# **Engineering Software Research Center**

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# **SANSPRO V.5.10** Tutorial

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March 2017

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## 1. Installation

Step by step to install the SANSPRO program:

- 1. Insert the provided CD
- 2. Run SETUP.EXE
- 3. Follow the instruction, install to a new directory (for example : c:\Program Files\SANSPRO510)
- 4. Copy the user license file SANSPRO.UIF from CD (inside your name's directory)
- 5. Right-Click the installed directory (SANSPRO510), change properties : [] Read Only



Fig.1. Set Directory for NOT Read Only

6. Select SANSPRO.EXE, Right-click, set [x] RUN AS ADMINISTRATOR



Fig.2. Set SANSPRO to "Run this program as an administrator"

- 7. Select SANSPRO.EXE, Right-click, select SEND TO DESKTOP to create Short-cut if needed
- 8. SANSPRO will be appear on desktop and ready to run
- 9. User can selected 7 supported languages from Param User preferences menu



Fig. 3. Short-cut for SANSPRO.EXE on desktop

## 2. About ESRC

ESRC is a research center founded by Dr. Nathan Madutujuh in 1989 in Bandung, INDONESIA. ESRC is focusing on development of advanced engineering software using latest numerical methods, software development tools, and available hardware technologies. ESRC provides the engineering software at affordable cost to equip more engineers with better tools to create better environment for the world.

## **Our Services**

We provides our engineering software and also special purpose software designed for specific industry needs. ESRC can also collaborate with other academic or research institutes to develop specific software for special needs. With our vast knowledge and million lines of available source code and library, both numerical and 2D/3D graphics, we can deliver new software in short time.

## **Our Products:**

### **Building Design:**

SANSPRO - Integrated Building Design DSGWIN - Concrete Section Designers BEAMCOL - Beam Column Joint Design CONBRIDGE - Concrete Bridge Design CAMBER - Bridge Camber Analysis

### **Foundation Design:**

RETWALL - Retaining Wall Design Program GRAVWALL - Gravity Wall Design Program BASEMENT - Concrete Basement Design PILECAP - Concrete Pilecap Design TOWERPAD - Tower Foundation Design FOOT - Spread Footing Program

### **Transportation:**

WinCANDE - Nonlinear Box Culvert Design BRASDAT - BRASS Post-Processing SapBRIDGE - SAP Bridge Post-Processing INSPECT - Bridge Inspection Program

## **Steel Structures:**

STEELCON - Steel Connection Design TOWERWIN - Steel Lattice Tower Design PURLIN - Steel Purlin Design NROOF - Light Steel Roof Design NBRIDGE - Steel Composite Bridge Design GABLE - Preliminary Gable Frame Design MATPLAN - Steel Material Planning

### **Geotechnics:**

SOILAB - Soil Laboratory Data Processing BORLOG - Boring Log Program NSLOPE - Slope Stability Analysis Program NPILE - Static Pile Capacity Program REESE - Pile Lateral Capacity Design

## **Retrofitting and Evaluation:**

TDS302 - Data Acquisition System SFRS - Fiber Wrap Strengthening Design

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## 3. Introduction to SANSPRO Program

SANSPRO is an Integrated Software for Structural Modeling, Finite Element Static & Dynamic Analysis, Steel and Concrete Design, Foundation Design, Volume & Cost, and Detail Drawing Generator. Using integrated approach, user needs only to enter a single comprehensive model, then other process such as analysis, design and reporting will be done using the same model.

SANSPRO can be used for 2D or 3D structures and has a very comprehensive interactive building modeler using layout oriented approach. It has capabilities to do static and dynamic spectrum response analysis, and also Direct Integration (Time History) Analysis. For building with stage construction, a sequential load analysis can be done to reflect more accurately the distribution of gravity load during construction, especially for transfer beam and bracings.

Truss elements, Frame elements and shell finite elements area available to model various beam, column, floor slab, shearwall and shell structures. For shell element formulation, there are several options available : Hybrid formulation, advanced ANDES and Discrete Kirchoff element with Drilling DOF.

The program also provide various load table and load generator for Self-weight, Floor slab (DL,LL), Static Equivalent earthquake load, Response spectrum load, mass calculation, and also wind load.

After analysis, one can choice to run a steel / concrete design, or a concrete capacity design using the latest building design code. Design results, including rebar number, floor slab rebar sketch, shearwall rebar detail can be shown and checked visually. Optionally, user can generate a detail drawing for building floor layout, column rebar, and beam rebar.

Simplified and also more detailed Capacity Foundation Design methods are also provided along with Foundation Detail Drawing Generator. Using this approach, designing a pile foundation for whole building can be done in few seconds.

For building model, user can calculate the total volume and cost per floor using the user provided unit price. The program will provide concrete volume and weight, steel weight, and formwork area. The final result will be concrete volume to area ratio, steel weight to area or concrete volume ratio, and total cost per floor area.

A comprehensive building model, analysis and design report can also be generated to a PDF file format.



Fig. 4. Main menu of SANSPRO V.5.10 Program

## 4. Program Layout



## 5. Design Code supported

SANSPRO support latest available design codes, among them are:

Earthquake Load Generator	: Indonesian Code 1726-2012, UBC-94, UBC-97, IBC-2003, IBC-2009, ASCE-7-10
_	Mexico-1993
Concrete Design Code	: Indonesian Code 2847-2013, ACI-2015
Steel Design Code	: Indonesian Code 1729-2013, AISC-2010
Foundation Design Code	: Indonesian Code 2847-2013

Other design code can be supported by changing the appropriate design parameters:

Load factors Material strength factors Earthquake Zone factor (Ss, S1)

## 6. Design Procedures

SANSPRO is a computer program that can be used for designing various type of structures: Continuous beams, Portal frames, Plane Truss, Factory Building, and Highrise Buildings. It has the following capabilities:

- a. Structural modelling
- b. Structural analysis
- c. Concrete and steel design
- d. Steel connection design for truss and frames
- e. Concrete slab design
- f. Foundation design
- g. Detail Drawing generator
- g. Volume and Cost calculation
- h. Report generator

Procedure for using SANSPRO program is as follows:

## 1. Model creation (File \*.MDL)

### a. Using Model Generator (to generate simple model for exercise)

- 1. Continuous beams
- 2. Plane truss
- 3. Portal + bracing
- 4. Gable frame
- 5. Simple Building
- 6. General Building
- b. Using Axis lines
- c. Using Import Mesh from AutoCad DXF Files
- d. Using Import Construction Lines (help lines) from AutoCad DXF Files
- e. Using Interactive method (one by one)

## 2. Data Checking (Export Data, File \*.DAT)

- a. Using Model Advisor
- b. Preparing for Analysis (Export Data)

### 3. Structural Analysis (Output file \*.OUT)

- a. Static Analysis (to find displacement, reactions, element forces)
  - \*.OUT Displacement, element forces, reactions
  - \*.SUP Support reactions summary
- **b. Eigen Value Analysis** (to find vibration mode only) \*.RSP - eigen values file

### c. Dynamic Spectrum Response Analysis (Dynamic analysis)

- \*.BSH Dynamic Spectrum response output, time period, base shear
- \*.ROT Floor eccentricity
- \*.DRF Story Drift and Building separation
- \*.SSH Story Shear and P-Delta Checking

## d. Direct Integration Analysis (Time History/Impact Load)

\*.DVA - Displacement, Velocity, Acceleration for each time step

### 4. Structural Design

- a. Concrete Frame/Building Design (ACI/PBI, Output \*.D02)
- b. Steel Frame/Building Design (ASD/LRFD, Output : \*.D02)
- c. Prestressed Concrete Design (Output : \*.D02)
- d. Steel Truss Design (Output : \*.D01)

## 5. Foundation Design

- a. Concrete Footing Slab Foundation Design
- b. Concrete Mini Pile Foundation Design
- c. Concrete Bored Pile Foundation Design

## 6. Detail Drawing Generator

- a. Structural Layout
- b. Floor slab rebar layout
- c. Beam Layout and Detail
- d. Column Layout and Detail
- e. Shearwall rebar layout
- f. Foundation layout and detail
- g. Other structural detail

## 7. Volume and Cost Report

- a. Installed unit price
- b. Formwork area
- c. Concrete Volume
- d. Steel and Rebar weight
- e. Concrete volume / area ratio
- f. Steel weight per concrete volume ratio
- g. Steel weight per area ratio
- h. Total Volume, Weight, Ratio and Cost per floor

## 8. Report Generator

- a. Structural Data Summary
- b. Comprehensive Building Report (File \*.BTR)
- c. Dynamic Analysis Result Checking
- d. Comprehensive Report Generator (File \*.PDF)

## 7. Basic Example:

## 1. Example 1: Simple Truss Design

A Roof Truss usually made from steel angle connected by bolt to conenctions plates. Load from DL, LL, Wind load will be considered.

- 1. Open Modeler
- 2. Click menu : ModelGen Roof Truss (Simple)
  - Click : Y
  - Click : **OK** (4 times, change data if necessary)
- 3. A simple truss model will be appeared, click icons [] Name to display section name



4. Click : File - Save (or Press F2) → Name it as Truss1.MDL
5. Click : File - Export (or Press F4) → Click [Export] - Click [OK] - Click [Continue] - Click [OK]



6. To run analysis: Click menu Analysis, Click Analysis Menu, a window will be appear



## 7. Click Analysis to start analysis procedure, then click Quit



8. To run a steel truss design, Click Design - Run Truss/Frame/Building Design, a window will appear



# 9. Click Truss Design – Click [Start Design] – Click [OK] – Click Quit

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10. To View Truss Reactions : Right-Click, Select View Support Reactions



Support reactions (factored) from all load combinations will be appear.

To see just support reaction from a certain load combination, select the right Load **Comb** number. To see unfactored support reactions, **Right-Click**, select **Change View Option**, [] **Show unfactored support** 

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### 11. To see truss design results, Right-Click, select View Moment Design Results



Steel truss stress ratio will be appear. Design is OK if the ratio is  $fr \le 0.85$  for truss with eccentric connection or single L diagonals and  $fr \le 1.0$  for symmetric connection.

### 12. To see steel truss bolted connection, Right-Click, select View Steel Connection



### NOTE:

- The procedure for Save, Export, Analysis, and View Support Reactions are same for all models, so it will not be repeated again in this tutorial
- The program will automatically save a backup file every t minutes (if asked) or after every SAVE command
- Design Code and Load factors can be changed by user before analysis
- After a model has been created, user can repeat analysis and design anytime
- Various more complex truss system can be generated by selecting the second menu : Roof Truss Parametric

### **Generating Roof Truss by Parametric Method**



User can select various parameters suitable for the model required:

Truss span, section, roof shape, support type, roof tile type, ceiling type, live load, wind load, point load, section type, etc.

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After a truss model generated, the procedure for analysis, design, visual design checking are the same as previous.

#### 2. Example 2: Gable Frame Design

A Gable frame is usually found at factory building. It may have a corbel to hold rail for crane. Load to be considered: DL, LL, Wind Load, Crane Load, Earthquake Load (for heavy Concrete frame)

- 1. Open Modeler
- 2. Click menu : ModelGen Gable Frame (Steel, 2D)
- Click : Y

1	SANSPRO V.5.10	) - WITH DRAWING MODULE - (C) Nathan Madutujuh, ESRC, 1989-2017	- 🗆 🗙
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3. A **Parametric Menu** will be appeared. User can select main span, section, roof shape, support type, frame distance, roof tile type, ceiling type, live load, wind load, point load, section type, etc.

