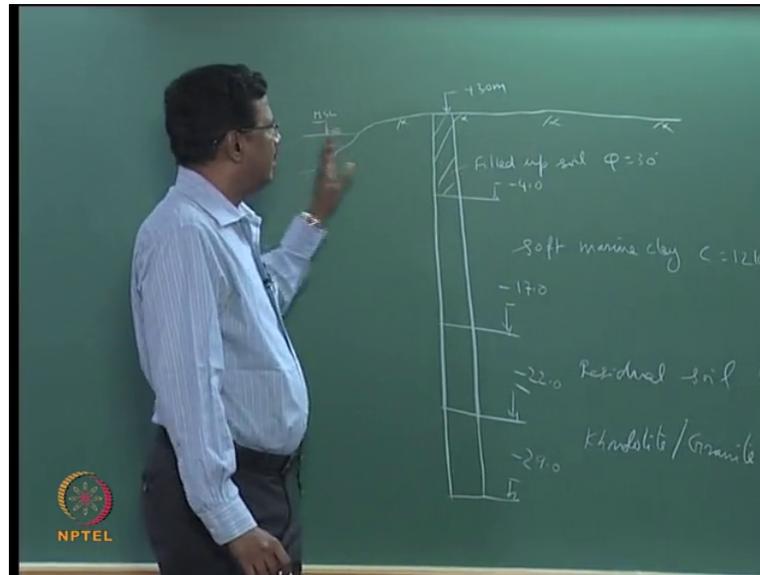**Port and Harbour Structures**
Prof R Sundaravadivelu
Department of Ocean Engineering,
Indian Institute of Technology Madras
Module 4, Lecture 16
Berthing Structures - Modeling

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So today's class we will discuss about design of a berthing structure, first of all we will need the information of soil profile, the structure is called as WQ6 is located at Vizag port, they have initially done a soil investigation so we have the natural ground occurring like this.

We have water this side and (th) the general level of the ground at present is plus three, so from plus three to minus four there is a filled up soil, now minus four to minus seventeen we have soft marine clay.

I discussed about n, typical value of n in this is about 1,2,4 like this, the different depths different values, so we are assuming the position that's 12 kilo Newton per meter square, this filled up soil is some kind of sand for which we are assuming 5 is equal to 80 degrees, then we have a residual soil it is called as residual soil, it is nothing but some kind of sand and mixed with clay for which we are assuming the phi value as 35 degrees.

All this in formations are coming from the soil investigation report, then from minus 22 to minus 29, we have the rock which is called as khondalite or granite rock, the position for this is about

700 kilo Newton per meter square, we will discuss about detail about soil investigation in another class, and what we want to do in this class is, I want to tell what kind of structure we are going to propose at this location, and then analysis using a package called as Staad Pro.

This is a finite elements software using finite elements method, how many of you have used this software Staad Pro, all civil engineers, all are civil, so uhh Ms Afreen will demonstrate tomorrow, I will not be taking class tomorrow he will be demonstrating that in the next class, first of all what we have to do is, we have to find out what is the size of the vessel DWT, DWT is about 100,00, this is the size of the vessel which you want to design.

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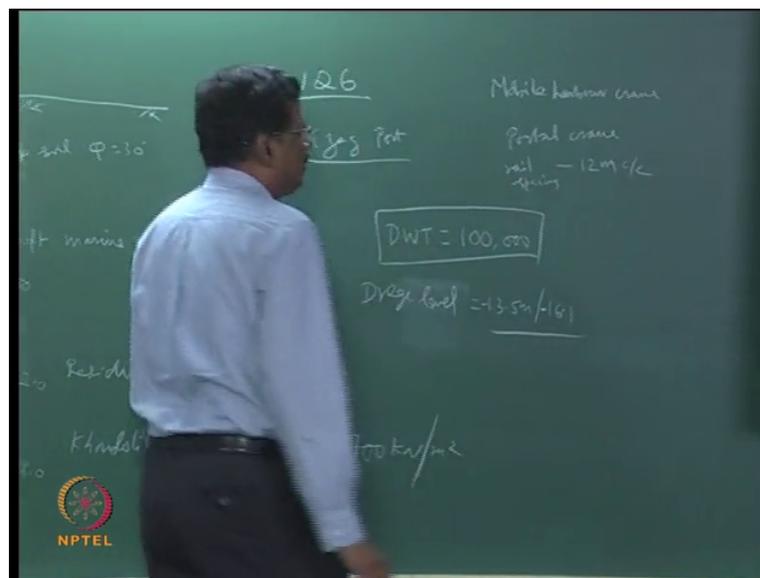
One of the important parameter for this is about the draft, draft is about 13.5 meter, the first phase we increase to 16 point minus, not call it as draft, drege level will be from minus 13.5 meter, in phase one to minus 16.1 meter in the second phase, another important criteria is what is a type of structure which you have to do, we are going to a file supported structure with diaphragm wall and raker piles, then what is a crane thereby to use for this.

Thereby it is two types of crane, one is called as mobile harbour crane, another is a portal crane, this portal crane, crane rail springs is 12 meter c/c, so a crane rail springs is 12 meter c/c, so that means you need two rails, one on the sea side, another on the land side, the spacing is about 12 meters.
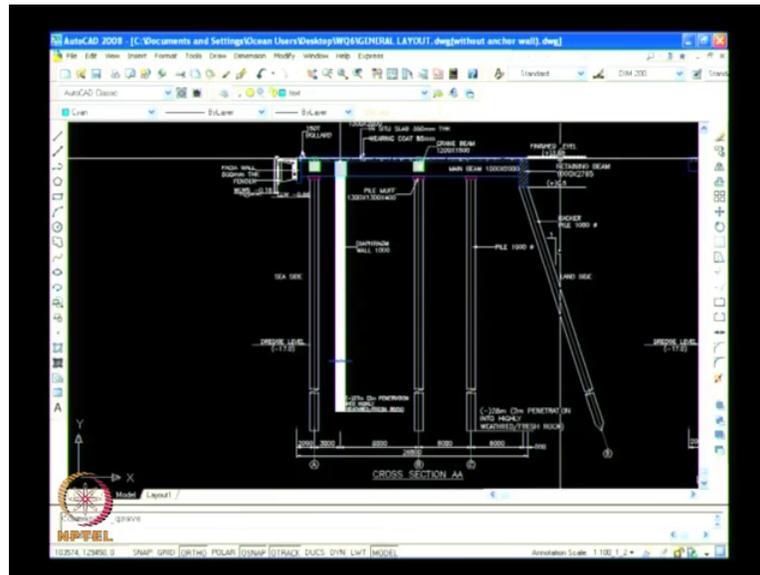
Now we will see the layout, first you have to fix the top level, top level is fixed as 3.85, that depends on what is the high water level and the natural ground level is plus three.

