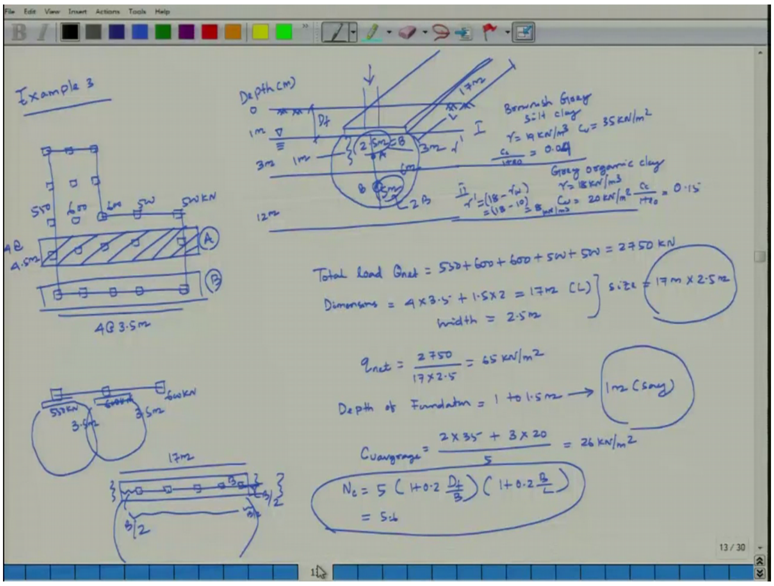
Foundation Design
Prof. Nihar Ranjan Patra
Department of Civil Engineering
Indian Institute of Technology, Kanpur

Lecture – 15A
Types of Foundations (Combined Footing)

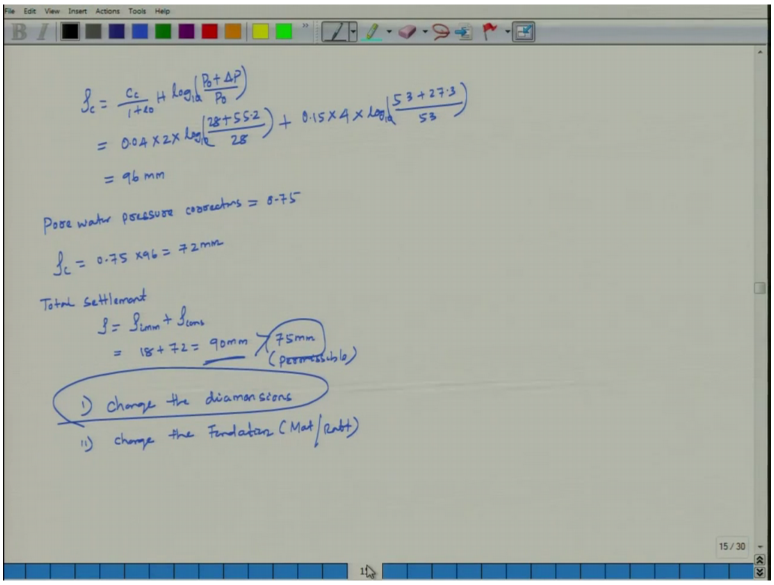
So, last class I Solved one example.

(Refer Slide Time: 00:15)



