

Pilot's Handbook of Aeronautical Knowledge



U.S. Department
of Transportation
Federal Aviation
Administration



Effect of Weight on Flight Performance

The takeoff/climb and landing performance of an aircraft are determined on the basis of its maximum allowable takeoff and landing weights. A heavier gross weight results in a longer takeoff run and shallower climb, and a faster touchdown speed and longer landing roll. Even a minor overload may make it impossible for the aircraft to clear an obstacle that normally would not be a problem during takeoff under more favorable conditions.

The detrimental effects of overloading on performance are not limited to the immediate hazards involved with takeoffs and landings. Overloading has an adverse effect on all climb and cruise performance, which leads to overheating during climbs, added wear on engine parts, increased fuel consumption, slower cruising speeds, and reduced range.

The manufacturers of modern aircraft furnish weight and balance data with each aircraft produced. Generally, this information may be found in the FAA-approved AFM/POH and easy-to-read charts for determining weight and balance data are now provided. Increased performance and load-carrying capability of these aircraft require strict adherence to the operating limitations prescribed by the manufacturer. Deviations from the recommendations can result in structural damage or complete failure of the aircraft's structure. Even if an aircraft is loaded well within the maximum weight limitations, it is imperative that weight distribution be within the limits of CG location. The preceding brief study of aerodynamics and load factors points out the reasons for this precaution. The following discussion is background information into some of the reasons why weight and balance conditions are important to the safe flight of an aircraft.

In some aircraft, it is not possible to fill all seats, baggage compartments, and fuel tanks, and still remain within approved weight or balance limits. For example, in several popular four-place aircraft, the fuel tanks may not be filled to capacity when four occupants and their baggage are carried. In a certain two-place aircraft, no baggage may be carried in the compartment aft of the seats when spins are to be practiced. It is important for a pilot to be aware of the weight and balance limitations of the aircraft being flown and the reasons for these limitations.

Effect of Weight on Aircraft Structure

The effect of additional weight on the wing structure of an aircraft is not readily apparent. Airworthiness requirements prescribe that the structure of an aircraft certificated in the normal category (in which acrobatics are prohibited) must be strong enough to withstand a load factor of 3.8 Gs to take care of dynamic loads caused by maneuvering and gusts. This means that the primary structure of the aircraft can withstand

a load of 3.8 times the approved gross weight of the aircraft without structural failure occurring. If this is accepted as indicative of the load factors that may be imposed during operations for which the aircraft is intended, a 100-pound overload imposes a potential structural overload of 380 pounds. The same consideration is even more impressive in the case of utility and acrobatic category aircraft, which have load factor requirements of 4.4 and 6.0, respectively.

Structural failures that result from overloading may be dramatic and catastrophic, but more often they affect structural components progressively in a manner that is difficult to detect and expensive to repair. Habitual overloading tends to cause cumulative stress and damage that may not be detected during preflight inspections and result in structural failure later during completely normal operations. The additional stress placed on structural parts by overloading is believed to accelerate the occurrence of metallic fatigue failures.

A knowledge of load factors imposed by flight maneuvers and gusts emphasizes the consequences of an increase in the gross weight of an aircraft. The structure of an aircraft about to undergo a load factor of 3 Gs, as in recovery from a steep dive, must be prepared to withstand an added load of 300 pounds for each 100-pound increase in weight. It should be noted that this would be imposed by the addition of about 16 gallons of unneeded fuel in a particular aircraft. FAA-certificated civil aircraft have been analyzed structurally and tested for flight at the maximum gross weight authorized and within the speeds posted for the type of flights to be performed. Flights at weights in excess of this amount are quite possible and often are well within the performance capabilities of an aircraft. This fact should not mislead the pilot, as the pilot may not realize that loads for which the aircraft was not designed are being imposed on all or some part of the structure.

In loading an aircraft with either passengers or cargo, the structure must be considered. Seats, baggage compartments, and cabin floors are designed for a certain load or concentration of load and no more. For example, a light plane baggage compartment may be placarded for 20 pounds because of the limited strength of its supporting structure even though the aircraft may not be overloaded or out of CG limits with more weight at that location.

Effect of Weight on Stability and Controllability

Overloading also affects stability. An aircraft that is stable and controllable when loaded normally may have very different flight characteristics when overloaded. Although the distribution of weight has the most direct effect on this, an increase in the aircraft's gross weight may be expected to have an adverse effect on stability, regardless of location