But you want to keep this level as 3.85,The drege level for diesel purpose, we want to take it as minus seventeen, so in the second phase 16, 1 meter is the drege level but we are increasing, because there will be some more drege levels and sounding accuracy in that, when we are keeping one pile here from the face of the birth, that is at a distance of 2.5meters, is shown as 2 but we have raised it up to 0.5 meters now, because we have to fix a bollard here.

Some services should come here, because of that (crescent we are evaged), and we have put a diaphragm wall at a distance of 3 meters from the central line of the front row pile, then the diaphragm wall and pile cannot be very close, the minimum distance required is 3 times the diameter of the pile or three times the thickness of the wall, we assumed 1000 millimeter as a thickness of the wall, I meter as a diameter of the pile, so we can keep 3 meter.

Less than 3 meter we cannot keep, if it take you have to take what is known as group affect, cannot be very close, next pile we are keeping at 9 meters, this 9 meter we have fixed because the distance between here we have one rail, it's called as landside rail, another rail is here this is called as a sea side rail, so the distance between from here to here is about 12 meters, so that the crane will move on this, the next two pile is about 6 meters.

Then we are putting a racker pile that is at a distance of about 6 meters, and we are putting on retaining beam here, there is a beam crane beam, there is another crane beam, there is diaphragm wall and perfect we have another beam and we have one cross beam which is connecting, this is a cross beam which is connecting all the piles and we have (06:21 provision for under c l) and these piles are at every 4 meters (cent) center in the longitudinal direction, the other direction.

And this diaphragm wall is a continuous wall, one of the reasons we want to go for this alternative is there is a active edge, active edge is here it is a clay soil, so active edge will be 45 degree line, so if we take a 45 degree line for this it will be within the duct, so that any load what is coming here, surcharge load will not give any active expression, so active edge means the soil will collapse and the diaphragm wall is moving like this.

So for that reason we want to keep (the) there is a load on top of the duct that is 5 kilo Newton per meter square, and the back will also 50 kilo Newton per meter square, there is a rail, another rail over which the crane will move, all the loads what is there on the duct will go to the diaphragm wall and piles will not go to the soil below, so if the duct is too close the surcharge load will go transmit some force on the main diaphragm wall.

That's why we want to keep it here; the diaphragm wall is now keeping it here, we can keep it here also but as you see here water is there very close by so we cannot build the diaphragm wall too close, that's why we have shifted the diaphragm wall, one pile row behind, so now we will see how to do a Staad pro analysis for this, for which what we do want to do is we want to model springs below this, drege level for the pile.

Here also below the drege level for the piles, for the diaphragm wall, then we assume a 45 degree line and then we put the spring below this for this pile, this pile as well as for the other pile also, piled element discretization is the 2d analysis in which we take a typical 4 meter panel, the ideal is the pile, beam, pile, practical pile, practical pile and diaphragm wall and racker pile as beam elements, and the duct system also by beam elements.

We don't model the slab which is connecting the beam, it is about 350 thick and we apply the forces, various forces acting one the structure and do the analysis, this shows Staad pro, now you will see the model how it is being generated.

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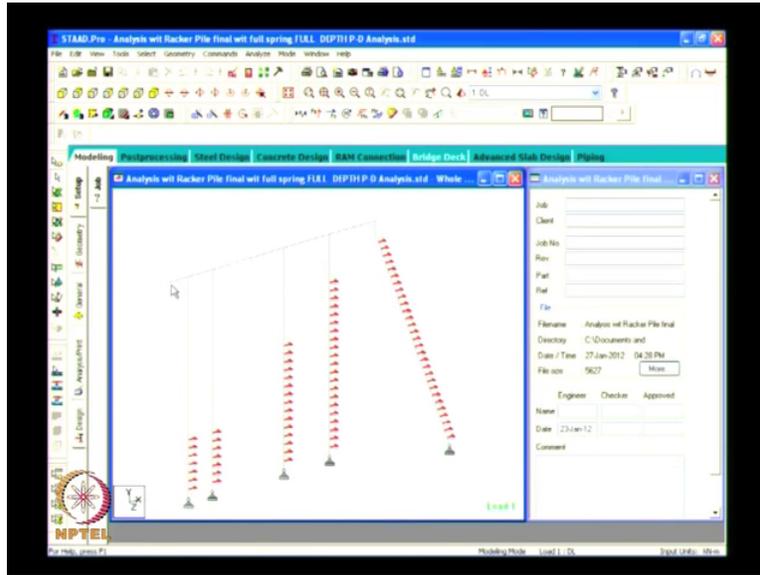
So this is a Staad pro model, so this is a place where we are attaching the fender, this is the pile, this is the diaphragm wall, this is another pile, another pile then you have the inclined pile.

The springs are starting at different levels depending on the active edge what we are assuming 45 degree line what we are assuming, then at the bottom we are assuming a hinge condition, this is to model the rock where it is getting embedment, so rock can be assumed as a hinge support, that is why we are giving this, then we will show the various forces considered in the analysis, now the 3d view.