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StripFnc	Purlin Spacing 1.5 m	Symmetric Axis	Mezzanine Beams	10	WF150x75				Danuung
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Beam D	Roof Dead Load Data	O 2 Symmetric Axes	Longitudinal Beams	12	WF250x125				PROJECT
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Clik [OK] 4 times to get:



- 4. Click F2 (save) and give new name : Gable1.MDL
- 5. Click F4 (export) and Run Analysis
- 6. Click Design Steel/Frame/Building Design, Select Steel Frame
- 7. View Moment Diagram by Right-Click, View Moment Diagram



## NOTE:

- If **load comb** = **0** selected, an envelope of moment diagram will be displayed.

## 8. View Steel Design Results by Right-Click, View Moment Design Results



Steel frame stress ratio will be appear. Design is OK if the ratio is  $fr \le 1.0$  (recommended  $\le 0.8-0.9$ ).

## 9. View Support Reactions by Right-Click, Select View Support Reactions



### NOTE:

- The procedure for Save, Export, Analysis, and View Support Reactions are same for all models, so it will not be repeated again in this tutorial
- The program will automatically save a backup file every t minutes (if asked) or after every SAVE command
- Design Code and Load factors can be changed by user before analysis
- After a model has been created, user can repeat analysis and design anytime
- Various more complex truss system can be generated by selecting menu : Roof Truss Parametric

## 8. Basic Building Design:

## 1. Example 3: Building Design (Gravity and Static Equivalent Load Analysis)

In this very simple building design example, we will use a very simple 4 story building model, with two floor layouts, two type of slab thicknesses, two column layouts and two beam layouts.



NOTE : Units are in kg, cm unless stated different.

## **Introduction to Building Layout Oriented Modelling Concepts**

SANSPRO uses a unique approach for modelling a building, called "Building Layout Oriented Modelling". Here a typical building floors is divided into several layout, analogue to building layout drawing. Floors with same layout will share same floor layout model.

SANSPRO uses terms : Beams and slab layout, Column layout, and Shearwall layout to allow combination of several layout in a floor. A Master table called Building Story Data Table will store all layout used in all floors. A layout can have more than one type and size of section. Slab layout will follow automatically a beam layout.



For sample building that we will use for exercise in this chapter, we can find out that there are at least 2 column layout needed, and also 2 beam layout needed. If the loading at roof level is different than at typical floor than 3 or 4 beam layouts will be needed.

Bui	Iding Story Data						
Flo	or Column Layout	Beam Layout	Shearwall Layout		Slab Type	qDL	qLL
0	0	0	0	1	0	0	0
1	1	1	0	1	1	125	250
2	1	1	0	1	1	125	250
3	2	2	0	1	1	125	250
4	2	2	0	1	2	100	400
						kg/m2	kg/m

|--|

Floor	Column Layout	Column Size
0	0	0
1	1	K1, K2
2	1	K1, K2
3	2	K2
4	2	K2
Floor	Beam Layout	Beam Size
0	0	0

	-	
0	0	0
1	1	B1, B2, BA
2	1	B1, B2, BA
3	2	B1, B2, BA
4	2	B1, B2, BA

### Visible Column

User will work on top view drawing of a floor layout. A column shown on the drawing can be selected as a column below this floor level, or on/above this floor level, or both below and above columns shown.

## **Node Coordinates and Axis**

A Floor layout will need a set of node coordinates (2 dimensional), defined on the floor top view, as local x,y coordinates. SANSPRO program will use this floor coordinates and floor height/level to generate 3D node coordinates in global direction (X, Y, Z), where : X = x, Y = floor level, Z = -y.

## Procedure for Creating a new Building Model:

- 1. Generate Building Material and Properties Wizard
- 2. Generate Project Data, Drawing Title
- 3. Generate Structural Parameters
- 4. Generate Analysis Option
- 5. Generate Building Parameters
- 6. Generate Node Coordinates (using Coordinate Axis, Construction Lines, or one by one)
- 7. Generate Load Combinations
- 8. Generate Story Data
- 9. Generate Element Properties
- 10. Generate Floor Slab Table
- 11. Generate Beam Load Table
- 12. Compute Floor Weight
- 13. Generate Earthquake Load
- 14. Continue with Analysis and Design

All steps above are already provided at a certain menu called **BUILDING**. This menu collect all necessary commands needed to model and design a building from other SANSPRO menu.

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∎ਿਡਿਿਿਿਿਟਿਯੋਡਿਿਿਟਾ	Concrete Building Properties Generator (No Mesh) - Medium Building	Export Run Design Update CFS AutoInvalidate Reopen Output Strs: Mx V Dir:	V Stage 0   Debug
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After a building model created, user can do the following:

- **1.** Run analysis
- 2. Run Section Design
- 3. Run Shearwall Design
- 4. Run Foundation Design
- 5. Run Volume and Cost Calculation
- 6. Generate Detail Drawing

The detail procedure for creating a building model is as follows.

Note that we will use this same building model for example 4 to 9 later.

1. Generate Building Material and Properties Wizard

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Hide Above Below Both	Compute Building All Floors Weight		FILENAME
Slab View Option	Generate Earthquake Load		untitled.mdl
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	Concrete Shearwall Design		
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Click Building - Concrete Building Properties Generator (No Mesh) - Small Building

This command will generate several material properties and section properties useful for small buildings.

Click **[Yes]** 2x, Enter Total Floor number : **NST** = 4

2. Click Building - Title and Notes, enter the following data

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Then Click Building - Drawing Title, enter data for drawing text

Please replace my name with your name !

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3. Generate Structural Parameters

# Click Building – Structural Parameters

Select Design Code : CONCRETE PBI-2013 Select Earthquake Design Code: IBC-2009/SNI-2012

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## NOTE:

Option [ ] Use Material Schedule Table will be useful for highrise building if the concrete strength varies due to floor height.

## 4. Click Building - Analysis Option



For this exercise using Static Analysis, nothing changes, just use default settings, then click [OK]

5. Click Building - Building Parameters

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See "Introduction to Building Layout Oriented Modelling Concepts" above:

Enter No. of Column Layout = 2 Enter No. of Beam Layout = 2 Click **[OK]**  6. Generate Node Coordinates (using Coordinate Axis, Construction Lines, or one by one)

Here we will use coordinate axis approach.

x-axis	: 1, 1a, 2, 2a, 3, 3a, 4	with spacing	: 400,400,300,300,400,400 cm
y-axis	: A, B, C	with spacing	: 600,600 cm

Click **Building – Define Coordinate Axis, enter** Name and Length as follows: (NOTE : **X-coord** and **Y-coord** data will be generated automatically, no need to enter it manually)

Remember to change **Range - X** to 2400 cm and **Range – Y** to 1400 cm (from Xmax + 200, Ymax + 200) to get a nice working space.

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Click [Apply] and [OK] : Coordinate Axis will be generated automatically

Click **icon** []]] to Show Axis lines:



Node coordinates can be generated by clicking : **Building – Generate Nodes from Axis Intersection** Click **[Yes]** 

#### Node coordinates will be generated from Axis Intersection as follows:



## 7. Generate Load Combinations

Several Pre-defined Load Combinations are available. After selecting a predefined load comb, user can change it later by changing the type to user-defined load comb.

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#### **Building Function : Office**

Select Load Comb Type : Self + Dead + Live + EQX + EQZ Load

Live Load Reduction Factor for Mass calculation	: 0.25
Live Load Reduction Factor for EQ Load Comb	: 0.50

Live Load Reduction Factor due to Area Contribution : 0.60 - 1.0 (depends on elements, distance)

## 8. Generate Story Data

We will now define Building Story data from the given building layout and section as follows :

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↔ Snap Ortho	. 🖬 🏢 :	ex = Xc.o.n	n · X.c.o.r, ed = des	ign ecc. 🜘	) None	(	Reduce E	x, Enlarge Ey		Defined	halaash	User Definer	d	Yo = 0	Yo = 0 m Generate 1 im SnapScr			
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Set LL R.F. (Reduction Factor) = 0.25 (Click Office and Apartment) Set Column Axial R.F. = 0.60 (from calculation of KLL, see attachment)

Calculation of LL R.F. :

$$L = L_o \left( 0,25 + \frac{4,57}{\sqrt{K_{LL}A_T}} \right)$$

Where:

L = Reduced Live Load

Lo = Unreduced Live Load

At = Tributary Area in m2

kLL = Coefficient (see table below)

Location	kLL
Interior column	4
Edge column	3
Corner column	2
Edge, interior Beam	2
Cantilever beam	1
Floor Slab	1

#### 9. Generate Element Properties

Element data set properties are defined into 4 tables as follows:

Material Table: Contains material data, E, unit weight, poissor ratio, etc.Section Table: Contains section size, b, h, etc.Design Table: Contains fc', fy, db, dbv, etc.ELSET Table: Combining the above tables into one ELSET table

## Material Table : Click menu Matprop – Material (Linear)



Click [Generate Linear Material] - Select Concrete fc' 25 Mpa



Section already generated by Wizard. Nothing to do.

This table can be added or deleted if necessary, but ELSET table must be generated afterward.

We need K1 = K50/50, but at the generated section table there is no K50/50, the maximum size is K40/40. Please change Section Number 22 : from K35/35 to K50/50 for next step.

## Change Section 22 from K35/35 to K50/50:



#### Change Design 22 from K35/35 to K50/50:



Elset table will automatically reflects this change:

Elset 22 📫				E	lement	Data Set (ELSET)	Editor		×				
Alpha 0 Degrees	Use Do (Right-0	Use Double Click for Table Lookup (Material/Section/Design Tables) (Right-Click to use Popup Menu) (Texture: 0=auto, 1=solid rgbcolor,no texture, 2=texture, 3=rgbcolor+texture)											
	ELSE1	Material	Section	Design	Texture	Section Name	RGB Color	Texture File	1				
Dsg Grp 0 Previou	20	1	20	20	0	K25/25							
Section K50/50	21	1	21	21	0	K30/30							
	22	1	22	22	0	K50/50							
_ Include Shear deformation	23	1	23	23	0	K40/40							
l ee/L-shaped Column Alighr	24	1	24	24	0	K15/20							
Centered (+ shape)	25	1	25	25	0	K15/25							
Number of floors skipped 🛛 🕤	26	1	26	26	0	K15/30							
below this floor:	27	1	27	27	0	K15/35							
Steel Connection Design	28	1	28	28	0	K15/40							
Left-end	<								>				
Right-end	Clear	All G	ienerate	Add		0K Cancel	]						
Note: End-Moment Spring date		ancca rai			Note: Len	igth of Left and Right Ha	aunched						

#### Design Data: Click menu Matprop - Design



Select Design Code Select Material

: Concrete PBI-2013, Click [Apply Dsg Code to ALL] : K-300 (fc'25), Click [Apply Concrete Properties to ALL]

We need K1 = K50/50, but at the generated Design table there is no K50/50, the maximum size is K40/40. Please change Design Number 22 : from K35/35 to K50/50 for next step.

#### ELSET Table: Click menu Matprop – ELSET Data



From this table it can be seen that all material index is 1 (using same material fc'25), while section and design index is from 1..41

This ELSET table will be used for selecting element data properties when we add any element.

