## 3.4. My First Building Project

This is your first tutorial on how to use SANSPRO effectively to design a building. This tutorial will highlight most useful commands and options.

In this tutorial we assume that you have already finished **My First Frame Project** tutorial. Please do it if you have not done it because it contains many basic tasks that will be used here and not be explained again in detail.

You can finish this tutorial in 30 minutes to 1 hour.

Please follow the step-by-step instruction below carefully, remember that you have plenty of time, do not be in hurry.

#### **Static Equivalent Analysis:**

- 1. Create New Model
- 2. Define Structural Analysis Option
- 3. Define Working Area and Axis
- 4. Define Building Parameters
- 5. Adding Load combinations
- 6. Adding Element Properties
- 7. Define Floor Slab Data
- 8. Adding Nodes
- 9. Adding Beam Elements
- 10. Adding Column Elements
- 11. Adding Shearwall Elements
- 12. Adding Support
- 13. Adding Floor Regions
- 14. Adding Beam Load
- 15. Compute Floor Weight
- 16. Generating Equivalent Load
- 17. Run Analysis
- 18. Output View
- 19. Element Design
- 20. Design View
- 21. Element Design View
- 22. Design Color Code
- 23. Invalidate Design
- 24. Revise Design
- 25. Printing Report
- 26. Foundation Design
- 27. Compute Volume and Cost
- 28. View Rebar Layout
- 29. Generating Drawing

#### **Dynamic Analysis:**

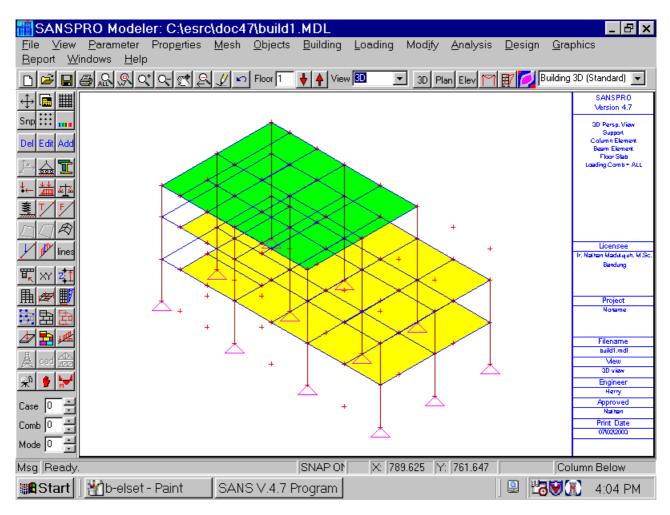
- 1. Define Mass Factor
- 2. Define Spectrum Response
- 3. Dynamic Analysis Option
  - Number of Eigen
  - Earthquake Direction
  - Static Condensation
- 4. Run Dynamic Analysis
- 5. Check Dynamic Output
  - Natural Period
  - First Mode/Dominant Mode
  - Mode Shape
  - Mass Participation Factor
  - Effective Mass Factor
  - Modal Direction Factor
  - Base Shear
  - Eccentricity
  - Displacements/Drift
- 6. Eccentricity
  - Eccentricity
  - Design Eccentricity
- 7. Base Shear
  - Base Shear
  - Base Shear Correction
  - Story Shear
- 8. Design for Dynamic Analysis
- 9. Visual Design Report

#### Capacity Design

- 1. Basic Concepts
- 2. Define Parameters
- 3. Run Capacity Design
- 4. Visual Design Report
- 5. Capacity Design Report: Beam Design Forces
- 6. Capacity Design Report: Beam Rebar
- 7. Capacity Design Report: Column Design Forces
- 8. Capacity Design Report: Column Rebar

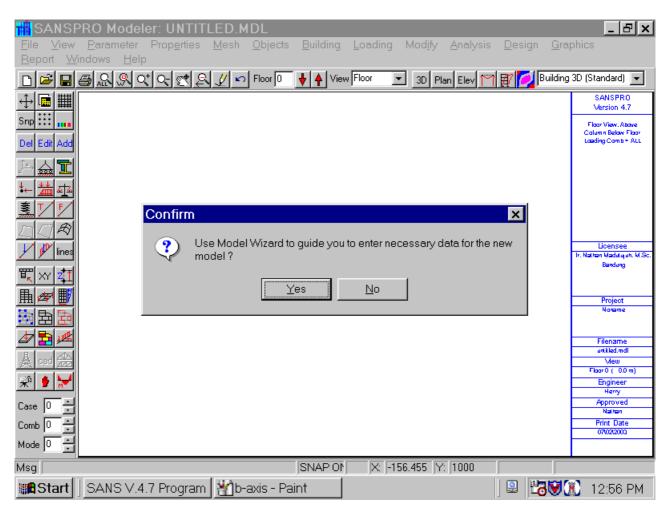
## **Problem Definition:**

- Design a three storeys concrete building for residential purpose



### 1. Create New Model

- Use Wizard to guide you step-by-step



- Click File-New
- Entering Model Name and Titles
- Title 1 can be used for Project Title
- Title 2 can be used for Job Title
- Title 3 can be used for Project Location
- Notes for Engineer can be used for notes to be shared with other engineers.

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### 2. Define Structural Analysis Option

- Structural Model = Building 3D (Standard) Select Building 3D (Extended) if you want to add 3D Trusses/Frames/Domes.
- Structure Material = Concrete
- Structure Type = Ductile Frame
- Design Method = Capacity
- Design Code = CONCRETE PBI-91 (Indonesian Code)
- Steel Design Option = Elastic (Not Applicable for this concrete building)
- Importance Factor of the building = 1.0 (Standard)
- Ductility Factor K = 1 (K is used for Cd = C.I.K)

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- Select Analysis Type = Static
- Model Type = Linear Elastic
- Condensation = No
  - Select Condensation = No, Rigid Floor = No for Open Frame
  - Select Condensation = No, Rigid Floor = Yes for Open Frame with Rigid Floor
  - Select Condensation = 3 Dof/Floor, Rigid Floor = Yes for 3 Dof/Floor Model
- Rigid Floor Model = YES
- Gravity Acceleration = 981 cm/second^2
- Uncheck Include Slab in Beam Contribution for Floor Weight/Mass Calculation
  - If checked, beam weight will be calculated using total beam height (should be selected for Precast slab system)
  - If not checked, beam height will be reduced by slab thickness for weight calculation (use this for cast-in-situ beam-slab system)

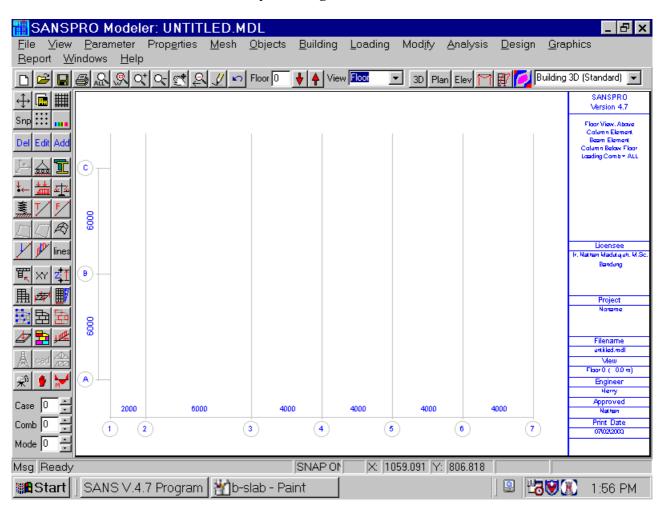
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#### 3. Define Working Area and Axis

- Define working area as X and Y coordinate ranges of building layout view from top.
- Here our X range is from 0 to 2400cm, Positive (+) direction is from left to right
- Here our Y range is from 0 to 1200cm , Positive (+) direction is from bottom-up
- Grid axis spacing is 500 (Coordinate will be snapped to grid axis system if Snap = on)
- We have 8 user define axis names and location for X axis and 3 for Y axis.
- If Snap on then every coordinate will be snap to user axis intersection, then to grid spacing, automatically.

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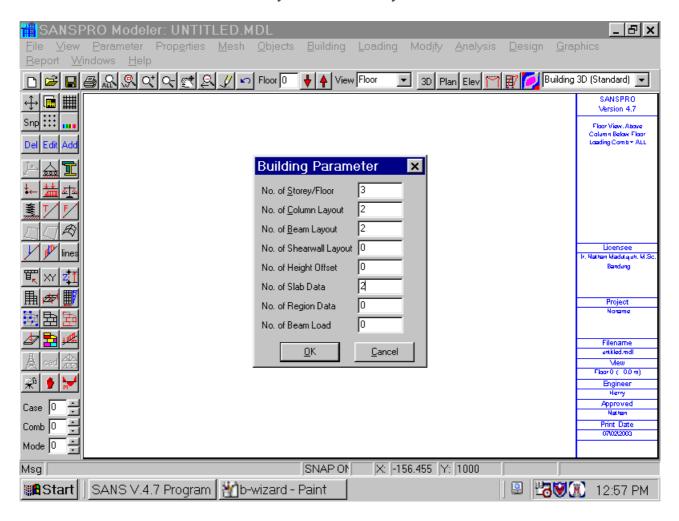
- User axis can be shown/hidden by clicking Icon User Axis.



#### 4. Define Building Parameters

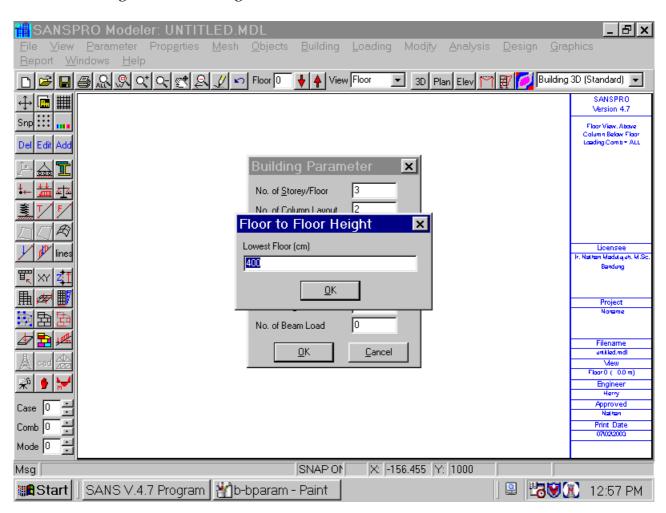
- Define Buiding Parameters

- Number of Floor = 3
  - (Start from Floor 0 at ground to Floor 3 at top)
- Number of Column Layout = 2
  - number of different types of column size and layout changes for a floor
  - Each column layout can contain more than 1 column elset type
- Number of Beam Layout = 2
  - number of different types of beam size and layout changes for a floor
  - Each column layout can contain more than 1 column elset type
- Number of floor slab data = 2
  - We will use two slab thickness: 12cm, 10cm
- Leave other fields blank, they will be filled by SANSPRO



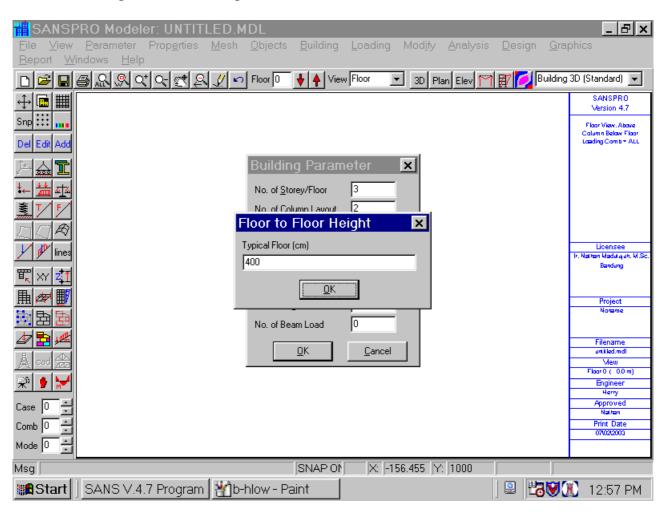
- Enter floor height for lowest floor = 400cm

- You can change each floor height later from STOREY DATA table



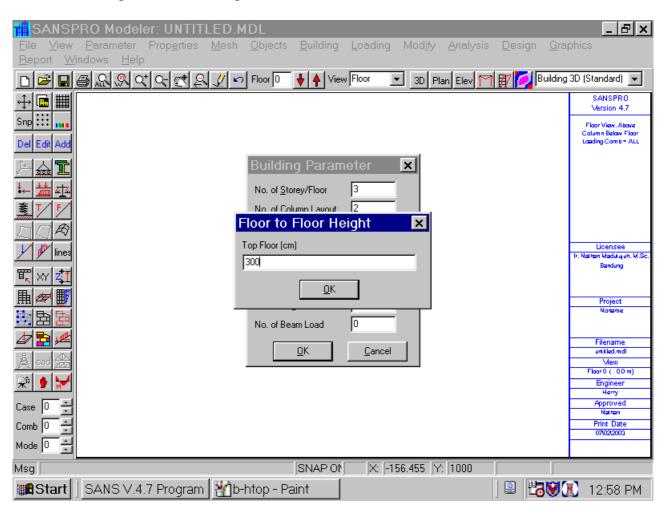
- Enter floor height for typical floor = 400cm

- You can change each floor height later from STOREY DATA table



- Enter floor height for top most floor = 300cm

- You can change each floor height later from STOREY DATA table



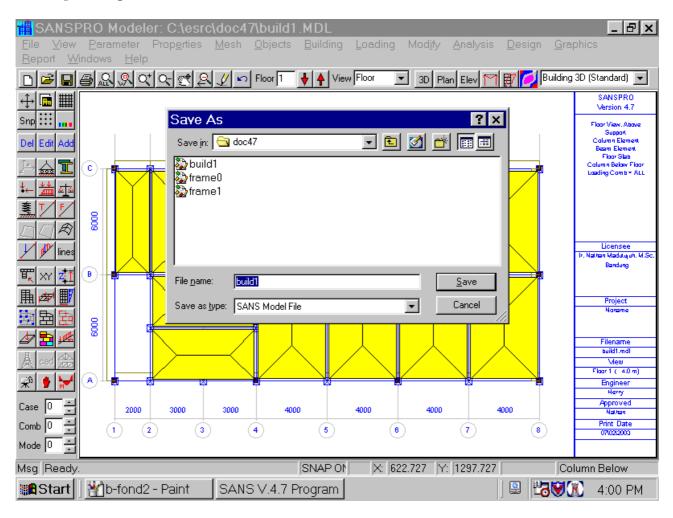
- Enter Live Load Reduction Factor for all floors, LLRF = 0.5 (means 50% LL reduction)
- You can change each floor LLRF later from STOREY DATA table
- This LLRF will be used to reduce Live Load for Floor Weight Calculation for Static Equivalent Load Analysis

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- Storey Data Table will be displayed
- You can change each floor parameters from this STOREY DATA table
- For this example, just click OK to accept the default values

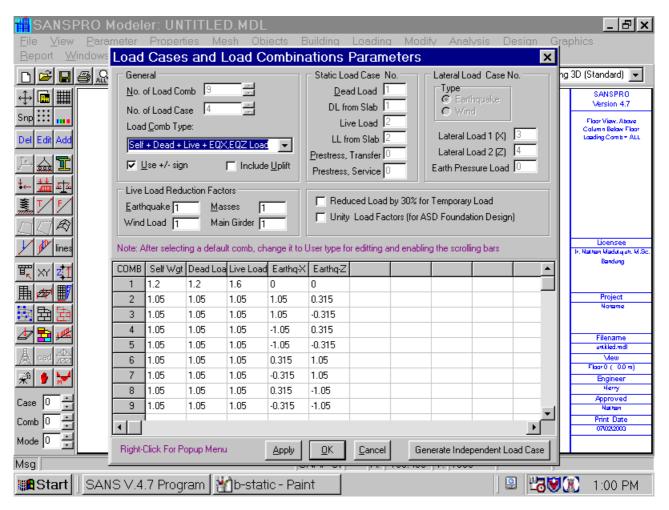
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- Save the model and name it BUILD1.MDL
- After first saving, we can save the model by pressing F2
- It is recommended to save the model after major changes
- SANSPRO provides two backup files:
  - BUILD1.~MD Created each time you save the model
  - BUILD1.SBK Created automatically every certain duration (user defined)
- Automatic Save should be turn on (recommended) for your protection
- Click File-Preferences to see the status
- If something wrong with your model you can rename the backup file to BUILD1.MDL and open it again



# 5. Adding Load combinations

- SANSPRO provides predefined load combination sets for concrete and steel structures
- User can select +/- option to get earthquake in all directions
- User can use **Uplift** option to get extreme uplift combination (reduced DL)
- Select Load Comb Type = Self + Dead + Live + EQX, EQZ Load with +/- sign on
- Here we will have Load comb = 9, and Load case = 4



