Research Plan at NAL on Drop Test of Fuselage Structure of YS-11 Turbo-prop Transport Aircraft

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*About **NAL** : National Aerospace Laboratory of Japan*

***Headquarters** : Tokyo*

***Project Centers** :*

Supersonic Transport Technology
Stratospheric Platform Airship
Reusable Space Transportation Systems

Technology and Research Centers :

Wind Tunnel Technology Center
CFD Technology Center
Advanced Composite Evaluation Technology Center
Fluid Science Research Center
Structures and Materials Research Center
Aircraft Propulsion Research Center
Flight Systems Research Center
Space Technology Research Center
KAKUDA Space Propulsion Laboratory

Research Program in Crashworthiness

- *Analytical Modeling*

  Estimation of crash mode of fuselage structures and impact environment around passengers

- *Evaluation of Crash Environment*

  Drop test of full-scale fuselage structure of transport airplane

- *Effective Structures for Impact Energy Absorption*

  Analytical and experimental study on design concept

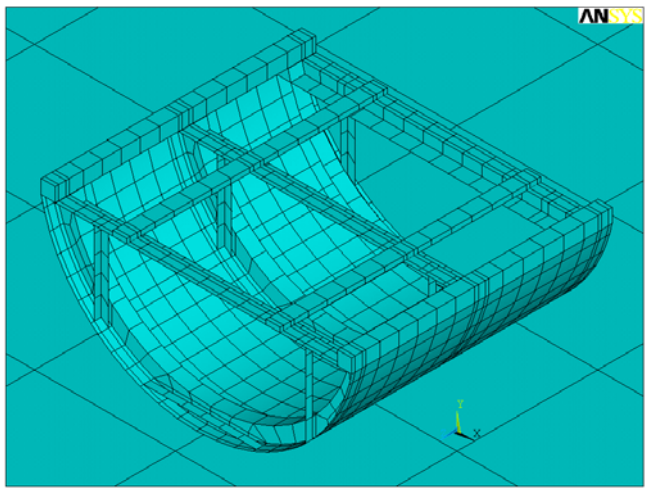
1. Analytical Modeling

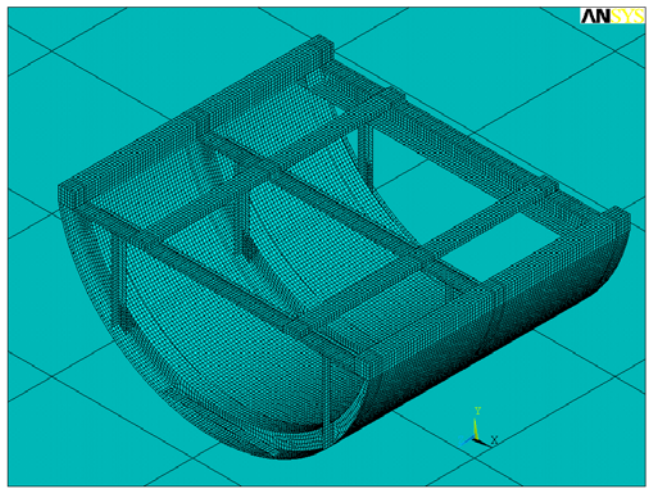
Basic study on small-scale structural models

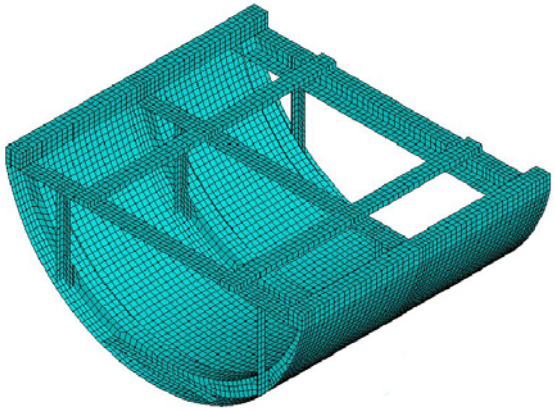
*Explicit dynamic analysis code : LS-DYNA3D

