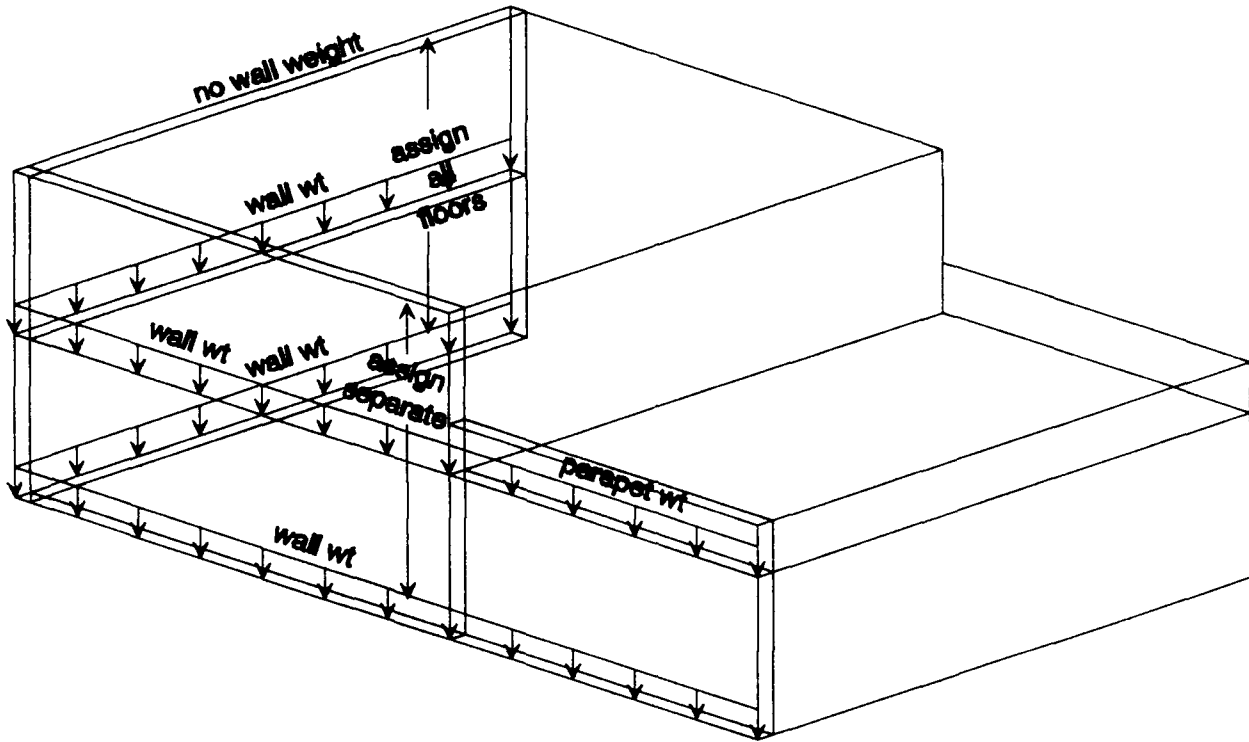
Draw Structure





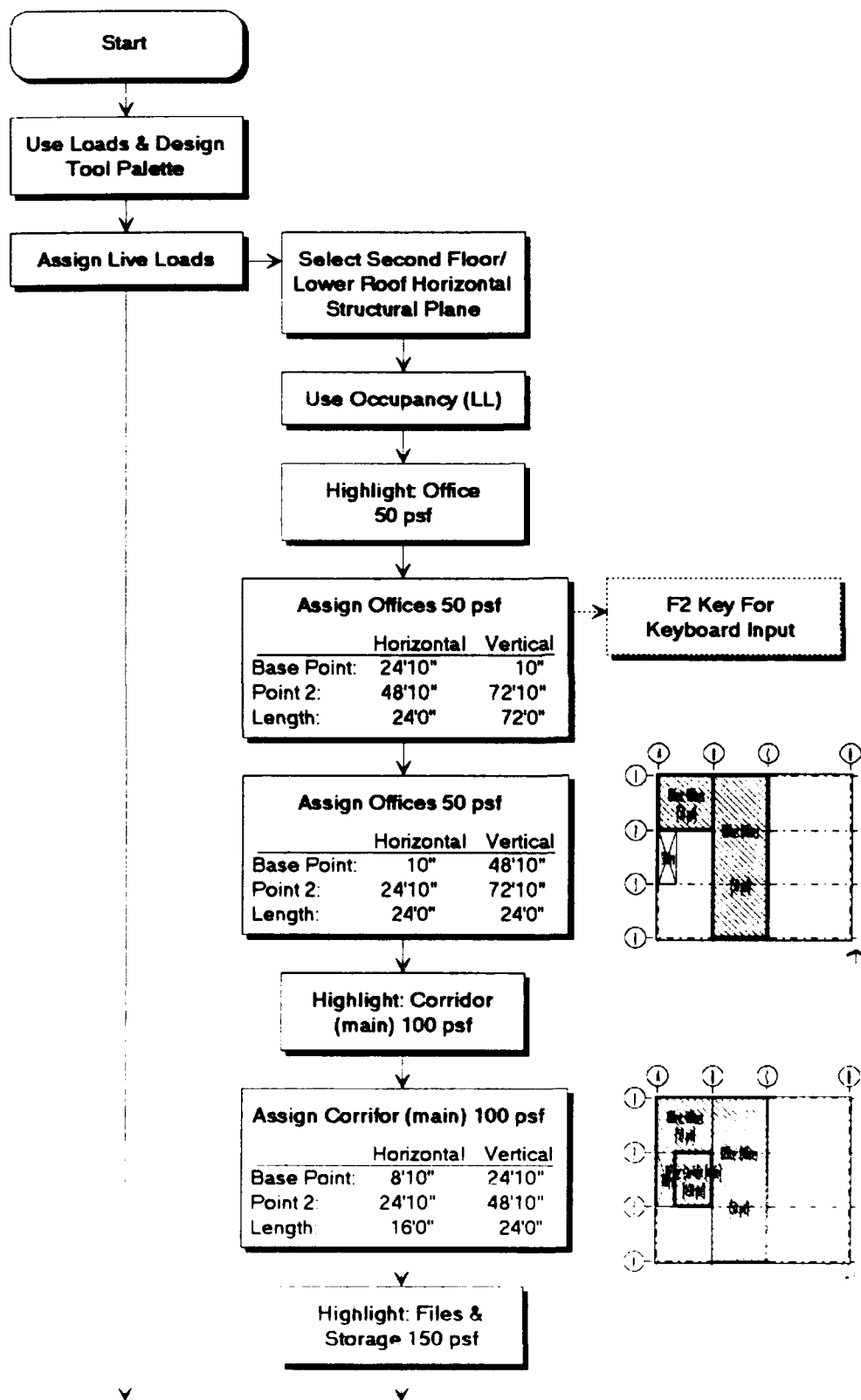


Assign Wall Loads Philosophy

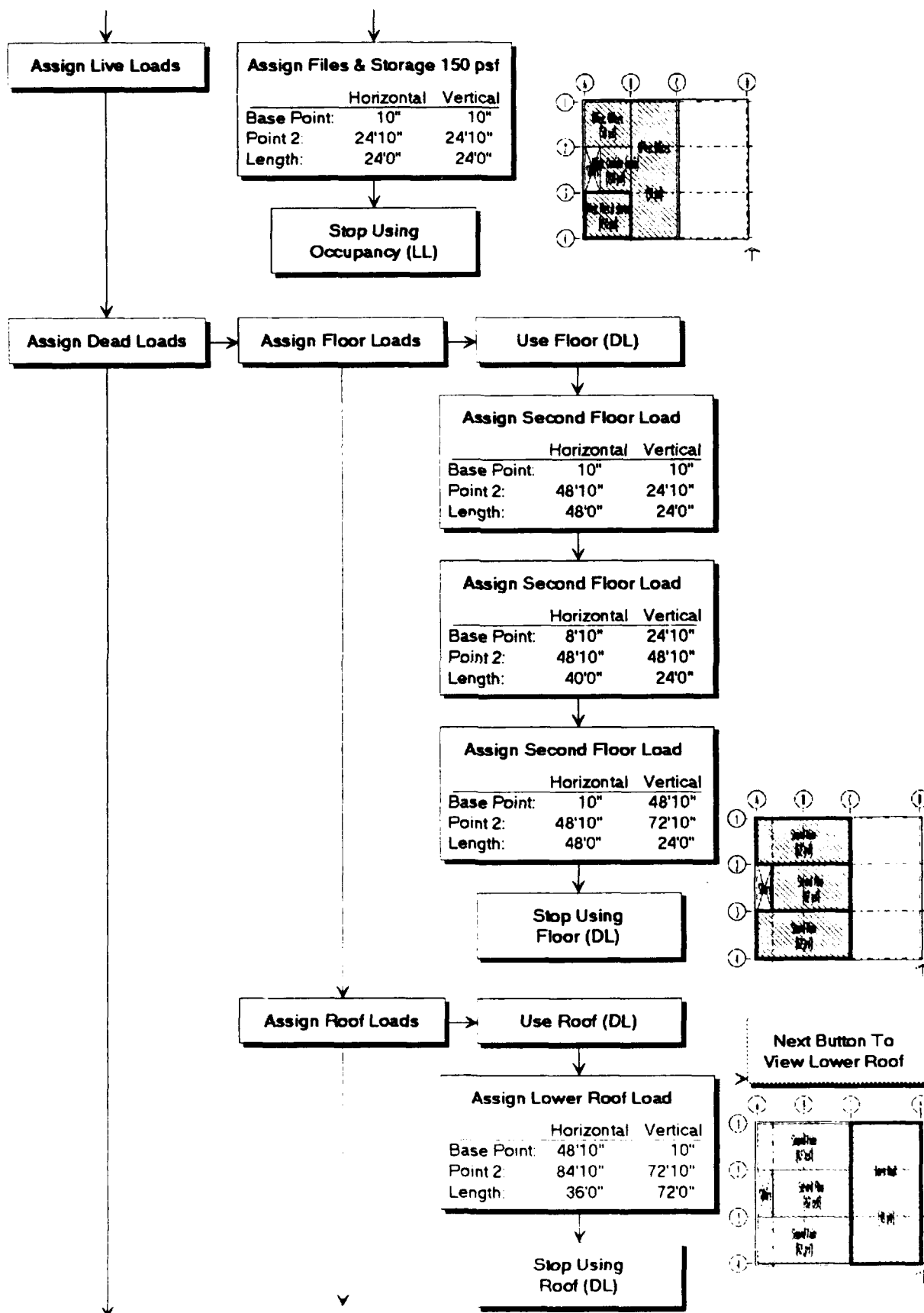


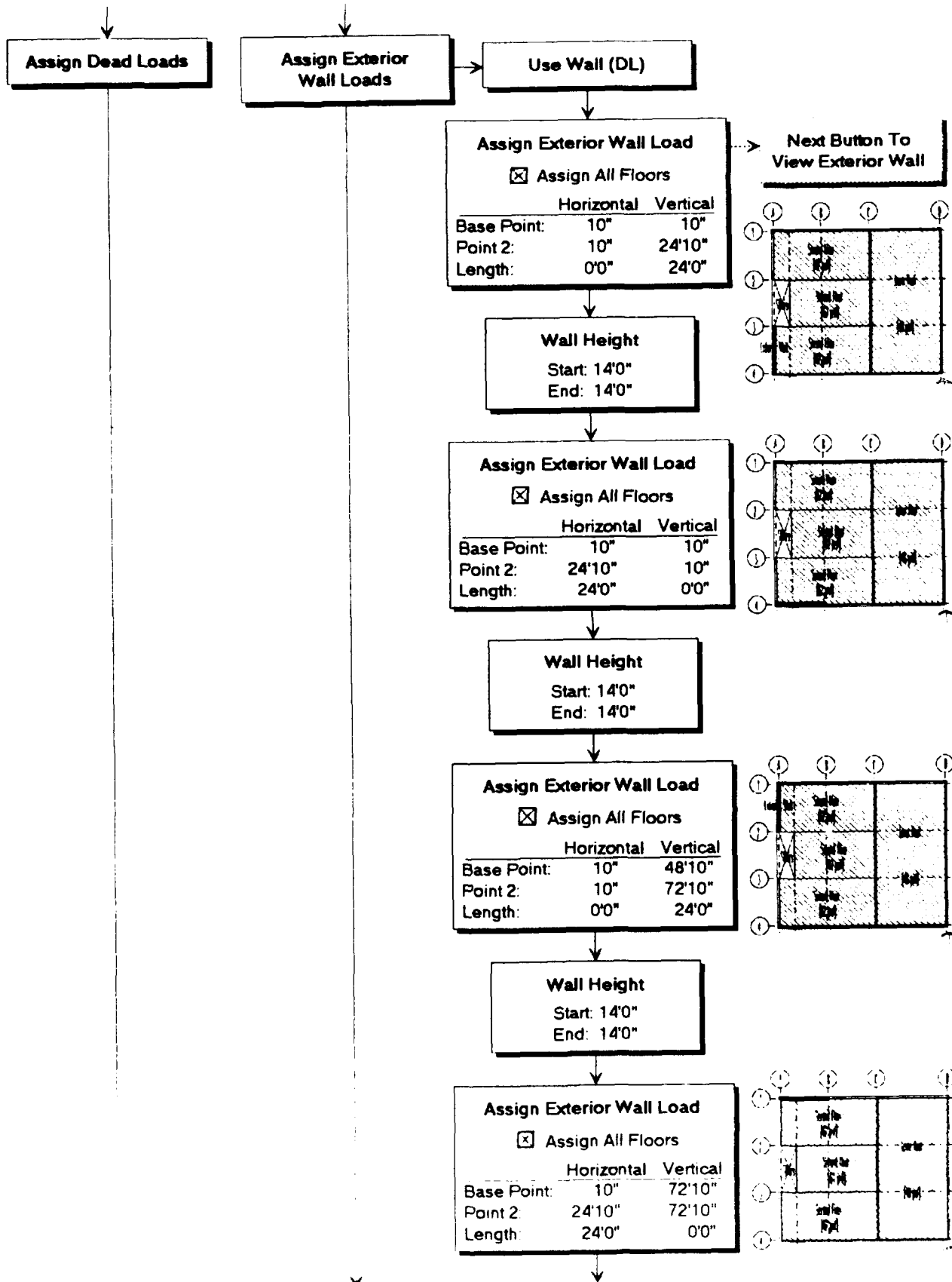
this approach saves memory

Assign Loads

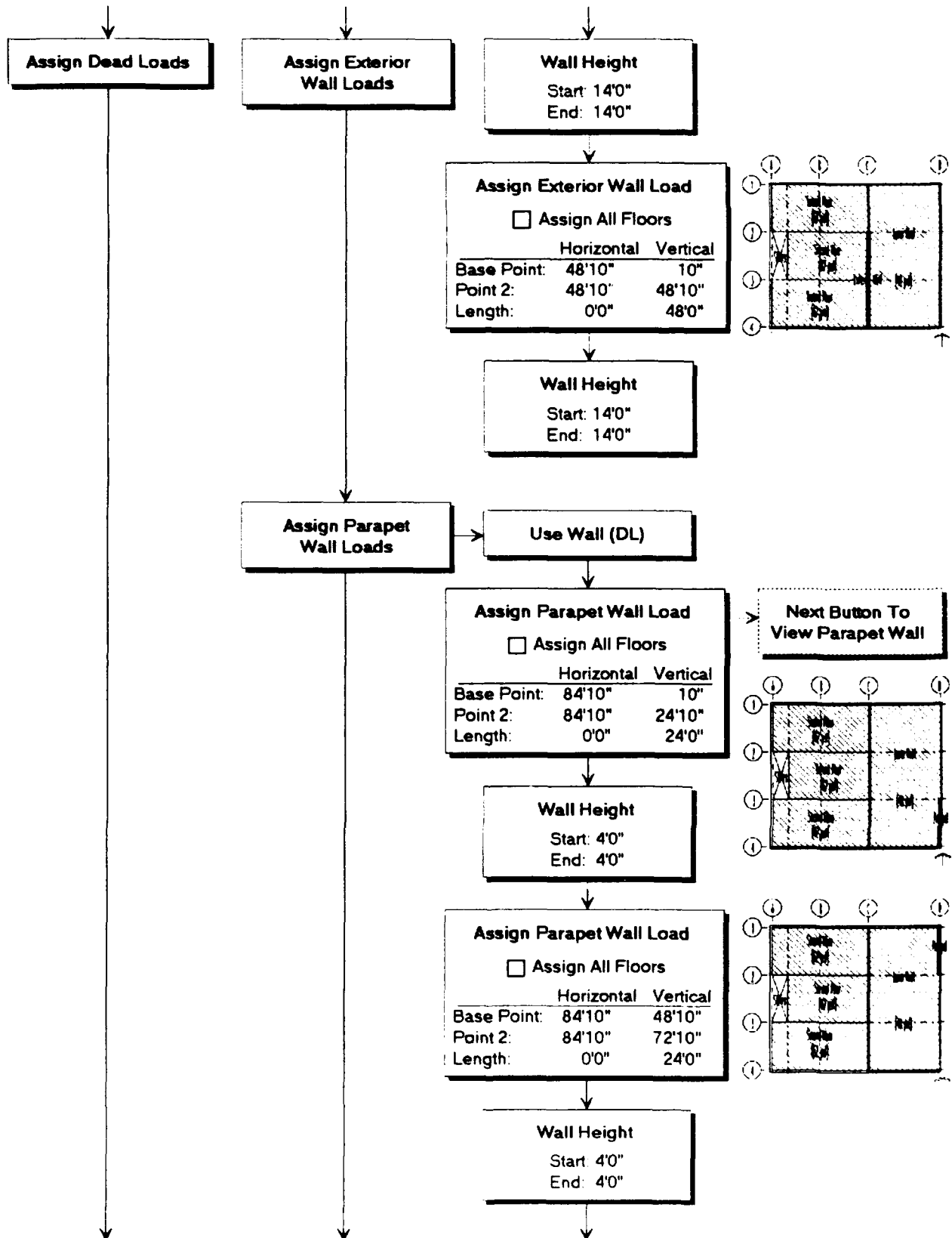


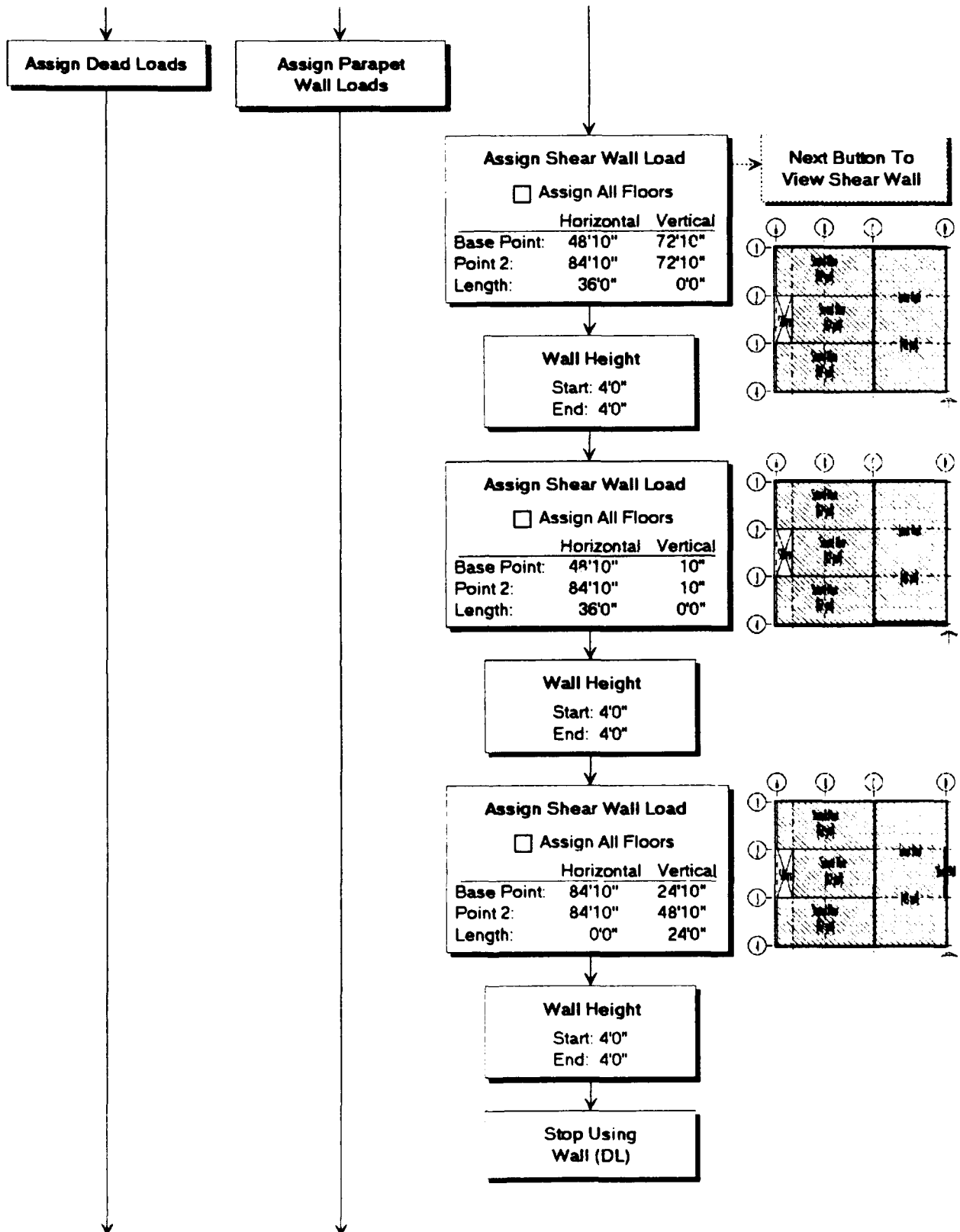
Assign Loads

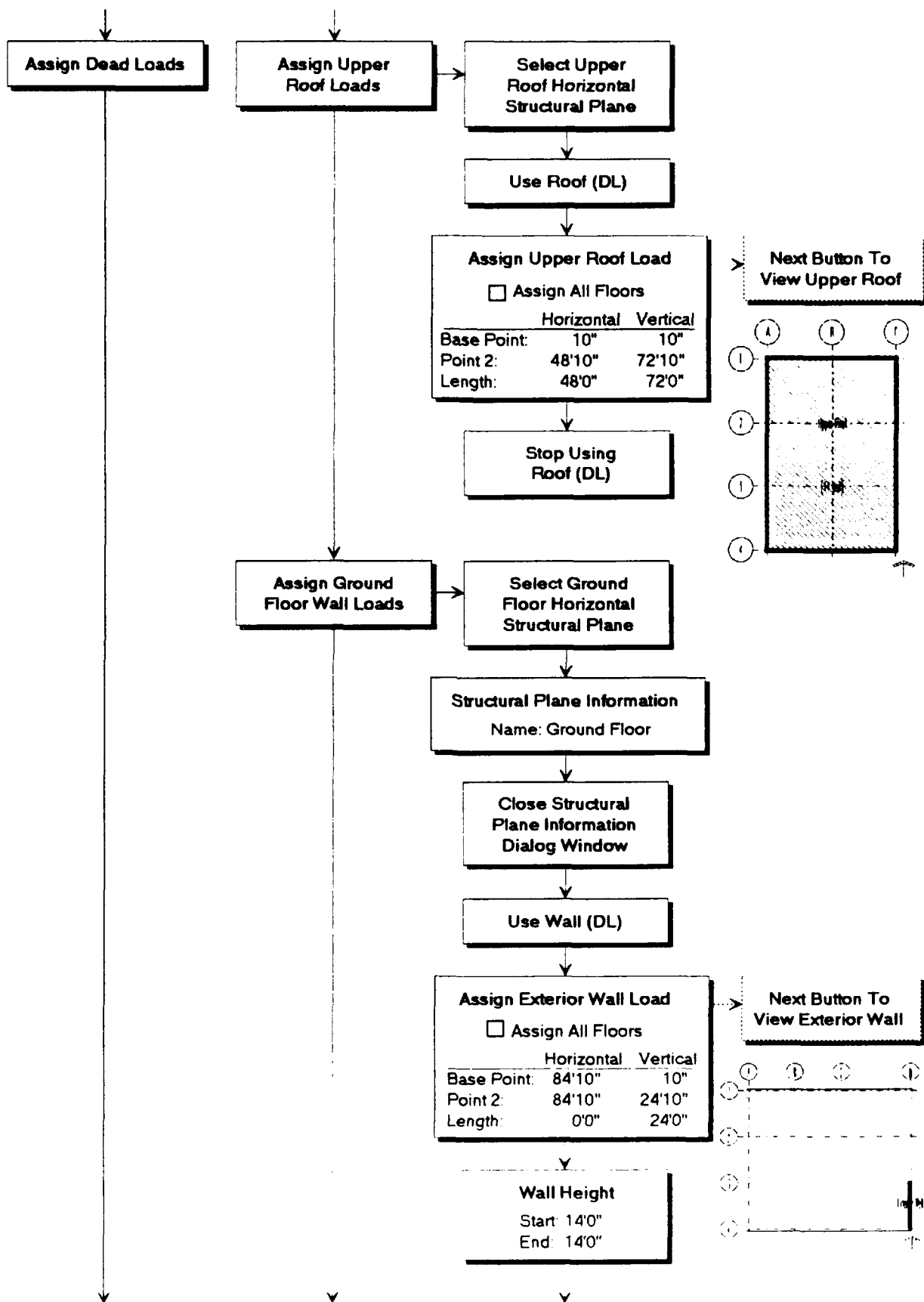


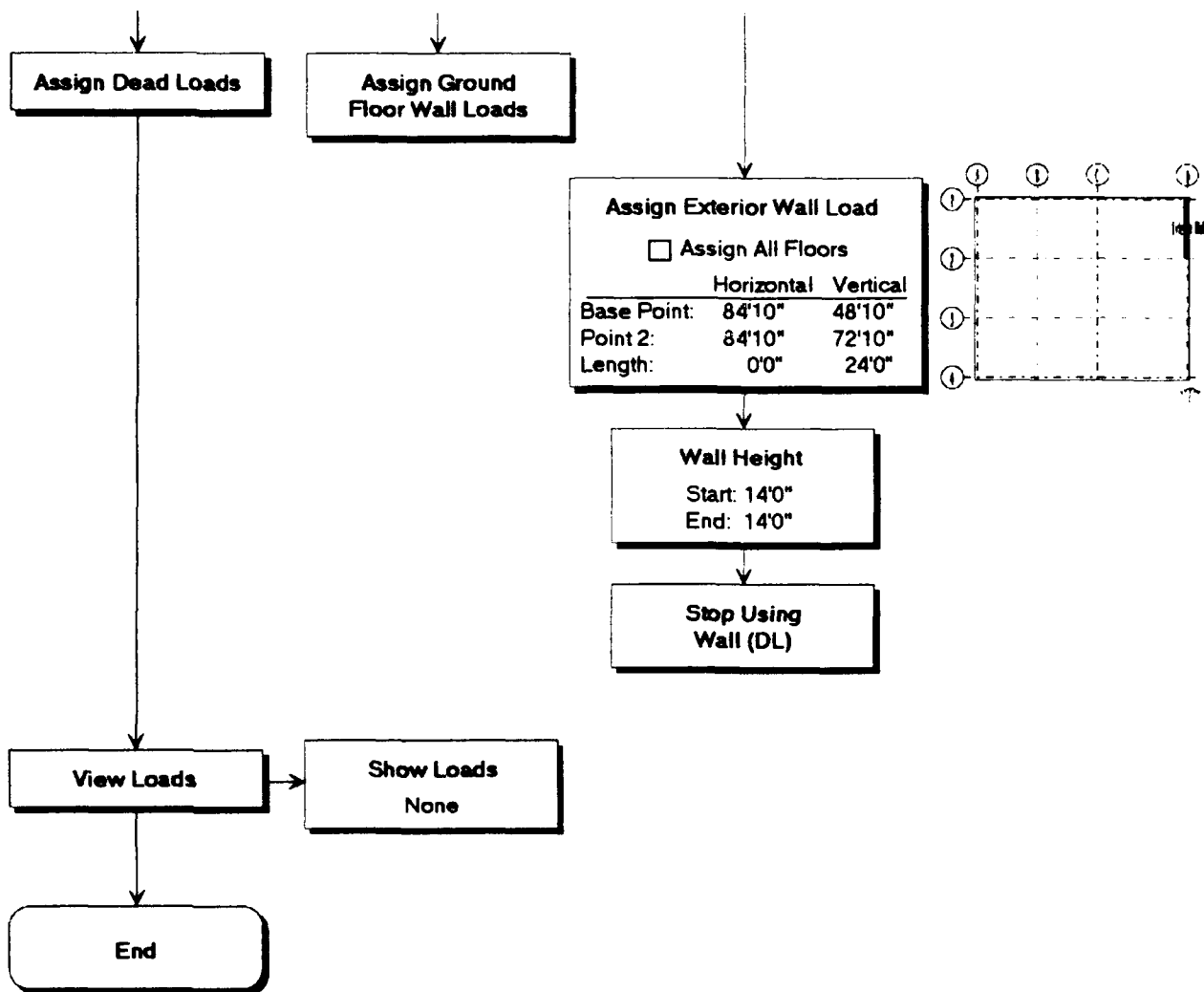


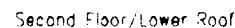
Assign Loads



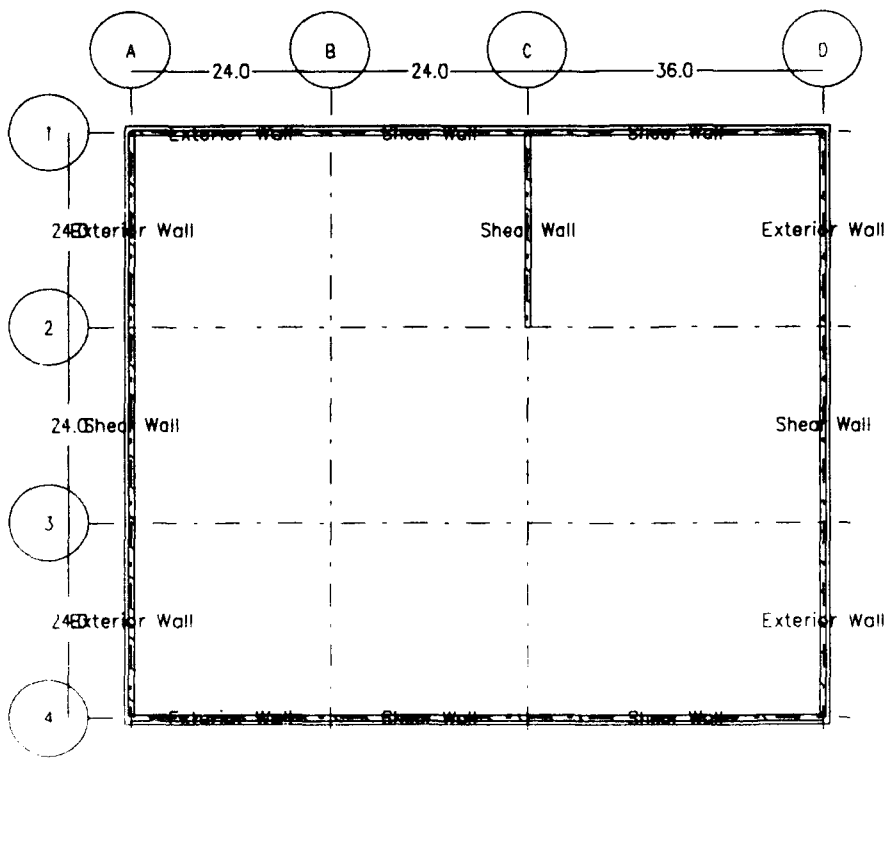
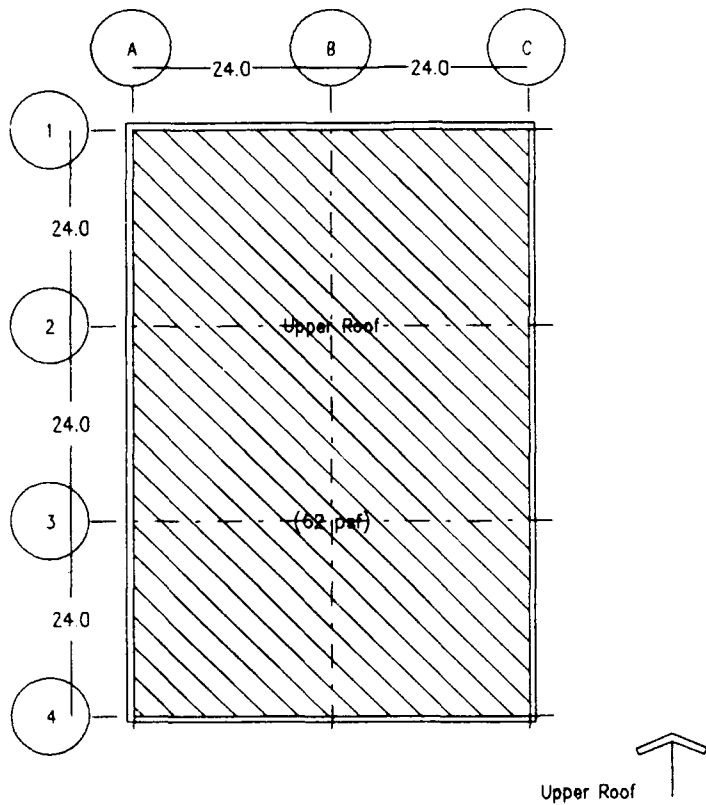








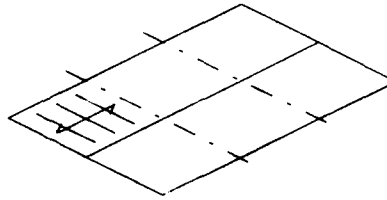
Assign Loads



Analysis & Design Philosophy

Preliminary Analysis

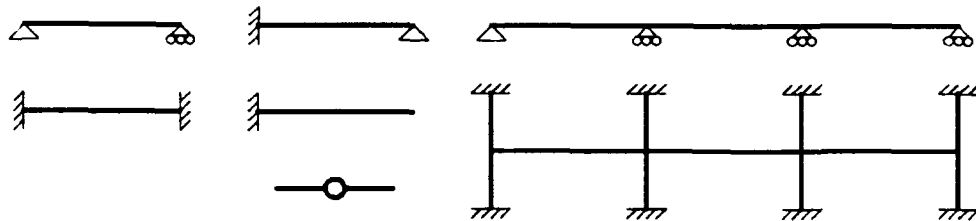
- A. Select:**
- * Material
 - * Load Combination
(Live Load Reduction)
 - * Element To Analyze



- B. Review:**
- * Attributes
 - * Guidelines



C. Connectivity



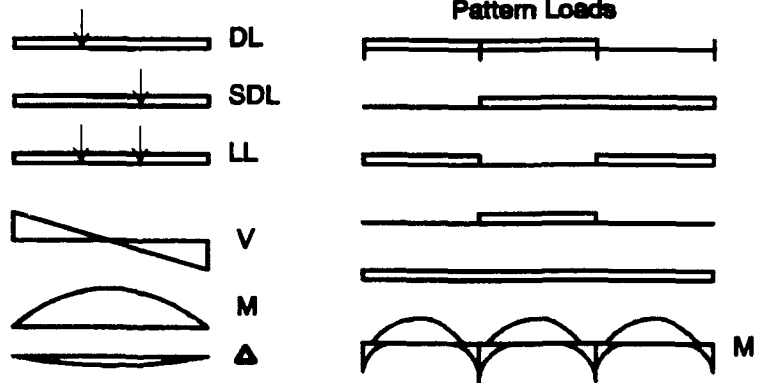
- D. Self Weight Estimate**
- * Guidelines



- E. Analysis**
- * Review Loads
 - * Connectivity

* Analysis Output

$I = 1$
 $E = 1$
 $A = 1000$

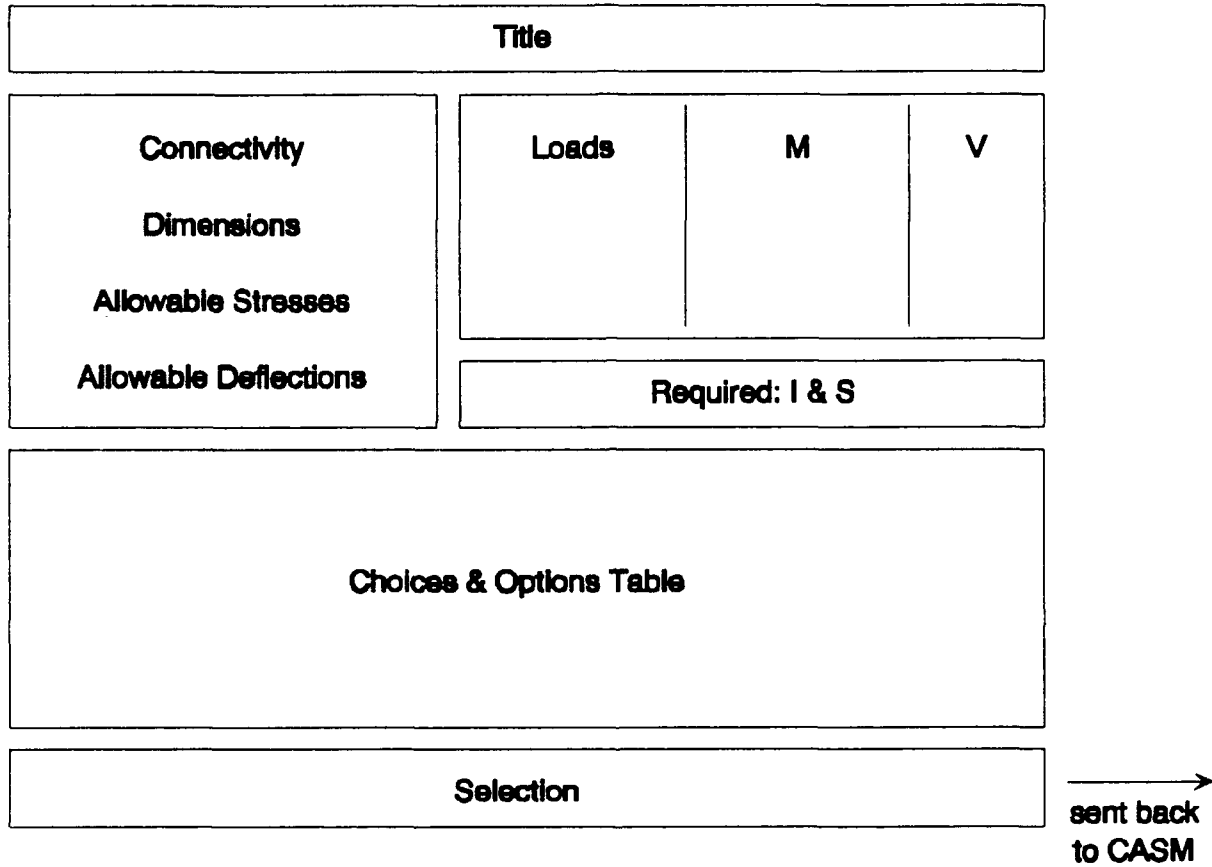


- F. Re-Analysis (with real properties)**

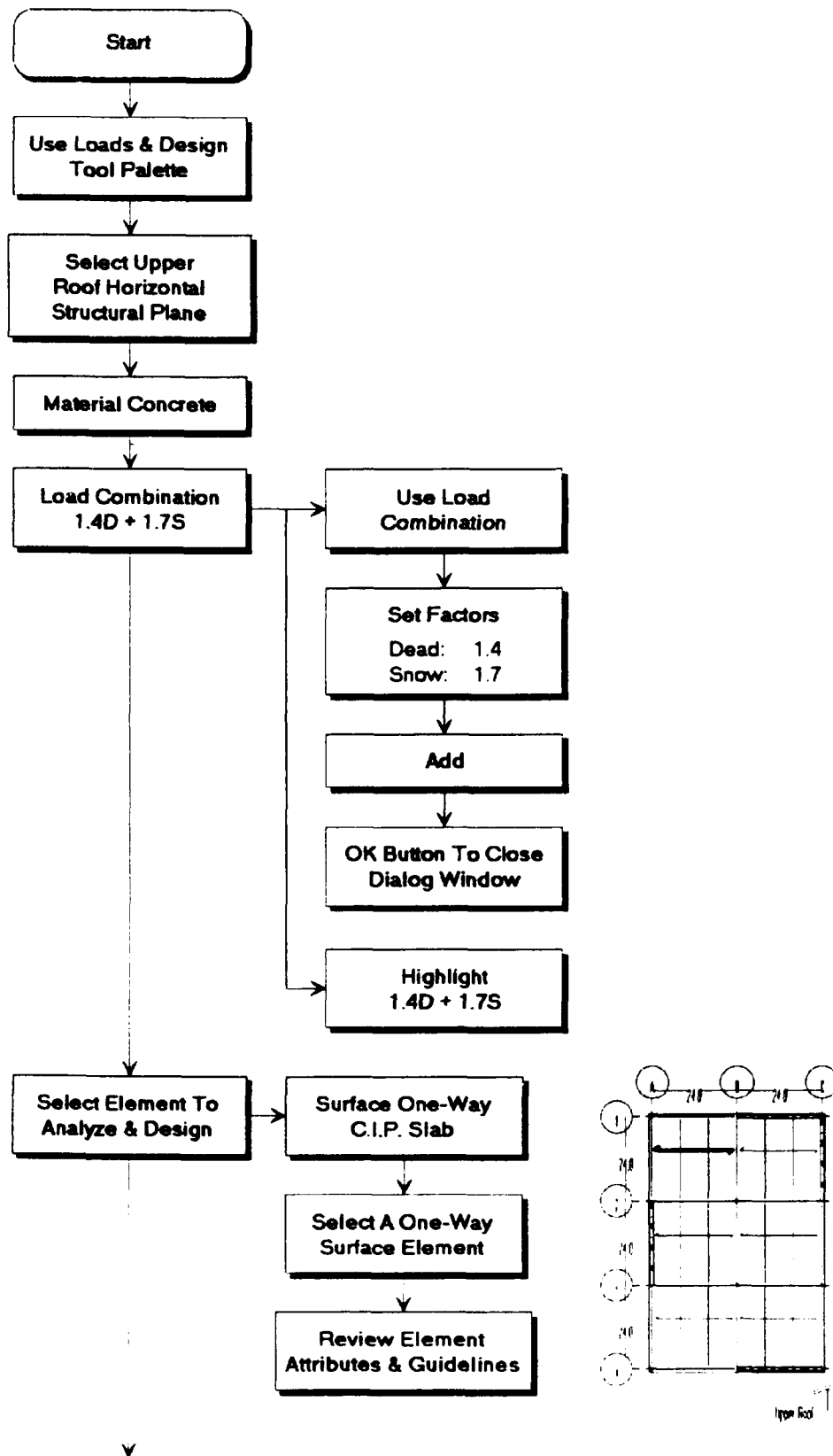
Preliminary Design

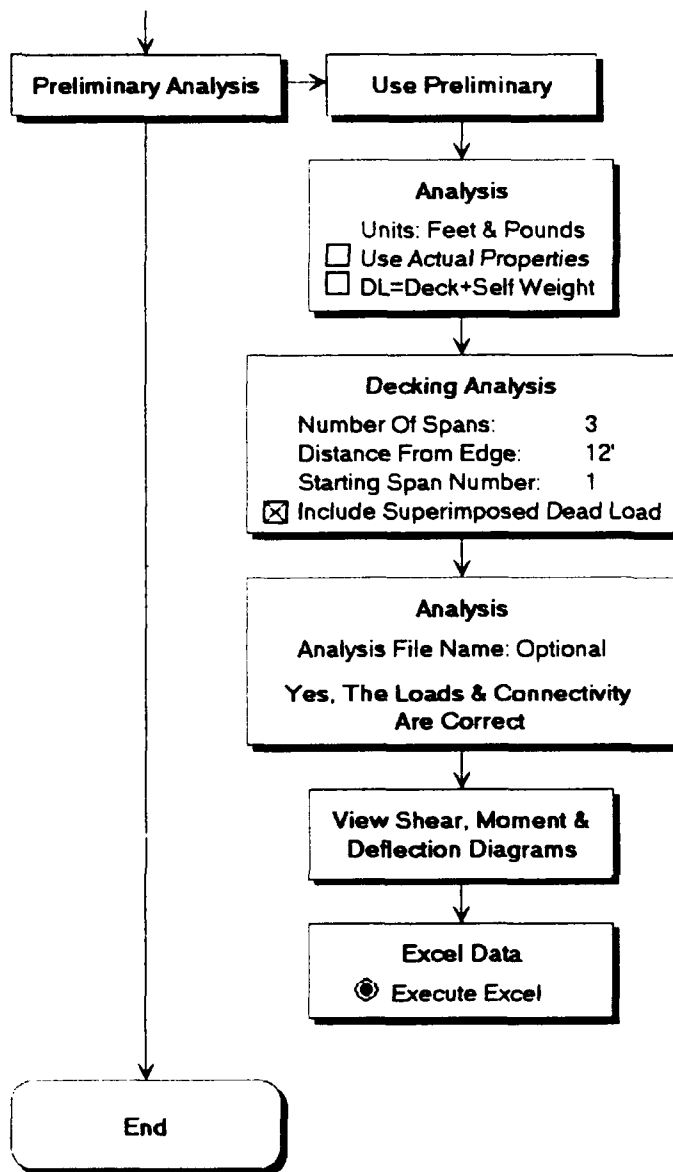
* Maximum V's, M's, R's, etc. sent to Excel

Spreadsheets

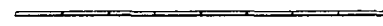


Surface Element Analysis

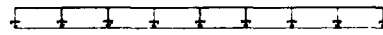




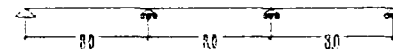
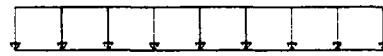
1.40 Dead (pl)



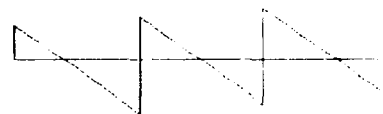
1.40 Superimposed Dead (pl)



1.70 Snow (pl)



Shear (b)

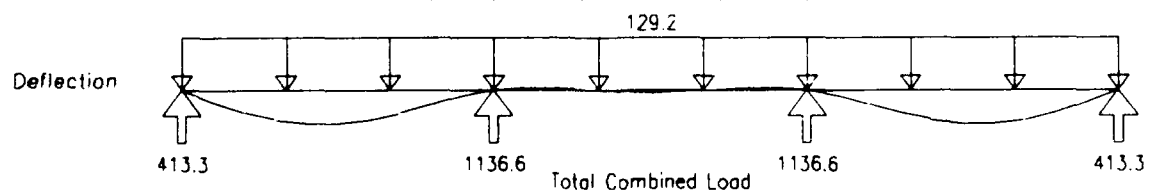
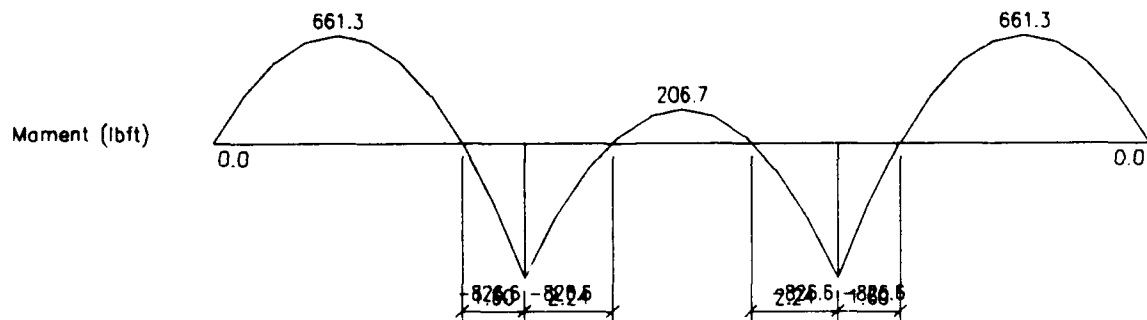
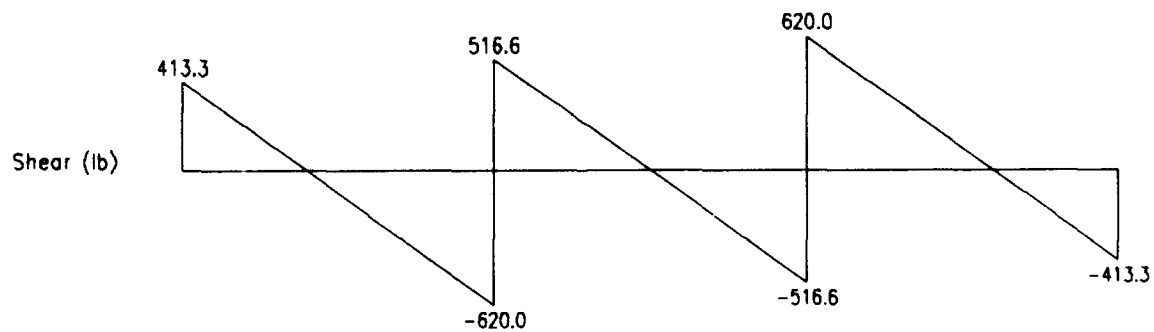
