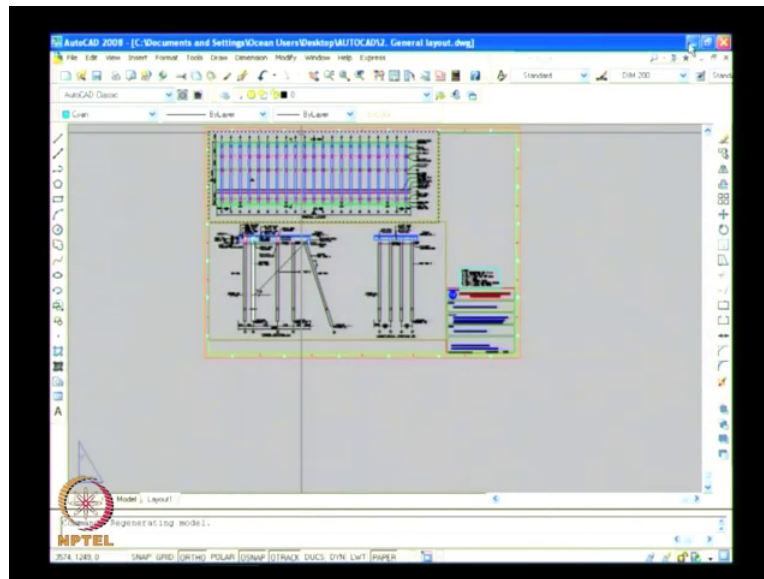


Port and Harbour Structures
Prof. R. Sundaravadivelu
Department of Ocean Engineering,
Indian Institute of Technology Madras
Module 4 Lecture 17
Berthing Structures- Analyses

Morning all of you, I am Afrin on behalf of Professor Velu I am here to explain you the analyses of a structure, in previous class you see how to analyze a port using a 2d analyses, see this is a general layout of a, this is a plant showing piles, diaphragm walls, and beams main beams everything.

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This is a fender location at every 20 meters, we will be fixing fenders, from the phase of the jetty from 2.5 meters we are providing the first row of pile.

From the first row central line of the pile we are providing a diaphragm wall at a distance of 3 meters and again from the central line of the diaphragm wall we are providing another row of pile at a distance of 9 meters, so total distance between the two pile is 12 meters, actually a crane is running through this thing, only will be placed in this beam location and another beam will be placed in this pile location, so we have to keep maintain this 12 meters.

And again another row of pile comes at 5.75 meters and another row of pile at 4.25 meters, this is the retaining beam, actually surcharge pressures will act here, in order to reduce the surcharge

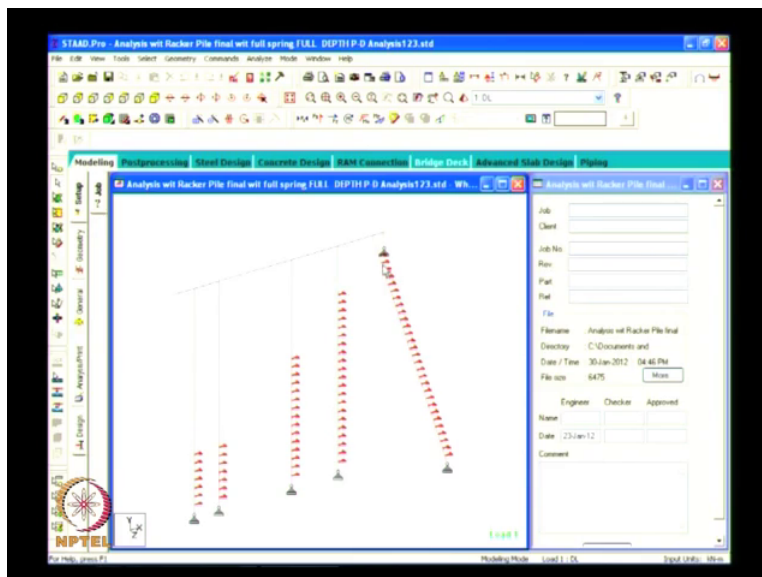
pressure we are providing a retaining beam at a depth of 2 meters, this is a cross section we are looking at this section, this is a typical section showing the fender, the distance of 2.5 meters (pile) first row pile is coming and again at a distance of 3 meters.

Another diaphragm wall is coming, we are providing a 45 degree inclination from the dredge level, actually the dredge level is coming here, surcharge load act here in this portion, surcharge load will be acting and 45 degree line will be drawn from this point to above the berth, so as to reduce the surcharge pressure acting on the diaphragm wall, now we are considering this pile diaphragm wall pile, pile, racker pile, this is a retaining beam.

And this is a marine beam as slab is above over it, these are the two crane beams in order to run the crane and this, above the diaphragm wall a coping beam will be provided so as to maintain the uniformity of the diaphragm wall, and this diaphragm wall will be running for a length of 84 meters, by constructing it we cannot maintain a single uniform path of the diaphragm wall, so in order to maintain and to transfer the load to the diaphragm wall.

We are providing a coping beam at (the) at a distance 1000 meters is a diaphragm wall weight and 150 is the tolerance (the) it means that the diaphragm wall will be placed some 75 meters or so, by constructing the other panel, so in order to transfer the load to the diaphragm wall we are providing a coping beam, I will go to the Staad pro, this is a structure

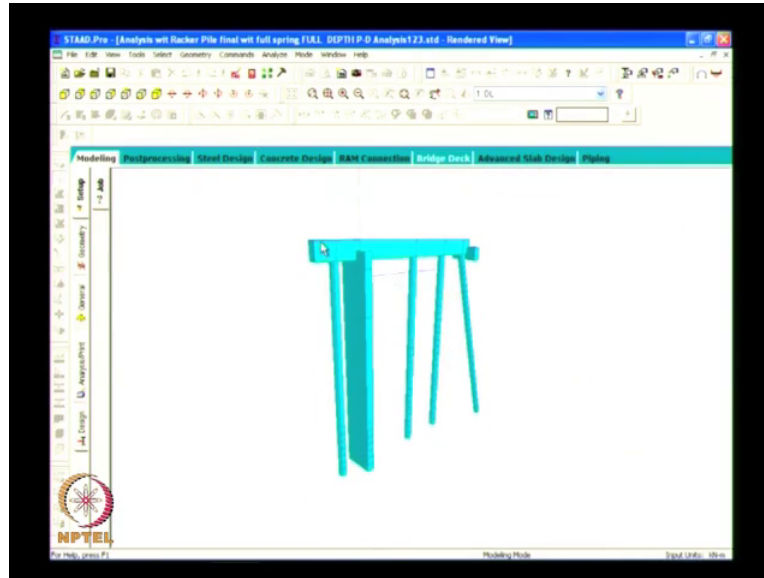
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Underlies, this is a main beam, no this is a pile, this is a diaphragm wall, other row of pile.

Another row of pile and the racker pile, retaining beam is coming here, the top is fixed to the middle beam and the bottom of the retaining beam is supported on the ground, this is a 3d view showing,

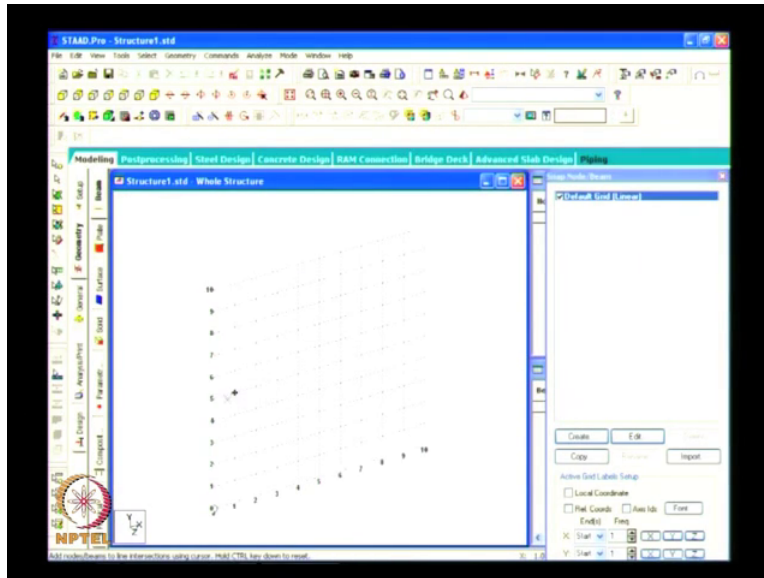
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This is the main beam, the main beam depth is 2000mm, this is a first row of pile at a distance of 3 meters and 9 meters 5.75 and 4.25, this is a racker pile, this racker pile is provided inclined so as to reduce the deflection of the total structure.