- Dynamic Load cases will not be counted as load case but will be included in load combination
- Use predefined load combinations carefully. If you want to modify it, please select the load comb type first then click User Defined.
- For Allowable Stress Design (ASD) as for steel or foundation design, user can reduced all load factors by 30% for temporary loadings and remove all load factors (change to unity).
- Live load reduction factors can be given according to local code. Please use this carefully.
- Usually live load reduction factor is used to reduce building mass for eathquake load calculation
- For live load factor at load combination, we usually use reduction factor for main girder only

# **6. Adding Element Properties**

- We will define material, section, design properties and elset data

### 6.1. Generate Material Data

## - Generate material data for Concrete K-300

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#### 6.2. Define Section Data

- Define SECTION table for this building
- Click Add to add new section
- Here we use 7 sections, 2 for columns, 3 for beams, and 2 for floor slabs
- Section data at Section table will be used for Analysis phase only
- For beam sections, parameter bf (flange width) and tf (flange thickness) must be entered.
- If not a flanged beam, bf should be equal to b and tf = 0
- Avoid to use space for section names
- Beam and column sections are type RECT and Slab sections are type THICKNESS
- Click Apply or Dark bar to apply the changes made to table

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### 6.3. Define Design Data

- Define DESIGN properties data for this building
- Click Add to add new section
- Here we use 7 designs, 2 for columns, 3 for beams, and 2 for floor slabs
- Section data can be copied from Section Table by clicking button Copy Section
- Section data at Design table will be used for Design phase only
- For beam sections, parameter bf (flange width) and tf (flange thickness) must be entered.
- If not a flanged beam, bf should be equal to b and tf = 0
- Avoid to use space for design names
- Column designs are type Concrete Biaxial Column
- Beam designs are type Concrete Girder
- Slab designs are type Concrete Slab
- Click Apply or Dark bar to apply the changes made to table

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- Column Design Type = Concrete Biaxial Column
  - Columns will be designed using Biaxial Bending Moment and Normal forces
  - User can select rebar placement: two faces or four faces
  - If two faces rebar selected, user can enter total number of side bar
  - If four faces rebar selected, main rebars will be distributed equally for all four column sides
- If Design Type = Rect Column selected:
  - Column will be designed using resultant of Mx,Mz and Normal
  - Resultant Moment will be applied to H direction of column.
  - H direction of column should be entered as column size parallel to dominant moment direction
  - User can select rebar placement: two faces or four faces
  - If two faces rebar selected, user can enter total number of side bar
  - If four faces rebar selected, main rebars will be distributed equally for all four column sides

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- Beam Design Type = Concrete Girder
- For beam sections, parameter bf (flange width) and tf (flange thickness) must be entered.
- If not a flanged beam, bf should be equal to b and tf = 0
- Enter delta factor as ratio of secondary to primary rebar area = 0.6
- For deep beam, one can enter total number of side rebar

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- Slab Design Type = Concrete Slab
- Slab will be design as concrete girder with equal top and bottom rebar
- Slab will be designed based on floor regions, so you do not need to analyze the model before viewing slab design.

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# 6.4. Define ELSET Data

- Generate elset data for this building

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- Press **F2** to save the model

## 7. Define Floor Slab Data

- Double-Click table column named Elset, select slab elset index
- Double-Click table column name Slab Type, select Concrete

Typical Slab:

- Enter q,DL as -0.015 kg/cm2 (equal to 150 kg/m2) for superimposed DL excluded selfweight of concrete slab that will be calculated automatically by SANSPRO
- Enter q,LL as -0.025 kg/cm2 (equal to 250 kg/m2) for superimposed LL

Roof top slab:

- Enter q,DL as -0.01 kg/cm2 (equal to 100 kg/m2) for superimposed DL excluded selfweight of concrete slab that will be calculated automatically by SANSPRO
- Enter q,LL as -0.01 kg/cm2 (equal to 100 kg/m2) for superimposed LL

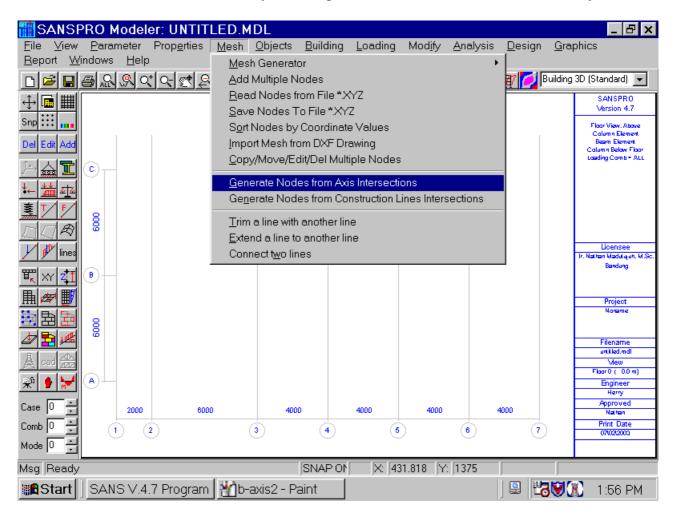
Other parameters:

- If Weight parameter filled, SANSPRO will use this value as weight of slab instead calculating it automatically using Unit weight x Thickness. This is useful for Hollow core precast slab or Cold-formed steel deck.
- If Cost parameter filled, SANSPRO will use this as unit price for calculating slab cost. This cost may include concrete, rebar, and additional rebar cost, placement cost, etc. If you entered formwork cost, exclude the cost from this slab unit cost.

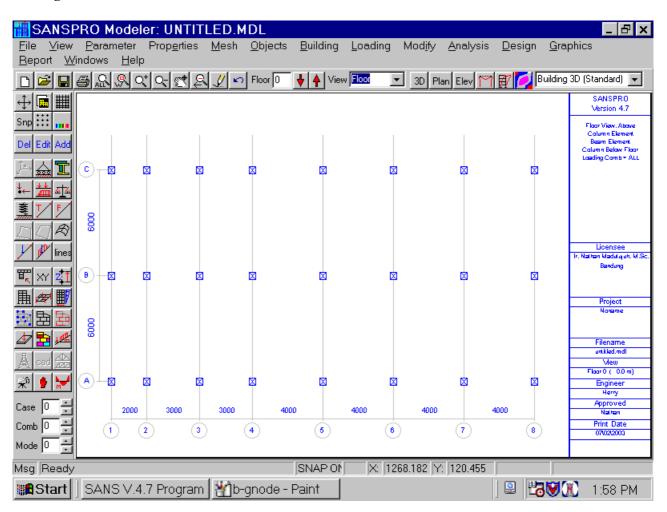
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## 8. Adding Nodes

- Nodes will be added automatically by generating them from all axis intersections
- Additional nodes can be added by Clicking Icon XY and Icon Add then click any location



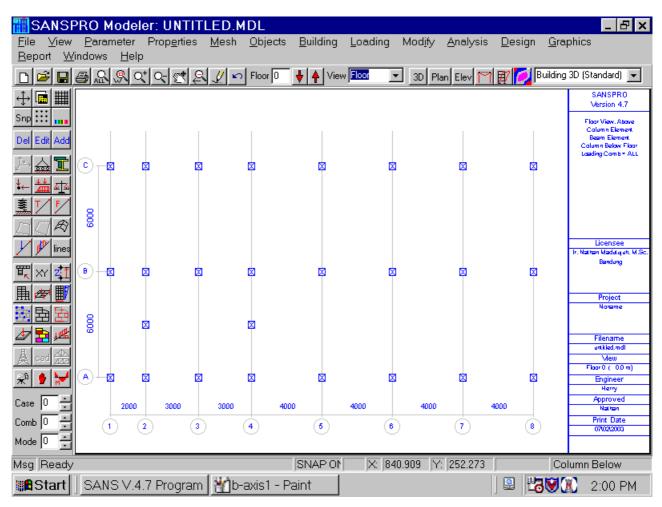
- The generated nodes will be as follows:



- Additional nodes can be added by Clicking Icon XY and Icon Add then click any location

- Here we will add two nodes at axis 2 and 4 for staircase void of the building

- After we add additional nodes, layout will be:



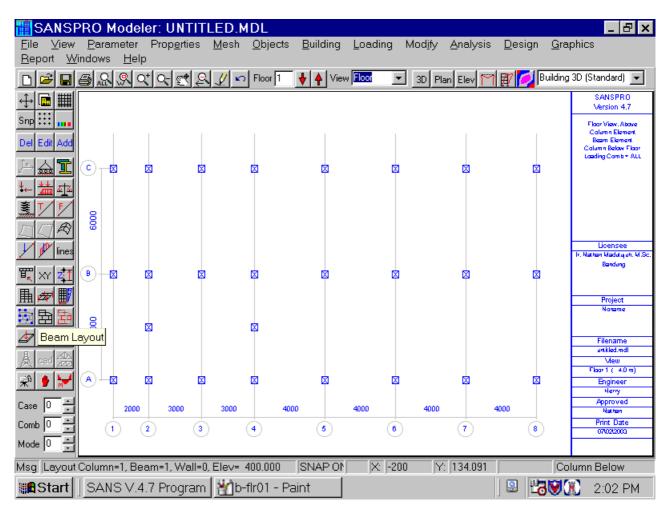
- Press F2 to save the model

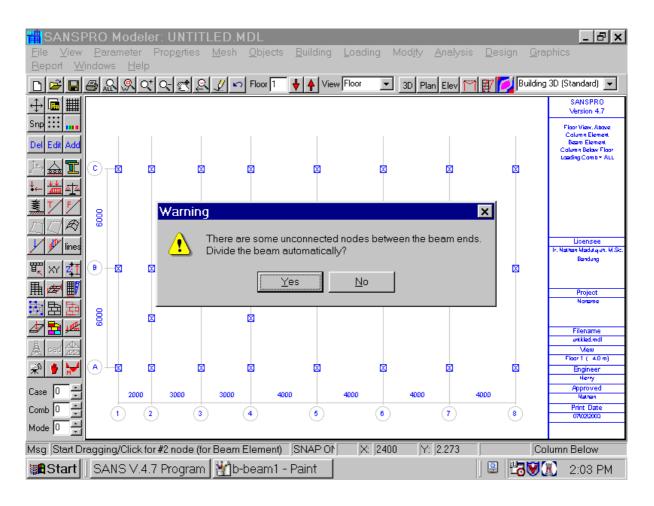
# 9. Adding Beam Elements

- Move to Floor No. 1
- Click Icon Beam Layout, Icon Add
- Click 2 nodes or Click a node and drag to another node and release the mouse button
- Select Beam Elset
- Select Beam Function:

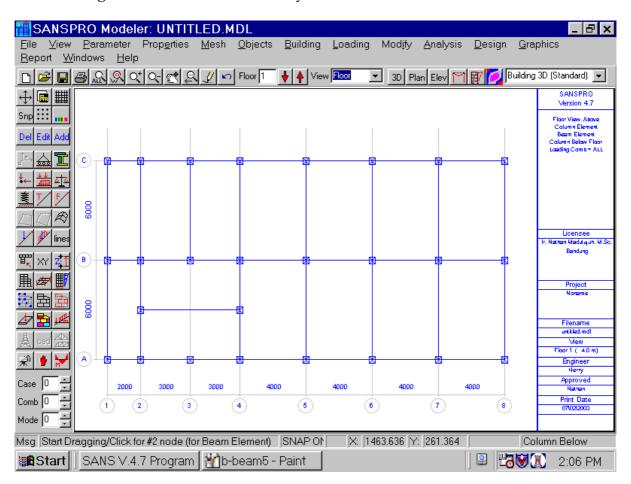
-> Beam will be included in capacity design
-> Beam will be excluded in capacity design
-> Beam will be weightless, exluded in any design
-> Beam will be weightless, exluded in any design

- Rigid Link is used for load transfer beams
- Dummy or Fictitious is used for slab region dividing beams
- Add Rigid End and node release options.
- If a beam is crossing any midpoints, user will be asked if he wants to divide the beam automatically. Answer with Yes if so.
- You may auto divide/correct beam mesh later easily using SANSPRO automatic mesh correction.
- Repeat for other floors with different beam layout
- You need to enter only beams at different layout, other floor with same beam layout will follow automatically.





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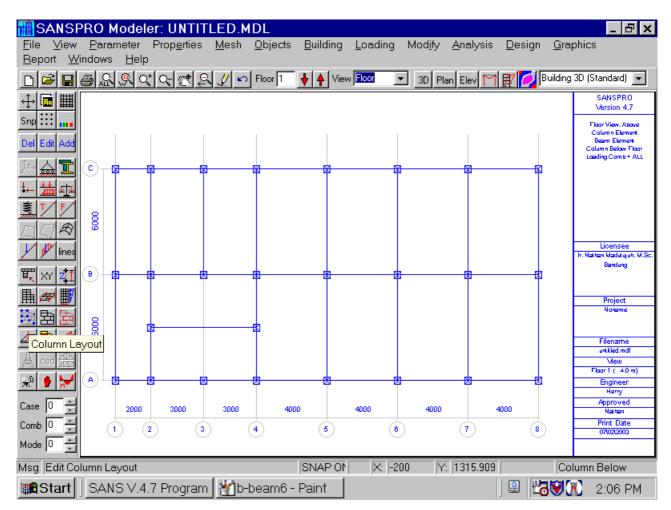
After adding all needed beams, beam layout for the Floor No.1 will look as follows:

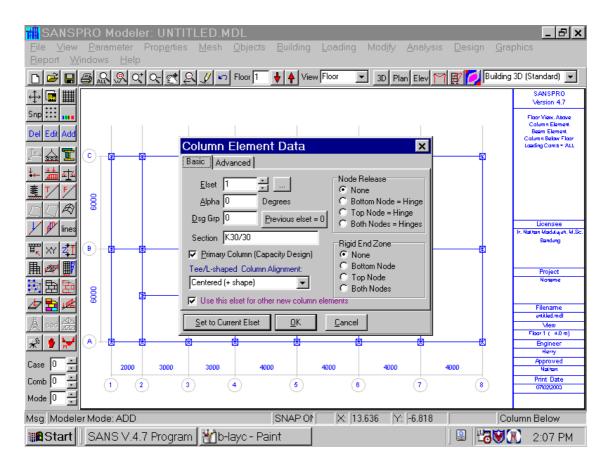
## 10. Adding Column Elements

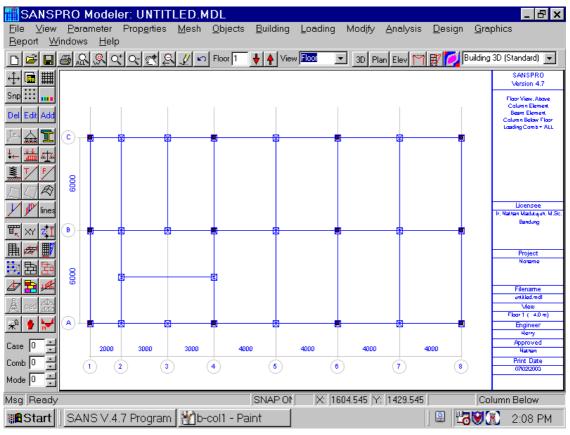
- Move to Floor No. 1
- What you see is columns below Floor No. 1 (see status bar, at right)
- To see columns above Floor No. 1, Change the View Option
- Click Icon Column Layout, Icon Add
- Click 1 node
- Select Column Elset
- Select Column Function:

Primary -> Column will be included in capacity design

- Secondary -> Column will be excluded in capacity design
- Add Rigid End and node release options.
- If a column is crossing any beam, the beam must be divided/splitted.
- You may auto divide/correct beam mesh later easily using SANSPRO automatic mesh correction.
- For Tee or L shaped columns, one can entered the alignment and direction of the flanges
- Repeat for other floors with different column layout
- You need to enter only columns at different layout, other floor with same beam layout will follow automatically.







