Jabiru UL-450, G-JUDD

AAIB Bulletin No: 10/2002	**Ref: EW/G2002/04/14**	**Category: 1.3**
Aircraft Type and Registration:	Jabiru UL-450, G-JUDD	
No & Type of Engines:	1 Jabiru Aircraft PTY 2200A piston engine	
Year of Manufacture:	2000	
Date & Time (UTC):	19 April 2002 at 0815 hrs	
Location:	Lark Engine Farm House, Ely, Cambridgeshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to propeller, wing tip and landing gear	
Commander's Licence:	Private Pilots Licence (Microlights)	
Commander's Age:	51 years	
Commander's Flying Experience:	689 hours (of which 200 were on type)	
	Last 90 days - 45 hours	
	Last 28 days - 26 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot, metallurgical examination of landing gear bolts and other enquiries by AAIB	

Description of accident

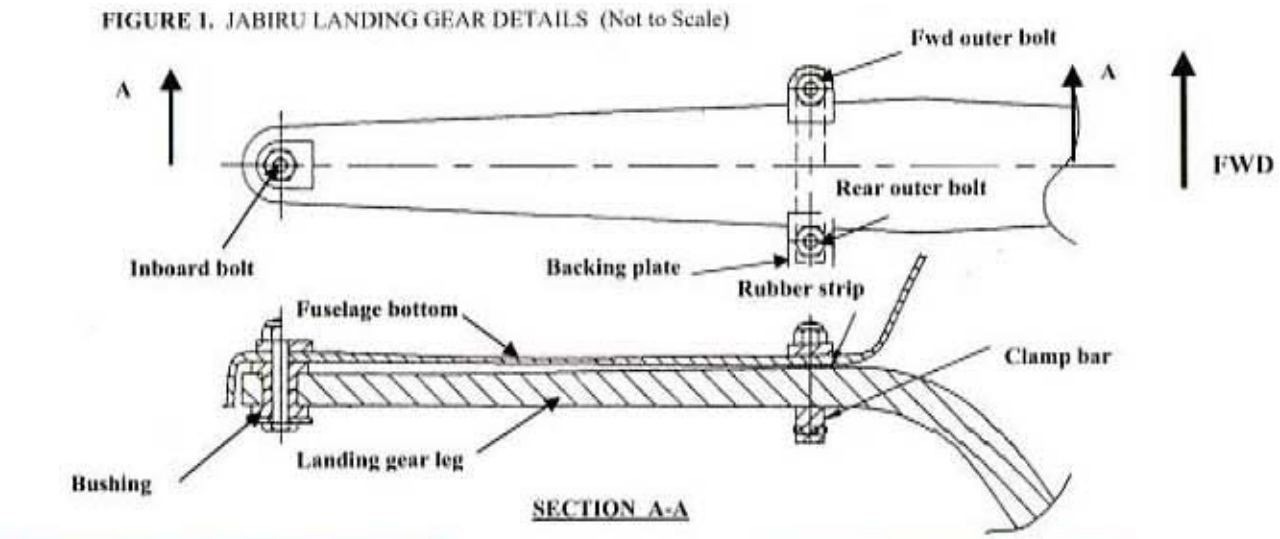
The aircraft was taxiing along a grass runway prior to take-off when there was a loud cracking noise followed by the immediate collapse, in a forwards direction, of the left main landing gear. This caused the aircraft to slew to the left and resulted in the nose wheel striking the raised edge of an adjacent road. The pilot and passenger were uninjured, but the aircraft sustained damage to the left wing tip, propeller and nose landing gear in addition to the left main landing gear.

Description of landing gear

The main landing gear legs on this type of aircraft are of composite construction, and they are attached to the underside of the glassfibre fuselage by means of three bolts. Figure 1 below shows the general layout. It can be seen that the inboard bolt passes through a bushing. The outboard bolts are unbushed, and pass through a protective rubber strip and a clamp bar, located respectively on the upper and lower side of the leg. The diagram shows the bolts to be all the same length (AN5-24A), although a separate parts list within the assembly manual calls up three different bolts. In

practice, each bolt may have to be individually selected to take account of variations in thickness of the fuselage underside.

Figure 1: Jabiru landing gear details.



(Photo: H T Consultants)
FIGURE 1a. Bolts as received

(Photo: H T Consultants)
FIGURE 1b. Underside of fractured bolt head showing lack of damage to plating. Thrust face of associated nut showed similar lack of damage

Examination of landing gear bolts

The three bolts from the left main landing gear were submitted to the AAIB for examination. One had failed approximately 20 mm from the underside of the head and the remaining two were intact but bent. One of the bent bolts was slightly shorter than the other two. The geometry of the landing gear is such that the landing shock loads tend to deflect the legs forwards; this imparts the greatest stress on the rearmost of the outboard bolts and it was this one that failed in the case of G-JUDD. The bolts were unlabelled on receipt at the AAIB, although it was assumed that the one of the same length as the failed item had been in the forward outer position.