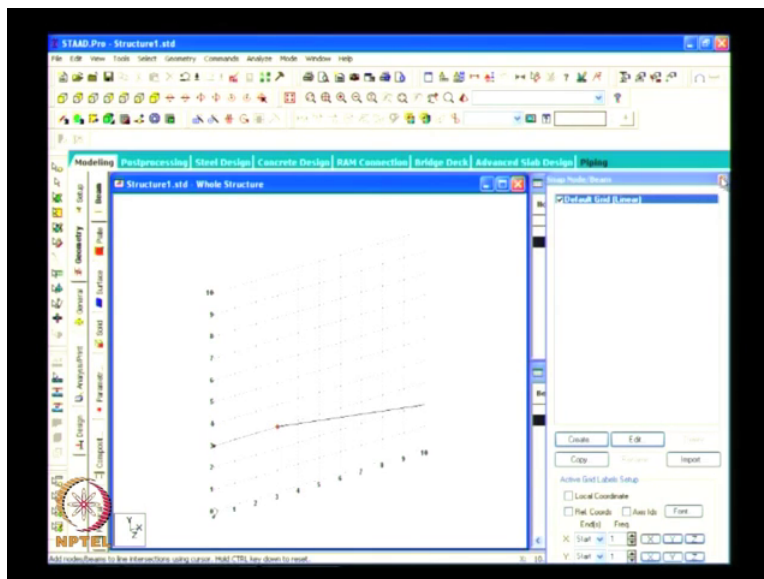
And now I start with how to create this model, so a new project space whatever you take and the unit should be in meter and the kilo Newton, see it is highlighted here

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And next add beams, so this is a grid we start from here, so actually it will be (defau) my default location it will be like this, the (05:11 cursor) will be like this only,

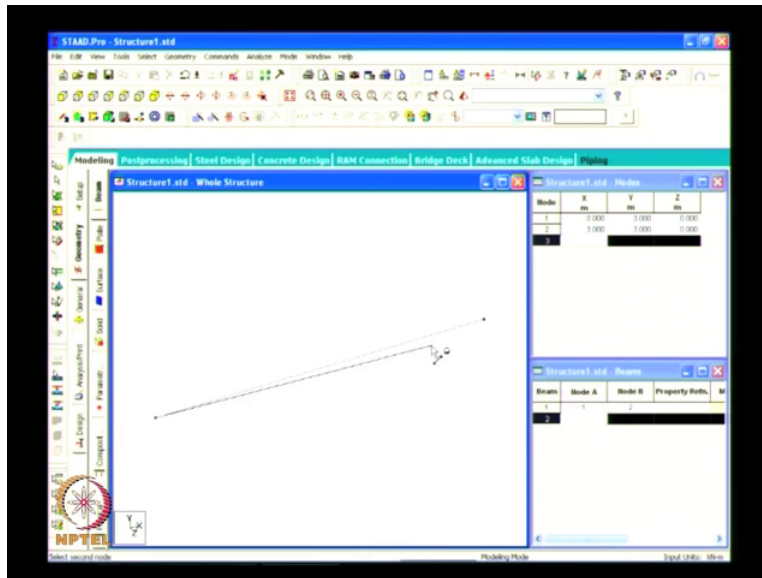
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We can fix the top level say now in our case a top level is 3.85, I will take as 3, see this is a 3, y axis 3, see here you are seeing the axis.

This is x and this is this is y, x and perpendicular to axis is that direction, now I am considering the top level as 3, first at a distance from the phase of the birth this is see this is phase of the birth and the first row of pile is located at a distance of 2.5, now here the distance now 2.5, I am taking 3 ok, and you control this snap node beam whatever, this is the distance between the node to node piles, display node to node distance.

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Simply you select this and find the distance between these two; it is coming around 3 millimeters, now what you have to do is you have to shift the node point into 0.5 meters I can say, oh sorry this is a node cursor this is a beam cursor you select node cursor, simply you select the node, what you do in Ms office, word or excel control c control v copy paste simply you move, we will move the node slightly move you find move.

Axis it is going in this direction so it is positive x this is positive y and this is positive az, you want to move inside it, so if you are giving minus 0.5, now this is asking whether to node the space, now we are providing so it is 2.5 it is created and next is coming at a distance of, this is a pile and this is at a distance of 3 meters, simply you copy this node, control c and paste the node control v at a distance of 3 meters this is in positive direction.

Axis towards this so we are providing 3 meters ok, it is created and again you copy this same thing control c control v providing at a distance of 9 meters, this is 2.539 and 5.75 and 4.25 same

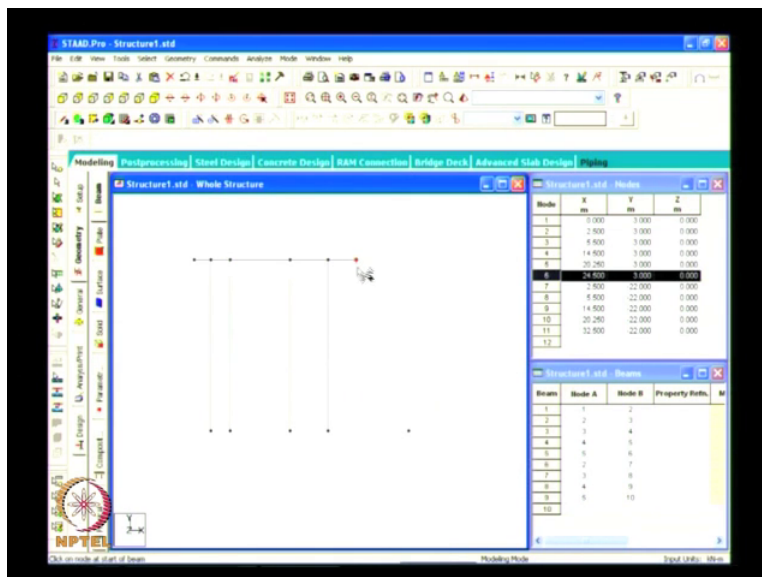
thing you copy this note control c control v this is 5.75 and again 4.25, see all the top nodes are (08:12 now located) now all you have to do is this is the removing of all that is dimensions, now here this is a cursor at beams now this beam is already added in grid by grid method.

We have added this beam, now we are connecting these all the members simply you go to add beams by just clicking these two nodes the beam will be created; now you can see the dimensions, display node to node distance 2.5 3 and 5.75 and 4.25, now the top level is created, you have created this thing the whole thing you have created, now we want to fix the founding level, this is minus 24 actually this is a one pile.

This is diaphragm wall, this is pile, this is pile ok, now I will come back to this later, now I want to fix this level to be connected with a bottom, so all I will do is control c control v, the y distance this is y positive, we are providing at bottom so by negative we will provide minus 25, a node will be created at the bottom, now the same thing we will do at beams top node and the bottom node, top and bottom, since the racker pile is inclined this is not a straight pile.