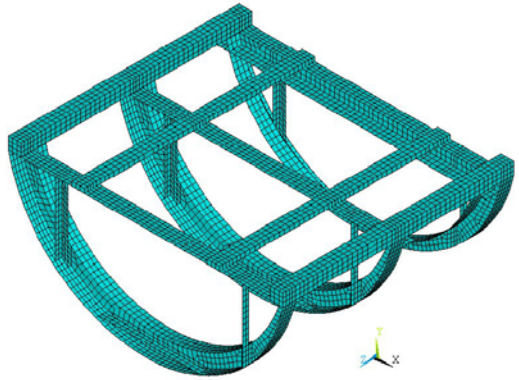
*Influence of element type, mesh size, material properties , etc. on the precision of estimation

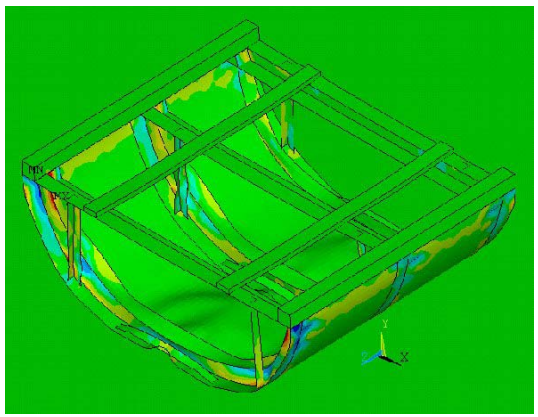
*Effect of open-ends, dimensional parameters,and the attitude of the fuselage at impact

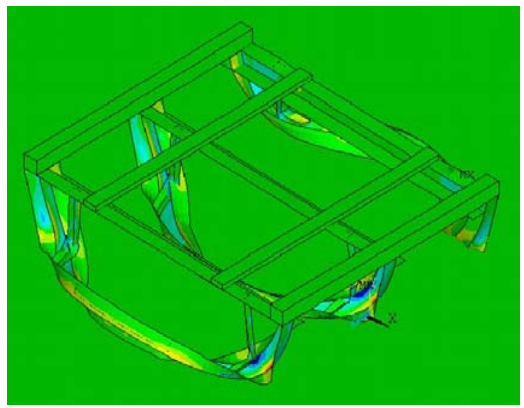












a) Baseline model

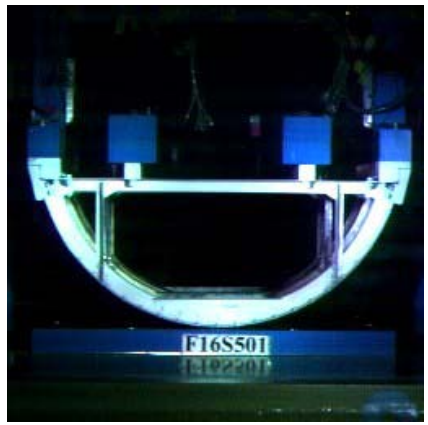
b) Simplified skeleton model

An example of analysis : Effect of thin skin panels on the deformation mode of under-floor section. Simplified skeleton models will yield improper estimation of deformation by neglecting the effect of skin panels on out-of-plane deformation of frames.

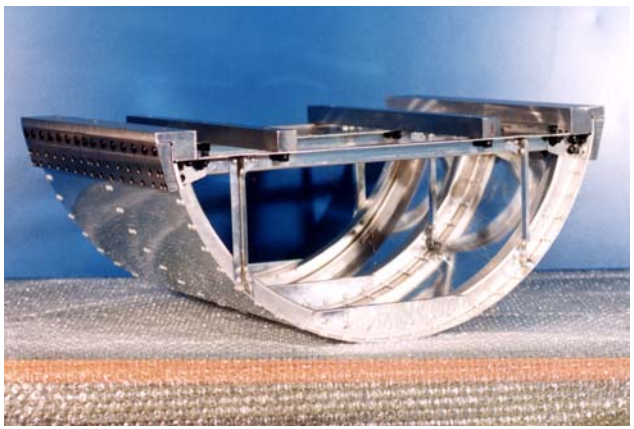
Related experiments

Drop tests of small-scale structural models of under-floor portion of fuselage , which will absorb the most part of impact energy.