#### 10. Generate Column elements

After we define all element properties and load combination, now we can define the structural elements. Starting from column elements as follows:

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CLin STR

Select Floor No. 1 (column below this floor will be defined) Click icon Click icon Add Click any column position with K1 Select Elset 22 = K50/50, Click [OK] (If you still have K35/35, see above) Click for other column position with K1 size

For Column K2:

Click icon Click icon Add Click any column position with K2 Select Elset 23 = K40/40, Click [OK] Click for other column position with K2 size



### Column Layout for floor 1 and 2 is :



## 11. Generate Beam elements

Click icon Click icon Add Click first point of any beam with size B1 = 30/60 Drag to second point of the beam along the line with same beam size Select Elset 16 = B30/60, Click [OK]



(If the dragged line passing some points, answer with [Yes] for Auto-Divide beams)



### For other beam line with same size:

Click first point of any beam with size B1 = 30/60 Drag to second point of the beam along the line with same beam size (If the dragged line passing some points, answer with [Yes] for Auto-Divide beams)

For other beam line with different size: B25/50, B25/40

Click icon E Click icon Add Repeat other steps (select Elset 11 for B25/40 and Elset 13 for B25/50) After all beams has been generated, the floor layout will be :



Click checkbox [x] Width to show beam size Click checkbox [x] Set Color to show beam size in different color



Because of the layout oriented modelling, all columns and beams at floor 1 and 2 will be automatically defined accordingly. Please check it by moving from floor 1 to 2.

Any changes made to any element at floor 1 will be follow automatically by floor 2 and vice verse.

## Note:

- For adding shearwall elements, the procedure is similar with beam elements execept using icon
- Shearwall below the floor will be added

#### 12. Generate Floor slab Table

After all beams defined, we can generate floor slab at this floor. But first we must define the floor slab table. Click Building – Building Floor Slab Table

Change TP10 Section and Design to be TP12. Change the rebar diameter from 0.8 to 1.0 cm, change fy = 2400 to 3900 kg/cm2

Edit for qDL dan qLL as follows:



## 13. Generate Floor Slab Elements

Because the layout regions are rectangular we can use floor slab region generator for this purpose. Any missing region of slab can be generated later manually.

Click menu Object - Edit/Add/Del Multiple Slab Regions



# click [x] Change Slab to [1] Tp12

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PhysBm Spring				✔ Use Middle Nodes (Will tak	ke longer time)	Сору	as Shell Element to Floor				PROJECT
Auto-divide Segment				Use Faster Search (can mi	ss some nodes)	Chang	ge All Regions to Shell Element (	All Floors)			ABC Building
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View Col Option		8	8	Select Bange Add E	dit Del			Close	8		
Hide Above     Below Both											FILENAME
Slab View Option			B30/60	B30/60	B25/50	B25/50	B30/60	B30/6	i0	K40/40	abc.mdl
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			4000	4000	3000	3000	4000	400	0		naulali
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Select a window range, click **[Add]** Totally 12 Regions will be added.



Floor slab regions at floor 2 will also automatically follow floor 1.

## Floor with different layout:

For floor 3,4 layout, we will use other method, by copying current layout and deleting some elements. We will do this after adding some beam loads.

## Adding a floor region manually:

User can add a certain floor region manually by clicking icon  $\frac{1}{2}$ , click icon  $\frac{1}{2}$  and click 4 nodes in counterclockwise direction. For a slab region with 3 nodes, the third nodes is clicked twice at the same location.

### Saving the model

## Before we continue, we will save the model : Click **File – Save** or press **F2** and give name : ABC Avoid file name with space or dot or commas or other strange characters.



14. Generate Beam Load Table and Beam Load

Beam load from weight of brick wall will be added as follows: hi = 3.5 m - hb = 3.5 - 0.5 = 3.0 m, qwall = 150 kg/m2qbeam = 150 x 3 = 450 kg/m = 4.5 kg/cm (- sign means downward)

Click icon **and** add the following data:

Click icon [Add], enter Type = qy, q = -4.5, s1 = 0, s2 = 1Click the shaded row, the right beam load data will appear on shaded row Repeat if there are more than one beam load type This beam load type can be used by many beams later.



Add beam load for staircase:

For staircase with U-shape, the stiffness of the staircase is not very significant to the whole structure, and only its weight will be included in the model as a beam load.

Total length of staircase =  $6m / cos(30 \text{ deg}) = 6.92 \text{ m} \rightarrow \text{take as } 7.0 \text{ m}$ Total load of a staircase = 1000 kg/m2 $qs = 1000 \text{ x } 7 = 7000 \text{ kg/m} \rightarrow \text{the load is divided into two beams, upper and lower beams :}$ 



qb = 7000/2 = 3500 kg/m = 35 kg/cm

Add the staircase beam load to upper and lower beams.

Note: - Floor slab at staircase void must be deleted if the staircase beam load already defined.

## 15. Add Beam Load to beams

To add a beam load to a beam:

- Hide Floor slab regions first to easier the visual checking
- Go to floor 1
- Click icon <u>m</u>, click icon Add
- Click an edge beam
- Select the beam load from table
- Click [OK]
- A second line will appear on the selected beam.
- If a beam has two or more copies of the beam load, the second line will change its color

(This to enable user easily check if he has click twice or just once. In some model, the double beam load may be needed.)

#### - Repeat for other beams



16. Create model for Floor 3 and 4

Floor 3 and 4 use the same layout no. 2 We can go to floor 3 or 4 and repeat the same above process OR we can use a facility from SANSPRO called MODIFY BY FLOOR command as follows:

## Warning:

- This is a very useful faility to work on a floor or several floors using only simple command
- We can copy or delete a floor easily
- Please use this modify by floor comamnd carefully because it can add or erase a whole floor in one click

The steps to create data for floor 3 and 4 are as follows:

- Go to Floor **3** (Floor 4 has the same layout as floor 3)
- Click menu Modify Modify/Copy/Delete Objects by Floor
- Enter the following data:
- Click [Execute] after entering the data, answer with YES
- Now floor no. 3 and 4 will have their data appeared
- We must delete some objects to reflect the actual model


Here we want to copy data from floor 1 (with layout no. 1) to floor 3 (with layout no. 2) :

- [x] Copy Column Layout
- [x] Copy Beam Layout
- [x] Copy Ordinary Beam Load
- [x] Copy Slab Regions

Although the floor layout no. 2 is smaller than layout no. 1, we will copy it then delete some objects to reflect the actual model.

# Checking the 3D view of the model (Click icon 🎇)



From the 3D view we see that the floor 3 and 4 now have same layout as floor 1 and 2. We will delete some objects from floor 3 and 4 to reflect the real model.

#### 16. Deleting some objects

Note: - Be careful on using the delete commands, because SANSPRO only provides limited undo for delete commands.

To delete objects :

- click the icon of the object
- click Del Icon
- click near centroid of any object to be deleted (repeat for multiple objects to delete)
- Selected objects will change color to red
- click icon  $\underline{Del}$  again to confirm deletion  $\rightarrow$  selected objects will be deleted

Note: Repeat for columns, beams, slab regions objects.

- Check the 3D View again:



Now floor 3 and 4 have the right objects and smaller floor layout. Click icon [x] Slabs to view slab region object in 3D View.

#### 17. Define Nodal Supports

The last objects that needed to be defined are nodal supports (2 methods). First, move to floor 0 or the lowest floor.

User can add a nodal support manually similar to adding a column, by clicking the icon  $\overrightarrow{\text{Add}}$ , then select support type available: hinges, rolled, fixed or general type (user defined type). Repeat for all supports.

Other easier method to generate all supports easily is by clicking menu **Object – Generate all supports below columns or walls**, then select a support type. All nodal supports below column or wall will be added automatically.



#### Generate all supports below columns or walls

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File View Naviga	te Param	ModelGen	BUILDING	CFSBUILD	B-Panel Ma	tProp Prelimi	inary Mesh	Object Modify Dele	te Load Earthquake	e Analysis Desi	gn DsgTools	Graph Report Nonline	ar Help TutorMaker Quit
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Answer question "Clear all support at this floor ?" with **Yes.** Select a **Nodal Support type** and click **[OK]**.

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All supports will be generated automatically.

#### All nodal supports generated:



Now a complete geometry model of a building has been defined. We can continue with generating earthquake load, analysis and design process.



#### 18. Compute Floor Weight

#### 19. Generate Earthquake Load

After Building Weight computed, we can generate Static Equivalent Earthquake Load. Click **Building – Generate Earthquake Load** 



Menu for Earthquake Load generator will appear:

#### At Basic Data Page:

#### Earthquake Design Code : IBC-2009/Indo-2012 (SNI-1726-2012)

Enter Building Width, X = 22m, Width, Z = 16m (*distance between farthest columns in X,Z direction*) Building Height will be automatically calculated by the program.

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File View Navigate Param Mo	Basic Data Earthquake Codes Lateral Load (Single Diaphragm) L	ateral Load (Multiple Diaphragm) Lateral Load Chart Storey Shear Chart Diaphragm Force Chart	Graph Report Nonlinear Help TutorMaker Quit
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Go to page Earthquake Codes:

#### Enter the following data:

Seismic Use Group : II : Residential, Shophouses, Office, Retail, Apartment, Mall, Hotel, Factory Building Type for T Calculation : RC Moment Resisting Frames Site Class : E - Soft Soil Rx = 8.0, Omega = 3.0, Rho = 1.3, Cd = 5.5 Rz = 8.0, Omega = 3.0, Ss = 0.65, S1 = 0.325 (for Jakarta area) Use Cmin for T > Tmax = 3.0 secs



#### Click [Compute], Click [Apply], Click [Generate] Response spectrum curve now has been defined.

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#### Preparing for Analysis:

- Save data by clicking File - Save or F2

#### - Export data by clicking File - Export or F4

When we export data for analysis, SANSPRO will do some important model checking to ensure that the model is suitable for analysis. SANSPRO will check for most common modelling error and mistakes. If there is an error, it is usually a serious one that must be fixed immediately before running analysis. But if there is only warning, some warnings that are not applicable to the model can be neglected.



Click [Export] to continue with Model Advisor Checking.

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Good. No warnings for this model. So we can continue with export data for analysis by clicking **[Continue]**. Click [Ok].

Now the model has been prepared for analysis.

We will run static analysis because this model is using Static Equivalent Earthquake Load. Analysis process also may gives some warnings or error messages.

#### 20. Continue with Analysis

#### File View Navigate Param ModelGen BUILDING CFSBUILD 8-Panel MatProp Preliminary Mesh Object Modify Delete Load Earthquake Analysis Design DsgTools Graph Report Nonlinear Help TutorMaker Quit Run as Blackbox Export Run Design ÷ Debug Check Data Menu 🕆 Drag Divide 🤳 🕂 🚽 🏒 🍫 🔳 Analysis Menu • Del Ed View Analysis Output NSPRO V.5.00 dard Ver + DM x.y ZIA View Eigen Values Output T (20) (1a)(2)(3 View Building Storey Drift (\*) ew, Abov ort (x 1) $\odot$ View Building Eccentricity (\*) View Building Dynamic Output/Base Shear (\*) Save Building Displacement/Drift Save Building Story Shears and P-Delta Stability (\*) Save Floor Diaphragm Design Force 8000 Save Support Reactions 1 Save Support Reaction per Load Combination Beambio ConLine Nodeld HideLine Save Building Floor Slab Stres HideLine Bracing BmLeng ElmLoad 働 働 Bandung m Dsg by Layou ABC Bui Dir Vert Both 6000 w Co de Above low Both FILENAME abc.mdl Qdl,Qll Rebar VIEW FL-1, Flr-1, 4.0 $(\mathbf{A})$ $(\mathbf{A})$ ENGINEER 4000 3000 4000 4000 4000 3000 ort Mass and Spectrum Dat SNAP ON 1400.00 Read MSG Exe ORTHO **D** 🕂 🖀 🐔 🚿 e 9 Ë Image: Amage: Ama RX **()** ð

#### Click menu Analysis – Analysis Menu

#### SANSPRO Analysis Menu will appear: Click **Analysis** to Start Analysis.

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SANSPRO Analysis module is very fast and can be run inside the model. This model can be run in 0.953 secs. Click **[Quit]** to back to model editor.