So we cannot provide in y direction but also we have to provide in x direction, this pile the starting pile it should be connected from this point to this point,

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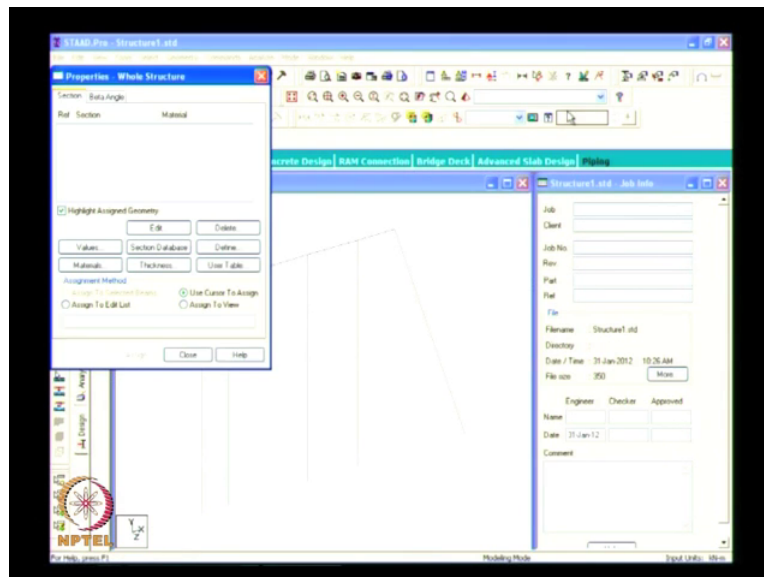


all I will do is I will copy this node and paste it at y minus 25 and also in the x direction, so I will put some 8 meters I will say, a node will be created here and go to add beams and simply you

add this, the selected pile is in a slope of 1m 3 that is the total distance divided by 3 will give you this horizontal distance.

Now model is created, now if you simply go to this structure rendering (wewe) we will see without the this thing, now property is assigned simply the line element will be here, now the next thing is to proceed property, to assume the property of the structure, the pile dais is actually 1 meter, so this is the property page,

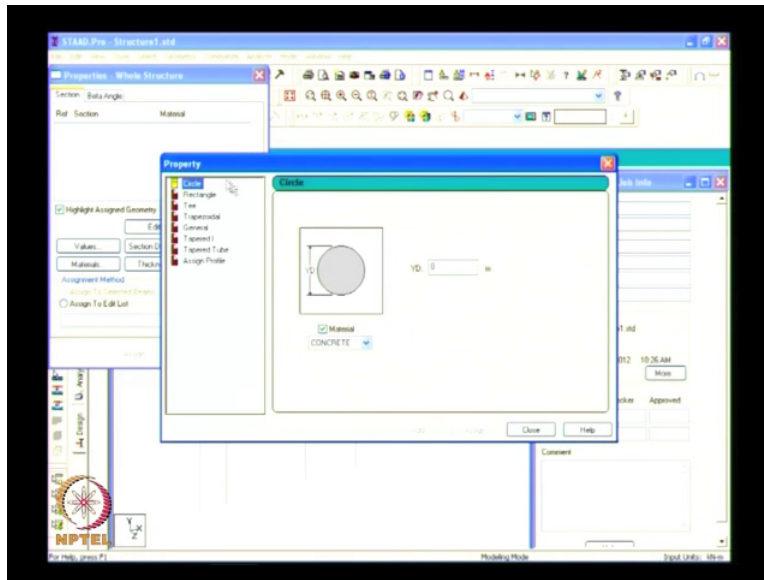
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Simply you take this and define there are so many things, you go to define you will circle pile dais you will giving as 1 meter.

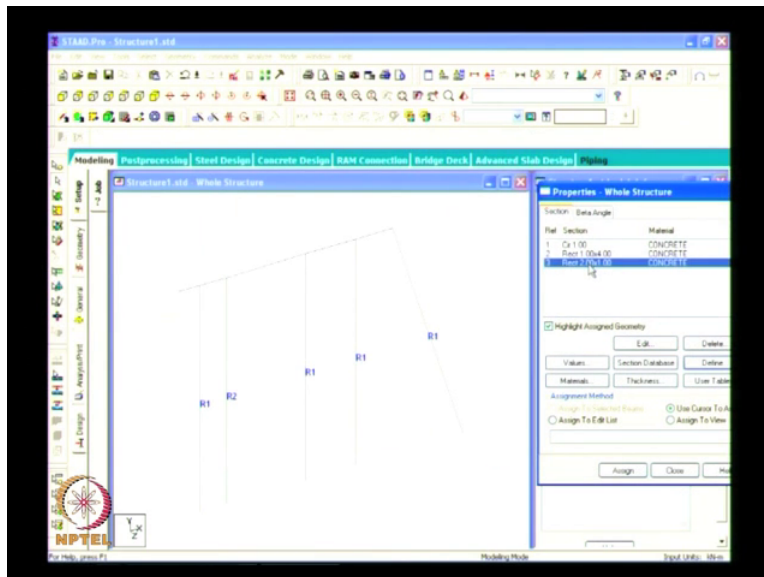
Now the diaphragm wall is rectangular, so we will go for rectangular section,

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you simply select rectangle yd, yd is a depth and zd z width, the width of the diaphragm wall is 4 meters, if you providing 4 meters by 1 meter close, now simply you select this what are the pile elements here 1,2,3 and 4 there are four piles here, so first you select the property and you assign it to the corresponding numbers 1,2,3,4 assign to selected beams, assign.

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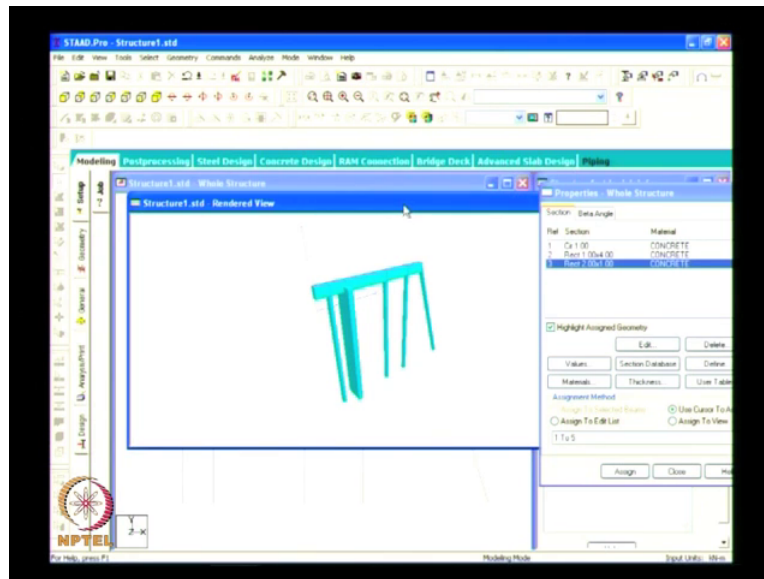


Now R 1, R 1 is the property of the circular pile it is assigned to the numbers, now we are providing the property for diaphragm wall, this is 1 meter by 4 meter this is the diaphragm wall, select to, assign to selected beams now the pile and the diaphragm wall is made, now all you

have to do is the main beam, main beam depth is 2 meters, now you have to create them, go to property page define rectangular beam, yd is the depth, (depth is).

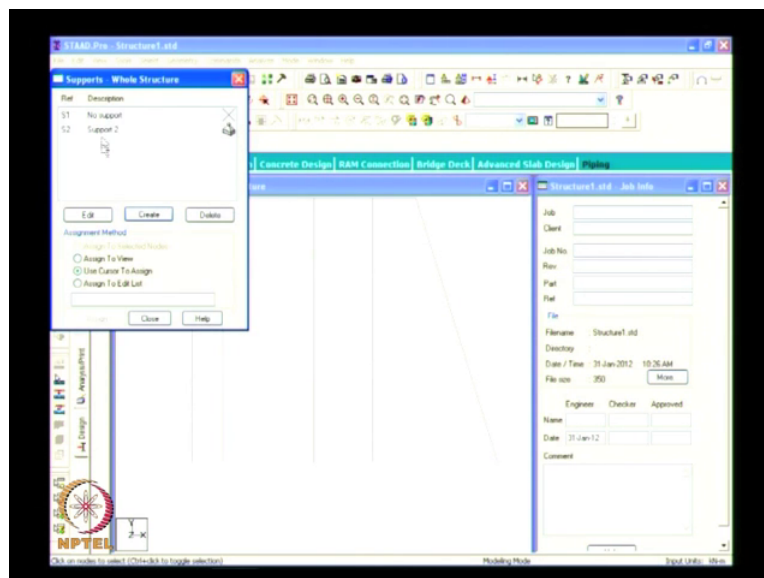
Depth of the beam is 2 meters and the width is we are considering 1 meter width, first you select this (whateva) what are you going to assign and you select the number which you are about to assign, select this beam assign to selected beams assigned yes,

