

# Foundation Design with SANSPRO

## 1. Simple Design : Axial Only, No Group Efficiency

- [x] Show N<sub>pile</sub>, P1 = 40 ton (for Minipile 25x25, 18m, 40 ton axial capacity)
- [x] Unfactored Support Reaction
- [x] Live Load Reduction, Storry Effects = 0.80 (NF ≤ 4)
- [x] Live Load Reduction, Earthquake = 0.50 (Public space, storage, parking, etc)
- Reactions Scale Option = x 1000 (for Ton unit)

The screenshot shows the SANSPRO Modeler interface with a floor plan view. The plan displays several pile reaction points labeled as follows:

- Top-left: 2p (78.6)
- Top-center: 4p (120.2)
- Top-right: 3p (88.9)
- Far-right: 1p (35.4)
- Middle-left: 4p (123.8)
- Middle-right: 5p (193.9)
- Bottom-left: 2p (79.0)
- Bottom-center: 4p (120.4)
- Bottom-right: 3p (105.7)
- Far-bottom-right: 1p (37.1)

The 'Model View Option' dialog box is open, showing various settings for the analysis and display. Key settings include:

- Display Option:** Show Support Reaction, Show Element Forces, Show Force Diagram, Show Axial Column, Show Beam Relative Disp.
- Element Model:** Global Forces Local Direction: Axial, Torsion, Major Shear, Minor Moment, Major Moment.
- Design Output:** Global Axis Directions: DX/RX, TY/MY, TZ/MZ.
- FE QUAD4 Element Stress & Disp Contour Option:** Show FE Stress Contour, Use FE Average Values, Save Stress to File, Stress Range Only for Current Floor, Show Maximum Slab Stresses, Fast Display (1 colour per element), Show Stresses Legend, Show Displacement Contour (Dx,Dy,Dz,Tx,Ty,Tz), Use HSL Contour Color Table.
- Support Reaction Option:** Automatic Load Comb (Inchek - Userdef), Show N pile, P1 = 40.0 [ton, Existing Pile, P1 = 0.0 [ton], Show Reactions x R/R1 (Capacity Drgn, w/EQ), Show Unfactored Support Reactions, Live Ld Reduction, Storry Effects = 0.80, Live Ld Reduction, Earthquake = 0.50, Increase Capacity 30% for Temporary Load, Show Support Group Id, ALL for or w/EQ, Show Absolute Value, DL+LL, DL+LL+EQ, Automatic LL Reduction.

On the right side of the interface, there is a summary table:

SANSPRO V.5.00 Standard Ver + DM
Floor View, Above Support (x 1000) Cap.Pile 40 ton Total = 35 Piles Beam Element Col/Wall Below Floor Joint Load Reactions, Global RY Unfactored Load R/R1 = 1.0 Storry Effects, LL=0.80 Earthquake, LL=0.50 LoadComb = ALL (w, w/o EQ)
LICENSEE Ir. Nathan Madutujuh, M.Sc. Bandung
PROJECT
FILENAME kantor1.mdl
VIEW FL-0, Fir-0, 0.0 m
ENGINEER
APPROVED
RPT DATE

## Result:

The screenshot shows the same floor plan view as above, but with updated pile reactions:

- Top-left: 2p (78.6)
- Top-center: 4p (120.2)
- Top-right: 3p (88.9)
- Far-right: 1p (35.4)
- Middle-left: 4p (123.8)
- Middle-right: 5p (193.9)
- Bottom-left: 2p (79.0)
- Bottom-center: 4p (120.4)
- Bottom-right: 3p (105.7)
- Far-bottom-right: 1p (37.1)

The 'Result' table on the right side is updated with the following information:

SANSPRO V.5.00 Standard Ver + DM
Floor View, Above Support (x 1000) Cap.Pile 40 ton Total = 35 Piles Beam Element Col/Wall Below Floor Joint Load Reactions, Global RY Unfactored Load R/R1 = 1.0 Storry Effects, LL=0.80 Earthquake, LL=0.50 LoadComb = ALL (w, w/o EQ)
LICENSEE Ir. Nathan Madutujuh, M.Sc. Bandung
PROJECT
FILENAME kantor1.mdl
VIEW FL-0, Fir-0, 0.0 m
ENGINEER
APPROVED
RPT DATE