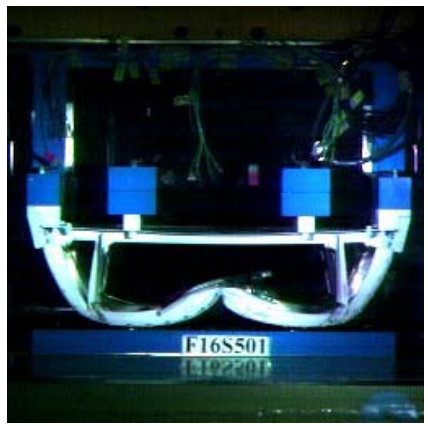
More than 40 specimens with various structural parameters were tested.



The moment of contact

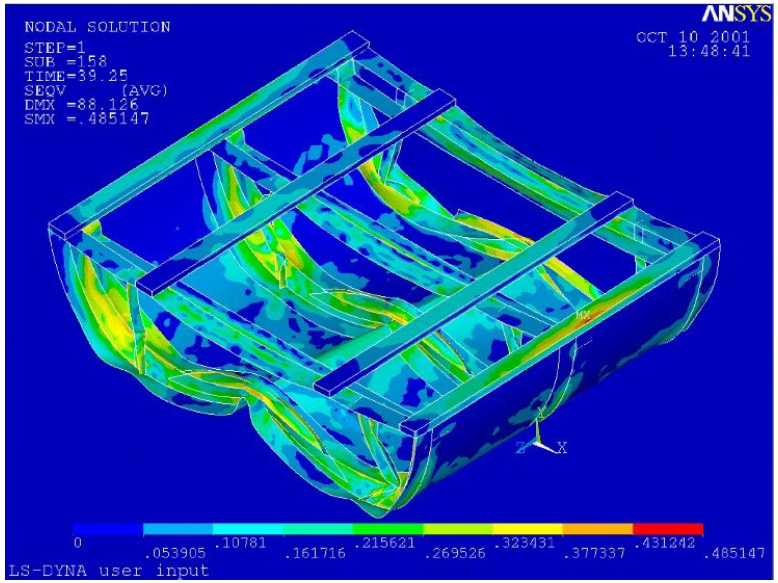


An example of structural model

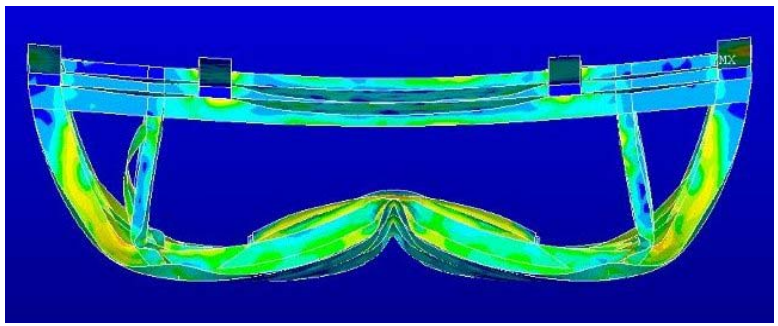


Maximum deformation

NAL Drop test facility

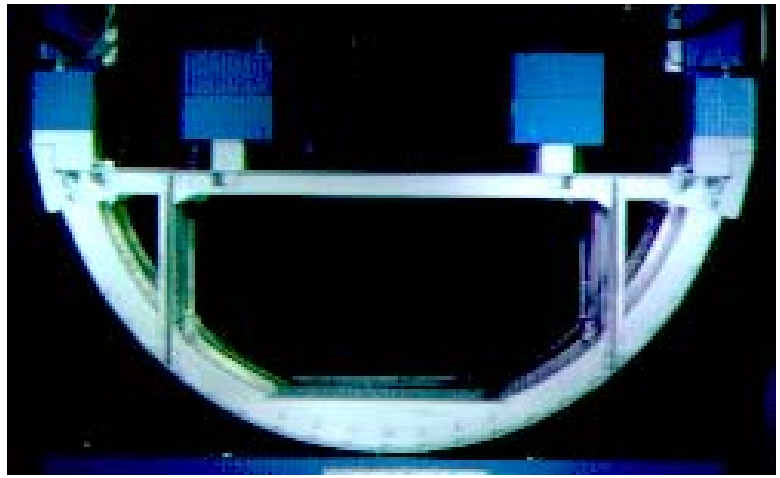


Bird's Eye View of Stress Distribution

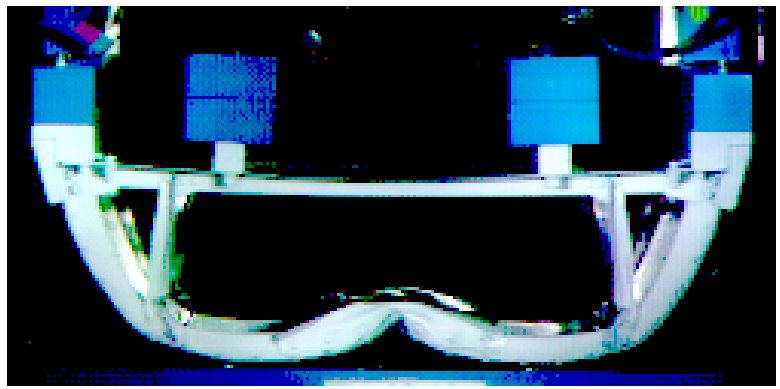


Maximum Deformation

(a) Analysis by ANSYS/LS-DYNA3D



Contact



Maximum Deformation

(b) Drop Test (High-Speed Video Camera)

An Example of Analytical Estimation and the Corresponding Experimental Result (Vertical Drop Test)

2. Evaluation of Crash Environment

* Drop test of full-scale fuselage sections of YS-11 turbo-prop transport airplane

    * Development of the analytical model of full-scale fuselage section by nonlinear dynamic analysis code, LS-DYNA3D

* FEM analysis of seat/occupant/floor response

* Evaluation of a new shock-absorbing element for seat structure

(1)Drop Tests of Full-Scale Fuselage Structure

**Preliminary Experiment Using a Sub-Scale Structural Model for Determination of*

- Test method of full-scale fuselage structures
- Impact condition
- Data acquisition system
- Analytical model

Structural model for preliminary test

Diameter : 1.25 m
Length : 1.5 m
Weight : 230 kg

Fuselage Structure of YS-11A

YS-11 series : The first turbo-prop transport aircraft which was developed by Japanese aircraft company, NAMC.

Two fuselage sections of YS-11 turbo-prop transport airplane were brought into NAL by ANK (Air Nippon Co.,Ltd., one of the airline operators in Japan) for drop tests.

