INSIDE Buildmaster

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Welcome back to **INSIDE BUILD-MASTER !**

**Mat foundation** or **Raft Slab** is commonly used where the base soil has a low bearing capacity or the column loads are so large, that the conventional spread footings overlap each other, as in the case of multi storied buildings.

Since mat foundations require both positive and negative steel at top and bottom of the slab, use of **spread footings** is **more economical** as compared with the cost of mat foundations. It is therefore preferred to use spread footings wherever possible.

Mat foundation is useful for the buildings with deep **basements** both to spread the column loads to a more uniform pressure distribution and also to provide the floor slab for the basement. It also helps as a water barrier for basements below Ground water table. Mat foundations are also used where settlement of foundation is a problem.

**Common types** of mat foundations are (i) Flat Plate, (ii) Flat Plate with Inverted Beams (iii) Flat Plate with Pedestals and (iv) Flat Plate with Rock Anchors. There are many methods to design a mat foundation. However two main methods of designing it with the computer programs are **Finite Element Method** (FEM) and **Finite Grid Method** (FGM).

Many programs are available now a day to do the Finite Element Analysis. However FEM output is very difficult to interpret. Concentrated Loads and Moments can be added easily but the nodal static check is difficult. Similarly vertical force summation is not easy since element node shears are difficult to compute, since Moments are obtained on a unit width basis in FEM.

**J. E. Bowles**, the author of book 'Foundation Analysis and Design' **does Not recommend** the use of **FEM for mat and plate problems**. There are many situations where FEM is particularly suited, however FGM is preferred for the more direct solution of foundation engineering problems.

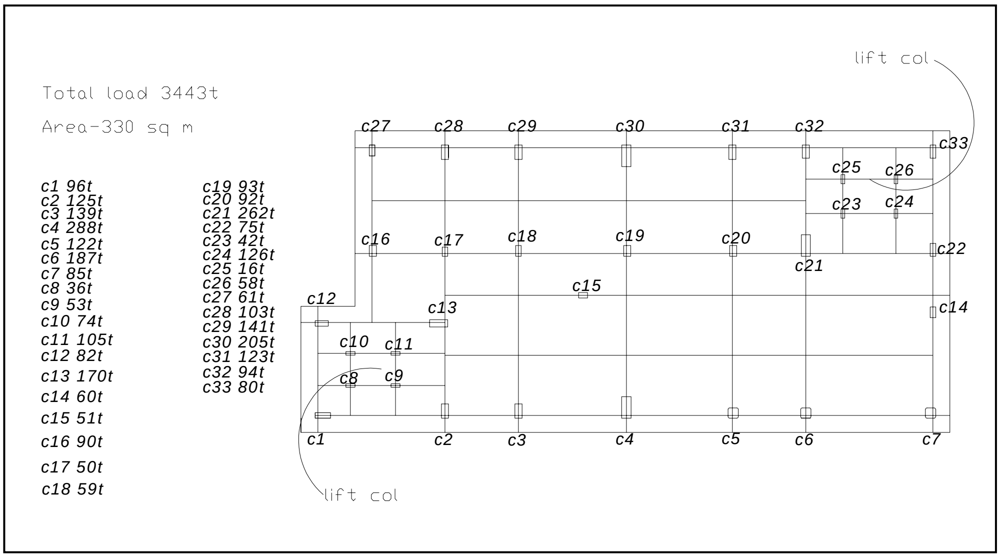
The procedure of idealizing **Raft Slab** or **Mat Foundation** with **Build-Master** using FGM method as per the above book is described here in brief.

# Idealizing Raft Slab with Build-Master

A Raft slab actually provided for a GR+7 storied building is taken here as an example.

Analysis & design of (building) superstructure was first carried out with **Build-Master** and **Column Reactions** at the Foundation level were obtained.

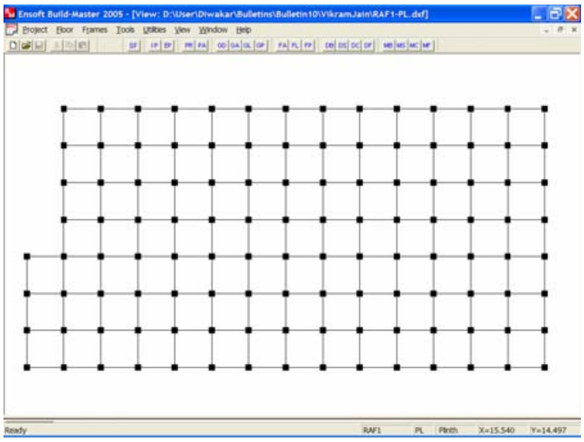
Following are the forces read from .FOT file.