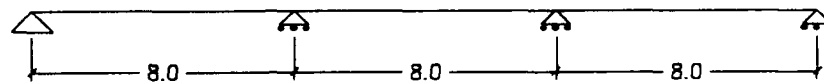
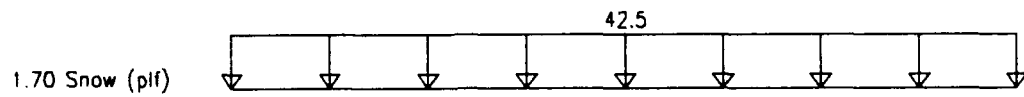
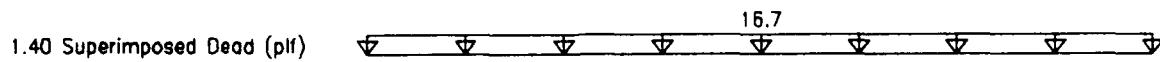
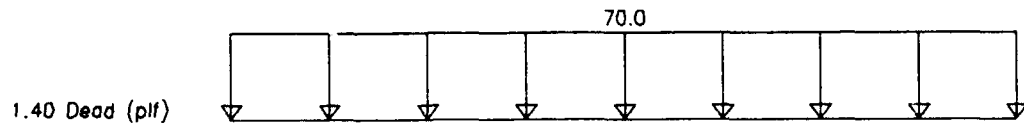


Moment (kft)

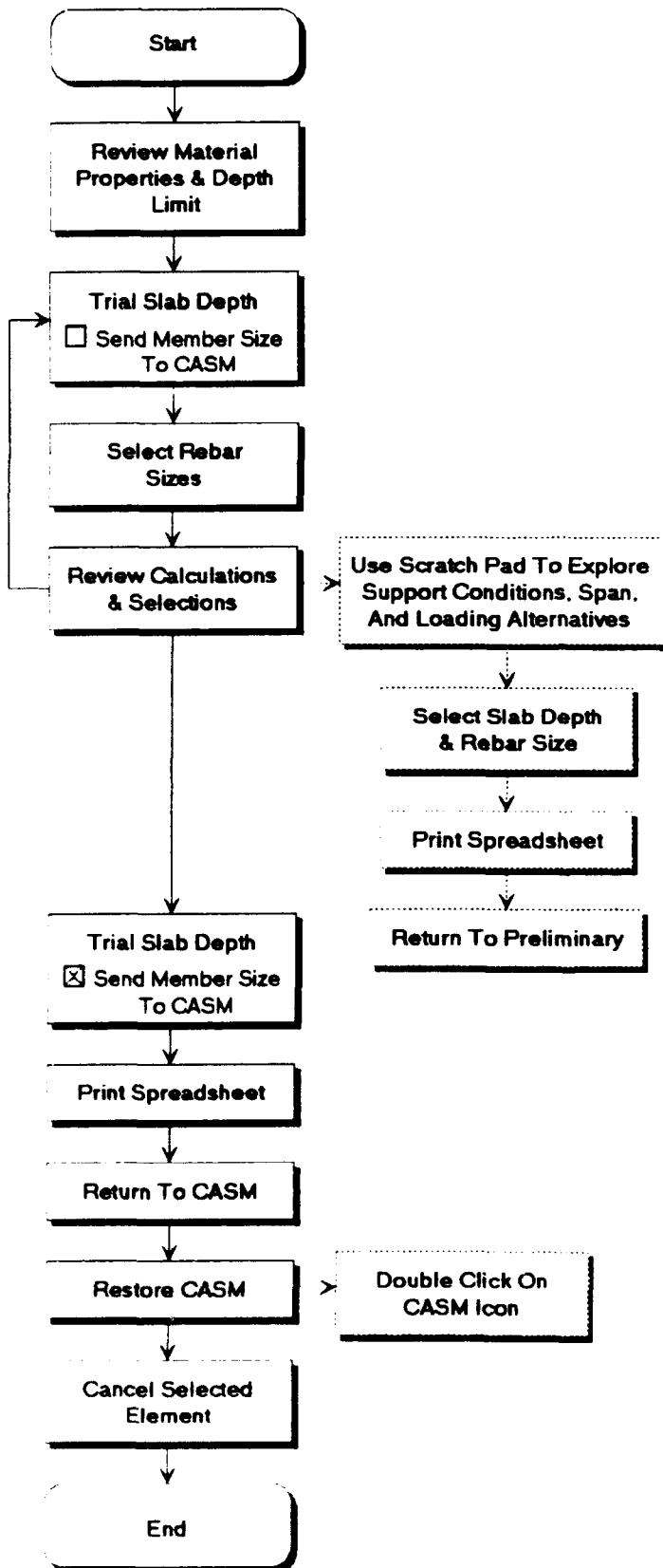


Deflection





Concrete Slab Design



Concrete Slab Selection

CONCRETE SLAB PRELIMINARY SELECTION

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

CASM Load & Analysis Data:

Method: Analysis		Load Combination: 1.4D + 1.7S					
Member ID:		Load Type	Factored Moments (k-ft)			Fact. Reactions	
Connectivity: Beam (Left)			Left	Mid	Right	Left(k)	Right(k)
	Beam (Right)	Dead	0.4	0.4	0.4	0.3	0.3
Slab Span: 8.0 ft		Sup Dead	0.1	0.1	0.1	0.1	0.1
Trib Width= 12.0 in		Live					
Depth Limit= 8.0 in. max		Lmin Roof					
Concrete F'c= 4.0 ksi		Snow	0.3	0.2	0.3	0.2	0.2
Concrete Wt= 145 pcf		Wind					
Steel Fy= 60.0 ksi		Summary	0.8	0.7	0.8	0.6	0.6

CASM Preliminary Slab Thickness/Values:

ACI Preliminary Dimensions:		Design Data:		Rebar Ratios:	
ACI Depth: L/ 28.0 = 3.4 in		Bending $\phi(\epsilon) = 0.90$		pmax= 2.14 %	
Trial Depth= 4.00 in	Span= 3	beta(B)= 0.85		1/2pmax= 1.07 %	
Cover: Top= 0.75 in	Btm= 0.75 in	m= 17.6		pmin= 0.33 %	
d'= 1.00 in	d= 3.00 in	Ru= 581 psi			

CASM Preliminary Slab Reinforcement:

		Left end		Midspan		Right end		
		Reqd	Select	Reqd	Select	Reqd	Select	
Mu (kf)		0.83	1.74	0.66	1.74	0.83	1.74	Shear Capacity:
Ru (psi)		102	215	82	215	102	215	$\phi V_c = 3.9 \text{ k}$
Reqd p (%)		0.19	0.37	0.15	0.37	0.19	0.37	
Reqd As (sq in.)		0.07	0.13	0.05	0.13	0.07	0.13	Shrinkage/Temp
Rebar &	#4	18.00		18.00		18.00		Reinforcement
Spacing	#5	18.00		18.00		18.00		Rqd As= 0.09
Options:	#6	18.00		18.00		18.00		Selected
Selected Bar Size:		#4		#4		#4		Bar Size= #3
Selected Spacing:		18 in		18 in		18 in		Spacing= 15 in
As (sq in/ft)= :		0.13		0.13		0.13		As= 0.09