# Simplified Foundation Capacity Design:

[x] Show Reactions x R/R1 (Capacity Design with W\*EQ)

## Reactions Submitted to Geotechnical Engineers (TPKB1):

### 1. All Load Combination : DL + LLr +/- EQ

For Axial (Ry), Horizontals (Rx, Rz), Moment (Mx, Mz) : 5 pages

[ ] Show Reactions x R/R1 (Capacity Design with W\*EQ)

### 2. DL+LLr (Gravity Load Only)

For Axial (Ry), Horizontals (Rx, Rz), Moment (Mx, Mz) : 5 pages

[ ] Show Reactions x R/R1 (Capacity Design with W\*EQ)

### 2. DL+LLr + w\*EQ

For Axial (Ry), Horizontals (Rx, Rz), Moment (Mx, Mz) : 5 pages

[x] Show Reactions x R/R1 (Capacity Design with W\*EQ)

## 2. Capacity Design : Axial, Horizontal, Moment Force, Group Efficiency, Pile distance, etc.

[ ] Design for Axial only

[ ] Neglect Horizontal Forces

[x] Neglect Tension Force

[x] Foundation Capacity Design

Axial Group Efficiency = Converse-Labarre

### Total Foundation Type = 2

1 = Minipile, Triangle, T28, 18m, Compression = 25 ton, Tension=12.5 ton, Lateral = 1.25 ton

2 = Minipile, Square, R25, 18m, Compression = 40 ton, Tension=20 ton, Lateral = 2.0 ton

The screenshot displays the SANSPRO Modeller software interface. The main window shows the 'Foundation Design Module' with various design parameters and a table of results. The results table is as follows:

No.	Foundation Type	Size (a+b)D	Thickness	Depth or L	Soil Strength	Pile Capacity	Tension Capa.	Lateral Capa.	Cost
		cm	cm	m	qa (kg/cm2)	Pc (ton)	Pt (ton)	Ph (ton)	Unit Price
1	1(Triangle Pile)	28	0	18	0	25	12.5	1.25	0
2	2(Square Pile)	25	0	18	0	40	20	2	0

The software interface also shows design parameters such as 'Axial Group Efficiency' (0.75), 'Concrete Properties' (F<sub>ck</sub> = 291 kg/cm<sup>2</sup>), and 'Rebar Properties' (Rebar F<sub>y</sub> = 3900 kg/cm<sup>2</sup>). The status bar at the bottom indicates 'HEADY' and 'Generate Only Design Forces for Foundation Design'.

# Result:

## Pilecap or Footing Size and Rebar Design

Support Index	Foundation Type & npile	Wid,x (cm)	Wid,y (cm)	Thick (cm)	db (cm)	spx,top (cm)	spx,bot (cm)	spy,top (cm)	spy,bot (cm)
1	3 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
2	4 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
3	3 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
4	2 x R 25	150.00	75.00	50.00	1.60	40.00	30.00	40.00	30.00
5	4 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
6	5 x R 25	181.06	181.06	50.00	1.60	37.36	14.94	37.36	14.94
7	4 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
8	2 x R 25	150.00	75.00	50.00	1.60	40.00	30.00	40.00	30.00
9	3 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
10	4 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
11	3 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
12	2 x R 25	150.00	75.00	50.00	1.60	40.00	30.00	40.00	30.00

Total Number of Piles/Footing = 39  
 Total Pile Cost (Only piles) = 0.0  
 Total Slab or Pilecap Cost = 15323947.5  
 Total Cost (Piles+Slab/Pilecap) = 15323947.5  
  
 Total Slab/Pilecap Concrete Volume = 12.3 m3  
 Total Slab/Pilecap Rebar Weight = 575.0 kg

1. 2(Triangle Pile), a= 28.0 cm, Pa= 25.0 ton

Pilecap ( 0 piles) = 0 units

2. 3(Square Pile), a= 25.0 cm, Pa= 40.0 ton

Pilecap ( 0 piles) = 0 units  
 Pilecap ( 2 piles) = 3 units  
 Pilecap ( 3 piles) = 4 units  
 Pilecap ( 4 piles) = 4 units  
 Pilecap ( 5 piles) = 1 units