So this figure shows the fendering of the whole things rotate,
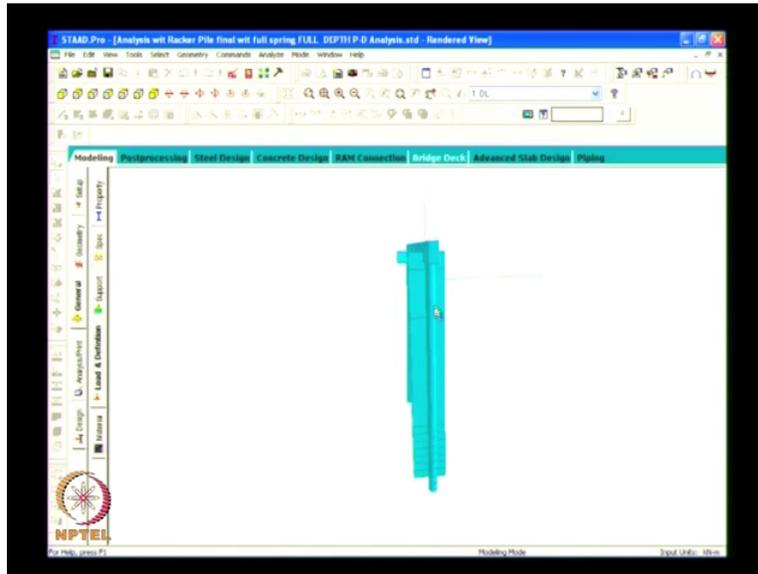
ok just keep it here rotate ok, so if you see here this pile is 1 meter diameter, this diaphragm wall is 4 meter width, getting a typical panel, there is one more pile coming after 4 meters, so we take only a typical panel, so on top of this diaphragm wall we have a beam for 4 meter that we are modeling, at the end we have a retaining beam that is also we are modeling.

And there is a cross beam which is connecting all the system together that is also being model, any doubt in this, uhh I am going little bit fast today, in one class you may not be able to understand everything you need some more classes, uhh just whatever you understand you please understand, about 50 percent if you understand it is ok, the balance 50 you can sit in front of the system and use it, this Straad pro is our C trail program.

It can be used for civil, mechanical and aeronautical and other purposes also, you have understood the view now, here there will be a drege level, it is 17.5 meter, backside there will be full soil is here, but there is an active edge here going, so this soil will be sliding, suppose the diaphragm wall is not there, if you fill up the soil what will happen to the soil, soil will slide down, that is at 45 degree which what we are assuming.

And the soil itself is sliding it will not offer support, that's why we are not offering support, below this active edge line, above this active edge line, only below that we are putting the spring, so now we will see what are the loads we are considering,
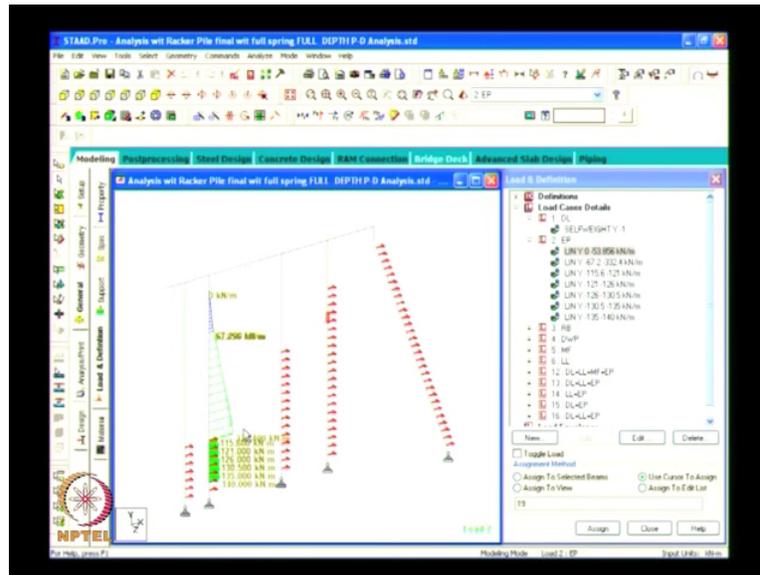
First we will see the dead load, so we are (way) putting the sulphide of each number, what we are doing, second load is air pressure, so the air pressure is acting on the diaphragm wall.

This calculation I will show in the next class, when the soil is like sliding here, if the diaphragm wall is not there the soil will collapse, since the diaphragm wall is there the soil it is sliding the weight of the soil will exert some pressure on the diaphragm wall, that is called as active air pressure means when the wall moves away from the soil, then it is called as active air pressure, there is a soil which is sliding because of the sliding of the soil.

This diaphragm wall will move, this movement is away from the soil, that is called as active air pressure, there is procedure to calculate so that active air pressure is shown here, next then we have removed the soil below this level, I will tell why we have removed the soil above this level, we have removed above this level because to reduce the air pressure on the main wall so that the air pressure will go on the back side.

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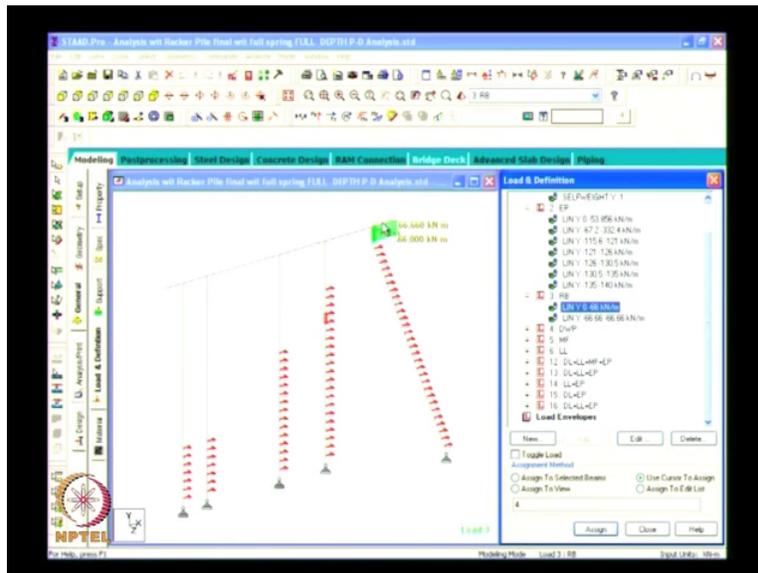
It is the air pressure due to the soil as well as due to the surcharge load, then we have the differential water pressure, differential water pressure means this side of the see the water level will go up and down, this going up and down will be based on the tidal range.