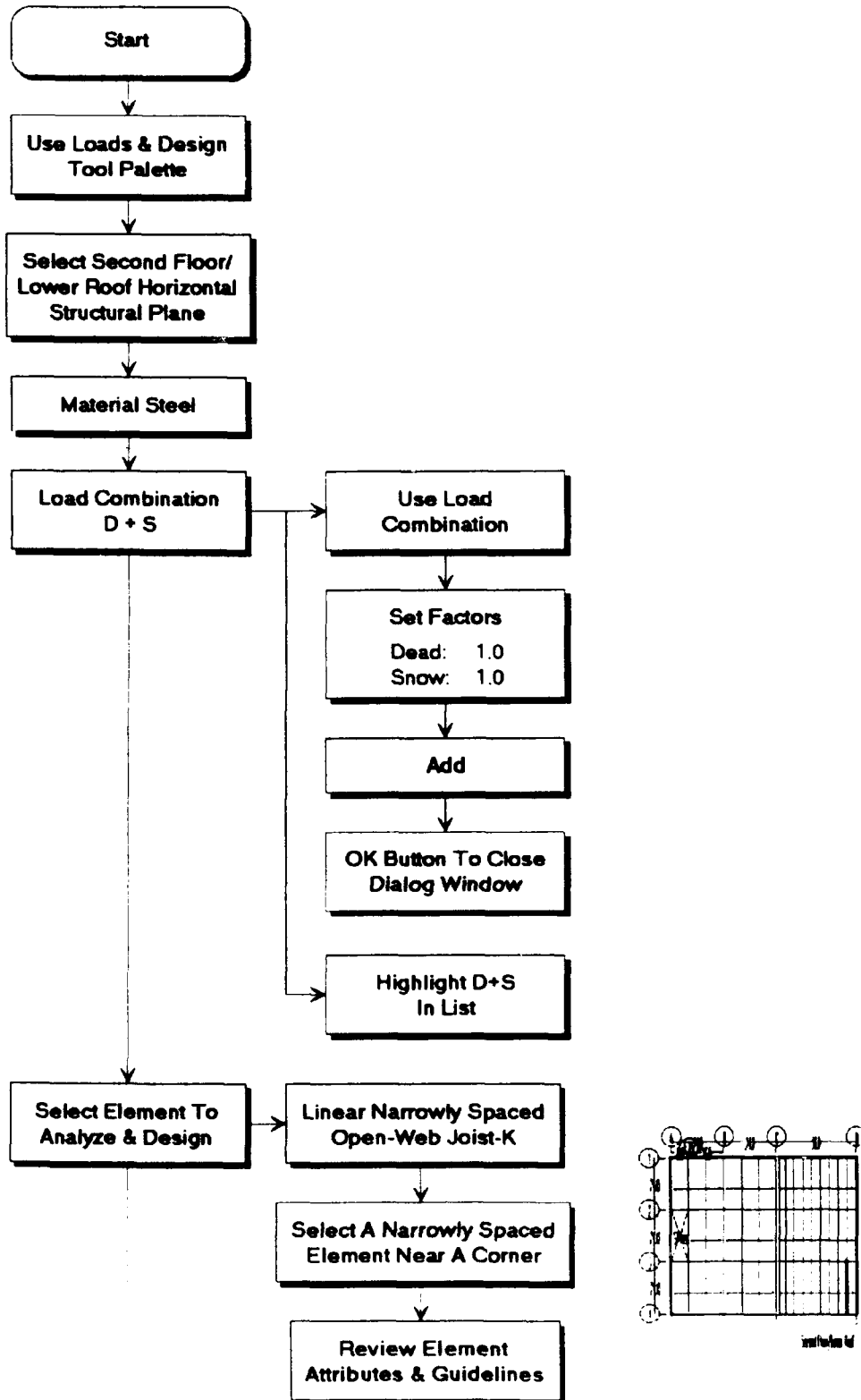
4." slab Quantities:

Depth= 4.00 in	Conc Vol= .012 cy/sf	Rebar Wgt = .0005 tons/sf
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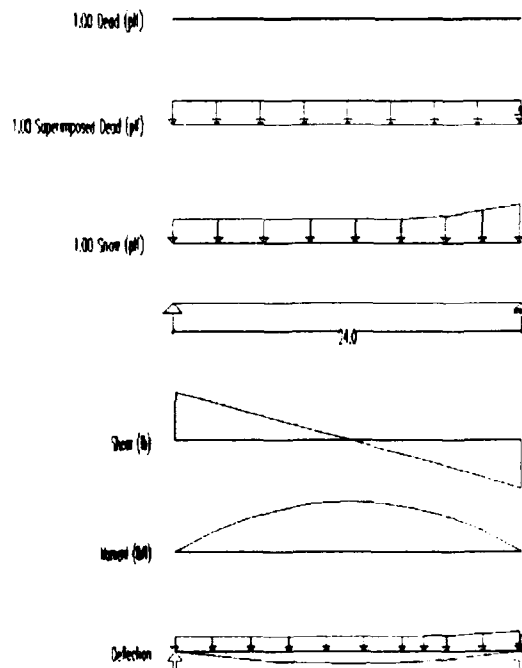
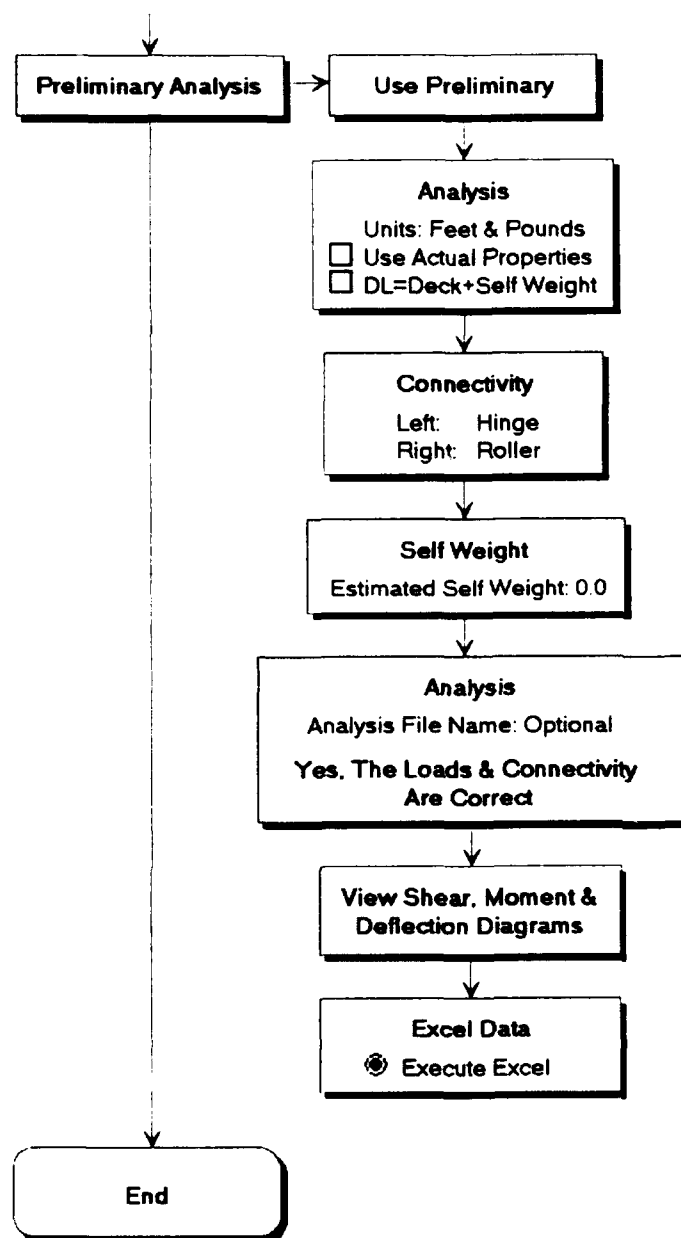
Notes:

1. ACI 318-89 Strength Design used for sizing member.

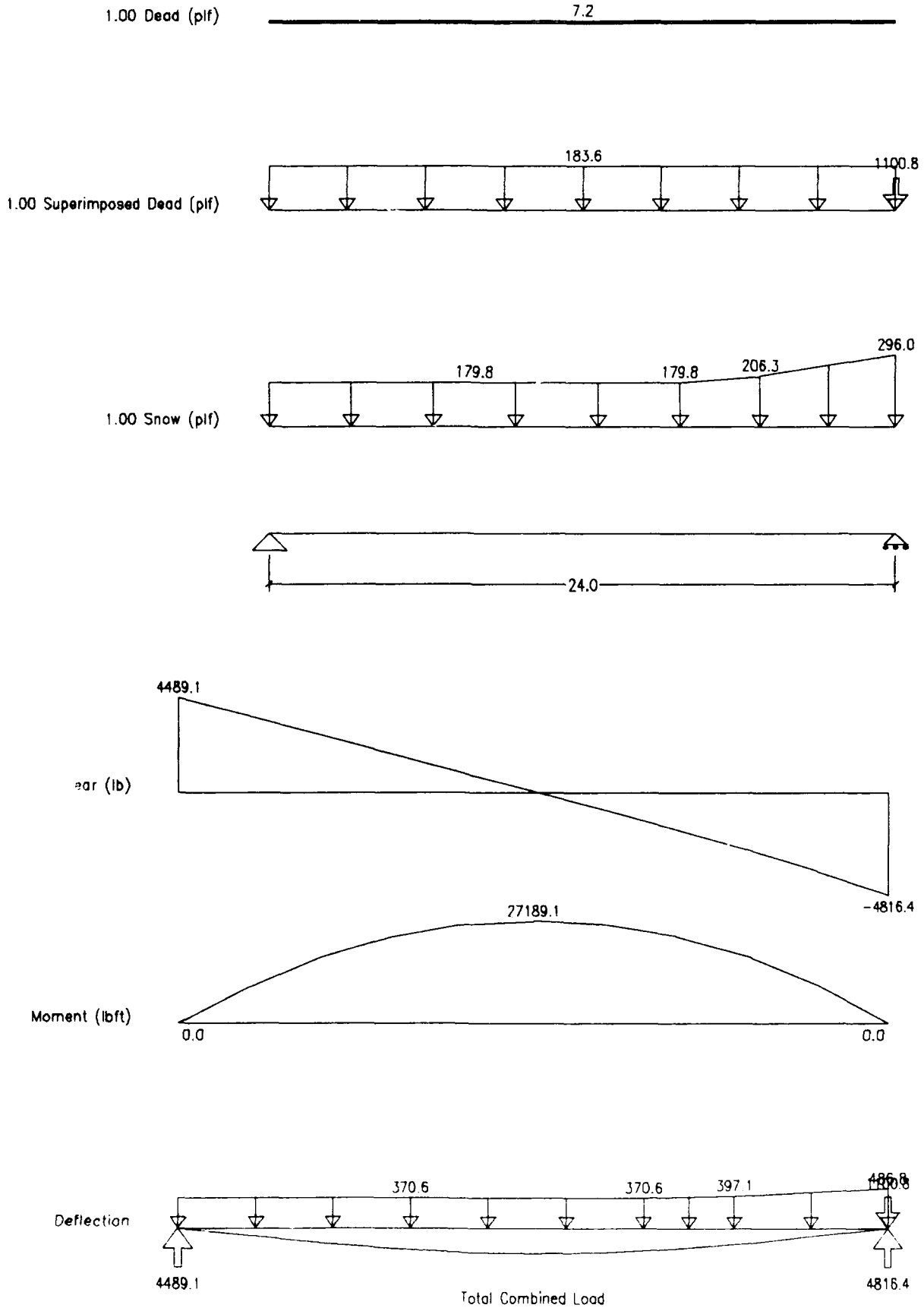
Narrowly Spaced Element Analysis



Narrowly Spaced Element Analysis



Narrowly Spaced Element Analysis



Narrowly Spaced Element Analysis

* TWO DIMENSIONAL FRAME ANALYSIS PROGRAM *

2-D FRAME ANALYSIS-V 8/77 RUN-Sun Jan 26, 1992 1:10 PM

***** I N P U T *****

Office Building - Scheme C -- Dead 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
NUMBER OF FIXED END FORCE TYPES = 1

MATERIAL TYPES

UNITS: INCHES, POUNDS

MATERIAL	YOUNG'S MODULUS	POISSON'S RATIO
1	1.0000	0.0000

MEMBER PROPERTIES

UNITS: INCHES

ELEMENT TYPE	AXIAL AREA	SEAR AREA	MOMENT OF INERTIA
1	1000.0000	0.0000	1.0000

SUMMARY OF IN-SPAN LOADS

POSITIVE IS UPWARD AND COUNTERCLOCKWISE

UNITS: FEET, POUNDS

LOAD SET TYPE	SPAN	STARTING MAGNITUDE	STARTING POSITION	ENDING MAGNITUDE	ENDING POSITION
1 UNIFORM	2.40	-7.20	0.00		2.40

FIXED END FORCES IN LOCAL COORDINATES

UNITS: FEET, POUNDS

TYPE	AXIAL I	SEAR I	MOMENT I	AXIAL J	SEAR J	MOMENT J
1	0.000	8.640	3.456	0.000	8.640	-3.456

JOINT DATA

UNITS: FEET, POUNDS

NODE CODE	NODAL COORDINATES		BOUNDARY CONDITIONS			ELASTIC SUPPORT TYPE
	X	Y	K	Y	S	
1	110	13.00	0.00	0.00	0.00	0
2	0	15.40	0.00	0.00	0.00	0
3	0	17.80	0.00	0.00	0.00	0
4	0	20.20	0.00	0.00	0.00	0
5	0	22.60	0.00	0.00	0.00	0
6	0	25.00	0.00	0.00	0.00	0
7	0	27.40	0.00	0.00	0.00	0
8	0	29.80	0.00	0.00	0.00	0
9	0	32.20	0.00	0.00	0.00	0
10	0	34.60	0.00	0.00	0.00	0
11	10	37.00	0.00	0.00	0.00	0

MEMBER DATA

EL	NOES	NOES	NOES	NOES	NOES	F.S.F.	REL	STIFF	CARRY OVER
I	J	TYPE	TYPE	CODE	TYPE	TYPE	KIJ	KJI	FACTOR
1	1	2	1	1	0	1	4.00	4.00	0.50
2	2	3	1	1	0	1	4.00	4.00	0.50
3	3	4	1	1	0	1	4.00	4.00	0.50
4	4	5	1	1	0	1	4.00	4.00	0.50
5	5	6	1	1	0	1	4.00	4.00	0.50
6	6	7	1	1	0	1	4.00	4.00	0.50
7	7	8	1	1	0	1	4.00	4.00	0.50
8	8	9	1	1	0	1	4.00	4.00	0.50
9	9	10	1	1	0	1	4.00	4.00	0.50
10	10	11	1	1	0	1	4.00	4.00	0.50

***** O U T P U T *****

JOINT DISPLACEMENTS

UNITS: INCHES, RADIANS AFTER DIVISION BY EI

JOINT	X-DISPLACEMENT	Y-DISPLACEMENT	ROTATION
1	0.0000	0.0000	-597196.7842
2	0.0000	-16872481.3041	-563753.7643
3	0.0000	-31821840.2654	-472979.8531
4	0.0000	-43703338.4237	-339207.7734
5	0.0000	-51185019.7359	-174770.2481
6	0.0000	-53747710.5762	-0.0000
7	0.0000	-51185019.7359	174770.2481
8	0.0000	-43703338.4237	339207.7734
9	0.0000	-31821840.2654	472979.8531
10	0.0000	-16872481.3041	563753.7643
11	0.0000	0.0000	597196.7842

MEMBER END FORCES

UNITS: FEET, POUNDS

EL	AXIAL I	SEAR I	MOMENT I	AXIAL J	SEAR J	MOMENT J
1	0.000	86.400	-0.000	0.000	-69.120	188.424
2	0.000	69.120	-188.424	0.000	-51.840	331.776
3	0.000	51.840	-331.776	0.000	-34.560	435.456
4	0.000	34.560	-435.456	0.000	-17.280	497.464
5	0.000	17.280	-497.464	0.000	-0.000	518.400
6	0.000	0.000	-518.400	0.000	17.280	497.464
7	0.000	-17.280	-497.464	0.000	34.560	435.456
8	0.000	-34.560	-435.456	0.000	51.840	331.776
9	0.000	-51.840	-331.776	0.000	69.120	188.424
10	0.000	-69.120	-188.424	0.000	86.400	0.000

APPLIED JOINT LOADS AND SUPPORT REACTIONS

UNITS: FEET, POUNDS

NODE	FORCE X	FORCE Y	MOMENT S
1	0.000	86.400	-0.000
2	0.000	0.000	0.000
3	0.000	-0.000	0.000
4	0.000	0.000	0.000
5	0.000	-0.000	-0.000
6	0.000	0.000	0.000
7	0.000	-0.000	0.000
8	0.000	-0.000	0.000
9	0.000	0.000	0.000
10	0.000	-0.000	0.000
11	0.000	86.400	0.000

PROBLEMS COMPLETED

* TWO DIMENSIONAL FRAME ANALYSIS PROGRAM *

2-D FRAME ANALYSIS-V 8/77 RUN-Sun Jan 26, 1992 1:10 PM

***** I N P U T *****

Office Building - Scheme C -- Superimposed Dead Load

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 FORCE TYPES = 1

MATERIAL TYPES

UNITS: INCHES, POUNDS

MATERIAL	YOUNG'S MODULUS	POISSON'S RATIO
1	1.0000	0.0000

MEMBER PROPERTIES

UNITS: INCHES

ELEMENT TYPE	AXIAL AREA	SHEAR AREA	MOMENT OF INERTIA
1	1000.0000	0.0000	1.0000

FORCAST OF IN-SPAN LOADS

POSITIVE IS UPWARD AND COUNTERCLOCKWISE

UNITS: FEET, POUNDS

LOAD SET	LOAD TYPE	SPAN LENGTH	STARTING MAGNITUDE	STARTING POSITION	ENDING MAGNITUDE	ENDING POSITION
1	UNIFORM	2.40	-183.60	0.00		2.40

FIXED END FORCES IN LOCAL COORDINATES

UNITS: FEET, POUNDS

TYPE	AXIAL I	SHEAR I	MOMENT I	AXIAL J	SHEAR J	MOMENT J
1	0.000	220.320	80.120	0.000	220.320	-80.120

JOINT DATA

UNITS: FEET, POUNDS

NODE CODE	NODAL COORDINATES		BOUNDARY CONDITIONS			ELASTIC SUPPORT TYPES	
	X	Y	X	Y	Z		
1	110	13.00	0.00	0.00	0.00	0.00	0
2	0	15.40	0.00	0.00	0.00	0.00	0
3	0	17.80	0.00	0.00	0.00	0.00	0
4	0	20.20	0.00	0.00	0.00	0.00	0
5	0	22.60	0.00	0.00	0.00	0.00	0
6	0	25.00	0.00	0.00	0.00	0.00	0
7	0	27.40	0.00	0.00	0.00	0.00	0
8	0	29.80	0.00	0.00	0.00	0.00	0
9	0	32.20	0.00	0.00	0.00	0.00	0
10	0	34.60	0.00	0.00	0.00	0.00	0
11	10	37.00	0.00	0.00	0.00	0.00	0

MEMBER DATA

ELI	MOOS	MOOS	MT	ELI	ELI	F.R.F.	REL	STIFF	CARRY OVER
I	J	TYPE	TYPE	CODE	TYPE	TYPE	KIJ	KJI	FACTOR
1	1	2	1	1	0	1	4.00	4.00	0.50
2	2	3	1	1	0	1	4.00	4.00	0.50
3	3	4	1	1	0	1	4.00	4.00	0.50
4	4	5	1	1	0	1	4.00	4.00	0.50
5	5	6	1	1	0	1	4.00	4.00	0.50
6	6	7	1	1	0	1	4.00	4.00	0.50
7	7	8	1	1	0	1	4.00	4.00	0.50
8	8	9	1	1	0	1	4.00	4.00	0.50
9	9	10	1	1	0	1	4.00	4.00	0.50
10	10	11	1	1	0	1	4.00	4.00	0.50

***** O U T P U T *****

JOINT DISPLACEMENTS

UNITS: INCHES, RADIANS AFTER DIVISION BY EI

JOINT	X-DISPLACEMENT	Y-DISPLACEMENT	Z-ROTATION
1	0.0000	0.0000	-15226518.6669
2	0.0000	-430248292.2500	-14375721.6235
3	0.0000	-814006942.7074	-12060966.7630
4	0.0000	-1114435179.0004	-8649798.6040
5	0.0000	-1305218060.8929	-4507641.5260
6	0.0000	-1370546480.2051	-0.0000
7	0.0000	-1305218060.8929	4507641.5260
8	0.0000	-1114435179.0004	8649798.6040
9	0.0000	-814006942.7074	12060966.7630
10	0.0000	-430248292.2500	14375721.6235
11	0.0000	0.0000	15226518.6669

MEMBER END FORCES

UNITS: FEET, POUNDS

ELI	AXIAL I	SHEAR I	MOMENT I	AXIAL J	SHEAR J	MOMENT J
1	0.000	2203.200	0.000	0.000	-1762.560	4758.912
2	0.000	1762.560	-4758.912	0.000	-1321.920	8460.289
3	0.000	1321.920	-8460.289	0.000	-801.280	11104.128
4	0.000	801.280	-11104.128	0.000	-440.640	12690.432
5	0.000	440.640	-12690.432	0.000	0.000	13219.201
6	0.000	-0.000	-13219.201	0.000	440.640	12690.432
7	0.000	-440.640	-12690.432	0.000	801.280	11104.128
8	0.000	-801.280	-11104.128	0.000	1321.920	8460.289
9	0.000	-1321.920	-8460.289	0.000	1762.560	4758.912
10	0.000	-1762.560	-4758.912	0.000	2203.200	-0.000

APPLIED JOINT LOADS AND SUPPORT REACTIONS

UNITS: FEET, POUNDS

NODE	FORCE X	FORCE Y	MOMENT Z
1	0.000	2203.200	0.000
2	0.000	-0.000	0.000
3	0.000	0.000	-0.000
4	0.000	0.000	-0.000
5	0.000	-0.000	-0.000
6	0.000	0.000	-0.000
7	0.000	0.000	-0.000
8	0.000	0.000	0.000
9	0.000	0.000	0.000
10	0.000	-0.000	0.000
11	0.000	2203.200	-0.000

PROGRAM COMPLETED

 * TWO DIMENSIONAL FRAME ANALYSIS PROGRAM *

2-D FRAME ANALYSIS-V 8/77 ROR-Gm Jan 26, 1992 1:10 PM

***** I N P U T *****

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
 NUMBER OF FIXED END FORCE TYPES = 5

MATERIAL TYPES

UNITS: INCHES, POUNDS

MATERIAL	YOUNG'S MODULUS	POISSON'S RATIO
1	1.0000	0.0000

MEMBER PROPERTIES

UNITS: INCHES

ELEMENT TYPE	AXIAL AREA	SHEAR AREA	MOMENT OF INERTIA
1	1000.0000	0.0000	1.0000

Narrowly Spaced Element Analysis

SUMMARY OF IN-SPAN LOADS

POSITIVE IS UPWARD AND COUNTERCLOCKWISE

UNITS: FEET, POUNDS

LOAD SET	LOAD TYPE	SPAN LENGTH	STARTING MAGNITUDE	STARTING POSITION	ENDING MAGNITUDE	ENDING POSITION
1	UNIFORM	2.40	-179.76	0.00		2.40
2	UNIFORM	2.40	-179.76	0.00		1.32
3	RAMP	2.40	-179.76	1.32	-189.06	2.40
4	RAMP	2.40	-189.06	0.00	-206.35	2.00
5	RAMP	2.40	-206.35	2.00	-213.18	2.40
6	RAMP	2.40	-213.18	0.00	-254.59	2.40
7	RAMP	2.40	-254.59	0.00	-296.00	2.40

FIXED END FORCES IN LOCAL COORDINATES

UNITS: FEET, POUNDS

TYPE	AXIAL I	SHEAR I	MOMENT I	AXIAL J	SHEAR J	MOMENT J
1	0.000	215.713	86.265	0.000	215.713	-86.265
2	0.000	216.129	86.581	0.000	220.311	-87.387
3	0.000	226.336	94.731	0.000	244.933	-96.788
4	0.000	270.727	110.279	0.000	290.603	-114.254
5	0.000	320.417	130.154	0.000	349.293	-134.130

JOINT DATA

UNITS: FEET, POUNDS

NODE CODE	MODAL COORDINATES		BOUNDARY CONDITIONS			ELASTIC SUPPORT TYPE
	X	Y	X	Y	Z	
1	110	13.00	0.00	0.00	0.00	0
2	0	15.40	0.00	0.00	0.00	0
3	0	17.00	0.00	0.00	0.00	0
4	0	20.20	0.00	0.00	0.00	0
5	0	22.60	0.00	0.00	0.00	0
6	0	25.00	0.00	0.00	0.00	0
7	0	27.40	0.00	0.00	0.00	0
8	0	29.80	0.00	0.00	0.00	0
9	0	32.20	0.00	0.00	0.00	0
10	0	34.60	0.00	0.00	0.00	0
11	10	37.00	0.00	0.00	0.00	0

MEMBER DATA

ELI	MOE	MOE	SLT	ELI	ELI	F.S.F.	REL	STIFF	CARRY OVER
I	J	TYPE	TYPE	CODE	TYPE	TYPE	ELI	ELI	FACTOR
1	1	2	1	1	0	1	4.00	4.00	0.50
2	2	3	1	1	0	1	4.00	4.00	0.50
3	3	4	1	1	0	1	4.00	4.00	0.50
4	4	5	1	1	0	1	4.00	4.00	0.50
5	5	6	1	1	0	1	4.00	4.00	0.50
6	6	7	1	1	0	1	4.00	4.00	0.50
7	7	8	1	1	0	2	4.00	4.00	0.50
8	8	9	1	1	0	3	4.00	4.00	0.50
9	9	10	1	1	0	4	4.00	4.00	0.50
10	10	11	1	1	0	5	4.00	4.00	0.50

***** O U T P U T *****

JOINT DISPLACEMENTS

UNITS: INCHES, RADIANS AFTER DIVISION BY EI

JOINT	X-DISPLACEMENT	Y-DISPLACEMENT	Z-ROTATION
1	0.0000	0.0000	-15477674.9486
2	0.0000	-437429473.1567	-14625130.2757
3	0.0000	-970920035.9628	-12306087.6764
4	0.0000	-1135615012.7337	-8878299.3904
5	0.0000	-1322510783.5772	-4699497.6362
6	0.0000	-1492544704.5933	-128094.6333
7	0.0000	-1339591507.7742	4478467.3991
8	0.0000	-1147871401.9354	8762676.3217
9	0.0000	-841413597.1693	12358723.8440
10	0.0000	-446232743.7972	14866528.1648
11	0.0000	0.0000	15019645.5356

MEMBER END FORCES

UNITS: FEET, POUNDS

ELI	AXIAL I	SHEAR I	MOMENT I	AXIAL J	SHEAR J	MOMENT J
1	0.000	2199.520	0.000	0.000	-1760.094	4761.137
2	0.000	1768.094	-4761.137	0.000	-1336.668	8486.852
3	0.000	1336.668	-8486.852	0.000	-909.241	11177.143
4	0.000	909.241	-11177.143	0.000	-479.615	12832.011
5	0.000	479.615	-12832.011	0.000	-42.369	13451.456
6	0.000	42.369	-13451.456	0.000	349.037	13035.477
7	0.000	-349.037	-13035.477	0.000	825.477	11582.273
8	0.000	-825.477	-11582.273	0.000	1304.746	9036.668
9	0.000	-1304.746	-9036.668	0.000	1866.076	5251.358
10	0.000	-1866.076	-5251.358	0.000	2526.785	-0.000

APPLIED JOINT LOADS AND SUPPORT REACTIONS

UNITS: FEET, POUNDS

NODE	FORCE X	FORCE Y	MOMENT Z
1	0.000	2199.520	0.000
2	0.000	-5.000	0.000
3	0.000	-5.000	0.000
4	0.000	0.000	-0.000
5	0.000	0.000	-0.000
6	0.000	0.000	0.000
7	0.000	0.000	-0.000
8	0.000	-0.000	-0.000
9	0.000	0.000	0.000
10	0.000	-0.000	0.000
11	0.000	2526.785	-0.000

*****PROBLEMS COMPLETED*****

* TWO DIMENSIONAL FRAME ANALYSIS PROGRAM *

2-D FRAME ANALYSIS-V 8/77 RDN-Gm Jan 26, 1992 1:10 PM

***** I N P U T *****

Office Building - Scheme C -- Total Combined Load

NUMBER OF ELEMENTS = 10
NUMBER OF MODAL POINTS = 11
NUMBER OF MATERIALS = 1
NUMBER OF ELEMENT TYPES = 1
NUMBER OF ELASTIC SUPPORT TYPES = 0
NUMBER OF FIXED END FORCE TYPES = 5