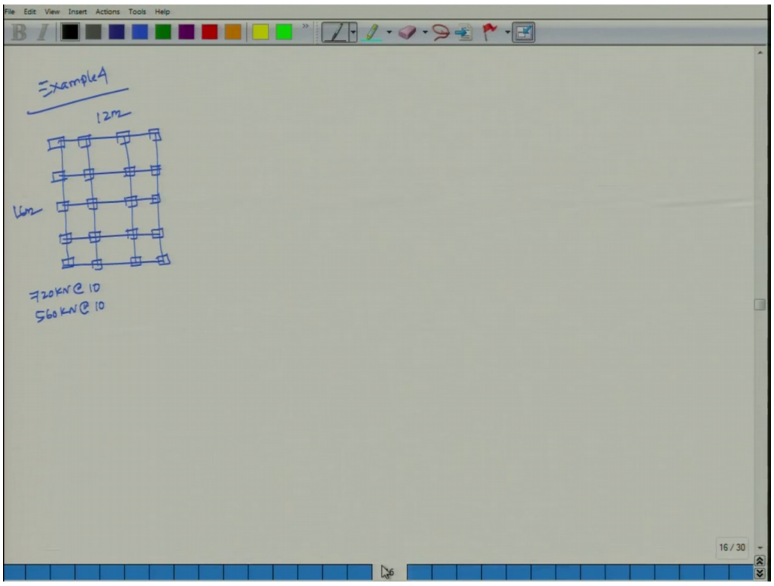
Considering different column loads. And I have solved only taking into consideration of strip footings, then at the end it was not satisfying the permissible settlement hence the dimensions has to be changed.

(Refer Slide Time: 00:32)



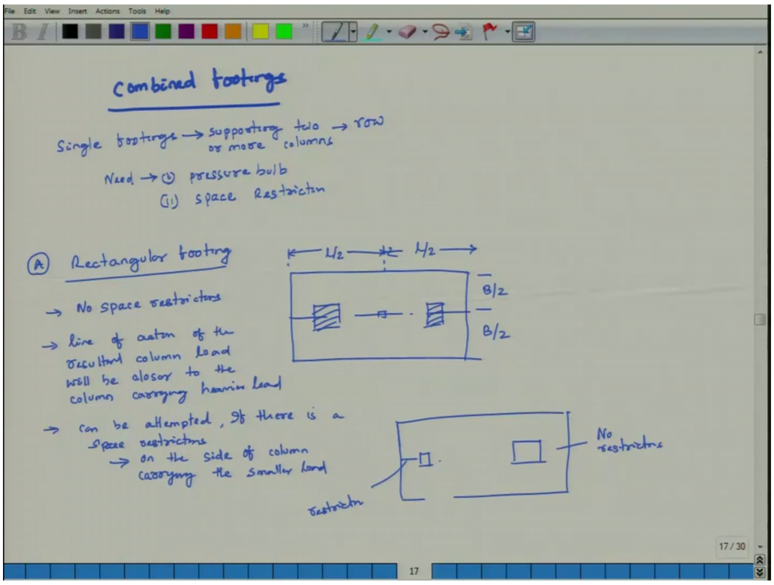
And it maybe it has been recommended you can change the foundation size to a mat or raft.

(Refer Slide Time: 00:49)



Now, this example four I will keep it this is for mat foundation before I go to the example 4 let me start with combined footings a detail description of combined footings. So, combined footings are single footings. Supporting 2 or more columns these are all single footings, supporting 2 or more columns particular in a row 2 or more columns particularly in a row.

(Refer Slide Time: 01:05)

