Structural Health Monitoring (SHM)
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Lecture - 40
Part - 2: Non-Destructive evaluation - I

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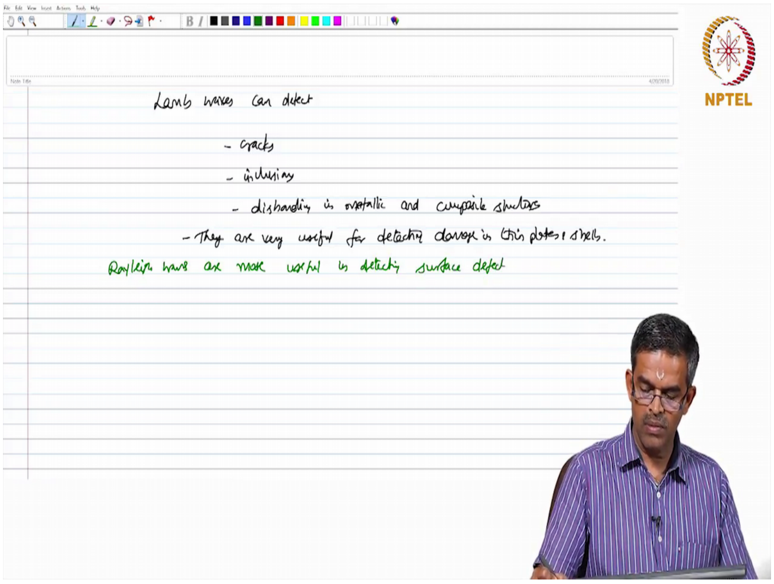

Lamb waves can detect cracks inclusions, disbonding in metallic and composite structures; they are very useful for detecting damage in thin plates and shells. However, Rayleigh waves are more useful in detecting surface difference.

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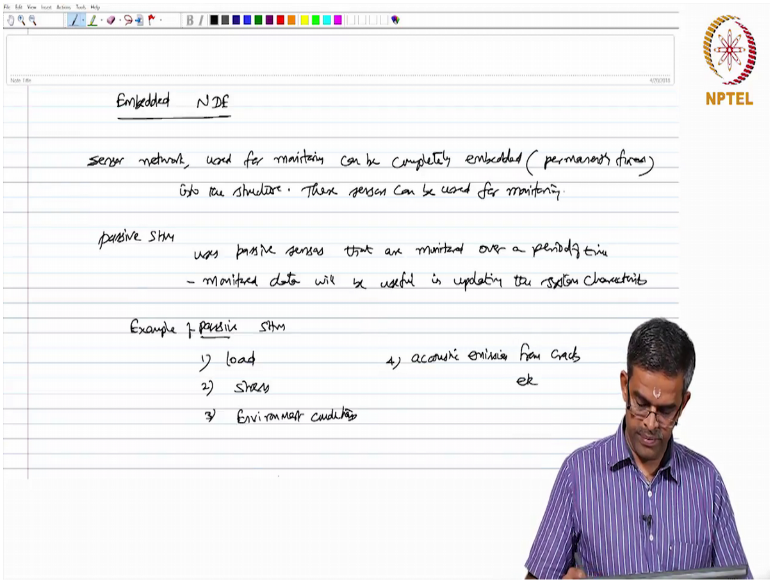

Let us now pay attention to something called embedded non destructive evaluation.

Interestingly friends, sensor network used for monitoring, can be completely embedded that is permanently fixed into the structure, then these sensors can be used for monitoring. There are two ways by which this can be done: one is the passive SHM which uses the passive sensors that are monitored over a period of time. The monitored data will be useful in updating the system characteristics. Now, example of passive dampers, load sensors, sensors to measure stress sensors to measure environment conditions, acoustic emission from cracks etcetera.