MATERIAL TYPES

UNITS: INCHES, POUNDS

MATERIAL	YOUNG'S MODULUS	POISSON'S RATIO
1	1.0000	0.0000

MEMBER PROPERTIES

UNITS: INCHES

ELEMENT TYPE	AXIAL AREA	SHEAR AREA	MOMENT OF INERTIA
1	1000.0000	0.0000	1.0000

SUMMARY OF IN-SPAN LOADS

POSITIVE IS UPWARD AND COUNTERCLOCKWISE

UNITS: FEET, POUNDS

LOAD SET	LOAD TYPE	SPAN LENGTH	STARTING MAGNITUDE	STARTING POSITION	ENDING MAGNITUDE	ENDING POSITION
1	UNIFORM	2.40	-370.58	0.00		2.40
2	UNIFORM	2.40	-190.80	0.00		2.40
2	UNIFORM	2.40	-179.76	0.00		1.32
2	RAMP	2.40	-179.76	1.32	-189.06	2.40
3	UNIFORM	2.40	-190.80	0.00		2.40
3	RAMP	2.40	-189.06	0.00	-206.35	2.00
3	RAMP	2.40	-206.35	2.00	-213.18	2.40
4	UNIFORM	2.40	-190.80	0.00		2.40
4	RAMP	2.40	-213.18	0.00	-254.59	2.40
5	UNIFORM	2.40	-190.80	0.00		2.40
5	RAMP	2.40	-254.59	0.00	-296.00	2.40

Narrowly Spaced Element Analysis

FIXED END FORCES IN LOCAL COORDINATES

UNITS: FEET, POUNDS

TYPE	AXIAL I	SHEAR I	MOMENT I	AXIAL J	SHEAR J	MOMENT J
1	0.000	444.673	177.869	0.000	444.673	-177.869
2	0.000	445.000	178.163	0.000	449.271	-178.971
3	0.000	463.296	186.315	0.000	473.693	-188.372
4	0.000	499.687	201.862	0.000	519.363	-205.636
5	0.000	549.377	221.738	0.000	569.253	-225.714

NODE	FORCE X	FORCE Y	MOMENT X
1	0.000	4489.129	0.000
2	0.000	-0.000	0.000
3	0.000	0.000	0.000
4	0.000	0.000	-0.000
5	0.000	0.000	-0.000
6	0.000	-0.000	-0.000
7	0.000	0.000	-0.000
8	0.000	0.000	0.000
9	0.000	-0.000	0.000
10	0.000	-0.000	0.000
11	0.000	4616.386	0.000

JOINT DATA

UNITS: FEET, POUNDS

PROBLEMS COMPLETED

MODAL COORDINATES		BOUNDARY CONDITIONS			ELASTIC	
MODE	CODE	X	Y	X	Y	SUPPORT TYPE
1	110	13.00	0.00	0.00	0.00	0
2	0	15.00	0.00	0.00	0.00	0
3	0	17.00	0.00	0.00	0.00	0
4	0	20.20	0.00	0.00	0.00	0
5	0	22.60	0.00	0.00	0.00	0
6	0	25.00	0.00	0.00	0.00	0
7	0	27.40	0.00	0.00	0.00	0
8	0	29.80	0.00	0.00	0.00	0
9	0	32.20	0.00	0.00	0.00	0
10	0	34.60	0.00	0.00	0.00	C
11	10	37.00	0.00	0.00	0.00	0

MEMBER DATA

ELS	NODE	NODE	MT	ELS	ELS	F.R.F.	REL	STIFF	CARRY OVER
I	J	TYPE	TYPE	CODE	TYPE	TYPE	KIJ	KJI	FACTOR
1	1	2	1	1	0	1	4.00	4.00	0.50
2	2	3	1	1	0	1	4.00	4.00	0.50
3	3	4	1	1	0	1	4.00	4.00	0.50
4	4	5	1	1	0	1	4.00	4.00	0.50
5	5	6	1	1	0	1	4.00	4.00	0.50
6	6	7	1	1	0	1	4.00	4.00	0.50
7	7	8	1	1	0	2	4.00	4.00	0.50
8	8	9	1	1	0	3	4.00	4.00	0.50
9	9	10	1	1	0	4	4.00	4.00	0.50
10	10	11	1	1	0	5	4.00	4.00	0.50

***** O U T P U T *****

JOINT DISPLACEMENTS

UNITS: INCHES, RADIAN AFTER DIVISION BY EI

JOINT	X-DISPLACEMENT	Y-DISPLACEMENT	ROTATION
1	0.0000	0.0000	-31368390.4217
2	0.0000	-864550246.7100	-29564605.6838
3	0.0000	-1674257638.9556	-248460024.3155
4	0.0000	-2283793890.1650	-17867308.7678
5	0.0000	-2688918664.2061	-8364189.4164
6	0.0000	-282659178.3746	-128094.6333
7	0.0000	-2695954560.4031	9163079.1732
8	0.0000	-2385009999.3675	17751462.6991
9	0.0000	-1687342400.1422	24692690.4629
10	0.0000	-893354517.3513	39606003.5325
11	0.0000	0.0000	31645380.8690

MEMBER END FORCES

UNITS: FEET, POUNDS

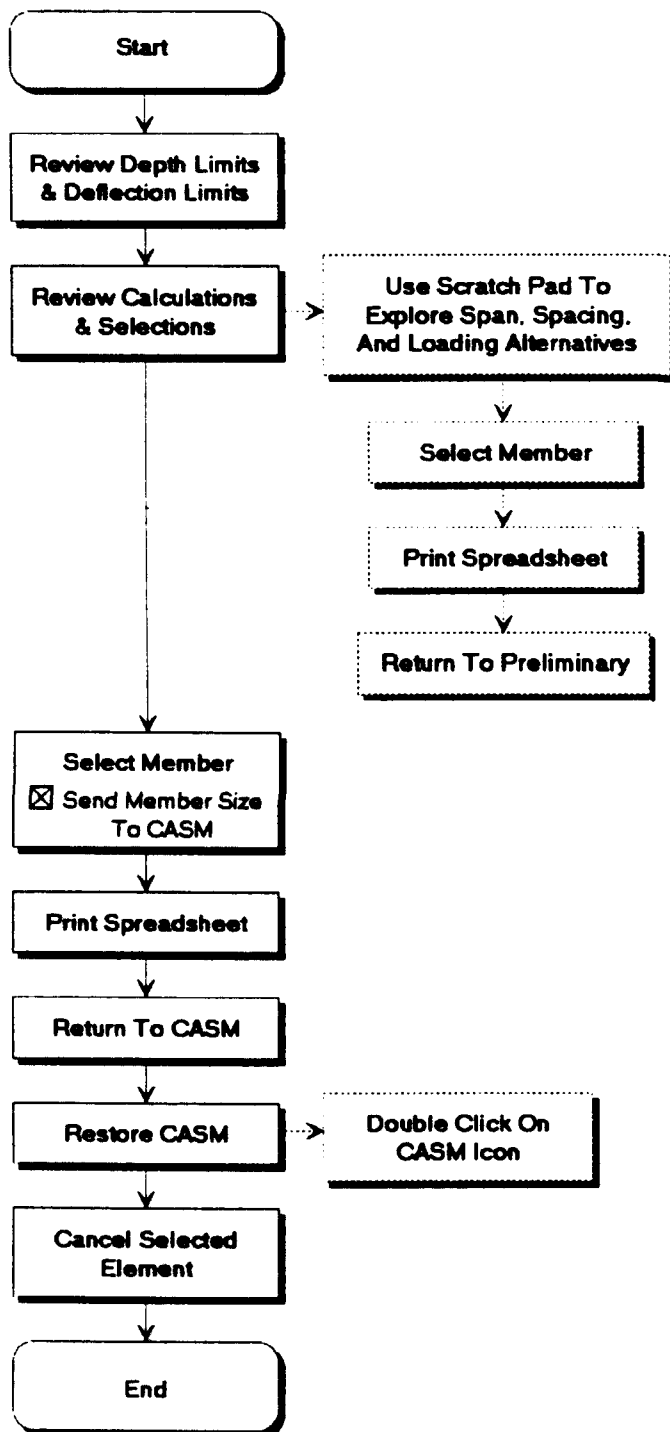
ELS	AXIAL I	SHEAR I	MOMENT I	AXIAL J	SHEAR J	MOMENT J
1	0.000	4489.129	0.000	0.000	-3899.774	9706.674
2	0.000	3899.774	-9706.674	0.000	-2710.428	17276.916
3	0.000	2710.428	-17276.916	0.000	-1821.081	22716.727
4	0.000	1821.081	-22716.727	0.000	-931.735	26020.107
5	0.000	931.735	-26020.107	0.000	-42.389	27189.055
6	0.000	42.389	-27189.055	0.000	846.937	26223.574
7	0.000	-846.937	-26223.574	0.000	1741.317	23121.859
8	0.000	-1741.317	-23121.859	0.000	2678.506	17828.732
9	0.000	-2678.506	-17828.732	0.000	3897.756	10197.094
10	0.000	-3897.756	-10197.094	0.000	4616.386	0.000

APPLIED JOINT LOADS AND SUPPORT REACTIONS

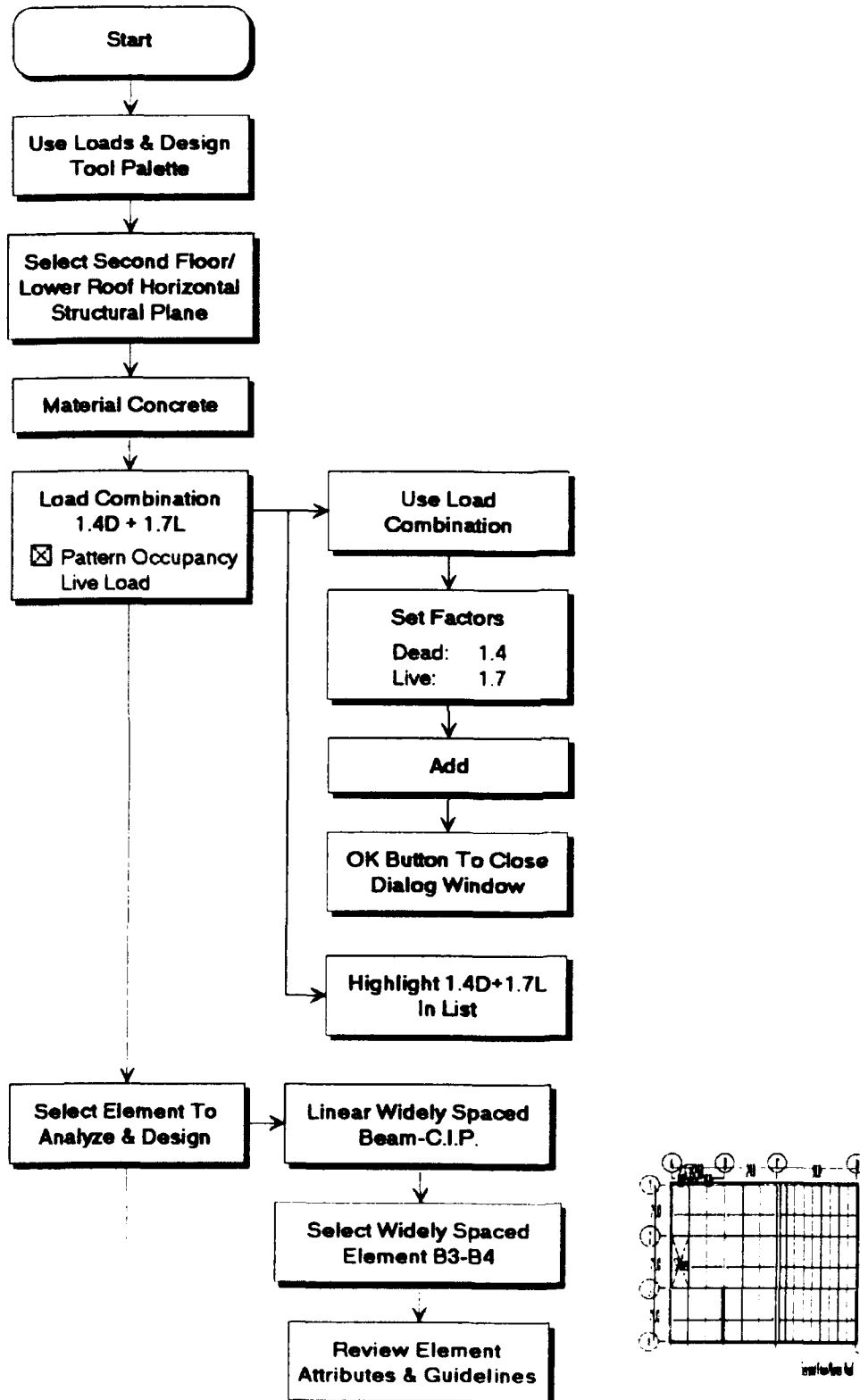
UNITS: FEET, POUNDS

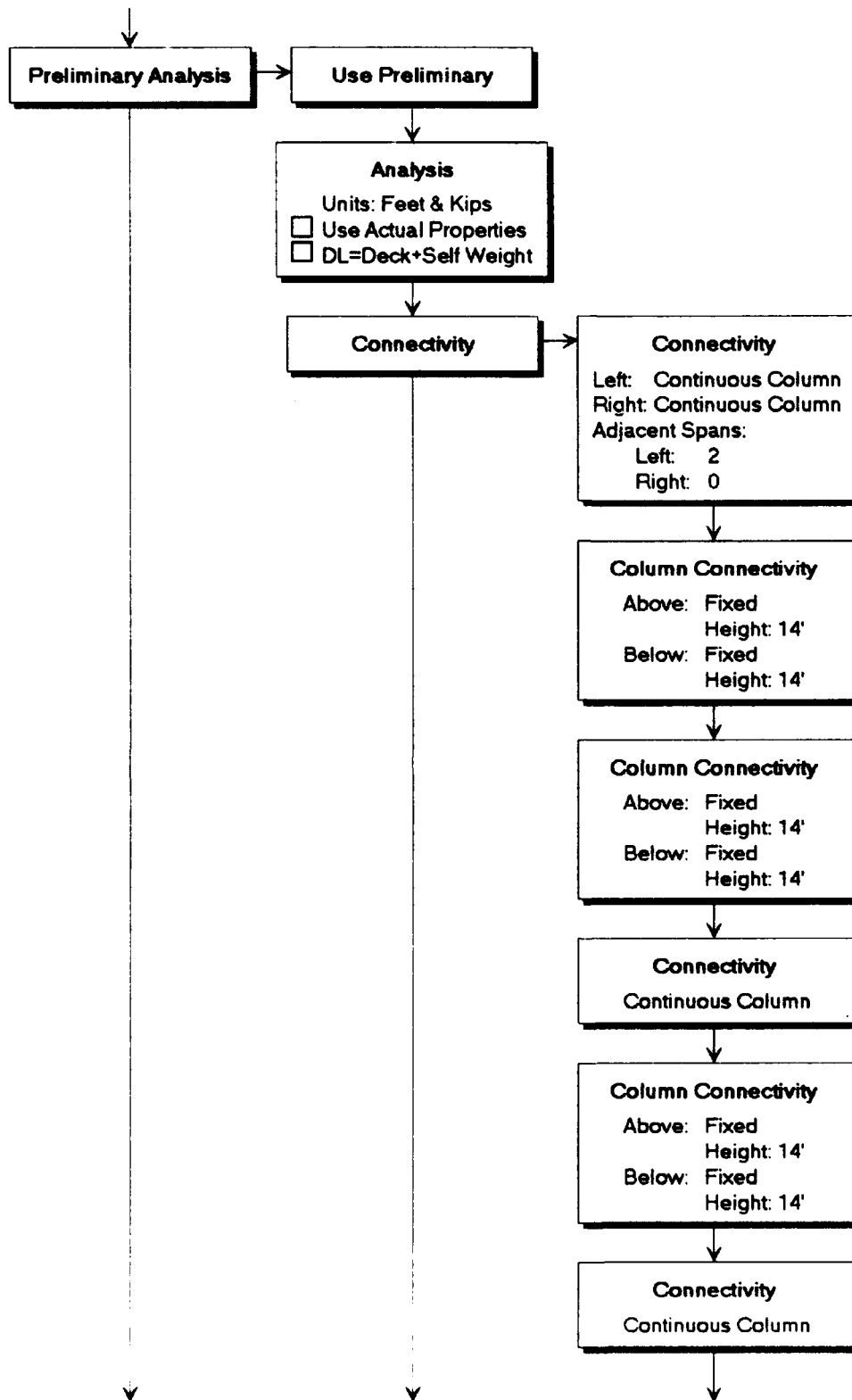


Steel Open-Web Joist Design

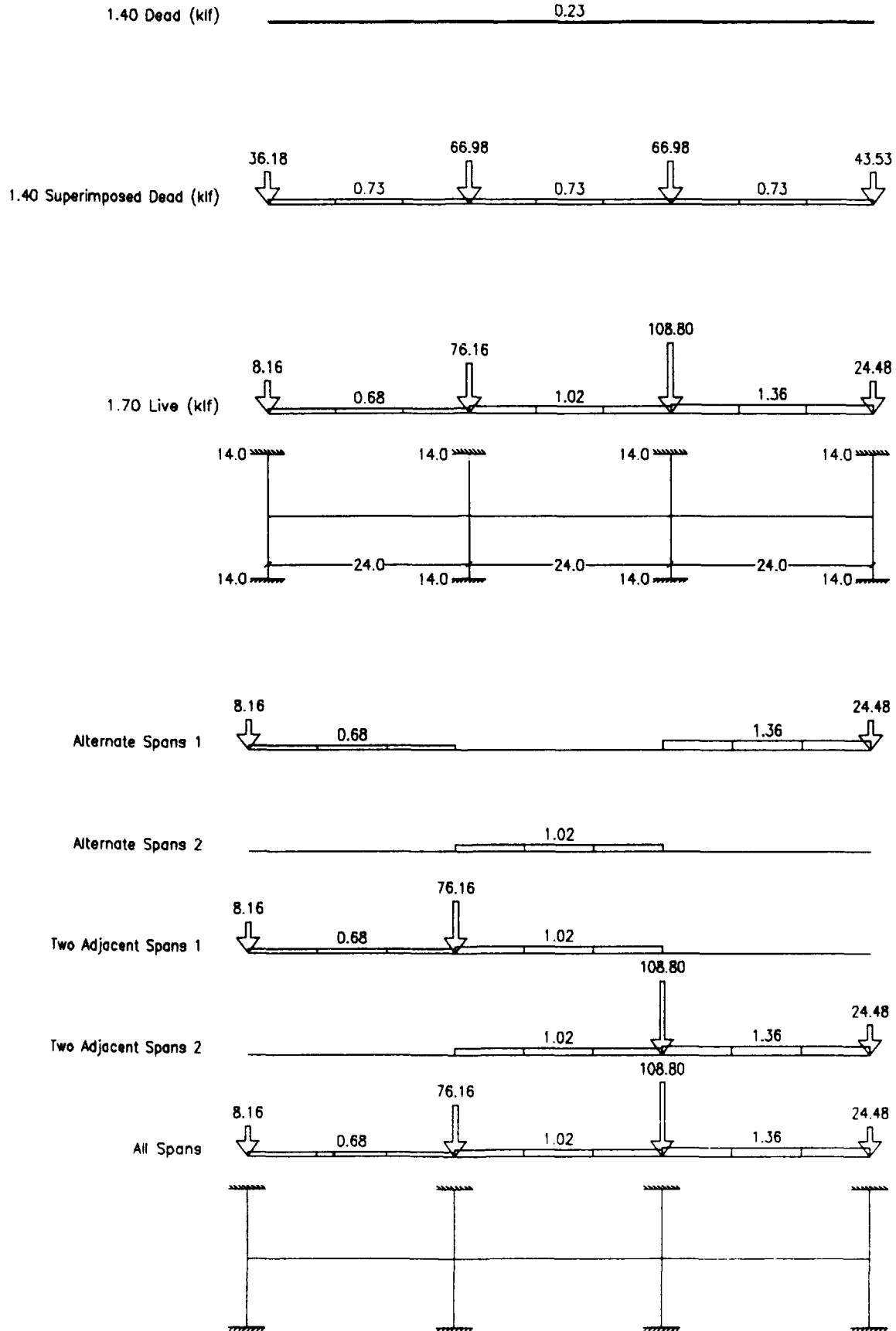


Widely Spaced Element Analysis: Continuous Beam

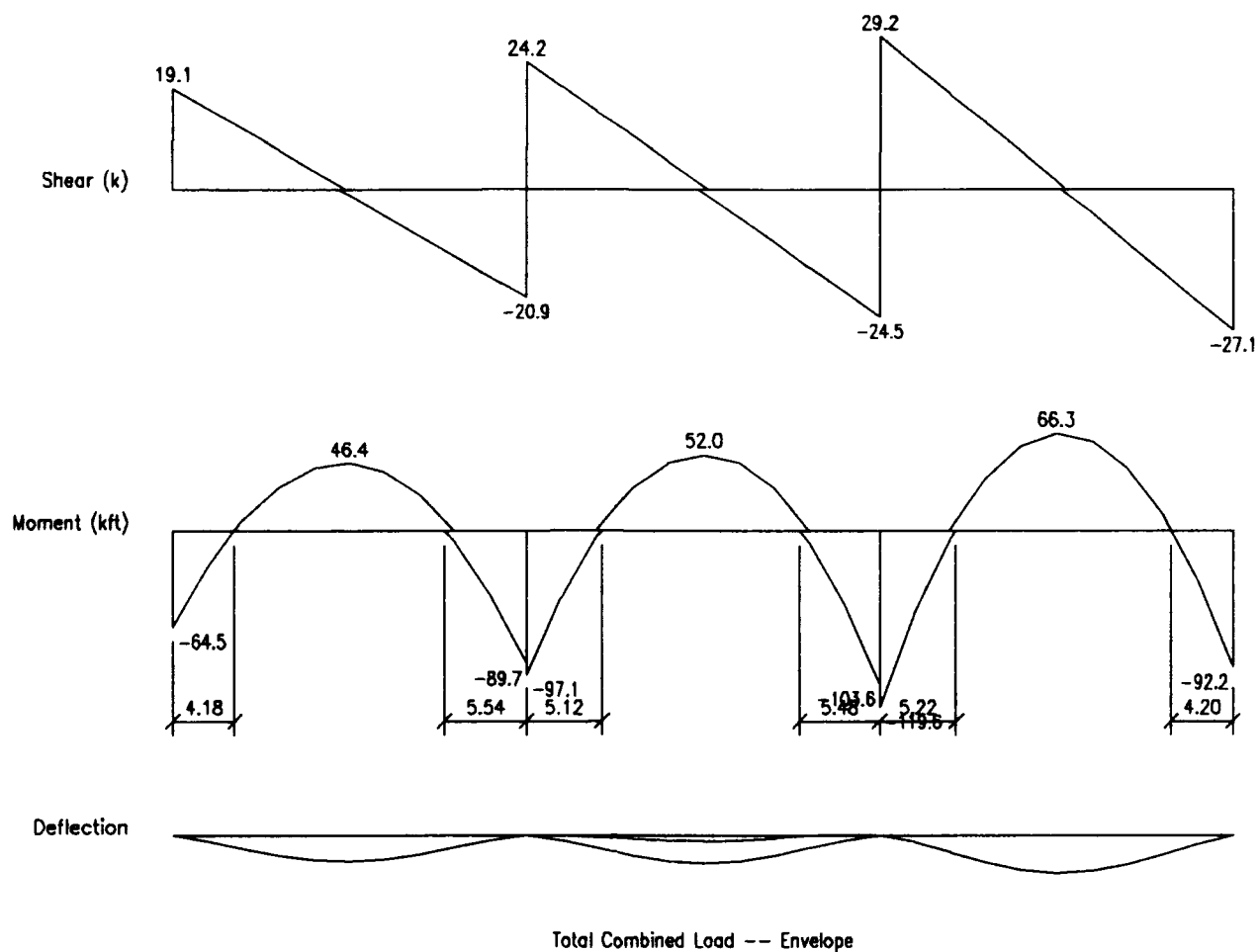




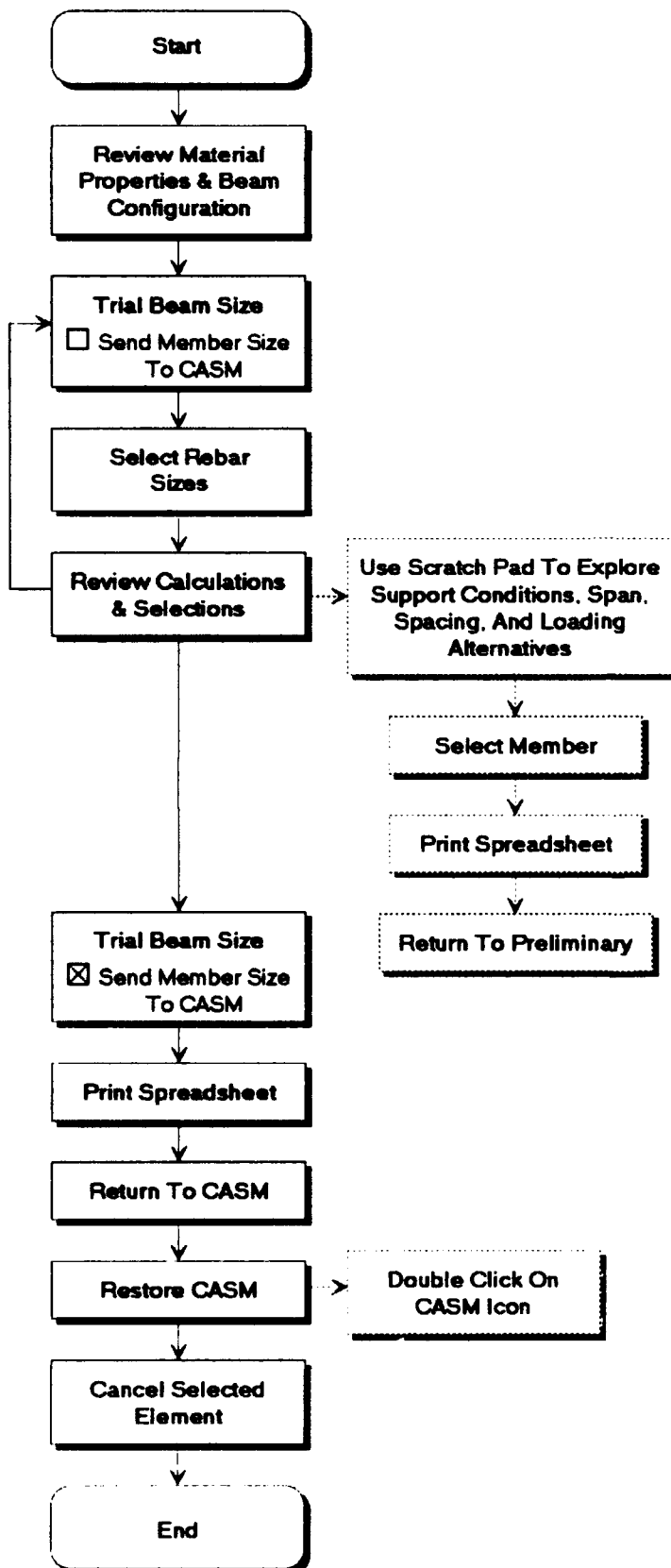
Widely Spaced Element Analysis: Continuous Beam