**Raft Slab** is idealized as a separate structure with **Slab** resting **on Soil**. Reactions of Columns of the Building above are applied as **External Loads** on this Slab at the Positions of the Columns as shown in the above Figure. **Soil** is idealized as **Springs** at equal intervals. Stiffness of the soil is assigned to these springs. Springs are assumed fixed at their base. Soil is a soft / flexible material, it can withstand only compressive force, ( can not take tension). Spring also have stiffnes only in one direction along its axis. If we do not allow tension to come in springs in this model, Springs represent the soil appropriately. When the analysis is done of this model, the recations of the springs represent the bearing pressure of the Soil. This pressure at all portions of the slab shall be less than the bearing capacity of soil.

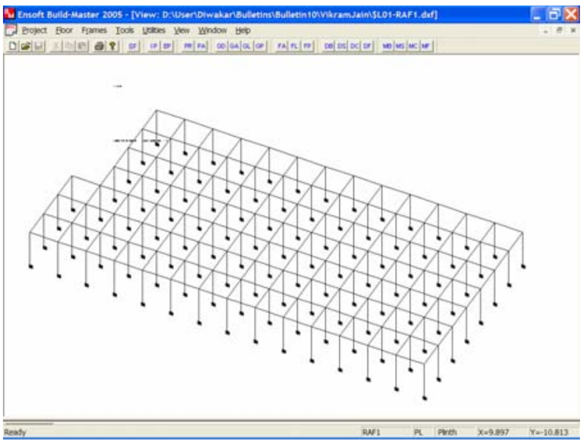
This **Raft Slab model** is idealized as a single storey structure is **Build-Master**. **Slab** is idealized as equidistant **Grid of Beams**. Width of Beams is assumed to be half the spacing between them, so that the self-weight of beams is equal to self-weight of the slab. **Columns** are placed at every intersection of Grid Beams to represent Springs. Equivalent Stiffness of the soil is assigned to these columns. **Loads** of the actual Columns of the Building are applied as Point Loads on the Grid Beams at the Locations of the actual Columns.

Start a new **Building Project** in Build-Master with Number of Levels equal to 1 and Storey height below Plinth = 3.0 Mt. Draw a mesh of **Beams** with equal spacing of 2mt x 2mt on both the sides.
Assume Beam Width = 1mt (Half the Beam Spacing) and Beam Depth = Raft Slab Thickness.



**Slabs** generated by Build-Master between this mesh of beams are to be ignored. To do this all these slabs are made of Zero Thickness with Zero Superimposed Dead Load and Live Load on it.

Add **Columns** at every intersection of the Grid Beams.
Calculate the size of Column to be assigned, such that the stiffness of the Columns will be equal to that of Soil Springs, as shown below:



Modulus of sub grade Ks for Clayey soil is 20000 to 60000 KN/Mt3 . (Refer Foundation Analysis and Design by J. E. Bowels )

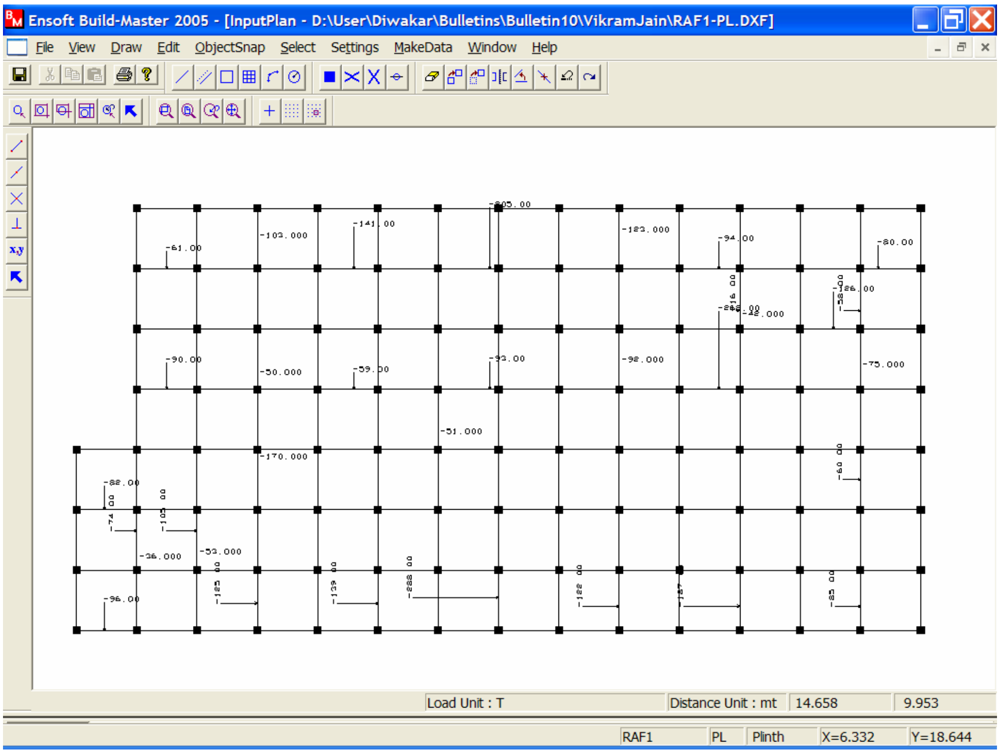
For Min. Value of Ks ( 20000 KN/mt3 ) i.e. 2000 T/ mt3, Stiffness of Soil for 2m x 2m Grid = 8000T/mt.

