Offshore structures under special loads including Fire resistance
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Module - 02
Advanced Structural Analyses
Lecture - 37
Marine Risers- I

Friends, in this lecture we will talk about some details on Analysis of Marine Risers. We also look into the types of marine risers, force stress acting on risers, and how to analyse them for the given set of environmental loads acting on the risers depending upon their profile and functional usage.

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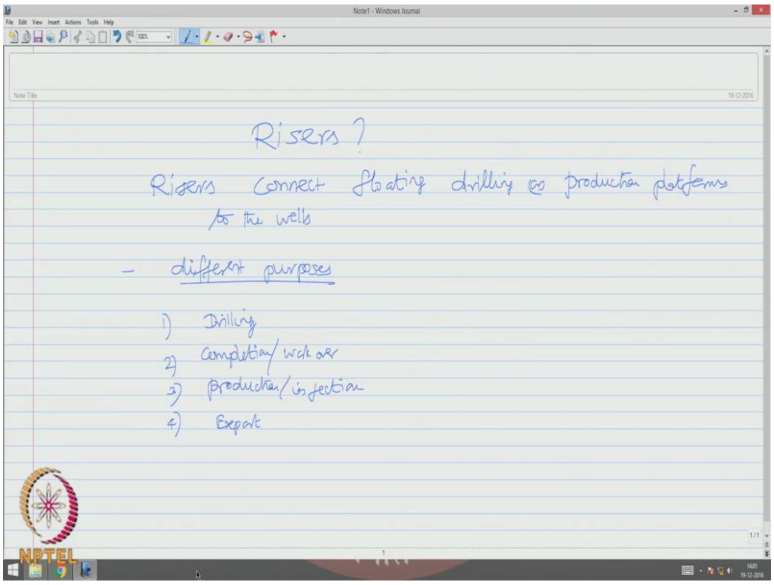

First question; let us try to ask in mine is, what are risers? Risers actually connect floating, drilling or production platforms to the wells. They are meant for different purposes: one they are meant for drilling, two completion or work over, three production or injection, and four for export.

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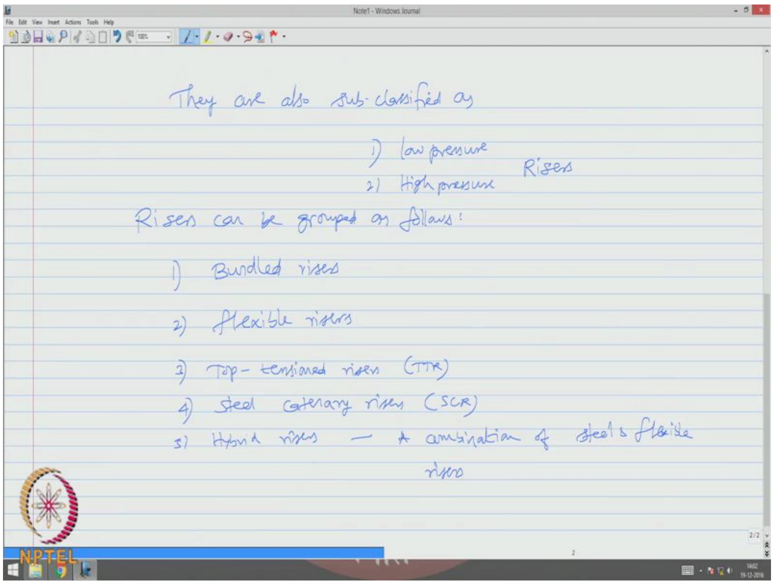

They are also sub classified as low pressure and high pressure risers. Risers can be grouped in different forms: one bundle risers, flexible risers, top tensioned risers; TTR, steel catenary risers; SCR and of course hybrid risers which can be a combination of steel and flexible risers. Before we look into the methods of analyzing the riser let us look few more details about these groups of risers.