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Now the model is created,

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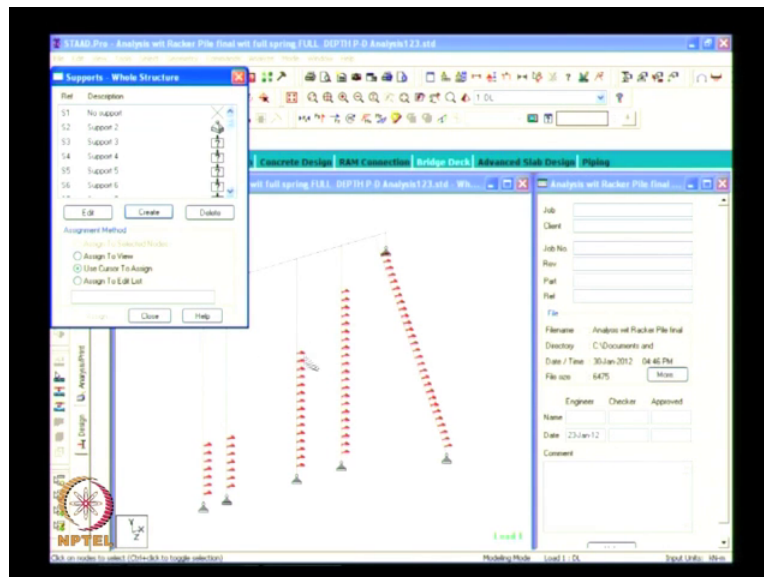


you have to now assign the boundary conditions, see this minus 24 level founding level, weathered rock is coming, so in weathered rock (we are) we will go for, this is a support page.

Support page if you select, in your support you have to create a support, it will be fixed pinned, fixed but there are so many supports will be going for the three fixed, pinned and the fixed but, (we are now) since all the piles and the diaphragm walls are resting on the weathered rock, I will be assigning pinned support, pinned support means you'll see the restraint functions are f_x , f_y and f_z all these things are placed, so we will go for pinned support.

Simply you select the structure and assigned to the corresponding bottoms, this is a pile, pile, pile, diaphragm wall and a pile,

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assign to selected nodes how the boundary conditions has made, now you will see a 45 (digr) degree inclination from the drege level to the top of the jetty means that at this point and at this point now soil will be actually the pile are inserted into the soil, so there will be some force which will hit the pile.

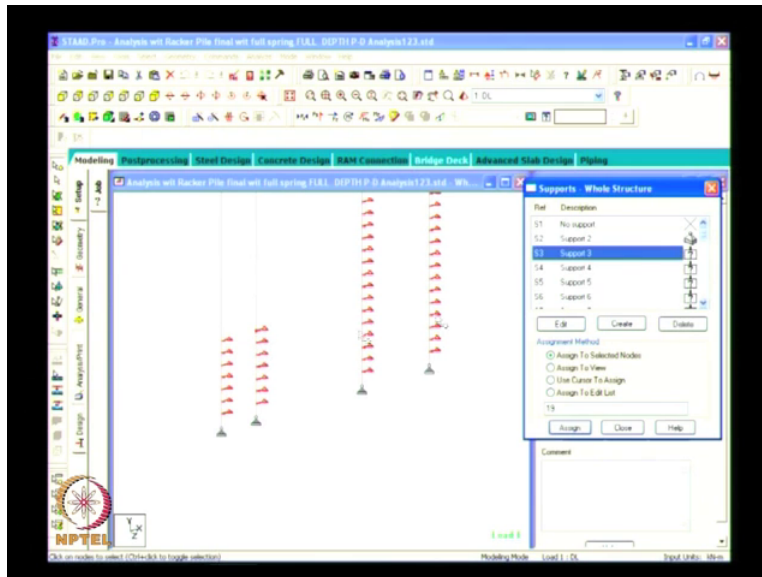
Now we have to give (the) what are the forces acting on the pile below that, which means we will give at a distance of 1 meter, new spacing should be diameter of the pile or 1 meter spacing whichever is smaller (15:17 if the pile design) in our case or piled as thousand, if the piled as 850

we have to apply the springs at a distance of 0.85 meters till the founding level, so it will take some lot of time to calculate this springs and all.

Now simply applied what is the springs, the spring application will notice you have to do is go to support page create fixed but condition you have to assign because since (only) we are considering only the 2d analysis, since we are considering only the 2d analysis, a force from the fx direction will hit the pile, so I am assigning only in the direction of x, if you are considering a 3d analysis over the direction we have to give the fx and fz.

The force under oppose to the pile, now I will create fixed but, here you have to do is you release all this things, only thing you have to give is fx, kfx this is a stiffness, (all you have to do i) it will come around some 9000 to 1, 00,000 kilo Newton per meter, force will act on the pile, you see this you will understand, so this is a fixed condition you have assigned (16:31 you see), (once I) this is support 3, this is applied at this point, you can see highlighted here.

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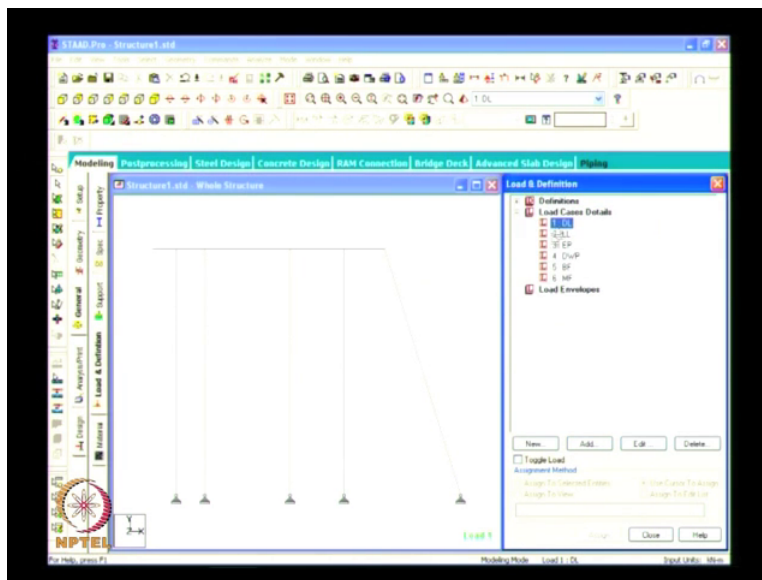


The support 4 will be assigned here, see you select the support 4, it will be assigned here see you select the support 4 it will be assigned here and the 5 below, 6 below, 7, 8, 9 see at every different locations the spring value will be changing that means the different types of forces acting on the pile below the soil, so like this for every pile and diaphragm wall I have assigned the spring constant values, at a distance of 1 meter display node to node distance you select.

And you go further, distance between the springs select any spring you say, from here to here the distance is 1 meter, from here to here the distance will be 1 meter, so at the (bo) bottom it may change, since the beginning if it is a 24.5, now in our case it is a 24, if it is 24.5 it will be 1.5 or so whatever, now in our case it is only 1 meter, I will close this, now the boundary conditions are applied, next step is we will go for load page, load calculation how to adopt load in the structure.