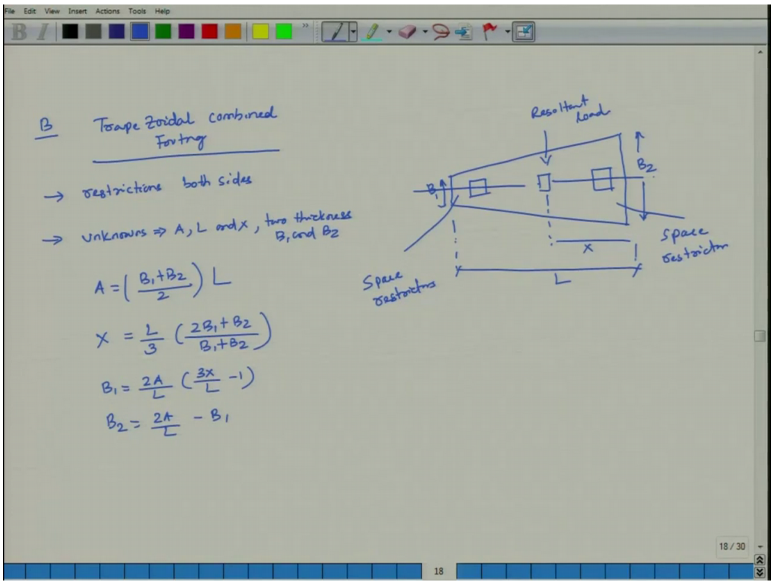


So, what check you should have it is need to check with your pressure bulb then space restrictions start one by one First one is your rectangular footings, rectangular footings let us plot it is L by 2 here it is L by 2 then this side is your B by 2, this side is your B by 2. It can be attempted where you can go for rectangular footings, can be attempted no space restrictions. Number one line up action of the column load will be closer to the column carrying of heavier load, line of action of the resultant column load will be closer to the column carrying heavier load, can also be attempted can be attempted there if there is a space restriction, if there is a space restrictions.

However; however, on the side of column carrying of the smaller load, there is a space restrictions on the side of column carrying the smaller load. What does it mean? If there is a space here, there is a space here, you plan in such a way that if there are 2 column loads coming into there, you plan in such a way that bigger column load will be here, in this side in this side there is no restrictions, this side there is a restriction.

So, for a smaller column load means you can attempt this rectangular load first one is no space restrictions second is higher side, third one is you consider space restriction can be considered only when the smaller column load will be placed, or smaller column will be placed nearer to your space restrictions.

(Refer Slide Time: 06:06)



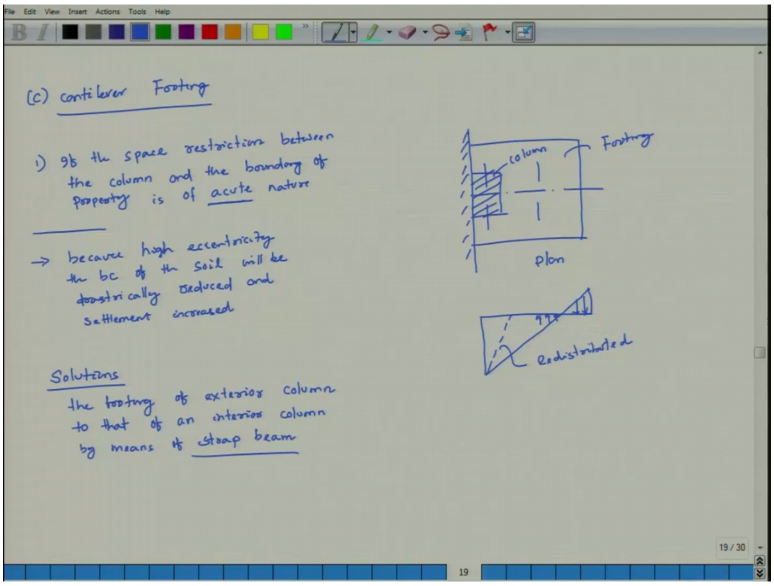
Second one is your trape zoidal combined footing let me draw, this size dimension is your B 1 this side dimension is your B 2 and this is your column 1 and column 2 this is your resultant load and from here to here this is your distance x, and total length is L.

So, where is the case you can go for trape zoidal combined footing? Number one restriction both the sides, both sides here also restriction this side also from this column load also there is restriction. When both the sides there are restrictions in that case you can go for trape zoidal footings. What are your unknown quantities? Unknowns are A L and small x and 2 thickness B 1 and B 2. What is A and L? A is your total area, L is your length of the trape zoidal, x is distance from one side of the column exterior site to your C G and 2 thickness B 1 and B 2.

So, A area is B 1 plus B 2 by 2 into L you can get it if you know the L if you know the B 1 if you know the know the B 2, then from their you can find it out this distance x which is equal to L by 3 into 2 B 1 plus B 2 divided by B 1 plus B 2, then you can find it out B 1 is equal to 2 A by L 3 x by L minus 1. B 2 is equal to 2 A by L minus B 1. So, once again I am repeating trape zoidal column footings it is applicable, when both the sides this side as well as this side both the side there is a space restrictions; that means, here there is space restriction also this side is your space restriction.