- Press **F2** to save the model

#### **11. Adding Shearwall Elements**

- In this example there is no shearwall but user can add shearwall as follows:

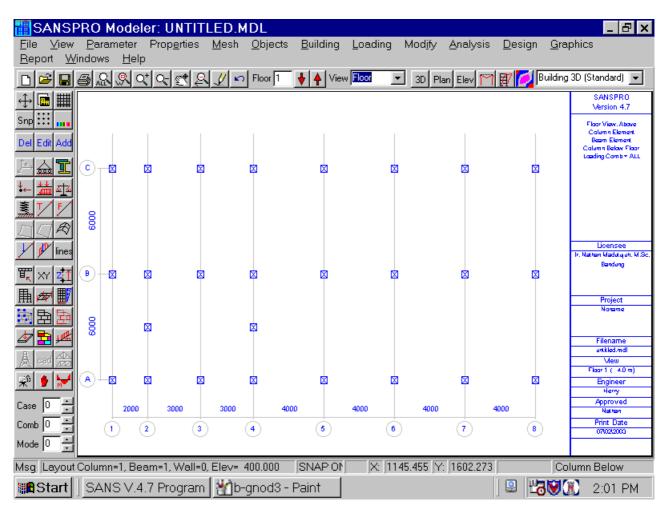
- Goto Floor with Shearwall layout
- Click Icon Shearwall
- Click Icon Add
- Click Two nodes
- Select Shearwall properties
  - Shell option is used for wall resisting in-plane and out-of-plane forces
  - Plane stress/strain option is used for wall resisting in-plane forces
  - Plate bending option is used for wall resisting out-of-plane forces
  - Shear panel is for wall resisting in-plane shear only (eq. brick walls)
- The walls you see is walls under the current floor

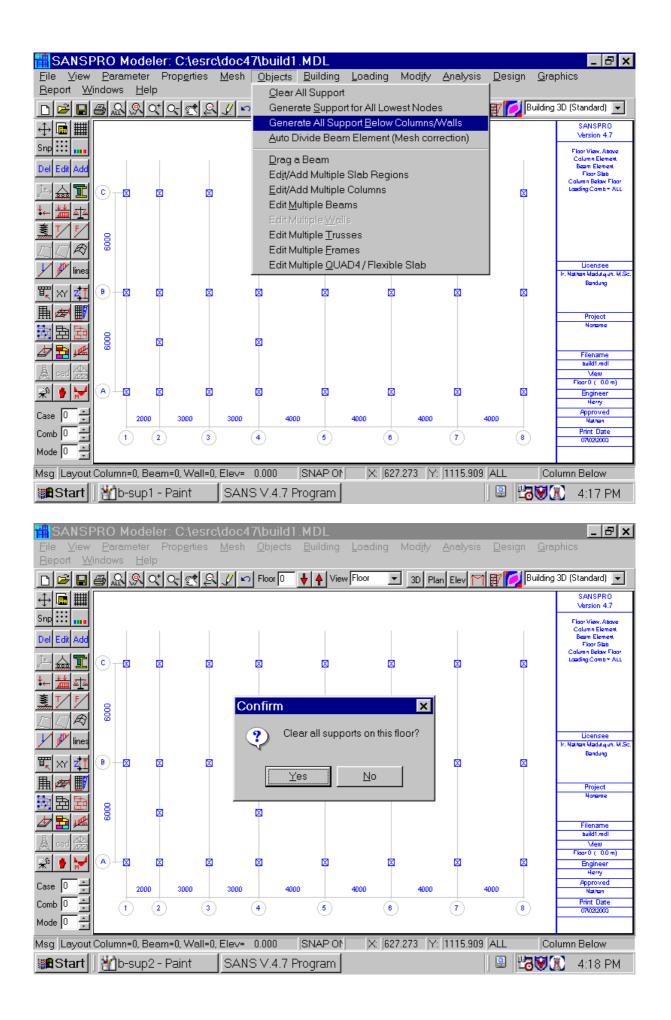
- To see walls above Floor No. 1, Change the View Option

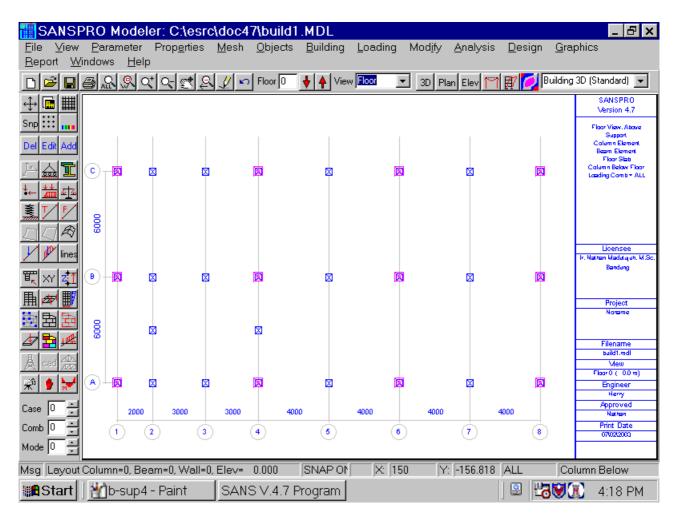
- Press F2 to save the model

# 12. Adding Support

- Generate Nodal Supports manually as follows:
  - Move to Floor No. 0
  - Click Icon Support and Icon Add
  - Click any target node
  - Select Support Type
  - Click OK
  - Click Other nodes
  - Click Icon Redraw if finished
- Alternatively (recommended), one can generate all needed supports automatically using Support Object Generator as follows:
  - Move to Floor No. 0



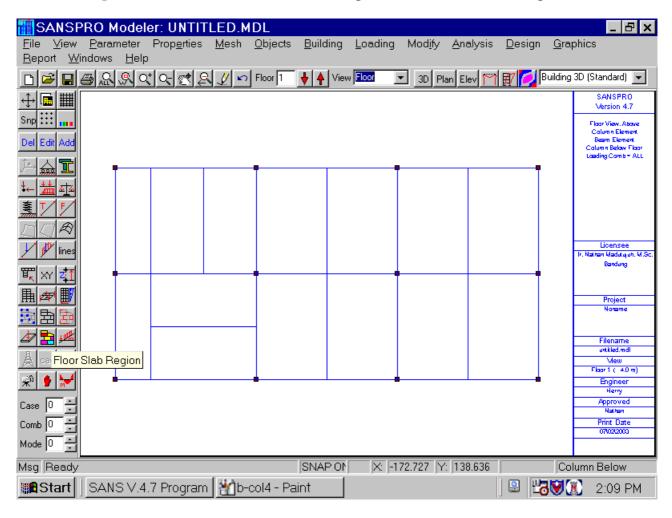




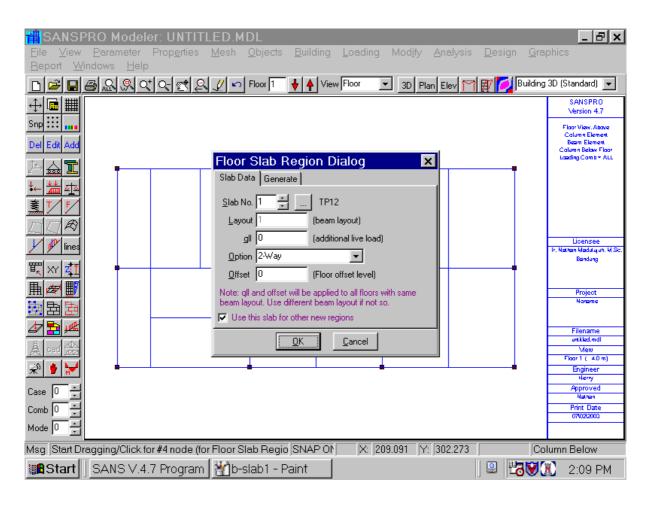
- Press F2 to save the model

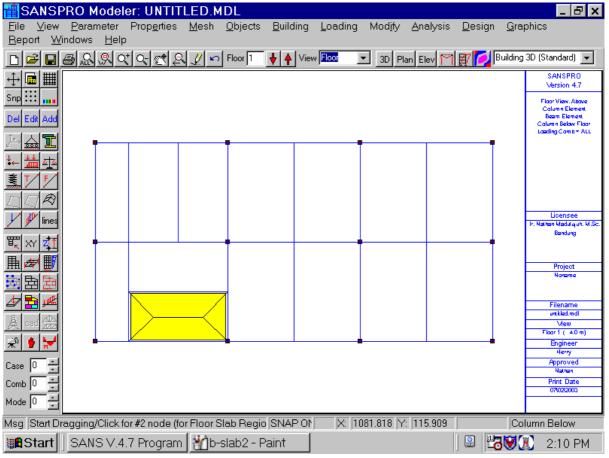
# **13. Adding Floor Regions**

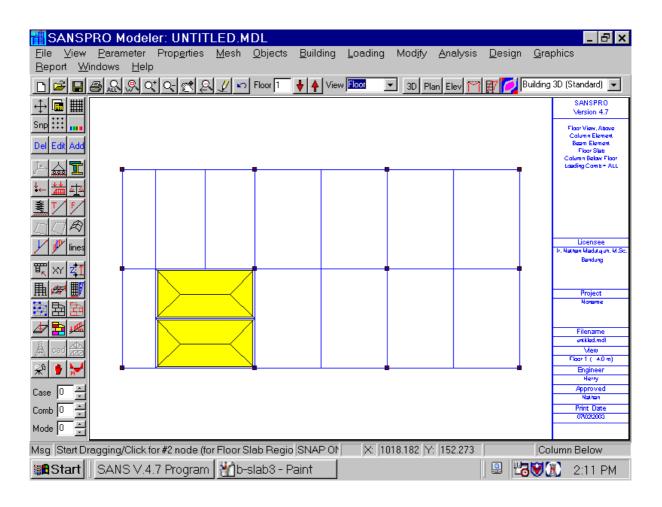
- SANSPRO models floor loading (self/dead load, live load) by dividing floor slab into 3 or 4 straight sides regions.
- Each region side can contain more than one beam.
- Default loading for floor slab is defined at Floor Slab Table previously entered.
- Additional Live Load for a certain region can be added to accommodate for different room functions.
- Click Icon Floor Regions, Icon Add, and Click 4 nodes as 4 corners of the regions.
- Click start from bottom-left, in counter-clockwise direction
- In case of 3 sides regions, Click the third node twice.
- Select Floor Slab Type
- Select Beam Load Pattern (One way or two way slab)
- A Load pattern will appear for the region
- If the load pattern is not nice, delete and add again with different starting node

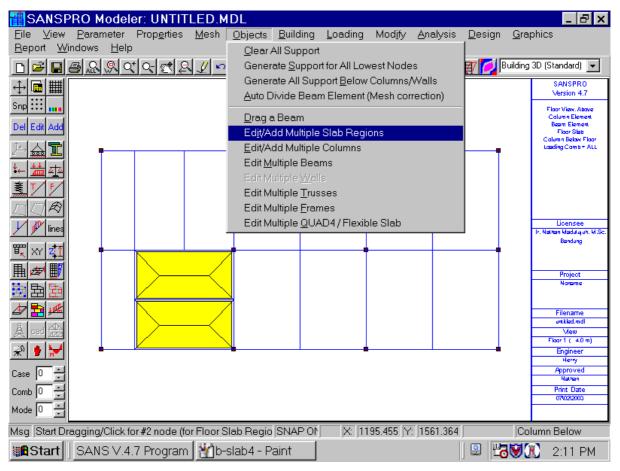


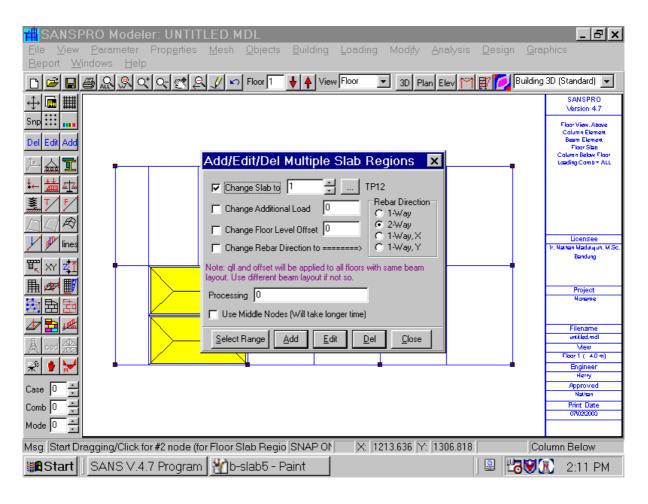
- Alternatively **(recommended)**, one can add all the regions of a floor at once using automatic floor regions generator.

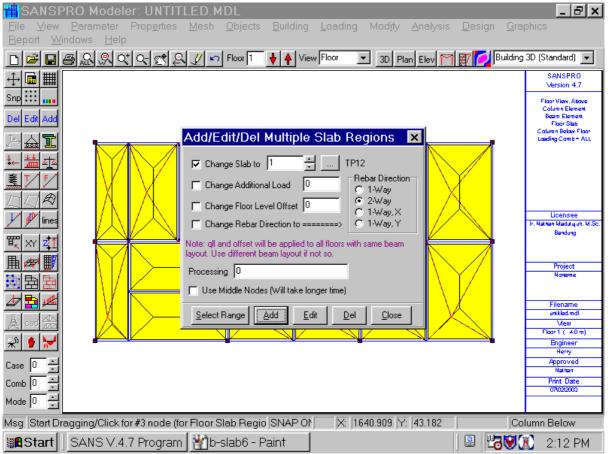




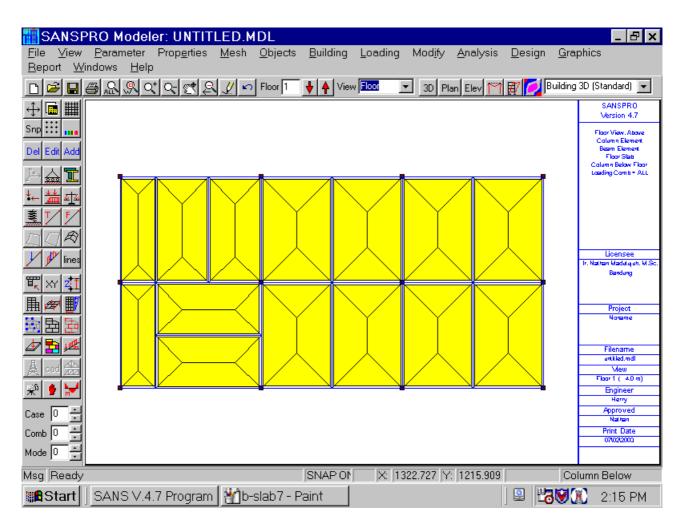








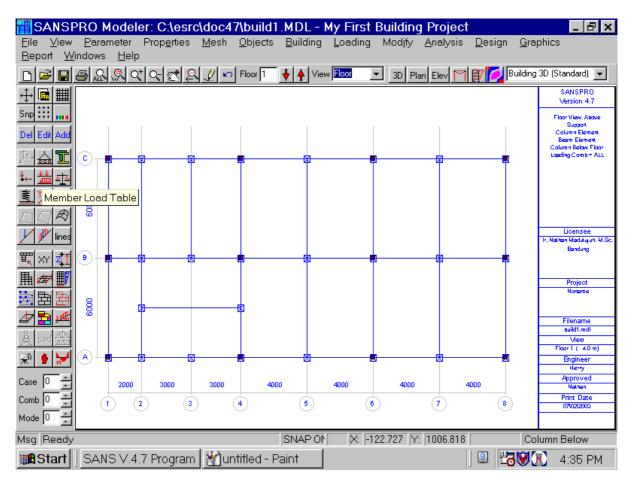
- The red lines is the iteration/search lines used in the generation process
- After generating all floor slab regions, the floor layout will look as follows:

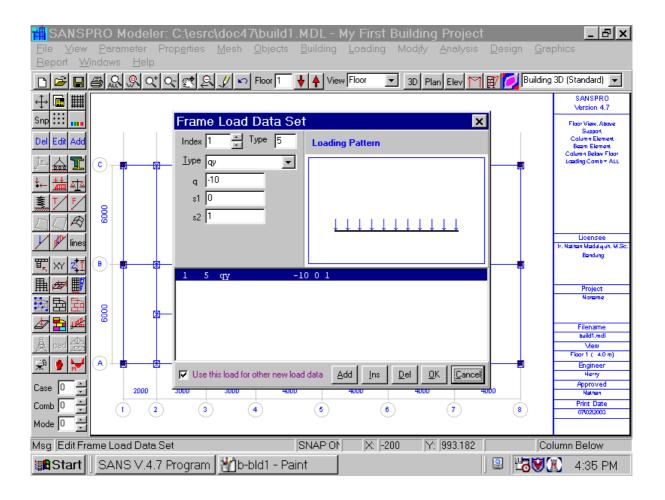


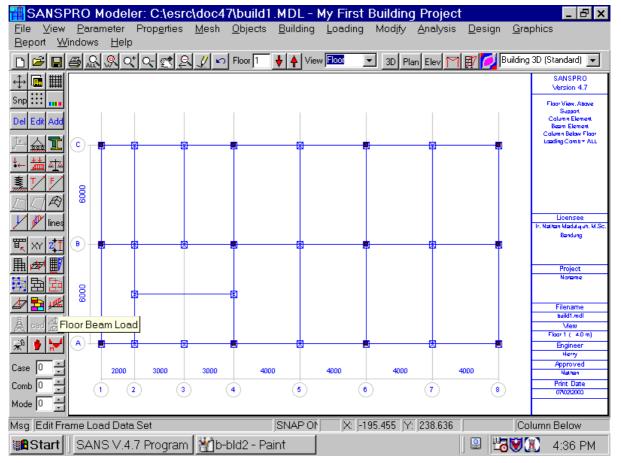
- Press F2 to save the model

# 14. Adding Beam Load

- To add some beam loads, we must create a beam load table first then assign the beam load to beams with beam load.
- SANSPRO provides 18 load types, including point load, distributed load, prestress load.
- Beam load table use absoulte distance (d1) or relative distance for load pattern definition, for example : s1 = d1/L
- Load units are kg, kg.cm, kg/cm
- Adding Member Load Table:
  - Click Member Load Table
  - Click Add
  - Select Load Type
  - Enter load magnitude and parameters
- Add beam load after creating the Member Load Table:
  - Click Beam Load
  - Click icon Add
  - Click target beam
  - Select beam load index
  - Select next target