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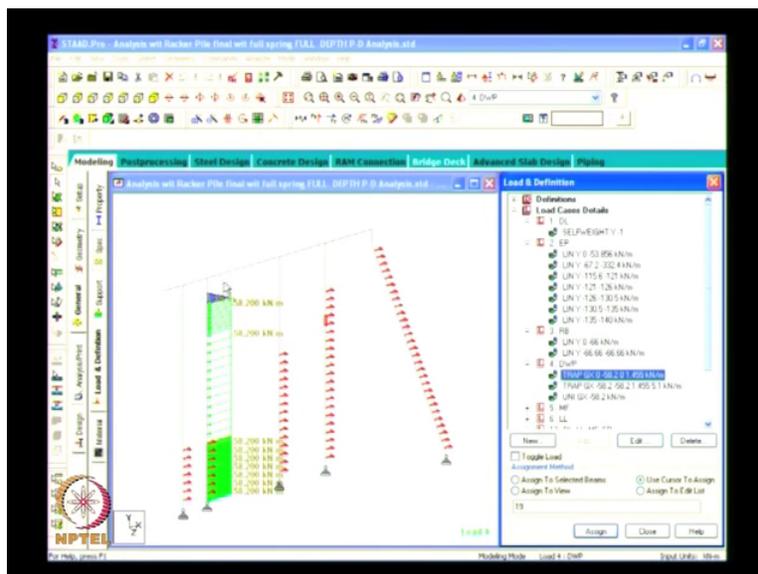
Here we put what is known as a good drainage condition, now whenever the high tide water comes, it goes inside and there is a ground water due to range that also comes here.

But when this water goes down, this water doesn't go down with the same phase that means this will go faster and this will go slower, that means it acts like a water tank and you will have some differential water pressure, a water pressure is about 0.58 meter height that is given about 58 kilo, sorry this is for 4 meter width, so about (1.), see here what we have to do is this 58.2 is calculated based on some differential water pressure.

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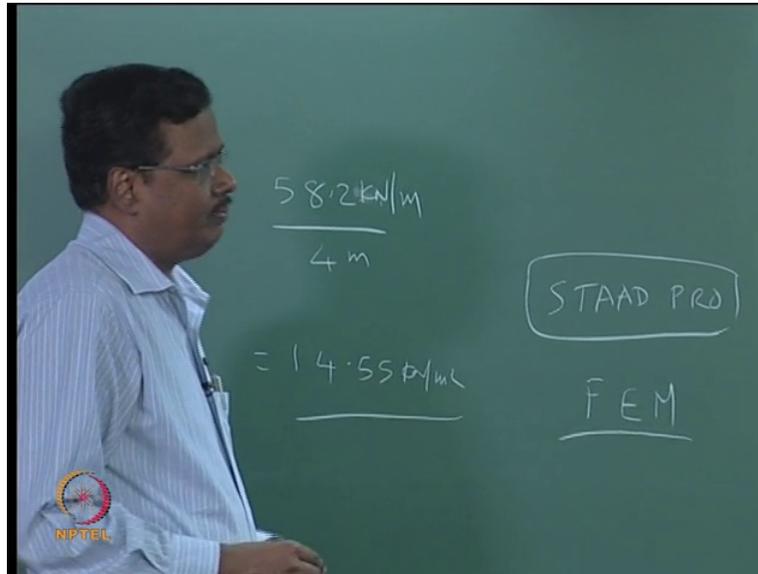
But this 58.2 meter is occurring over a panel width of 4 meters, 58.8 kilo Newton per meter, so this is equal to kilo Newton per meter square. What it means is this is water level is here and this water level is here, this difference between these two water level is about 1.455 meters, I will show the exact calculation for this and that is acting over the diaphragm wall, but for 4 meter panel we are considering so whatever air pressure and differential water pressure we are calculating that should be multiplied by 4 meters,

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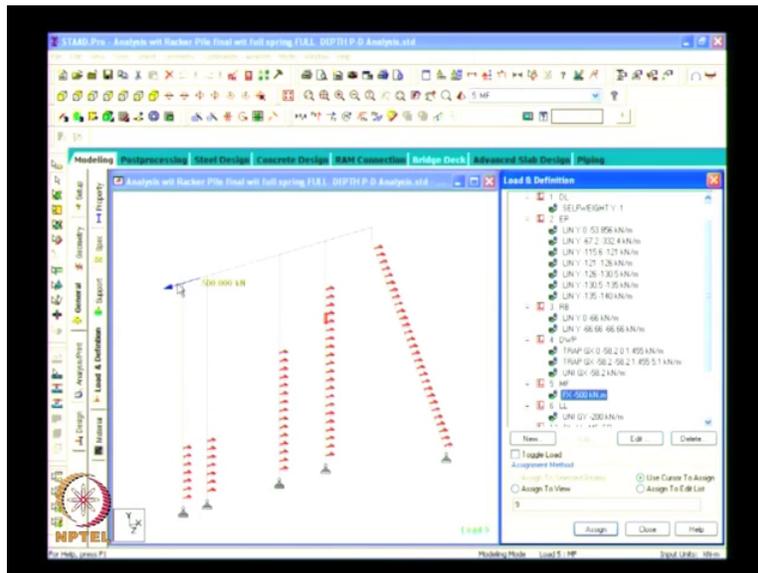
Next so when the ship is tide here there will be a mooring force, the mooring force is about 1500 kilo Newton but that 1500 kilo Newton will be distributed for three panels, each panel is 4 meter, so three panel is 12 meters, the bollard spacing is 20 meters, so suppose I am pulling from this center point of the table, it will not go only in the panel here, it will distribute adjacent panels also.