All three bolts were subjected to a metallurgical analysis. It was apparent that they had been cadmium plated and chromate passivated. Two of the bolts (including the failed bolt) were embossed with the letters CXS on the heads. The third bolt bore only the letter X. According to the aircraft kit manufacturer's hardware supplier, 'X' denotes an AN bolt (an American aircraft quality standard), whilst 'CS' is the manufacturer's identifier.

The examination revealed that the bolt failure had occurred as a result of a simple bending fatigue mechanism, with multiple initiation sites. There was evidence, in the form of a relative lack of

smearing of the cadmium plating on the thrust face of the nut and the underside of the bolt head, which suggested that the assembly had not been fully tightened. This would have reduced the bolt's fatigue resistance. The condition of the forward outer bolt was the same, although the inboard bolt appeared to have been adequately tightened. It was noted that the threaded end of the inboard bolt contained at least three fatigue cracks in the thread roots. The UK agent for the aircraft kit manufacturer examined the aircraft and formed the opinion that one or more of the bolts may have been insufficiently tight, allowing movement of the gear leg within the clamp. He additionally noted that the failed bolt had been installed upside down, although it seems unlikely that this had any influence on the failure. The owner stated that he had tightened the bolts approximately 20 flying hours before the accident, and previously at the renewal of the annual Permit to Fly.

AN bolts are widely used in general aviation and the examination indicated that these had been manufactured from drawn bar stock, with rolled threads and forged heads. The shanks had not been ground; this process is usually only carried out on close tolerance bolts. There were a number of corrosion pits on the shanks and it was evident that these had been plated over. The presence of 'old' areas of plating, together with evidence of 'dirt' under other plated areas, indicated that the bolts could have been incompletely stripped and re-plated up to three times; ie they were reclaimed items.

Finally, the failed bolt was sectioned, and microhardness tests were conducted on the core material. This showed that the hardness reduced from the centre to the sub-surface, reflecting a reduction in the tensile strength of the steel from 60 tonf/sq in to around 48 tonf/sq in. These results indicated that the surface layer of the material had been decarburised during final heat treatment after manufacture.

For comparative purposes, a new bolt, obtained from the UK importer of the aircraft kits, was also subjected to a metallurgical examination. It was evident that this bolt, which also had the letters CXS embossed on the head, had not been previously used or re-plated. Hardness tests showed that no significant decarburising had occurred at the surface and that the bolt had been manufactured from steel with a nominal tensile strength of 55 tonf/sq in. Although this figure is lower than that for the core material of the failed bolt, it nevertheless falls within the limits specified for this grade of material.

Bolt supplier's comments

The aircraft owner stated that the bolts used in construction of the aircraft were those supplied with the kit. The kit manufacturer, which is based in Australia, uses a local aviation hardware supplier approved by the Civil Aviation Authority of Australia. They stated that they had never knowingly sold bolts which have been remanufactured and have never stocked bolts of commercial quality. They also pointed out that the AN series of bolts is the lowest of the aircraft quality standards, implying that some variability can be expected.

Summary and discussion

G-JUDD had achieved in excess of 200 hours at the time of the accident, which reflected a relatively high annual utilisation for this type of aircraft. Although the owner stated that he had periodically tightened the landing gear bolts, the presence of a protective rubber strip in the clamp assembly, through which the outboard bolts passed, would not have helped to retain assembly torque. Evidence of a lack of torque was provided by a comparative absence of damage to the thrust face of the nut and the underside of the bolt head. In addition, it was reported that the taxiing areas were uneven, thereby possibly increasing the peak loads imparted to the landing gear mountings.

These factors could have combined to produce conditions conducive to a simple bending fatigue mechanism.

The metallurgical examination indicated that the bolts from the aircraft were reworked items. Although this raises questions as to their origin, the fact that they had been reclaimed had no bearing on the bolt failure. The decarburised surface found on the failed bolt would have reduced the fatigue resistance; however this condition almost certainly occurred in the original manufacturing process, rather than the stripping/re-plating operation(s). Some variability in bolt quality is to be expected with the AN standard, and while the reduction in the microhardness at the surface may seem excessive, it is probable that the lack of assembly torque was the main factor that led to the failure.

The airworthiness aspects of this aircraft are the responsibility of the Popular Flying Association (PFA). They are currently considering a modification that introduces bushings in the outboard clamp assembly, similar to the inboard bolt installation. This would assist in achieving and maintaining satisfactory assembly torque within the clamp.