Relative Armor Thickness

By Christian Ankerstjerne

The most obvious method of increasing the armor protection of an armored vehicle is to increase the physical thickness of the armor plate. Another method is to counter specific types of anti-tank ammunition with special add-on armor. A cheaper method, effective against the anti-tank ammunition used during the Second World War, was to slope the armor plate, to decrease the angle of attack.

Contents

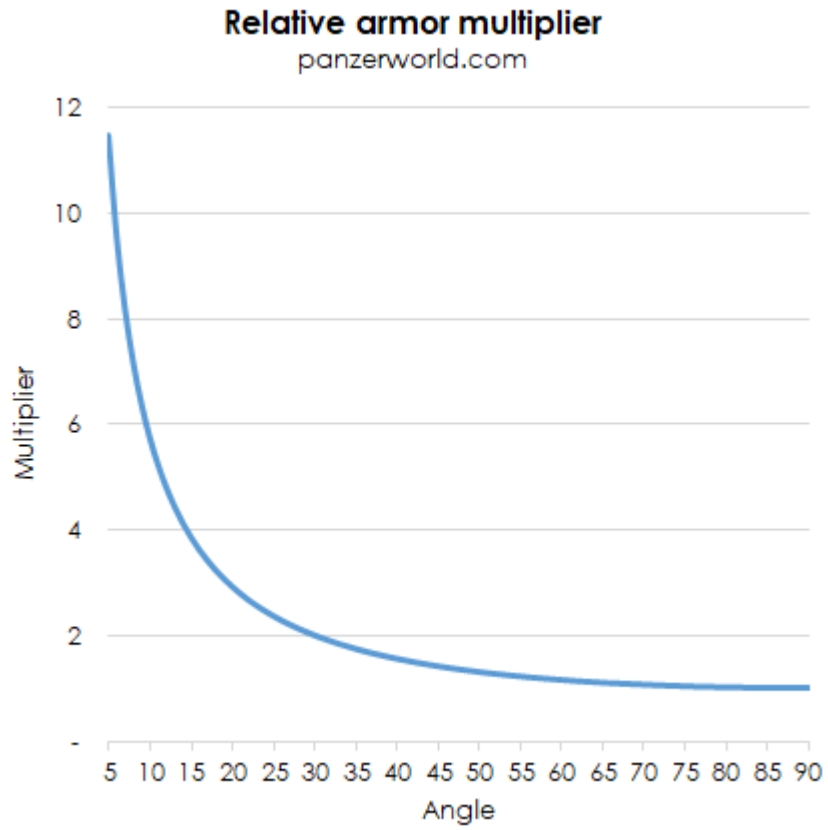
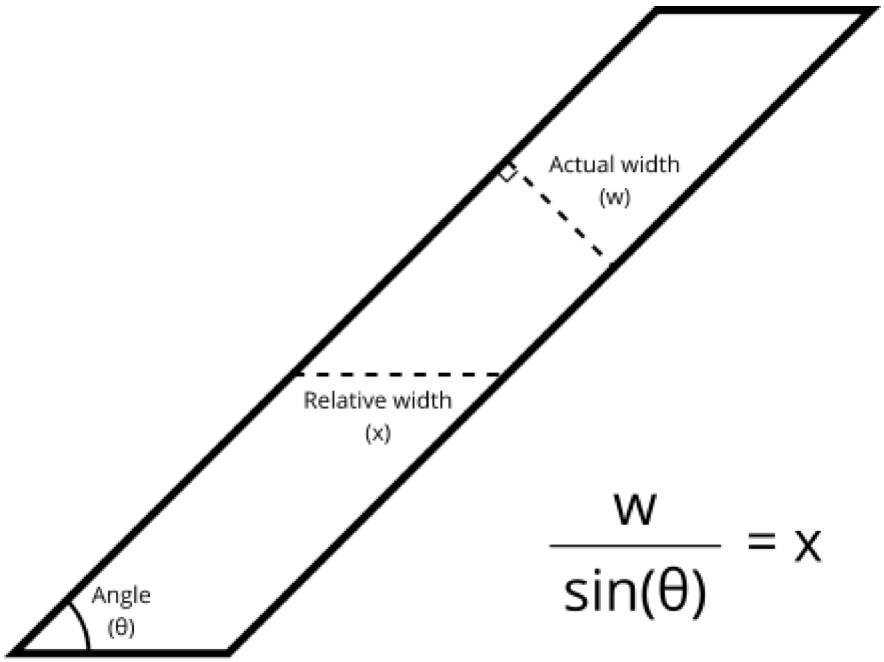


Chart of the relative armor multiplier from 5 to 90 degrees.

When an armor plate is sloped relative to the angle of attack, the relative armor thickness, or line of sight, increases. The armor piercing shot therefore have to penetrate a greater amount of armor than the actual thickness of the armor plate.

As the angle decrease, the relative armor thickness increase significantly. Thus, while an angle of 20 degrees will only increase the relative armor thickness by about seven percent, an angle of 30 degrees will increase the relative armor thickness by about 36 percent.

The relative armor thickness (x) can be calculated as the actual armor thickness (w), divided by the sine of the angle (θ). It is important to use degrees, not radians, when doing this calculation.



Demonstration of how the relative armor thickness is greater than the actual armor thickness of a sloped armor plate.

Sloped Armor Effectiveness

The extreme of sloped armor: The Swedish Cold War Stridsvagn 103 has almost horizontal frontal armor. In addition, vertical steel bars have been added to prematurely detonate HEAT ammunition.

There are two main advantages of sloped armor; easier armor plate manufacturing, and increase chance of shot deflection.

It is more difficult to manufacture a thick armor plate than a thin one. Without careful control of the heating and cooling processes, an armor plate can easily become either soft or brittle. This will lower the armor plate's resistance to armor piercing and high-explosive ammunition. As the thickness, and thereby the volume relative to the surface, of the armor plate increase, the temperature of the core become more difficult to control. Therefore, a thinner armor plate, placed at an angle, can negate some of the shortcomings of a country's steel industry.

In combat, the sloped armor plate will also increase the chance of a show deflective without penetrating. The chance of shot deflection not only depends on the angle of the armor, however, but also on the shot. Some shots are designed to lower the chance of shot deflection.

It is incorrect to assume that well-sloped armor will decrease the weight of a vehicle. While thinner armor plates can be used to achieve the same relative armor thickness, the armor plates must be equally longer to cover the same height. Furthermore, the sloped armor can decrease the space effectively available inside the vehicle. Thus, while saving steel and reducing the weight of a vehicle is often the most commonly used argument for sloped armor, it is the least viable.

One important disadvantage of sloped armor is its effectiveness against large-caliber ammunition. When the diameter of the shot is greater than the actual thickness of the armor plate, the risk of a plug-type penetration is increased. This type of penetration will punch out a steel plug from the armor plate in front of the shot, rather than the shot forcing its way through the armor. As this requires less energy, a penetration of this type will exceed the expected penetration when based on results against armor plates thicker than the shot diameter.

One factor which is of little importance against sloped armor, but which should be mentioned, is shot drop. A shot which is fired horizontally will slowly dip towards the ground. This will increase the angle of impact against sloped armor, decreasing the relative armor thickness. As the angle of most armor piercing shots will not change more than three degrees, even at extreme distances, and since the shot is rarely fired at a perfect 90 degree angle to the vehicle, this difference is largely irrelevant.

Additional Reading

Relative armor calculator
: Tool for calculating the relative thickness of a sloped armor plate.

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