NPTEL

NPTEL ONLINE COURSE

Structural Dynamics
Week 11: Tutorial 01

Non Structural Elements

Ramancharla Pradeep Kumar
Earthquake Engineering Research Center
IIIT Hyderabad

In today's tutorial we are going to discuss about how to calculate the safety of a non structural elements.

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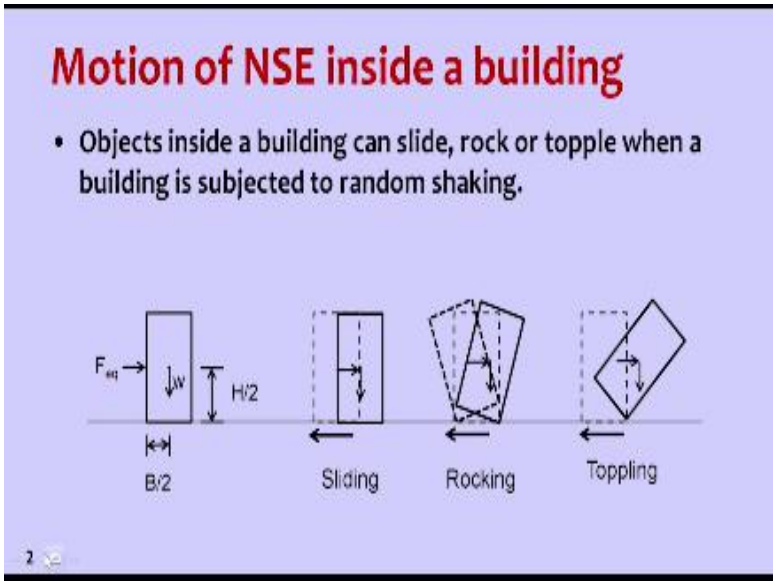

So if you see the three elements which can give a failure of a non structural element is first is sliding another one is rocking and third one is a toppling. Now how exactly it happens suppose this is my non structural elements say almera now for in first case sliding will it will go like this so if this is happening we will tell it as a identify it as a sliding. Second is rocking behavior so this is the rocking behavior where object will not slide but it will rock at one of the side and third

one is in case of excessive rocking this will topple ,so these are the three failure we will check the safety of non structural element.

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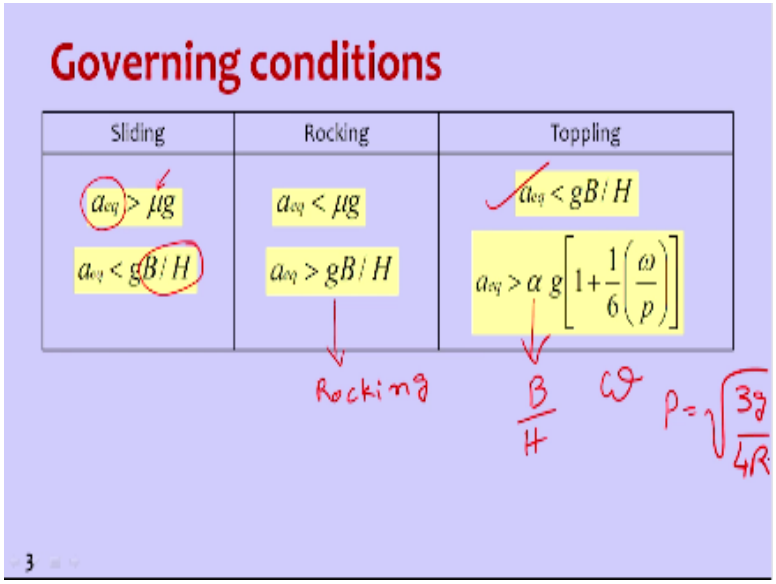

Now let us go to the problem now these are the three basic condition for which we are checking the sliding. So in case of sliding if a_{eq}, a_{eq} is nothing but the floor acceleration if low acceleration is greater than the μg which is nothing but μ is nothing but the friction coefficient and if this is meeting then sliding will happen and if a_{eq} is less than g into B:H so B:H B/H is nothing but this is a geometrical property of a non-structural element where B is a width and H is the height.