In this case you have to go for trape zoidal combined footings. And you need to have to have B 1 B 2 and L, once you know B 1 and B 2 and L from there you can find it out your A. Once you get total area then from there you can find it out x distance from your c g. Then you can find it out other factors also assuming other factors also you can get it B 1 and B 2. Now come to the next will solve one by one typical problems.

(Refer Slide Time: 10:44)



Next is your cantilever footing. Let me draw it cantilever footing. There is a column and this is your footings. I can say this is my plan. And this will be this is your original and it will be redistributed. Where if the conditions, number one if the space restriction between the column and the boundary of property is of acute nature. Look at here, if the space restriction between the column and the boundary property.

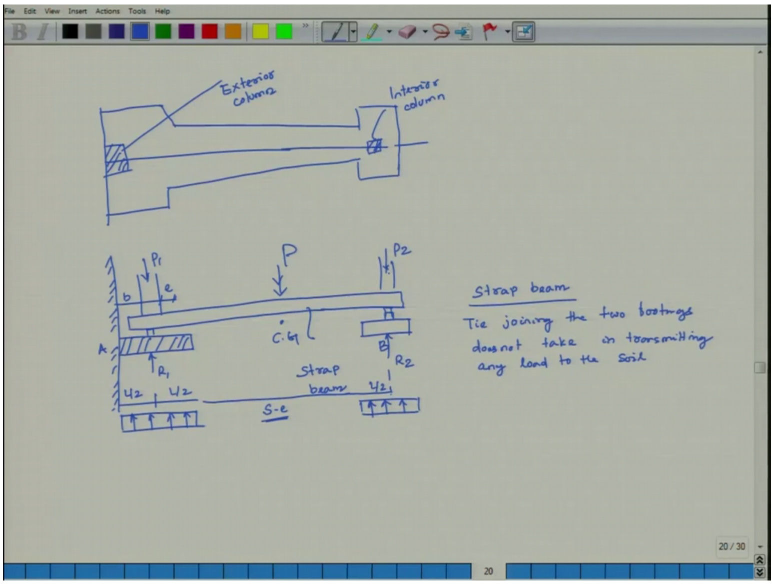
Space restriction between the column and the boundary property is of acute nature. Means I am not getting anything else. This is where the column as to be placed. And there is hardly any space there is no space; that means, the boundary will start from along the column side, boundary will start from along the column side that is your case one, what will happen from this? What will happen because of because high eccentricity the bearing capacity of soil will be drastically reduced and settlement increased.

So, what will happen? Suppose see look at here there is a cantilever footing, why I say it cantilever footing? This space is restricted here, this is my boundary I cannot go beyond this, and the column has been designed. So, that it will placed here. So, hardly any space number one because of that what will happen high eccentricity will be developed. Once high eccentricity will be developed what will happen your settlements will be more, than what is the solution the solution will be, the footing of exterior column to that of an interior column by means of strap beam.

Look at here, why it is called cantilever footing? Example, because hardly there is any space in the boundary your column load has to be applied. Because once you apply the column load what will happen this C G has been shifted then because of that you are it will be become highly eccentricity. Because of that you are supposed to get a high settlement. What is the solutions? The putting of exterior column to that of an interior column has to be joined by means of strap beam that is called strap beam.

If I write it how it looks like your strap beam.

(Refer Slide Time: 16:13)



This is your exterior column, this is some (Refer Time: 16:33) it is your interior column. From here it is coming out. How it looks your plan? This is interior column, this one is your interior column this one is your interior column, this is your exterior column. In exterior column hardly any space there should be strap beam has to be connected between these 2 columns. If I look at in other way around, if I look at in other way around how it looks if I take it.

Let me put it in that way. This is my column say A. Here say this is my column say B. So, what will happen? This column A is connected to your restriction or boundary. Then this is your column B in between this 2, suppose this is my say R 1. So, this is say R 2.