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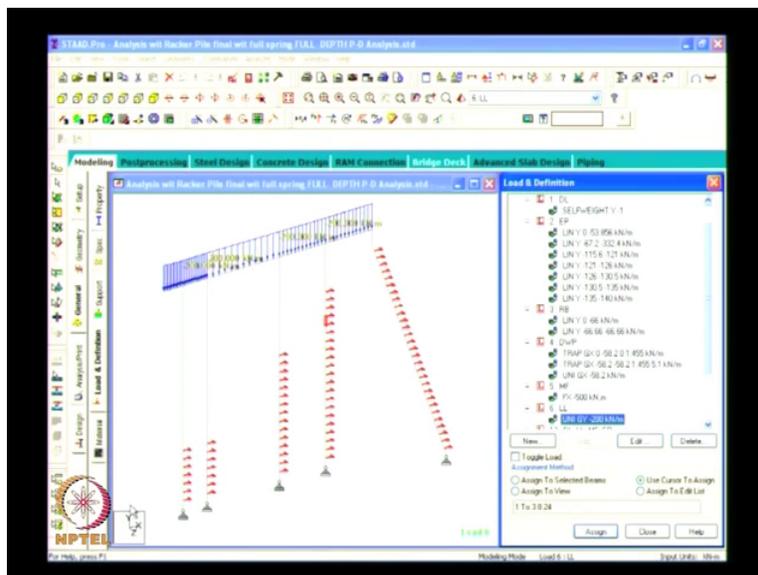
Three panels we are taking, so 1500 kilo Newton we are dividing it by three that is why we are getting 500 kilo Newton, is it clear to you, the bollard pull at a particular point is 1500 kilo Newton but that bollard will get distributed to three panels, so each panel we are doing a 500 kilo Newton, but when you do a 3d analysis, you will exactly get how much is going to each pile, next so this is the live load on this which is about 50 kilo Newton per meter square.

But we are applying 200 kilo Newton per meter its mainly because we are taking a 4 meter width, so whatever load coming on the slab it is 4 meter this side, it will go into this, you have to see the axis here, x axis is along this line, y axis is vertical and the z axis is perpendicular to the plane of this uhh (paror) laptop, so it will be perpendicular to this, when you say minus sign, minus is half positive to the positive y direction.

That's why we are giving a minus sign, the previous slide we have given bollard in this direction that also we have put minus because positive axis is like this, so this sign convention is very important and the loading what you give also important, when you are giving the load as kilo Newton and length as meter, you have to consistently follow for young's modulus, for cross sectional area everything meters and kilo Newton next. So we have to do the analysis for different load combinations so we will not,

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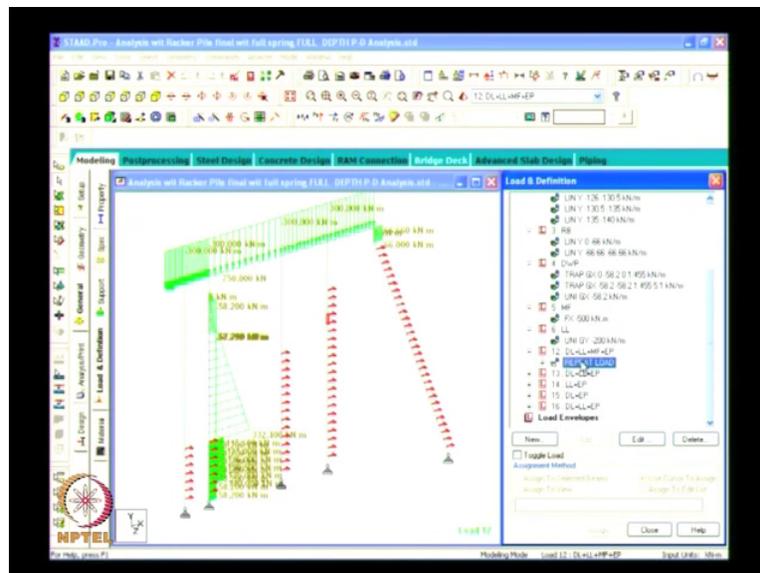
Some of them will last together so this is one such combination, So we are (compare a) uhh combining dead load, live load, mooring force and air pressure and differential water pressure, so this is the most uhh the live load means taking out some cargo and other things, this may come at sometime this may not come at sometime.

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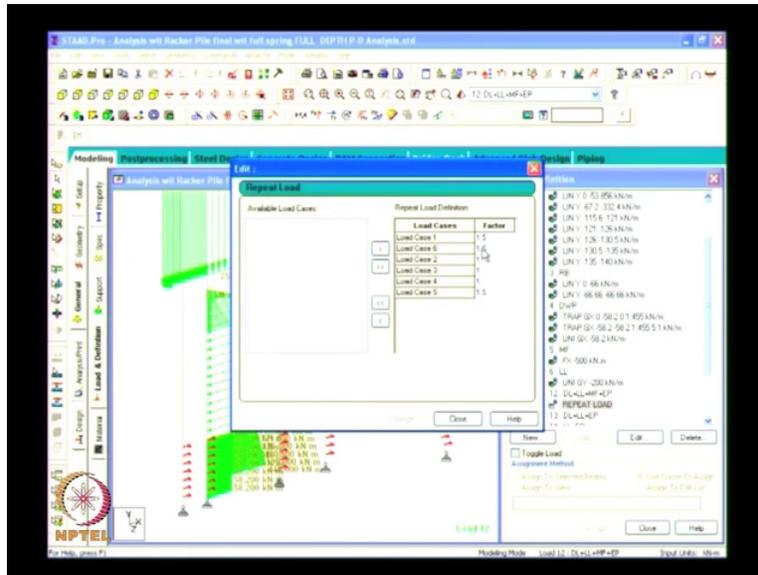
But permanently your soil will be here your weight of the structure will be there, so we have to do this for dead load plus air pressure, it is shown here, so here we have listed the various load combinations, load factor, limit state, so this is one such load combination, we have two methods of design one is known as working Strauss design another is known as limit straight design, so when you do the combination, some of the loads, the first load is a dead load.