Similarly, rocking it is just opposite to the sliding condition, so if this is one of the condition is satisfying we will tell it as a the behavior is rocking. Now similarly third one is toppling, now toppling apart from the condition of rocking we have one more thing we need to check α, α is nothing but the it is a ratio of B/H multiplied by g one of 16 ω is this is not ω is a forcing frequency and p=√3g/3R. So once these are the basic equation for which we will check the element safety non structural safety of an element.

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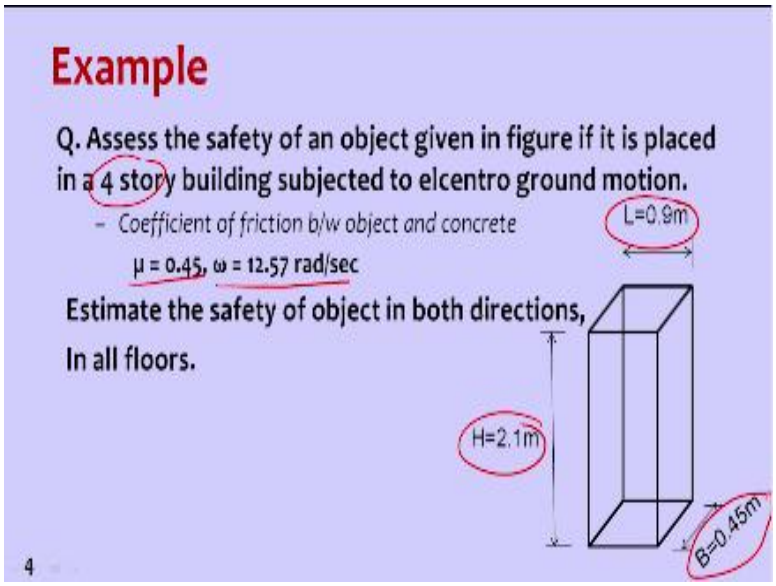

Now let us move to the problem here we have to assess the safety of an object given in a figure so here we can see there is a 1 almera having the object rectangular object shaving b width as a 0.45 meter height as a 2.1 meter and length has a 0.9 meter it is placed at the four storey building subjected to elcentro ground motion. Now the same element displays at the different, different stories so from ground floor, first floor, second floor, third floor and fourth floor so like that it is spaced at the four different places and another two values given it as a μ=0.45 and three forcing frequencies 12.57 rad/sec.

So with this property we have to estimate the safety of an object in both the direction for all the floor.

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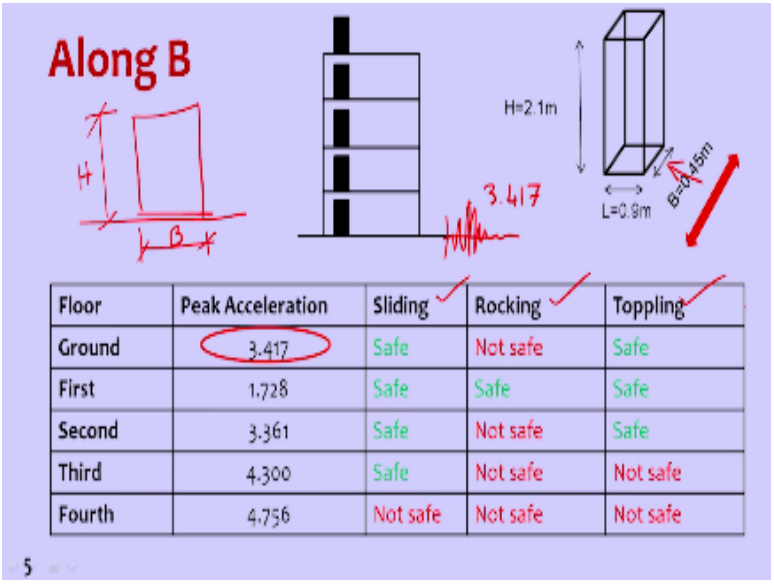

Floor	Peak Acceleration	Sliding	Rocking	Toppling
Ground	3.417	Safe	Not safe	Safe
First	1.728	Safe	Safe	Safe
Second	3.361	Safe	Not safe	Safe
Third	4.300	Safe	Not safe	Not safe
Fourth	4.756	Not safe	Not safe	Not safe

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Now this problem was already discussed in class we will, I will show you only the one calculation so when the object is placed along B so this is a B-side now when object is placed like this, this is a B this is the H and we have earthquake ground motion elcentro ground motion with PG as 3.417 we will see what is the condition of sliding, rocking and toppling in successive session.

