Comparison Virtual Landing Gear Drop Test for Commuter Aircraft Utilize MSC ADAMS And Solidworks Motion Analysis

Dony Hidayat¹²*, Jos Istiyanto³ and Danardono Agus Sumarsono³

¹) Aeronautics Technology Center, National Institute of Aeronautics and Space (LAPAN), Indonesia
²) Department of Mechanical, Faculty of Engineering, Universitas Indonesia, Indonesia

*dony.hidayat@lapan.go.id

Abstract. Loads at main landing gear while touchdown impact is function of aircraft weight and ground reaction load factor. In regulation states ground reaction load factor at \( v_{sink} = 3.05 \text{ m/s} \) is below 3. Contact/impact force from simulation using MSC ADAMS is 94680 N, while using Solidworks Motion Analysis is 97691 N. The difference between MSC ADAMS and Solidworks Motion Analysis is 3.08%. The ground reaction load factor in MSC ADAMS is 2.78 while in Solidworks Motion Analysis is 2.87.

1. Introduction

The design process of 19 passengers commuter airplane for flight in remote areas has reached the testing stage of its components. The requirements for this test refer to CASR (Civil Aviation Safety Regulation) Part 23 issued by the Ministry of Transportation.

Loads that occur in the main landing gear when touchdown impact is a function of the aircraft weight multiplied by the ground reaction load factor. In CASR Part 23.473 (Ground Load Conditions and Assumptions) stated that the value of ground reaction load factor is between 2 s / d 2.67 and should be proved by LGDT [1].

Computer Aided Engineering (CAE) developed rapidly in recent decades, one of which is the Multi-Body Simulation (MBS). Many MBS programs capable of automatic generation and integration of the differential equations of motion have been developed, namely DAP, MSC ADAMS, COMPAMM, and SIMPACK [2]. MBS provides very fast tools for modeling and simulating an assembly consisting of several complex components. This is one of the advantages of MBS rather than finite element analysis (FEA) that tends to partially separate components on an assembly that moves and interacts with each other [3].

Romeo et al [4] has developed a methodology for simulating landing gear drop tests using MSC ADAMS and comparing simulation with experimental testing. Krason and Malachowski [5] introduced a methodology for evaluating several landing gear models and numerical research on a complete landing
gear system. Fu et al [6] modeled a LGDT using the SimMechanics module approach on Matlab/Simulink.

Sundry studies have been conducted to create a simulated LGDT using a MBS approach. However, comparison of performance (result of simulation, ease of set up simulation and speed at simulation) some MBS software in the same case is very interesting to be examined, therefore conducted a study on the comparison of MSC ADAM and Solidworks motion analysis.

2. Method
Experimental test of landing gear drop test was conducted based on regulation from Ministry of Transportation which is contained in Civil Aviation Safety Regulation (CABR) Part 23 [1]. The LGDT testing prerequisites are in CASR 23.473, CASR 23723, CASR 23725, CASR 23726 and CASR 23.727 [7].

Initial condition of simulations using MSC ADAMS and Solidworks Motion Analysis comply to DRO (Design Requirement and Objective) condition of the 19 passenger commuter aircraft. Simulation conditions (vLGDT) are shown in Table 1 below.

| No. | Conditions | Load (kg) | Vsink (m/s) | High estimation (mm) |
|-----|------------|-----------|-------------|----------------------|
| 1   | DRO        | 3470      | 3.05        | 470                  |

Simulation input for contact is stiffness (k), force exponent (e), damping (c_{max}) and penetration depth (d). Whilst simulation input for rubber damper only stiffness coefficient and damping coefficient. Time step simulation for this case is 0.001 seconds.

3. Results and Discussions
To compare MSC ADAMS and Solidworks Motion Analysis, accordingly conduct simulated with 3D rigid model approach.