We apply a factor 1.5, the second load is, the sixth load is live load or which also we apply a load factor 1.5, second load is a air pressure for which we apply load of 1.0, third load is air pressure on the retaining wall 1.0, and this is differential water pressure 1.0, this is a mooring force 1.5, there is a reason for applying different load factors, for differential water pressure we assume 1.0 because we are very sure that the water pressure load may not increase very much.

Whereas dead load mooring force and live load depending on the situation there will be some variation in the load, there can be a increase in load, a load when it is design for 50 kilo Newton per meter square, they may stuck a cargo more than its capacity that's why it is likely to increase

for that only here factor, active edge pressure also I will explain when the diffraction is increasing the active pressure air pressure will go to a limit.

So this I will explain in the next class, now you will show how to generate this uhh discretization, we will start from the beginning and show how you can do this, now create the model, we are starting a new (problem prab) problem go slow, so this is a screen which we will be getting initially, in this plane we will be putting the piles diaphragm wall and vertical pile and racker pile beams, what are you doing concentrate.

2 meter you are taking it, 2.5 second one, so this is a top duct which is model, it is given some random number, now we will put exactly how much we need, the distance between the sea side to this first row pile is 2.5, so is now made 2.5 from the first pile to the diaphragm wall is 3 meters, actually is reducing it by one meter uhh 0.5 meter so that it becomes exactly 3 meters, then the distance is 9 meters, so will increase it by 3.5 meters, 4.75 , one more 2 meter.

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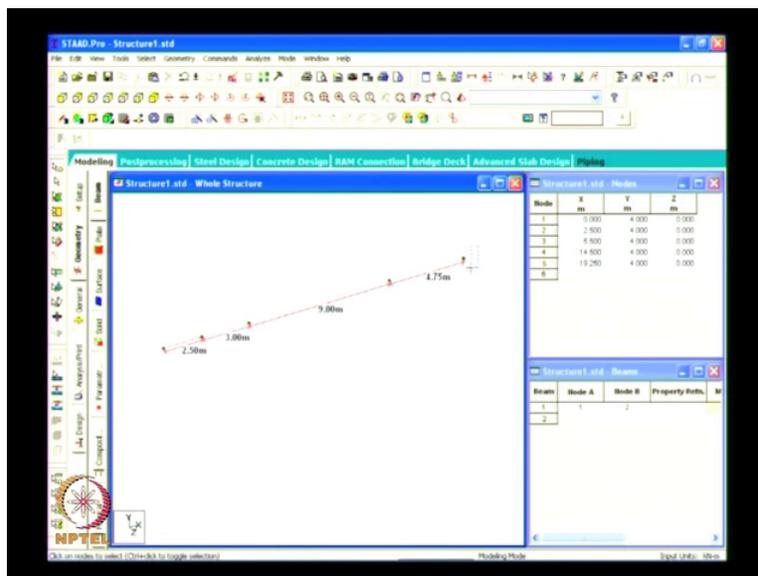
So this is the way in which we have to give the graphical input, you can enter the code in it also but this will be much easier, so this is the sea phase of the beam,
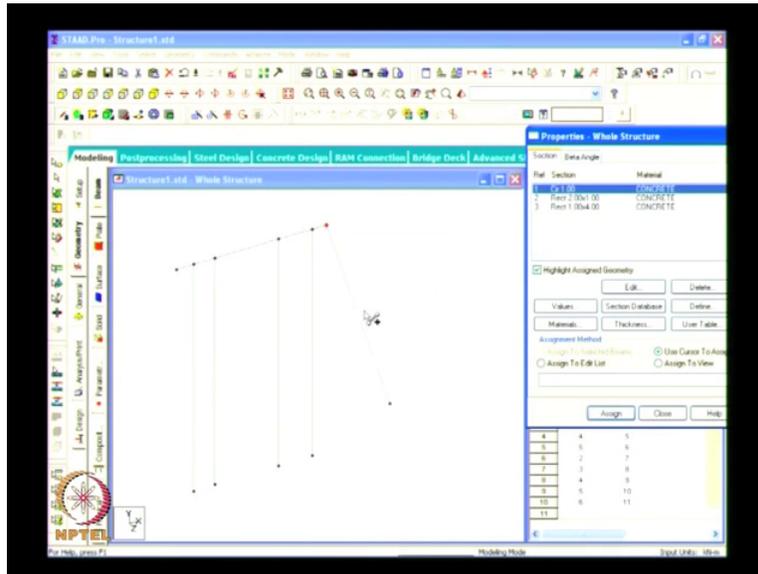
Then we have the first row pile, then diaphragm wall, then second row pile, third row pile and the racker pile, this distance is more, ok we will correct the distance, so here we will be adding one pile attaching a pile here and diaphragm wall will be attached here, one more row pile will be attached here.

One more row pile will be attached here, the distance between this first row of pile and the second row of pile after diaphragm wall is 12 meter, so that you will have one crane here and another crane here, now we will model the piles, it is the pile which is model, it took me to the diaphragm wall, this is another pile, this is a next row of pile, and there will be a racker pile, racker pile means this is a inclined pile, ex coordinate will be depending on the racker.