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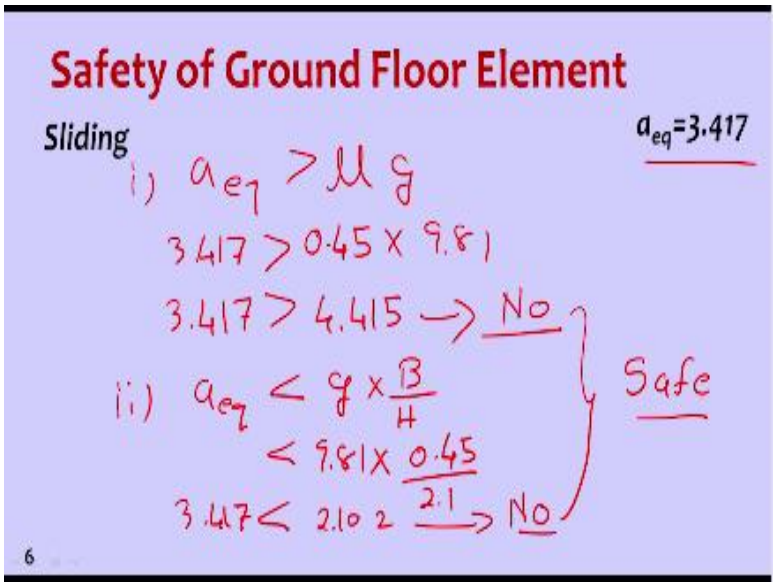

So now let us start with the sliding a_{eq} is 3.147 so for sliding first condition is if a_{eq} is greater than μg so μ is nothing but the 0.45x 9.8 one now a_{eq} is nothing but the 3.4 17 so this will give me 4.4 15 so 3.47 is not greater than 4.4 15 so this condition is not meeting so we will write it as a no. Now second a_{eq} is less than gxB/H where g is 9.81 as all of you know B is a 0.45, h is 2.1 which is coming around 2.102.

Again3.4 17 is not less than 2.10 to this condition is also not satisfying so we will write it as a no, so together if any one of the condition is satisfying we can say that the structure is failing in sliding, so here since both are not we will conclude it as a safe, so the object the current object given in the study safe against sliding.

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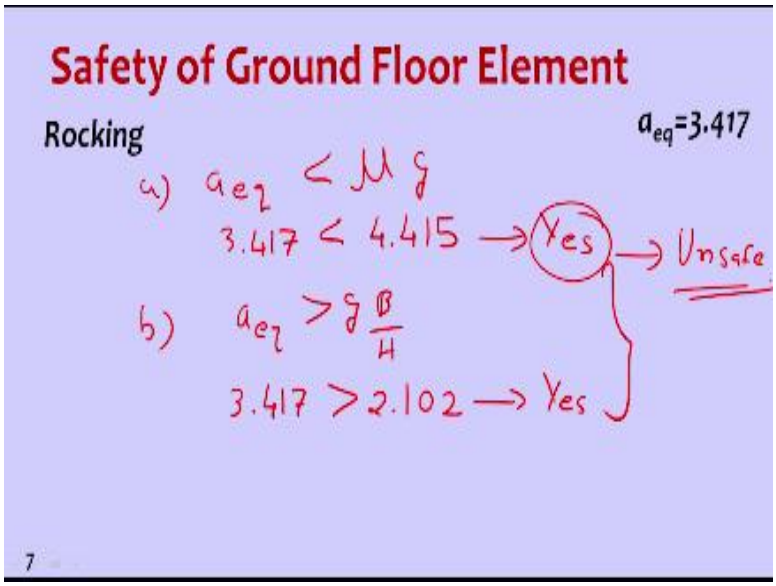

Now similarly we will assess the safety for rocking, now we already have value a_{eq} should be less than μg so earlier it was 3.4 17 the floor acceleration will be the constant and we know that we have value of 4.415 which is already calculated for the condition of sliding. So now this condition is meeting as we will write it as yes. Now one can directly tell that if one of the condition is satisfying we can say that it is unsafe, but let us for the sake of calculation let us check the second condition where a_{eq} should be greater than g B/H.