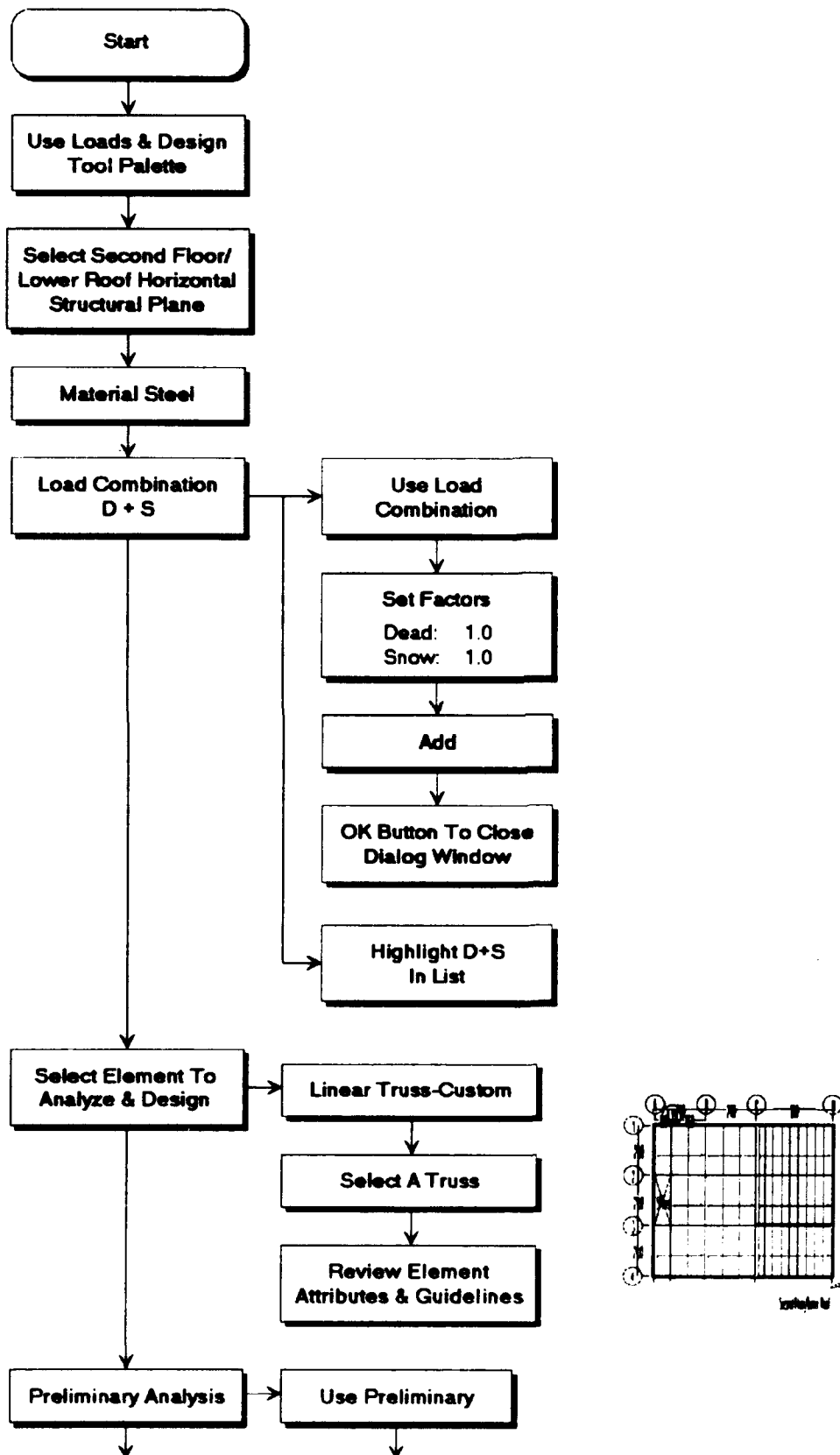
Widely Spaced Element Analysis: Continuous Beam

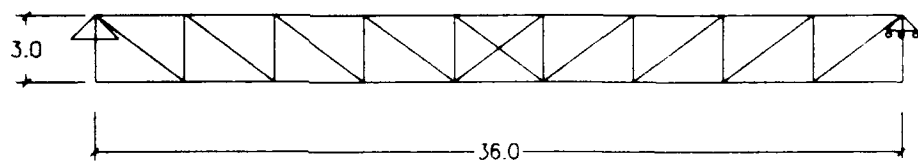
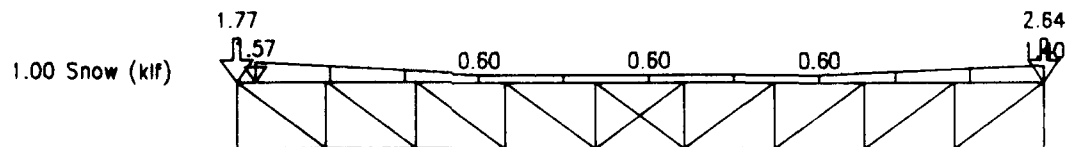
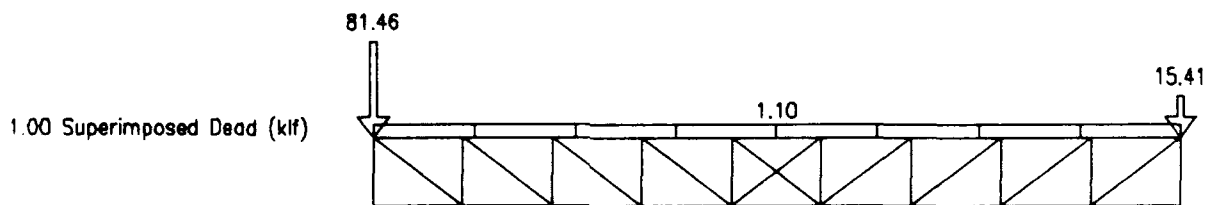
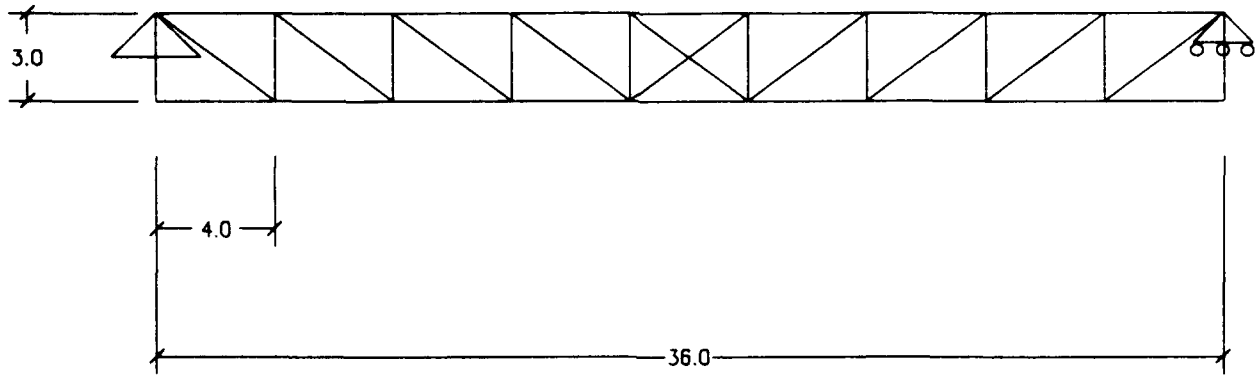


Concrete Beam Design

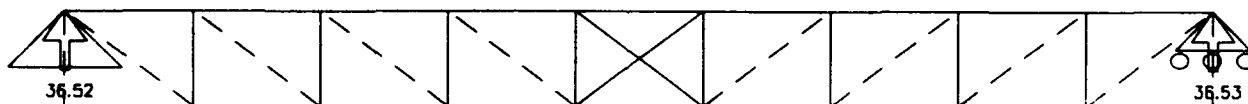
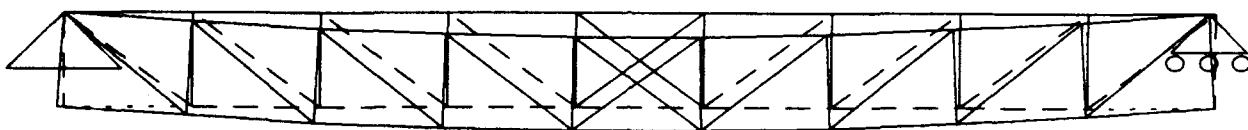
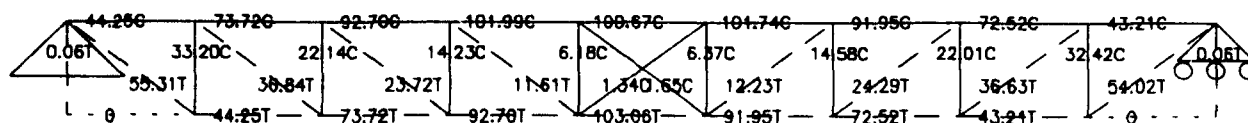


Truss Element Analysis

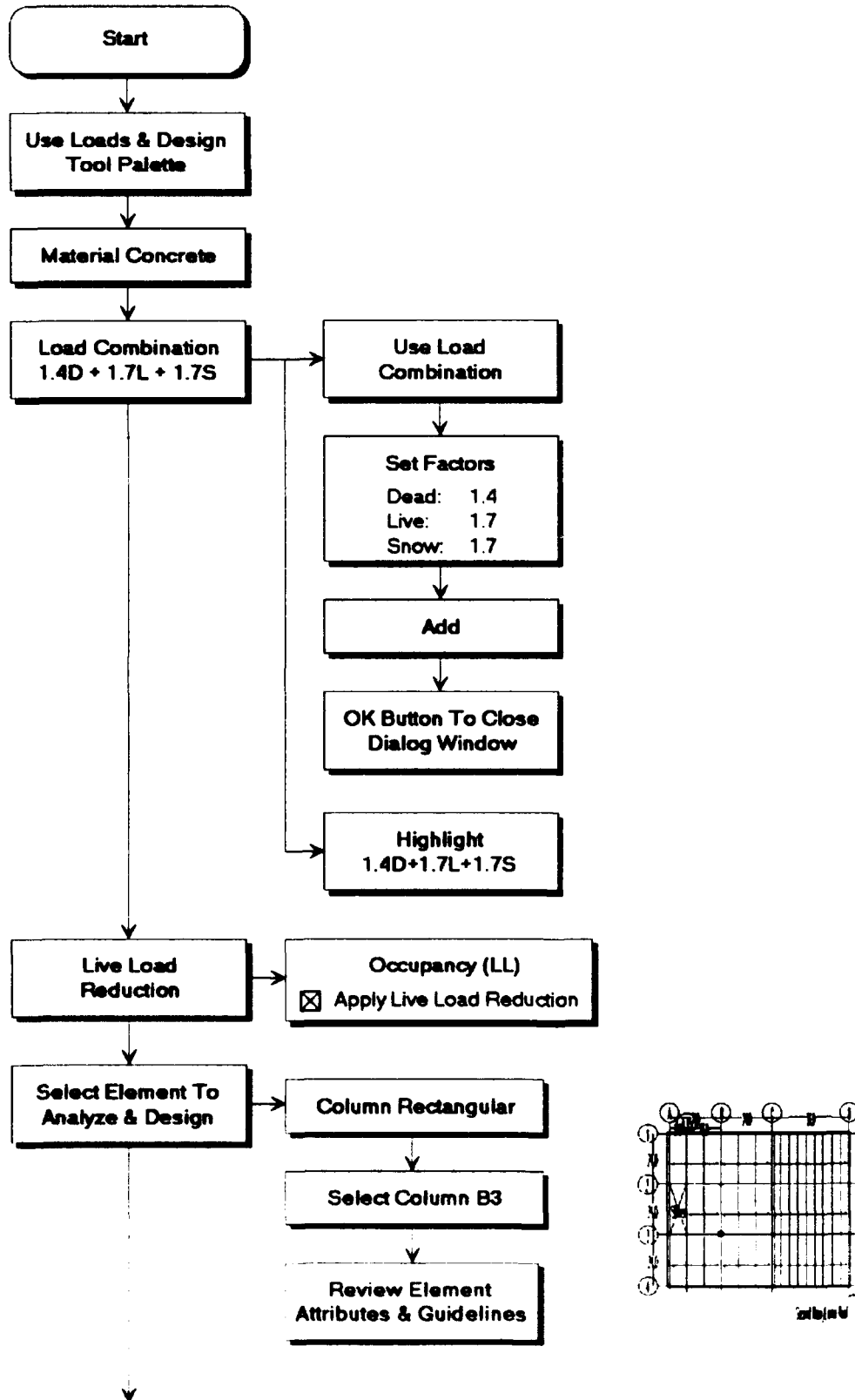


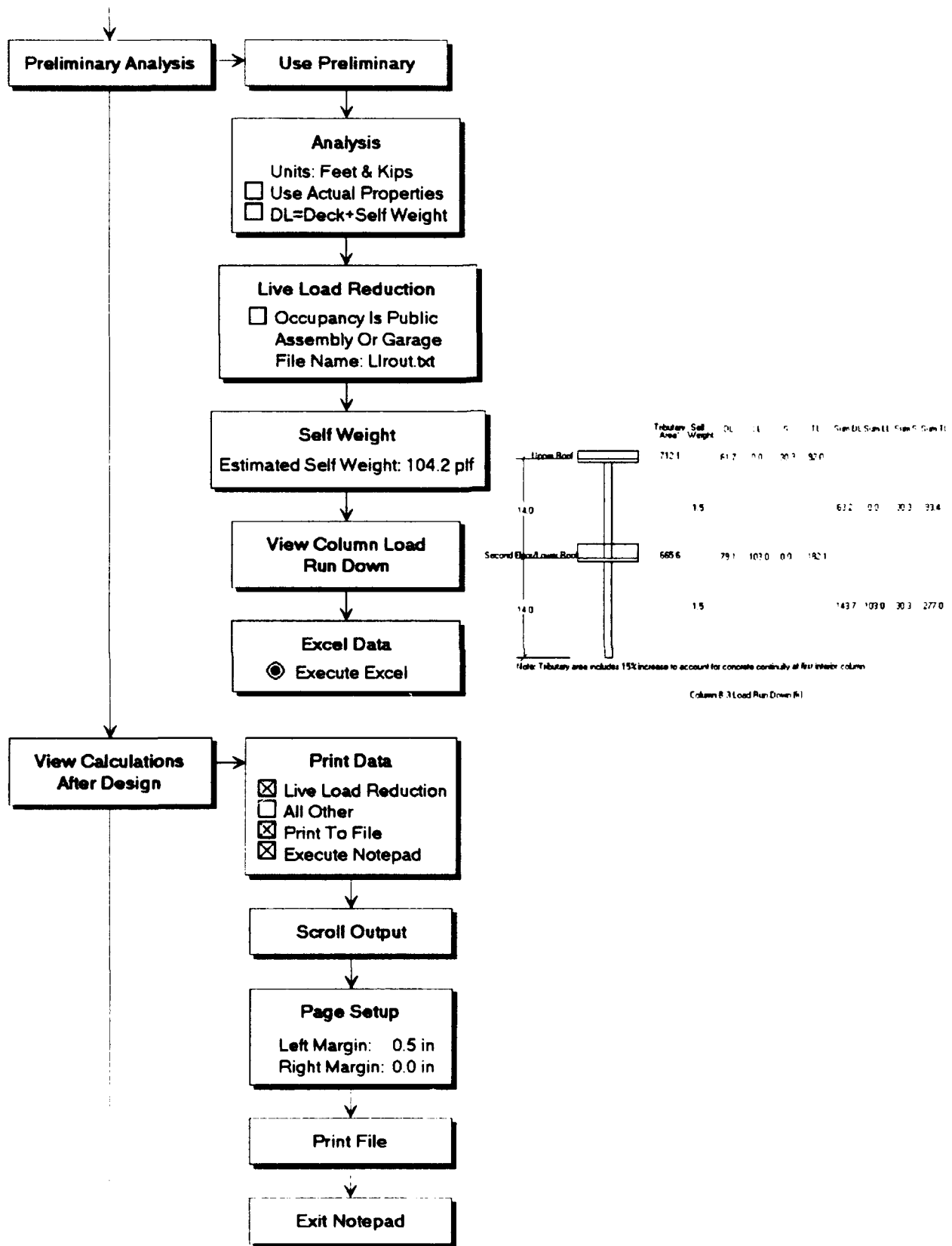


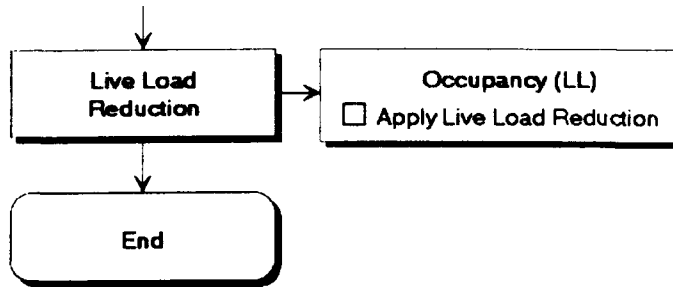
Truss Element Analysis



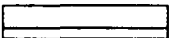
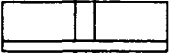
Column Load Run Down







Column Load Run Down

		Tributary Area*	Self Weight	DL	LLR	LLR	S	TL	Sum DL	Sum LLR	Sum S	Sum TL
Upper Roof		712.1		61.7	0.0	0.0	30.3	92.0				
14.0			1.5						63.2	0.0	30.3	93.4
Second Floor/Lower Roof		685.6		80.0		79.2	0.0	159.2				
14.0			1.5						144.6	79.2	30.3	254.1

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

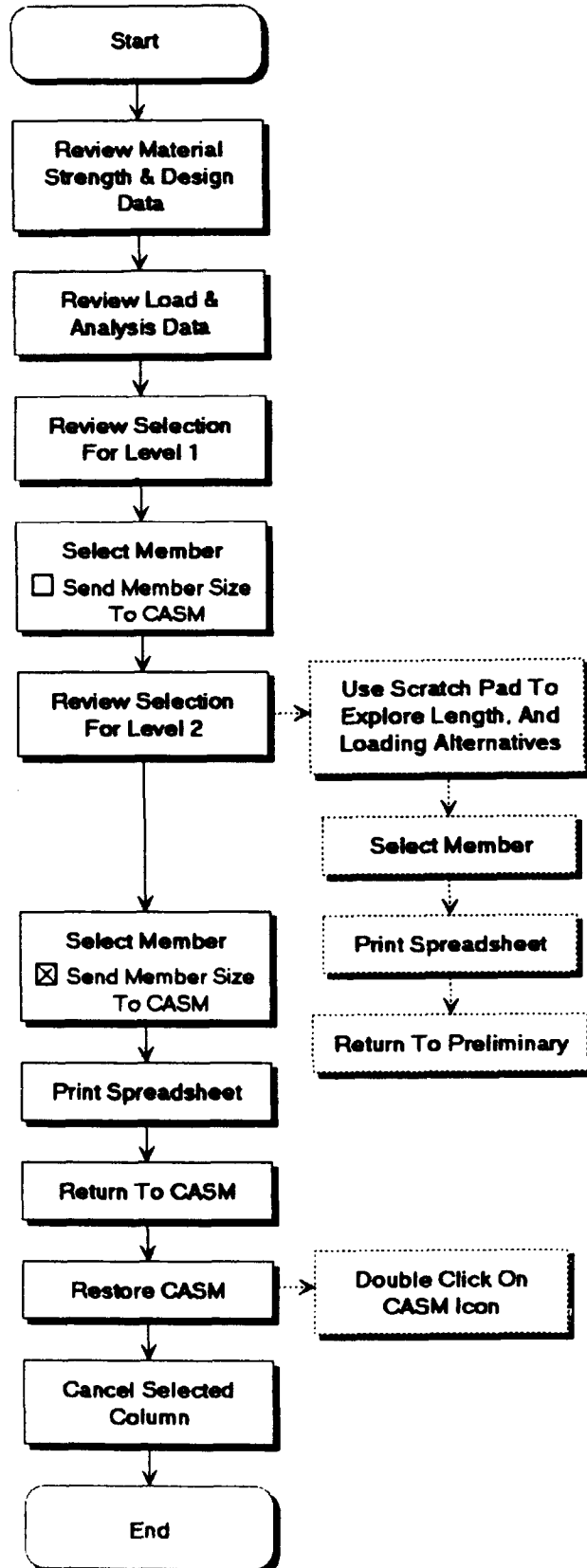
Member supports only one floor.

No live load reduction taken.

L = Lo

+-----+
| L = 150.00 psf |
+-----+

Concrete Column Design



Concrete Column Preliminary Selection

CONCRETE COLUMN PRELIMINARY SELECTION

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

CASM Load & Analysis Data:

Method: Analysis		Load Combination: 1.4D + 1.7L + Conc F'c=					4.0 ksi		
Member ID: B-3		Size Limit= 16.0 in. max					Fy= 60.0 ksi		
Name	Level	Flr to Flr Ht	Trib Area	Floor Level Area Load (kips)					Load Totals
				Dead	Live	Lmin	Snow	Wind	
	6								
	5								
	4								
	3								
Upper Roof	2	14.00	576	63.2			30.3		93.4
Second Floor/Lc	1	14.00	576	144.6	79.2		30.3		254.1

CASM Column Selection Table

Column Data:		Calculated Values:						
Floor Level:	2	Floor Level	Ag (in^2)	b (in)	p (%)	Ast (in^2)	Rebar & Size	Pu (k)
Column Shape:	Square	6						
Reinf. Ratio:	1.5 %	5						
Ties:	Tied	4						
Fire Rating:	1 Hour(s)	3						
Estimated Ave.		2	111.8	11	0.5	0.56	4- #4	294
Beam Depth:	20.0 in.	1	111.8	11	1.2	1.30	4- #6	325
Concrete Wgt:	145 pcf							

CASM Column Design Data:

Level	b (in)	Ag (in^2)	Rebar & Size	Ast (in^2)	p (%)	Pu (kip)	Reqd Pu	Pc (kip)	Tie & Spacing
- 6									
- 5									
- 4									
- 3									
Upper Roof - 2	11	121	4- #4	0.80	0.7	256	93		#3@8
r/Lower Roof - 1	11	121	4- #6	1.76	1.5	286	254		#3@11

Notes:

1. Initial column size based on larger of:

- Size based on axial load $Ag = P_n / (.8 * (.85f'_c + p * (f_y - .85f'_c)))$
- Size based on fire resistance rating.
- Size assuming $k=1.0$ and neglecting effects of slenderness by solving for b:
 - first story - - - - - $l_u/b \leq 10$
 - above first story - $l_u/b \leq 14$

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

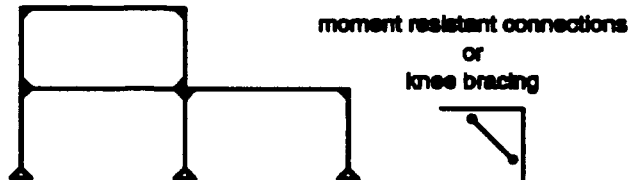
Lateral Resistance Philosophy

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

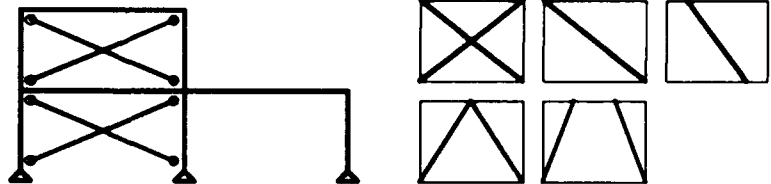
Options:

1. Unbraced Frames

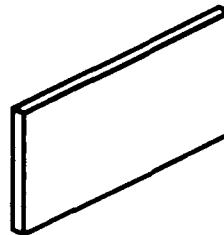


2. Braced Frames

A. Trussing



B. Shear Walls

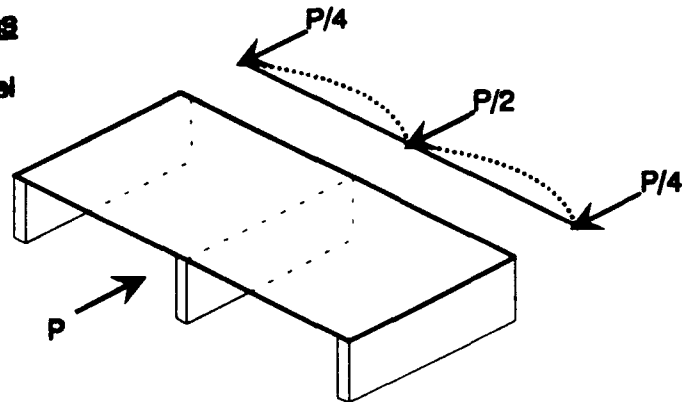


7. Define horizontal diaphragm systems

- All flexible
- All rigid
- Floors rigid & roof flexible

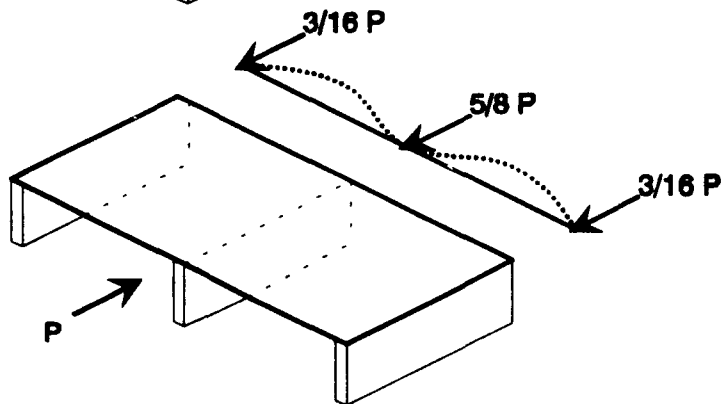
Flexible Diaphragms

Simple Beam Model
(tributary area)



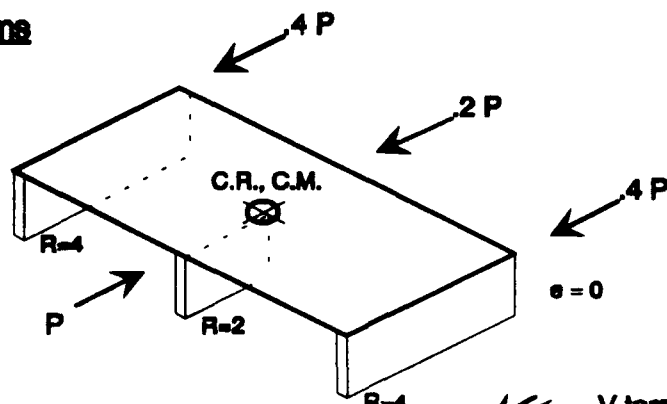
* No Torsion

Continuous Beam Model



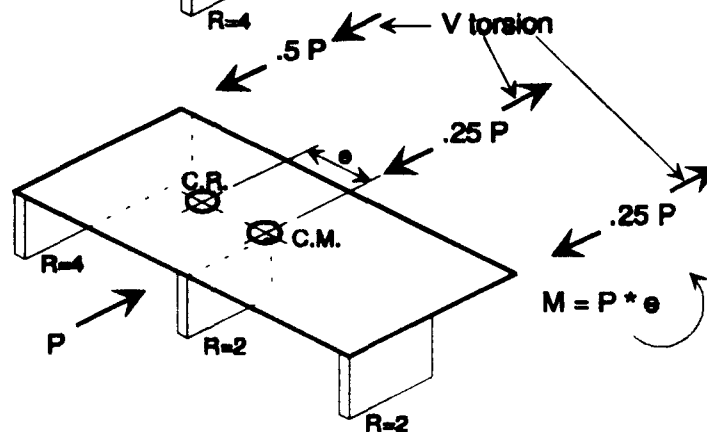
Rigid Diaphragms

Symmetrical

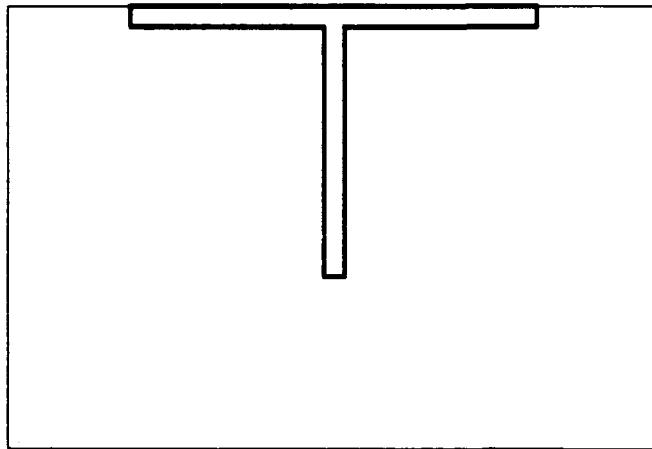


Torsion
(even accidental
minimum required)