YS-11 Specifications

Fuselage Diameter : 2.88 m

Max.T/O Weight : 24.5 tons

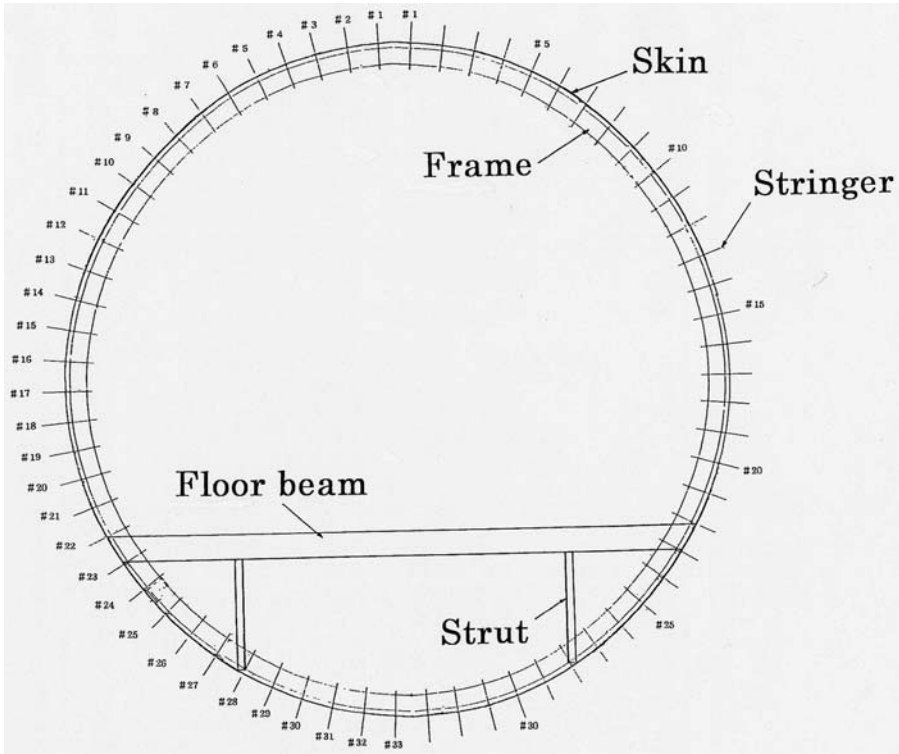
Passengers : Max. 64

Wing Span : 32.0 m

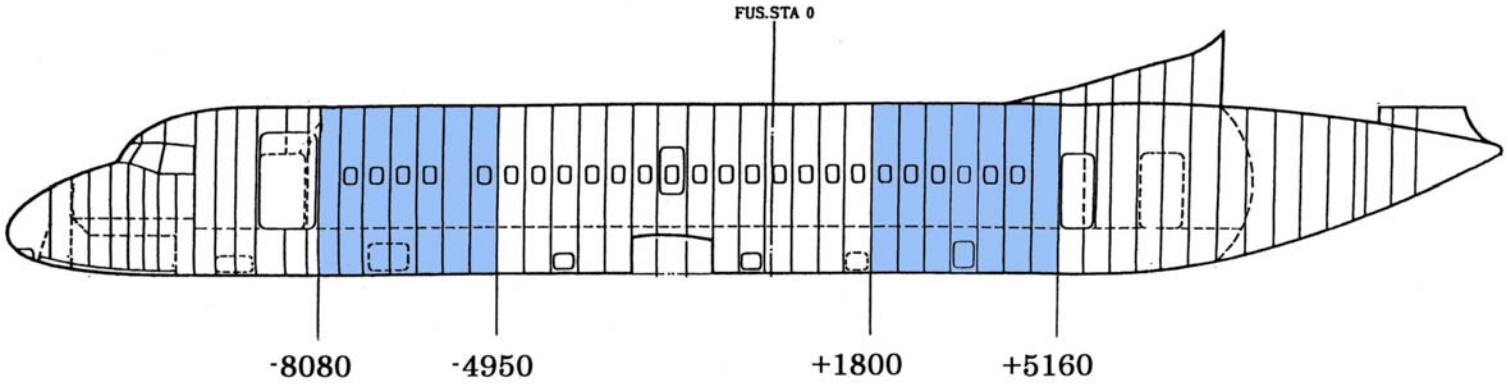
Overall Length : 26.3 m

Tail Height : 9.0 m

Cruising Speed : 450 km/h