Now here a_{eq} is 3.4 17 which is greater than the value calculated as a 2.102, so this condition is also yes. So together we can say that the structure is unsafe for the condition of talking.

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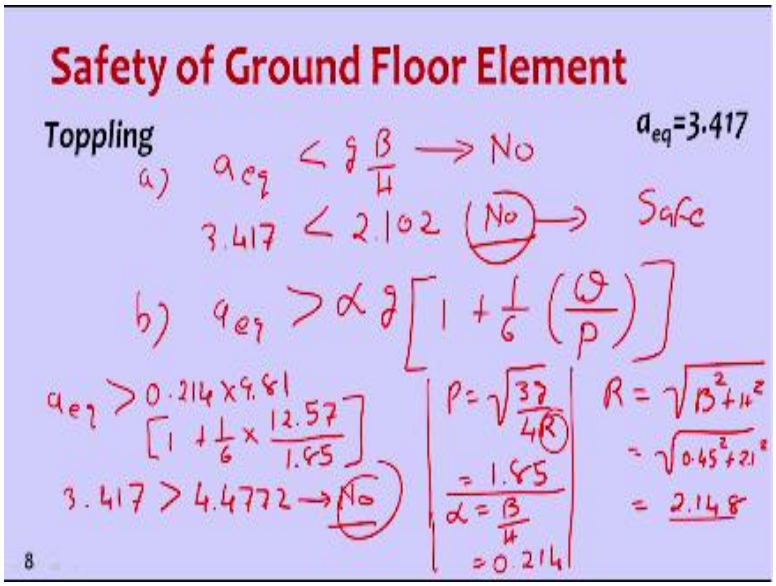

Now let us move for the toppling, toppling we have a_{eq} less than g B/H so which is already not satisfying this condition is now we have value of 3.4 17 which is less than 2.102. So hence this is no, now let us can go for the second guess. Now second guess a little bigger equation where we have to compare a_{eq} with product of α g[1+1/6 ω] which is nothing but the forcing frequency divided by P. Now before we go to this one let us calculate what this P, P depends upon H, so i will first of all I will calculate our R is B^2+H^2 so here B^2 is $0.45^2+2.1^2$ so which will give me value of 2.1 48.

I will use this R for the calculation of P which is nothing but the √3g/4R, now substituting value of R over here I will get value of P as a 1.85. Now let us calculate put all the values before that we need to get α also α is nothing but the B/H which gives us ratio of B is 0.45 H is 2.1 we will get it as a 0.2 14. So substituting all the values we will get it as a product of we need to compare a_{eq} with 0.2 14x9.81[1+1/6] into forcing frequency was given as a 12.57 rad/sec NP is 1.85.

So when we compare it, it comes around 3.417 is greater than 4.4772 so this condition is not meeting this is no, this is no, so both together we can say that it is safe against toppling.

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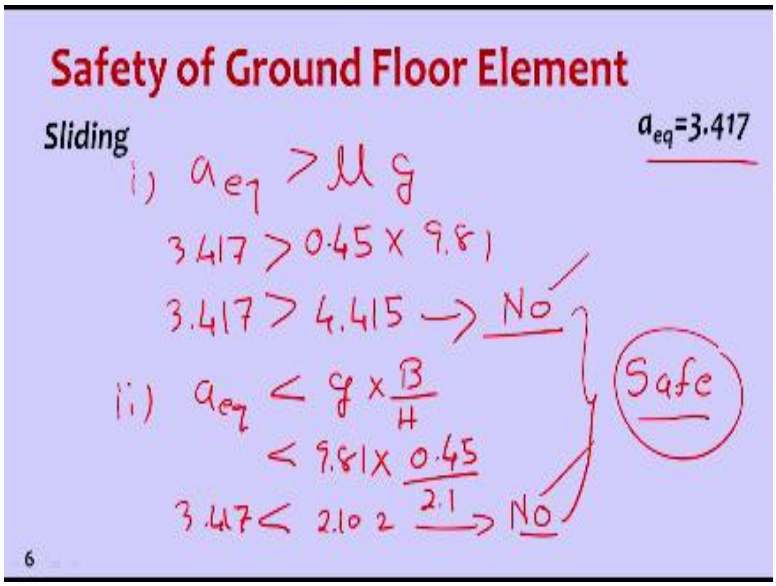

So this is the result we got it here we can see for a first condition it was no, it was no hence it was safe.