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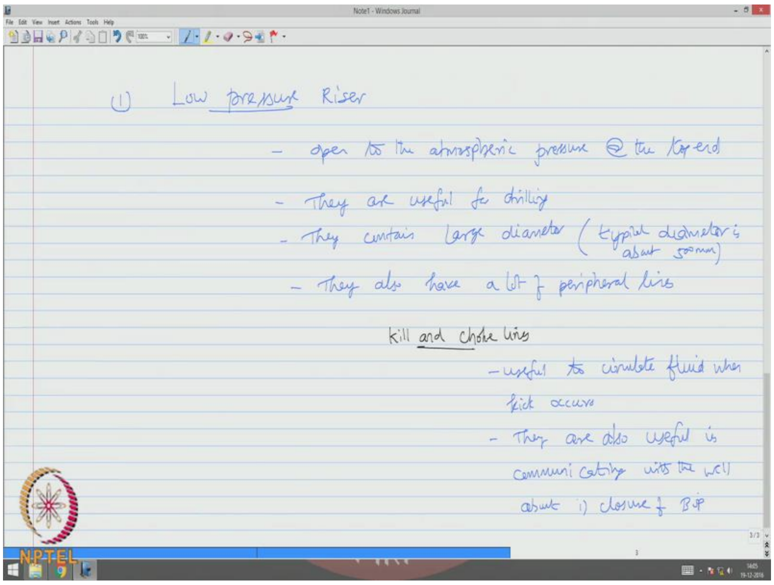

Let us start with a low pressure riser. Low pressure riser is one which is open to the atmospheric pressure at the top end. Essentially, they are useful for drilling. They have or they contain large diameter pipes. Large in since typical diameter of this kind of risers is about 500 mm; they also have lot of peripheral lines. What are the functions of these peripheral lines? The peripheral lines can be kill and choke lines which are useful to circulate fluid then kick occurs they well. They are also useful in communicating with the well about closer of Bop in case of a gas leak.

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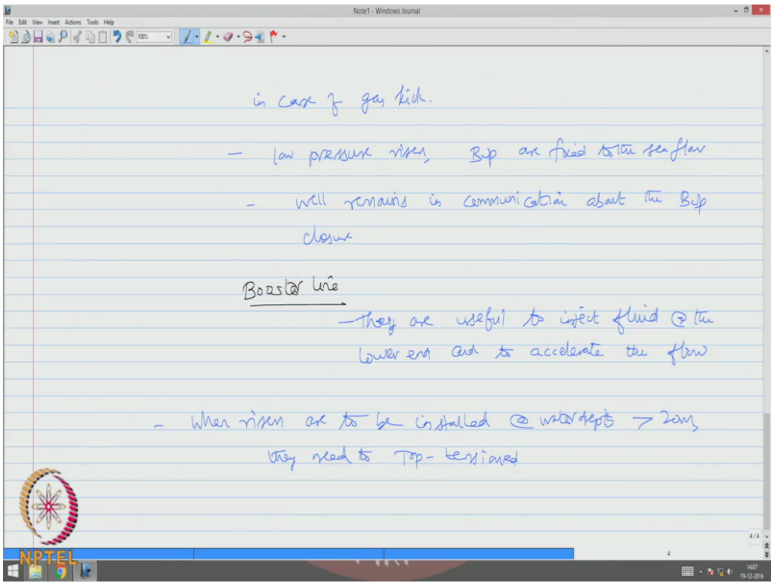

Or let say in case of gas kick; one can ask the question why this should be communicated. Generally, in case of low pressure risers Bop are fixed to the sea flow. So, it becomes essential that the well remains in communication about the Bop closer etcetera, so in peripheral lines to communicate this data.

The next one could be booster line they are useful to inject fluid at the lower end and to accelerate the flow; that is why they call booster lines. Generally, when risers are to be installed at water depth more than 20 meters they need to be top tensioned. Why top tensioning is required?

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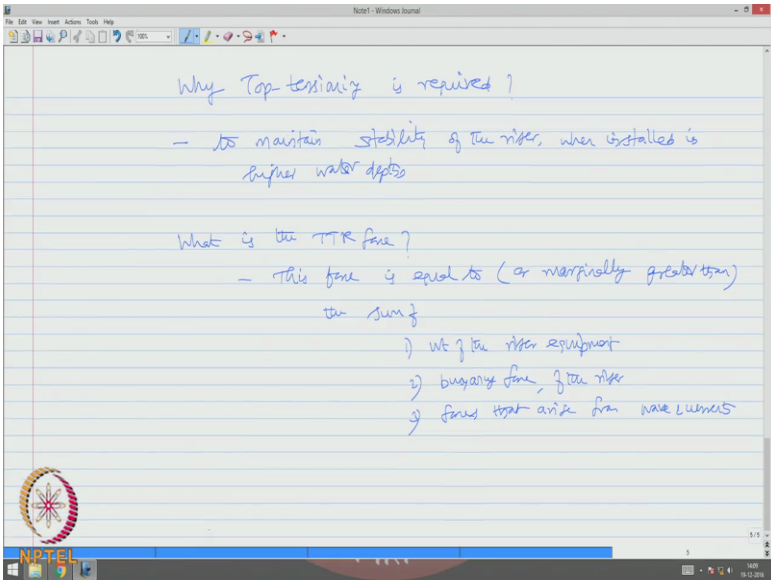