The ex coordinate will be different, so here will be joining the top node to the bottom node, now you will assign the diameter and size of the number, so we are giving a rectangular beam 1 meter by 2 meter, 1 meter in the depth direction v d, this set d is perpendicular to the plane of this frame, 1 meter is the width of the beam, this is from the diaphragm wall, thickness of the diaphragm wall is 1 meter.
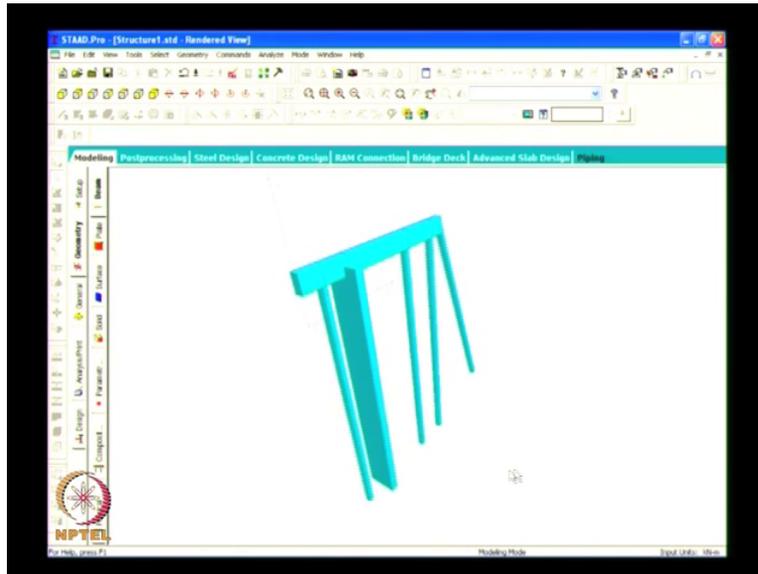
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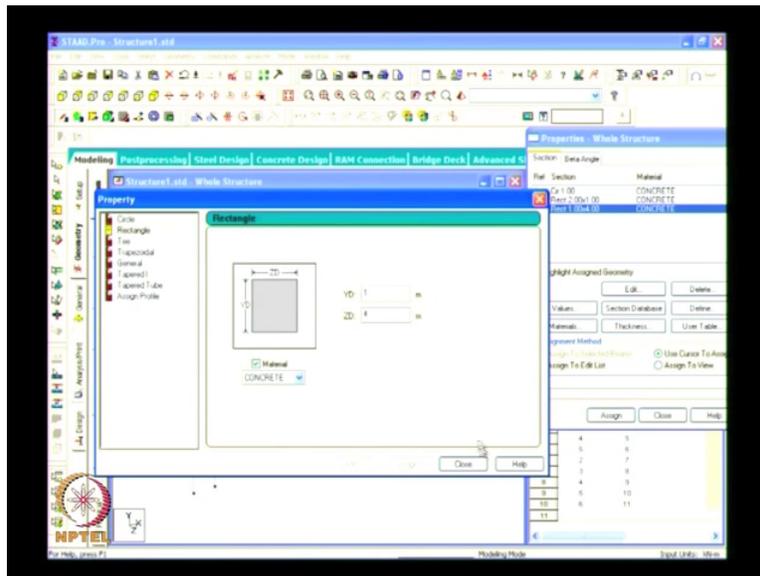
That is given as 1 meter perpendicular to the plane of the frame is 4 meter is what is given here,

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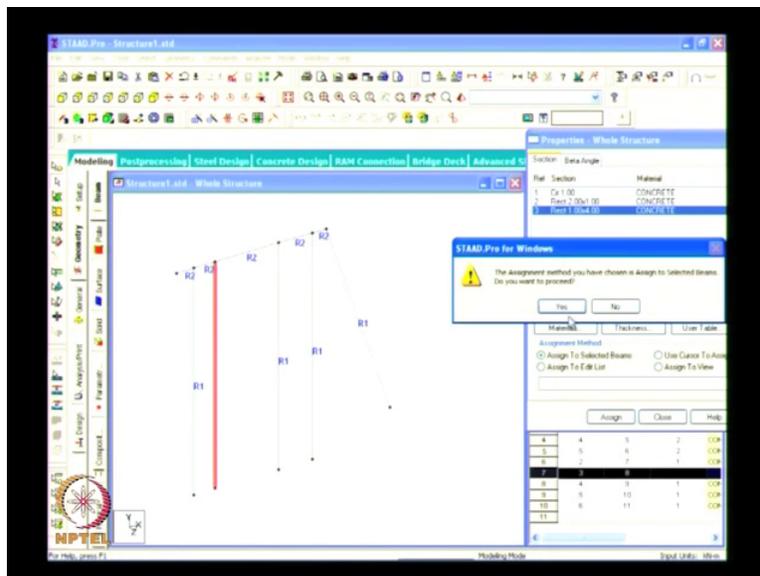
So we are assigning for the piles 1 meter in diameter, So we have to assign the properties for each number separately, what we have create through the entire view, so now we rotate, now this is a model what we have created,