This is a load definition, this is load page you have select this, you have to select load case details, load case details you select and here new you select add, what is this load case number, this is a primary you have to see this primary load, load generation, combinations, auto load combinations,

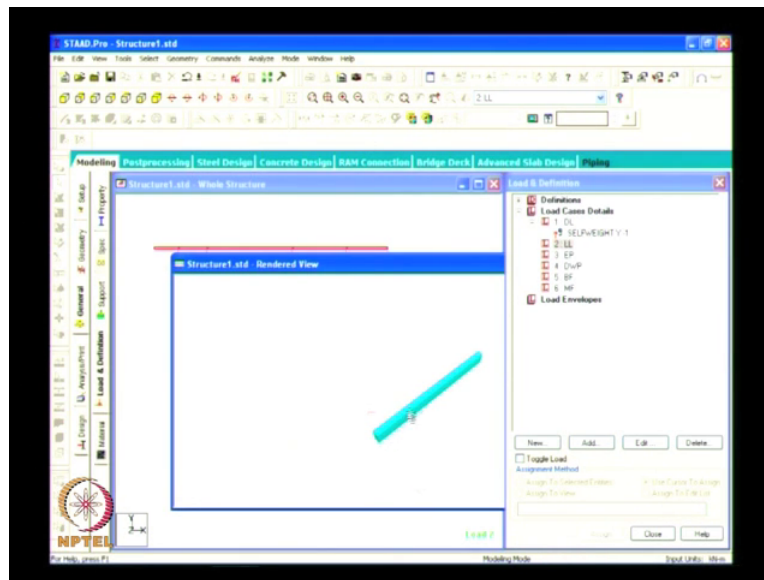
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The primary load you have to select and number is 1, I say one type of the load is dead load, total dead weight of the structure you have to consider.

This is dead load I am considering da again live load considering live load simply you select none, air pressure will be mainly acting on diaphragm walls air pressure, differential water pressure, berthing force, mooring force, now I created the primary load cases, dead load we have to assign the dead loads, now you select the dead load and go to add you see self weight, here it is self weight,

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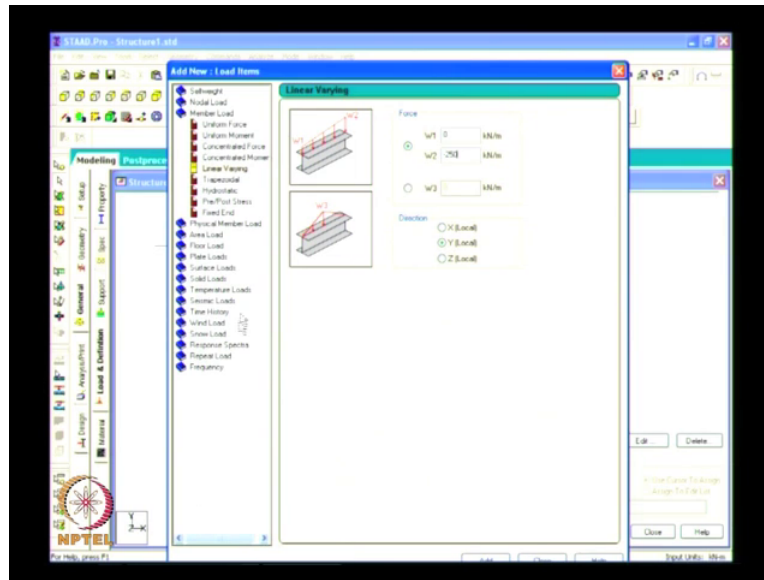


It should be assigned in y direction, the factor is minus 1 we will add this.

And dead load, live load again the second case is live load you select this and go to add, live load will be acting on the structure, once you throw into structure throughout from this point till this point the live load will be acting, at a distance of at a force of 50 kilo Newton per meter square, since I have considered only this section, say (I have) I have selected this section for analysis, live load from half of the distance from here and half of the distance from here.

It will be acting on this whole beam, so the total distance between half and half is 4 meters, actually this is a 4 meter, the half is 2 and the other half is 2 here so total 4 meter will be acting on this in this particular beam, so since the live load is 50 kilo Newton per meter square, I am considering it for a 4 meter width, so 50 into 4 is 200 kilo Newton will be acting, kilo Newton per meter will be acting on this beam, from y the 200 kilo Newton per meter will be acting here.

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I will assign this, live load go to add see (this is a) there are various load case self weight, nodal, number and pressure load there are so many we will go for member load , member load you can see here W 1 is a load which is acting throughout this you want to assign in a particular distance we can give the distance, this is d1, d2 and d3, now we want to apply (at) throughout the distance, so simply you will assign minus 200, it should be applied in y direction.

This is a positive y (we) we want to apply it in negative direction so I am providing minus that has to be given by client actually based on what type of the berth it is, this may be a small berth, boat jetty or something but in Vishakhapatnam or Chennai footage we will be seeing later with a larger vessel will be coming, if it is 10,000 Dwt or 80,000 Dwt the live load will be higher, since they will take the container and everything will be placing on the berth.

Now we will go for air pressure, see this is a top level 3.85 there is a soil below this, soil below the top level will not be remain same till the founding level, the soil at this level may change from this to this may change from this to this may change there can be a different type of soil below it, so air pressure will not be the same throughout the diaphragm wall it may change, since the soil is safe it is sometimes (then we we) may be a clay here and sand here.

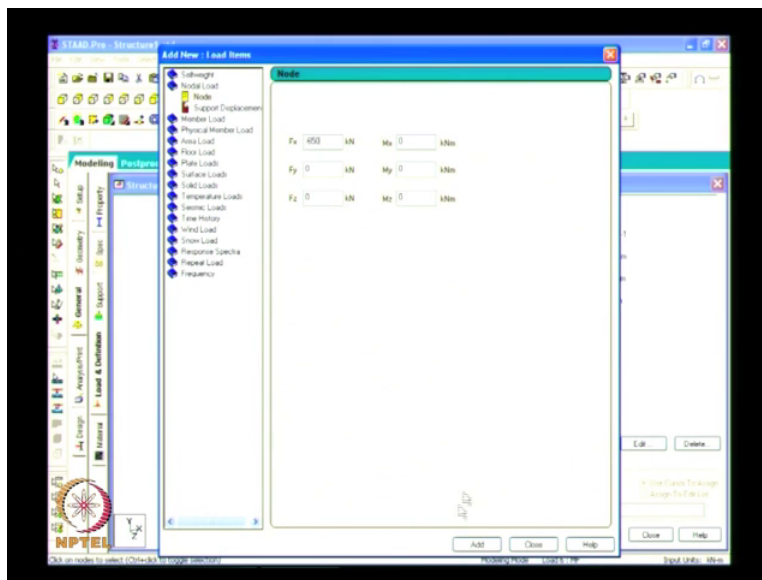
And again a clay here and a rock here like that the soil property will change, so based on the soil property will be assigning the calculating the active air pressure and a passive air pressure, the air pressure we will be at, this is you go to member load linearly varying actually there will be no

air pressure will be acting from here to here, since the more soil is here it means that for understanding I will say soil will be more at this point.

So there will not be any active air pressure or passive air pressure at this point, it will be zero and it will be higher here at this point, it will be act like this, you see linearly varying like this only the air pressure will act on the structure, w_1 is small and w_2 is higher, I will go for w_1 is zero and w_2 is say minus 250 hours, 250 kilo Newton per meter will act, it will be acting in x direction, this is y, I have did it for by it is in a y direction.

Y is this here you want to apply it in x direction select add, now differential water pressure the same thing you select this and go to add member load, uniform force we will act, since the differential water pressure will be very low, it will provide only 20 hours, that's to be assigned in gx global x direction add close, berthing force this is the pace of the jetty, this is the pace, ship will hit in this direction to restrict that we are providing a mooring force at this direction.