Let us try to answer this question; top tension is required to maintain stability of the risers when installed in higher water depths. What is the top tensioned riser force? Generally, this force is equal to or marginally greater the sum of; one, weight of the riser equipment, two buoyancy force of the riser, three forces arise from waves and currents.

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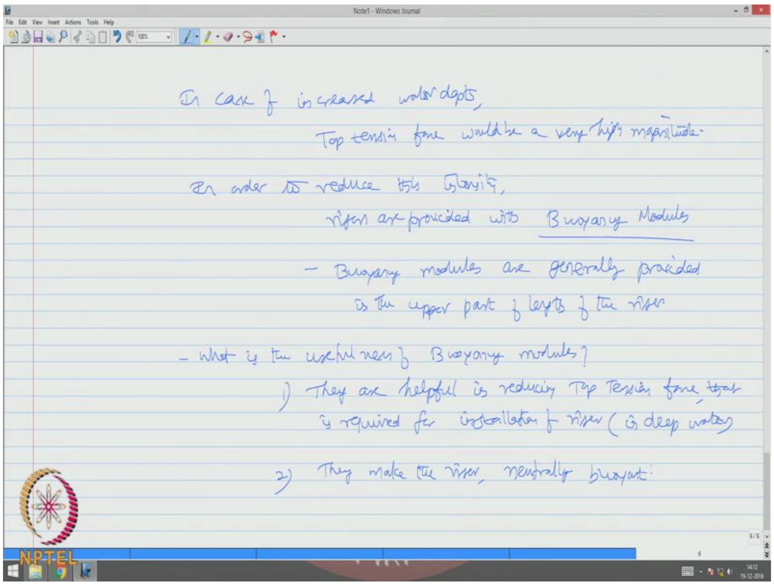

Now, in case of deep water depths the top tension force would be of a very high magnitude. There is not the healthy practice have a large magnitude top tension force an given system because applicability will be issue. In order to reduce this weight this intensity risers are provided with buoyancy modules. Generally, buoyancy modules are provided in the upper part of the length of the riser.

Now the question is; what is the usefulness of buoyancy modules? They are many; first could be they are helpful in reducing top tension force that is required for the riser for installation of the riser in particular in deep water depth; that is the first advantage. The second advantages they make the riser neutrally buoyant.

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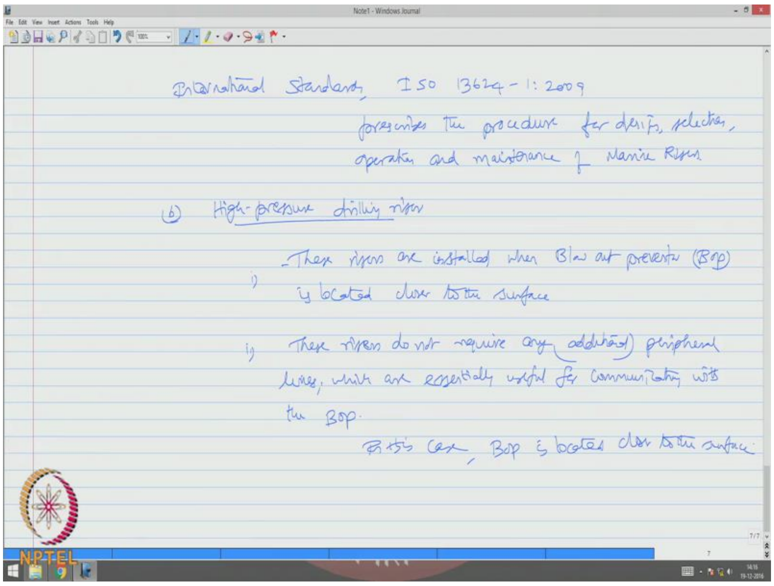

International standards, ISO 13624 – 1: 2009 prescribes the procedure for design selection, operation and maintenance of marine risers. The second one what we have is, high pressure drilling riser. These risers are installed when the blow out preventer is located closer to the surface, so that the technical requirement mended to have a high pressure drilling riser. The second point with this kind of riser is, these risers do not require any additional peripheral lines which are essentially useful for communicating with the blow preventer.