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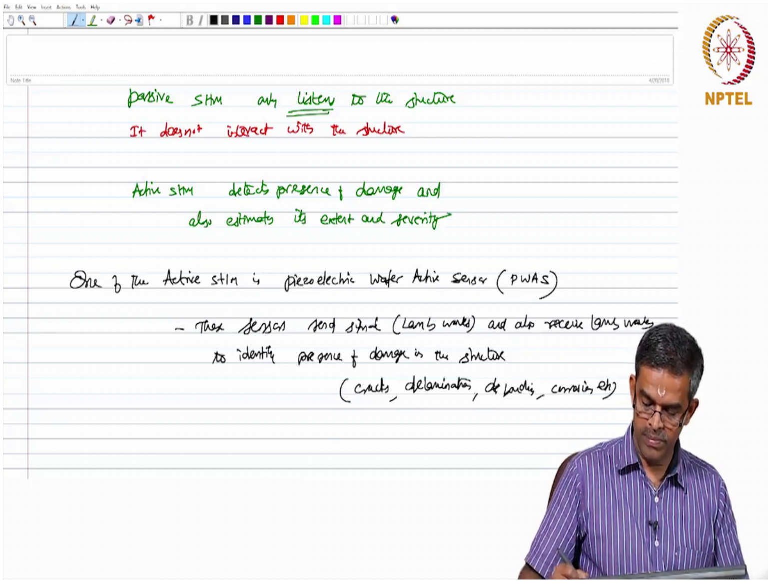

Interestingly, passive SHM only listens to the structure. It does not interact with the structure. Active SHM detects presence of damage and also estimates its extent and severity. One of the active SHM piezoelectric wafer active sensor, which we call as pediatric wafer active sensors, these sensors send signal which are essentially lamb waves and also receive lamb waves presence of damage in the structure.

The damage could be cracks, delamination, debonding corrosion etcetera.

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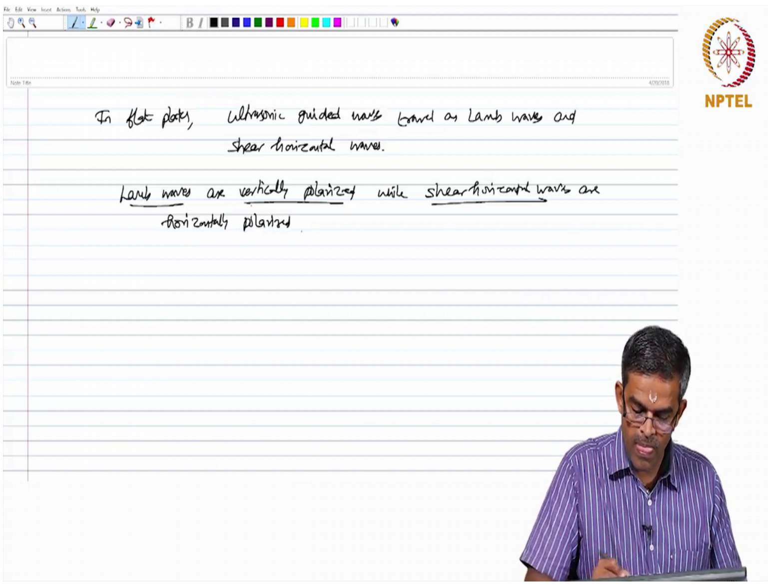

In flat plates ultrasonic guided waves travel as lamb waves and shear horizontal waves. Lamb waves are vertically polarized, while shear horizontal waves are horizontally polarized.

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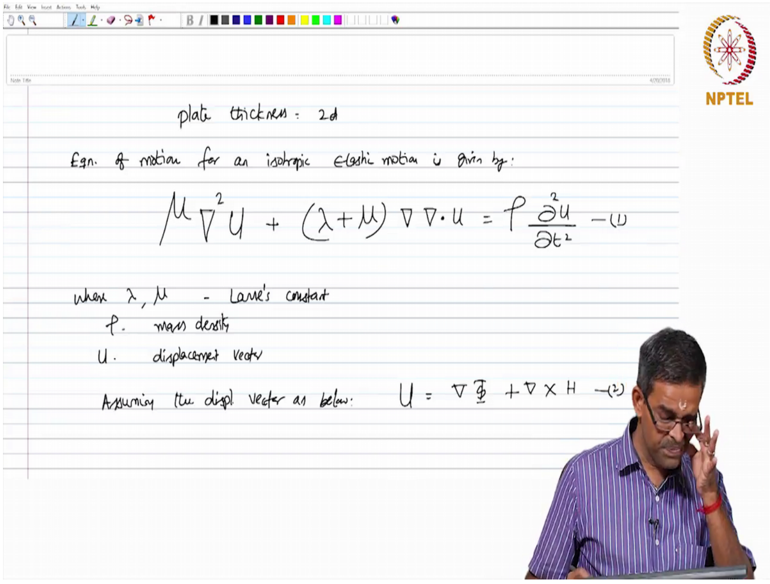

Let us consider a plate, stress free upper and lower surface as shown in the figure.