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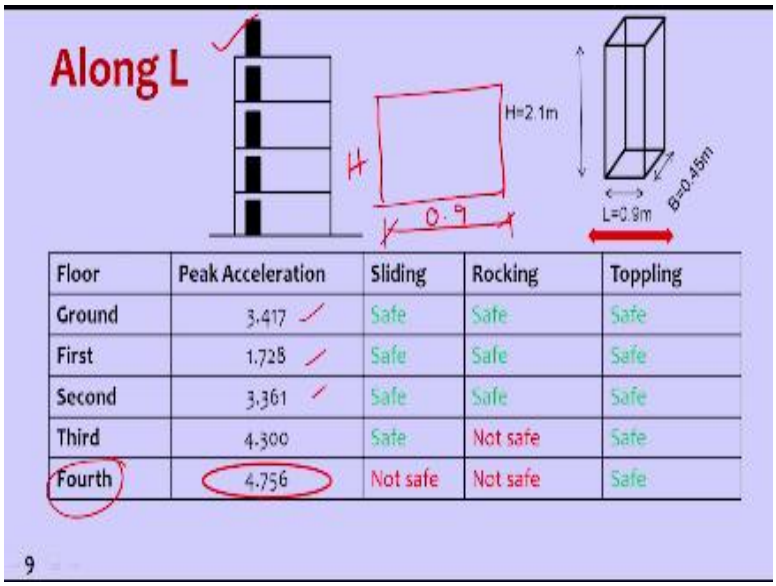

Floor	Peak Acceleration	Sliding	Rocking	Toppling
Ground	3.417	Safe	Safe	Safe
First	1.725	Safe	Safe	Safe
Second	3.361	Safe	Safe	Safe
Third	4.300	Safe	Not safe	Safe
Fourth	4.756	Not safe	Not safe	Safe

So here we have safe for sliding not safe for rocking and again safe for toppling. Now similar the same problem here we will consider one more case where r almera is placed along the longer dimension, so now we have greater l it is place along l, l is nothing but the 0.9 meter and here we have edge so the case is safe here all the PGS value for all the floor is given earlier we have selected the case for ground floor now I will consider case for the force floor which is nothing but the over here. Now PGA is given as 0.4756.

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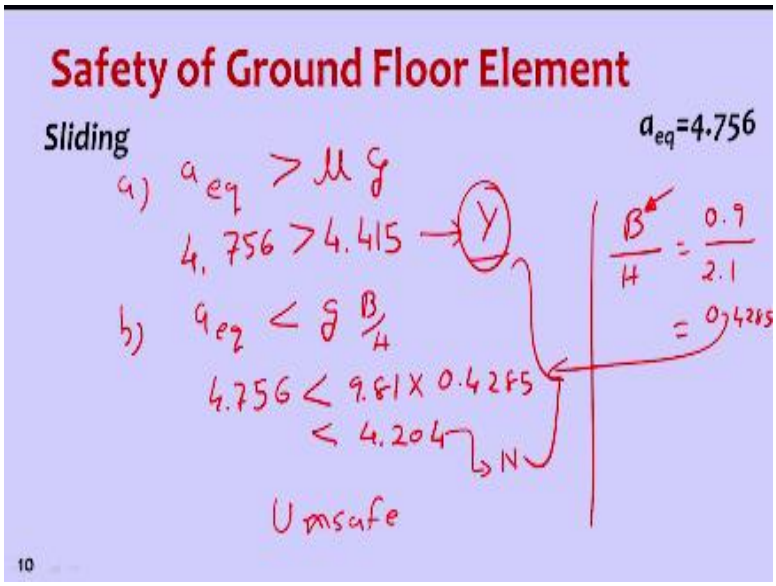

So you will check it for sliding now for sliding again we have two equation, first equation we need to check it as a a_{eq} which is a ground acceleration if it is greater than μg so 4.756x4.415 so this is, this condition is meeting so we got for first case itself we got yes, so we can directly say unsafe. But let us go for second as well a_{eq} g into B/H this is 4.756 less than 9.81 into B/H, B/H is nothing but the 0.4285 now here you just need to consider though it is it in equation it is written as a B/H, B is a side or the dimension along which our element displaced so here B is 0.9/2.1 it will give us 0.4285.