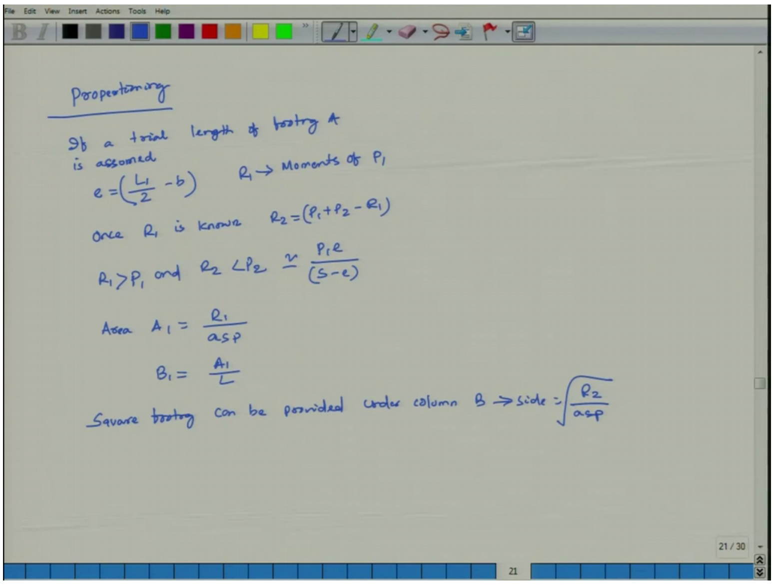
So, here it as been connected by means of a strap beam. It is called this is my strap beam. Then what will happen? Here is your coming P 1, here it is coming P 2. Then this is your C G capital P and this will be distance at a distance you can say from here to here this is my B and this to this is your eccentricity e.

So, this point is your this is your C G this is your C G. Now if I plot it. So, this will be coming out to be this completely if I take half of this, L by 2, L by 2 and from here it is it is you L by 2. And this to this is your plus minus e distance. What will happen what is the mechanics. What will happen as I say there is a column here, and it is at the at the boundary then there is another column. Because there is a exterior column this load is more as compared to your interior column. What will happen if I leave it in that way there will be eccentricity because of that eccentricity, settlement will be more, than one settlement will be more it will fail, the foundation will fail. What will happen considering this is your footing exterior column this is your interior column; this 2 column as been joined by means of a strap or by means of a beam that is called strap. What will happen the moment you connect it will take care of your P 1 and P 2 and C G will be coming into picture So that this strap will connect between this 2 columns again it will allow load to be distributed smoothly below your ground surface.

What is your strap beam? Basically it tie this is a tie joining the 2 footings does not at the same time. It does not take in transmitting any load to the soil. Are you getting this? What is the role of this strap? Role of this strap basically redistribute your load. It bring back load to C G, but at this same time load of the strap is only a tie beam it is connecting between the 2 columns at the same time it does not take in transmitting any load to your soil.

Actually load will be transmitted from here to here, but this is just connected So that your C G is shifted and C G will be coming central is So that there should not be any eccentricity. This is a part of this what I have covered it till here combined footing first one is your rectangular footing, rectangular footing then second is your trape zoidal footing. Third one is your cantilever footing in the form of strap. And what is your requirement? Are proportioning because of certain dimensions required, you need to have to have your certain dimensions.

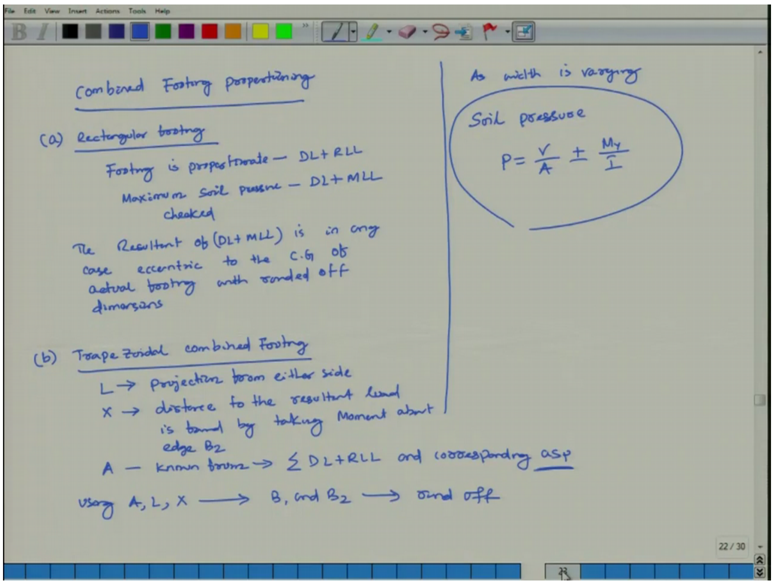
(Refer Slide Time: 23:12)