The local axis are marked as shown in the figure, the thickness of the plate is 2 d, let us take a free bar diagram of a small area extracted from this plate, let us mark the axis sigma xx sigma yy, which is 0 and sigma yx also 0 and sigma y z also 0, which will be sigma z z.

So, let us say this is my free body diagram of a small area, extracted from the plate that is this figure let us say 2, this figure 1 consider as a plate with free boundary. Plate thickness is 2 d, equation of motion for an isotropic elastic motion is given by where lambda and mu or called lamb is constant rho is the mass density u is the displacement vector, assuming the displacement vector as below u is del phi plus del cross H.

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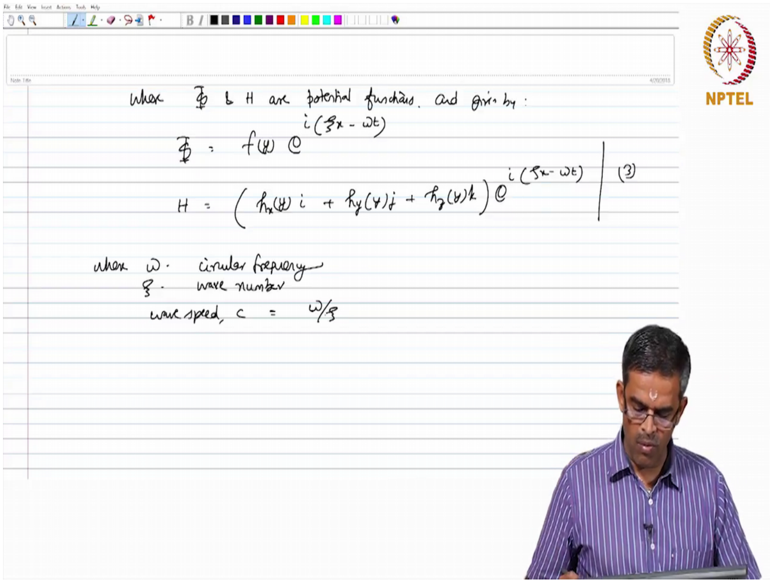

Where phi and H are potential functions and given by phi is fy e i minus omega t on H is hx y i plus hy y j plus h z y k e to the power i x minus omega t, where omega is the circular frequency and zeta is the wave number and wave speed c is given by ratio between omega and zeta in that omega zeta and z.

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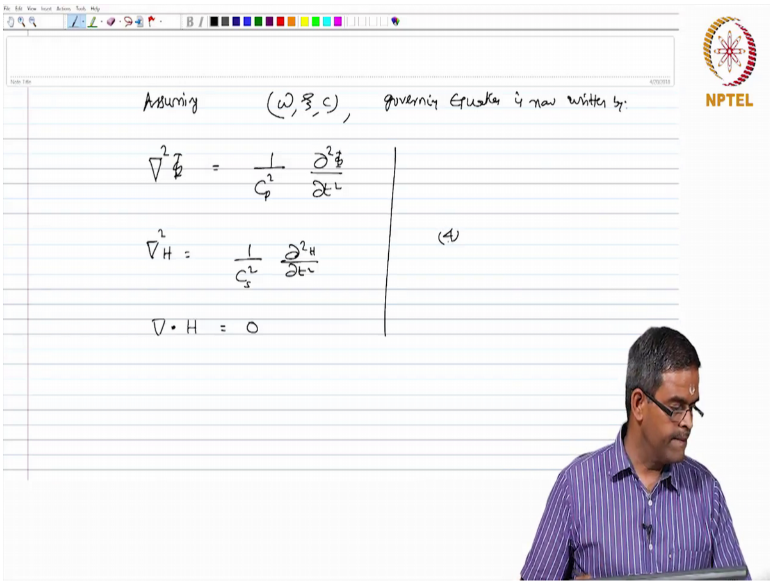

The governing equation is now written by del square phi is 1 by C p square dou square phi by dou t square, del square H is 1 by C s square dou square H by dou t square and del dot H is 0 equation 4.