So the same value we are putting and we will get it as a 4.204 so though this condition is not satisfying but one of the condition got satisfied so ultimately we can say that when the almirah is placed against along the l for fourth floor it is unsaved, it is unsafe for sliding.

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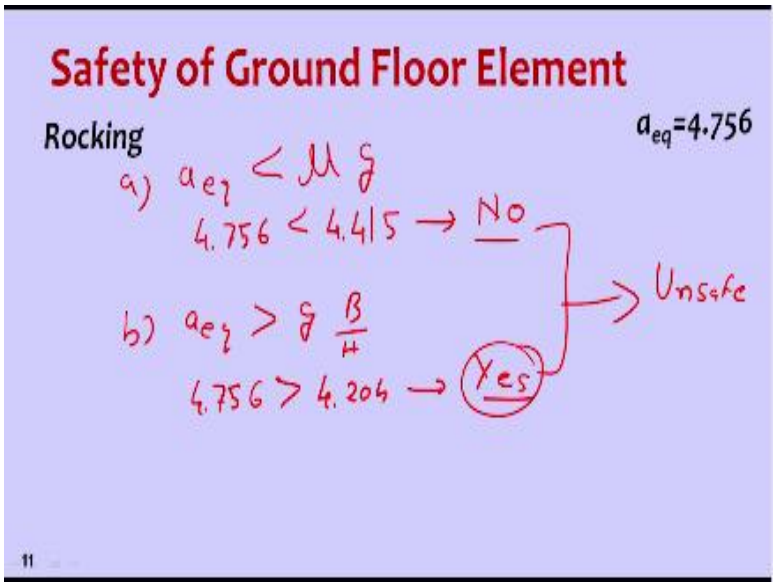

Now let us move for the rocking behavior, the first case for rocking is just opposite to the sliding where acceleration is or it should be lesser than the μg so value was 4.756 earlier we got it as a yes, so it should be no, this is no, and second guess which we got it as a no, here it is reverse we will get it as a yes, B/H value was 4.756 it is greater than 4.204 so this is yes, so as I said one of the condition is getting satisfied ultimately this element at the fourth level is unsafe for rocking.

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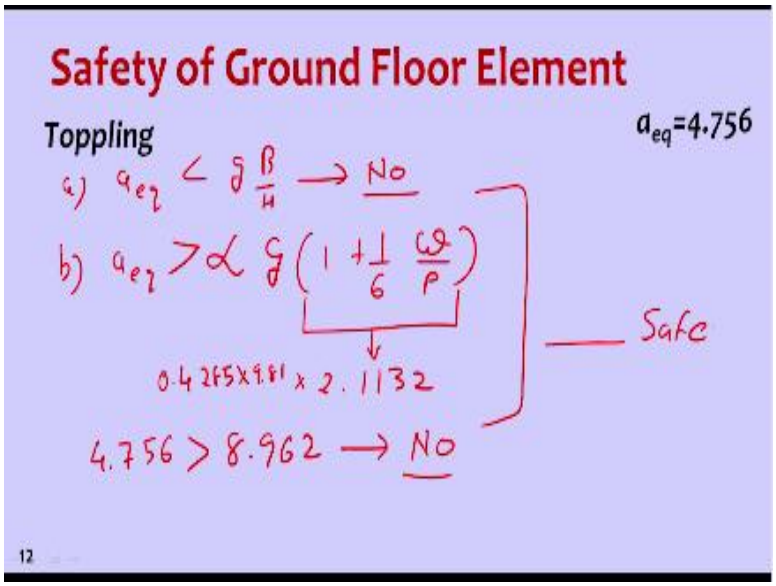

Now let us move to the last one, lastly we have the first condition for toppling is a_{eq} should be less than g B/H which was not satisfied you can directly see from the sliding case I will move to the B case where we have to compare a_{eq} with α g(1+1/6ω/P) now this value will be constant this will here there is no parameter which can change the B value, hence we can directly go with earlier value of 2.1132 α is the only value which will change which is 0.4285x9.81, so this will give me 4.756 greater than 8.962 so this condition is also not meeting so we can say that if both are not meeting it is safe.