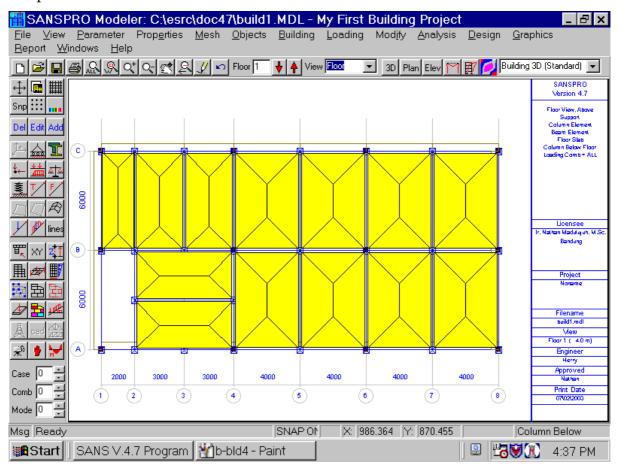






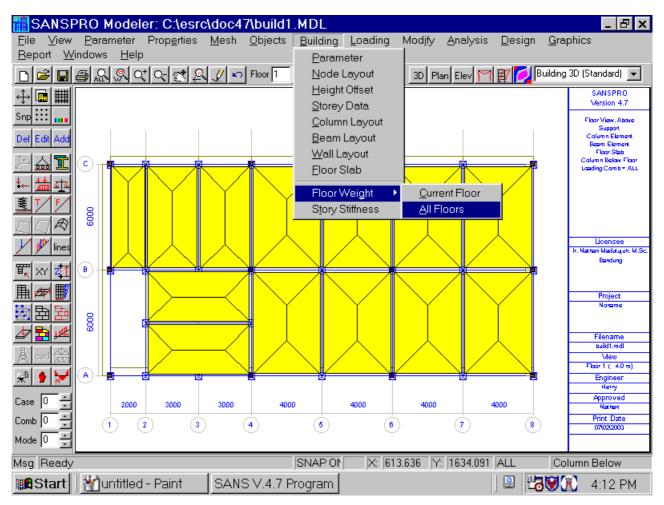
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- Repeat for other beams:



# **15. Compute Floor Weight**

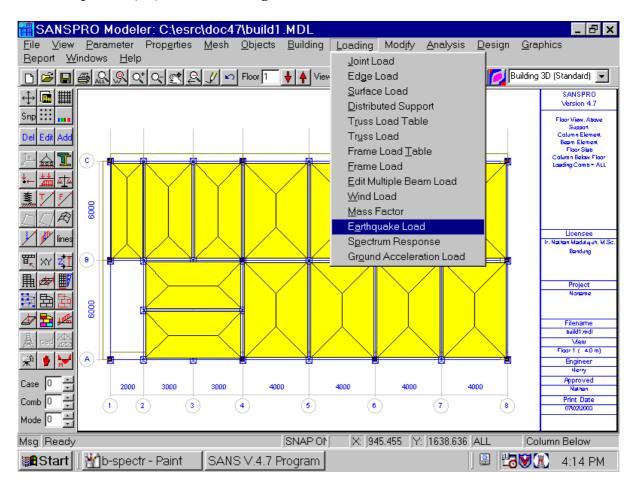
- For Static Equivalent Analysis, SANSPRO can calculate floor weight of all floors automatically using unit weight of each material use, section properties, and floor dead load and live load with live load reduction factors.
- User must input Cx, Cz, WidthX, WidthZ



- Storey Data Table with updated floor weight and center of mass will appear
- Center of Mass can be shifted to enlarge eccentricity after first analysis to get center of rigidity.
- The design eccentricity can be computed also automatically by selecting the enlargement option and button *Compute Design Eccentricity*

# 16. Generating Equivalent Load

- SANSPRO generates equivalent load from floor weight, design earthquake coeficient, floor number, and building width and height.
- One can put additional load at top floor, usually 0.1 to 0.2 V.
- Natural period (To) will be calculated using approximate/empirical formula.
- For refined solution, one can enter drift for each floor to calculate more precisely the natural period (To) of the building



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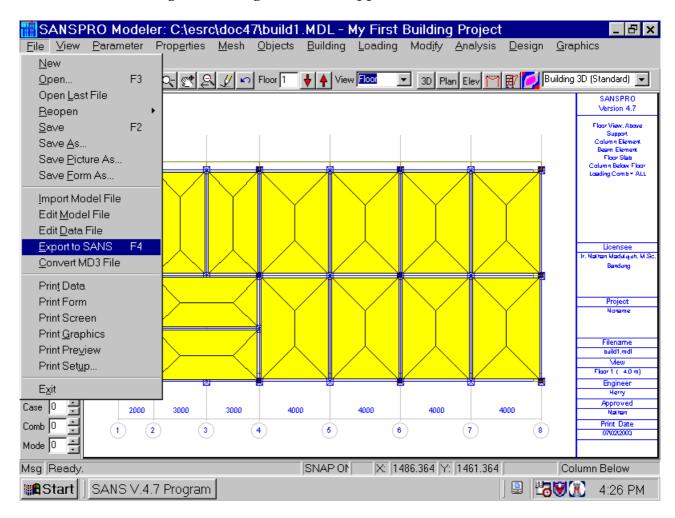
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# 17. Run Analysis

- The modelling process is now finished.
- Press **F2** to save the model
- Now we can export the data to Analysis module and run it.
- Why we need to export the data for analysis ? SANSPRO model file contains complicated data for modelling, analysis, design, drawing, cost calculation, while analysis module only needs geometry, loading, and constraint information.

#### - Mesh Correction:

- Before run analysis, it is wise to check the mesh compatibility by calling Objects-Mesh Correction (Auto Fix). Every beam and column joints will be check for mesh compatibility and fixed automatically.
- Click File-Export or Press F4 to export the data
- SANSPRO will call for Model Advisor to intelligently check your model consistency.
- Check **Use Design Eccentricity** if you want to use the shifted center of mass
- Check Export Equivalent Load if you are using Static Equivalent Load Analysis
- Some of the warnings can be neglected if not applicable to the current model

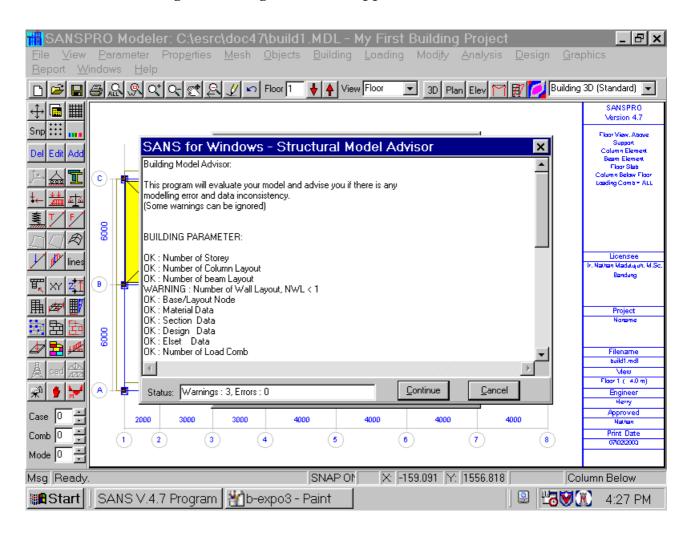


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### - What Model Advisor Check ?

- Invalid element properties
- Unconnected columns or beams
- Missing of support below columns or walls
- Missing Load data
- Zero Mass
- etc.

### - Some of the warnings can be neglected if not applicable to the current model



- After export, Click Run-Analysis Menu

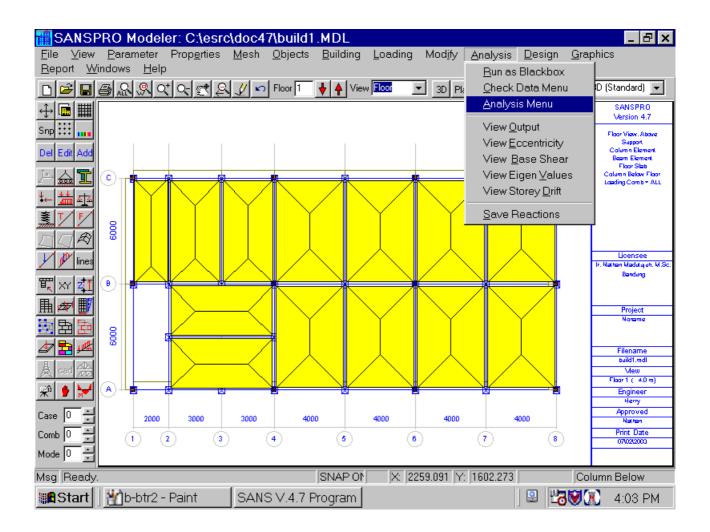
- If you click Run as Blackbox, no warning messages will appear
- If there are some errors, messages will be displayed.
- Please fix the error and do **F2-F4-Run** again
- After running, output file will be created and the model is ready for output view, moment diagram view.

- Data file from <b>Export Data</b>
- Report File
- Expanded Data File
- Binary Format (Compacted) Output File
- Graphics File (SANSGRAPH)
- Text Format Output File (large size)

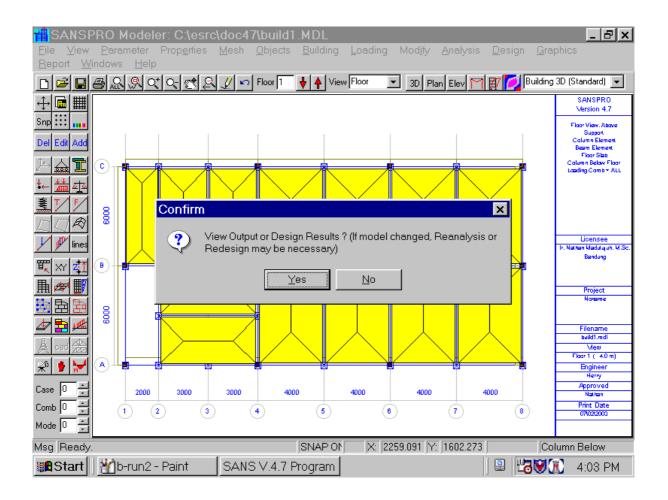
- SANSPRO will use BUILD1.BIN for visual reporting the output and moment diagram.

- BUILD1.OUT can be printted for complete report if asked

- After analysis, click Quit and Answer with Yes if you want to see the output view.

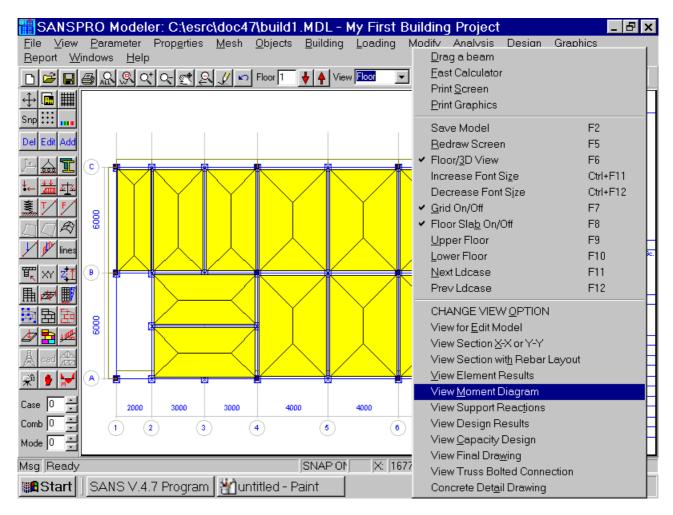


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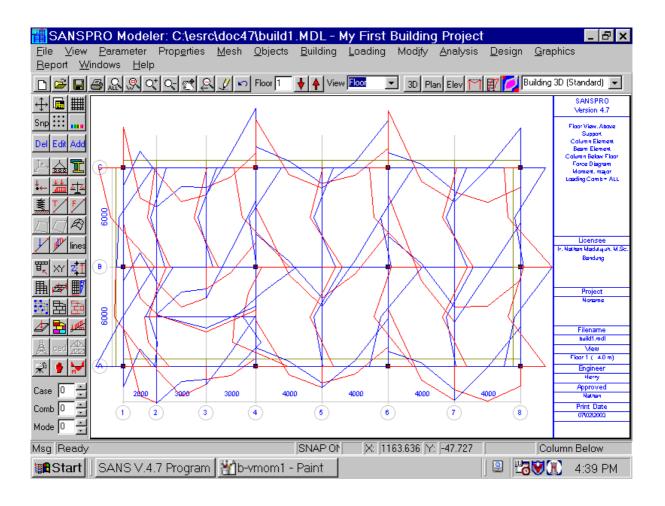


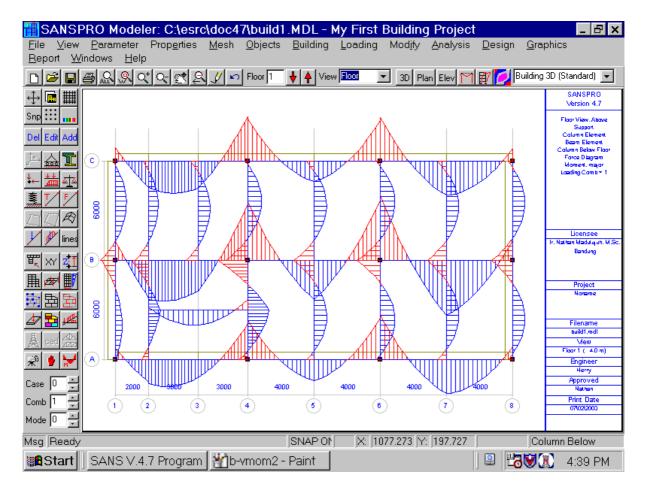
### 18. Output View

- After running analysis we can see deformations, element forces, support reactions, moment diagram, and animation of the deformation.
- By default, if no load combination selected, ldcomb = 0, then the envelope (maxima/minima) of the output will be displayed. In case of the moment diagram, two
- diagram will be drawn represent the range of the force values.
- If any load combination is selected, only the forces or diagram related to the diagram is shown.