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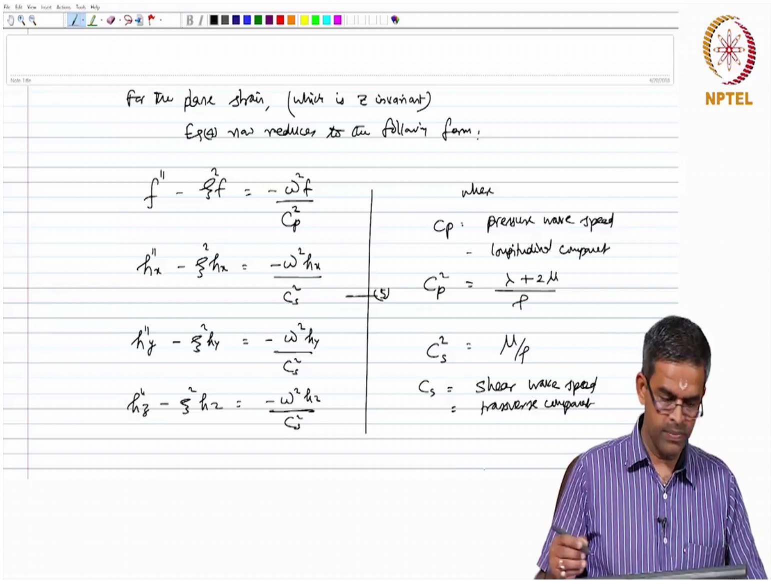

Now, for the plane strain, which is z in variant, equation 4 now reduces to the following form for a plane strain problem; f double dash minus zeta squared f is minus omega squared f by C p square h double dash x minus zeta square hx is minus omega square h x by C s square.

H double y minus zeta square h y is minus omega square h y by C s square, h double prime z minus zeta square h z is minus omega square hz by C s square, where C p which is a longitudinal component and is given by lambda plus 2 mu by rho, whereas C s square s this is equation 5 this is cp square, whereas this is C p C s square is given by mu by rho, whereas C s is called shear waves p and this is transverse component.

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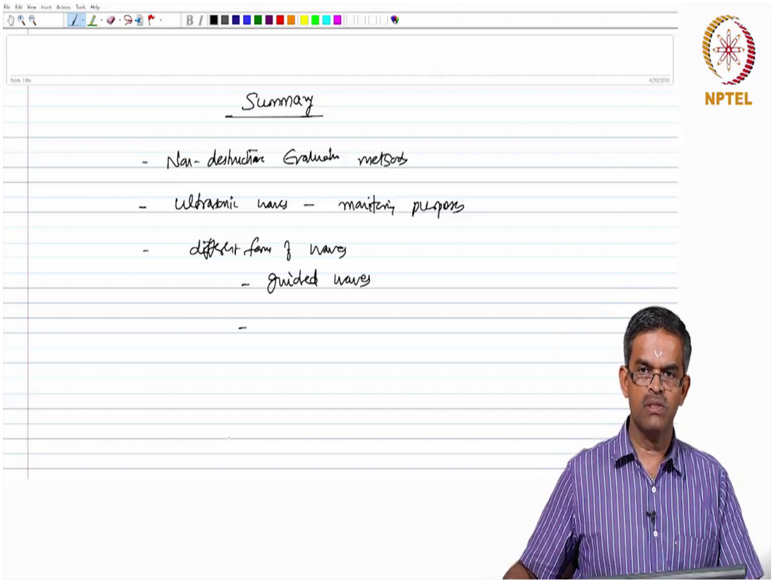

In this lecture we tried to understand; what are the various non destructive evaluation methods, what is the speciality about these ultrasonic waves which are used for monitoring purposes. What would be the different forms of ways and what would be the use of guided waves in comparison to the conventional ultrasonic waves.

And we are in the process of identifying understanding how these guided waves like lamb waves can be used for monitoring purposes. We will continue this lecture in the next class.

Thank you very much and bye.