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So there is a end beam we have to create, curtaining beam you create, 3d view, now we have added one retaining beam.
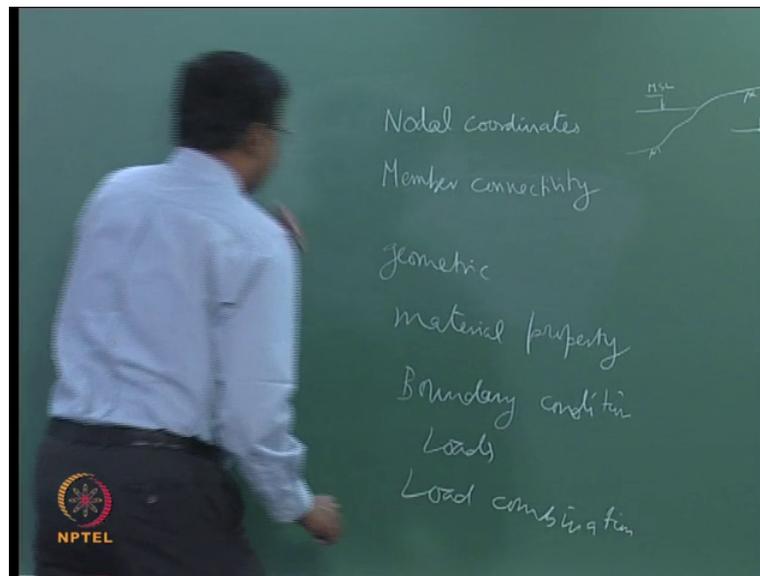
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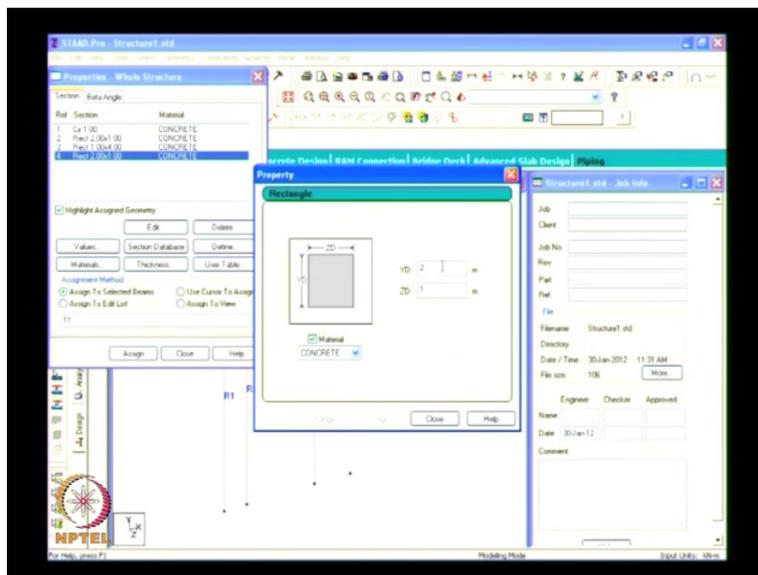
The beam is shown at the end, so you will assign the boundary conditions, now since the boundary condition is hinged at the bottom, ok tomorrow we will see the springs and the results
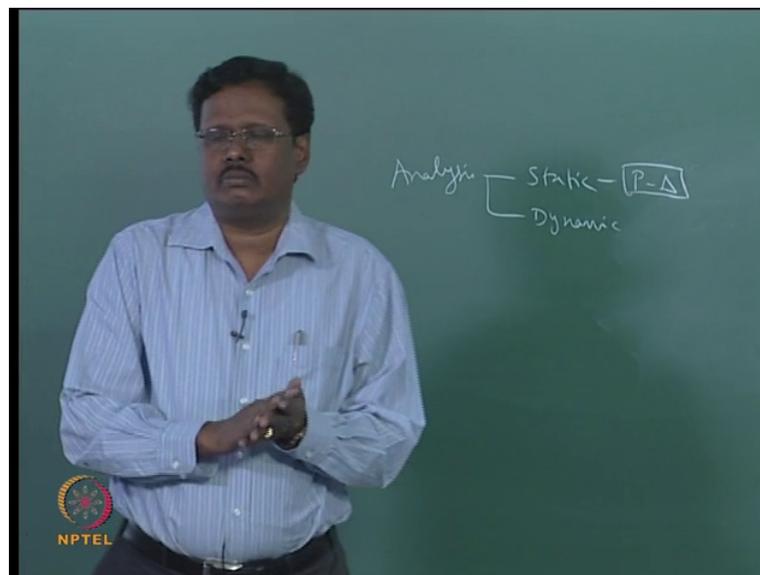
also, let's go, so in finite element method I will write briefly what are the data that is required, whatever he has done he will give this following sections,

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One is called as a nodal coordinates, other is member connectivity data, geometric properties, material property. Boundary conditions, loads, load combination,

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Then we will have analysis, here we can have a static analysis, any dynamic analysis, static we have a special analysis called as P delta, these are the things which you have to learn but it takes time to learn this, you should have a formal knowledge about finite element analysis, how many of you have taken a finite element course, how many are planning to take a course, no one want to study finite element.

If you are an IIT you should take this course finite element, all branch of engineering only civil, mechanical, most of you are taking this course as pre elective, you better take finite element course also,

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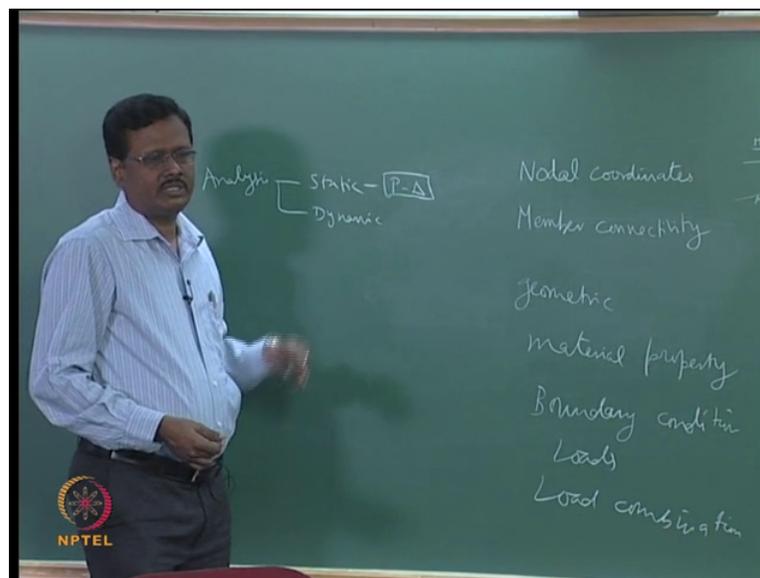
You please read some text books and Straad pro manual you have to give this nodal coordinates, member connectivity, geometric properties, material property, geometric property means the moment of inertia, area of the section, material properties.

Young's modulus, poison's ratio, boundary condition means whether it is a hinged support, fixed support or spring support, loads various loads which we have discussed, then the combination of the loads, the analysis we can have a static analysis or a dynamic analysis, this is to calculate the natural period, once you have a natural period only you will have the seismic ports, we will see tomorrow.