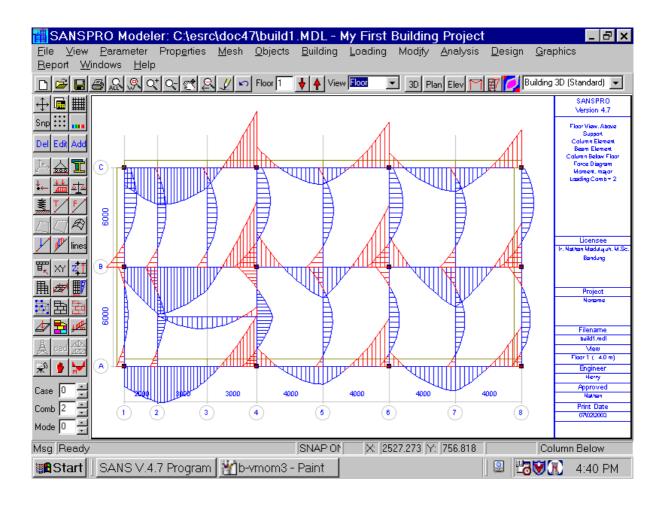


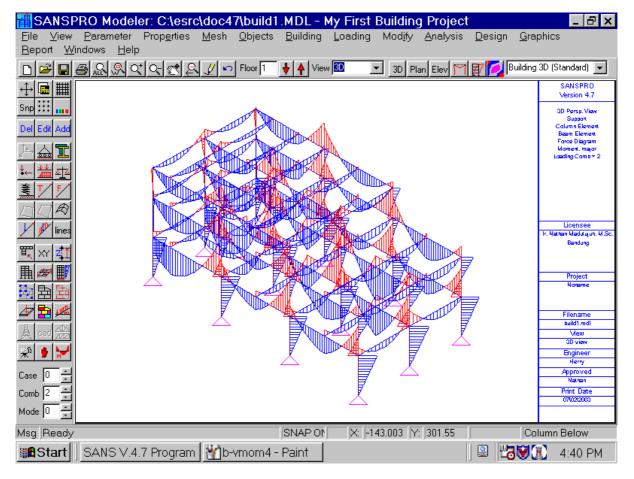
## View Moment Diagram





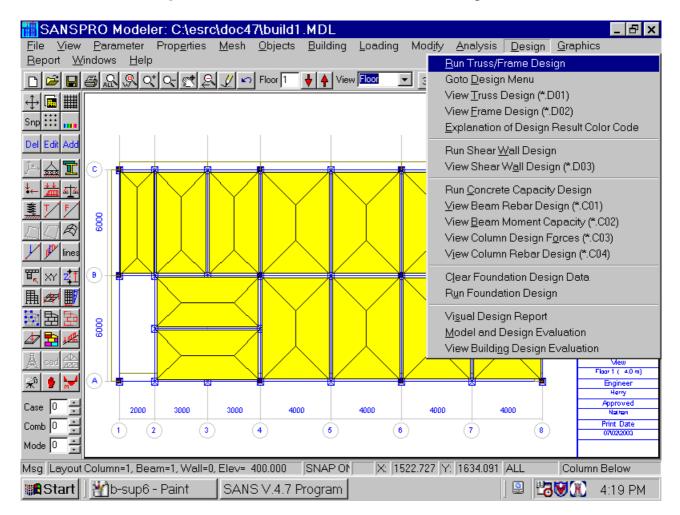
My First Building Project





## 19. Element Design

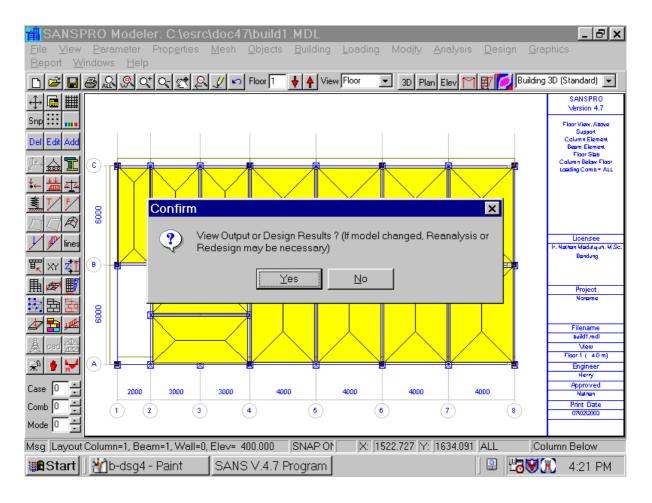
- After analysis, we can run element design.
- Click Design Truss/Frame Design
- Click Start Design
- Check Design Beam for Torsion for precast slab system or beam at void area
- Check Use Seismic Resistant Stirrup Requirements for building in seismic area
- After final design, you can check the **Modify Design Results** and **Round Up** option to refine the design result. This option should be checked only after you get a good design result.
- SANSPRO will design all elements of the building for all load combinations at stored at file BUILD1.DSB (binary format) and BUILD1.D02 (text format)
- Answer View Design Results? with Yes to activate visual design result view mode.



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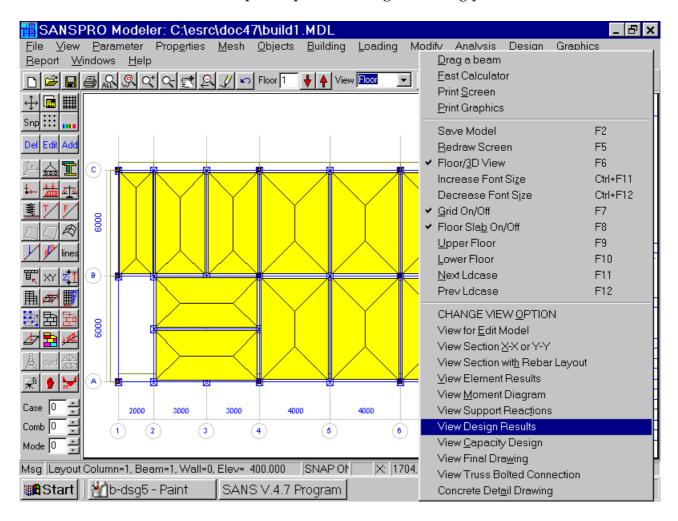
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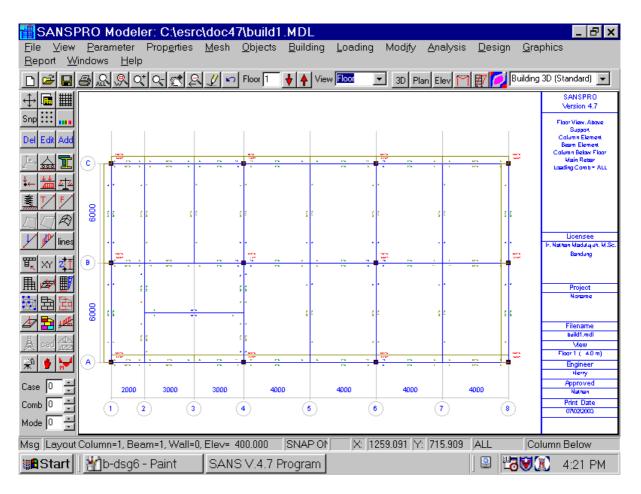
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### 20. Design View

- After design, we can view design results interactively.
- Right-Click and Select View Design Results
- Beam rebar and column rebar will be displayed in color code
- SANSPRO uses color code to speed up visual design checking process





#### - Use Ctrl-F11 to increase font size and Ctrl-F12 to decrease font size

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## 21. Element Design View

- To see element-by-element output and design results, do:
- Right-Click, Select View Element Results
- Select any element (beam, column) type icon
- Select any element (beam, column)
- A dialog box will be displayed containing element results in three pages:
  - Element forces for selected load combination, maximum, minimum
  - Design results for selected load combination, maximum, minimum
  - Moment Diagram for selected load combination, maximum, minimum

### 22. Design Color Code

To make design result checking easily, SANSPRO provides a scheme called Design Color Code. The color of the design output is related to its design quality. Currently the color table is fixed, but newer version of SANSPRO will allow user to change the color code to customize the design result for local use.

Your target color depends on your material cost and your beam depth requirement. For guidance, good steel structures will give **Blue** color code, while good concrete structure will give **Green**, **Olive**, **Blue** color code.

#### **Steel Strees Ratio Color Code:**

Stress Ratio	Color Code	Description
<= 0.6	Green	OK, Section too big
0.6 >= fr < 1.0	Blue	OK, Good
1.0 >= fr < 1.3	Magenta	Not OK, but OK for temporer load
>= 1.3	Red	Not OK

#### **Concrete Rebar Color Code:**

Beam Rebar	Color Code	Description
0.0-0.5%	Blue	OK, Section maybe too big
0.5-1.0%	Olive	OK, Section maybe too big
1.0-2.0%	Blue	OK, Rebar maybe too densed
2.0-3.0%	Purple	OK, Rebar too dense
>= 3.0%	Red	Not OK, Rebar too dense
		-
<u>Column Rebar</u>	<u>Color Code</u>	Description
0.0-1.5%	Green	OK, Section maybe too big
1.5-3.0%	Blue	OK
3.0-4.0%	Maroon	OK, Rebar maybe too densed
4.0-6.0%	Purple	OK, Rebar too dense
>= 6.0%	Red	Not OK, Rebar too dense

You can also limit beam rebar percentage range by changing the View Option. This option is useful to find beams with certain rebar percentage among a large number of beams.

### 23. Invalidate Design

If you are in Design View mode, and you press a menu or icon that may affect the model, SANSPRO will automatically ask you if you want to invalidate the design results.

If you answer with Yes then you will not be able to view the design results anymore, you must run the design process again.

If you answer with No then you will be asked if you want to reset the flag so you will not be asked again until another model changes.

# 24. Revise Design (Design Optimization)

If analysis failed or some element design failed, you can change the element by :

- Changing the Section table or Design table (This change will affect the whole elements using the same elset)
  Changing element elset index
  - (This change will only affect the target element)

After changing the model, then Save (F2), Export (F4), Run and Design again. Then21 visually check the design results again.

Repeat the whole process until we get a good and economical design results.

# 25. Printing Report

Visual Report can be printed by selecting **File-Print Graphics** or **Right-Click** and select **Print Graphics**.

To print output file (text format), click **Analysis-View Output File-Print**, etc. To print design output file (text format), click **Design-View Design Output-Print** 

SANSPRO can print drawings to A4 to A1 size printers.

Drawing can also be first exported to Autocad for further processing before printing using Autocad.

## 26. Foundation Design

SANSPRO provides easy and fast way to do foundation design. Just press a button and in seconds you will get a detailed report of foundation design of all the supports.

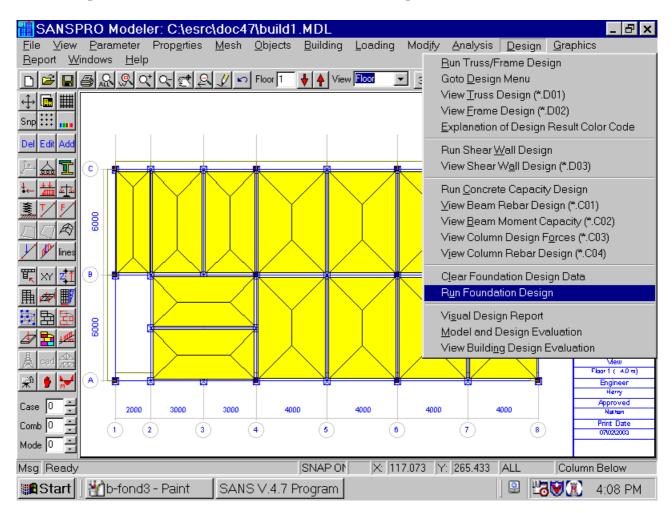
SANSPRO foundation design can deal with several types of foundation or pile. It will search for pile type with minimum cost.

Because foundation design needs factored load for concrete design and unfactored load for pile design, SANSPRO is designed to be able to retrieve the factored or unfactored reaction forces automatically from your model with factored load.

What SANSPRO do for foundation design are:

- Pile and footing design for axial, shear and biaxial bending moment
- Pilecap design for punching shear and bending moment
- Simplified tie beam design
- Volume and cost of pilecap and pile
- Select pile type with minimum cost

Detail design report can be saved to a file or print directly. All assumptions used are attached to the front of the report.



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Y	- Live Load Reduction Factor for Storey Number LLRF1 = 1.0	M.Sc.						
<u> </u>	- Live Load Reduction Factor for Temporer Load LLRF2 = 0.3							
<u>Ц</u> ,	- Load combinations included are for 1.0 DL and 0.9 DL for maximum tension - Forces Included: N.Vx.Vz.Mux.Muz (Axial and Biaxial Bending)							
畕	- Axial forces used : Nmin, Nmax to accomodate compression and tension	⊢						
E.	- Foundation capacity is increased by 30% for temporary loading							
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4	- Three Conditions of Soil Stress Pattern (no tension allowed) - Uplift Force is resisted by slab weight and soil weight	⊢						
-4	- Rebar Minimum uses value given by user (rho >= 0.15%)							
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# 27. Compute Volume and Cost

SANSPRO provides easy and fast way to do volume and cost analysis. Just press a button and in seconds you will get a detailed report of volume and cost of all the elements in the building.

User only needs to provide unit price of concrete, rebar, formwork, and steel profile. SANSPRO will calculate the volume and cost automatically.

For concrete rebar, three options are available:

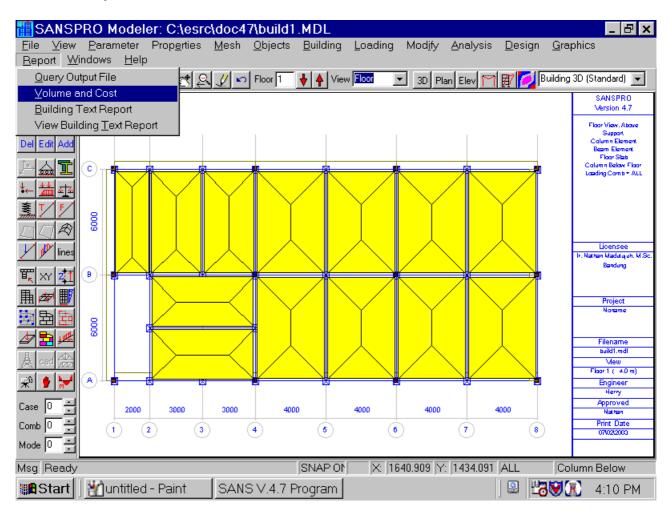
- 1. Use user defined rebar percentage (Select this for preliminary, no design results)
- 2. Use design results, different for each element
- 3. Use design results, maximum for same elset

Use the third method for better results.

In any case, slab will be design only use the rebar percentage for slab.

If you want to overwrite this value, provide cost/m2 for all slab type at Floor Slab table. This will give you a more accurate slab rebar weight and cost.

Exclude formwork for slab cost/m2 because SANSPRO can calculate the formwork cost automatically.



- Cost multiplier for each storey level may be used to increase material cost due to differences in handling cost for different floor level.
- Some additional options are also provided
- For cost example, click Example Unit Cost
- Cost reports are given per floor and per elset.
- Cost summary will be given including concrete density and average cost/m2.

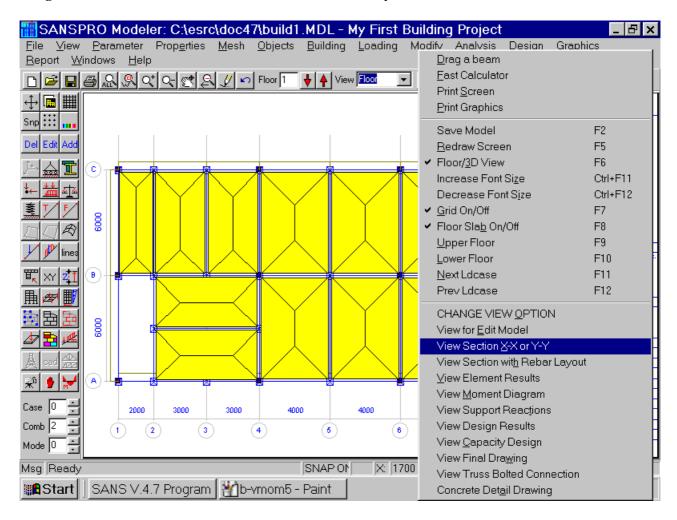
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	Steel Profile (Angle)       0       per kg         Option       Image: Constraint of the state of the s	Cost Multiplier for each Storey       Floor     Multiplier       1     1.0       2     1.0       3     1.0       4     1.0       5     1.0       6     1.0       7     1.0       8     1.0
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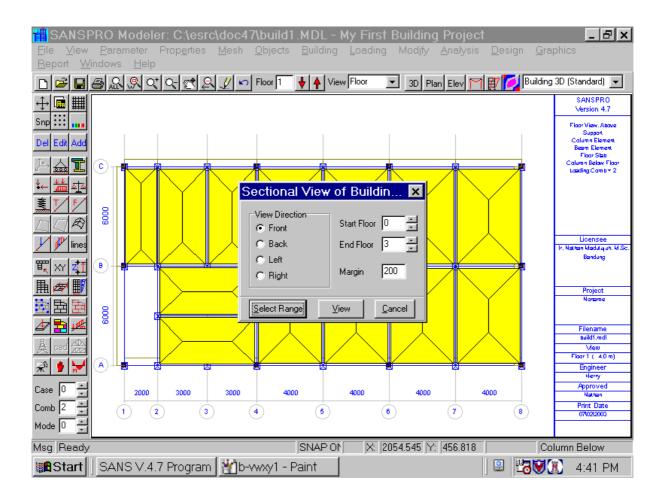
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	Option  Exclude Volume and Weight  Report Cost Calculation per F  Include Shear Reinforcement  Lower Column rebar must be  Increase Column Rebar for sp  Column Option  Below Floor  C Above Floor	loor nt for HCS Support (100mm) arger than Upper Column	<150mm)	Cost Multiplier for each Storey       Floor     Multiplier       1     1.0       2     1.0       3     1.0       4     1.0       5     1.0       6     1.0       7     1.0       8     1.0
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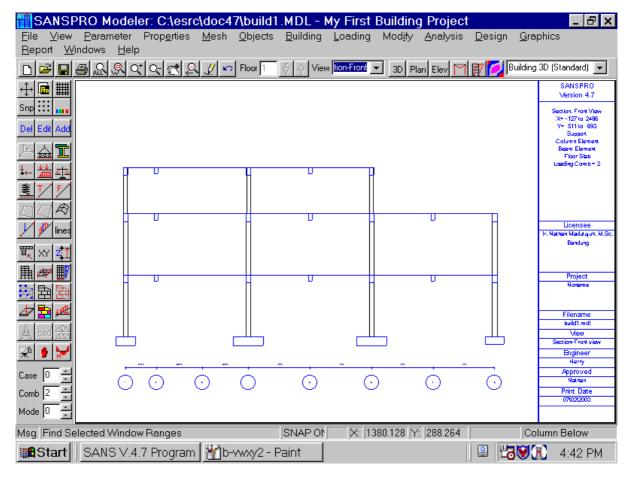
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#### 28. View Rebar Layout

