NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Aviation Engineering Division
Washington, DC 20594
June 21, 2007

STRUCTURES

STUDY

NTSB Case No.: ANC05LA123

1.0 ACCIDENT:

1.1 Description

Location:	Palmer, Alaska
Date:	August 12, 2005
Time:	1500 Local Time
Airplane:	Van's Aircraft RV-9A, N63EB

1.2 Summary

On August 12, 2005, about 1500 Alaska daylight time, a tricycle gear-equipped experimental Brabandt RV-9A airplane, N63EB, sustained substantial damage when it nosed over during the landing roll at a private airstrip, about 6 miles west of Palmer, Alaska. The airplane was constructed in part from a kit sold by Vans's Aircraft. The airplane was being operated as a visual flight rules (VFR) local area personal flight under Title 14, CFR Part 91, when the accident occurred. The pilot operated the airplane. The commercial certificated pilot, the sole occupant, received minor injuries. Visual meteorological conditions prevailed. The flight originated at the Palmer Airport about 1450, and no flight plan was filed.

Staff has examined data for 18 recent accidents and one incident in which Vans Aircraft series RV-6A, RV-7A, RV-8A, or RV-9A airplanes have become inverted during landing. Several involved hard landings such as hard touchdowns, bounced landings (six), or landing in a slip. Several others involved off-field landings in rough terrain, hitting a ditch, or going down an embankment.

Four of the accidents and one incident involved a touchdown and the start of a rollout on an unpaved runway, followed by the nose gear folding back. The airplanes would then slide for varying distances before nosing over. Staff also examined data for four additional incidents in which the nose gear collapse during taxi but the airplane did not nose over. These nine accidents and incidents occurred on various unpaved surfaces including gravel, turf, soft turf, hard surface with "washboard" bumps, and slight depressions. These nine cases involve the nose gear fork digging into the ground and the nose gear bending aft.

Of the five cases noted above that involved a touchdown at the start of a rollout on and unpaved runway, one was equipped with a Lycoming O-320 engine and, three with Lycoming O-360 engines, and one with an unknown engine type. Of the four additional incidents that involved a nose gear collapse during taxi, two were equipped with Lycoming O-320 engines, one with a Lycoming O-360 engine, and another with a Subaru engine. Of the six accidents that involved a bounced landing, one was equipped with a Lycoming O-320 engine, two with Lycoming O-360 engines, two with Subaru engine engines, and one unknown.

In the five nose-over cases noted above, the nose gear forks exhibited evidence of contact with the ground (grass and soil were found imbedded in the front of the fork). The propeller spinners were found to be compressed aft, and the engine inlets were undisturbed. The nose gear struts just above the fork had a smooth radius bend in the aft direction, and, in some cases, there was a sharper bend at the strut-to-engine mount attachment point. Additionally, in some of the cases, the paint was worn off of the front of the strut, about 9 to 15 inches above the fork. Consistent with the worn paint, there was a long, narrow furrow through the ground or grass with a soil disruption at the end of the narrow ground scar. In all of these cases, the airplane was found inverted a short distance beyond the ground scar. The worn paint and corresponding narrow ground scars are evidence that the strut was sufficiently bent to allow the forward part of the strut to drag on the ground. The narrow ground scars varied in length but the distance from the disruption to the inverted airplane in each case is only a few feet. In two cases, the nose gear fairings were available for examination and had scrapes on the bottom. Many exhibited cracking in the forward portion. The cracking is consistent in shape and position with the front portion of the nose gear fork.

2.0 DETAILS of the STUDY:

2.1 Finite Element Analysis (FEA)

The NTSB's FEA of the nose gear strut and fork incorporated drawings and material properties provided by Van's Aircraft.

The strut model was pinned at the attachment end consistent with the engine mount. Loads and moments were simulated at the axel. Upward loads were used to simulate landing loads. Aftward loads were used to simulate the nose gear fork digging into the ground. Moments were applied at the axel to simulate a tire being grabbed by the nose gear fairing.

The FEA revealed that upward loads at the axel caused the strut to deflect in an upward direction as expected, and the moment produced because of the aft offset of the axel from the front of the strut did not significantly rotate the fork in a clockwise direction, when viewed from the right side.

The FEA also revealed that the aft force required to deform the strut sufficiently to produce contact with the forward side of the gear to the surface was between 1,000 and 2,000 pounds, depending on the amount of the rearward deflection used in the analysis. The FEA also revealed that the nose wheel fairing grabbing the tire is not a significant contributor to the fork's clockwise rotation, when viewed from the right side. Seizing the tire does increase the aft loading on the strut, but its affect was shown to be insignificant. A significant amount of stored energy in the nose gear strut during the event was revealed by the FEA. Once the forward momentum of the airplane is reduced to some critical value, the nose gear will spring back toward its original shape, less the permanent deformation. The stored energy in the strut would tend to aid in lifting or rotating the airplane during the nose over.