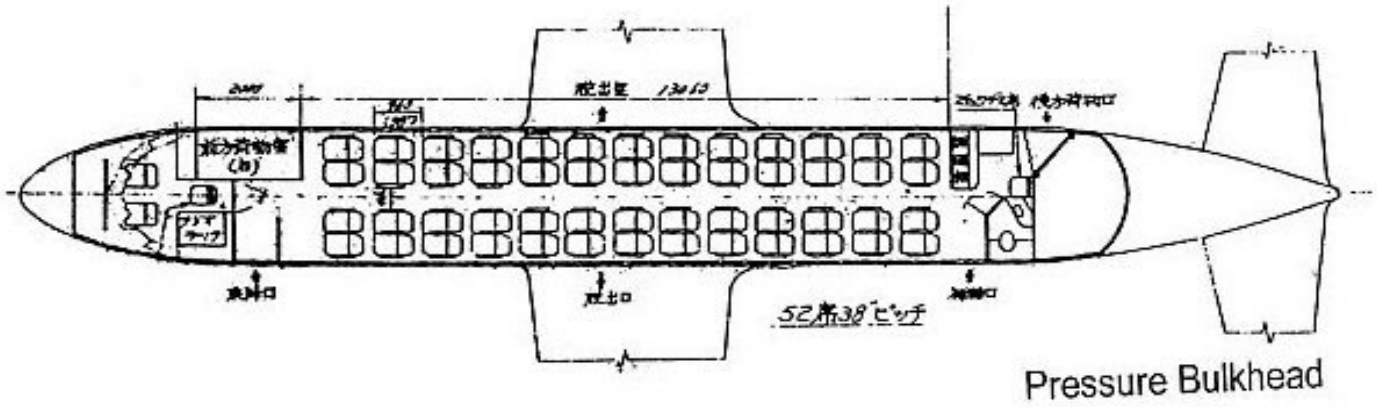
Cross section

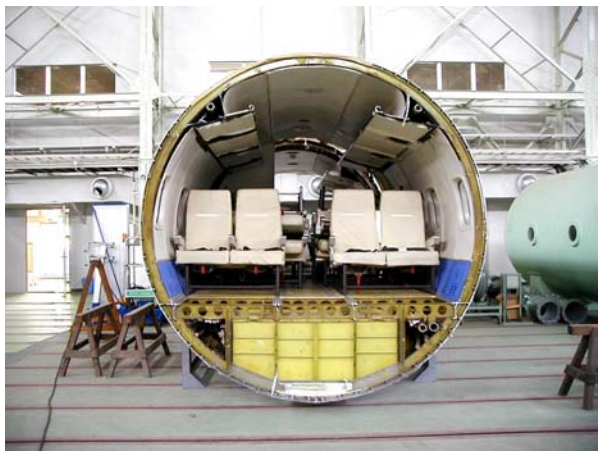


(1) FWD Section

(2) AFT Section

Test section





Instrumented and un-instrumented dummies of occupants (Hybrid II or Hybrid III) are prepared for drop tests to measure their impact response