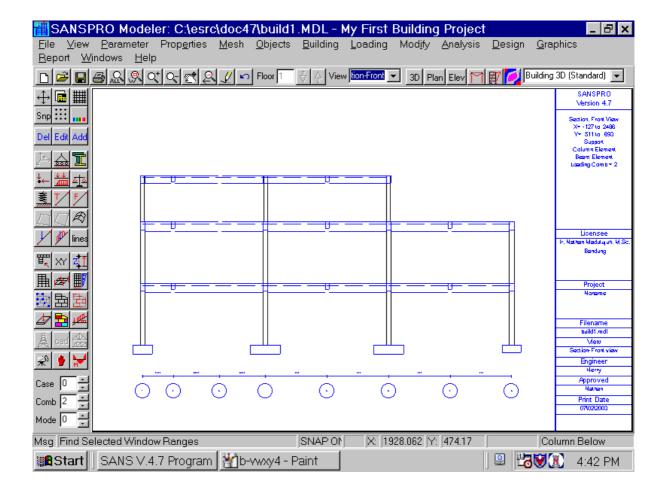
- SANSPRO also provides sectional view of rebar layout (portal view)
- Right-Click and select View Section
- Select the view range by dragging a window
- Select view direction (front or right)
- Select Ok
- Sectional View will be displayed
- Right-Click and select View Final Drawing/Size
- Right-Click and select View Section with Rebar Layout



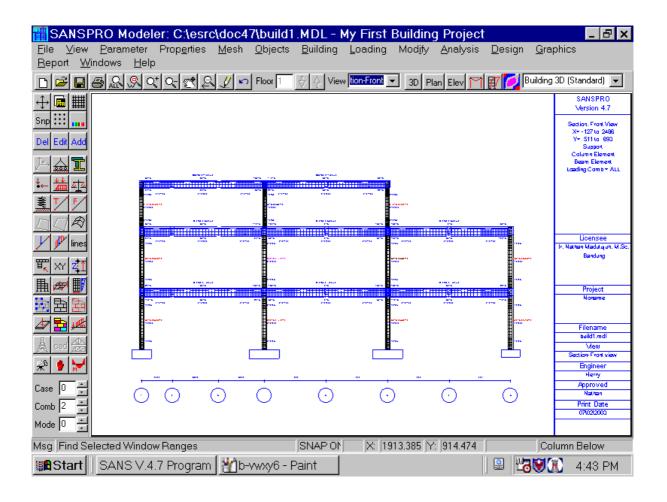




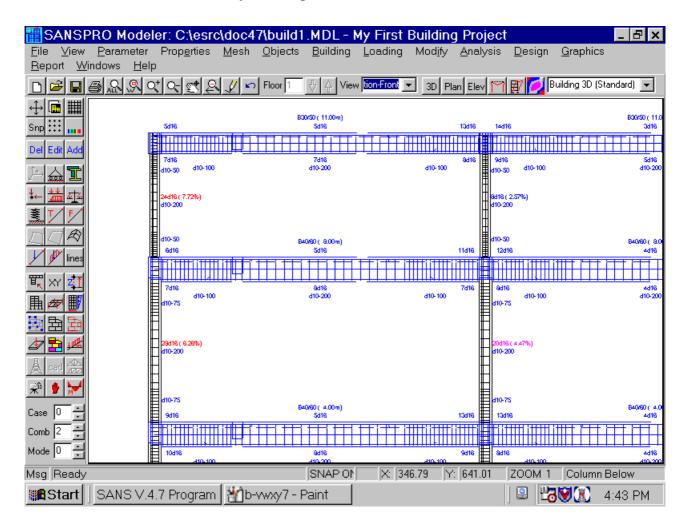
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- To see larger drawing, use zoom in or zoom rectangle/window.
- The sectional drawing can be printed or saved to AutoCad DXF format to be editted inside AutoCad or other DXF compatible CAD programs.
- Increase/decrease font size by clicking Ctlr-F11 or Ctrl-F12

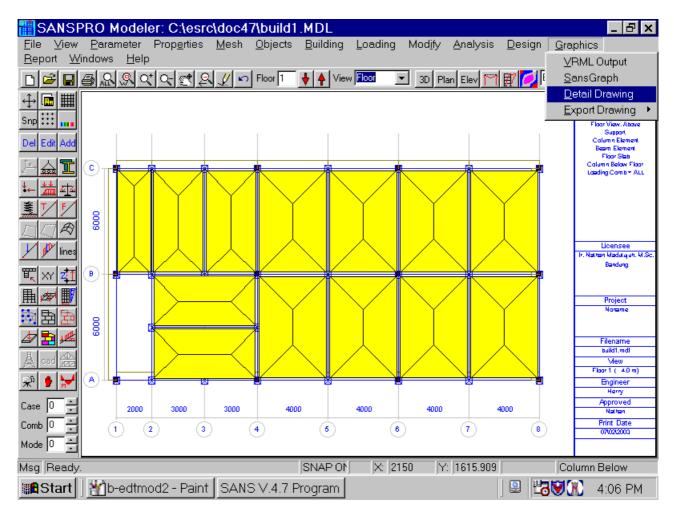


# 29. Generating Drawing

- SANSPRO is capable to generate detail structural drawing in seconds.
- Only SANSPRO with Drawing Module activated can be used to generate drawings
- Before drawn, the drawing parameters are stored to a table that can be editted by user
- This approach is called Parametric Drawing
- Objects that can be drawn by SANSPRO are:
  - Beam sectional detail
  - Beam longitudinal detail
  - Column elevation table
  - Foundation/Pile layout
  - Pilecap detail
  - Other objects

# - Click Graphics-Detail Drawing to call the Drawing Generator Module

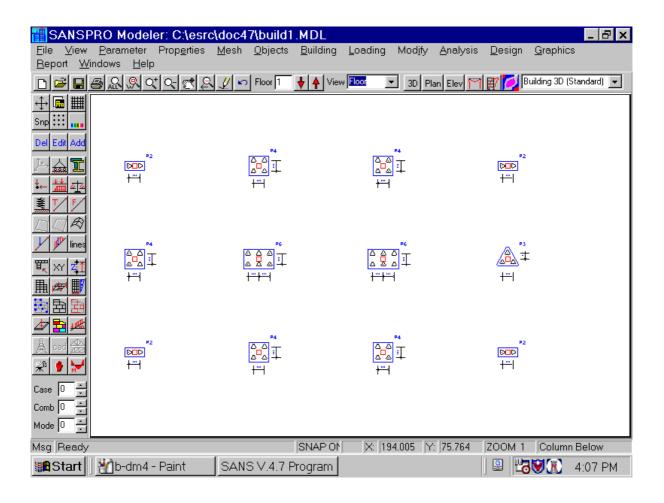
- Use Zoom to get a larger view



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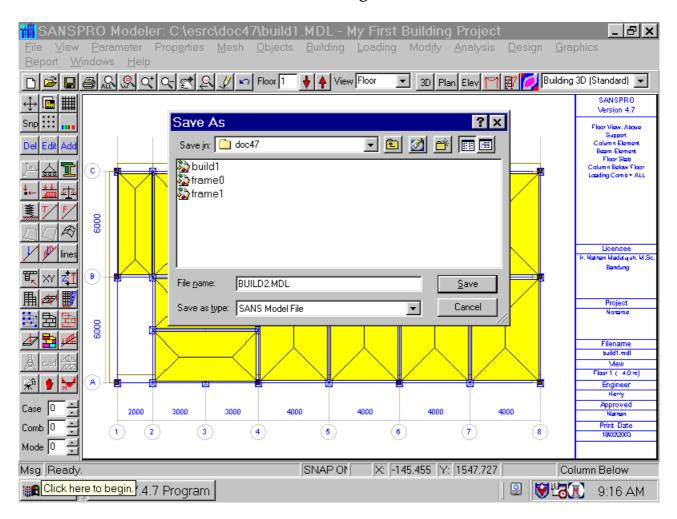


## **Dynamic Analysis:**

SANSPRO can be used for dynamic analysis by adding few model changes:

- Mass Contribution Factor
- Spectrum Response
- Dynamic Analysis Option

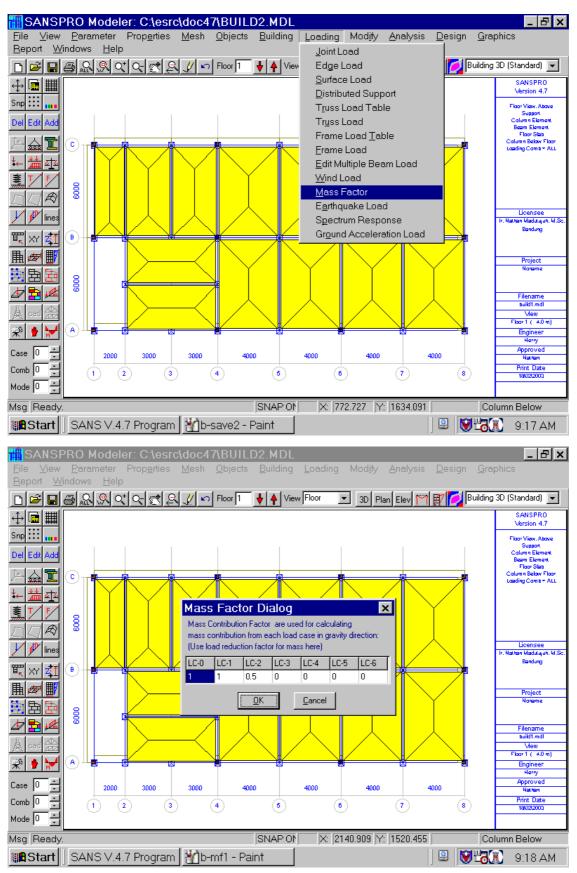
First, we must **save** the prevous model file into a new file named BUILD2.MDL so that we will have two models and two **incremental design** results.



After saving to BUILD2.MDL, do the following:

# 1. Define Mass Factor

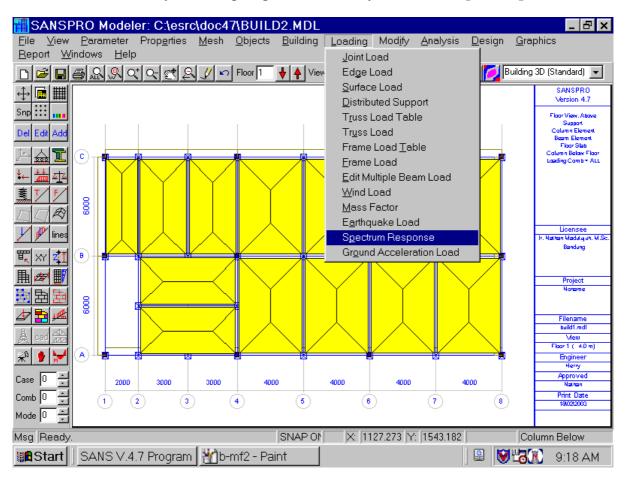
Mass Contribution Factors are multipliers for each load case for calculating nodal masses. Usually for self-weight (load case 0) and dead load (load case 1) we use 1.0 (100%), for live load (load case 2) = 0.3 to 0.8, while for earthquake/lateral load case, mass factor = 0.



My First Building Project

### 2. Define Spectrum Response

Dynamic Analysis Method that will be used is Dynamic Response Spectrum Analysis. The method needs Response Spectrum Data that depends on the earthquake zone and soil stiffness. Most country Building Regulators already have the response spectrum data.



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## 3. Dynamic Analysis Option

We need also to select option for Dynamic Spectrum Response Analysis. Enter the following parameters:

- Number of Eigen NE = 3\*MO <= 3\*NF (MO = Mode shape order, 1..NF)
- Earthquake Direction = 2 (X and Z direction, measured from Z+)
- Earthquake Direction = 90 and 0 degrees measured from Z+
- Static Condensation = 3 Dof/Floor
- Rigid Floor = YES
- MO should be >= 2 or 3, <= NF
- Rigid Floor = Yes will make dynamic analysis faster and give almost same eigen values.
- Static Condensation is a method used by SANSPRO to reduce the linear equation size:
  - Static Condensation = None
  - Static Condensation = Zero Mass
- : No DOF reductions
- : DOF with zero mass will be reduced
- Static Condensation = 3 Dof/Floor : For lat
- : For lateral load case, NDOF = 3 dof/flr
- For building, using Static Condensation = 3 Dof/Floor will give a good results.

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- Number of Eigen = 6
- Damping Ratio = 0.05(5%)
- Earthquake Direction = Linear Combination of two perpendicular Earthquakes Dir.
- Direction Angles: 90, 0 degrees
- Base Shear Correction: Unchecked
- Eigen Analysis Option: Default = Lanczos Method

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#### **Explanation:**

- Most concrete buildings have damping ratio between 2% to 5% (0.02 to 0.05)
- SANSPRO can deal with several earthquake directions at once.
- Most regular buildings only require two perpendicular earthquake directions.
- Earthquake direction angles are measured from Z+ to X+ (counter-clockwise)
- Eigen Solver uses Lanczos Method to find starting vector for Modified Subspace Iteration
- Sometimes the default starting vector fails to converge, in this case user can select other option.

SANSPRO load cases are only for external load.

Earthquake load is not counted as load case, so the number of load case is automatically reduced to 2, for dead load and live load.

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But, load combination requires load factors also for earthquake loading.

### 4. Run Dynamic Analysis

After defining needed parameters, the process to run dynamic analysis is exactly the same as for static analysis:

Compute Floor Weight to calculate center of mass (if you have not done it yet) F2 – Save the model F4 – Export the model Analysis-Menu-Start Analysis Output files from Dynamic Analysis:

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BUILD2.BIN	- Deformations, Reactions, Element Forces (Binary)
BUILD2.GRA	- Deformations and Mode Shapes (SANSGRAPH)
BUILD2.GEN	- Expanded Data
BUILD2.ROT	- Floor Individual Eccentricity
BUILD2.BSH	- Base Shear, Effective Mass, MPF, MDF, Scale
BUILD2.RSP	- Eigen Values, Mode Shape
BUILD2.SSH	- Building Story Shear
BUILD2.DSP	- Building Story Displacement

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#### 5. Check Dynamic Output

Some checkings need to be done for dynamic analysis output:

#### - Natural Period

To should be approximately 0.1 NF (depends on structural type and layout) Natural period or dominant period To should be less than the maximum requirements, usually To << Tmax = 0.17 \* NF

#### - First Mode/Dominant Mode

First mode must be translational mode. It can be seen from the Mode Shape graphics that the shape of the building does not twist. It this is not the case, one must rearrange building layout.

#### - Mass Participation Factor

Effective Mass Factor or Mass Contribution Factor for the results should be larger than 90%. If this is not the case, one must increase number of eigen.

#### - Effective Mass Factor

#### - Modal Direction Factor

Determine in which direction a mode shape is dominant One should avoid rotational mode as first mode

#### - Base Shear

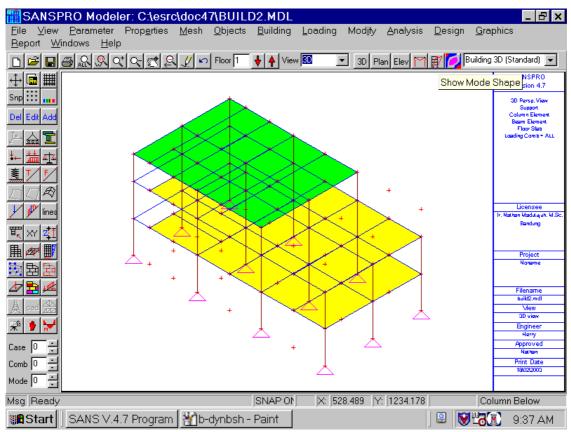
Dynamic Base Shear should be larger than 80% Static Base Shear (Vd  $\geq 0.8$  Vs) If this is not the case, check the following:

- 1. Is the structure too flexible, To near Tmax, or column/wall to few or small, that cause the earthquake coefficient taken from Response Spectrum Chart is very small. If so, increase column/wall stiffness
- 2. Is the mass too large, To will be large also, causing small earthquake coefficient. If so, check mass reduction factors being used.
- 3. Is the dominant mode not translational but rotational. In this case most of the earthquake energy is absorbed as twisting/rotational deformation, causing small base shear. Rearrange the size and location of columns/walls to achieve smaller eccentricity.