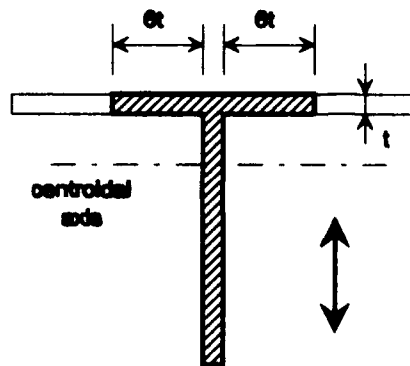
Non-Symmetrical



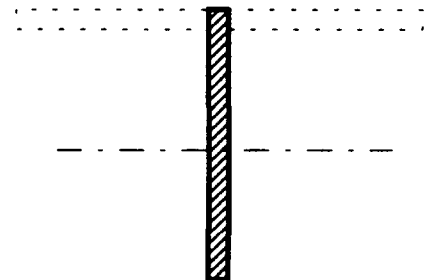
Monolithic Perpendicular Shear Walls



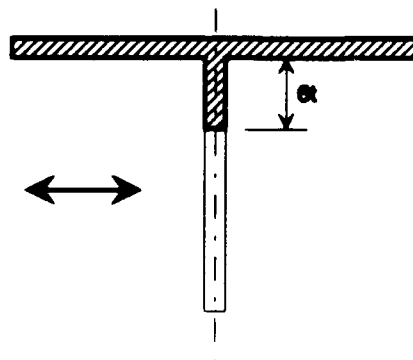
For N-S



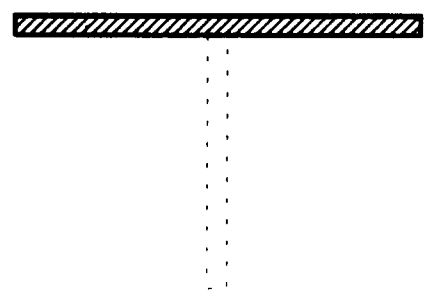
or



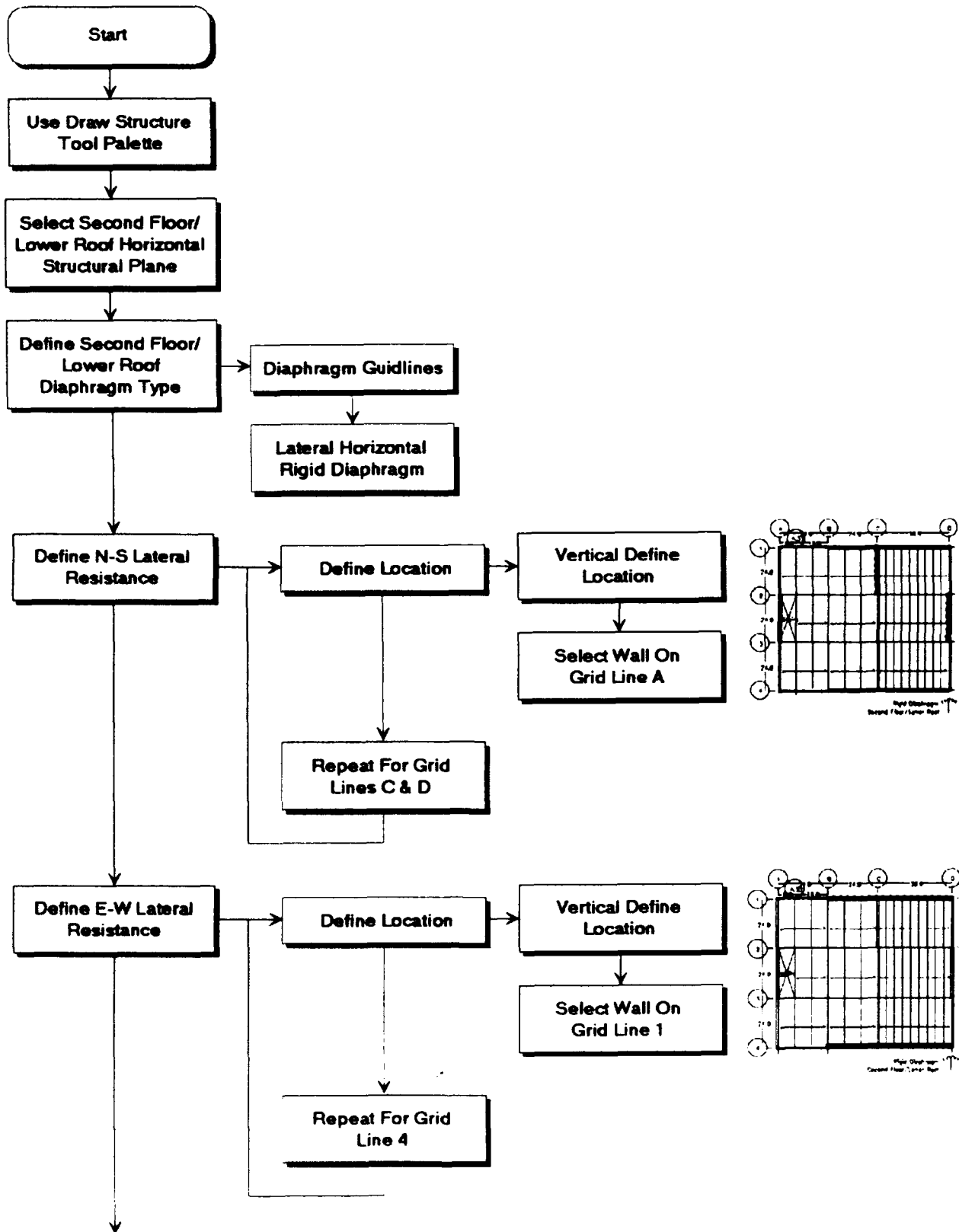
For E-W



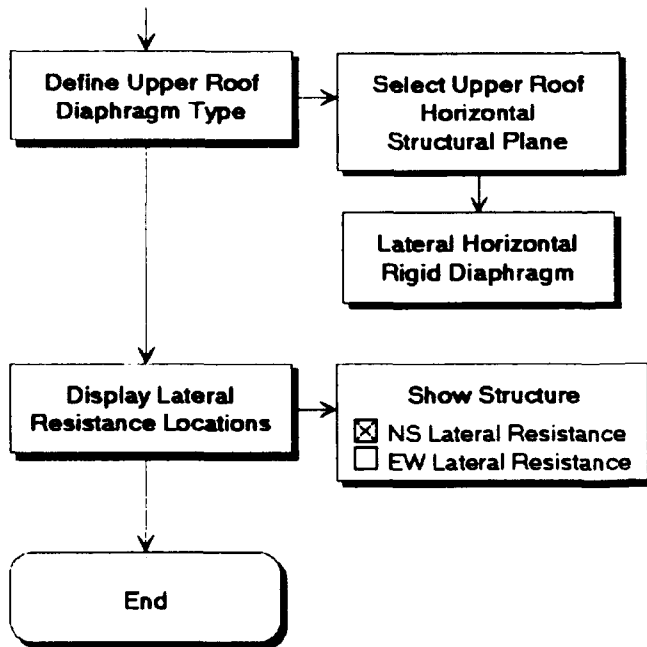
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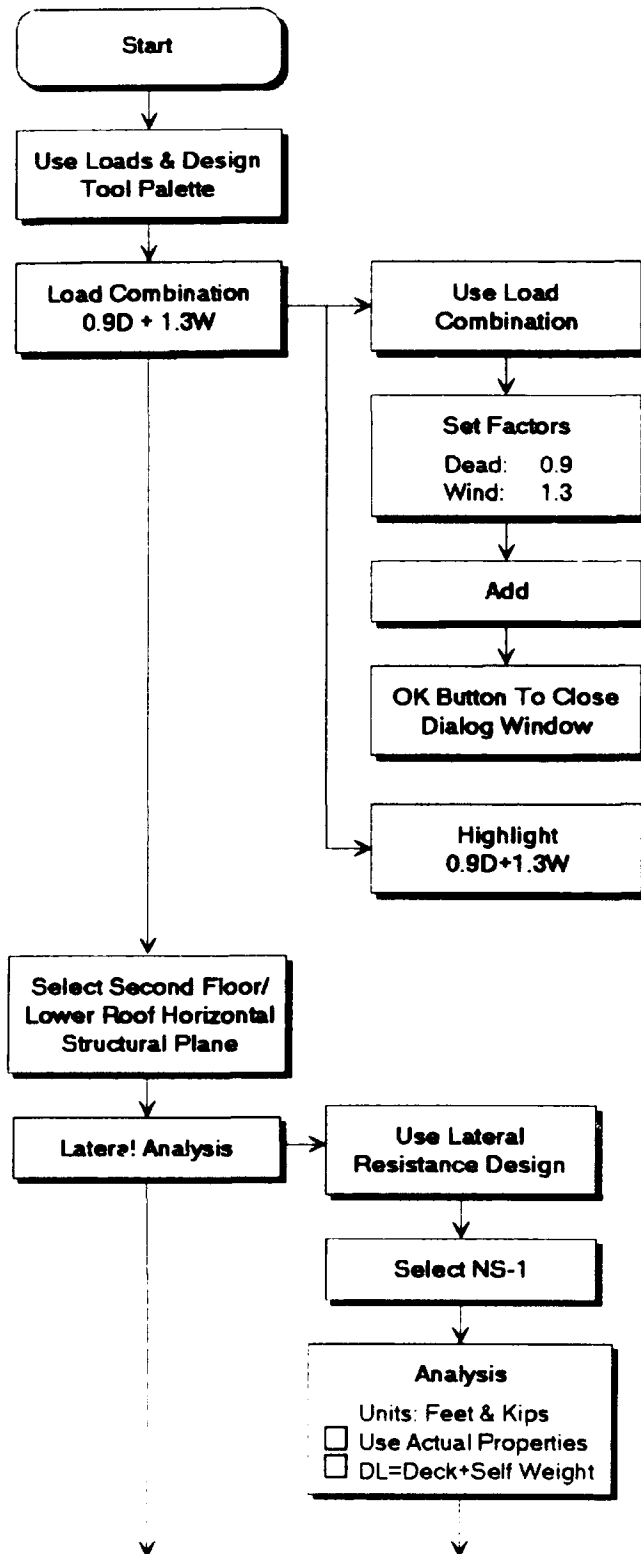
Define Lateral Resistance

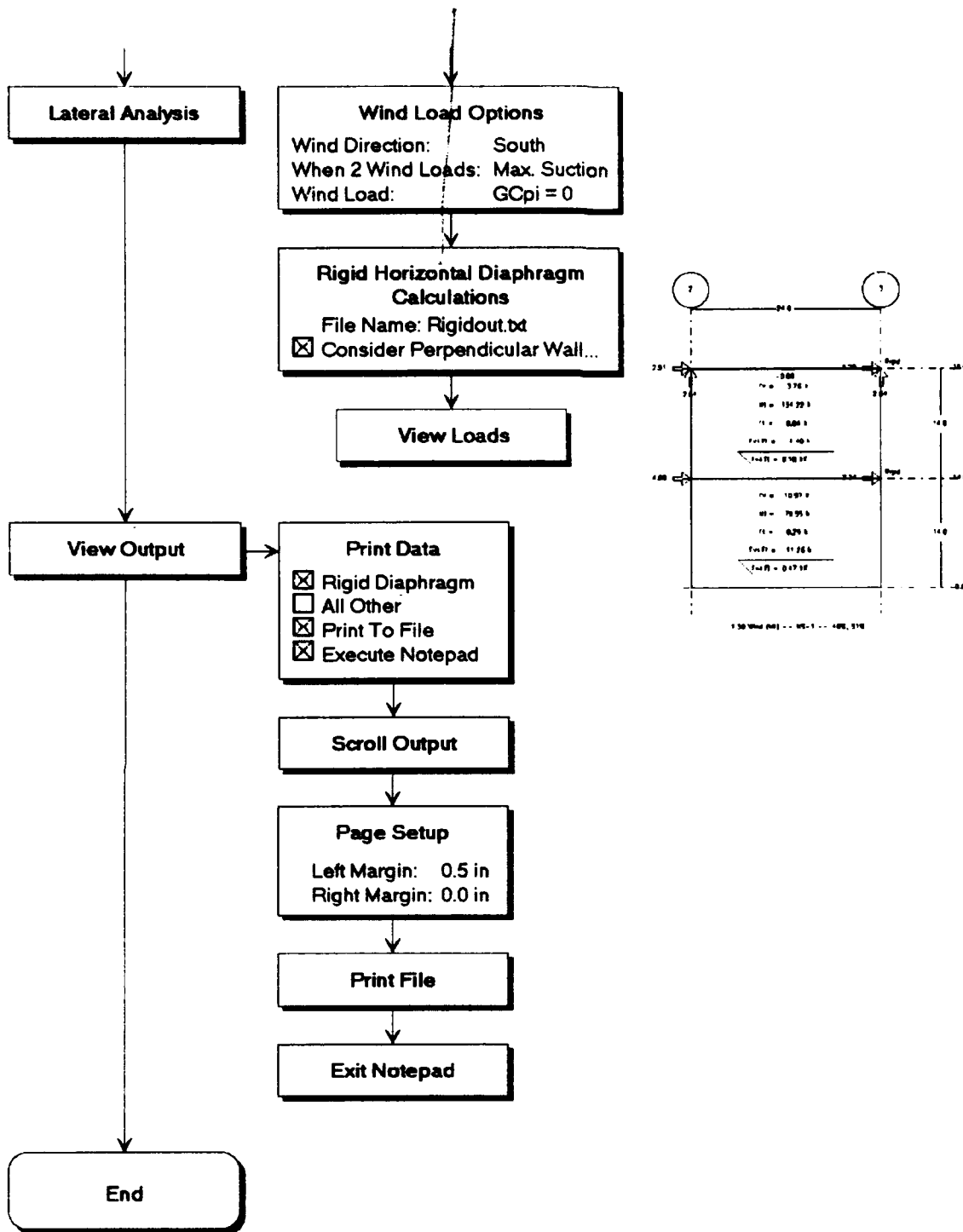


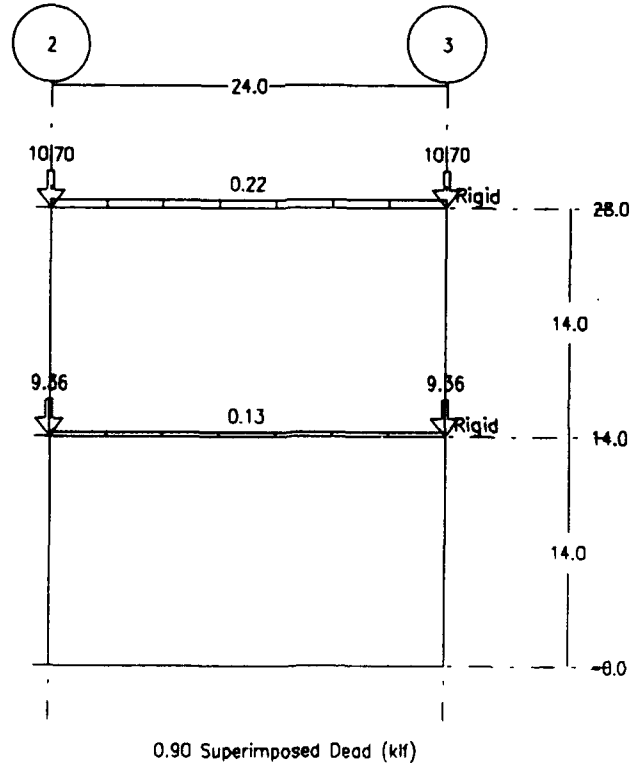
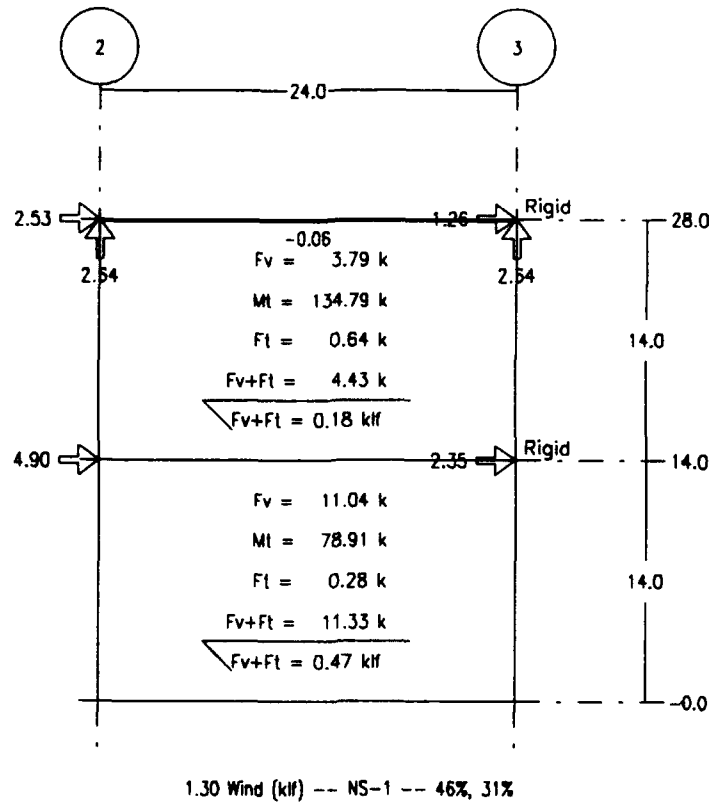
Define Lateral Resistance

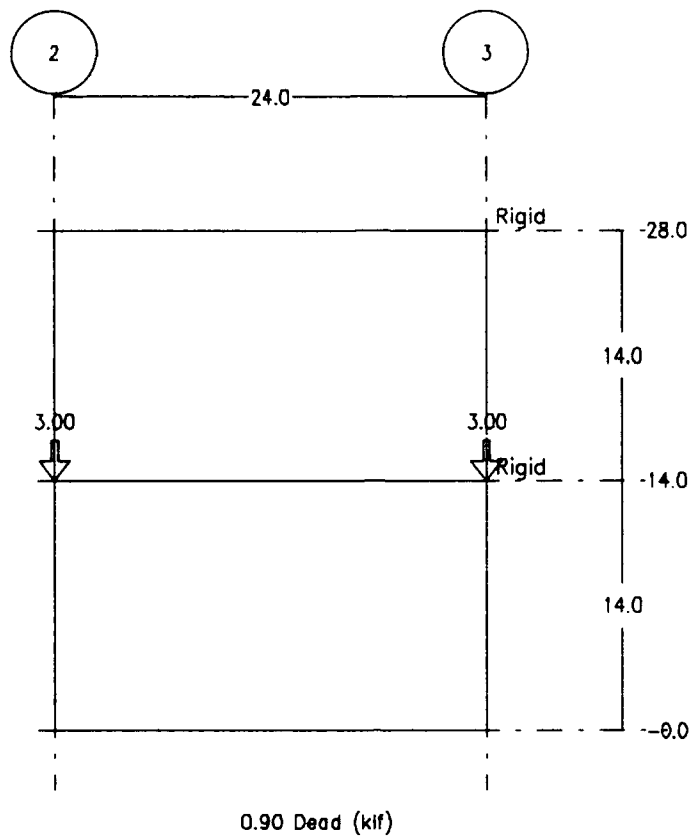


Wind Lateral Analysis









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

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

NS-1
-----Level Height: 14.0 ft

Centroidal Axis							
Name	t (ft)	l (ft)	Area (ft^2)	NS Arm (ft)	NS Moment Area (ft^3)	EW Arm (ft)	EW Moment Area (ft^3)
NS-1	0.83	24.00	20.0	12.00	240	0.00	0
Sum			20.0		240		0

Centroid = sum(MomentArea)/sum(Area)

NS Centroid : 12.00 ft EW Centroid : 0.00 ft

Av : 20.00 sqft

Moment of Inertia							
Name	b (ft)	h (ft)	bh^3/ 12 (ft^4)	Area (ft^2)	d (ft)	Ad^2 (ft^4)	I+Ad^2 (ft^4)
NS-1	0.83	24.00	960	20.0	0.00	0	960
Sum							960

Deflection : 0.254 in Height : 14.0 ft

Total Deflection : 0.254 in

Level Height: 28.0 ft

Same As Previous Level

NS Centroid : 12.00 ft EW Centroid : 0.00 ft
 Av : 20.00 sqft Moment of Inertia: 960 ft^4
 Deflection : 0.254 in Height : 14.0 ft
 Total Deflection : 0.509 in

NS-2
-----Level Height: 14.0 ft

Centroidal Axis							
Name	t (ft)	l (ft)	Area (ft^2)	NS Arm (ft)	NS Moment Area (ft^3)	EW Arm (ft)	EW Moment Area (ft^3)
NS-2	0.83	24.42	20.3	12.21	248	0.00	0
EW-1	0.83	5.00	4.2	24.00	100	-2.92	-12
EW-1	0.83	5.00	4.2	24.00	100	2.92	12
Sum			28.7		448		0

Centroid = sum(MomentArea)/sum(Area)

NS Centroid : 15.63 ft EW Centroid : 0.00 ft

Av : 20.35 sqft

Moment of Inertia							
Name	b	h	$\frac{bh^3}{12}$	Area	d	Ad^2	$I+Ad^2$
	(ft)	(ft)	(ft ⁴)	(ft ²)	(ft)	(ft ⁴)	(ft ⁴)
NS-2	0.83	24.42	1011	20.3	-3.43	239	1250
EW-1	5.00	0.83	0	4.2	8.37	292	292
EW-1	5.00	0.83	0	4.2	8.37	292	292
Sum							1833

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

Level Height: 28.0 ft

Centroidal Axis							
Name	t	l	Area	NS Arm	NS Moment	EW Arm	EW Moment
	(ft)	(ft)	(ft ²)	(ft)	(ft ³)	(ft)	(ft ³)
NS-2	0.83	24.42	20.3	12.21	248	0.00	0
EW-1	0.83	5.00	4.2	24.00	100	-2.92	-12
Sum			24.5		348		-12

Centroid = $\frac{\text{sum}(\text{MomentArea})}{\text{sum}(\text{Area})}$
 NS Centroid : 14.21 ft EW Centroid : -0.50 ft
 Av : 20.35 sqft

Moment of Inertia							
Name	b	h	$\frac{bh^3}{12}$	Area	d	Ad^2	$I+Ad^2$
	(ft)	(ft)	(ft ⁴)	(ft ²)	(ft)	(ft ⁴)	(ft ⁴)
NS-2	0.83	24.42	1011	20.3	-2.00	82	1093
EW-1	5.00	0.83	0	4.2	9.79	399	399
Sum							1492

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

NS-3

Level Height: 14.0 ft

Centroidal Axis							
Name	t	l	Area	NS Arm	NS Moment	EW Arm	EW Moment
	(ft)	(ft)	(ft ²)	(ft)	(ft ³)	(ft)	(ft ³)
NS-3	0.83	24.00	20.0	12.00	240	0.00	0
Sum			20.0		240		0

Centroid = $\frac{\text{sum}(\text{MomentArea})}{\text{sum}(\text{Area})}$
 NS Centroid : 12.00 ft EW Centroid : 0.00 ft
 Av : 20.00 sqft

Moment of Inertia							
Name	b	h	$\frac{bh^3}{12}$	Area	d	Ad ²	I+Ad ²
	(ft)	(ft)	(ft ⁴)	(ft ²)	(ft)	(ft ⁴)	(ft ⁴)
NS-3	0.83	24.00	960	20.0	0.00	0	960
Sum							960

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

EW-1

Level Height: 14.0 ft

Centroidal Axis							
Name	t	l	Area	NS Arm	NS Moment Area	EW Arm	EW Moment Area
	(ft)	(ft)	(ft ²)	(ft)	(ft ³)	(ft)	(ft ³)
EW-1	0.83	60.00	50.0	0.00	0	30.00	1500
NS-2	0.83	5.00	4.2	-2.92	-12	24.00	100
Sum			54.2		-12		1600

Centroid = $\frac{\text{sum}(\text{MomentArea})}{\text{sum}(\text{Area})}$
 NS Centroid : -0.22 ft EW Centroid : 29.54 ft
 Av : 50.00 sqft

Moment of Inertia							
Name	b	h	$\frac{bh^3}{12}$	Area	d	Ad ²	I+Ad ²
	(ft)	(ft)	(ft ⁴)	(ft ²)	(ft)	(ft ⁴)	(ft ⁴)
EW-1	0.83	60.00	15000	50.0	0.46	11	15011
NS-2	5.00	0.83	0	4.2	-5.54	128	128
Sum							15139

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

Level Height: 28.0 ft

Centroidal Axis							
Name	t	l	Area	NS Arm	NS Moment Area	EW Arm	EW Moment Area
	(ft)	(ft)	(ft ²)	(ft)	(ft ³)	(ft)	(ft ³)
EW-1	0.83	24.42	20.3	0.00	0	12.21	248
NS-2	0.83	5.00	4.2	-2.92	-12	24.00	100
Sum			24.5		-12		348

Centroid = $\frac{\text{sum}(\text{MomentArea})}{\text{sum}(\text{Area})}$
 NS Centroid : -0.50 ft EW Centroid : 14.21 ft
 Av : 20.35 sqft

Wind Lateral Analysis

Moment of Inertia							
Name	b (ft)	h (ft)	$bh^3/12$ (ft ⁴)	Area (ft ²)	d (ft)	Ad^2 (ft ⁴)	$I+Ad^2$ (ft ⁴)
EW-1	0.83	24.42	1011	20.3	-2.00	82	1093
NS-2	5.00	0.83	0	4.2	9.79	399	399
Sum							1492

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

EW-2

Level Height: 14.0 ft

Centroidal Axis							
Name	t (ft)	l (ft)	Area (ft ²)	NS Arm (ft)	NS Moment Area (ft ³)	EW Arm (ft)	EW Moment Area (ft ³)
EW-2	0.83	60.00	50.0	0.00	0	30.00	1500
Sum			50.0		0		1500

Centroid = $\text{sum}(\text{MomentArea}) / \text{sum}(\text{Area})$

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

Moment of Inertia							
Name	b (ft)	h (ft)	$bh^3/12$ (ft ⁴)	Area (ft ²)	d (ft)	Ad^2 (ft ⁴)	$I+Ad^2$ (ft ⁴)
EW-2	0.83	60.00	15000	50.0	0.00	0	15000
Sum							15000

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

Level Height: 28.0 ft

Centroidal Axis							
Name	t (ft)	l (ft)	Area (ft ²)	NS Arm (ft)	NS Moment Area (ft ³)	EW Arm (ft)	EW Moment Area (ft ³)
EW-2	0.83	24.00	20.0	0.00	0	12.00	240
Sum			20.0		0		240

Centroid = $\text{sum}(\text{MomentArea}) / \text{sum}(\text{Area})$

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

Moment of Inertia						
Name	b	h	$bh^3/12$	Area	d	Ad^2
	(ft)	(ft)	(ft ⁴)	(ft ²)	(ft)	(ft ⁴)
EW-2	0.83	24.00	960	20.0	0.00	0
Sum						960

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

Center of Rigidity

Name	h	I	Av	Deflection	Rigidity	R/ sum(R)	x	R*x
	(ft)	(ft ⁴)	(ft ²)	(in)			(ft)	
NS-1	14.0	960	20	0.254	3.931	31.34%	0.8	3.276
NS-2	14.0	1833	20	0.214	4.682	37.33%	48.8	228.633
NS-3	14.0	960	20	0.254	3.931	31.34%	84.8	333.467
Sum					12.544			565.376

Centroid from lower left = $\text{sum}(R*x)/\text{sum}(R)$: 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*max. dimension : 4.28 ft
 Eccentricity (e) used for torsional analysis : 6.00 ft

Name	h	I	Av	Deflection	Rigidity	R/ sum(R)	x	R*x
	(ft)	(ft ⁴)	(ft ²)	(in)			(ft)	
NS-1	28.0	960	20	0.509	1.965	46.19%	0.8	1.638
NS-2	28.0	1492	20	0.437	2.290	53.81%	48.3	110.691
NS-3	28.0	0	0	0.000	0.000	0.00%	41.8	0.000
Sum					4.255			112.329

Centroid from lower left = $\text{sum}(R*x)/\text{sum}(R)$: 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*max. dimension : 4.28 ft
 Eccentricity (e) used for torsional analysis : 4.28 ft

Name	h	I	Av	Deflection	Rigidity	R/ sum(R)	x	R*x
	(ft)	(ft ⁴)	(ft ²)	(in)			(ft)	
EW-1	14.0	15139	50	0.075	13.327	50.02%	72.6	967.669
EW-2	14.0	15000	50	0.075	13.319	49.98%	0.8	11.099
Sum					26.646			978.768

Centroid from lower left = $\text{sum}(R*x)/\text{sum}(R)$: 36.73 ft
 Center of mass from lower left : 36.53 ft
 Eccentricity (e) : 0.20 ft
 Maximum dimension : 73.67 ft
 e min = 0.05*max. dimension : 3.68 ft
 Eccentricity (e) used for torsional analysis : 3.68 ft

Wind Lateral Analysis

Name	h (ft)	I (ft ⁴)	Av (ft ²)	Deflection (in)	Rigidity	R/ sum(R)	x (ft)	R*x
EW-3	28.0	1492	20	0.298	3.354	52.50%	72.3	242.633
EW-4	28.0	960	20	0.329	3.035	47.50%	0.8	2.529
Sum					6.389			245.162

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

Assumptions used:

