Pre-normative research for civil aviation safety: Seat-floor attachment

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Abstract

Since 1988, seat dynamic tests have been defined to demonstrate both occupant response and seat/restraint system structural performance. Furthermore, cabin floor should be designed taking into account static load factors applied on seat+occupant center of gravity.
This CEAT/Aerospatiale program sponsored by the French Civil Aviation Administration (DGAC) aims at studying the seat attachment at the cabin floor according to the applicable norms and checking if the imposed specifications allow to limit the risks of cabin floor failures. Seat attachement failures express misunderstanding of realistic loads between statics and dynamics.
Thus, the study will insist on the acknowledge of these real loads by using a mixed approach test+simulation. Three tests, two of them with a representative cabin floor structure, will be performed to measure the attachement loads. Then these information will be introduced in the finite element model to obtain the complete behaviour of cabin floor under dynamic sollicitations.

Introduction

In an aircraft accident, the occupants'chances of evacuation largely depend on the structural strength of seats and floor. But seat-floor attachment failures have been observed in aircraft accidents.
Since 1988, floor and seats have been crash-sized. The cabin floor which is made up of cross beams and rails is crash sized according to FAR/JAR 25.561. Static load factors are defined in the three axes and are applied to the center of gravity of the seat/occupant system. Likewise the seat to be fitted to aircraft must undergo dyn amic qualification testing in acordance with FAR/JAR 25.562. The aircraft manufacturer is responsible for the cabin floor sizing and the equipment supplier for the seat.
The DGAC (French civil aviation authority) decided to investigate for the first time the equipment supplier/aircraft manufacturer interface and to sponsor a research program on the seat-floor attachment proposed by CEAT and Aerospatiale as associated partner.

Scope of the study

The attachment of the seat to the floor is presented on the following sketch:

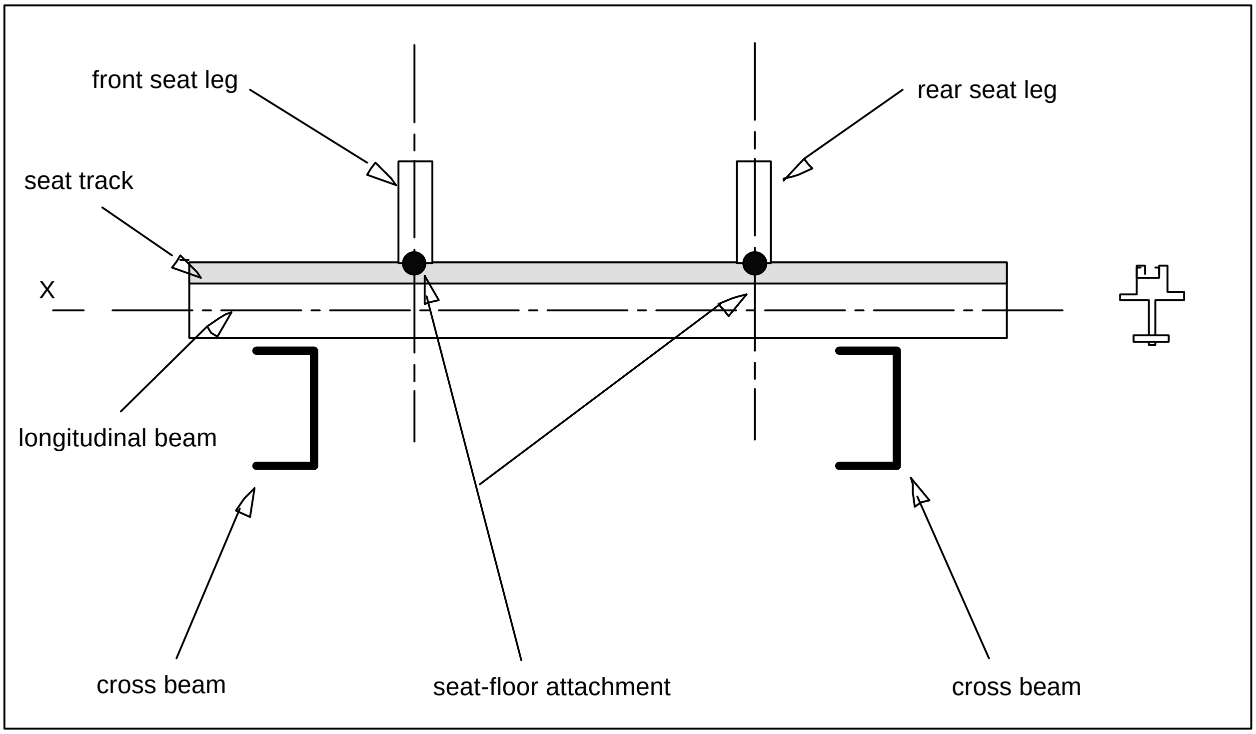


figure 1

The introduction of seat loads affects two or even three crooss beams and two rail support beams. The rail can be fitted on to the rail support beam or directly integrated into the rail support beam.
Due to the seat dimensions and seat pitch, the seat/floor attachment location on the floor is not always the same.