## Visual Foundation Checking

Klik Graph – Detail Drawing

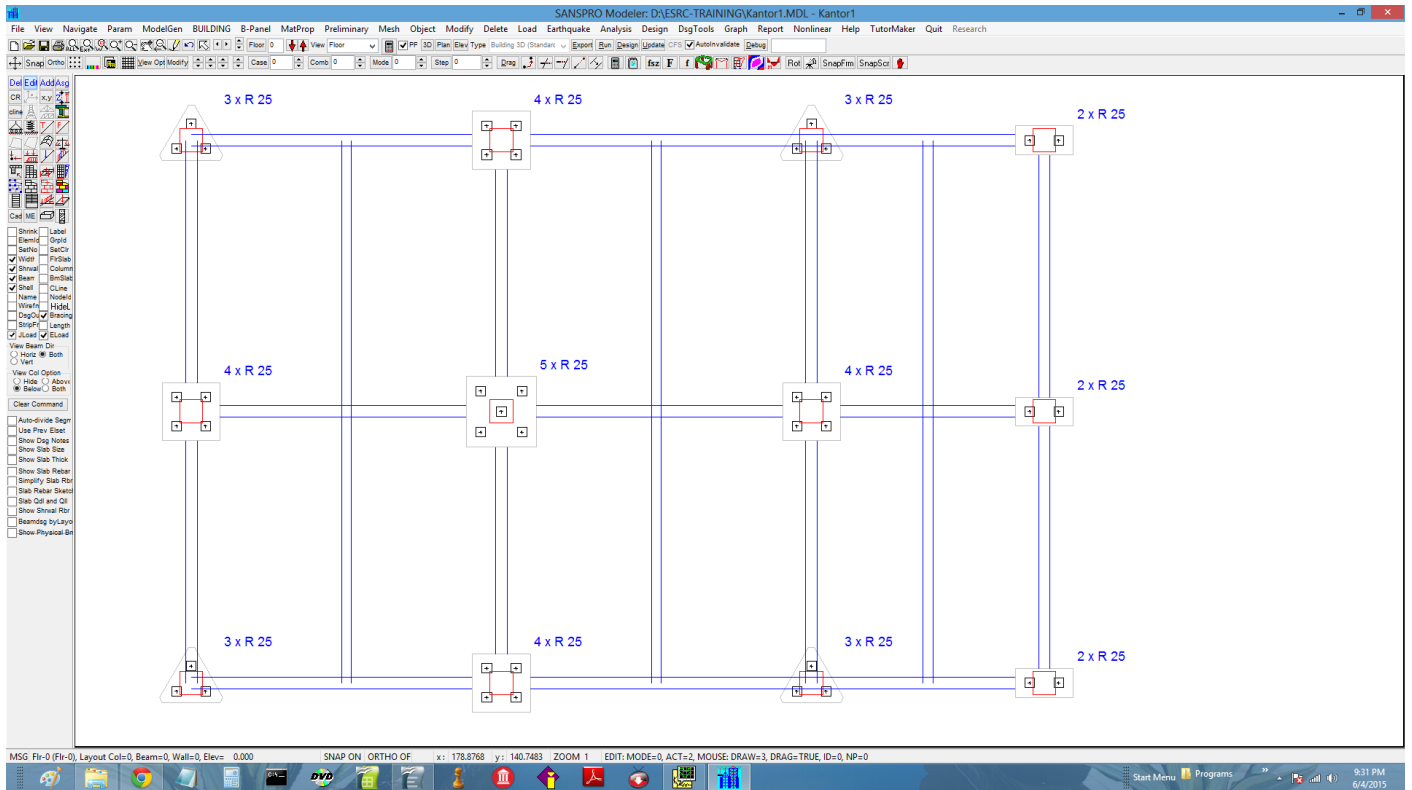
[x] Turn On Detail Drawing (at Top-Left)

Drawing Type = Foundation Drawing

Tie Beam Layout = 1 (Use first floor beam layout, if not provided)

[ ] Show Pile Distance

Klik [OK] then klik menu icon [Width] then zoom it !



**The result is the number of piles needed is larger than the simplified design because:**

1. Group efficiency will reduce the axial capacity
2. Horizontal forces requires more piles than compression force  
Some Solutions:
  - a. Use pile with large lateral capacity or inclined pile
  - b. Replace and compact the first 1-2m top soil layer with sand or gravel.
  - c. Horizontal forces can be neglected if there is basement floor

If we neglect the horizontal forces, the result will be close to the simplified design.