Passenger Seats

Test Plan

Test Method : Vertical drop test to a rigid flat base

Fuselage Sections : No.1 : FSTA- 8080 FSTA- 4950

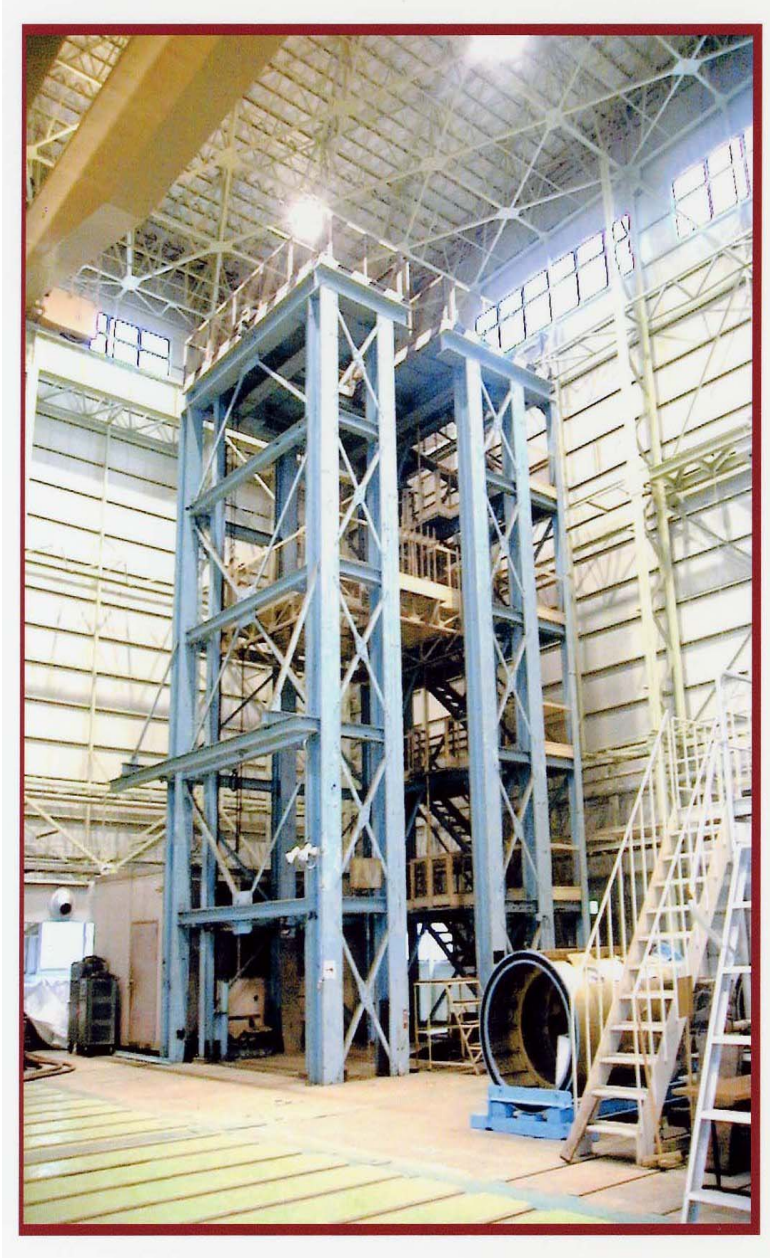
No.2 : FSTA+1800 FSTA+5160

Impact velocity : 20 ft/sec or 30 ft/sec

Schedule(tentative) : December, 2001 and May, 2002

Test Site : NAL Chofu Airfield Branch,Tokyo

Technical or advisory supports by FAA Technical Center, JCAB, Kawasaki Heavy Industries, Mitsubishi Heavy Industries, Tenryu Industries Co.Ltd.(Seats), Air Nippon Co.,Ltd.(Airline Operator),etc



Drop Test Tower at NAL Chofu Airfield Branch

Data Acquisition System

Instrumentation

Accelerations : Floor Beams, Frames, Dummies, etc

(More than 80 Channels)

Strains : Floor beams, Frames, Struts, Seat Legs,etc

Deformation : Image processing of video records (500 and 1000 frames/sec)

All of data are recorded by automatic digital recording system. Double-action trigger signals and independent multiple recording systems are used for avoidance of miss-triggering of data acquisition system.

(2) Developing Analytical Models

Analytical Model of the Fuselage Section

- Nonlinear dynamic analysis code : LS-DYNA3D
- Optimal numerical model of full-scale fuselage structures for reasonable precision of estimation and computational efficiency

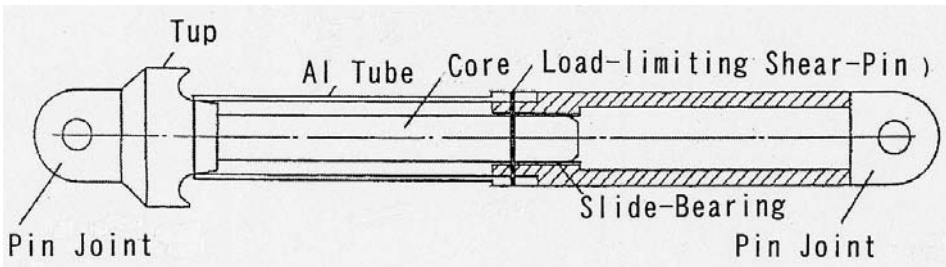
FEM Analysis of Seat/Occupant/Floor System

- Dynamic test of seats for obtaining baseline data
-Correlation between finite element analysis and drop test

3. Effective Structures for Impact Energy Absorption

* Structural concept : Analytical and experimental study on fuselage structures

* Application of shock-absorbing structural elements to seats or fuselage structures



An example : Thin-walled tube element for axial compression