The scrapes on the bottom of the nose wheel fairings indicate that they were relatively level when making contact with the ground, consistent with the FEA. The upward loads on the strut do not appear to account for the nose gear fork contacting the ground. The FEA indicates that the tire either, or in combination, has to penetrate the surface or compress sufficiently to allow the fork to come into contact with the surface. Increased engine weight over the nose gear, low tire pressure, and runway surface composition combined with the possibility of dynamic loads can cause, or combine to cause the bottom front corner of the fork to make contact with the ground. Once the fork contacts the ground the aft forces at the fork become immediately significant. The strut then begins bending aft and continues to rotate downward until it becomes fully imbedded in the runway surface. As the strut bends and the fork moves aft, the airplane's nose rotates downward allowing the portion of the strut just above the fork to produce the previously mentioned ground scars and scraped paint.

2.2 Tire Pressure Analysis

The distance from the bottom of an uncompressed, properly inflated tire to the bottom of the landing gear strut is 4.0 inches. Therefore, any combination of tire compression and ground penetration that adds up to 4.0 inches will result in the strut/fork combination making contact with the runway surface.

The weight on the nose gear at empty weight is about 370 pounds. At 30 pounds per square inch (psi) tire pressure, a tire footprint of about 12.3 square inches is required. The tire is about 3.7 inches wide at the tread, thus the flat spot on the tire would be about 3.3 inches when viewed from the side. At a static condition, the strut would now be about 3.7 inches from the ground. At twice the static load (740 pounds), the flat spot would be about 6.7 inches when viewed from the side. Because of the tire radius, the compression is significantly greater to obtain twice the tire footprint. In this case, the strut would be 2.9 inches from the ground. At three times the load (1,110 pounds), the ground clearance would be 1.4 inches.

At 20 psi, each footprint would be 50% greater for each load factor. Starting at a load factor of one, the strut to ground clearance is 3.4 inches. At twice the load factor the ground clearance is reduced to only 0.8 inches, by calculation.

The nose gear tire pressure is not known for any of the accidents or incidents cited in this study. In addition, the bottom of the nose wheel is below the bottom edge of the strut and fork and would provide some resistance to ground penetration.

2.3 Engine Weight

A heavy engine/propeller combination will add to the tire compression. Seventy extra pounds has little effect on the ground clearance for nominal conditions at 30 psi. However, at twice the static load factor, ground clearance would be reduced to 2.3 inches. At twice the static load factor and 22 psi, the strut would contact with the ground, by calculation.

2.4 Runway Condition

On soft runway surfaces the tire will tend to penetrate the ground using a portion of the 4-inch ground clearance. For example, if the tire would tend to penetrate 2 inches into the ground, ½ of the available fork/strut clearance is lost.

2.5 Dynamic Considerations

Small ridges of only an inch or less can be significant if the clearance is already reduced due to tire pressure. Washboarding can create a dynamic loading that will dramatically increase the load factor. Low tire pressure and extra weight above the nose gear will exacerbate this condition allowing the fork to come into contact with the ground.

2.6 Additional Events

Several cases of the nose gear moving far aft or collapsing while the airplanes were traveling at taxi speeds have also been reported; however each case involved additional unique circumstances. In one case, the nose gear dropped into a tie-down depression allowing the fork to come into contact with the edge of the depression as was evidenced by the witness marks on the fairing. In another case, it was reported that the airplane was moving very slow and encountered a washboard or uneven runway surface creating a dynamic or bouncing affect allowing the ground clearance between the fork and runway surface to be minimized allowing the fork to make contact with the ground. As noted earlier, the tire pressure is unknown in these cases.

3.0 SUMMARY:

Once the strut and fork have contacted the ground, the strut will bend aft. The aft loading from the dragging fork and the spring-back reaction of the strut produces an overturning moment and lifting action that may result in the airplane overturning without any additional forces acting on the airplane. The aerodynamic load on the horizontal stabilizer may prevent the airplane from overturning while the airspeed is greater than some critical yet presumably low airspeed. This could provide the circumstances for varying lengths of the observed ground scars, in that the airplane needs to slow down to a critical low airspeed regardless of the airspeed at the start of the event. At low airspeeds, the aerodynamic loads on the horizontal stabilizer lessen to the point that the tail can now start to rise allowing the airplane to rotate about the nose gear and become inverted. This could provide the result of the relatively constant distance from the end of the ground scars to the final resting place of the inverted airplanes. In addition, as the airplane starts to overturn, the stored energy in the strut tends to raise the airplane vertically on the propeller spinners and leaving the engine inlets undisturbed.

Several factors may combine to reduce the nominal ground clearance. Low tire pressure, heavier engine weights, and runway condition can each increase the risk of the fork contacting the runway surface. It should be noted that the manufacturer has redesigned the nose gear fork to provide an extra inch of ground clearance.

The FEA shows that the nose gear strut has sufficient strength to perform its intended function. In all cases, the landing gear struts and forks were making contact with the ground and initiating the damage sequence.

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