Support Index	Foundation Type & npile	Wid,x (cm)	Wid,y (cm)	Thick (cm)	db (cm)	spx,top (cm)	spx,bot (cm)	spy,top (cm)	spy,bot (cm)
1	3 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
2	4 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
3	3 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
4	1 x R 25	75.00	75.00	50.00	1.60	40.00	30.00	40.00	30.00
5	4 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
6	5 x R 25	181.06	181.06	50.00	1.60	37.36	14.94	37.36	14.94
7	4 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
8	2 x R 25	150.00	75.00	50.00	1.60	40.00	30.00	40.00	30.00
9	3 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
10	4 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
11	3 x R 25	150.00	150.00	50.00	1.60	40.00	30.00	40.00	30.00
12	1 x R 25	75.00	75.00	50.00	1.60	40.00	30.00	40.00	30.00

Total Number of Piles/Footing = 37  
 Total Pile Cost (Only piles) = 0.0  
 Total Slab or Pilecap Cost = 14647535.1  
 Total Cost (Piles+Slab/Pilecap) = 14647535.1

Total Slab/Pilecap Concrete Volume = 11.8 m3  
 Total Slab/Pilecap Rebar Weight = 551.2 kg

1. 2(Triangle Pile), a= 28.0 cm, Pa= 25.0 ton

Pilecap ( 0 piles) = 0 units

2. 3(Square Pile), a= 25.0 cm, Pa= 40.0 ton

Pilecap ( 0 piles) = 0 units

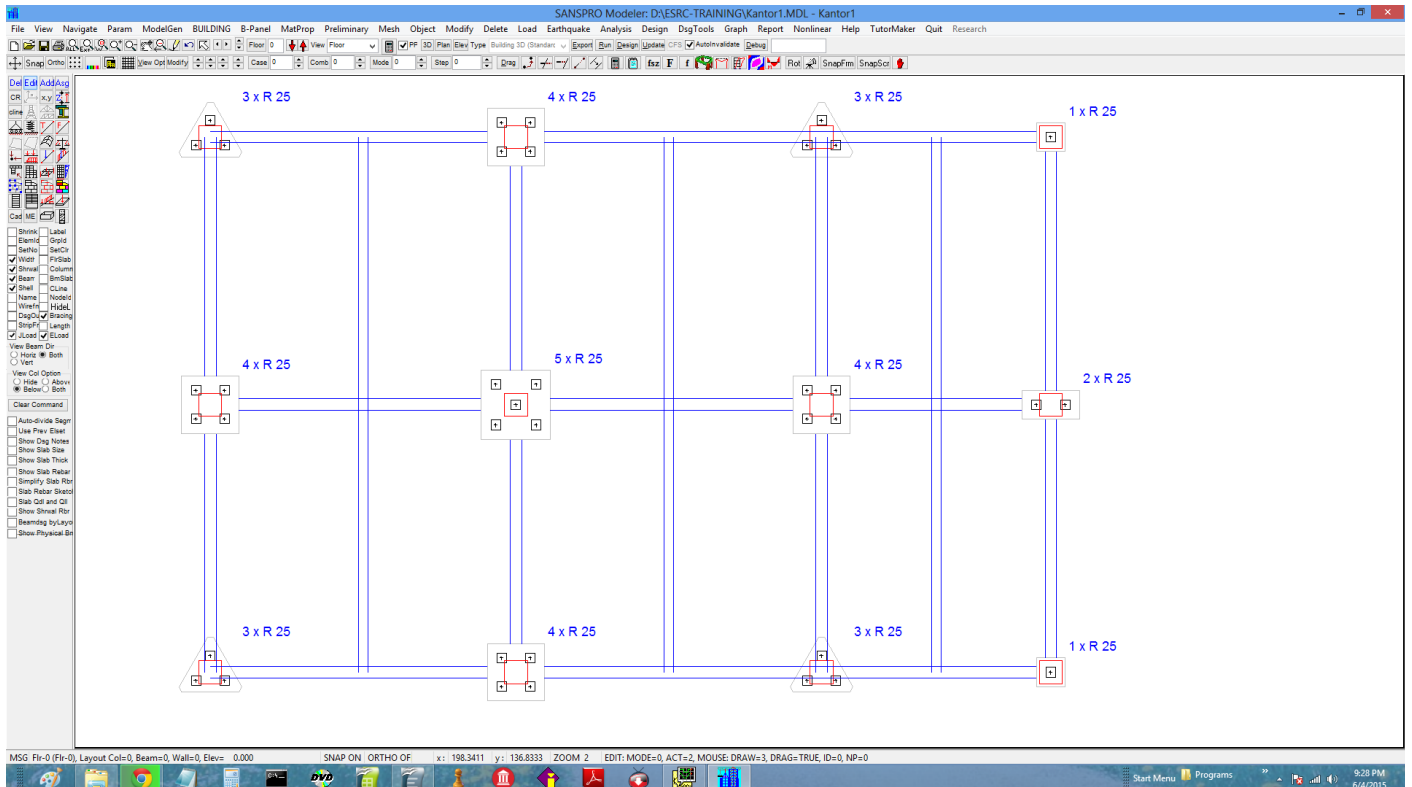
Pilecap ( 1 piles) = 2 units

Pilecap ( 2 piles) = 1 units

Pilecap ( 3 piles) = 4 units

Pilecap ( 4 piles) = 4 units

Pilecap ( 5 piles) = 1 units



## Notes on Foundation Design:

### 1. Typical Foundation Capacity

#### Mini Pile      Axial capacity (ton)

T28	25-30
T32	30-40
R20	25-30
R25	30-40

#### Precast Pile

R30	40-60
R35	40-60
R40	50-70
R45	60-90

#### Bored Pile

D30	30-40
D40	40-60
D50	50-70
D60	90-150
D80	150-250
D100	300-600
D120	500-800

#### Spun Pile

D60	90-150
D80	150-250

#### Franki Pile

D50	70-120 ton
-----	------------

Tension pile capacity = 50% of axial capacity

Lateral pile capacity = 5% of axial capacity

Minimum diameter or size of Pile =  $L/100$  (L=30m, minimum size = 30 cm)

Pile-Pile distance = 3 to 6 D, Pile-Edge distance = 1.5 to 3 D

Note: These values are just rough estimation, consult geotechnical engineer for more accurate one.