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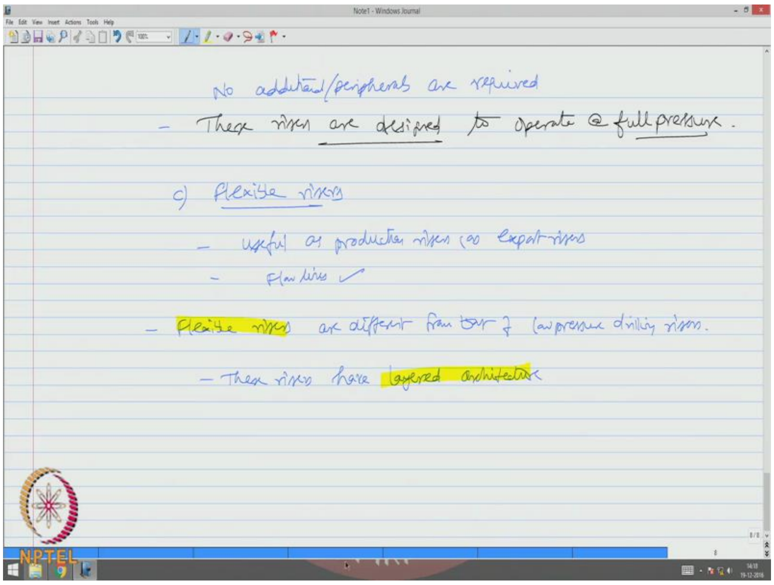

So, in this case Bop is located closer to the surface as a result of which no additional peripherals are required when we use this kind of riser. Most importantly these risers are designed to operate at full pressure.

The next one what we have in the line is flexible risers. These risers are more useful as production riser or export riser, they also useful in flow lines. Flexible risers are different in structure configuration from that of low pressure drilling risers. These risers that are flexible riser, these risers have layered architecture.

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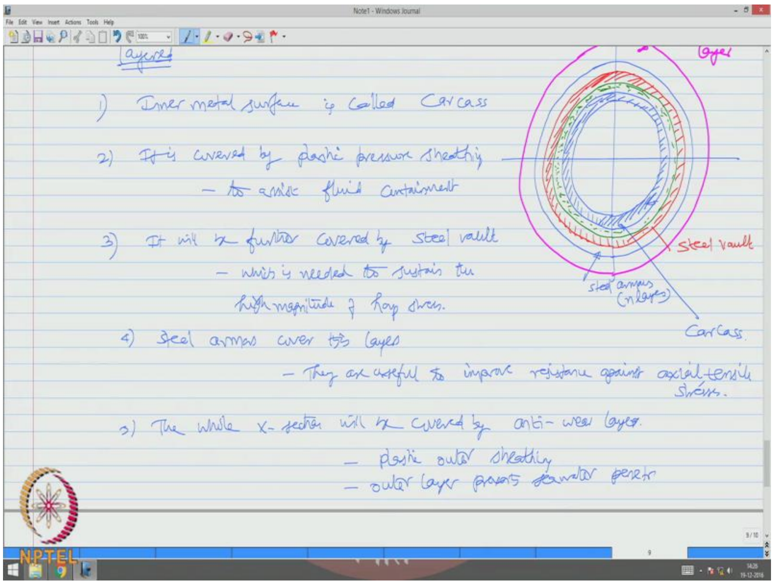

A typical cross section looks like this. This layer is an inner most layer of the flexible riser. So, flexible risers are layered the inner metal surface is called carcass, so I should say this is carcass. So, the carcass is covered by plastic pressure sheathing this is required to assist fluid containment, so the layer which is plastic pressure sheathing. So, this is plastic pressure sheathing layer, the one shown in green.