Because of the analysis time is very fast, user is encouraged to re-run analysis as many times as needed to get the optimized design results. Re-analysis is needed if there is some changes in section size changed, material properties, building height or size, floor height, node coordinates, load values, support conditions, live load reduction, load combination, or earthquake load parameter.

After analysis, we can see : Support reactions, Moment diagram and node displacement of the model

Concrete Floor Slab Design can be visually checked even before analysis if modelled using Slab Region.

#### Support reactions View

#### Move to Floor 0.

**Right-Click**, click **View Support Reactions**, all vertical support reactions will be shown (in kg) (Direction of support reaction and unit system can be changed from **Right-Click**, click **Change View Option**)



#### Moment Diagram View

Move to Floor 1 or 2,3,4.

**Right-Click**, click **View Moment Diagram**, all moment diagram envelope of beams will be shown. This is envelope of moment diagrams from all load combinations. To see moment diagram from a certain load combination, select the right Load Comb No.



#### Moment Diagram for Load Comb = 1 : 1.2 DL + 1.6 LL



Moment Diagram for Load Comb = 2 (Earthquake in X Direction)



# Right-Click, select Change View Option, change the following options:Display Option:Global Axis Direction[x] Show Displacement[x] DY,RY][x] Total, Unfactored



Nodal Displacement in vertical direction will be shown for every nodes in the model (in cm):



#### **Checking node displacements:**

Maximum unfactored displacement usually  $\leq L/300$  to L/480.

Maximum displacement is computed as displacement at tip of cantilelever or midspan of beam deducted by displacement at beam ends connected to support or columns.

If camber provided, only maximum unfactored displacement from Live Load should be used in above checking.

#### 21. Run Element Design

Concrete floor slab design can be checked by Right-Click, select View Floor Slab Design.

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Slab Rebar for mid and support in short and long direction will be shown (in mm). Click [x] Rebar Sketch, [x] Rebar, [x] Simplify to see the slab rebar sketch for this floor.



For column, shearwall and beam elements, we must run a certain element design procedure provided. For earthquake zone, after analysis phase, we can run concrete capacity design to find rebar for beams and columns.



Click menu Design - Run Concrete Capacity Design (with Messages) or press F8

Clik **[Ok]**, then main menu for Concrete Capacity Design will appear. Click **[Set Reduction Factor as Constant]**, enter **0.7** for column axial reduction factor.

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DsgOut StripFnd Bracing				Notional Load - DLX 0	O By Default (Automatic)	PBI-2003 (ACI-)	2009)			Y	Bandung
✓ JLoad ✓ ElmLoad PrevEset ShwRebr				Notional Load - DLZ	⊖ All 2 Ences	O PBBI-2013 (LR	-D-2010)				
PhysBm Spring				Notional Load - LLX U	U Mil 21 doos	Note: To get correct Secondary, etc) and	results, all beams mi the model must hav	ust be assign appropriate beam type I e passed the ordinary concrete desig	(Primary, in before		PROJECT
Auto-divide Segment				Notional Load - LLZ	All 4 Faces	continuing with capa for Linear/Nonlinear	icity design. For Stee Static Analysis	el Building, Capacity Design currently	works only		ABC Building
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Click **[Ok]** to start Concrete Capacity Design, click **[Ok]** For Beams : Click **[Yes]**, click **[Ok]**, click **[Ok]** For Columns : Click **[Yes]**, click **[Ok]**, click **[Ok]** Click **[Ok]** to quit.

Now we can visually see and check concrete beam and column rebar easily as follows:

Right-click, select View Momen Design Results:



Concrete column rebar with percentage, concrete beam rebar will appear:

<b>11</b>								SANS	PRO Mo	odele	r: D:\TR	AINI	NG/T	UTORI	AL\AI	BC.MDL	ABC I	Building	3				– 🗖 🗙
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We can see rebar layout at other floor by moving to certain floor.

We can see also sectional view (side view) of the rebar detail by : Right-Click, select View Section XX or YY



Click [Select Range], and drag a window range of sectional view:



Click [View], now the rebar will be shown in the selected sectional plane.



We can see also detail rebar using this sectional view by Right-Click, select View Section with Rebar Layout to get the following View:



View Section with Rebar Layout :

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転曲/☎ ■ 47		20d16 ( 1.61%)		32d1	6 ( 2.57%)	16d16 (	1.29%)			Beam Element Torsion Rebar
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Bear BeamSib		d10-200		d10-3	200	d10-20	1			
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StripFnd BmLeng		5d19	3d19	5d19 3d19	9 2d19	3d19 6d19	3	H 6d1		Bandung
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Zoom and enlarge a certain area to see more detail drawing:

<b>iii</b>					SANSPRO	O Modeler: D:	(TRAINING(TUT)	DRIAL/ABC.V	IDL - ABC Bui	lding					
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2. Example 4: Building Design (Gravity and Dynamic Earthquake Load Analysis)

We will now repeat the whole process again using Dynamic Analysis.



- We will now change some parameters needed for Dynamic Analysis:
- Click menu Analysis Option



# Change Analysis Method to Dynamic Analysis



- Go to page : Dynamic Analysis
- click button [Default] and button [Default]
- The Dynamic Analysis page will look as follows:

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Here we will use Neigen = 6, Damping = 0.05 (for concrete), and Linear comb of 2 directions at 90 and 0 deg. Click [OK] to quit.

Next, we need to define mass from 100% of SW+DL and 25% of LL as follows: Click menu Load – Mass Contribution Factor



Enter data : LC0 = 1.0, LC1 = 1.0, LC2 = 0.25 (for 100% of SW+DL and 25% of LL), then click [Ok] :



We need to run the analysis again, now using Dynamic Analysis Method:

- Click **F2** to save the model
- Click **F4** to export the model for running analysis
- Click menu Analysis click Analysis Menu click Analysis
- SANSPRO will finish the dynamic analysis in about 1.364 secs.

#### - After Dynamic Analysis:



Before we continue with Concrete Capacity Design, Results from Dynamic Analysis must be verified for code requirements as follows:

To1 <= Tmax (see Tmax from **Earthquake** menu, applicable for NF >= 8) Modal direction of first 2 modes: DX, DZ Effective Mass >= 90% Base Shear Vd/Vs >= 0.85



- Check the content of file \*.bsh as follows:

- Checking To1 <= 0.72 sec (recommended to keep To1 <= 0.1 to 0.15\*NF in secs) :



- Click menu Analysis View Building Dynamic Output/Base Shear
- To1 = 0.45 secs  $\leq$  Tmax = 0.72 secs  $\rightarrow$  OK



#### NOTE :

If To is too large, building is too flexible, there will be large drift and also earthquake load generated will be too small.

If To > Tmax, we can correct the model as follows:

- Reduce mass using LL reduction factor if possible (*in this case Llrf* = 0.25 *is already used*)
- Increase concrete strength  $fc' \rightarrow to$  increase Ec
- Increase column size or shearwall thickness
- Increase beam height (if beam height is less than L/14)
- Decrease floor height  $\rightarrow$  to increase column stiffness

#### Checking Modal direction of first 2 modes: DX, DZ

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From above report: Mode 1 = Translational in DZ, Mode 2 = Translational in DX  $\rightarrow$  OK If not satisfied, building may experience torsion vibration, column size must be re-arrange so that the dominant movement will be in translation direction.

#### Checking for Effective Mass Factor >= 90%

From above results, the Sum of Modal Effective Mass Factor is  $94.12\% > 90\% \rightarrow OK$ 

if not satisfied, the number of mode involved in dynamic analysis is not enough. The number of eigen must be increased to fulfill the requirement, but not more than NF\*3/2 for small buildings and NF for large building (NF = number of story).

To ensure that the dynamic analysis will absorb same earthquake energy as in static equivalent, the base shear from dynamic analysis is limited to  $\geq 0.85 *$  Vbs,static for X and Z direction.

Base Shear Vdx/Vsx =  $84.4\% \le 85\%$ 



Base Shear Vdz/Vsz = 77.9 % <= 85%



In this case, both base shear are less than the minimum required. We can do some revision of the model here:

- Add more eigen values (at Analysis Option) OR
- Use Scaling Factor (at Analysis Option)

Because we have only 4 floors, we will use second method, using Scaling Factor as follows:

For X Direction: FS,X =  $85 / 84.4 = 1.0071 \rightarrow \text{Use FS},X = 1.008$ For Z Direction: FS,Z =  $85 / 77.9 = 1.0911 \rightarrow \text{Use FS},Z = 1.10$ 

We can enter the Scaling factor at Analysis Option and run the analysis again. After running, the base shear should be  $\geq 85\%$ .

Entering the Base Shear Scaling Factor:

- Click [x] Use Base Shear Correction
- Enter : Correction Factor for Vx = 1.008
- Enter : Correction Factor for Vx = 1.1
- Click [Ok]
- Click F2 and F4
- Run Analysis again



The Base Shear Vx and Vz now are  $\geq 85\%$  of Vbsh,static.



The dynamic analysis is now in good correlation with static analysis and satisfying the code requirements.

Now we can run the Concrete Capacity Design as before.

Click menu **Design – Run Concrete Capacity** Design (With Messages) After the design process, we can visually check the concrete rebar by **Right-Click**, **View Moment Design**.

#### View Concrete Rebar (after Dynamic Analysis)



Typically, because the base shear involved is only 85% of static base shear, the concrete rebar shown may be a little bit smaller than from static analysis. But because the lateral earthquake load distribution of dynamic analysis is more accurate than of static analysis, at mid floors the rebar required may be larger.

View Moment Diagram (after Dynamic Analysis)



# NOTE:

Please note that using Dynamic Spectrum Response analysis will give all + sign for element forces (because of the Square root or CQC combination method), so the moment diagram when combined with results from static load must be taken carefully.

#### 3. Example 5: Concrete Floor Slab Design

SANSPRO provides many design option for concrete slab:

- Concrete slab design moment (using plate moment coefficient table)
- Concrete slab rebar design (*using doubly reinforced concrete beam section*)
- Simplification of concrete slab rebar arrangement (using bent or additional rebar)
- Human induced Vibration analysis for slab
- Short-term and long-term displacement of slab

## To design a floor slab, go to the floor level, and Right-Click, select View Floor Slab Design



Concrete slab rebar (for M+ midspan and M- support) and for short and long span will be shown. Click bottom-left icon **[x] Rebar, [x] Rebar Sketch** to see the concrete slab rebar



The program will show continuous rebar layout that satisfy the above slab design moment required.