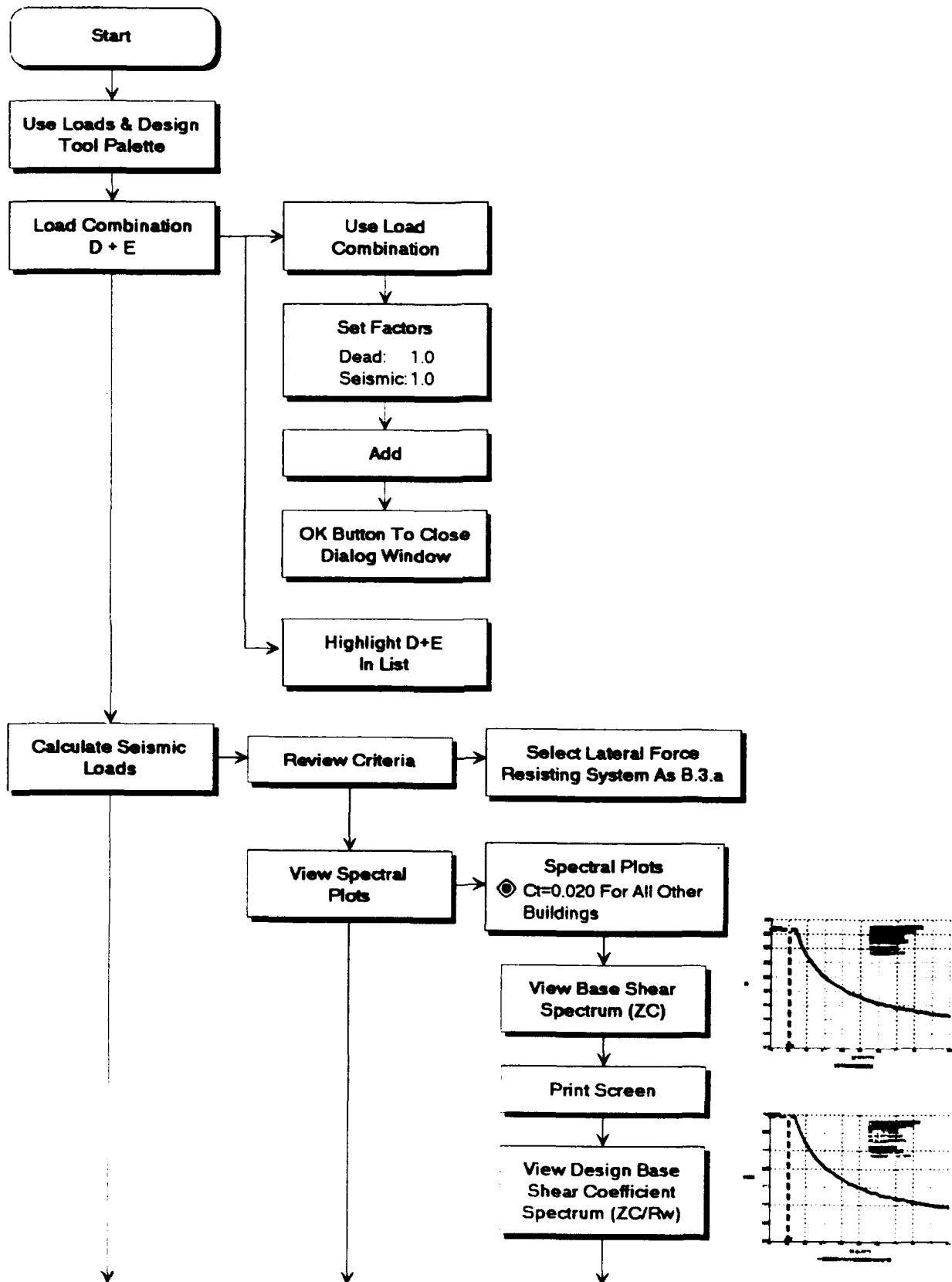
$E_m = 144,000 \text{ ksf}$
 $E_v = 0.4 * E_m = 57,600 \text{ ksf}$
 All wall thicknesses are equal.
 Deflections calculated by applying a 1,000 kip load.
 Interstory shear wall deflection is calculated based on cantilever action. Deflection at a level is obtained by summing each story's cantilever deflection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

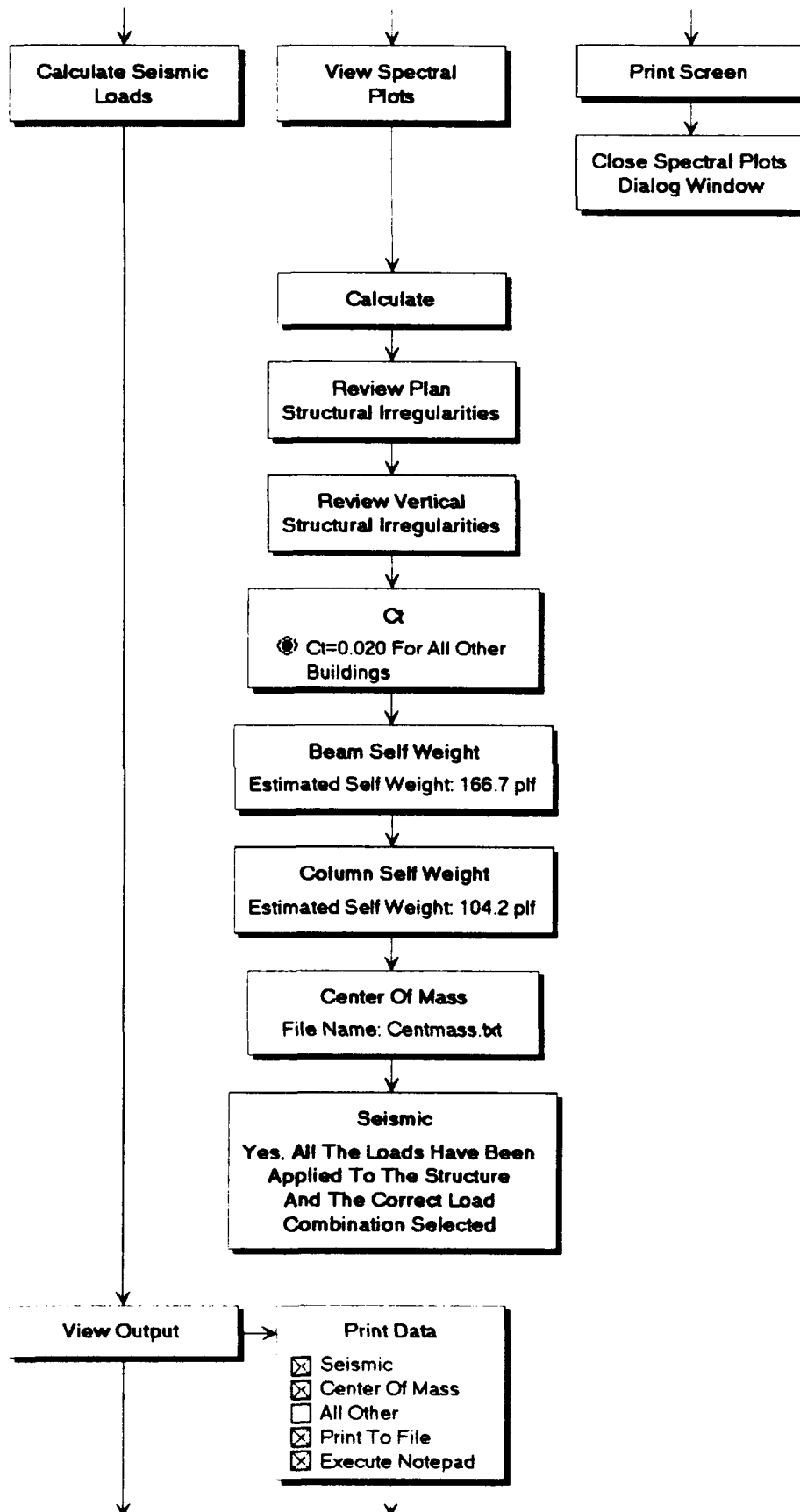
Name	h (ft)	Rigidity	dx (ft)	R*dx	R*dx*dx	R*dx/ sum(R*dx*dx)
NS-1	14.0	3.931	44.2	173.899	7693.191	0.00360
NS-2	14.0	4.682	3.8	17.606	66.208	0.00036
NS-3	14.0	3.931	39.8	156.292	6214.263	0.00324
EW-1	14.0	13.327	35.9	478.133	17153.838	0.00990
EW-2	14.0	13.319	35.9	478.133	17164.481	0.00990
Sum					48291.982	

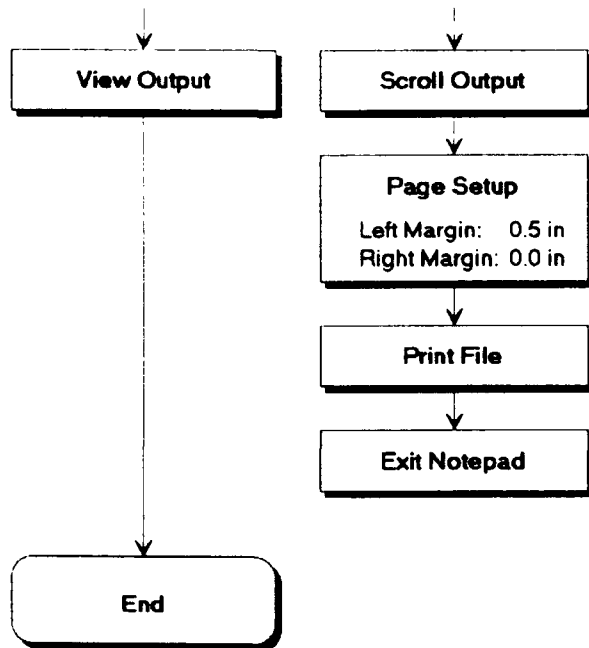
Name	h (ft)	Rigidity	dx (ft)	R*dx	R*dx*dx	R*dx/ sum(R*dx*dx)
NS-1	28.0	1.963	25.6	50.243	1284.395	0.00477
NS-2	28.0	2.290	21.9	50.243	1102.371	0.00477
NS-3	28.0	0.000	15.4	0.000	0.000	0.00000
EW-1	28.0	3.354	34.0	113.930	3869.819	0.01082
EW-2	28.0	3.035	37.5	113.930	4276.657	0.01082
Sum					10533.242	

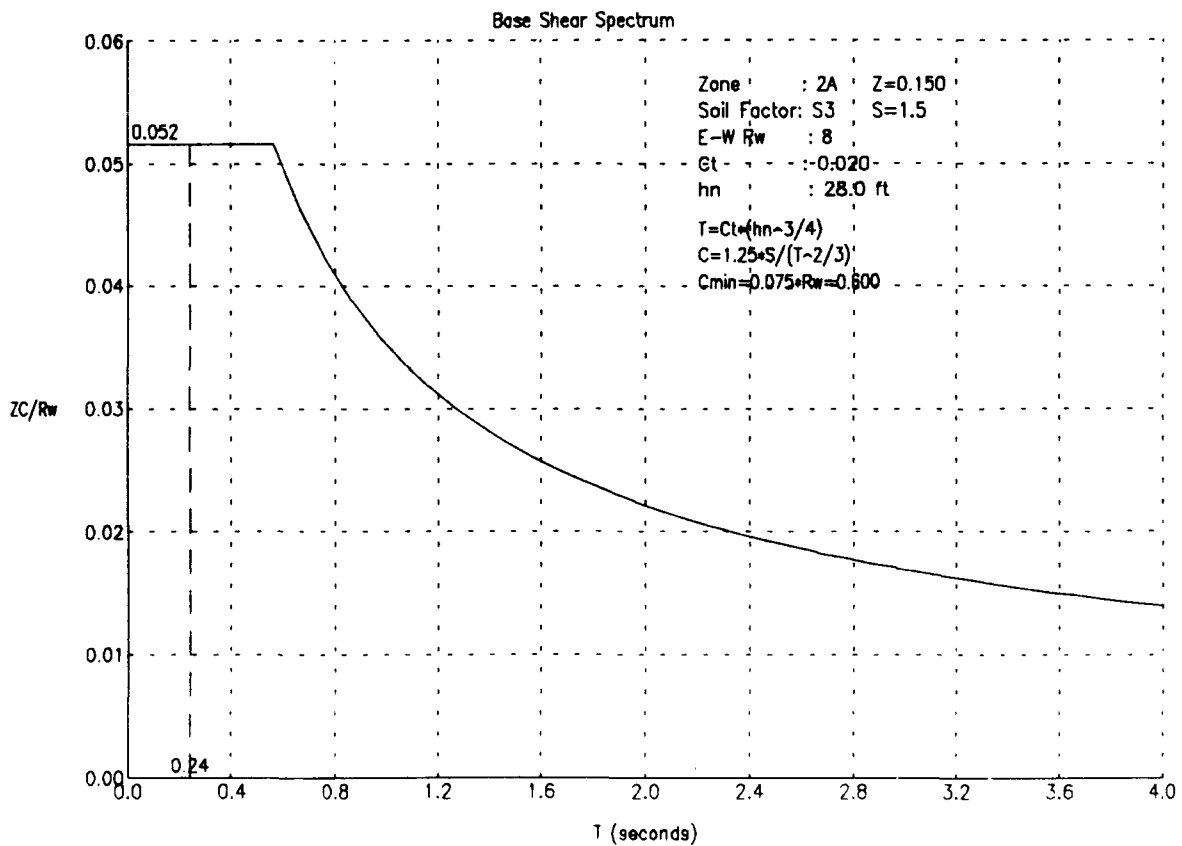
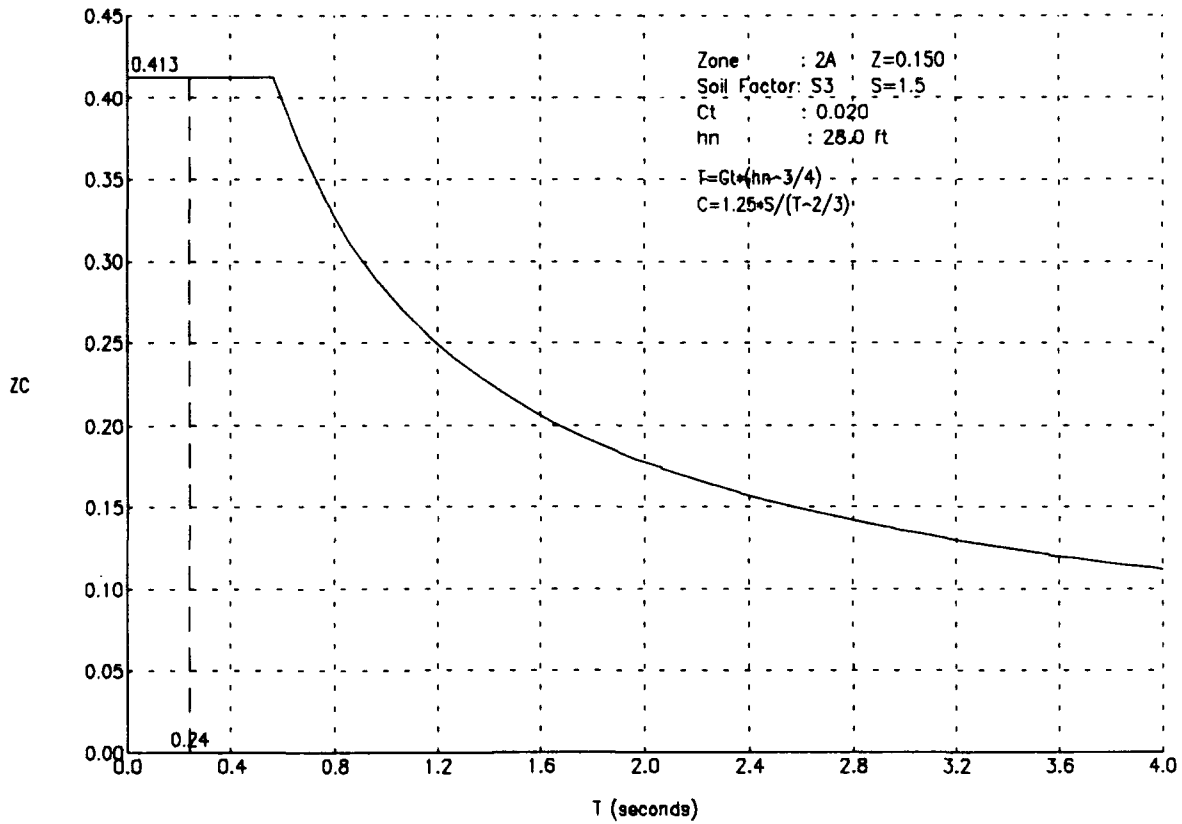
Shear distribution : $F_v = V * R / \text{sum}(R)$
 Torsional moment : $M_t = V * e$
 Torsional component : $F_t = M_t * R * dx / \text{sum}(R * dx * dx)$
 Total shear to element: $F_{\text{total}} = F_v + F_t$

Seismic Loads









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

***** N - S and E - W *****

Zone: 2A: Z = 0.150
 Importance Category: IV: I = 1.00
 Soil Factor: S3: S = 1.5
 System: B3a: Rw = 8
 Ct = 0.020
 hn = 28.0 ft
 T = Ct*hn^{3/4} = 0.24 sec
 C = 1.25*S/T^{2/3} = 4.86 > 2.75
 C = 2.75
 C/Rw = 0.344 > 0.075
 W = 1051.3 k
 V = Z*I*C*W/Rw

+-----+
 | V = 54.2 k |
 +-----+

T < 0.7 sec

+-----+
 | Ft = 0.0 k |
 +-----+

+-----+
 | V-Ft = 54.2 k |
 +-----+

Level	h (ft)	Floor to Floor h (ft)	w (k)	sum(w) (k)	w*h (kft)	w*h/ sum(w*h) (kft)	F (k)	sum(F) V (k)
3	28.0		350		9810	0.500	27.1	
		14.0		350				27.1
2	14.0		701		9813	0.500	27.1	
		14.0		1051				54.2
1	0.0							
Sum			1051		19623	1.000	54.2	

Level	h (ft)	Floor to Floor h (ft)	w (k)	sum(w) (k)	sum(F) V (k)	OTM (kft)	sum(OTM) (kft)	Ft+sum(F) / sum(w)
3	28.0		350					
		14.0		350	27.1	379		0.077
2	14.0		701				379	
		14.0		1051	54.2	759		0.052
1	0.0						1138	
Sum			1051			1138		

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

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

 Upper Roof -- 28.00 ft

Name	Weight (k)	NS (ft)	NS*Weight (kft)	EW (ft)	EW*Weight (kft)
Shear Wall	1.8	72.8	127.5	36.8	64.5
Shear Wall	1.8	60.8	106.5	48.8	85.5
Shear Wall	1.8	36.8	64.5	0.8	1.5
Shear Wall	1.8	0.8	1.5	36.8	64.5
Exterior Wall	12.3	12.8	157.8	0.8	10.2
Exterior Wall	12.3	0.8	10.2	12.8	157.8
Exterior Wall	12.3	60.8	748.1	0.8	10.2
Exterior Wall	12.3	72.8	895.7	12.8	157.8
Exterior Wall	24.6	24.8	610.8	48.8	1201.1
Upper Roof	213.9	36.8	7879.6	24.8	5312.5
Beam Self Weight	52.0	36.8	1915.7	24.8	1291.6
Column Self Weight	3.6	36.8	134.3	24.8	90.6
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

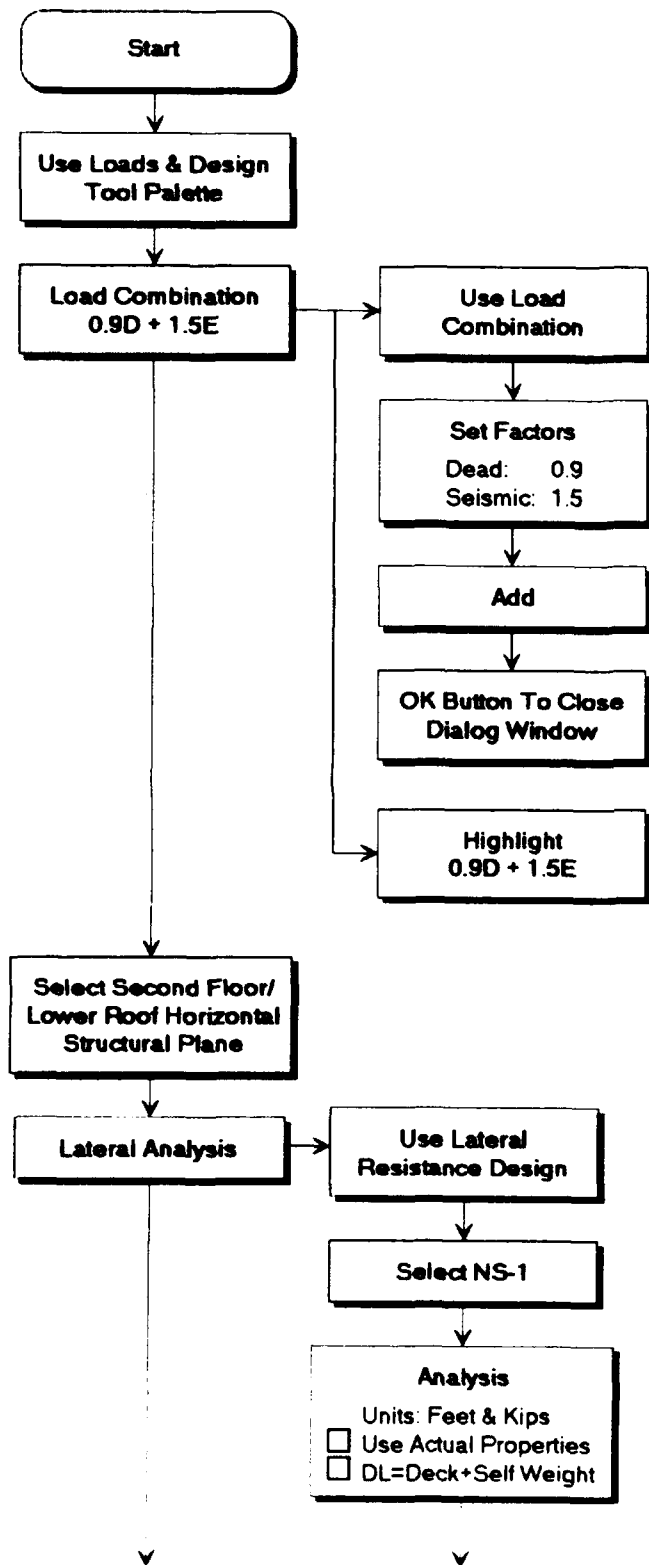
Name	Weight (k)	NS (ft)	NS*Weight (kft)	EW (ft)	EW*Weight (kft)
Shear Wall	3.5	72.8	254.9	36.8	128.9
Shear Wall	3.5	60.8	212.9	48.8	170.9
Shear Wall	3.5	36.8	128.9	0.8	2.9
Shear Wall	3.5	0.8	2.9	36.8	128.9
Second Floor	98.9	12.8	1269.0	24.8	2455.6
Second Floor	82.4	36.8	3035.2	28.8	2376.0
Second Floor	98.9	60.8	6015.5	24.8	2455.6
Lower Roof	123.6	36.8	4554.0	66.8	8263.2
Exterior Wall	24.6	12.8	315.6	0.8	20.5
Exterior Wall	24.6	0.8	20.5	12.8	315.6
Exterior Wall	24.6	60.8	1496.2	0.8	20.5
Exterior Wall	24.6	72.8	1791.4	12.8	315.6
Exterior Wall	24.6	24.8	610.8	48.8	1201.1
Parapet	6.6	12.8	84.8	84.8	560.3
Parapet	6.6	60.8	401.8	84.8	560.3
Shear Wall	20.6	72.8	1502.2	66.8	1378.4
Shear Wall	20.6	0.8	17.2	66.8	1378.4
Shear Wall	13.8	36.8	506.5	84.8	1166.5
Beam Self Weight	60.0	36.8	2210.4	36.2	2174.1
Column Self Weight	3.6	36.8	134.3	36.2	132.1
Exterior Wall	12.3	12.8	157.8	84.8	1043.2
Exterior Wall	12.3	60.8	748.1	84.8	1043.2
Column Self Weight	3.6	36.8	134.3	24.8	90.6
Sum	700.9		25605.3		27382.6

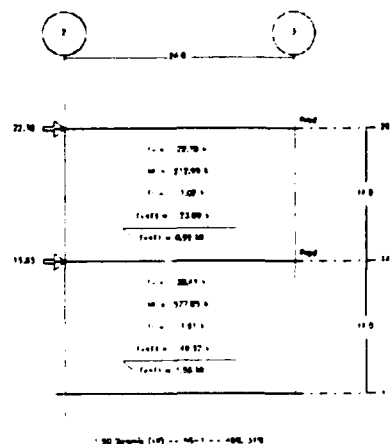
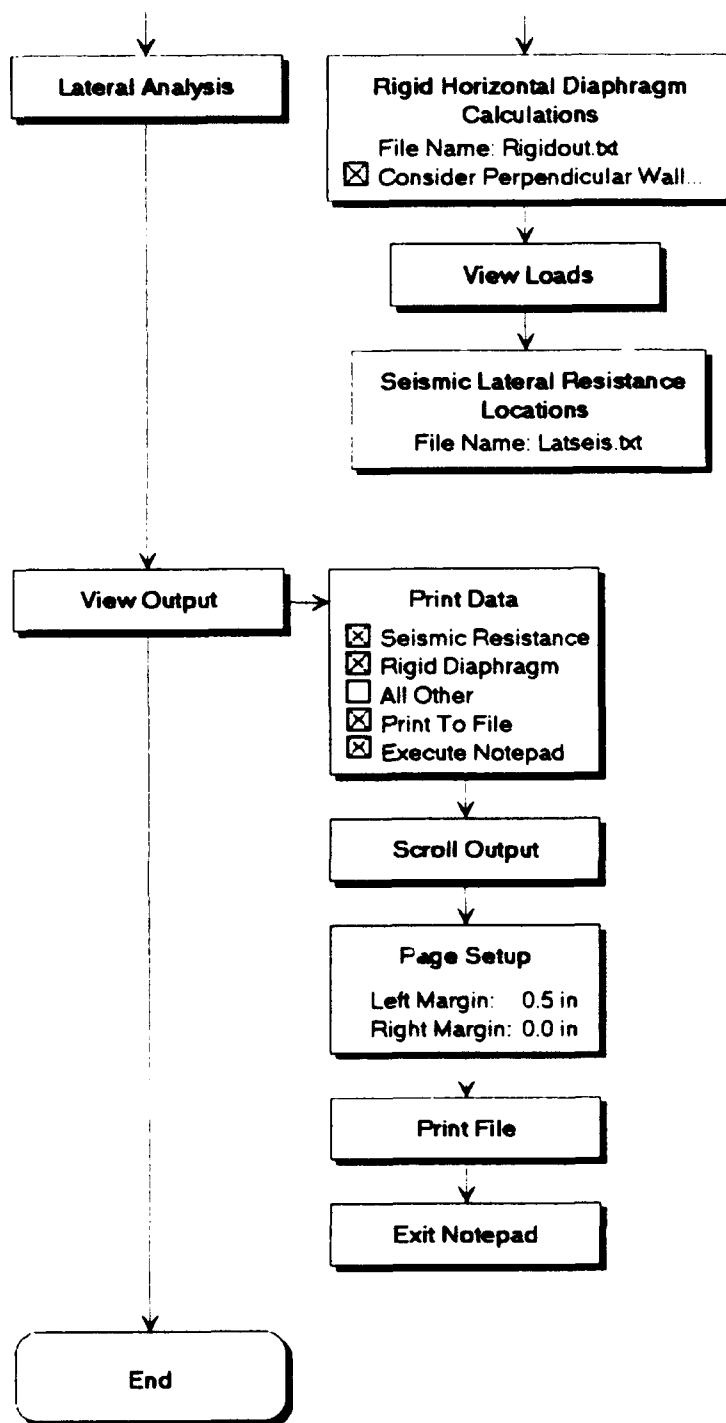
N-S Center Of Mass: 36.53 ft