The plastic pressure sheathing layer it will be further covered by a steel vault which is needed to sustained the high magnitude of hope stress. So, I have one more layer which is steel vault, so this layer is steel vault. Steel armors cover this layer; they are useful to improve resistance against axial especially tensile stresses. So, I should have steel armored in n layers to improve the distance against axial tensile stresses of the riser. The whole cross section now will be covered by anti wear layer, is usually plastic outer sheathing. This is the anti wear layer which is covering the entire cross section. The outer layer, this outer layer actually prevents sea water penetration into the riser.

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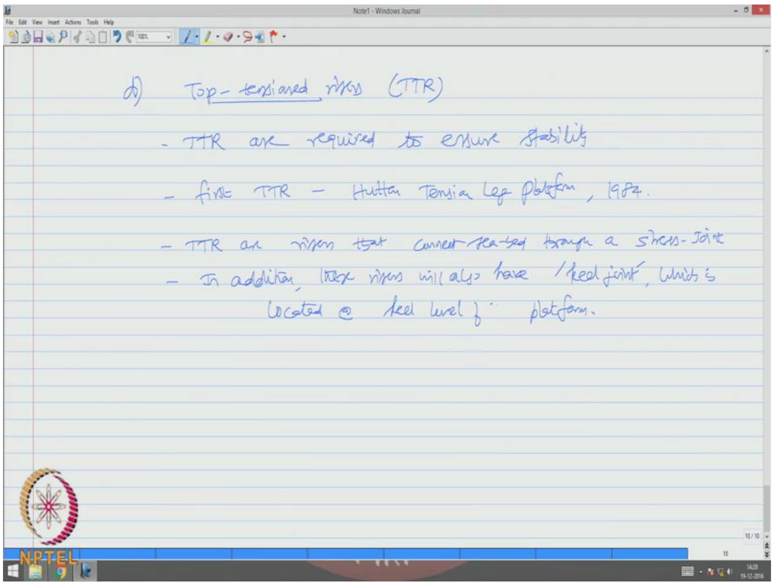

Let us talk about the next type which is top tensioned risers. In fact all risers are mostly top tensioned because in order to balance their weight and buoyancy the top tension forces applied when the riser is installed or commission at higher water depths. TTRs are required to ensure stability. First TTR was commissioned Hutton TLP in the year 1984 top tensioned risers are risers that connect sea bed through what we call as a stress joint.

In addition, these risers will also have what we call as keel joint which is located at the keel level of the platform.

Let us quickly see the details of this graphically.

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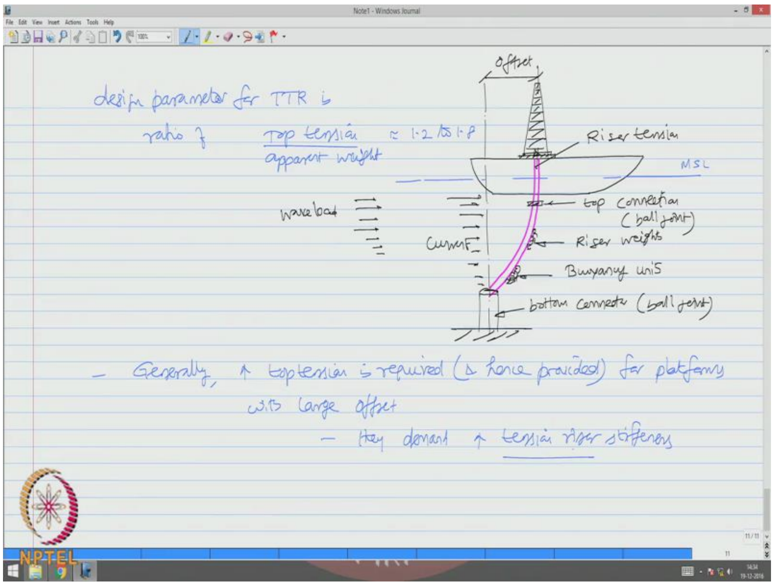

Let say this is the vessel and this is my mean water level, I will have a drilling derrick which will have a base housing through which riser is connected. These risers will have top connection, usually a ball joint. They also have some counter weights which are called riser weights to hold down the riser in specific profile geometry. They may also have buoyancy units to hold on the riser. Now the riser is then connected through a bottom connector to the sea bed which is also through the ball joint. So, that in flexibilities introduce in the connection points between the riser at the top and the bottom ends of their connectivity.