Rubber damper on the main landing gear is a function of stiffness (k) and damping (c_{max}), whereas the tire is a function of stiffness (k), damping (c_{max}), force exponent (e) and penetration depth (d) as shown in Fig. 1 above. 3D models built using CAD software afterward exported to MSC ADAMS and Solidworks Motion Analysis as shown in Figure 2.
Rubber damper stiffness \( k \) varied from 1500 - 12000 N/mm, whereas the damping \( c_{\text{max}} \) is 1% of the stiffness value [8]. For tire stiffness parameters use data from Dunlop tire vendor [9], force exponent \( e \) for rubber \( \approx 1.1 \) and penetration depth \( d = 1.0e^{-4} \) m [10, 11].

Comparison of simulation results using MSC ADAMS and Solidworks Motion Analysis with rubber damper stiffness 2000 N/mm and 65 psi tire pressure shown in Figure 3 below. Vsink simulation results from MSC ADAMS of 3.03 m/s, while Solidworks Motion Analysis of 3.05 m/s.

From the simulation that has been done using MSC ADAMS and Solidworks Motion Analysis software, to get the value of ground reaction load factor below 3 then the stiffness of rubber damper ranged from 1900 N/mm to 2100 N/mm and tire pressure between 60 psi to 65 Psi as shown in Figure 4 and Figure 5 below. From the figure also obtained that the stiffness of rubber damper has non linear function to ground reaction load factor. Significant changes occurred in the stiffness value of rubber damper 2000 N/mm to 3000 N/mm. Stiffness function above 3000 N/mm tends to linear, but the value of ground reaction load factor is above 4. Virtual landing gear drop test of Partenavia AP.68 TP-300 [4] with fix landing gear configuration obtained ground reaction load factor 3.87 while experimental result of 3.9. This configuration only uses leaf spring and tire as damper. While on 19 passengers commuter airplane were added rubber block as a damper.
The ground reaction factor value at the pressure of the 55 psi tire is generally below the 60 psi and 65 psi pressure, but on the rubber damper stiffness of about 2000 N/mm, the ground reaction load factor value is not below 3 such as 60 psi and 65 psi tire pressures. The pressure of a 55 psi tire is not recommended for this commuter aircraft.

**Figure 4.** Effect of rubber damper stiffness on ground reaction load factor with tire pressure variation using Solidworks Motion Analysis software

**Figure 5.** Effect of rubber damper stiffness on ground reaction load factor with tire pressure variation using MSC ADAMS
Contact/impact force simulation results using MSC ADAMS software of 94680 N, while using Solidworks Motion Analysis of 97691 N as shown in Figure 8 below. The difference in simulation results between the two software is 3.08%. The ground reaction load factor of MSC ADAMS software is 2.78 while in Solidworks Motion Analysis is 2.87.

In the simulation results there is a difference in contact/impact force value between the two software. There are several factors that cause these differences, including: the difference between the assembly process of both software and the placement of the spring model. In MSC ADAMS, component assembly and spring modeling processes are still conservative like most early 2000s software, while Solidworks Motion Analysis is more detailed with accurate constraints such as modern CAD software.
In Figure 8, there is also a force drop phenomenon at 0.6 second, the contact/impact force drops suddenly and then rises again in seconds to 0.7. This phenomenon is caused by the load that occurs towards the y-axis (Fig 1) is not able to be retained by the wheel. This phenomenon is caused due to slip on the wheel toward the y-axis.

4. Conclusions or Concluding Remarks

Virtual Landing Gear Dropt Test (vLGDT) was successfully created using MSC ADAMS and Solidworks Motion Analysis software. To obtain the ground reaction load factor value below 3 then the stiffness of rubber damper ranges from 1900 N/mm up to 2100 N/mm. Tires use a stiffness of 590 N/mm or identical to a 65 psi tire pressure.

Simulation using 3D approach with MSC ADAMS, contact/impact force obtained of 73650 N while with Solidworks Motion Analysis of 74468 N with the difference between two software 1.1%. From the ease in the set up simulation, Solidworks Motion Analysis is easier to use than MSC ADAMS while from the speed at simulation, both software is relatively the same.

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