This shall be equal to Stiffness of RCC Column, i.e. = AE / L
Where L is Length of the Column, A is Area of Column.

For L = 3 mt, E of Concrete = 2200000 T/ mt2,

Area required for Column = 8000 *L/ E= 0.011 mt2 .
Hence Size of Square Columns required = Sqrt(0.011) = 0.1mt

Thus Columns of 100 mm x 100 mm size are added at all grid intersections.




Add **Point Loads** on these Beams at the Actual Column Position using **Input Plan.**

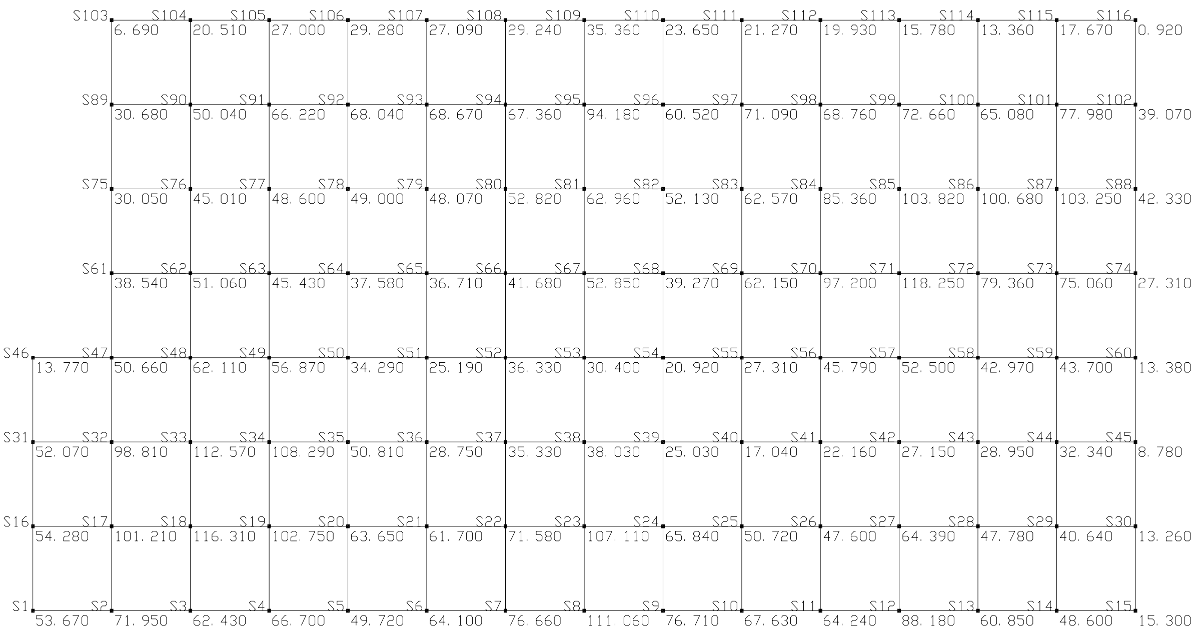
Make **Space Frame** of single storey. Value of Moment of Inertia of Columns Shall be made Zero / Negligible, Since Soil Springs cannot take moments. This can be done using Edit Frame Data File option.