The distance with which the riser force and connect to the sea bed is called as an Offset. The riser will be now subjected to high tensile force, riser tension. In addition, they will be subjected to wave loads; they will also be subjected to current loads. There are very interesting design guide lines, what generally people use to follow in case of top tension riser. A very interesting and whittle design parameter for the top tension riser is actually the ratio of top tension to its apparent weight. Usually for a good design this is kept between 1.2 to 1.8.

It is very interesting to note that generally higher top tension is required and hence provided for platforms with large offset. Therefore, the main reason for this is they demand higher tension riser stiffness.

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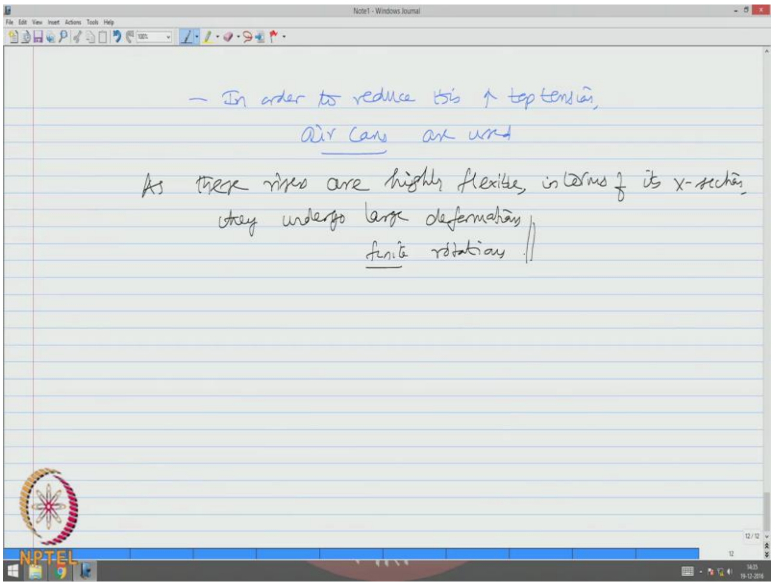

In order to reduce this, this increased top tension air cans are used. The most whittle point in this cases is, as these risers are highly flexible in terms of its cross section they undergo large deformation and of course finite rotations.

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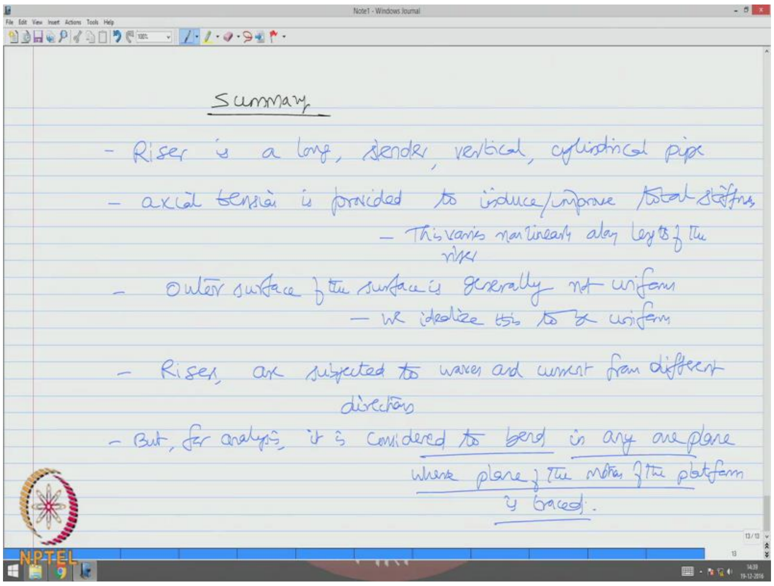

So in general riser is a long, slender, vertical, cylindrical pipe. Axial tension is generally provided to induce or improve total stiffness. Please understand this varies nonlinearly along the length of the riser. Another assumption what we have going to make in the riser analysis is; outer surface of the riser is generally not uniform, but we idealized this to be uniform. Friends in the analysis risers are actually subjected to waves and current from different directions, but for analysis it is considered to bend in any one plane where plane of the motion of the platform is traced. That is a very interesting and important statement in the analysis of marine risers.