### 2. For location with potential for liquefaction

Earthquake magnitude > MW6

Layer of loose sand ( $N_{spt} < 25$ ) is thicker than 3m

High ground water level

Usually found at : Coastal cities (Padang, Ende, Maumere, etc)

- Pile foundation must go through the liquefaction layer to bedrock layer
- Friction within and above liquefaction layer must be set to zero  
(Reduction in pile capacity)
- Use raft foundation or raft-pile to reduce large differential settlement due to liquefaction

### **3. For location with very soft soil at top layer, resisting large load**

Usually found at: Mine storage area

Pile load capacity will be reduced by Negative Skin Friction (around 20-50%)

Pile must go through the bedrock

Use raft or raft-pile to reduce large differential settlement

### **4. For location with expansive soil**

Usually found at : area with high plasticity of soil

Signs: not flat surface, differential settlement of ground slab, cracking of ceramic tile

Additional test : Swelling test

- Swelling pressure can be from 0.1 to maximum of 15 ton/m<sup>2</sup>
- Pile load capacity will be reduced significantly by expansive soil (20-50%)
- Layer of expansive soil can be at top layer or middle layer of soil
- Expansive soil at top layer can be deactivated by mixing with cement or lime.
- Pilecap must be separated with ground slab with gap filled with tar or flexible material
- Surrounding soil must be kept from direct contact with surface or rain water

### **5. For location with very soft soil, very deep bedrock**

- Use raft foundation or raft pile
- Use Caisson system (Pondasi laba-laba, cakar ayam, etc)
- Use Floating foundation

Raft contribution for raft-pile system must be considered zero

Raft foundation must be design as elastic system (with omega factor)

### **6. For location with shallow stiff soil**

- Use raft foundation or raft pile
- Use Caisson system (Pondasi laba-laba, cakar ayam, etc)
- Use Floating foundation

Reduce load by weight of excavated soil when calculating bearing pressure of raft

Raft contribution for raft-pile system is maximum 25% of the total load

Raft foundation must be design as elastic system (with omega factor)