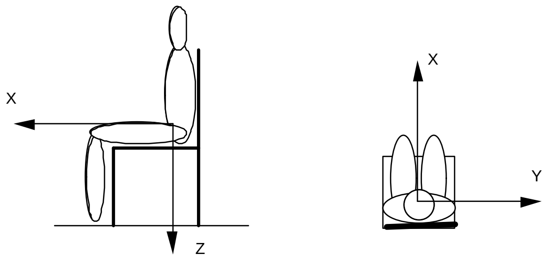
Identification of the issue

The purpose of this chapter is to show the factors likely to account for failures at seat attachments while respecting current regulations.

<u>Comparison of sizing criteria</u>

The following figure shows the differences between para. 25.562 and 25.561 are given:

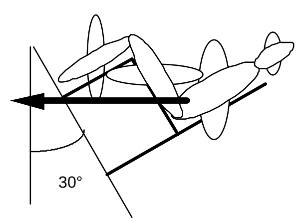
FLOOR DIMENSIONNING FAR/JAR 25.561	SEAT DIMENSIONNING FAR/JAR 25.562



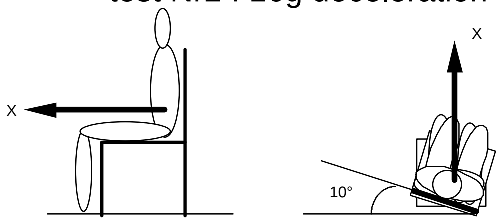
load cases:

9g.1.33 forward
1.5g.1.33 rearward
6g.1.33 downward
3g.1.33 upward
3g.1.33 side

test Nr1 : 14g deceleration



test Nr2 : 16g deceleration



The standards are different on the one hand but the sizing assumptions are also different:
- seat and occuppants are supposed to be rigid for FAR/JAR 25.561 whereas in dynamic testing seats and anthrompomorphic dummies are set in motion,
- the floor is supposed to be infinitely rigid for FAR/JAR 25.561 whereas floor distortion is simulated for a dynamic test Nr2.
- the floor composed by cross beam and seat rails is taken into account for FAR/JAR 25.561 whereas only the upper part of the seat rails is represented for dynamic tests.

It is obvious that the loads introduced into the floor by the loading of the seat-occupant system are different. If the rail lips withstand the loads introduced by the seats, one must checked that the lower structure does.

Influence of seat position on floor

Considering the seat and cross beams pitches, you get four extreme floor loading cases:

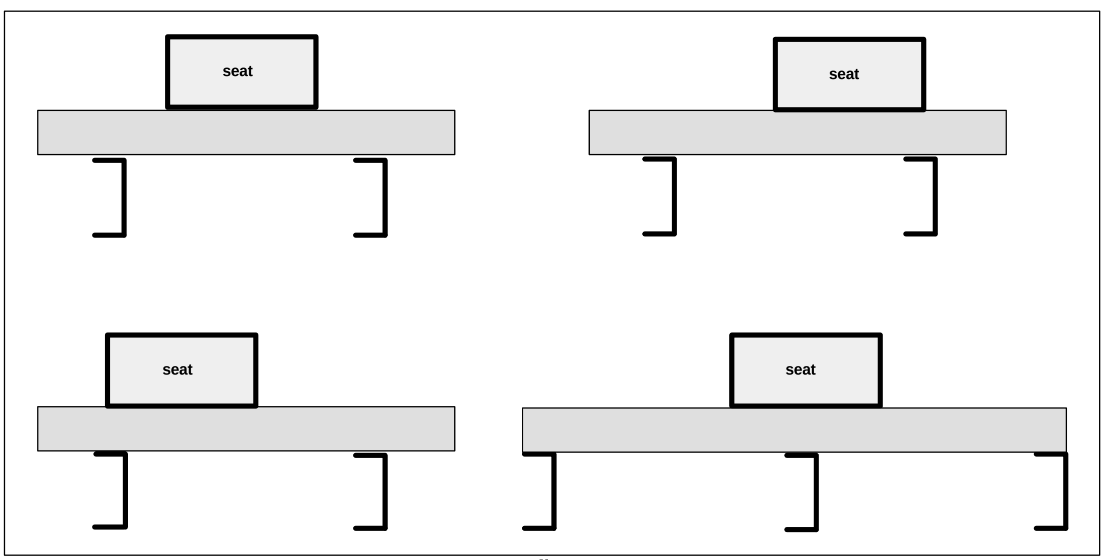


figure 4

Influence of the number of attachment points

The cabin floor is sized by assuming at a first stage that today the seat has been secured on each rail by two attachment points.
As a result of a changing demand, seat manufacturers may be led to make seats with four or five anchoring points. The load distribution in the rail is then different and can change the global seat behaviour.