User can click icon **[x]** Simplify to further simplifying the rebar layout to get more economical solution using bent rebar or non-continuous additional rebar as follows:

#### Required rebar spacing after simplifying:

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The program will try to simplify the rebar arrangement as follows:



# NOTE:

- Max recommended main rebar spacing for concrete slab is 2\*tp
- For Metal deck, the rebar shown is the additional rebar needed
- For Hollow Core Slab, the design result is not applicable, because prestressed wire is used instead
- For Half-slab system, add more M+ rebar due to its behavior during construction load (the slab will behave as simple beam before casting the topping)
- Minimum slab thickness should be about L/30 L/35
- Concrete cover at top and bottom of concrete slab must be <= 1.5 to 2.0 cm to avoid Mn reduction

Slab can be analyzed for vibration and deflection as follows:

- Go to the floor slab to be checked
- Right-Click, select Change View Option
- click [x] Save Slab Rebar Design Report
- click [Ok]



click menu Design - View Slab Design Calculation



A file named SLABDSG.TXT will be generated for this floor. The content of this file can be incorporated into final report.

# NOTE:

- This option is automatically set to OFF after first click, to speed up the program.
- Repeat again above procedure for other floors.



#### Report for one slab region is as follows:

#### Floor = 1, Beam Layout = 1, nr = 1

```
Two-Way Concrete Slab Design:
typ = 1, elset = 1, mat = 1, dsg = 1, tp = 12.00 cm
qdl = -413.00, qll = -250.00, qrd = 0.00, qrl = 0.00 kg/m2, fcl = 249, fy = 3900 kg/cm2, db = 10.00 mm
Lx = 400.00 cm, Ly = 600.00 cm, rdf = 1.2000, rdfl = 1.0000
Minimum Thickness (2-way slab with edge beams, no drop panel, U-39 = Ln/34 = 11.76 cm
Maximum Deflection due to Live Load = Ln/360 = 16.67 mm
Maximum Deflection due to Total Load = Ln/480 = 12.50 mm
Deflection Calculation (4 sides semi-rigid, Bares, 1971) :
 Aspect Ratio = Lmax/Lmin = 1.500, Deflection Coef. k = 0.0110
  Concrete Strength, fc1 = 249.0 kg/cm2, Modulus, Ec = 253656.939 kg/cm2
                       = k*(Lmax^4*qtl /(Ec*tp^3)) = 0.813 mm
= k*(Lmax^4*qtot/(Ec*tp^3)) = 2.156 mm
  Deltal (qll only)
  Delta2 (q,total)
  Long-term deflection factor =
                                     1.778
Maximum Deflection (Cracked section, multiply by 1.50) :
  Delta1 (qll only) = 1.220 mm <= maxdelta1 = 16.667 mm, OK
Delta2 (q,total) = 3.235 mm <= maxdelta2 = 12.500 mm, OK
Maximum Long-term Deflection (Cracked section, multiply by 1.50) :
  Delta1 (qll only) = 2.168 mm <= maxdelta1 = 16.667 mm, OK
Delta2 (q,total) = 5.750 mm <= maxdelta2 = 12.500 mm, OK
  Delta2 (q,total)
Plate Vibration Analysis :
  Damping ratio beta = 0.030, Emd = 317071.174 \text{ kg/cm2}, PR = 0.20 f0 constant, phi = 1.57*(1+r^2) = 5.103 (all sides supported)
  Coeficient c = sqrt(Emd*tp*tp*tp*grav/(12*(1-nu*nu)*qtot)) = 838883.687
  First Natural Frequency, f0 = c*phi/(Lmax^2) = 11.890 Hz
  Constant K : 58 kN (Office, Residences, Halls), 20 kN (Malls)
  Constant K for minimum frequency, K = 39.000 (Averaged)
  Total Weight of slab under vibration, Wgt = 15912.000 kg
  Minimum First Natural Frequency, fn = 2.86*Ln(K/beta*Wgt) = 6.062 Hz
  STATUS of f0 : fn <= f0 -> OK
  Peak Response Acceleration:
  Walking speed = 2.0 Hz, DLF = 0.53, Person Wgt, P1 = 100.0 kg
  Constant Force walking Po = DLF*P1 = 53.0 kg
  Peak Response Acceleration, ap = Po*e^{(-0.35*f0)/(beta*Wqt)} = 0.0017 = 0.17 
  Check for Vibration (ATC Chart) :
          STATUS of ap : ap <= 0.721 % -> OK
Slab Rebar Design:
  ss2 = 0.8970, ax2 = 0.8350, ay2 =
                                                     0.1650, qu = -895.60 kg/m2
          ss2 * ax2 * q * lx*lx / 24 = 44719.9948 kg.cm/m (mid-span) -> d10 - 240.000 mm
  Mux =
  Muy = ss2 * ay2 * q * ly*ly / 24 = 19882.9917 kg.cm/m (mid-span) -> d10 - 240.000 mm
```

Short=d10-300 / [/, Long=d10-225/225 //

4. Example 6: Building Volume and Cost Design

SANSPRO has an useful feature for evaluating the total volume, weight and cost of concrete, rebar, formwork used in the model. The cost calculation will follow user defined unit price. This facility is only available for concrete building.



Click menu Report - select Volume and Cost Report

Enter the following unit price: (*in this case we use Rupiah/IDR currency, use any currency you prefer*) Select (x) **From Design Results, Max from Elset**, then click **[Compute]** 

Orthe	QQQO+O-∞+Q // ⊷ Data Result	Volume and Co	st Calcula	tion for Concrete Build	Plan Elev Type Building 3D ding	Standarc V Excort	Run Design Update CFS	AutoInvalidate Reopen Ou	atput Strs: Mao ∨ Dir: D	Y v Stage 1 ≑ Debug Frm SnapScr ∳ SANSPRO V.5.00
	Unit Cost Concrete (excluded rebar) Concrete Rebar Slab Formwork Beam Formwork Column Formwork Wall Formwork Steel Prolite (wF, H, C, Pipe,Te Steel Prolite (Angle)	800000 8000 100000 120000 120000 100000 9) 15000 15000	per m3 per kg per m2 per m2 per m2 per m2 per kg per kg	Reba Area Calculation       From Percentage (Appro.)       From Design Results. In       ● From Design Results. In       Beam 20       X       Delay Results. In       Column 30       X       Shearwall 1.5       X       Additional Volume Info	xximate, No design neede dividual Value (Lowest Vo ax from Elset of each Floo Use Cost Multiplier for e Use Cost Multiplier for Use Cost Multiplier 1 0 1 0 1 0 2 1.0	d) lume) (Average Vol) ach Storey ofer Example	(a) 00 <u>5-010</u>			Standard Ver - OM Flore View , Above Support (e1) Colume Element Beam Element Beam Element Roo Sab ColWall Below Flore Sab Design Loading Comb + 1
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The program will give some useful results :

- Volume, weight, area and price per floor, divided into shearwall, columns, beams, slabs, precast slab
- Total building volume, weight, area and price for concrete, rebar and formwork
- Concrete ratio : total concrete volume / total floor area = equivalent thickness (usually 0.20 0.45)
- Rebar ratio : total weight of rebar / total concrete volume (usually 125 250 kg/m3)
- Rebar usage per diameter (if design stage has been finished)
- Warnings if some ratio is outside typical values range

For concrete volume, it will give very accurate results (beam height will be corrected by slab thickness, etc).

culation	for Co	ncrete Bui	lding	-			Bu					
Rebar Area Calculation From Percentage (Approximate, No design needed) From Design Results, Individual Value (Lowest Volume) © From Design Results, Max from Elset of each Floor (Average Vol)												
Rebar A	rea Perce	entage	Cost Multiplier for each 9	Storey								
Slab	1.2	% Find	Use Cost Multiplier	Example								
Beam	2.0	%	Floor Multiplier									

For rebar weight, there are 3 options available:

- 1. From percentage (estimation by user defined % based on section size, no design needed)
- 2. From Design Results, Individual value (Lowest value)
- 3. From Design Results, Max from Elset of each floor (maximum value)

The actual weight of rebar needed typically is between average of 2 and 3.



Concrete ratio = 0.224 m3/m2

Rebar ratio = 134.3 kg/m3 to 139.8 kg/m3Average rebar = 137.05 kg/m3

Overall cost = 662 761 Rp/m2 to 672 813 Rp/m2 Average cost = 667 787 Rp/m2

#### NOTE:

- Volume and weight of pilecap, tie beam, retaining wall, staircase are excluded and must be added manually

- Using this feature, we can conduct WHAT-IF study easily for various parameters:
  - Concrete strength fc'
  - Column size
  - Beam size

#### 5. Example 7: Simplified Foundation Design

Very simple and fast pile foundation design can be done using SANSPRO as follows:

- Right-click, select View Support Reactions
- Right-Click, select Change View Option
- Enter the allowable pile axial load capacity (ton)
- Enter the following parameters:
- For pilecap with more than 2 piles without shallow bedrock :
  - Pile axial load capacity may be reduced by pile group efficiency factor = 0.65 1.0
  - Group efficiency must be applied for friction type pile
  - In this case we will use : Pcap = 40 ton x 0.85 = 34 ton
- Enter the following parameters:
  - [x] Show N,pile, P1 = **34** ton
  - [x] Show Unfactored Support Reactions
  - [x] LL Reduction for Column Axial = 0.7
  - [x] LL Reduction for Earthquake = 0.5
- click [OK]



Estimation of number of piles needed will be appear :

## NOTE:

- Total number of piles needed is given at top-right of screen (Total = 31 piles)
- This simplified pile design only considers axial load and neglected shear and moment
- Total number of piles needed for shear is : Vbsh / P1, where P1 = 34 ton
- Special load combinations including SW,DL,LL,EQX,EQZ and Llrf will be used
- More detail foundation design considering Moment, Tension, Shear forces can be done in the other menu (Run Foundation Design)
- If more than 1 type of pile used, repeat the process again using different value of P1
- If using for foundation strengthening, enter the existing capacity of foundation. The number of piles shown will reflect the additional piles needed for foundation strengthening.



Pile number estimation, BP 60, 150 ton x 0.85  $\rightarrow$  Total 13 piles @ BP 60 (Bored Pile D600)



6. Example 8: Generate Detail Drawing

Most drawings that can be seen on screen can be exported to Autocad DXF file format by clicking menu : click Graph – Export Drawing – Autocad DXF Format (\*.DXF)



Enter a new DXF File for this drawing: ABC-Dyn-Layout.DXF A new DXF file will be created and can be open by any CAD Program:



SANSPRO has another useful feature that enable a user to generate detail drawing from the current model.

#### - Click Graph - Export All Drawings to One Big DXF File



Option menu for the drawing generator will appear: (Usually no changes will be needed except paper size)



#### - Enter a file name: ABC-Dyn-Drw

click [Ok] to generate the whole detail drawings in one big DXF file:

What is inside the drawing file:

- Building floor layout
- Floor slab rebar skecth
- Shearwall rebar detail
- Column rebar layout and detail
- Beam rebar layout and detail
The whole detail drawing sets generated for this building :

(Simple border and title is given for drawing notes, the generated drawing can be edited by drafter later)

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## Floor Slab Rebar Sketch:



#### Column and Beam Rebar Layout:



This drawing will contain column and beam layout with index pointing to detail drawing below. For large building and also if the building is not regularly shape, many beam detail can be generated and user must reduce it manually by selecting the needed ones.