If a trail length of footing A is assumed then e is equal to L 1 by 2 minus B. R 1 is your moments of P 1. Once R 1 is known then R 2 is equal to P 1 plus P 2 minus R 1. If R 1 is greater than P 1 and R 2 is less than P 2; that means, P 1 e by S minus e. Then area A 1 is equal to R 1 by a S P allowable safe bearing pressure a S P. Then B 1 is equal to B 1 is equal to A 1 by L 1, B 1 by L 1. So, then square footing can be provided under column B side which is equal to R 2 by a S P root over.

I will stop it here. I start next is your combined footing all proportioning at one of the one of the design problems I will I will start it. I will stop it here.

(Refer Slide Time: 25:49)



So, combined footings Proportioning, first one is your rectangular proportioning means how do get your dimensions and other part. So, first one is your rectangular footing, rectangular footings footing is proportionate; that means, it is your dead load plus reduced live load. Maximum soil pressure has to be checked considering your dead load plus maximum live load are you getting my point. In rectangular footing if proportionating how you are going to start for the design for footing dimensions footing proportionate, you have to find it out considering dead load plus your reduced live load. And for maximum soil pressure you have to check it what is the soil bearing pressure.

Considering dead load plus maximum live load then the resultant the resultant of dead load plus maximum live load is in any case eccentric to the C G of actual footing with rounded of the rounded of dimensions. The resultant of dead load plus maximum load is in any case eccentric to the C G of actual footing then it as to be rounded off. Now second one is your trape zoidal combined footing trape zoidal combined footing; that means, L projection from either side how much projection you can get it in trape zoidal footing if you look at here how much projection you are getting it from either side you consider, then x distance to the distance to the resultant load is found by taking moment about edge B 2.

Distance to the resultant load is found by taking moment about edge B 2. A area known from you can calculate known from means you can derive or calculate from your summation of dead load plus reduced live load and corresponding allowable soil pressure using A L and x then from their you have to find it out B 1 and B 2 then you round off L. Projection from the either side x is the distance to the resultant load is found by taking moment about edge B 2. A you have to calculate a is area you have to calculate hence you have to find it out based on your dead load plus reduced live load, and corresponding allowable soil pressure considering both this cases, then using area L and x find it out B 1 and B 2 and at the end you round it off.

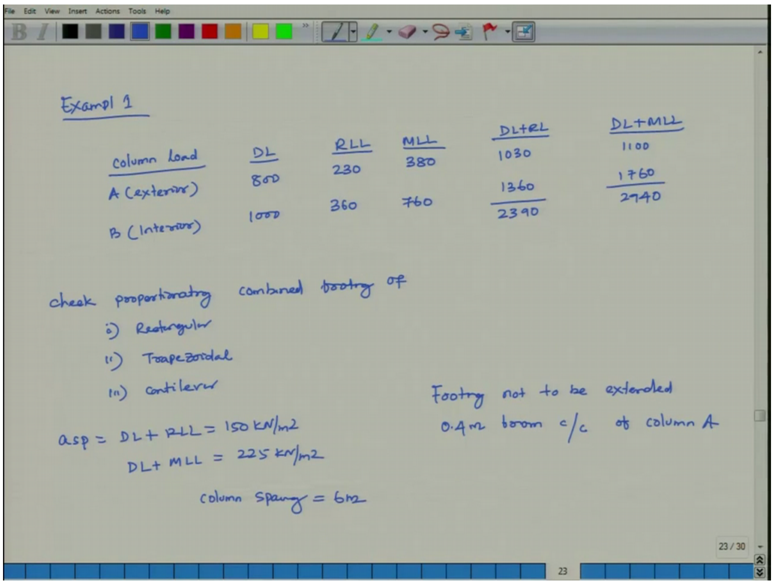
Also you can as width is varying as width is varying then soil pressure P is equal to B by A plus minus M y by I. I is your moment of inertia about the central axis M is your moment. So, this as to be calculated this is your about your proportionating, then all what I have discussed now I will solve a problem probably in the next class it will take long time. All what I have discussed how to design for a combined footings and what are the conditions ground reality rectangular footing no stress restriction is not necessarily, but there is a case of pressure bulb overlapping a pressure bulb in that case you can go for a rectangular footing.