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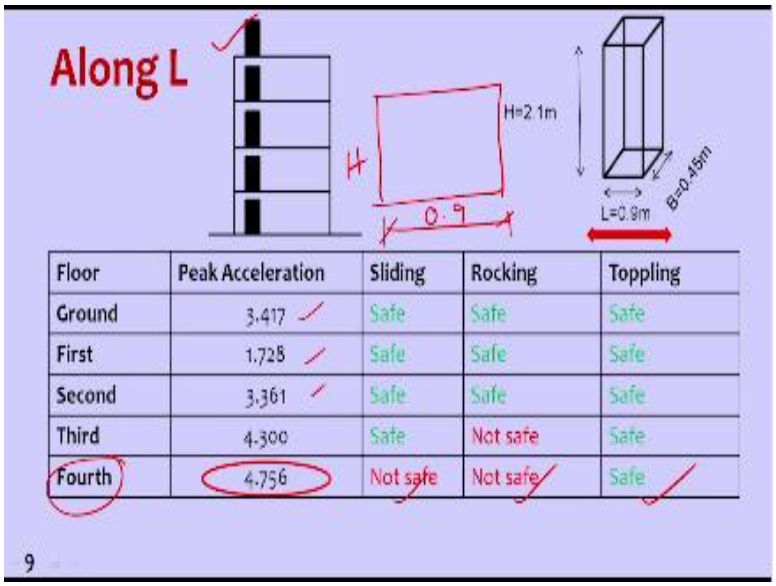

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So now we can see here it was not safe, not safe and safe.

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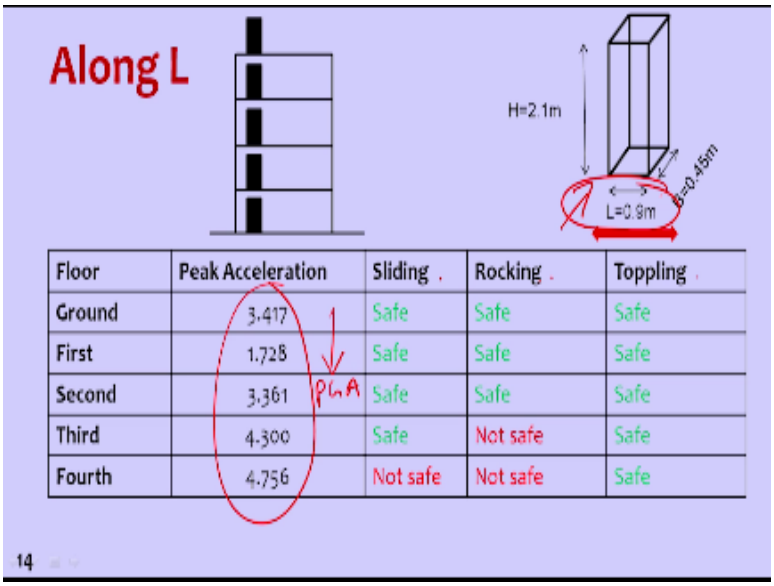

So in summary we can see that when the structure is placed along the direction of B and we are considering the force or the acceleration direction is parallel to B here we can see it was safe, not safe or safe like this and here one more point we have to consider it as we go, go from first floor to the fourth floor PGA goes on increasing and the two major factor which decide the safety of any non structural element for sliding, rocking and toppling is one is the PGA value another one is the direction or the side along which it is kept.

Now here for this is a table for when the element is kept along the B direction, now the same PGA here for this example we are keeping PGA constant, but in reality the earthquakes have different PGA or the different PGA value in two different direction. But for the calculation here we kept a same so there is no change in PGA for the floor but by just changing the dimension or the direction of a nonstructural element we can see the safety of element in sliding, rocking and toppling for different, different floor changes. So the placing of element on the particular floor will decide whether it is failing because of sliding rocking or toppling. Thank you.

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