Full-Scale Crash Test of a Civil Helicopter

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Overview of Crash Test

- Second crash test of a helicopter in Japan
- Crash trajectory determined by guided rail method
- Cooperation with Mitsubishi Heavy Industries, Ltd. (MHI)
- Test on February 25, 2004 at Aerospace Center Aerodrome Branch of JAXA
Overview Video Picture of the Test
Objective

1. Determine the impact response of a helicopter to a full scale crash test
2. Validate helicopter analytical computer model against actual crash test data
3. Develop guided rail method to conduct crash testing
4. Evaluate performance of NAL developed pilot seat shock-absorbing device
A prototype of Mitsubishi MH2000A multi-purpose helicopter

- Total weight: 4,500 kg (10,000 lbs)
- Number of seats: (pilots 2, passengers 8)

Anthropomorphic Test Dummies
(7 Hybrid II ATDs, 1 Hybrid III ATD)
Facility Overview

- Crane
- Hook
- Trolley
- Trolley rollers
- I-beam rail
- I-beam support
- I-beam fulcrum
- Tiedown cable
- Concrete surface
- Test height - 9m

Test height - 9m
Figure: Comparison of Impact Velocity Envelope

- Civil Rotorcraft 95th Percentile Evaluated Accidents Boundary Line
- Civil Rotorcraft 95th Percentile Survivable Boundary Line
- Planned Test Condition
- Actual Test Condition
- Previous BK117 Test (1985)

Test Conditions

Vertical Impact Velocity (m/s) vs. Longitudinal Impact Velocity (m/s)
Velocity components (Planned)
Vertical : 7.9 m/s (26 ft/sec)
Longitudinal : 10.5 m/s (34 ft/sec)
(derived from the vertical component of the dynamic seat test condition and an approach angle of 37°)

Pitch angle
+4°
(Half of 8° angle which a line from the skid to the tail makes with the horizontal)

Test article slides down I-beam (14.8 m), drops on concrete surface
Beam angle : 36°
Height of test : 9m
Height of free fall : 0.3m (from end of beam)
Data Acquisition

- 140 accelerometers
- 45 strain gauges
- 6 load of seat belts
- 8 high-speed cameras
- 6 standard video cameras

Signal distribution device

Two onboard data acquisition systems
Two onboard high-speed cameras

Ground data acquisition System

Four high-speed cameras

Trigger device

Trigger
Sensor Installation

Main Frame

STA4735

STA5455

Accelerometer (140 DOF in total)

Strain Gauge (45 DOF in total)
Pretest Overview of Onboard Measurement Devices

Onboard data acquisition systems

Onboard high-speed camera
On-board High Speed Camera Position

Standard MH2000 seat
Pilot seat with JAXA energy absorbing device
High speed camera
Four Meter High Mock-up Test

Mock-up test:

2m → 4m → 5m Step-up verification of our test method
Video Picture of the Test from Backside

Offered by MHI
High-Speed Video Picture of the Test

Offered by MHI
Overall Post-test
Test Results from Analysis of High-Speed Camera Pictures

- Impact velocity components
  - Vertical: Planned 7.9 m/s  Actual 7.5 m/s  ( - 5.1% error)
  - Horizontal: Planned 10.5 m/s  Actual 9.6 m/s  ( - 8.6% error)
- Pitch angle: Planned +4°  Actual +2.7°
Vertical Velocity

Large differences between C.G. and TGB

Maximum vertical velocity
Horizontal Velocity

- FWD Upper Cabin
- Near C.G.
- Tail Gear Box

Large difference between C.G. and FWD upper cabin
Incline of almost 0 degree
Gently-sloping portion
Energy Dissipation

- Energy Dissipation due to Friction
- Absorbing Energy by Article
- Mechanical Energy of Article
Sample Accelerations

$T_0 = \text{landing skid impact.}$
Standard MH2000 Seat

Wire bender energy absorber
JAXA Energy Absorbing Device

Pretest
Did not function properly due to off-axis loading

Post-test
Deformation of Structure after Impact

Before Test
After Test
Cabin Deformation of STA 2725 Cross Section

Crash Distances of the Cabin

* Cabin Ceiling Height : 19~50mm
* Cabin Ceiling to L/H Side 26~30mm
* Cabin Ceiling to FWD Side :
  -8mm(R/H)~9mm(L/H)mm

Note: Outlines of post-crash are drawn exaggeratedly.
Cabin Deformation of STA 4125 Cross Section

Crash Distances of the Cabin

* Cabin Ceiling Height: -22~-23mm
* Cabin Ceiling to L/H Side: 23~-24mm
* Cabin Ceiling to FWD Side: 8mm(R/H)~-13mm (L/H)mm

Note: Outlines of post-crash are drawn exaggeratedly.
Schematics of Rear View of Cabin
Cross Section Near STA 4010

Impact surface (Concrete)
Cabin Floor

Before Test
After Test

L/H
R/H

770
471
498
770

Impact surface (Concrete)
Overview of Cabin Deformation

L/H

STA2725

STA4125

Cabin Floor

R/H

Skid (FWD cross beam)

Skid (L/H)

Skid (R/H)
Conclusion

- Able to successfully acquire real time helicopter crash data for verifying full-scale helicopter analytical computer model and for being utilized as reference for new helicopter design
- Able to utilize guided rail method to conduct a crash test