Also if there is a space restriction in that case exterior column or column load having less it should be close to your space restrictions. Then trape zoidal combined footing in trape zoidal combined footings there are space restrictions both the sides. Then in cantilever footing what will happen? Absolutely there is no space if there is a boundary in the boundary you have your footing it has to be placed, then you have to apply a strap beam which will connect to unequal footings. One is at the boundary other is here connected by a strap beam. This strap beam has a function to only connections nothing else.

Then how you are going to do your proportionating for rectangular footing as to be footing size as to be footing means footing size as to be calculated based on your dead load, and reduced live load soil pressure can be calculated based on your dead load. Plus maximum live load then it has to be whatever you are going to get it, it has to be round off in trape zoidal footing projection from either side you measure and find it out L total length x distance you have to calculate it by taking moment about one of the edge that is your B 2. A you have to; that means, area as to be calculated from your dead load plus reduced live load and corresponding allowable soil pressure, using a L x find it out B 1 and B 2 then you just round it off.

Soil pressure can be calculated P is equal to B by a plus minus M y by I, I is your moment of inertia B is your total vertical forces or shear forces divided by your area. Then there is one example just I am brief description is their. So, example one I will solve it next class.

(Refer Slide Time: 33:39)



But I am Just explaining example one. What is the example? First one is your column load then it is given dead load, then it is given reduced live load, then it is given maximum live load, then it is your dead load plus reduced live load, then it is dead load plus maximum live load.

So, column 1 a is your exterior B is your interior. So, dead load is 800 these are all you can say that kilo Newton these are all in kilo newtons. Then here it is 1000 reduced live load is your 230 kilo Newton here it is 360 kilo Newton. Maximum live load is your 380 kilo Newton; then 760 kilo Newton. Then this is your 1030, then 1360 total is coming 2390 kilo Newton. Then here it is 1100, then here it is 1760, total is coming 2940. What is the question? Question is check proportionating combined footing of first one is your rectangular footing, second one is your trape zoidal, third one is your cantilever, then allowable soil pressure considering dead load plus reduced live load is equal to 150 kilo Newton per meter square, also considering dead load plus maximum live load 225 kilo Newton per meter square, column spacing is given.

Column spacing is given that is your 6 meter footing, not to be extended also it is given footing not to be extended 0.4 meter from center to center of column A. This is what given example one column load is given one there are 2 columns one is your exterior column other is your interior column. Dead load reduced live load maximum live load it is given. We have to check the proportionating; that means, dimensions we have to find it out considering rectangular trape zoidal and cantilever.

Allowable soil pressure is given 150 kilo Newton per meter square considering dead load. And live load reduced live load considering dead load and maximum live load it is 225 kilo Newton per meter square. Column spacing as been taken as 6 meter. Footing not to be extended 0.4 meter from center to center of column A, this is what given. This required a complete one hour to solve one by one I will check for rectangular for trape zoidal for cantilever footing, if it is not satisfied for the combined footing then only recommendation is for mat foundations or may be raft foundations. If it is not satisfied then we can go for defoundation.

I will stop it here. May be next class I will solve this complete example it will take more than an hour, at the same time you can bring your calculator you can check the calculations.

Thank you.