Carry out Frame Analysis and Proceed for Design of Beams.

**Design of Beams** will give us Area of Steel. If beam widths are entered as 1 mt., it will be the Area of Steel required per Mt. width of the slab.

Check that any of the Support Reaction of Columns has gone in Tension. Since Soil cannot have tension, it will be equivalent to the loss of contact of Slab and the soil. Remove the spring (column) at these locations and reanalyze the Frame till there is no tension in the springs, any where in the raft. Redesign Beams to get Area of Reinf. Steel.

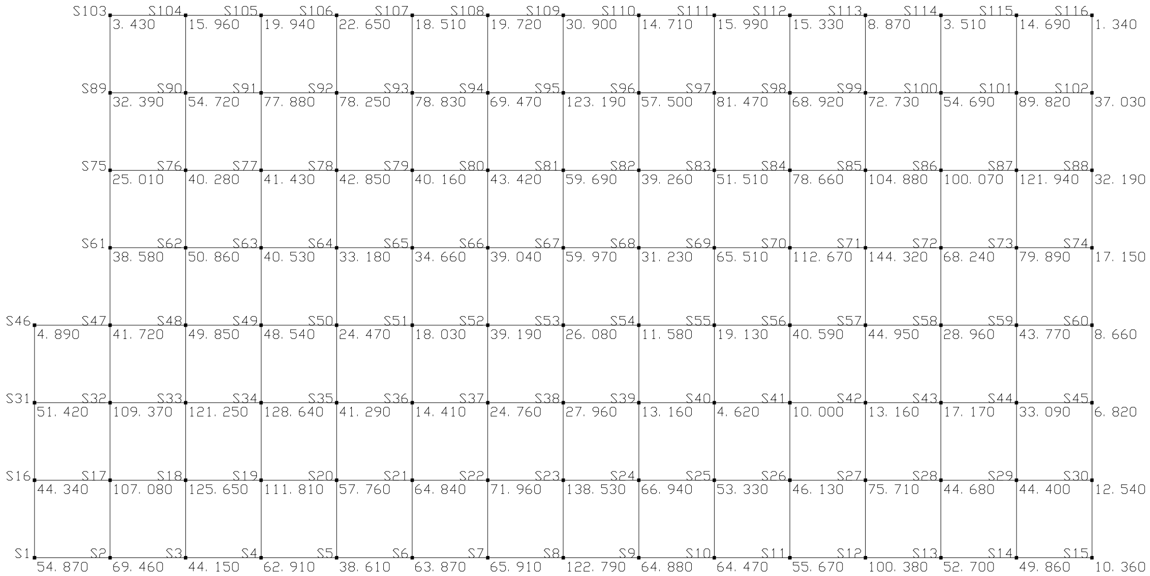
## Raft Slab Analysis Results With 600 mm Thickness




Reactions of the Springs obtained for Raft Slab with 600 mm thickness of Beams, are Shown above. It is seen that the Value of Spring Reactions S8 and S23 are 111.06 T and 107.11 T at the position below the Maximum Column Load of C4 as 288 T Load. Thus we see that the Load gets distributed due to the provision of raft slab.

Distribution of the Column Loads on the soil will depend on the thickness of the Raft Slab and also the stiffness of the soil. Raft Slab shall be redesigned with different thickness to check the load distribution pattern.

## Raft Slab Analysis With 450 mm Thickness




Reactions of the Springs obtained for the same Raft Slab with 450 mm thickness of the Slab, are Shown above. It is seen that the Value of Spring Reaction has increased to 138.53 T instead of 107.11 T value obtained with 600 mm thickness. Values of Spring Reactions can also be compared at various internal points of the Raft Slab.

It is seen above that Thicker Raft Slabs Spread Column Loads to a larger areas of the Soil below and Show more Uniform distribution of total Column Loads. Slab with Lesser Thickness behaves more flexible and does Not spread the Column Loads.

Contributory Area of each Spring is 2 mt x 2 mt i.e. 4 mt2. There fore value of Bearing pressure below each Spring will be equal to the Spring Reaction divided by Contributory Area. Maximum value of Bearing pressure shall be less than the bearing capacity of the soil.

Vertical Deflection value of the Spring Support shall be checked against allowable value of deflection of the Raft Slabs. Thus we see that Raft Slabs can be easily idealized and designed with Finite Grid Method.
We hope that the information provided will be useful to you.

See you soon in the next issue of INSIDE BUILD-MASTER.

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