Column Rebar Detail:



#### NOTE:

- Column hoops and ties arrangement must be same along the columns. The drawing generator will be revised later to correct the drawing.
- For highly seismic zone, the maximum distance of stirrup legs is 150 to 200 mm.
- Maximum column stirrups spacing is 150 mm

Beam rebar drawing:

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# NOTE:

- User is advised to always re-check the beam rebar detail compared to the visual rebar checking per floor

For highly seismic zone, the maximum distance of stirrup legs is 200 mm.
Maximum beam stirrups spacing is 150 mm

#### 9. Detail Foundation Design

### 1. Example 10: Detail Pile Foundation Design

More detail foundation design covering Axial compression, tension, shear and moment forces can be done using

- click menu Design Run Foundation Design
- Enter the following parameters:

Data Result Desig Load Factors for Des LL Reduction Factor LL Reduction Factor Design for Axial L Neglect Shear Iff	SANSPRO n Recommendat gn Forces ior Gravity 0.70 ior Earthq. 0.50 pad Only (Mx=Ma vrizontal) Forces	Foundatic ions Pileca Auto =0)	p Configuration Axial Group El Not used Simple For Conversed Los Angek Seiler-Keet	fliciency C mula Labarre P es ney C . Efficncy C	SANSPROT r this new v procrete Properti hi, Moment hi, Shear omp Strength, f oncr. Cover, To	vodeler: D:\ ersion: Mod 0.9 0.75 c' 291 kg/cm/ p 5.0 cm	Rebar Pr Rebar D Rebar D Stirrups I Side bar Rebar Fy	operties (user de iameter, db 1.6 Diam., dbv 1.3 Diam., dbs 1.2 o 3900 kg	fined) Fo cm Ex cm Cc cm Cc cm Tc v/cm2 La	thttp://www.communications.communi	ign DsgTools Graph Report dolnvalidate Beopen Output Stra Mao I I I I I I I I I I I I I I I I I I I	Nonlinear Help TutorMaker Quit     Dr [DV > Stage 1 @
Played Data Calc     Save Data Calc     Increased Pile Cap     Reduce Pile cap     Include Slab or P     S.F. Tension 1.5     Use Automatic Lc     [18 Load combine     Do not check for     Foundation Capacity     Multipier for ED Loa	lation W Negle bacity by 30% city by 30% city by pile weigh ecap cost for co S.F. Shear 1 ad Combination ions used, includ ther piletype for Design city Design d, OmgFacX = d, OmgFacZ =	t Tension t mparison 5 ing 0.9 DL) single pile Help 3.00 3.00	Efficiency 0. Efficiency 0. Pile Spacing F S,internal 3. S1,edge 1. Pilecap/Footin Tp,min 50 frustrum 15 Y,soil 1500 V Auto Size	75 2x2 C 5 3x3 P Ratio D D B 5 D L ng Slab Cm H deg R kg/m3	oncr. Cover, Bo ile Embedded L e Beam/Sloof S 30 cm H 8.0 m V plift Nett Head f ead 0 eport Option (In ) ALL	t 10 cm en 7.5 cm iize ii 60 cm v 6.0 m or Tie Beam m dex Number) 0 1.10	Rebar Fy Rebar Fy Pilecap/S (Rang Material Concrete Rebar Rebar Start Ide	v 3900 kg slab MinRebar 0 e: 0.18% to 0.25 Cost a 80000 . adex Range	//cm2 //cm2 1/	Le Support excitons will be under by Existing Net Coascily stat capacity per column) uuto Pcap. Rebar Selection Rebar Spacing 10 om ditional Options Avoid np = 3, use 3/2 piles Avoid np = 3, use 3/2 piles Avoid np = 10, use 3/4 piles Avoid np = 15, use 4/4 piles Avoid np = 15, use 4/4 piles		Cap Pie: 34 ton Total = 31 Pies Beam Element CoVival Below Floor Reactions, Global RY Unfactured Load Story Effects, LL=0.70 Earthquake, LL=0.70 LoadComb = ALL (w, w/o EQ)
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Note: "This Module w	l give good appr Ex 2: All Piles	oximation. Fo	r more refined or READY	optimized resu	lt, please use F	ILECAP or FOOT	ING program Print	u Ok C	v		4000	FLENAME           abc-dyn.mdl           VEW           FL-0, FIr-0, 0.0 m           ENGNEER           Nathan           APPROVED

[ ] Neglect Shear forces
 [x] Neglect Tension
 Capacity increased for temporary load = 1.20
 Capacity increased for temporary load \* F = 1.56

Axial Group Efficiency : (x) Converse-LabarreTie Beam size: B=30, H=60Uplift Head: 0 mRebar Dia, Db: 1.6 cm

(for medium earthquake load combination) (For large earthquake load combination)

(higher coefficient than standard / simple method)

(No uplift water pressure)

Total Foundation Type = 1 Foundation Type = 3(Square Pile), Size = 25, Depth = 18m, Pile capacity = 40, Tension = 20, Lateral = 2.0 ton

click [Run] to start the foundation design process.

(NOTE: Due to many iterations, it may requires some time to finish, usually couple of minutes).

#### **Output of the detail foundation design are:**

- Number of pile (from total load including weight of pile and pilecap, axial, shear, tension, moment force, group efficiency, gravity and earthquake load combinations)
- Recommended pilecap size and rebar diameter selection (checked for punching shear and bending moment)
- Detail calculation report for each support
- Foundation and Pilecap layout detail drawing

Detail Foundation Report:

SANSPRO Modeler: D:\TRAINING\TUTORIAL\ABC-Dyn.MDL - ABC Building	- 0 ×
SANSPRO Foundation Design Module (For this new version: Model can be run with any Load Factors) – 🗖 🗙 ign DiggTools Graph Report N	Ionlinear Help TutorMaker Quit
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Pilecap or Footing Size and Rebar Design	SANSPRO V.5.00
Support Foundation Nid x Nid y Thick db snx ton snx bot sny ton any bot	Standard Ver + DM
I Index Type & npile cm) (cm) (cm) (cm) (cm) (cm) (cm)	Floor View, Above Detail Drawing
1 3 x R 25 150.00 50.00 50.00 1.60 40.00 22.29 40.00 22.29	Support (x 1) Cap.Pile 34 ton
<b>1</b> 2 3 x x 25 150.00 150.00 50.00 1.60 40.00 22.25 40.00 22.25	Total = 31 Piles Beam Element
4 2 x R 25 150.00 75.00 50.00 1.60 37.65 15.06 40.00 30.00	ColWall Below Floor
<b>3</b> 5 3 x R 25 150.00 150.00 50.00 1.60 40.00 22.29 40.00 22.29	Unfactored Load
	R/R1 = 1.0
Mod 2 x R 25 150.00 75.00 50.00 1.60 37.65 15.06 40.00 30.00	Story Effects, LLr=0.70
9 3 x R 25 150.00 150.00 50.00 1.60 40.00 22.29 40.00 22.29	LoadComb = ALL (w, w/o EQ)
10 3 x R 25 150.00 150.00 50.00 1.60 40.00 22.29 40.00 22.29	
11 3 x R 25 150.00 150.00 1.60 40.00 22.29 40.00 22.29	
Total Number of Files/Footing = 34	LICENSEE
Total Pile Cost (Only piles) = 0.0	Ir. Nathan Madutujuh, M.Sc,
Total Slab or Filedap Cost = 1439/136.8	Bandung
Ideal cost (Filestolad/Filecap) = 1457/358.8	
Total Slab/Filecap Concrete Volume = 11.8 m3	
Total Slab/Pilecap Rebar Weight = 618.4 kg	PROJECT
	ABC Building
Ver 1 3(Smare Dile) az 25.0 cm Daz 40.0 ton	
Pilecap ( 0 piles) = 0 units	
Pilecap ( 2 piles) = 3 units	FILENAME
Pilecap ( 3 piles) = 8 units	abc-dyn mdl
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Total number of piles = 34 (a little bit larger than simplified design due to Shear forces considered in design) Pilecap size and recommended rebar diameter and spacing also given above.

Generating Pile foundation detail drawing :

SANSPRO provides easy way to generate and visually check the foundation results above as follows:

- click menu Graph – Detail Drawing



Enter the following parameters:

1		SANSF	RO Modeler: D:\TRAIN	ING\TUTORIAL\ABC-Dyn.	MDL - ABC Building		- 🗆 🗡
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	Image: Column Elevation         W           Detail Drawing         Column Elevation         W           Image: Turn ON Detail Drawing         English         Indonesian	etail Drawing Generator (0 al Elevation   Beam Table   Found   Drawing Name   FOUNDATION   Drawing Type   Drawing Border and Title   Dolumn Elevation Table   Wal Flevation Table	DNLY FOR SANSPRO + ation Staircase / Box / Elevat LAYOUT Column Section Detail Floor No. 4	DRAWING MODULE VERS or Userdef Axis StatCase2 De Wall Section Detail Floor No. 0 0	ION) – C × bug Generate Beam/Col Detail: Select Window Range		SANSPRO V.5.00 Standard Ver + DM Floor View, Above Support (x 1) Cap.Pile 34 ton Total = 31 Piles Beam Element ColWail Below Floor Reactions, Global RY
Image: Section 2         Image: Section 2           Image: Section 2	Paper Size and Direction Size USER	Wat Evidion 1 able     Beam Detail Table     Bran Detail Table     Forundang/Judna Section     Forundang/Judna Section     Forudang/Judna Section     Forudang/Judna Section     Forudang/Judna Section     Forudang/Judna Section     Forudang/Judna Section     Torwing Table Type     None     Standard 1     Brant Foundation (Thickened     Torwing Table Type     None     Standard 1     Brant Section Section     Torman Section     Forudang/Judna Section     S	Col Index 0 C Pos:	Wall Index 0 0 Pos:	Select All Objects on this Floor Get Beam Detal, max per Eltet Get Column Detal, max per Eltet Generate Beam/Col Detail (NEW): Get Beam Detal, individual, 1 Floor Get Column Detal, individual, 1 Floor Note Generate individual, 1 Floor		Unfactored Load RR1+1-0-70 Sent Effects, L+0-50 LeadComb = ALL (w, w/o EQ) LOCINSEE I. Nathan Maduujah, M.Sc, Bandung PROJECT ABC Building
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click [x] Turn ON Detail Drawing
click (x) Foundation Layout
Tie Beam Layout = 1
[ ] Show Pile Distance
[ ] Show Bored Pile detail

#### click [Ok]

zoom to enlarge the drawing.



Using this visual checking we can easily check the foundation design result and revise it if necessary.

The shown drawing can be exported to Autocad DXF by clicking menu Graph – Export Drawing.

## **Foundation Design Report :**

A very comprehensive detail calculation report for the foundation design is also given. To save some paper, only some reports for certain columns or support needed to be included in final report.

