VIBRATION OF LAMINATES WITH DELAMINATION AROUND A CUTOUT

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A substantial work has been done to understand the free vibration response of solid composite plates for different combinations of parameters that affect the dynamic characteristics of plates. A good number of references are available on plates with cutouts as well (see [1]). But most of the investigations are confined to some pre-selected cutout sizes. In case of rectangular plates with rectangular or square cutouts, a complete picture of the effect of the geometry of rectangular cutout on dynamic characteristics is not available. Moreover, very little research has been carried out on the effect of cutouts on the vibration response of thick laminates, especially if there is some delamination present around the cutout. Hence, the objective of this investigation is to understand the effect of the presence of a rectangular cutout on the free vibration response of a thick laminated plate using Higher-order Shear Deformation Theory. The concept of a frequency envelope is found to be quite convenient for this purpose. The study also includes the effect of material orthotropy, the laminate thickness and boundary conditions on natural frequencies of the laminate. The finite element modeling is done in such a manner that it takes into account delamination around the cutout [2].

Some important observations of this investigation are summarized below:

- Natural frequencies obtained using HSDT are higher than those using FSDT; this difference increases with increasing mode number. Also, for a given mode, the difference between two results increases with the increase in the cutout size.
- The fundamental frequency changes only marginally if a small cutout (either of the two cutout ratios being small) is made in the plate. However, for intermediate and large size cutouts, the fundamental frequency increases rapidly; the amount of increase depends on cutout ratios in two directions.
- Frequencies corresponding to first and second modes (and similarly frequencies corresponding to third and fourth modes) tend to be closer as the cutout size increases. This trend gets enhanced if constraints at the boundary of the plate are increased.
- For a given area of the cutout, the fundamental frequency of the plate is the largest for a square cutout.
- Natural frequencies increase with the increase in E_1/E_2 ratio. However, the manner of increase in natural frequency with cutout size is not affected by degree of orthotropy.
- Natural frequencies increase if constraints at the boundary increase. However, the amount of increase depends on the type of boundary condition as well as on the particular mode of vibration.
- Increasing constraints at the boundary amplify the effect of cutout size on the fundamental frequency of the plate.
- The effect of side-to-thickness ratio in increasing the fundamental frequency of the plate is more for plates having large size cutouts.
- The presence of delamination in thick plates with moderate and large size cutouts, severely affects the dynamic characteristics of the plate. However, the effect of size of delamination is not significant especially with large cutouts.
- Natural frequencies decrease substantially if the location of delamination shifts from middle plane of the plate towards lateral free surfaces.

References

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Keyword: vibrations, laminates, cutout