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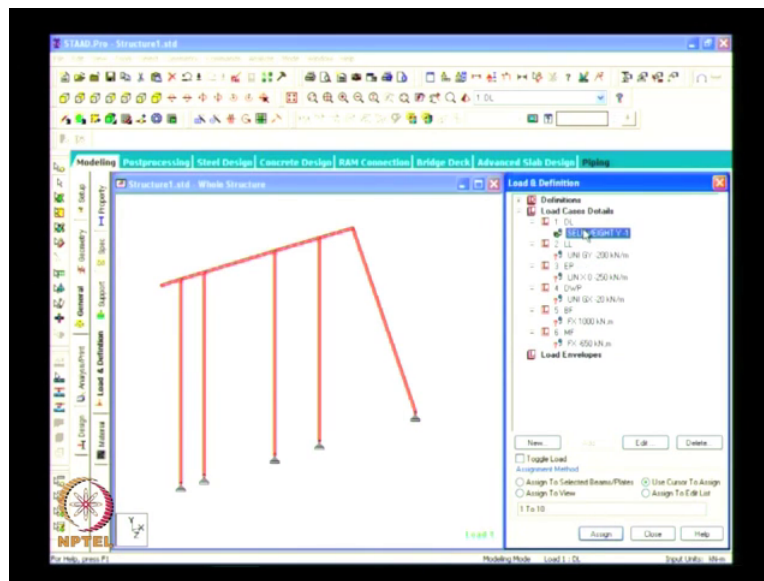


Bollard will be fixed here and from this bollard pull of some thousand five hundred or so it will act on the this thing (this part) this particular point both the berthing and mooring will happen, berthing force I will go at nodal load see already we have applied in member forces, now we are applying at a nodal point, at only a particular only 1 point berthing and mooring will take place, so node it is in positive.

Positive x we are providing 1000 kilo Newton say add and the mooring force will be in the opposite direction, add auto nodal load minus some 650 or so whatever, now how to apply this load to the structure, now we have created the load all you have to do is you have to apply dead load, live load, air pressure, differential water pressure, berthing and mooring to the structure, select the self weight (self) self weight, self weight it is to be assigned for the whole structure.

For pile, diaphragm wall everything will be having a self weight so select the whole structure over to here,

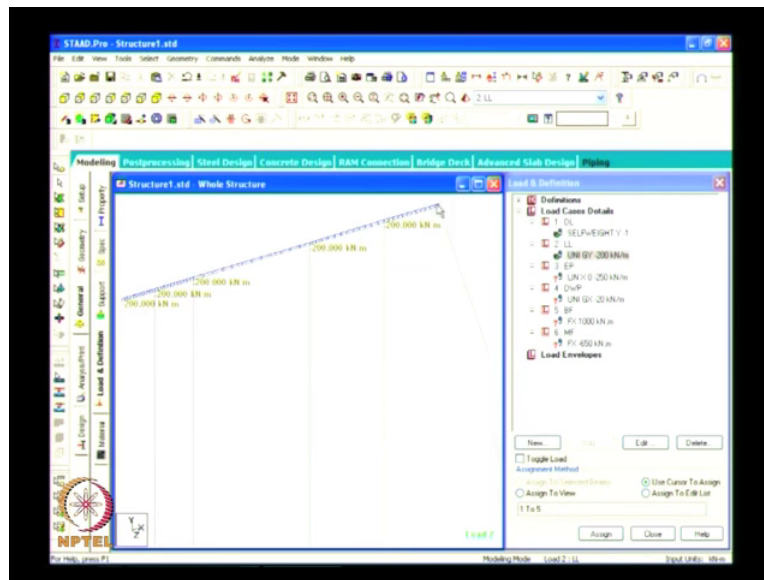
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assigned the selected beams and place, select assign, this is asking whether you want to proceed yes, now total self weight is acted over the structure, now the live load will be acting only in this point, I told you earlier live load from the 2 meters from this side and (2 frm) 2 meters from this side will act on this point.

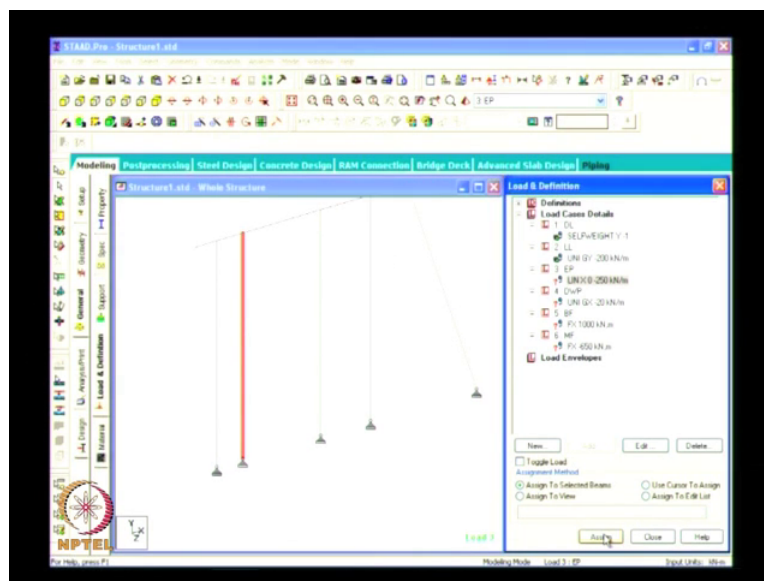
So we are providing, we are adopting minus 200 kilo Newton per meter on this beam, assign to selected beams, now the load is applied you can see the value of the load by shift and v,

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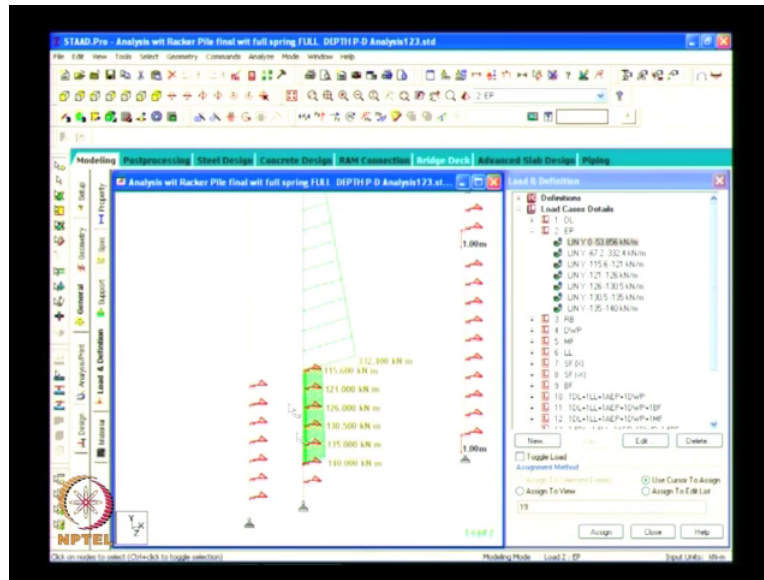
This is 200 kilo Newton per meter is acting from this point to this point, now I applied self weight and live load I have applied, dead load and live load, now I will go to air pressure,

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This is starting from zero and (dita) 250 at the end. See this is a diaphragm wall air pressure only act in this diaphragm wall it won't act in the piles and all, so I will select the diaphragm wall assign to selected beams, assign see it is starting zero and it ends at minus 250,

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Since the soil pressure may change, if somewhere here it will be low and here it will be high, (I am just) exam for exam I have applied here in next lecture see the air pressure.

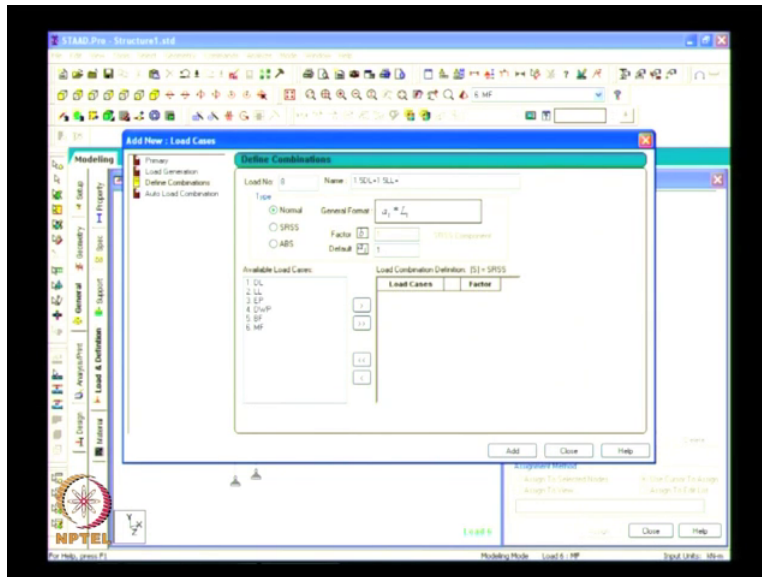
See from (he) this level only (the soil) the earth is there so starting from zero it is about 53. Something some value here and it starts it at 67 to it ends at minus some 332 at this point, see the level I will show you at zero location is zero air pressure is at 1.1 meter, from zero to 53.86 is this level at minus 4, from 1.1 to minus 4 the air pressure is (this) like this and from minus 4 to minus seventeen air pressure is like this and below the air minus seventeen.

