EXPERIMENTAL INVESTIGATIONS OF RIVETED PLATES IN THE LOW, MID AND HIGH FREQUENCY RANGE

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1 - INTRODUCTION

The simulation of the vibration and acoustic response of canonical structures such as beam, plate and shells is now well under control. However, even buy using finite element or boundary element method, practical simulations are still not well understood: This is the case about joints such as riveting. In this paper a riveted plate is compared to an homogeneous one based on measurement data in term of quadratic velocity and natural mode shape, eigenfrequency and damping. It is shown that the rivets line induced a weakening in stiffness for modes having high bending moments in the rivets line area, and additional damping related to the relative "in plane" motion of the plates in the zone of the rivets line.

2 - EXPERIMENTAL SETUP OF A SIMPLY SUPPORTED RIVETED PLATE

The experimental setup (figure 1) which was used is composed of two plates joint by three rivets (two rivets near the plate edges and one rivet in the middle), the joint has been designed in order to keep a constant thickness, and the same mass per unit area than the homogeneous plate.

The plate was excited by a shaker and normal plate velocities have been measured using a laser vibrometer. Then, quadratic velocity was calculated (cf fig. 2) and Natural modes shapes, eigenfrequencies and dampings were calculated (using SMS STAR*Struct* software[2] (cf fig. 4 to 7).

3 - EFFECT OF THE RIVETS LINE ON THE PLATE STIFFNESS

Natural frequencies of the riveted plate are compared with the natural frequencies of an homogeneous plate which are reported in figure 3. It can be seen that, as expected, the general tendency is a decrease in eigenfrequencies. This decrease is induced by the weakening of the plate bending stiffness on the rivets line. However, this weakening do not affect all the modes with the same proportions, and some of them are even unaffected. It can be seen that mode (2,1) have a 7% decrease in natural frequency. Natural shapes of mode (2,1) is reported in figures 5. It can be observed that this shapes present a slope discontinuity in the rivets line area, due to a weakening in bending stiffness. For the corresponding homogeneous plate mode (2,1), the line coinciding with the rivets line corresponds to a zone containing high bending moments. These high level bending moments cannot be transmitted by the rivets line. Then these riveted plate modes are less stressed than the corresponding full plate modes. that is why eigenfrequencies of these kind of modes are greatly decreased.

4 - EFFECT OF THE RIVETS LINE ON THE PLATE DAMPING

Damping of the 11 first modes of the riveted and homogeneous plates are plotted in figure 4. Damping relative to the riveted plate mode (3,1) and (1,3) must be disregarded as it was very difficult to extract their modal parameters because both modes have very closed eigenfrequencies. It can be seen that the general tendency induced by the rivets line is increase in damping. However, like for eigenfrequencies, modes are not affected in the same proportions. Looking at figure 4, it can be observed that dampings of riveted plate modes (2,1) is multiplied by 6 comparatively to the homogeneous plate modes, while dampings of riveted plate mode (1,2) is just slightly increased. After observing carefully several modes shapes like those given in this paper, it can be stated that the main source of damping is the slip damping which occurs between the two plates in the rivets line area. This slip damping is directly related to the differential "in plane" motion between the two plates in the rivets line zone. These conclusions on the origin of damping are in agreement with previous papers treating of damping in joints [3].

SUMMARY

The influence of rivets has been studied, based on experimental data. Physical tendencies were found which will allow to know what assumptions can be made when theoretically predicting the effects of a rivets line. In term of stiffness, the rivets line can be taken into account by a punctual weakening of bending stiffness. In term of damping, it was shown that in plane motion of the plates must be taken into account as damping depends on it.

REFERENCES

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[3] "Structural Damping by slip in joints", L. Jézéquel, *Journal of Vibration, Acoustic, Stress, and Reliability in Design,* 105, 497-504 (1983)

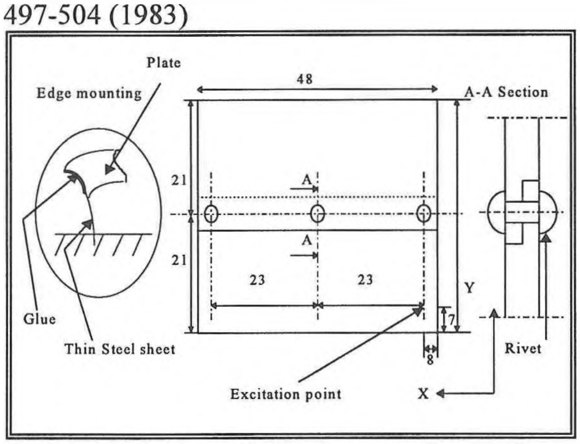
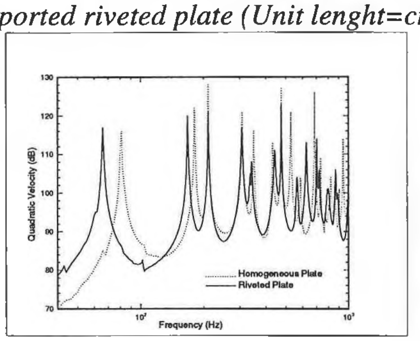


Figure 1: Experimental setup of a simply supported riveted plate (Unit lenght=cm).



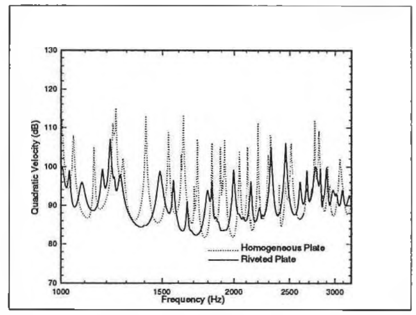


Figure 2: Experimental quadratic velocity of an homogeneous and riveted plate submitted to a point excitation force.

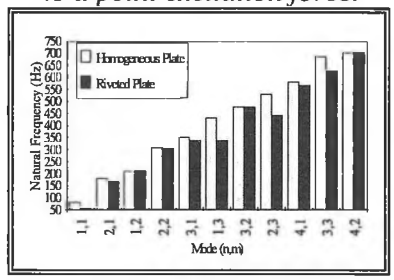


Figure 3: Natural frequencies of riveted/homogeneous plates modes

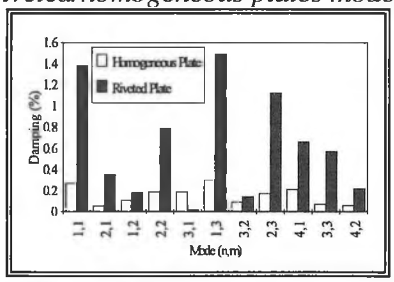


Figure 4: Damping factors of riveted/homogeneous plates modes

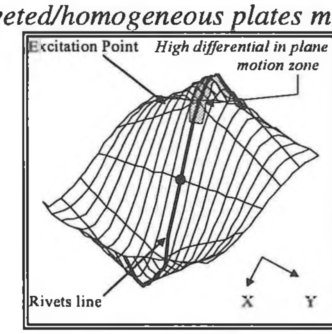


Figure 5: Riveted plate mode (2,1)

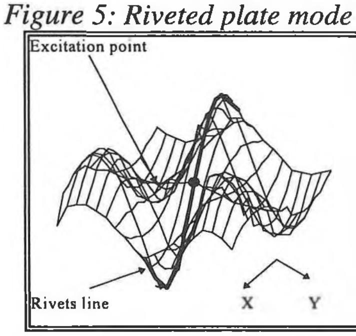


Figure 6 Riveted plate mode (2,3)