#### - Story Shear

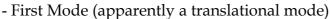
#### - Story Displacement and Drift

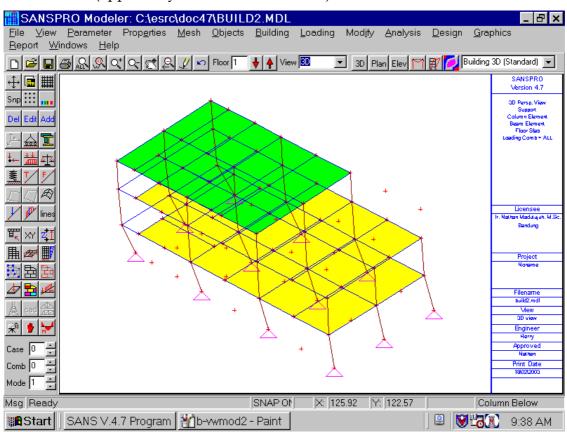
- To view mode shape:



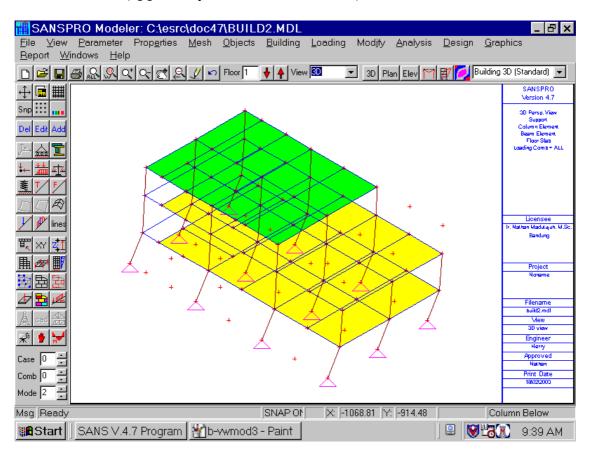
- Mode shape deformation/displacements must be scaled up, here we use 100

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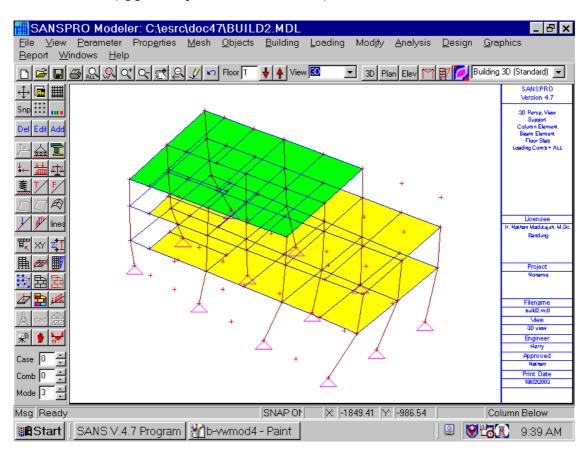




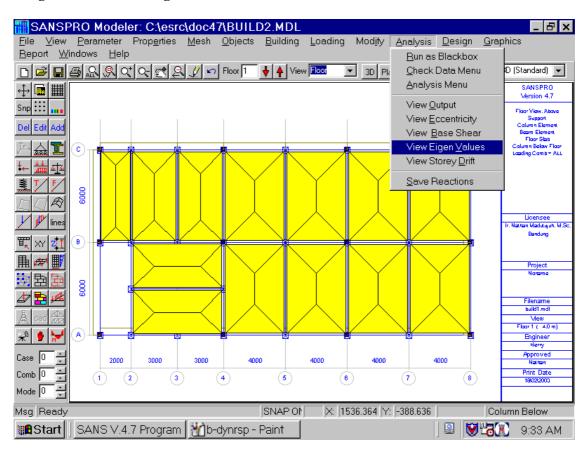
- Second Mode (apparently a translational mode)

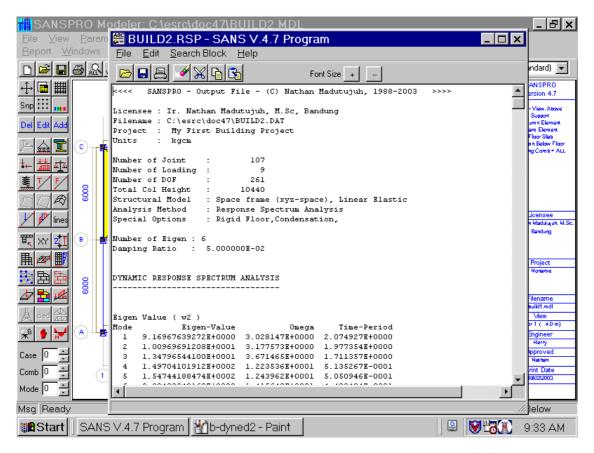


- Third Mode (apparently a rotational mode)



- Eigen values and Eigen Vectors

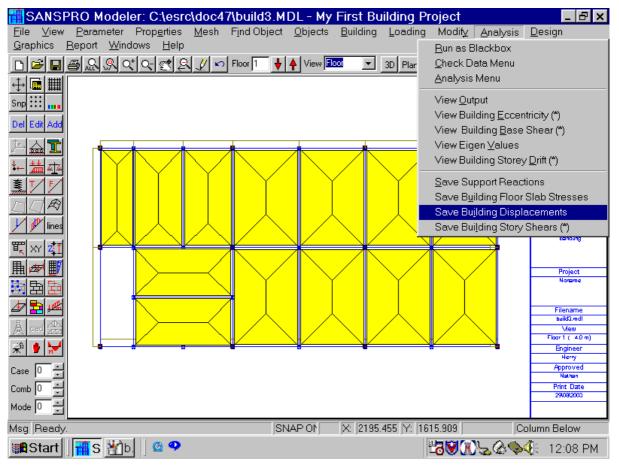


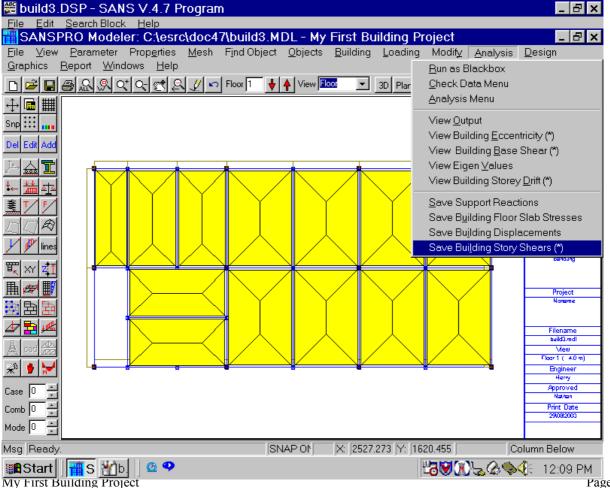


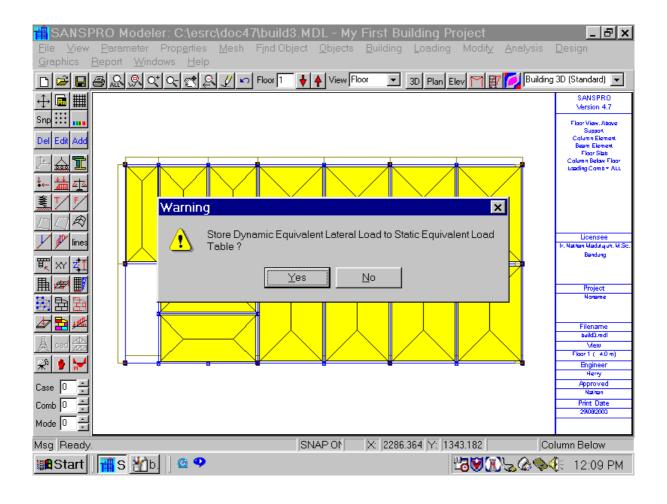
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# - Effective Mass and Mass Participation Factor

#### View Building Displacements/Drift







### **Building Story Shear**

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SANSPRO will display story shear using ABS (Absolute Sum), SRSS (Square Root Sum) and CQC (Comple Quadratic Sum).

Usually values from CQC will be selected.

If Damping = 0 then SRSS and CQC will give equal values.

Fi is computed as difference between two stories.

# 6. Eccentricity

Floor Eccentricity should not be larger than the code requirements. If so, existing eccentricities should be magnified by scaling factor to get design eccentricity. There are at least 5 conditions that will give 5 sets of output.

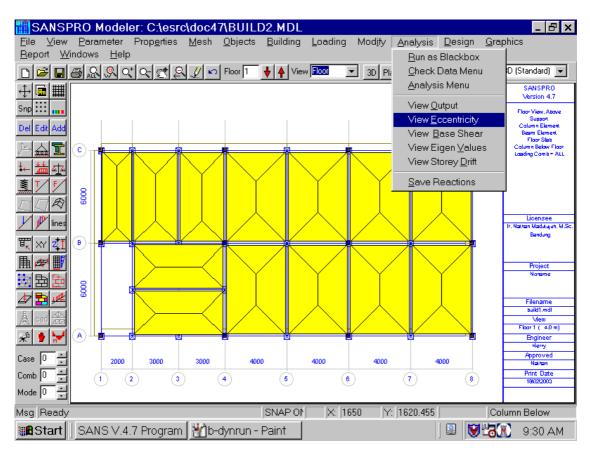
- 1. No magnification
- 2. Magnify Ex, Magnify Ey
- 3. Magnify Ex, Reduce Ey
- 4. Reduce Ex, Magnify Ey
- 5. Reduce Ex, Reduce Ey
- 6. Reduce Ex,Ey if negative, Enlarge if positive

Correction of Eccentricity is done by shifting the floor center of mass. SANSPRO can do this automatically by selecting the magnification option at Building Storey Data and at Export Dialog.

The original Center of Mass can be restored by unchecking the magnification option.

Currently, user must check one by one the separate output files from each magnification option, to get the maximum response.

Alternatively, user can check option 6, and get the maximum design eccentricity.



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- Existing Eccentricity (file BUILD2.ROT)

- Design Eccentricity can be calculated after first run because it needs file BUILD2.ROT

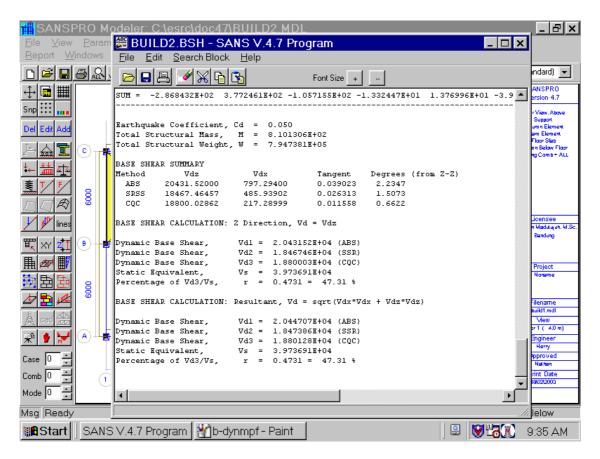
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# Computed Design Eccentricity using Abolute Maximum:

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#### 7. Base Shear

- Base Shear can be seen from file BUILD2.BSH



- Base Shear Correction can be done from Analysis Option:

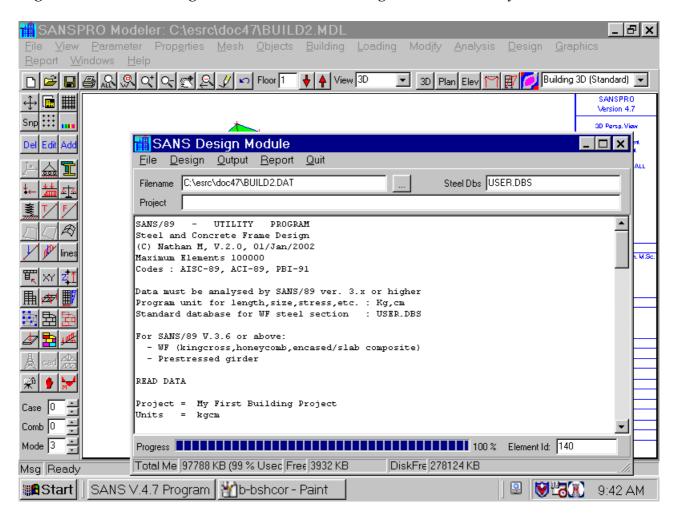
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### 8. Design for Dynamic Analysis

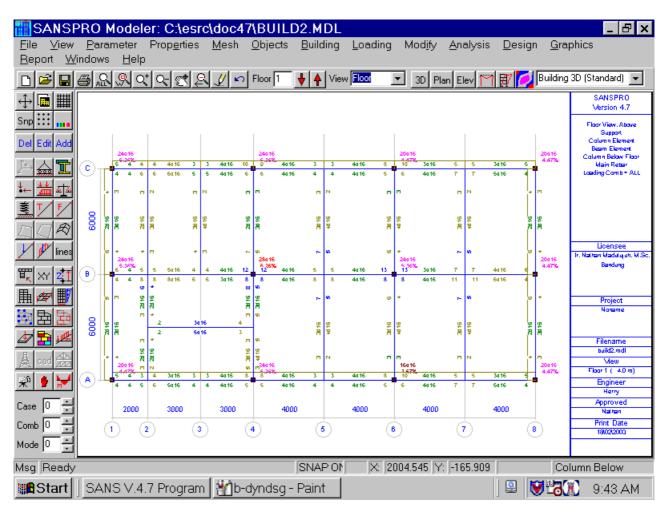
Element Design process for Response Spectrum Dynamic Analysis is exactly the same as for static analysis.

Click Design – Truss/Frame Design – Concrete Frame Right-Click – View Design Results to view the design as in static analysis



# 9. Visual Design Report

- Right-Click View Design Results to view the design as in static analysis
- Move up/down floor to see other floors
- Select different load combinations too see result from different load combinations



## Capacity Design

#### 1. Basic Concepts

SANSPRO uses Capacity Design Concepts to design Seismic Resistant Concrete Buildings.

Design a building to be able to resist full earthquake load will give a very strong structure and also not economical design. To get an economical solution, the capacity of the building to absorb earthquake energy should be increased, so that the building will be able to resist large earthquake in certain amount of time before total failure. The time delay will be used for evacuation of people and other actions.

In other words, buildings are only designed to resist moderate earthquake without severe damaged, and are allowed to be damaged by large earthquake without sudden failure.

Sudden failure usually comes from shear failure, so the design shear strength should be larger than the capacity of bending strength.

Capacity Design assumes that most of the earthquake energy will be absorbed by plastic hinges due to bending forces, so it requires that the structure dominant vibration mode should be in translational mode. If not so, user should design manually the capacity of the elements using other methods.

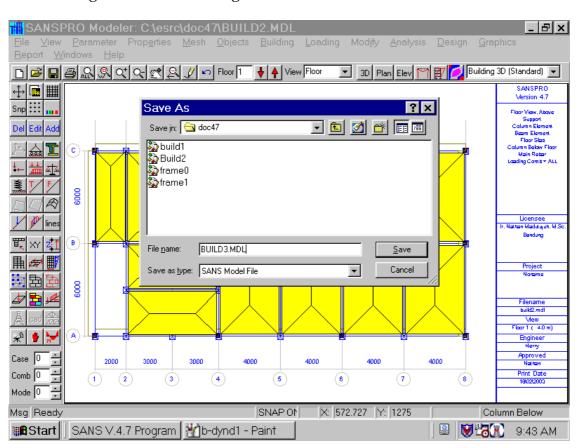
Currently SANSPRO can deal with full ductile design only.