The air pressure is reducing, see at minus 17 it is 332 at minus 22 it is getting reduced, like this based on the soil the air pressure value will change, air pressure we have applied and the now the differential water pressure it will act only in this diaphragm wall, so you select the air pressure, differential water pressure select assign to selected beams yes, it is applied toward the diaphragm wall it is applied and the berthing force and the mooring force will be applied.

At this particular node, berthing force and mooring force, berthing you select the berthing force and select the node, assign to selected nodes assign yes, see 1000 kilo Newton is berthing coming on it and the mooring force is 650 I have assigned, 650 berthing and the mooring so now a total load on the structure is assigned, now all you have to do is according to limit status, limit state method we will go for combination.

Same thing we will go for load case add different combinations, according to IS4651 par 3 there are so many combinations based on the several civility condition and collapse civility condition, I will go for a one thing for a (30:19 lemenstrate and collapse civility) one dead load plus one live load plus one air pressure plus one differential water pressure plus one berthing force, I created the name, name of the combination here you see the factor.

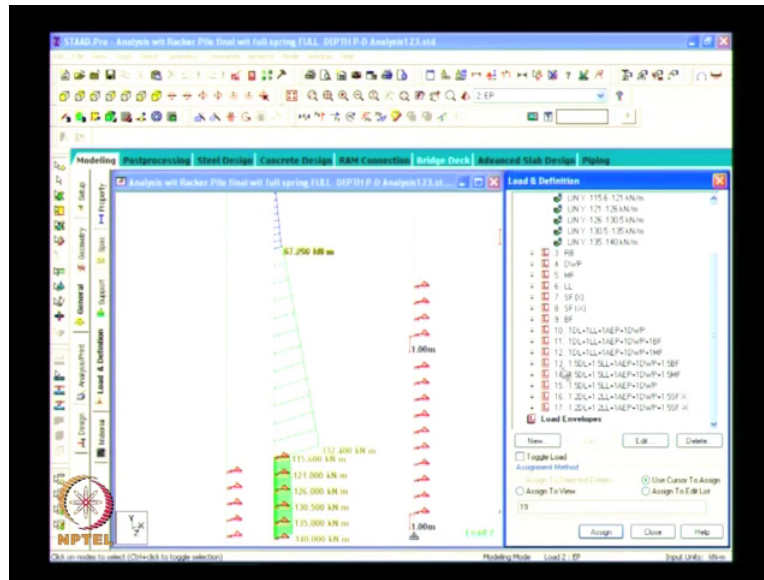
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Default factor is what, so one here everywhere the load factor is one , it is already one so what to do is dead load you select to this side(30:59 somewhere like) and live load select right, air pressure and one differential water pressure and one berthing force, ok now the load combination is created add ok, now I will go for collapse civility condition, 1.5 dead load plus 1.5 live load plus and whatever the several civility condition and collapse civility condition.

The load factor of air pressure and differential water pressure must be one, it should not be greater than one, one air pressure plus one differential water pressure plus 1.5 berthing force, load factor is 1.5, all you have to do is assign it at 1.5, dead load, live load, and berthing and other air pressure and differential water pressure should be one so you change it to (1pa) 1 air pressure and differential water pressure, so there are so many combinations based on IS4651.

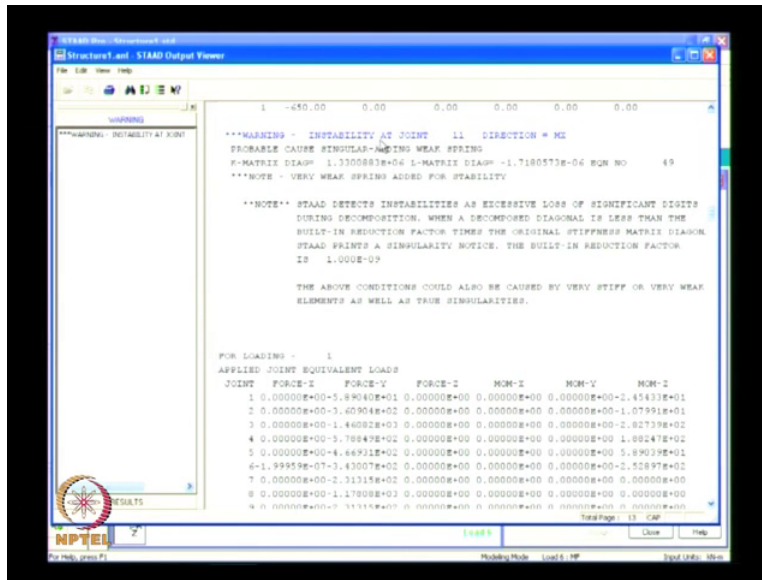
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I have created here see one dead load one live load, one dead load one live load, one active air pressure, one differential water pressure, dead load live load air pressure and berthing and mooring, see this three demonstrate of several civility condition and the 1,2,3,4,5, 5 is demonstrate of collapse civility condition, this is 1.5 factor dead load live load and berthing, see in everywhere the air pressure and the differential water pressure factor.

Should be one everywhere it is one and the collapse civility condition 1.5 dead load live load and berthing, dead load live load and mooring, 1.2 dead load and 1.5 seismic force, seismic force I will include in this case, see seismic force which will give the force in this points 1,2,3,4,5 at this five particular point will give the seismic force,

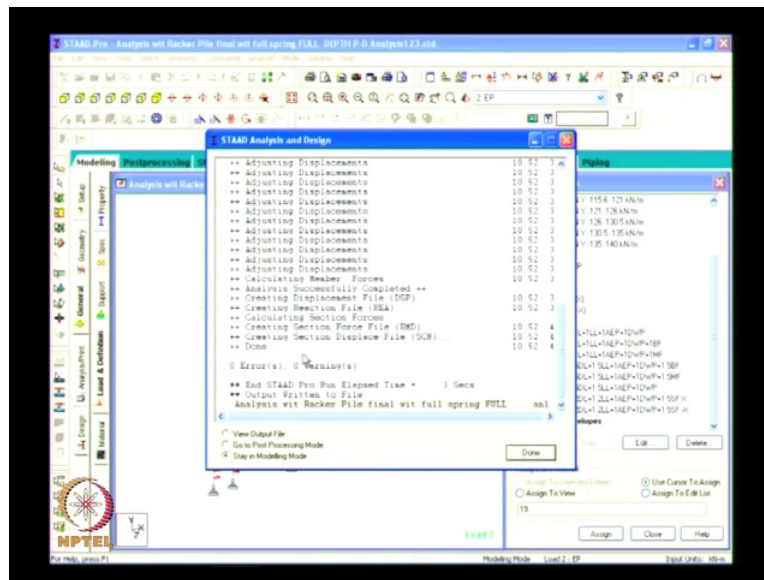
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Like this only the load combinations will be created once you create it, you go for commands, now everything the geometry.

Boundary conditions, load everything is created, you go for commands analysis, perform analysis select print option all ok ok, now though go to analyze, run analysis say, there should not be any zero, errors and zero warning, now we will see what the warning is, stability at a joint 11, now what is a joint 11 we will see, select you go to select by list, the joint is a node point you go to by list, you go to nodes like the 11 will highlight here.