#### **Detail Foundation Report:**

SANSPRO V.5.10 Foundation Design Utility (C) Nathan Madutujuh, 1988-2017 Code: ACI-318-2011, PBI-91, PBI-2002, PBI-2013 Licensee: Ir. Nathan Madutujuh, M.Sc, Bandung

#### A. ASSUMPTIONS:

1. Reactions Forces

- Reactions are taken Automatically from Load Cases and combined into design group
- User Load Factors will not be used for combinations - Live Load Reduction Factors use user defined live load reductions:
- Live Load Reduction Factor for Storey Number LLRF1 = 0.7
- Live Load Reduction Factor for Temporer Load LLRF2 = 0.5
- Load combinations for maximum tension/uplift use 0.9\*DL
- Load combinations selected = ALL
- Use Vertical Earthquake, Av = 0.12
- Forces Included: N, Vx, Vz, Mux, Muz (Axial and Biaxial Bending)
- Axial forces used : Nmin, Nmax to accomodate compression and tension
- Foundation capacity is increased by 120.0 % for temporary loading

2. Spread Footing

- Three Conditions of Soil Stress Pattern (no tension allowed)
- Uplift Force is resisted by slab weight and soil weight
- Rebar Minimum uses value given by user (rho >= 0.15%)
- Slab Thickness is checked for punching shear
- Slab Rebar is calculated for compression and tension condition
- 3. Pile Foundation
  - Pile configuration is from standard/optimum configuration
  - Pile to pile/edge distance ratio are determined by user
  - Pile min/max force is determined using rigid slab assumption
  - Rebar Minimum uses value given by user (rho  $\geq 0.15\%$ )
  - Tension pile rebar is determined using max tension force
  - Capacity Design Method used
  - OmegaFacX = 3.00
  - OmegaFacZ = 3.00
  - RR1FAC = 0: Pile capacity is not increased, P = 1.0 x P
  - RR1FAC = 1: Pile capacity P = P x LFTEMP1 for temporary load (Default = 1.5) (moderate earthquake case)
  - RR1FAC > 0: Pile capacity P = P x LFTEMP2 for temporary load (Default = 2.5) (strong earthquake case, capacity design)
  - Pile capacity is NOT reduced by pile self-weight
  - Pile axial capacity is reduced by pile group efficiency
  - theta = ArcTan(D/s)eff = 1.0 theta \* ((n-1)\*m+(m-1)\*n)/(0.5\*Pi\*m\*n)

  - Pile lateral capacity reduction factor for 1x1 pile
    Pile lateral capacity reduction factor for 2x2 pile : 1.0
  - : 0.75 - Pile lateral capacity reduction factor for > 3x3 pile : 0.5

#### 4. Pilecap Design

- Pilecap size is from standard/optimum configuration
- Pilecap Thickness is checked for punching shear from column and group block Punching shear from column is neglected if d > 1.1\*(2\*dp-bcol)
- Mininum Thickness from punching shear of column is 1.1\*(2\*dp-bcol)
- Pilecap Thickness is checked for punching shear from pile
- Pilecap rebar is designed for nett bending (beam action)
- Pilecap rebar is designed differently for top and bottom rebar
   Minimum Pilecap rebar ratio is 0.18% to 0.25% depends on Fy or user defined
   Top and Bottom Concrete Cover can be different values
- Segment of pile embedded to pilecap is included in calculation
- Bending Moment Mx = cmbx \* P1, My = cmby \* P1
- Where P1 = Single Pile Compression Capacity
- Where cmbx, cmby are properties of pilecap configuration
- 5. Tie Beam/Sloof Design
  - Longitudinal rebar is designed for tension and bending
  - Tension is calculated from 10% of maximum column compression
  - Bending is calculated from self-weight and uplift force (LxW area)
- 6. Cost Calculation
  - Pile cost is unit cost per pile (for total length of pile)
  - Cost includes pilecap, excludes tie beam/sloof and basement slab
  - Only detail calculation for foundations with minimum cost are displayed
  - Unit price of concrete = 800000 / m3 Unit price of rebar = 8000 / kg

1. SUPPORT NO. 1, Node= 1, Location: x= 0.00000, y= 0.00000 phi,m = 0.80 phi,v = 0.60 fc1 = 291.0 kg/cm2 fy = 3900.0 kg/cm2 fyv = 3900.0 kg/cm2 fys = 2400.0 kg/cm2 s,ratio = 3.00 s1,ratio = 1.50 col,bx = 50.00 cm col,bz = 50.00 cm sloof db=1.60 cm, dbv=1.30 cm, dbs=1.20 cm pilecap db=1.60 cm, dbv=1.30 cm, dbs=1.20 cm foot db=1.60 cm, pile embeded=7.5 cm Unfactored forces: all(f1\*f2), static, temporary (f1\*f2), temporary (f1\*f2=1) Maximum Axial, Pu = 76829.8, 59124.4, 76829.8, 67637.6 kg Minimum Axial, Pu = 26024.8, 39813.1, 26024.8, 35217.0 kg.cm Moment, X-Dir, Mux = 1755788.9, 175691.4, 1755788.9, 708541.1 kg.cm Moment, Y-Dir, Muy = 2152478.2, 124274.1, 2152478.2, 803633.5 kg.cm Horiz Force, Vux = 7250.5, 1503.8, 7250.5, 3469.9 kg Horiz Force, Vuy = 7571.6, 911.3, 7571.6, 3156.2 kg Factored forces: all(f1\*f2), static, temporary (f1\*f2), temporary (f1\*f2=1) Factored forces: all(T1^T2), static, temporary (f1\*f2), temporary (f1\*f2)Single Axial, Pu =0.0,0.0Maximum Axial, Pu =88295.7,74148.0,88295.7, 74148.0,88295.7,79103.4 kgMinimum Axial, Pu =26024.8,39813.1,26024.8,39813.1,26024.8,35217.0 kg.cmMoment, X-Dir, Mux =1788530.4,222706.9,1788530.4,741282.6 kg.cmMoment, Y-Dir, Muy =2174762.3,159091.6,2174762.3,825917.7 kg.cmHoriz Force, Vux =7529.0,1909.3,7529.0,3748.4 kgHoriz Force, Vuy =7735.6,1165.7,7735.6,3320.2 kg PILE FOUNDATION DESIGN: 1. Pilecap Thickness: a. Given Pilecap Thickness, Tp = 30.70 cm b. From Punching of Single Pile: Factored Punching Force, 1 pile, Pu = 60000.00 kg Allowable Punching Stress, vc = 18.09 kg/cm2, fc1 = 291.00 kg/cm2 Perimeter Length of Punching Area, Kp1 = 200.00 cm Tpmin from Punch Shear of One Pile = 40.00 cm c. From Punching of Single Column: Prom Punching of Single Column: Punching of Single Column Status = Skipped Factored Punching Force, Column, Pu = 79103.45 kg Allowable Punching Stress, vc = 18.09 kg/cm2 Perimeter Length of Punching Area, Kp2 = 310.53 cm d. Minimum Thickness required by user, Tpmin = 50.00 cm e. Selected Pilecap Thickness, Tp = 50.00 cm Allowable Punching Stress, vc = 18.09 kg/cm2 Shear Stress, Punching of Pile, vc = 15.77 kg/cm2 -> OK Shear Stress, Punching of Column, vc = 14.95 kg/cm2 Neglected 2. Pile Number Calculation: a. First Trial (pilecap weight = 0, + for compression) 59.12 ton, Pcap1 =40.00 ton, np1=276.83 ton, Pcap1 =62.40 ton, np1=267.64 ton, Pcap1 =48.00 ton, np1=2 Unfactored Max Force, Static Load Pul = Unfactored Max Force, Temp. Load, F=f1\*f2, Pul = Unfactored Max Force, Temp. Load, F=1.0, Pul = Pilecap Weight Wpcap = 0.00 ton Weight of One Pile, Wp = 0.00 ton Gross Capacity of One Pile, Nett Capacity of One Pile, P1 = 40.00 ton 40.00 ton P1 = Number of Piles needed for Compression Force, Np1 = 2 piles Total Compression Capacity (No Earthquake), Pn = 80.00 ton -> OK Total Compression Capacity (f1\*f2=1.0), Pn = 96.00 ton -> OK Total Compression Capacity (Use f1\*f2), Pn = 124.80 ton -> OK Total Compression Capacity (Use f1\*f2), Pn = 124.80 ton -> OK Unfactored Min Force, (Tension=negative), Pumin = 35.22 ton Wpcap = 0.00 ton Pilecap Weight Unfactored Tension reduced by Pilecap Wgt, Tu = 0.00 ton (compression) No Tension Force Occured -> OK Unfactored Max Force, Static Load Unfactored Max Force, Temp. Load, F=f1\*f2, Unfactored Max Force, Temp. Load, F=1.0, 1.50 ton, Pcap1 = 20.00 ton, np1=1 7.57 ton, Pcap1 = 20.00 ton, np1=3 3.47 ton, Pcap1 = 20.00 ton, np1=2 V111 = Vul = Vul = Vu = P3 = 0.00 ton Unfactored Lateral Force, Lateral Capacity of One Pile, 2.00 ton Np3 = 3 piles Vn = 2.00 ton -> OK Vn = 4.80 ton -> OK Vn = 9.36 ton -> OK Number of Piles needed for Lateral Force, Total Lateral Capacity (No Earthquake), Total Lateral Capacity (f1\*f2 = 1.0), Total Lateral Capacity (f1\*f2 > 0), Number of Piles needed, Np = 3 piles b. Second Trial (with Pilecap Weight) 59.12 ton, Pcap1 = 76.83 ton, Pcap1 = 67.64 ton, Pcap1 = 40.00 ton, np1=2 62.40 ton, np1=2 48.00 ton, np1=2 Unfactored Max Force, Static Load Pul = Unfactored Max Force, Temp. Load, F=f1\*f2, Pu1 = Unfactored Max Force, Temp. Load, F=1.0, Pul = 67.64 ton, Pcap1 = Pilecap Weight Wpcap = 0.00 ton Unfactored Force + Pilecap Weight, Pul = 59.12 ton 0.00 ton Weight of One Pile, = qW

Gross Capacity of One Pile, P1 = 40.00 ton 40.00 ton Nett Capacity of One Pile, P1 = Number of Piles needed for Compression Force,Np1 = 2 piles Number of Piles needed for Compression tele, Total Compression Capacity (No Earthquake), Total Compression Capacity (f1\*f2=1.0), 80.00 ton -> OK 96.00 ton -> OK Pn = Pn = 124.80 ton -> OK Total Compression Capacity (Use f1\*f2), Pn = Unfactored Min Force, (Tension=negative), Pumin = 35.22 ton Wpcap = 0.00 tonPilecap Weight Unfactored Tension reduced by Pilecap Wgt, Tu = 0.00 ton (compression) No Tension Force Occured -> OK Number of Pile needed, Np = 3 piles 