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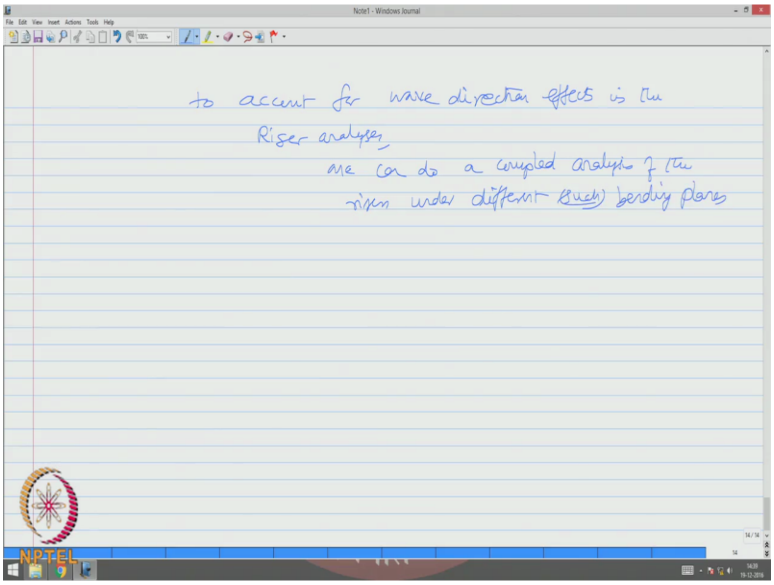

Of course to accounts for wave direction effects in the riser analysis one can do a coupled analysis of the risers under different such bending planes. But at a time only one plane is considered where the platform of the motion is traced. So, we should now draw a free vault diagram of the segment of the riser and try to derive the governing equation which gives me the stresses on the risers.

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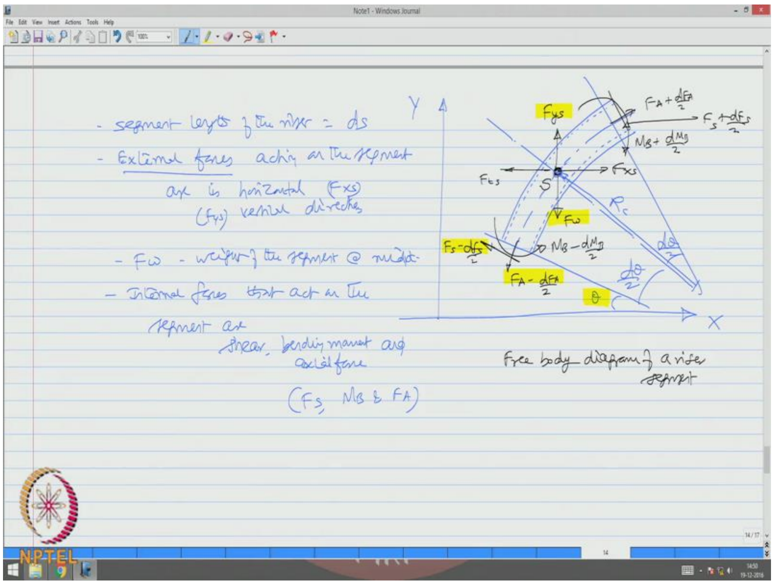

Let say this is my x y plane and this indicates segment of the risers. So, this is point which gives me the (Refer Time: 39:02) of curvature of the riser. And initial segment is theta and the total segment is at d theta by 2 from both sides. And at this point we have F ys F w acting vertically and horizontally and horizontally F xs and F ts where this point is considered to be s. There are differential forces which are acting as F A minus df A by 2 and F A plus df A by 2.

And the moments could be M B minus dM B by 2 and this could be M B plus dM B by 2. They are again could be F s minus dF s by 2 and F s plus dF s by 2. This is the typical free body diagram of a riser segment. The segmental length riser is ds. External forces acting on this segmental length of the riser is ds. The external forces acting on the segment are both in horizontal and vertical directions which is F xs and F ys. Respectively F w is the weight of the segment acting at the midpoint. Internal forces, these are external forces; internal forces that act on the segment or shear bending moment and axial force as you see in the figure at sent to the screen which is F s M B and F A.