#### SANSPRO Capacity Design Procedures:

- 1. Design Beam Rebar using Factored Load
- 2. Calculate Beam Bending Capacity for each direction of column face
- 3. Compute Beam Shear from Beam Bending Capacity
- 4. Compute Additional Column Axial from Beam Moment Capacity
- 5. Compute Column Design Bending Forces
- 6. Compute Column Bending Rebar
- 7. Compute Column Bending Capacity
- 8. Compute Column Shear from Column Bending Capacity

#### **Output of SANSPRO Capacity Design (Text Files):**

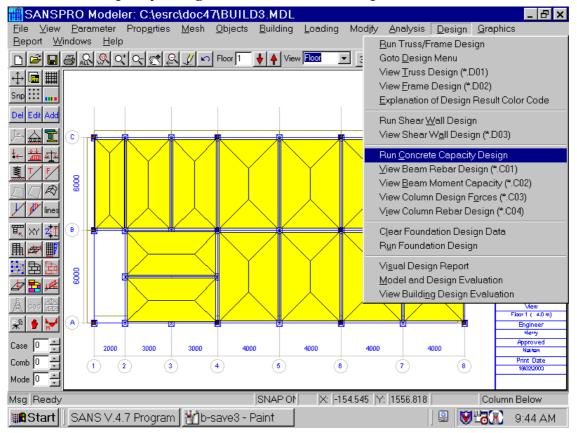
Beam Rebar Design	BUILD3.C01
Beam Moment Capacity	BUILD3.C02
Column Design Forces	BUILD3.C03
Column Rebar Design	BUILD3.C04



- To get incremental design results, save the current file to new file : BUILD3.MDL

# 2. Define Parameters

- SANSPRO Capacity Design needs several control parameters:



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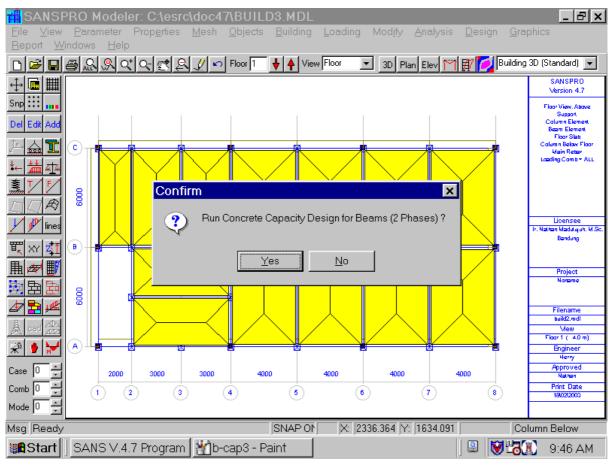
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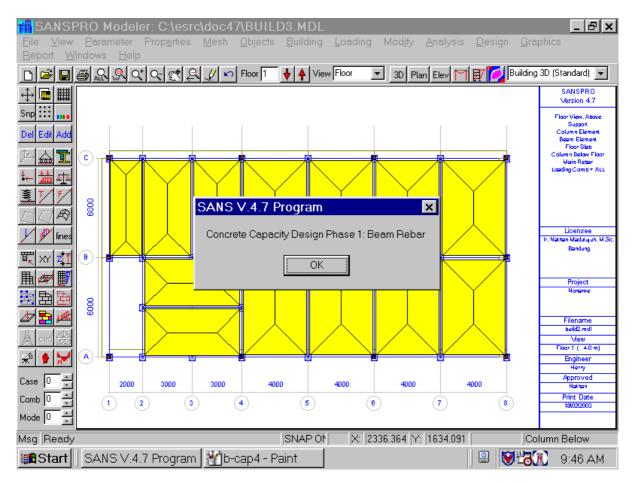
- Capacity Design Module will use its own load combination because of the use of different load factors and load reduction. Enter the load case number for dead load, live load, etc.
- Load Factors also can be entered for flexible usage.
- Contribution of perpendicular earthquake (usually 30%) should be entered
- Steel Rebar Overstrength Factor should be entered
- Column axial reduction factors for each floor should be entered
- Structural Ducktility Factor (1.0 for full ductile) should be entered
- Beam can be designed for torsional forces and also for axial forces.
- In case you have changed the Beam Moment Capacity file, please check the Update Beam Capacity File flag

(For example, if the moment capacity of prestressed beams have been calculated manually or outside the SANSPRO, the values can be entered into file BUILD3.C02 to be used for column capacity design)

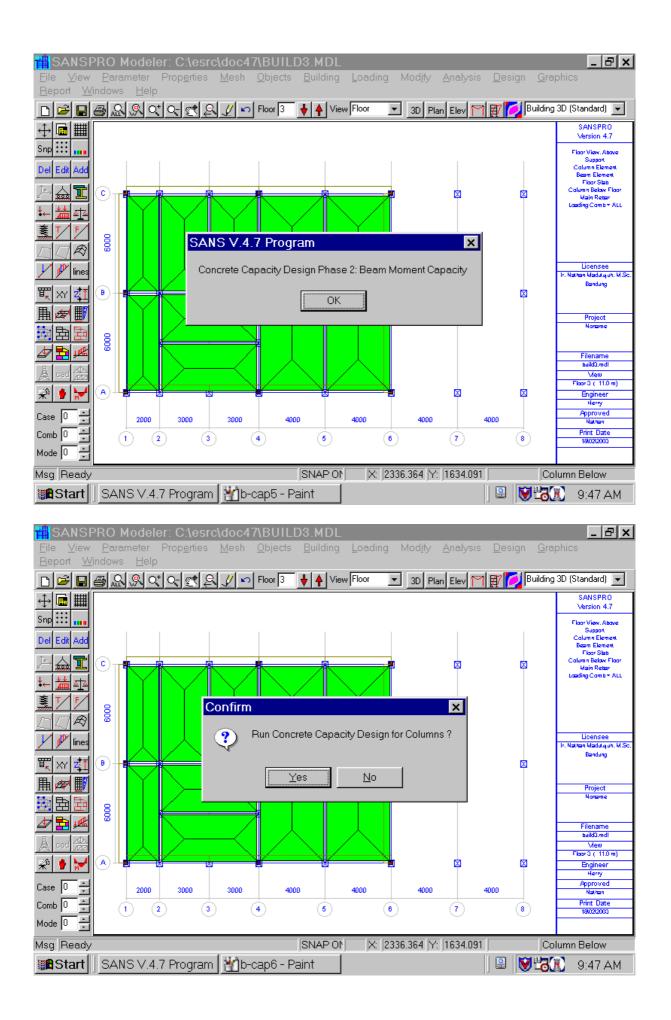
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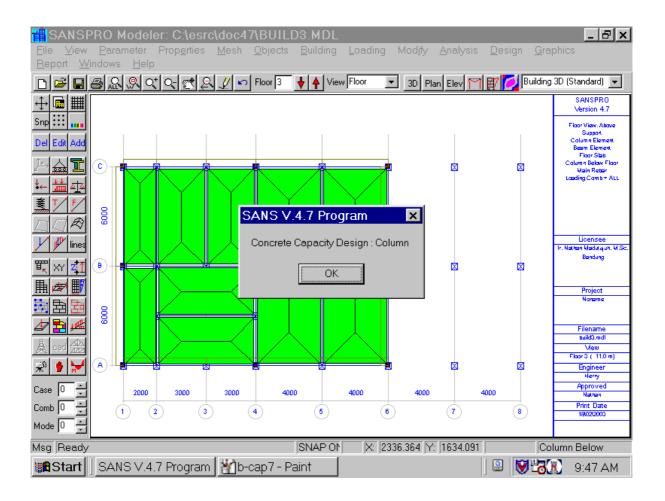
# 3. Run Capacity Design





My First Building Project



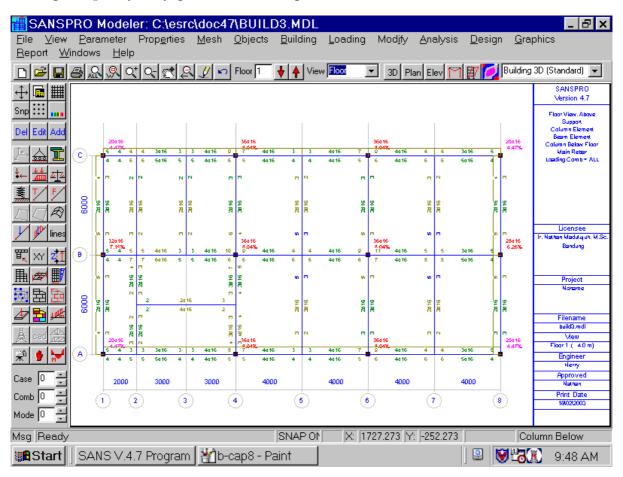


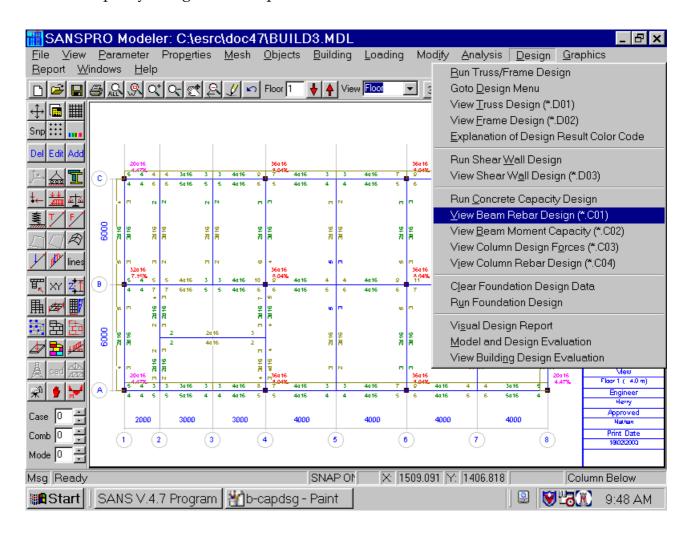
# 4. Visual Design Report

- To see Capacity Design Results, Right-Click and Select View Design Results as usual.

- Move up/down floor to see other floor

- Design Capacity only give a set of design result stored at Load Combination 1





- To see Capacity Design Text Output:

# 5. Capacity Design Report: Beam Rebar

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# 6. Capacity Design Report: Beam Moment Capacity

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s   o   s	Design Co Unit syst (C) Natha	ode : ACI-89,1 ;em : kg.cm, 1 an Madutujuh,		-					<u> </u>
- <u>√</u>	Unit Syst		(Using 1.25 fy	M.Sc, Bandung and 1.4 fps)					
	Project Notes		: Building Pro ys, 3x2 bays	ject					
<u>」</u> 間		NT AND SHEAR	CAPACITY						
月	Idl	M1-top	Ml-bot	Mr-top	Mr-bot	Vl	Vr	Tl	Tr
	34	2031329.92 1264229.20	1648186.96   2031261.93		2031261.93   1646714.35	15077.7 4341.2	12821.4   6355.3	410878.95 56021.07	410878.5 56021.C
4	36	1264229.20	1646714.35		•		18949.7	56021.07	56021.0
- 5	37	2793853.22	2031457.47		1646714.35		6156.3	222573.66	222573.6
b	38	1262824.47	1646714.35	2793853.22	2031457.47	6556.3	15481.3	206821.48	206821.4
<u>e</u> R	39	3516267.15	2487369.75	1648663.43	2413622.28	17493.8	7993.0	214664.18	214664.1
Ź	40	1648663.43	2413622.28	2031329.92	1648186.96		- · · · · ·	231234.45	231234.4
	41	2031329.92	1648186.96		2793853.22		17718.4	210535.69	210535.6
C.	42	2031457.47	2793853.22	1264229.20	,	2941.0	5662.3	214304.70	214304.7
C	43	1264229.20	2031261.93	4018311.42			21001.2	353953.30	353953.3
0.	44	3516267.15	2487369.75	1648663.43	2413622.28	16767.4	9837.4	74995.95	74995.5
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# 7. Capacity Design Report: Column Design Forces

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		ACI-89,PBI-91,						
		kg.cm, lbs.in, dutujuh, 1992-2						
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)esi(		PBI-91 (Using						
Jnit	System :	kg,cm, kg.cm						
Proje	ect.	My First Build	ing Project					
_			1					
_		3 Storeys, 3x2	bays					
Note:			bays					
Notes		3 Storeys, 3x2	bays					
Notes	is :	3 Storeys, 3x2	bays					
Note: COLUI	is :	3 Storeys, 3x2	bays Nmax	Nmin	Muy	 Nmax	 Nmin	
lote: COLUI	s : MMN DESIGN	3 Storeys, 3x2   FORCES		Nmin   11384.0	Muy 571659.7	Nmax 13395.4	 Nmin 9460.7	
Note: COLUI 71r	s : MN DESIGN Id	3 Storeys, 3x2   FORCES Mux	 Nmax					
Note: COLUI 71r	s : MN DESIGN Id	3 Storeys, 3x2 FORCES Mux 672579.6 572845.9 505275.2	Nmax 13032.5 13524.7 26149.2	11384.0   11876.2   24688.0	571659.7 356289.9 577936.8	13395.4 13887.6 26398.4	9460.7 9952.9 22983.1	
Jotes COLUI 71r 3 3	25 : 14   25   26   1 26   1	3 Storeys, 3x2 FORCES Mux 672579.6 572845.9 505275.2 506574.6	Nmax 13032.5 13524.7 26149.2 26641.4	11384.0   11876.2   24688.0   25180.1	571659.7 356289.9 577936.8 355967.5	13395.4 13887.6 26398.4 26890.6	9460.7 9952.9 22983.1 23475.3	
Jotes COLUI 71r 3	:s : MIN DESIGN Id   25   	3 Storeys, 3x2 FORCES Mux 672579.6 572845.9 505275.2 506574.6 697632.4	Nmax 13032.5 13524.7 26149.2 26641.4 12685.7	11384.0   11876.2   24688.0   25180.1   11255.6	571659.7 356289.9 577936.8 355967.5 518737.0	13395.4 13887.6 26398.4 26890.6 13091.7	9460.7 9952.9 22983.1 23475.3 9587.0	
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Note: COLUI 71r 3 3 3 3	RMN DESIGN Id   25   25   26   27   28   1 28   1	3 Storeys, 3x2 FORCES Mux 672579.6 572845.9 505275.2 506574.6 697632.4 541312.8 749247.6 586455.1 488509.7	Nmax 13032.5 13524.7 26149.2 26641.4 12685.7 13177.9 23351.6 23843.8 34747.6	11384.0   11876.2   24688.0   25180.1   11255.6   11747.8   21876.4   22368.5   33856.4	571659.7 356289.9 577936.8 355967.5 518737.0 356289.9 507808.2 485808.9 466424.7	13395.4 13887.6 26398.4 26890.6 13091.7 13583.9 23351.6 23843.8 34747.6	9460.7 9952.9 22983.1 23475.3 9587.0 10079.2 19953.1 20445.3 31933.2	
Jote: COLUI 71r 3 3 3 3 3	PMN DESIGN Id   25   26   27   28   28   1 29   1	3 Storeys, 3x2 FORCES Mux 672579.6 572845.9 505275.2 506574.6 697632.4 541312.8 749247.6 586455.1 488509.7 495967.5	Nmax 13032.5 13524.7 26149.2 26641.4 12685.7 13177.9 23351.6 23843.8 34747.6 35239.8	11384.0   11876.2   24688.0   25180.1   11255.6   11747.8   21876.4   22368.5   33856.4   34348.6	571659.7 356289.9 577936.8 355967.5 518737.0 356289.9 507808.2 485808.9 466424.7 429711.3	13395.4 13887.6 26398.4 26890.6 13091.7 13583.9 23351.6 23843.8 34747.6 35239.8	9460.7 9952.9 22983.1 23475.3 9587.0 10079.2 19953.1 20445.3 31933.2 32425.3	

# 8. Capacity Design Report: Column Rebar

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E	<u>F</u> ile	<u>E</u> dit	: <u>S</u> ea	rch Blo	ock <u>H</u> el	р											
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m   /   /   s   s   1 −   s	Desi Unit (C) Engi LICE Desi Unit Proj Note	gn Coo . systo Nathan neerin NSEE .gn Coo . Systo ect .s	de : A em : k n Madw ng Soft : I de : P em : k : M	CI-89, g.cm, tujuh, tware r. Nat BI-91 g.cm, g.cm, y Firs Store	(Using ) kg.cm st Buildi sys, 3x2	,RFD- N.cm 103 1 Cen 1 tuju 1.25 .ng P	94 ter h, M.Sc, fy and l		-								
围 王 王	Flr	No.	Id	Set	н	1	Nbt Nbf	*As	Atr	ntr	spc	Nx	Ny	Atx	Aty	spcx	
E	з	1	25	2	300.00	1 2	0 0 dl	5 6.4	0.06	0	7.50	20	16	0.04	0.06	7.50	
	3	3	26	2	300.00	• -			0.04	0	7.50		20	0.04	0.03	7.50	
Ē	3	5	27	21	300.00	• -			0.06	0	7.50		16	0.03	0.06	7.50	
ł	3	8 10	28 29	21	300.00 300.00	•			0.06	0	7.50   7.50		16   12	0.03 0.02	0.06   0.03	7.50 7.50	
2	3	10	30	21	300.00	•			0.03	0	7.50		12	0.02	0.03	7.50 9.60	
2	3	15	31	21	300.00	•			0.04	0	7.50		16	0.00	0.04	7.50	
_	3	17	32	21	300.00				0.04	ŏ	7.50		16	0.04	0.04	7.50	
C.	3	19	33	21	300.00				0.06	0	7.50		16	0.03	0.06	7.50	
0	2	l	13	1	400.00	1 2	0 0 41	5 4.5	0.16	0	10.00	20	8	0.16	0.00	10.00	
C	2	з	14	1	400.00	1 3	2 0 dl	5 7.1	0.14	0	10.00	32	8	0.14	0.03	10.00	<b>_</b> 1
м	٩Î	-		• •	100.00		· · ··			^	10.00		~ ·			10.00	ا ک
M																	
	<b>8</b> St	art	SAN	S V.4.	.7 Progra	am	🖞 b-cap	ot3 - Pa	aint						<b>8 13 (K)</b>	9:50 A	٨M