 Compres: Pl = (Nmax+Mpcap-Po)/np =
 23445.85 kg, dPMx =
 4723.61 kg, dPMy =

 Tension: Pl = (Nmin+Wpcap-To)/np =
 12639.00 kg, dPMx =
 4723.61 kg, dPMy =

 Pcomp=
 52000.00 Ptens=
 26000.00, Plmax =
 33527.01, Plmin =
 2557.84

 5357.56 kg 5357.56 kg c. Third Trial (with Group Efficiency and Bending Moment) Number of Pile needed, 3 piles Np = = Converse-Labarre e = 0.795 Group Efficiency Method Group Efficiency, Unfactored Max Force, (+ -> compression), Pumax = 76.83 ton Unfactored Min Force, (Tension=negative), Pumin = 26.02 ton Pilecap Weight Wpcap = 2.70 ton Pu1 = 59.12 ton Unfactored Max Force + Pilecap Weight, Unfactored Min Force + Pilecap Weight, 37.92 ton Weight of One Pile, = aW 0.00 ton 40.00 ton 40.00 ton Gross Compression Capacity of One Pile, P1 = Nett Compression Capacity of One Pile, P1 = 20.00 ton 20.00 ton 33.53 ton -> OK Tension Capacity of One Pile, P2 = Tension Capacity of One Pile + Pile weight, P22 = Maximum Compression on Pile, Plmax = Minimum Compression on Pile, Plmin = 2.56 ton -> OK Concrete Slab Design Status, X-Direction = OK Concrete Slab Design Status, Y-Direction = OK Optimum Foundation Selected, Index = 1 Pile, Rect, a= 25 cm Pile Size Parameter: a = 25.00000 cm 25.00000 cm b = 75.00000 cm sp = spl = 37.50000 cm spx = 75.00000 cm spy = 75.00000 cm 625.00000 cm2 = qA 25.00000 cm dp = Apw = 0.00000 cm2 Kp = 100.00000 cm Kpl = 200.00000 cm PILE FOUNDATION DESIGN. 1. Pilecap Thickness: a. Given Pilecap Thickness, Tp = 30.70 cm b. From Punching of Single Pile: Factored Punching Force, 1 pile, Pu = Allowable Punching Stress, vc = 60000.00 kg 18.09 kg/cm2, fc1 = 291.00 kg/cm2 Perimeter Length of Punching Area, Kp1 = 200.00 cm Tpmin from Punch Shear of One Pile 40.00 cm c. From Punching of Single Column: = Skipped Punching of Single Column Status Factored Punching Force, Column,Pu = 79103.45 kgAllowable Punching Stress,vc = 18.09 kg/cm2Perimeter Length of Punching Area, Kp2 = 310.53 cm d. Minimum Thickness required by user, Tpmin = 50.00 cm e. Selected Pilecap Thickness, Tp = 50.00 cm Allowable Punching Stress, vc = 18.09 kg/cm2 Shear Stress, Punching of Pile, vc = 15.77 kg/cm2 -> OK Shear Stress, Punching of Column, vc = 14.95 kg/cm2 Neglected 2. Pile Number Calculation: a. First Trial (pilecap weight = 0, + for compression) 40.00 ton, np1=2 62.40 ton, np1=2 48.00 ton, np1=2 Unfactored Max Force, Static Load P111 = 59.12 ton, Pcap1 = Unfactored Max Force, Temp. Load, F=f1\*f2, P111 = 76.83 ton, Pcap1 = Unfactored Max Force, Temp. Load, F=1.0, 67.64 ton, Pcap1 = P111 = Pilecap Weight Wpcap = 0.00 ton Weight of One Pile, = qW 0.00 ton 40.00 ton P1 = Gross Capacity of One Pile, Nett Capacity of One Pile, P1 = 40.00 ton Number of Piles needed for Compression Force, Np1 = 2 piles Total Compression Capacity (No Earthquake), Pn = 80.00 ton -> OK Total Compression Capacity (f1\*f2=1.0), Pn = 96.00 ton -> OK Total Compression Capacity (Use f1\*f2), Pn = 124.80 ton -> OK 124.80 ton -> OK 35.22 ton Unfactored Min Force, (Tension=negative), Pumin = 0.00 ton Pilecap Weight Wpcap = Unfactored Tension reduced by Pilecap Wgt, Tu = 0.00 ton (compression)

Vul =1.50 ton, Pcap1 =20.00 ton, npl=1Vul =7.57 ton, Pcap1 =20.00 ton, npl=3Vul =3.47 ton, Pcap1 =20.00 ton, npl=2Vu =0.00 ton Unfactored Max Force, Static Load Unfactored Max Force, Temp. Load, F=f1\*f2, Unfactored Max Force, Temp. Load, F=1.0, Unfactored Lateral Force, Lateral Capacity of One Pile, P3 = 2.00 ton 
 Np3 =
 3 piles

 Vn =
 2.00 ton -> OK

 Vn =
 4.80 ton -> OK

 Vn =
 9.36 ton -> OK
 Number of Piles needed for Lateral Force, Total Lateral Capacity (No Earthquake), Total Lateral Capacity (f1\*f2 = 1.0), Total Lateral Capacity (f1\*f2 > 0), Number of Piles needed, Np = 3 piles b. Second Trial (with Pilecap Weight) 59.12 ton, Pcap1 =40.00 ton, np1=276.83 ton, Pcap1 =62.40 ton, np1=267.64 ton, Pcap1 =48.00 ton, np1=2 Unfactored Max Force, Static Load Pul = Unfactored Max Force, Temp. Load, F=f1\*f2, Pu1 = Unfactored Max Force, Temp. Load, F=1.0, Pul = Wpcap = 2.70 ton Unfactored Force + Pilecap Weight, Pul = 59.12 ton 0.00 ton Wp = Weight of One Pile, 40.00 ton 40.00 ton Gross Capacity of One Pile, P1 = Nett Capacity of One Pile, P1 = Number of Piles needed for Compression Force, Np1 = 2 piles Total Compression Capacity (No Earthquake), Pn = 80.00 ton -> OK Total Compression Capacity (f1\*f2=1.0), Pn = 96.00 ton -> OK Total Compression Capacity (Use f1\*f2), Pn = 124.80 ton -> OK Total Compression Capacity (Use f1\*f2), Pn = 124.80 ton -> OK Unfactored Min Force, (Tension=negative), Pumin = Pilecap Weight Wpcap = Unfactored Tension reduced by Pilecap Wgt, Tu = 35.22 ton 2.70 ton 0.00 ton (compression) No Tension Force Occured -> OK Number of Pile needed, Np = 3 piles Pile Configuration: np, total = 3, npx= 2, npy= 2 Pilecap, bx= 150.0 cm, by= 150.0 cm Column Block size, cx= 50.0 cm, cy= 50.0 cm Furthest pile, xp,max = 37.50, yp,max= 37.50 Sigma dx<sup>2</sup> = 5625.00, Sigma dy<sup>2</sup> = 5625.00 Bending Moment Coefficient, cmbx = 25.00000, cmby = 25.00000 Bending Moment (Factored) : Mx = 1400000.00000 kg.cm, My = 1400000.00000 kg.cm Compres: Pl = (Nmax+Wpcap-Po)/np = 23445.85 kg, dPMx = 4723.61 kg, dPMy = Tension: Pl = (Nmin+Wpcap-To)/np = 12639.00 kg, dPMx = 4723.61 kg, dPMy = 5357.56 kg 5357.56 kg 52000.00 Ptens= 26000.00, P1max = 33527.01, P1min = 2557.84 Pcomp= c. Third Trial (with Group Efficiency and Bending Moment) Pile Configuration: np, total = 3, npx= 2, npy= 2 Pilecap, bx= 150.0 cm, by= 150.0 cm Column Block size, cx= 50.0 cm, cy= 50.0 cm Furthest pile, xp,max = 37.50, yp,max= 37.50 Sigma dx^2 = 5625.00, Sigma dy^2 = 5625.00 Bending Moment Coefficient, cmbx = 25.00000, cmby = 25.00000 Pardia Marent (Textend), Mus = 1400000, 0000, cmby = 25.00000 Bending Moment (Factored) : Mx = 1400000.00000 kg.cm, My = 1400000.00000 kg.cm Np = 3 piles Number of Pile needed, e = 0.795 Group Efficiency Method Group Efficiency, e Pumax = 76.00 c. - 26.02 ton Unfactored Max Force, (+ -> compression), Unfactored Min Force, (Tension=negative), Pilecap Weight Unfactored Max Force + Pilecap Weight, Wpcap = 2.70 ton 59.12 ton 37.92 ton P111 = Unfactored Min Force + Pilecap Weight, Pu2 = 0.00 ton Weight of One Pile, Wp = 0.00 ton 40.00 ton 20.00 ton 20.00 ton 33.53 ton -> OK 2 56 ton Gross Compression Capacity of One Pile, P1 = P1 = Nett Compression Capacity of One Pile, Tension Capacity of One Pile, Tension Capacity of One Pile + Pile weight, P2 = Tension Capacity of One Pile + Pile weight, ite Maximum Compression on Pile, Plmax = Plmin = 2.56 ton -> OK Concrete Slab Design Status, X-Direction = OK Concrete Slab Design Status, Y-Direction = OK 3. Pilecap Rebar Design: = 0.20 % Rebar pct min Minimum Rebar Spacing = 10.00 cm Bx, By, Tp = 150.00 x 150.00 x 50.00 Bending Section in X-direction, b = 150.00 cm, h = 50.00 cm Bending Section in Y-direction, b = 150.00 cm, h = 50.00 cm Bending Moment in X-direction, Mpx = 1400000.00 kg.cm Bending Moment in Y-direction, Mpy = 1400000.00 kg.cm Rebar Spacing, X-Dir, Bottom = d16- 22.3 cm (0.28) Rebar Spacing, X-Dir, Top = d16- 40.0 cm (0.16) Rebar Spacing, Y-Dir, Bottom = d16- 22.3 cm (0.28) Rebar Spacing, Y-Dir, Top = d16- 40.0 cm (0.16%)

No Tension Force Occured -> OK

#### TIE BEAM DESIGN:

Tie Beam / Sloof Width,	В	=	30.00	cm
Tie Beam / Sloof Width,	Н	=	60.00	cm
Factored Maximum Column Axial Load,	Pu	=	79103	.45 ton
10% of Factored Axial Load,	Tu	=	7910	.34 ton
Required Rebar for Tension,	Ast	=	2.54	cm2
Nett Uplift Height,	Hw	=	0.00	m
Tie Beam / Sloof Length,	L	=	8.00	m
Tie Beam / Sloof Tributary Width,	W	=	6.00	m
Distributed Load on Tie Beam,	qL	=	0.00	kg/m
Distributed Weight on Tie Beam,	qsw	= 4	32.00	kg/m
Bending Moment,	Mql	= 2	76480	.00 kg.cm
Shear Force,	Vql	=	1728	.00 kg
Req. Rebar for Bending Moment, Bo	ttom	=	4.02	cm2
Req. Rebar for Bending Moment,	Тор	=	1.87	cm2
Longitudinal Rebar, at Support = 3	d16	/ 2	d16	
Longitudinal Rebar, at Midspan = 2	d16	/ 3	d16	
Shear Reinforcement Spacing at Supp	ort =	= d13	-	0.00

- 2. Example 11: Simple Slope Stability Analysis
- 3. Example 12: Soldier Pile Design using Linear Spring
- 10. Advanced Building Design
  - 1. Example 12: Stage Construction Sequential Loading Analysis
  - 2. Example 13: Concrete Shearwall Design
  - 3. Example 14: Drift, P-Delta, Story Shear Checking
  - 4. Example 15: Dual System Design Checking
  - 5. Example 16: Diaphragm Chord and Collector Design
  - 6. Example 17: Pile-Raft Foundation Design
- 11. Steel Building Design
  - 1. Example 18: Basic Steel Building Design
  - 2. Example 19: Bracing Design using Stage Construction Sequential Loading
  - 3. Example 20: Beam-Column Steel Connection Design
  - 4. Example 21: Steel Capacity Design
  - 5. Example 22: Beam with Tapered Section
- 12. Nonlinear Analysis and Direct Integration Analysis
  - 1. Example 23: Soldier Pile with Nonlinear Spring
  - 2. Example 24: Geometrically and Materially Nonlinear Truss Analysis
  - 3. Example 25: Dynamic Direct Impact Load Analysis
- 13. Special Structures Design (Optional)
  - 1. Example 26: B-Panel Building Design
  - 2. Example 27: Cold-formed Steel Building Design
  - 3. Example 28: Blast Door Design
- 14. Additional Design Tools (Optional)
  - 1. Example 29: Concrete Section Design
  - 2. Example 30: Concrete Beam-Column Joint Design
  - 3. Example 31: Concrete Rebar and Cutting Plan
  - 4. Example 32: Concrete Shearwall Design
  - 5. Example 33: Concrete Retaining Wall Design
  - 6. Example 34: Concrete Footing Design
  - 7. Example 35: Concrete Pilecap Design
  - 8. Example 36: Steel Database and Design Search
  - 9. Example 37: Steel Purlin Design
  - 10. Example 38: Steel Connection Design