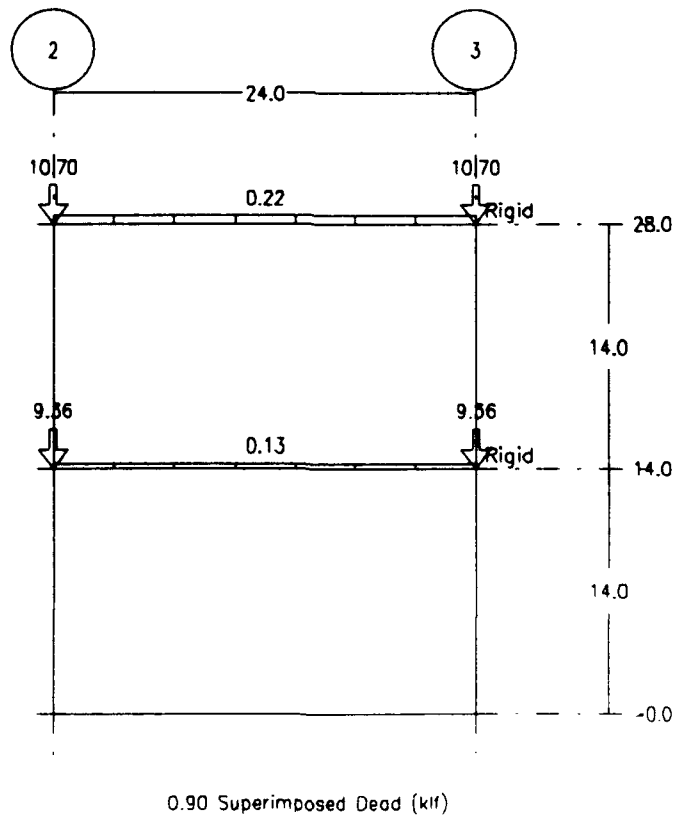
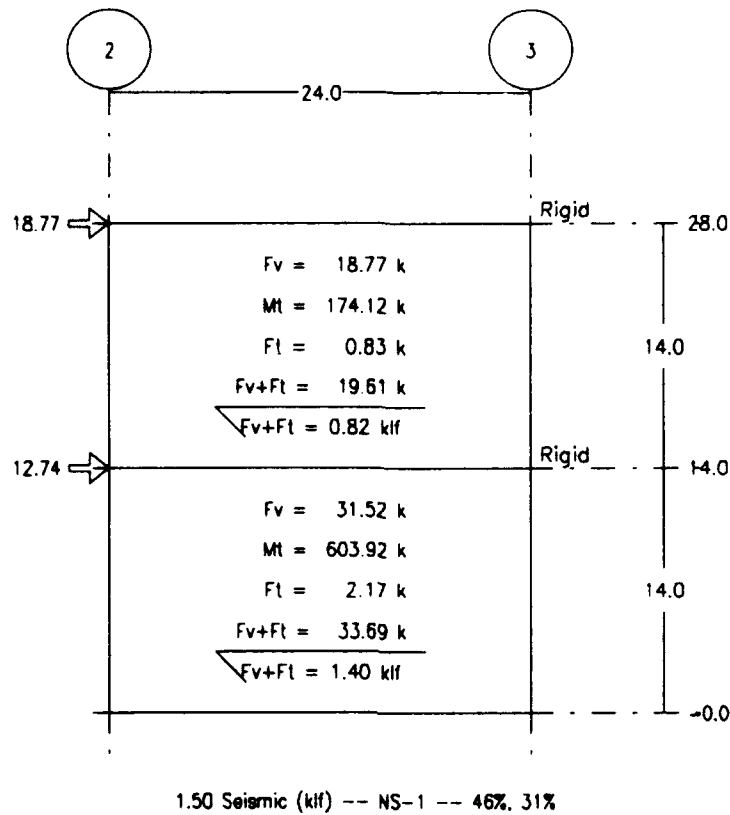
E-W Center Of Mass: 39.07 ft

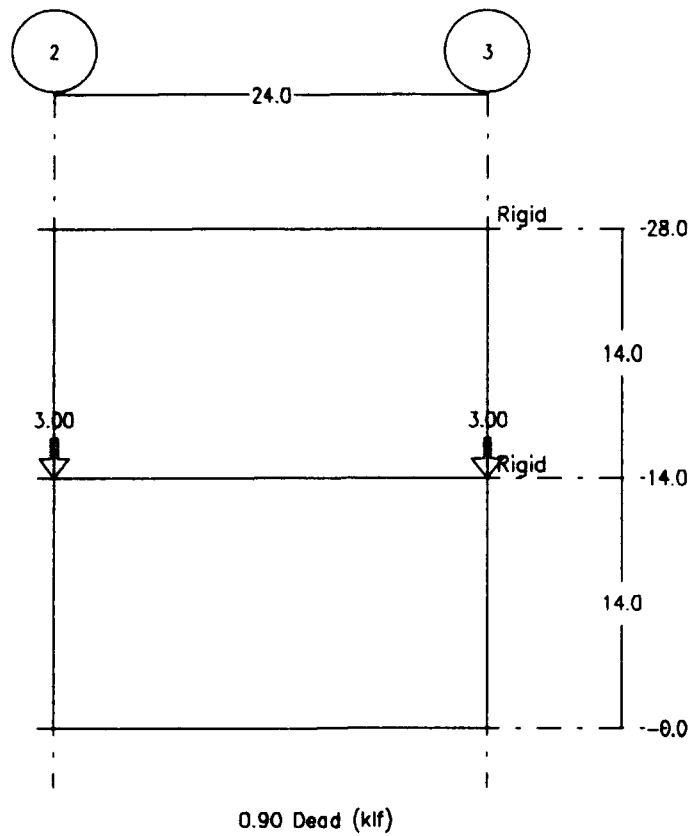


Seismic Lateral Analysis









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 *****

 NS-1 -- 46%, 31%

Level	h (ft)	Floor to		sum(F)		OTM (kft)	sum(OTM) (kft)
		h (ft)	Floor h (ft)	F (k)	V (k)		
3	28.0			40.6			
			14.0		40.6	569	
2	14.0			40.7			569
			14.0		81.3	1138	
1	0.0						1707
Sum				81.3		1707	

 NS-2 -- 54%, 37%

Level	h (ft)	Floor to		sum(F)		OTM (kft)	sum(OTM) (kft)
		h (ft)	Floor h (ft)	F (k)	V (k)		
3	28.0			40.6			
			14.0		40.6	569	
2	14.0			40.7			569
			14.0		81.3	1138	
1	0.0						1707
Sum				81.3		1707	

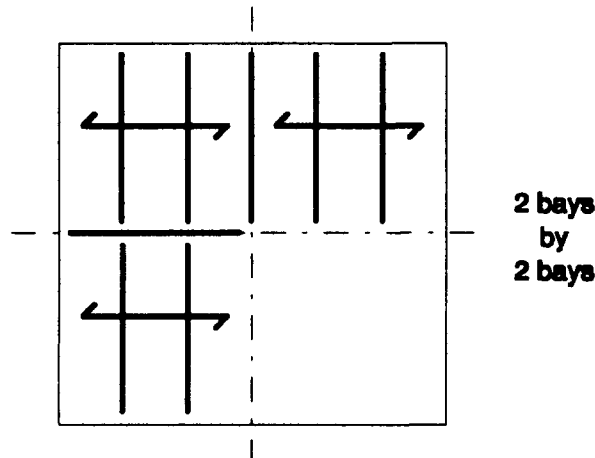
 NS-3 -- F, 31%

Level	h (ft)	Floor to		sum(F)		OTM (kft)	sum(OTM) (kft)
		h (ft)	Floor h (ft)	F (k)	V (k)		
2	14.0			40.7			
			14.0		40.7	569	
1	0.0						569
Sum				40.7		569	

Quantity Take-Off Philosophy

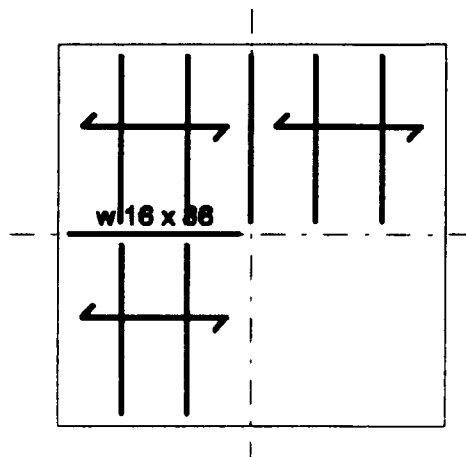
3 Considerations

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

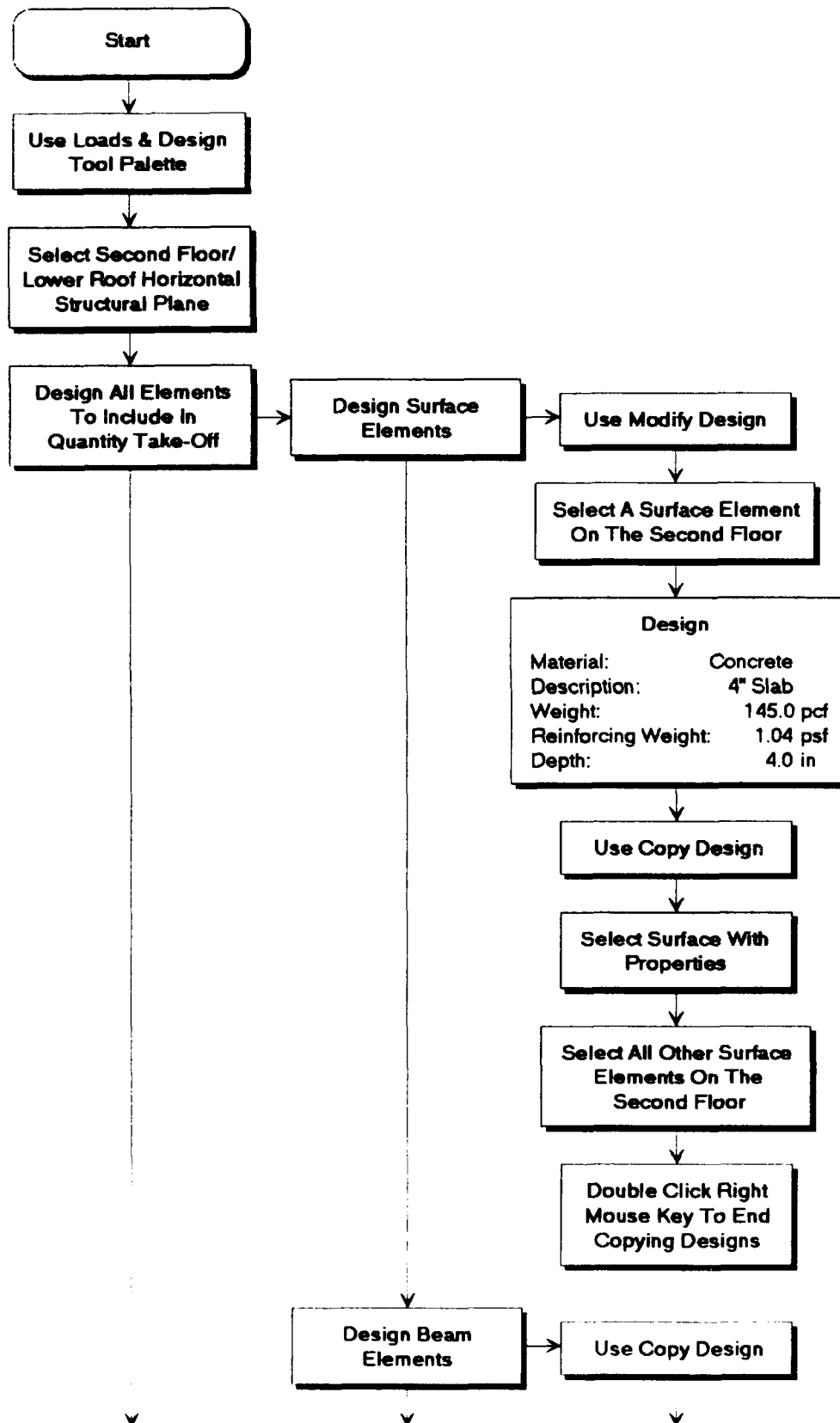
Elements designed by Excel
spreadsheets are used

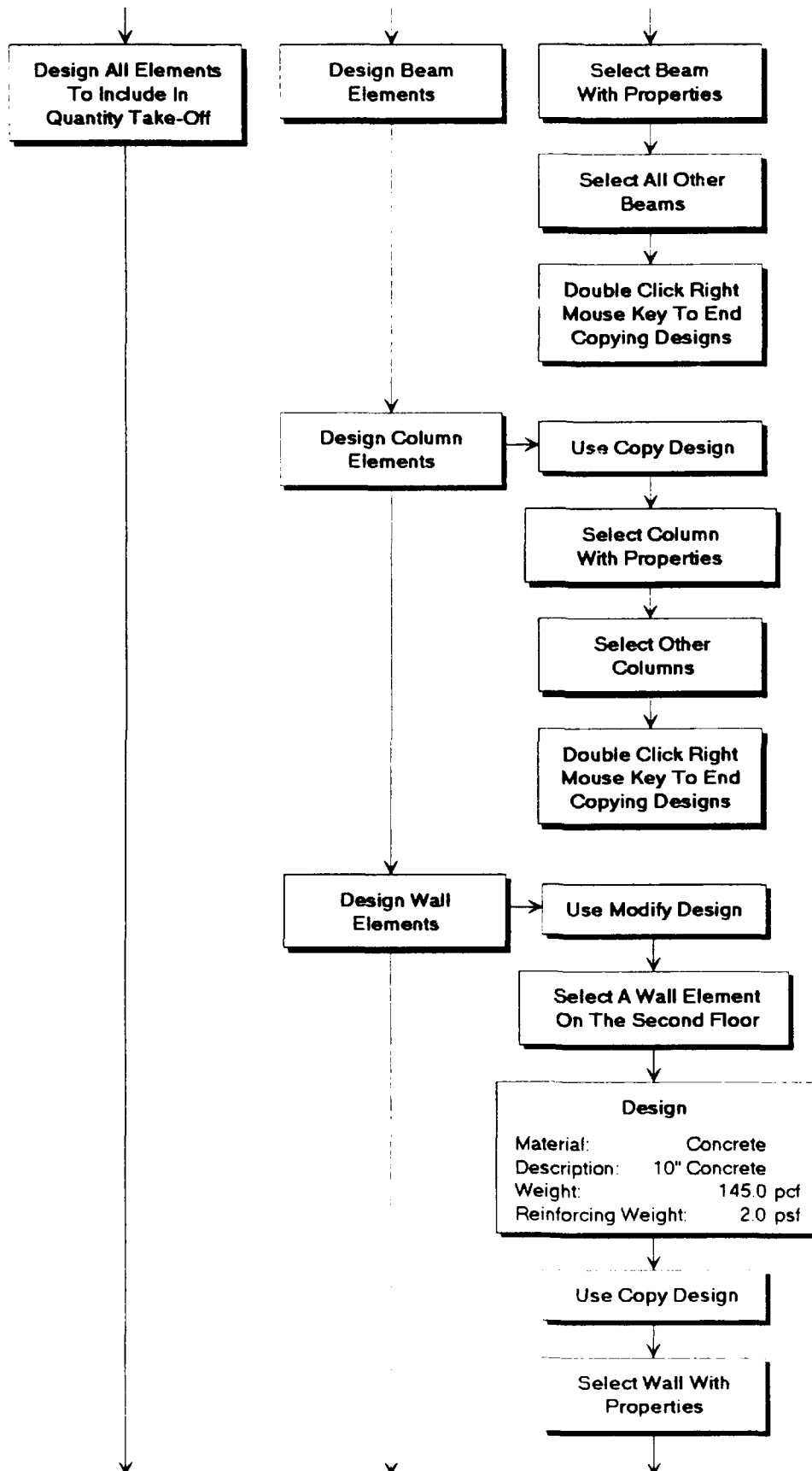
Use Modify Design and Copy Design
to manually enter element sizes

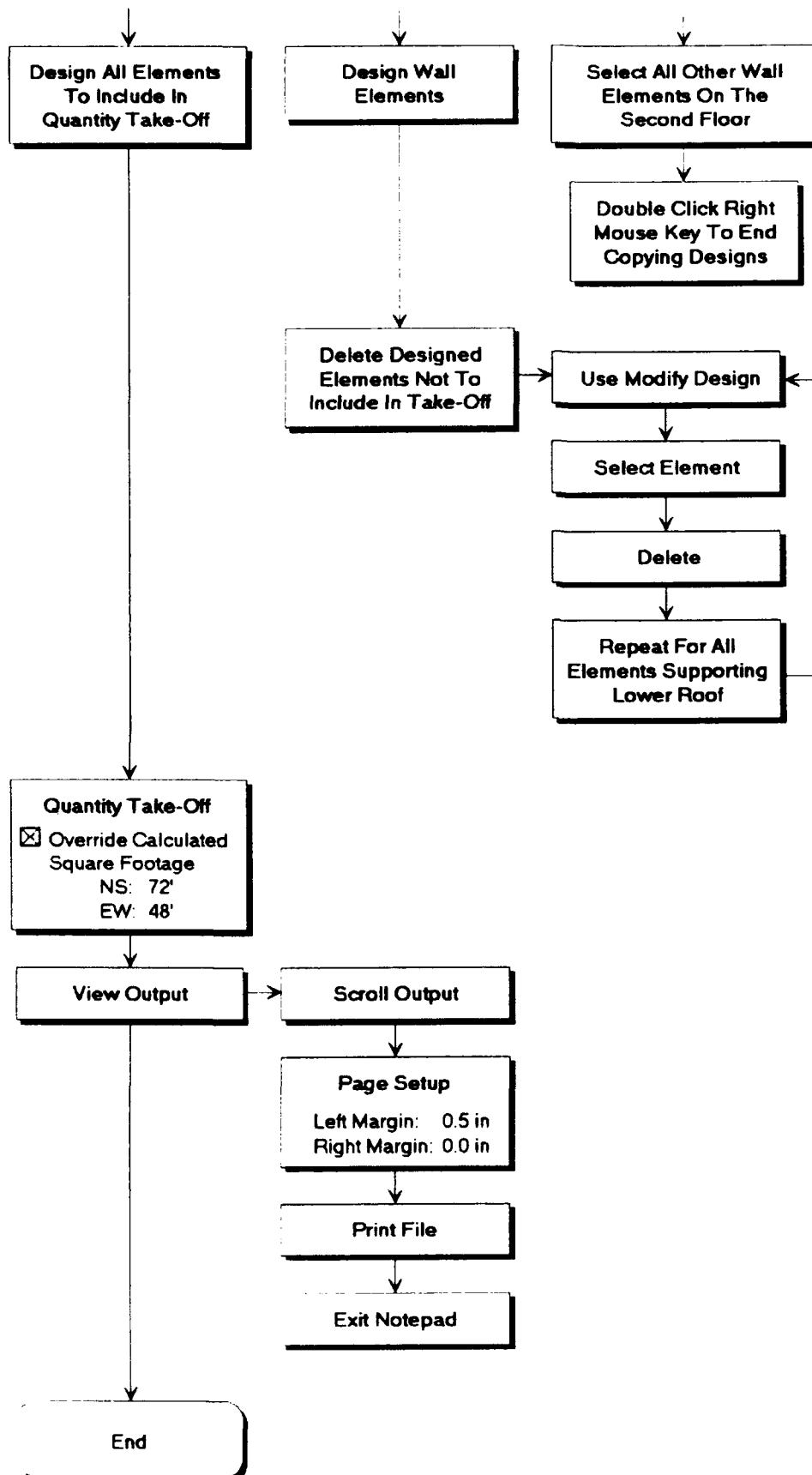
Calculated square footage
can be overridden



Quantity Take-Off







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

Description	Area (sqin)	Length (ft)	Conc Weight		Conc Weight/Element		Total Weight	Conc	Reinf
			Weight (pcf)	Weight (plf)	Conc (lbs)	Reinf (lbs)			
	0	24.0	0	0.0	0	0.0	24	0	0
Sum								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

Description	Area (sqin)	Length (ft)	Conc Weight		Conc Weight/Element		Total Weight	Conc	Reinf
			Weight (pcf)	Weight (plf)	Conc (lbs)	Reinf (lbs)			
10 x 16	160	24.0	145	161.1	3867	360.0	25	96667	9000
	0	24.0	0	0.0	0	0.0	2	0	0
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

Description	Depth (in)	Area (sqft)	Conc Weight		Reinf Weight (psf)	Total Weight	
			Weight (pcf)	Weight (psf)		Conc (lbs)	Reinf (lbs)
4" Slab	4.0	2880	145.0	48.3	1.0	139200	2995
4" Slab	4.0	384	145.0	48.3	1.0	18560	399
	0.0	2592	0.0	0.0	0.0	0	0
Sum						157760	3395

Concrete Cubic Yards : 40.3
 Reinforcing Total Weight: 1.7 tons

Quantity Take-Off

CONCRETE: Column Elements

Description	Area (sqin)	Length (ft)	Conc		Weight/Element		No.	Total Weight	
			Weight (pcf)	Weight (plf)	Conc (lbs)	Reinf (lbs)		Conc (lbs)	Reinf (lbs)
11 x 11	121	14.0	145	121.8	1706	112.0	5	8529	560
Sum								8529	560

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

Description	Width (in)	Length (ft)	Height (ft)	Surf Conc		Weight/ Element (lbs)	No.	Total Weight (lbs)
				Area (sqft)	Weight (pcf)			
10" Concrete	10	24.0	14.0	336	145	40600	4	162400
	10	36.0	14.0	504	0	0	2	0
	10	24.0	14.0	336	0	0	1	0
Sum								162400

Concrete Cubic Yards : 41.5

Description	Width (in)	Length (ft)	Height (ft)	Surf Reinf		Weight/ Element (lbs)	No.	Total Weight (lbs)
				Area (sqft)	Weight (psf)			
10" Concrete	10	24.0	14.0	336	2	672	4	2688
	10	36.0	14.0	504	0	0	2	0
	10	24.0	14.0	336	0	0	1	0
Sum								2688

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.

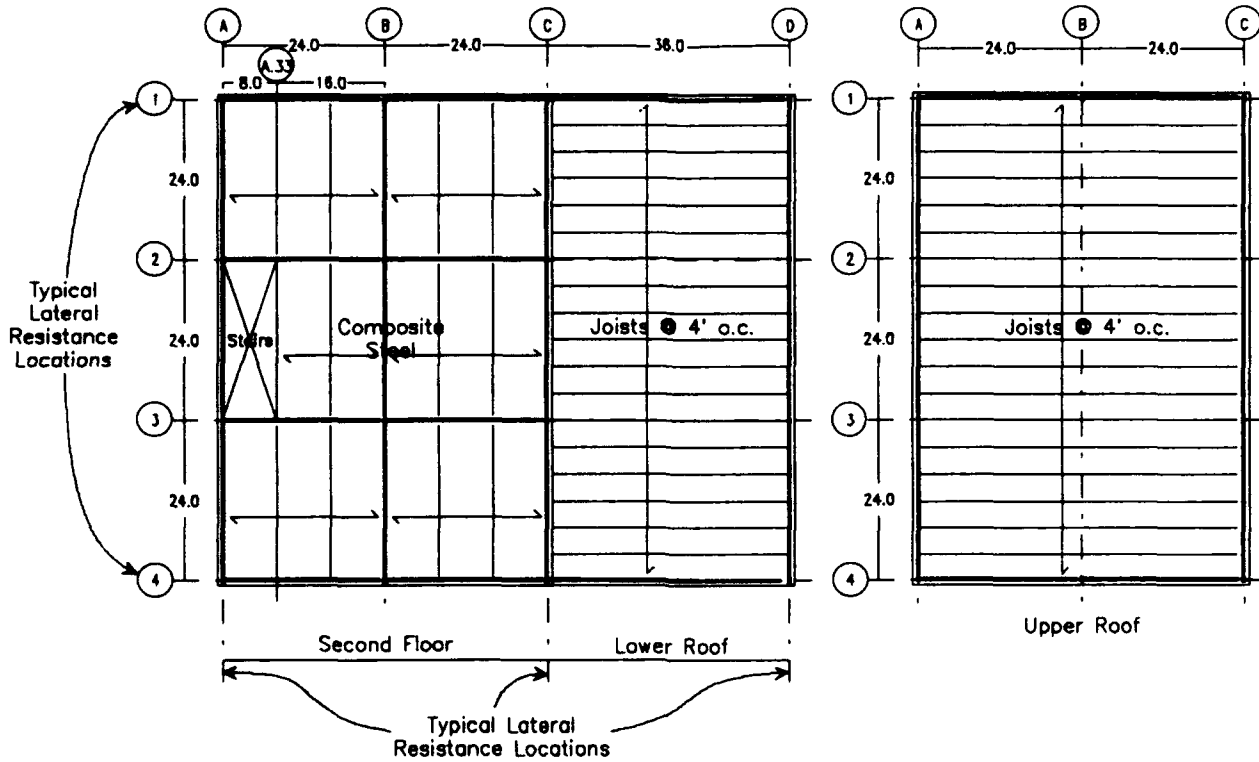
A logical steel framed beam/column solution for "real" consideration would include open web steel joists spanning 48 feet for the upper roof to eliminate a central column in the second floor space. The lower roof would be framed with 36 foot span open web steel joists (without inclusion of custom trusses) 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.

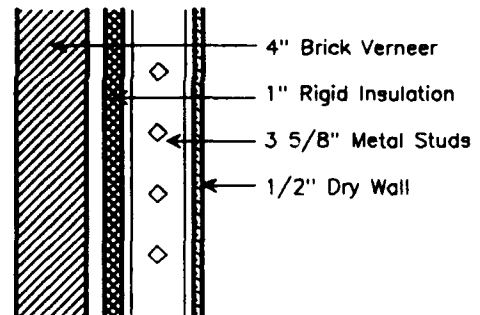
The structural engineers that become proficient with the use of CASM will be able to explore many other ideas to arrive at the most structurally efficient and economical solution for this hypothetical project.

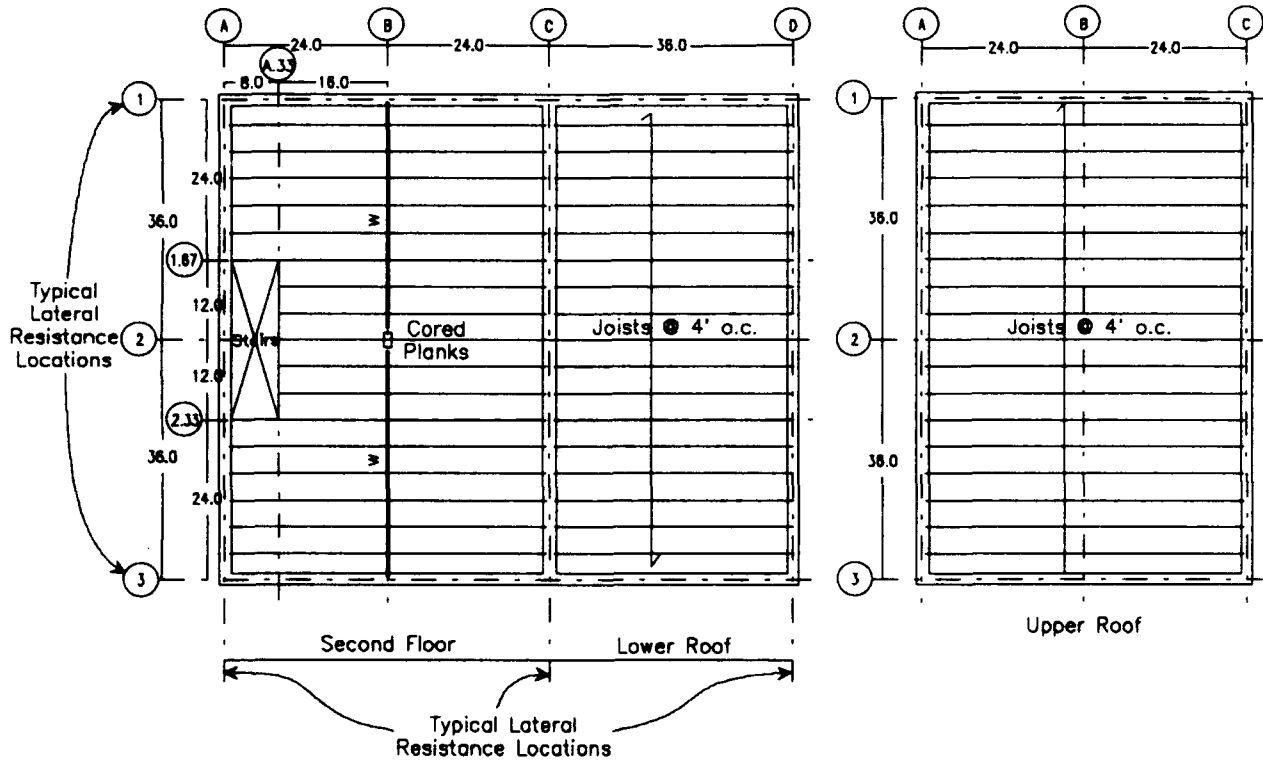
Concluding Remarks



Scheme 1: Moment connections for lateral load resistance

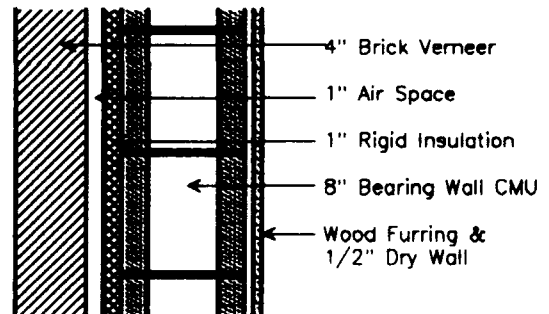
Scheme 2: Trussing for lateral load resistance





Scheme 3: Shear walls for lateral load resistance

8" CMU walls can be used as shear walls



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13. ABSTRACT (Maximum 200 words) 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.				
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Computer Aided Structural Engineering Modeling (CASE)

Computer programs

Preliminary structural design

Structural modeling

Three-dimensional graphics

Three-dimensional loads

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