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Frequencies of vertical and lateral load factors resulting from ground manoeuvres of aircraft

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FREQUENCIES OF VERTICAL AND LATERAL LOAD FACTORS RESULTING FROM GROUND MANOEUVRES OF AIRCRAFT

CONTENTS

	Page
1. INTRODUCTION	1
2. NOTATION	1
3. VERTICAL LOAD FACTORS	1
4. LATERAL LOAD FACTORS	2
5. COMMENTS	2
6. DERIVATION AND REFERENCE	3
6.1 Derivation	3
6.2 Reference	4
7. EXAMPLE	4

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FREQUENCIES OF VERTICAL AND LATERAL LOAD FACTORS RESULTING FROM GROUND MANOEUVRES OF AIRCRAFT

1. INTRODUCTION

This Item presents data on the frequency of occurrence and magnitude of vertical and lateral load factors obtained during ground operations. The majority of the data were deduced from measurements recorded by accelerometers situated at or near the centre of gravity of aircraft. The accelerometers recorded the incremental accelerations (about the steady condition) experienced by the aircraft. Upward accelerations result from upward forces applied to the aircraft: the resulting load factors were taken to act in the opposite direction to the accelerations. In a few cases the load factors were deduced by other methods, generally by strain measurements from strain gauges positioned on the undercarriage members. In order to obtain non-dimensional load factors these have been related to the associated static undercarriage loads. All the aircraft were operating from airfields with paved runways and in most cases the measurements were recorded during the normal service of the aircraft.

2. NOTATION

f	cumulative frequency per flight
Δn_y	incremental lateral load factor
Δn_z	incremental vertical load factor

3. VERTICAL LOAD FACTORS (Δn_z)

Figures 1 to 5 present incremental vertical load factors, deduced from acceleration data measured at the centre of gravity of aircraft, plotted against their cumulative frequencies of occurrence. Figures 1 to 4 relate to different groups of aircraft categorised according to their design take-off mass and their approximate maximum range (where the information is available). The data are presented for discrete ground operations, that is, pre-flight taxi, take-off, landing run and post-flight taxi. Some of the load factors presented on Figures 1, 3 and 4 are not deduced from accelerations recorded at the centre of gravity of the aircraft. These load factors have been deduced in several ways and the particular methods employed are defined on the figures where the data appear. For the load factors measured at the aircraft undercarriage, the type of undercarriage is described because it would be expected that, for example, aircraft with twin axle (bogie) undercarriages would be less sensitive at lower speeds to bumps shorter than the axle spacing and to small steps in the taxiways.

In the calculation of the cumulative frequency per flight, the frequency of upward and downward values of Δn_z , of equal magnitude about the steady condition, have been combined without regard to their direction and this summation is divided by the number of flights so as to obtain the number of times per flight a load factor has been reached or exceeded. Figure 5 presents the overall total frequencies of occurrence per flight (that is, cumulative totals for pre-flight and post-flight taxi, take-off and landing run) of incremental vertical load factors for the four groups of airliners of Figures 1 to 4, together with some further data on two fighter aircraft.

When constructing the loading spectra the data will have to be separated into upward and downward values of Δn_z , of equal magnitude, with respect to their frequency of occurrence per flight. Where the information was available it was found that, generally, the data divided into 53 per cent upward acceleration values and 47 per cent downward acceleration values. In the case of one airliner, only downward load factor data were available; therefore to obtain total cumulative frequencies of occurrence the general distribution ratio as stated above was used.

The fighter aircraft data, presented on Figure 5 (shown dotted on Figure 4), could not be analysed in the same way as the airline data and therefore, only the frequencies of the downward peak load factors are shown.

4. LATERAL LOAD FACTORS (Δn_y)

Incremental lateral load factors are presented in Figure 6. The data are presented for five types of aircraft from recordings taken during taxi operations during normal service. For the other aircraft included the data were recorded during a limited number of turning operations on the ground.

In the calculation of the cumulative frequency per flight, the frequency of lateral load factors, of equal magnitude, have been combined irrespective of the direction of Δn_y and this summation is divided by the number of flights to obtain the number of times per flight a load factor has been reached or exceeded.

When constructing loading spectra the data will have to be separated into left-hand and right-hand values of Δn_y with respect to their frequency of occurrence per flight. The separation of the data will be dependent on the proportions of left- and right-hand accelerations encountered; analysis of the present data is inconclusive but Reference 14 recommends an asymmetric distribution of frequency of occurrence.

5. COMMENTS

The data presented in the Item may be used to estimate a spectrum of loads resulting from ground manoeuvres. It should be noted that the load factors presented are influenced by the dynamic effects of the aircraft, including that of the undercarriage, which vary considerably from aircraft to aircraft.

Figures 1 to 4 show that for each type of aircraft the differences between the load factors obtained in pre-flight and post-flight taxi operations are small in most cases. Also, the incremental vertical load factors deduced during the landing run are the most severe and the pre-flight and post-flight taxi load factors are the least severe. The take-off load factors lie between these extremes.

Some factors that influence ground manoeuvre load factors are variations in speed and aircraft mass. Taxiing speeds are much lower than take-off and landing speeds and take-off mass is larger than landing mass. In interpreting the landing run data it is probable that some part of the landing impact has been included in these data thus increasing the magnitude of the load factors. In general the difference between the take-off and landing mass of long range aircraft is much greater than that of short range aircraft. This suggests a reason for the trends shown in Figures 1, 2 and 3, that is, as aircraft range is reduced there is a reduction in the differences between the magnitudes of the load factors (at a given frequency) deduced from the take-off and landing run accelerations. The data for short range airliners given on Figure 4 do not follow this trend, but in this case the landing run load factors are a little high, probably because the undercarriage was hard.

Figure 5 shows that scatter between the curves for the four types of airliner considered is not large (less than $0.1 \Delta n_z$ at most frequencies). The single engine jet fighters have the most severe overall load factors.

Figure 6 shows that lateral load factors deduced during ground manoeuvres on smaller types of military aircraft are the most severe recorded. Lateral load factors deduced during turning manoeuvres of large aircraft tend to be small.

6. DERIVATION AND REFERENCE

6.1 Derivation

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