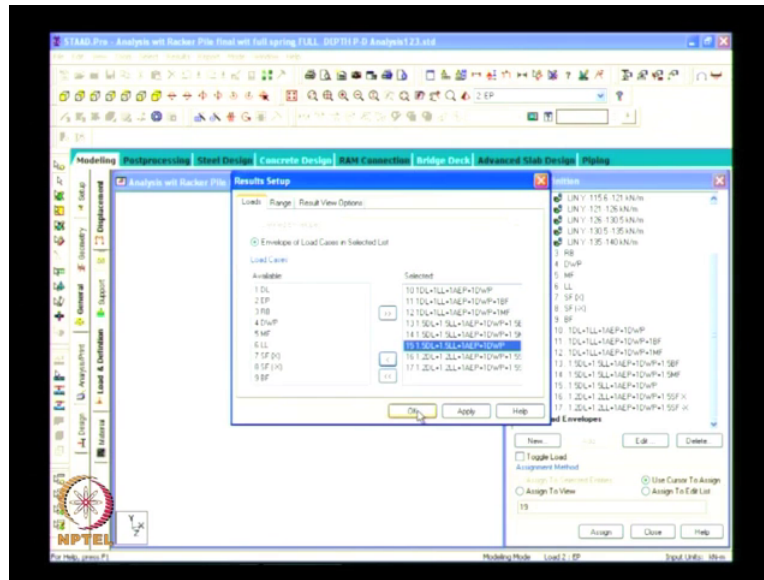
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So there is some warning in this case, see now in this next structure if you analyze there is zero errors, zero warnings ok, now pre analysis is over now we will go to post processing mode from here only we will find the bending moment shear force, axial force for the structure, go to post processing mode, unless you if you have any error it will not go to post processing mode, if you the warnings are there means it will continue, we will be dealing with that later.

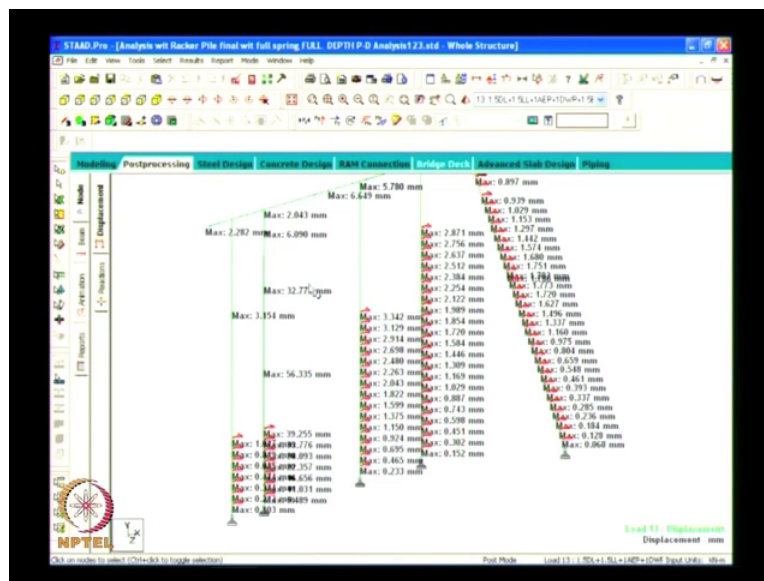
Go to post processing mode, done in this post processing mode maximum bending moment and shear force theorem will be considered for the load combinations only, not for the primary load case, now you select all the primary load case and you select to available portion, now the selected portions are only the load combinations you select it for the post processing mode now you go for ok, maximize this see now we will check the deflection of the structure.

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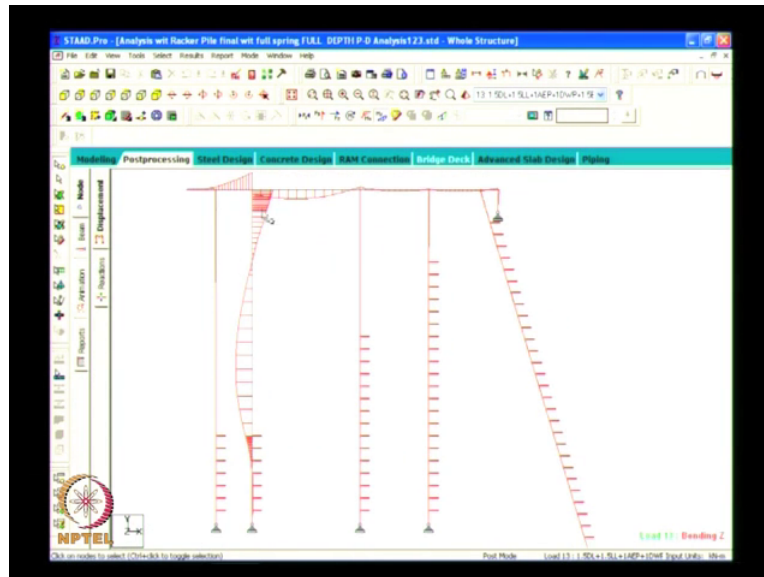
See this is the deflection diagram showing how the structure will deflect if all the forces will act, I will change the load case to maximum of several civility condition berthing force ok, this is a load deflection diagram showing the structure go to result, view value beams and results here you find the bending, shear, axial, displacement combine bending and x axis, now you want to see the displacement, this is the displacement maximum resultant got it.

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The structure will be deflected at maximum of 32 mm at diaphragm wall see all the beams and all it will only deflect to 6,7,5,1 or something, now we will see the bending moment in the whole structure, go to scale you edit the various bending z, if you show it now I will show you it will be in large scale, you will not see anything, I will reduce the scale of this, this is the bending moment of the structure,

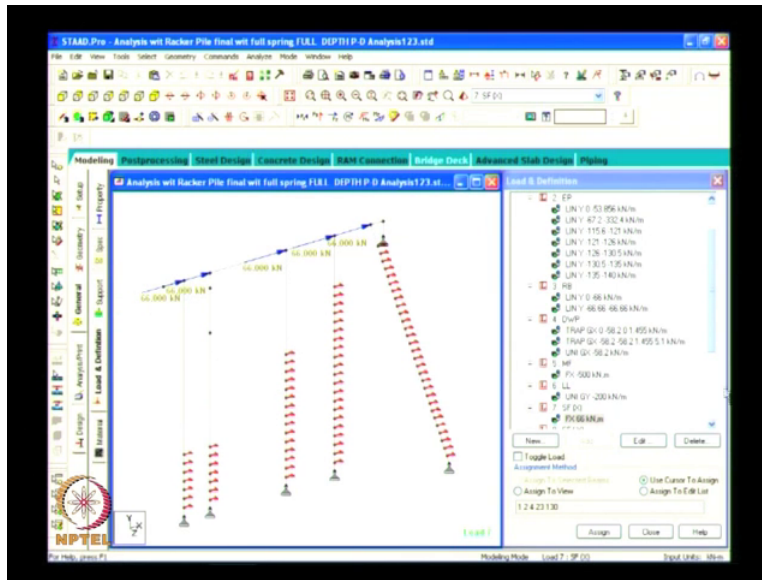
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Diaphragm wall will bend like this. Beam will be bending like this; you increase the scale it will show, we want to see the highest value, what is the maximum bending coming on the structure, now I have selected the same is at bending at az direction maz, you go to result, view value beams and results bending, maximum bending at the ends over the bending is coming and at the midpoint, I will select the maximum bending got it, this is the maximum bending on the pile.

Diaphragm wall, pile, pile and the racker pile,

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And air pressure is applied here, retaining beam I told you surcharge pressure will act on here to reduce the surcharge pressure acting on the diaphragm wall we are applying, we are providing a retaining beam here, it will take the surcharge pressure, surcharge pressure will act here, surcharge as well as the air pressure will act on this retaining beam, this is differential water pressure which will act on this structure.

This is a mooring force which is acting in the base of the berth; this is the live load 200 kilo Newton per meter is acting on the top of the beam, the seismic, seismic at each beam and pile junction the seismic force will be acting, we are considering like that, this is the main beam going throughout it and the pile is hitting at the center of the beam, so we are providing seismic force at this direction, both the positive direction as well as negative direction.

We will be applying and berthing force, in my case it is coming 1000 640 berthing force and the mooring of 500 kilo Newton, like this way we will be calculating to analyze the structure, by based on this we will be taking the maximum bending moment and shear force and go for design purpose for beam, diaphragm wall and (42:36 everything)

Thank you.