

**NORMAL AND OBLIQUE IMPACT OF PROJECTILES
ON SINGLE AND LAYERED THIN PLATES**

By

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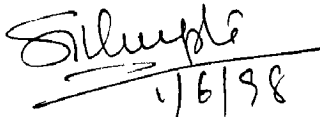
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CERTIFICATE

This is to certify that the thesis entitled **Normal and Oblique Impact of Projectiles on Single and Layered Thin Plates** by *Mr. Raisuddin Ansari* has been prepared under our supervision and has attained a standard required for a Ph.D. degree of the institute. The thesis is a record of bonafide research work carried out by him and its contents have not been submitted to any other University or Institute for the award of any degree or diploma.



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ABSTRACT

Experiments were carried out to study the response of thin single and layered plates to normal and oblique impact of a projectile, and to identify the modes of deformation of different materials in sub-ordnance velocity impact. The plates employed were those of aluminium, polycarbonate, fibre glass, perspex and hessian. The projectiles were essentially ogival nosed and the impact velocities were generally greater than the ballistic limit of the target. d/h_0 in our experiments varied from 7.5 to 30. Details of experimental setup and procedure are presented.

The impact and residual velocities were measured in a study of the perforation dynamics of both single and layered plates under normal and oblique impact. For a given plate thickness, residual velocity, velocity drop and energy absorbed have been related to the impact velocity. The response of single plates is compared with the response of layered plates as well as single and layered plates in oblique impact.

Five different thicknesses of thin commercial aluminium plates and two projectile diameters had been selected for the present study. Plates of four non-metallic materials were also employed as targets. Circular targets of 255 mm total diameter with 205 mm diameter free span were made from as received sheets of different materials. Ogival nose hardened steel projectiles of 2.0 caliber radius head and two diameters. i.e., 10 and 15 mm, were employed in the experiments. The length to diameter ratio (l/d) of 10 mm diameter projectile was varied from 1 to 4, whereas 15 mm diameter projectile had l/d ratio 2.

Experiments were performed with a pneumatic gun with a fixed barrel. Projectiles were fired at varying impact velocities. Projectile carriers were used for accommodating projectiles of different sizes in the same barrel. The barrel had a carrier stopper at its exit end for holding the carrier just before projectile leaves the barrel. Three infrared emitters and same number of photo diodes were fixed at known distances on the exit of the barrel to measure the impact velocity of the projectile. Residual velocities were measured with the help of two sets of aluminium foil screens placed behind the target plate. Data were recorded by electronic counter timer and digital storage oscilloscope (Gould 1604). Projectile carriers made of teflon had been designed, fabricated and successfully used for firing 10 and 15 mm diameter projectiles through the barrel of 31.7 mm bore diameter.

Single aluminium plates of different thicknesses were first impacted at varying velocities with 15 mm diameter projectiles to study the influence of thickness of the plate and impact velocity. Non-metallic targets were also studied in same fashion. Projectiles of 10 mm diameters and varying l/d ratios were then impacted at different impact velocities on single aluminium plates to study the influence of projectile diameter and its l/d ratio.

An analytical model, based on the experimental observations, is proposed for the study of the normal impact of projectile on single aluminium plates. The model is quite good in evaluating the ballistic limits of the plate and residual velocity of the projectile in sub-ordnance velocity range. A simple empirical relation, based on the experimental results, is developed to evaluate the ballistic limits of the plate and residual velocity of the projectile.

Impact experiments on layered aluminium plates (in contact) were carried out to study the response of plate thickness, number of layers and impact velocity. Some combination of layering of different thicknesses were studied to find out the variation of properties due to the plates of varying thickness and their sequence in layered targets. Non metallic targets were layered in combination with aluminium in different configurations and tested again at varying impact velocities to study the influence of the material and their sequence. Layered targets with different spacings had been tested to study the effect of the space in between the plates on the response of a layered target. Steel rings of thicknesses 5, 10 and 15 mm were used as spacers for the layered plate targets with space.

The empirical relations developed for single plates are quite good for layered (in contact) and layered (spaced) aluminium plates with different values of constants. In the analysis of layered plates of different materials, empirical relations developed for each material are employed, and the results show good correlation with experimental results.

Oblique impact of projectile at four different angles, mentioned above, were performed at varying impact velocities on single aluminium plates to study the effect of the angle of obliquity on various output parameters and mode of deformations. Inclined mounting rigs of 15° , 30° , 45° and 60° were made with mild steel pipe and plates for the oblique impact experiments. Few combinations of layered aluminium plates were also tried to study their response in oblique impact. Analysis of the results is carried out by considering the effective thickness of the plates.

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BIO-DATA OF THE AUTHOR