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Perspective

# Structure and Characteristics of a Delta Wing

**Srikanth Nuthanapati***

*Department of Aeronautics, IIT Madras, Chennai, India*

## PERSPECTIVE

A triangle-shaped wing is referred to as a delta wing. It gets its name from its resemblance to the Greek uppercase letter delta (). Despite extensive research, it did not find widespread application until the Jet Age, when it proved suited for high-speed subsonic and supersonic flight. At the opposite end of the speed spectrum, the Rogallo flexible wing proved to be a workable design for hang gliders and other ultralight aircraft. The delta wing shape provides distinct aerodynamic properties as well as structural advantages.

Over the years, many design modifications have emerged, both with and without extra stabilising surfaces. The delta wing's long root chord and minimum construction outboard make it structurally efficient. It can be made to be stronger, stiffer, and lighter than a sweeping wing with similar lifting capabilities. As a result, it is simple and affordable to construct, which contributes significantly to the success of the MiG-21 and Mirage aircraft. Its long root chord also enables a deeper structure for a given aerofoil section, allowing for more internal space for fuel and other storage without significantly increasing drag. However, for supersonic designs, the ability to use a thinner aerofoil instead is frequently taken advantage of in order to really cut drag. Alexander Lippisch refined his thoughts on the high-speed delta throughout the final years of WWII, significantly increasing the sweepback of the wing's leading edge. In 1944, an experimental aircraft, the Lippisch DM-1, was built and flown as a glider in low-speed handling experiments. Following the end of the war, the DM-1 project was continued on behalf of the United States, and the DM-1 was shipped to Langley Field in Virginia for NACA inspection. Following the war, the British produced a number of subsonic jet aircraft using data from Lippisch's research

The Avro 707 research aircraft, for example, took to the skies for the first time in 1949. The Avro Vulcan (a strategic bomber) and the Gloster Javelin (an all-weather fighter) were among the first delta-equipped aircraft to enter production. Whereas the Vulcan was a traditional tailless design, the Javelin included a tail-plane to increase low-speed handling and high-speed manoeuvrability, as well as to allow for a wider centre of gravity range. A delta wing requires a high angle of attack to maintain lift at low speeds. A thin delta generates a distinct vortex pattern across the upper surface, which increases lift. To assist vortex formation, certain varieties with intermediate sweep incorporate retractable "moustaches" or fixed Leading-Edge Root Extensions (LERX).

As the angle of attack increases, the leading edge of the wing forms a vortex that energises the flow on the upper surface of the wing, delaying flow separation and giving the delta an extremely high stall angle. With a broad enough angle of rearward sweep, the wing's leading edge remains behind the shock wave boundary or shock cone created by the leading edge root in the transonic to low supersonic speed range. This permits air beneath the leading edge to flow out, up, and around it before returning inwards, resulting in a sideways flow pattern. This sideways flow has a significant impact on lift distribution and other aerodynamic parameters. The shock cone from the leading edge root angles further back to lie along the wing surface behind the leading edge at high supersonic speeds. Sideways flow is no longer possible, and the aerodynamic properties change dramatically. The wave rider technique, as utilised on the North American XB-70 Valkyrie, becomes feasible in this flight regime.

The tailless delta wing, like other tailless aircraft, is poorly suited to high wing loadings and requires a large wing area for a given aircraft weight. Because the most efficient aerofoils are pitch unstable, the tailless variant must utilise a less efficient design and thus a larger wing. A traditional tail stabiliser enables the main wing to be optimised for lift, allowing it to be smaller and more heavily loaded. The development of aeroplanes with this configuration dates back to the late 1940s. Francis and Gertrude Rogallo devised the concept of a flexible wing that could be collapsed for storage during and after WWII. Francis recognised potential use in spaceship recovery, which piqued NASA's interest. Ryan flew the XV-8, an experimental "flying Jeep" or "fleep" in 1961. Its flexible wing was a delta, and when in operation, it billowed out into a double-cone profile, giving it aerodynamic stability.

**Correspondence to:** Srikanth Nutanapati, Department of Aeronautics, IIT Madras, Chennai, India, E-mail: nutanapati8807@gmail.com

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