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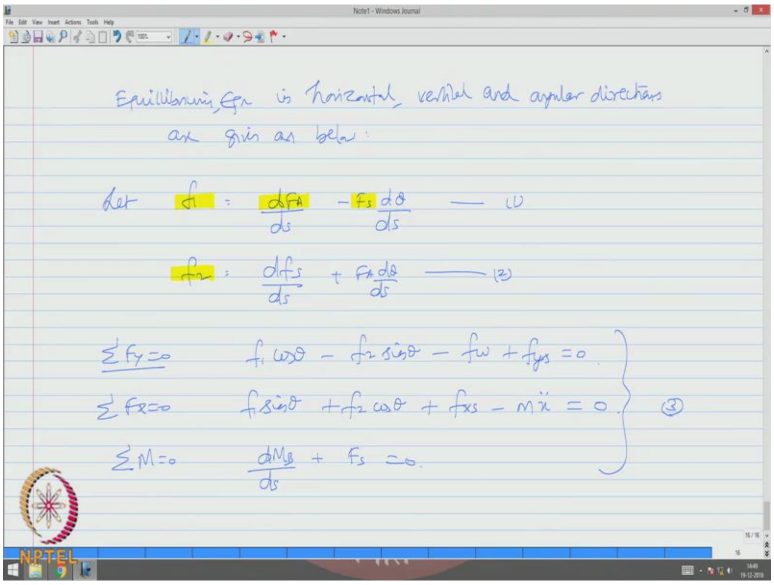

So, the equilibrium equation in the horizontal, vertical and angular directions are given by let say as below. Let f 1 be df A by ds minus F s d theta by ds and f 2 be dF s by ds plus F A plus F A d theta by ds. Let say algebraic sum of all forces in the vertical direction is 0 looking at this figure.

So, now I should say f 1 cos theta minus f 2 sin theta, I can see the figure here the angle of this is theta were resolving it in the vertical direction. F 1 consists of both F A and F s, in fact both f 1 and f 2 consists of F A and F s. F A and F s or the axial force and the shear force acting in the system. Therefore, sigma F A 0 f 1 cos theta minus f 2 sin theta minus F w plus F ys is 0, we can see here F w is acting downward and F ys as is acting as upward, so minus F w plus F ys 0.

Similarly, if a writes sigma F x 0 this should be f 1 sin theta plus f 2 cos theta plus F xs minus mx double dot should be 0. If we talk about algebraic sum of moments 0 then should be say dM B by ds plus F s should be 0; I call this set of equations as 3.

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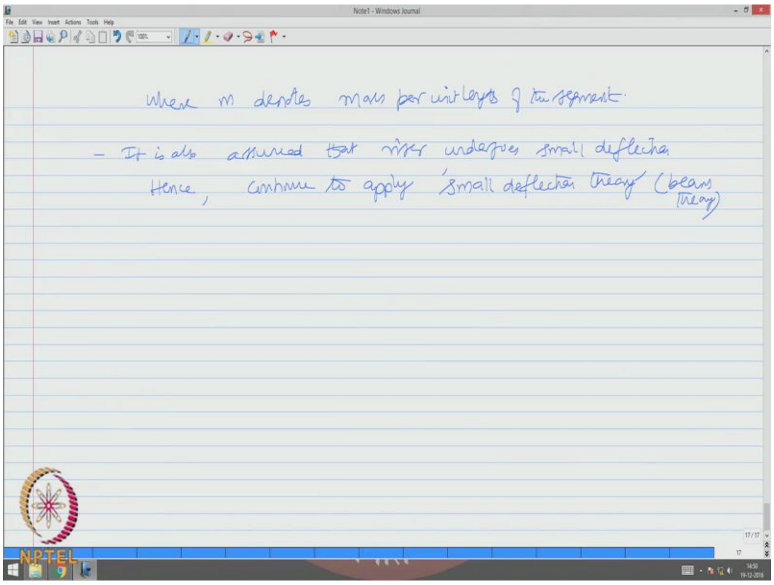

In this equation small m denotes mass per unit length of the segment. It is also assume that the riser undergoes small deflection. Hence, we will continue to apply small deflection theory rather, small deflection beam theory to the system.

So friends, in this lecture we discussed about the types of marine risers. We picked up the segment of the riser; we explain the force acting on the segment of the risers. And we are now going to apply small deflection beam theory to derive whitely equation that governs the response behavior of the riser under the given set of forces. I shown the free body diagram on the screen which will continue and discuss in the next lecture.

Thank you.