Conclusions

Actually, many factors may affect the seat/floor attachment behaviour . The purpose of the study is to bring out the causes that may lead to failures of the seat/floor attachment despite the change in regulations in 1988.

Study proposal

In aircraft accidents, the seat and its occupants introduce loads into the floor. To check that these loads are lower than those used to design the floor, the load profiles must be identified and can be assessed only by tests.
As the number of configurations to be considered is high, it would be necessary to conduct many tests consuming aircraft structures, in order to check the seat/floor attachment behaviour .
However to take all the configurations above mentionned into account and because of costs induced, a mixed approach test/finite element will be used.
The aircraft floor fine modelling associated to realistic load introduction will lead to reliable conclusions on the attachment behaviour.

TASK 1 : seat definition

The purpose of this task is to draw up a list of arguments based on crash findings allowing to justify the choice of a type seat. This seat will be the only reference on the whole study.
Contacts are to be made directly with the Bureau Enquête Accident (Crash Investigation Office) and Mr Cherry, the author of a study conducted for the CAA, to identify the scenarios that have resulted in seat/floor subassembly damages. The results of this inquiry will lead to the seat configuration (single seat, two-seat, three-seat configuration).
The proposed study also focused on the number of attachment points. The seat manufacturers and the certification authoritites are to be requested to bring out the differences between a seat equipped with two or five attachments points per rail.
On completion of this investigation, a seat can be defined and manufactured. The seat has to be infinitely rigid to avoid associating the study with a seat manufactured by a company. Furthermore, one seat only will be used for all the tests proposed to make the results of the different tests directly comparable. Lastly an optimized seat instrumentation will record the loads to the floor which will be used for numerical simulations. This information required for numerical simulations will be easily accessible with a seat designed on the basis of this study rather than with an existing manufacturer seat that has been adapted.

TASK 2 : aircraft floor modelling

The modelled structure will be made up of two or three cross beams and four rails (two by seat row) as to be found on a commercial AIRBUS type aircraft. This task will be performed by Aerospatiale.
The model validation will be obtained by a near tension test in a floor area. Three loading cases will be determined allowing to fully validate the model in near static conditions.

TASK 3 : fullfilment of requirements

The aim is to repeat the manufactyurer's calculations to size his cabin floor on the basis of the applicable FAR/JAR 25.561requirements. The loads introduced into the floor are calculated by applying a load factor at the seat/assembly center of gravity as shown in table 2 page 2.
At this stage, working assumptions have to be defined e.g
- center of gravity position
- seat/occupants weight
- seat stiffness
By this process the sizing loads for the cabin floor to be introduced into the model can be determined.

TASK 4 : determination of dynamic load spectra

The spectra are determined by a dynamic testing campaign with an appropriate type of seat. A study will be conducted to bring out the seats geometric differences with two or four attachment points per rail.
The test 2 configuration will be common to the three tests. It is indeed structurally more penalizing for the seat compared to test 1 and therefore introduces higher loads into the floor. The tests parameters are in compliance with FAR/JAR 25.562.
The three tests performed are :
- test 1 : infinetly rigid floor with two attachment per rail,
- test 2 : floor representative of a real structure with two attachment points per rail,
- test 3 : floor representative of a real structure with four or five attachment points per rail
Test number 1 is typically the tests performed for the purpose of seat qualification.
Test number 1 and 2 will show the influence of floor representativity.
Tests number 2 and 3 will allow to validate on the one hand the finite element model in dynamic conditions and on the other hand the influence of the number of attachment points.

TASK 5 : verification of floor structural strength

The records made during the tests will be introduced according to the different configurations in term of anchoring points and seat position in relation to cross beams. In total eight simulations will be done.
The results of the dynamic calculations will show the good or bad behaviour of the seat/floor attachment to meet the study purposes.
An analysis will be made to identify the dimensions of the seat with five anchoring points and the actions 4.2 will be carried out again.

TASK 6 : proposals concerning changes in regulations

If the analyses performed during the study show a weak point between the rail lips and the floor cross beams, this would mean that dynamic loads must be taken into account for floor sizing; the dynamic seat tests must be conducted then with a more representative floor structure.
On the contrary, if the the test and simulations show that the floor structure is sized properly, we could conclude that the efforts introduced into the model were not high enough. More loads means more deceleration on the seat. Therefore FAR/JAR 25.562 would need revision.
This task will be used to draw up a list of structure modifications which would be necessary to ensure the seat/floor attachment strength. It will allow an assessment of the extra cost of such modifications for the aircraft manufacturer. The data base of the Cherry study will then give assess to potentially saved lives. It will be possible then to prepare a short cost/adavantage study.