Test Report Simulated landing with a defect landing gear on AGAT

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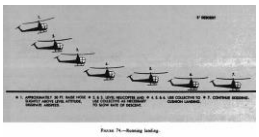
Content

Test subject and reason for testing

The reason for testing the AGAT (Aviation Grade Artificial Turf)

AGAT has been installed in airports since 1998 and a significant number of helipad landing pads all over Europe the last 8 years. So far, only undocumented landing test have been made with helicopters to confirm any landing risks, such as dynamic rollover due to a stuck landing gear in the installation, as a result of the layout/design of the AGAT or a damaged landing gear structure.



Full down landings with an AS350 (full weight) was performed on a newly installed AGAT installation in Nepal, without any challenges for the pilot and with no damage to the AGAT installation.

Evergreen Aviation has asked Flight Test Engineering ApS to perform a simulated landing with a defect landing gear on AGAT to show any risks of landing with helicopters during normal operation including full down auto-rotations even with a defect skid for small/medium size helicopters.

Helicopter landings with forward speed is performed in several situations. During education and type ratings for different helicopter types to train skills in case of hydraulic or engine failure.

Helicopters may even without the knowledge of the pilot have a damaged skid (skid-plate) or mounting bolts which can have a tendency to grab the surface material during a forced landing in an unfortunate manner, increasing the risk of a sideway torque to the helicopter and end in a rollover, or if in direction of landing in a nose over landing.

Test subject and reason for testing

The test subject (base) used was the 8 year old AGAT installation at EKMD (Maanedalen).

The tested area and product: 8 year old helipad AGAT installation located in Maanedalen, Hoersholm (EKMD), Denmark. The AGAT is as a standard installation, on gravel. Too sides of the AGAT was not installed as normally fixed sides, but just layed out on the gravel, with the 25 kg / square meter sand infill on top. This had no influence on the test.

The test equipment was a Volvo Valp installed with several different devises to simulate a damaged landing skid.

Picture of different devises installed on the Volvo Valp to simulate a damaged helicopter landing gear.

The rather violent looking test devises was developed after use of more landing gear-like used test-parts, as they had zero effect on the AGAT during the first test runs, even with full weight of the front part of the Volvo lifting the wheels to provide full weight pressure on the test subject toward the impact zone and attempt to damage and eventually penetrate the AGAT.

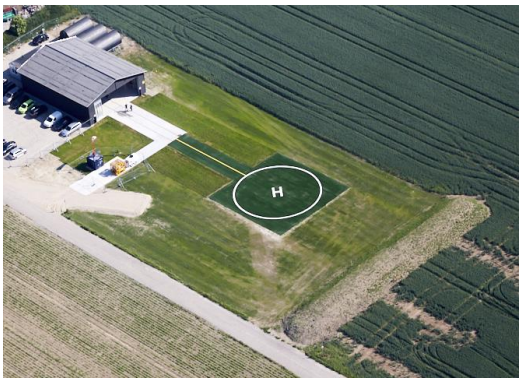
The AGAT installation is of the type described in the Advisory Circular AC No: 150/5370-15B. This Advisory Circular (AC) provides guidance for the product specifications, planning, design, installation, and maintenance of aviation grade artificial turf in areas adjacent to the

Test subject and reason for testing

operational areas of an airport. There is only one type of aviation grade artificial turf design listed in the advisory circular and Evergreen Aviation use these specifications as the design criteria during production from the manufacturing-vendors. Today Evergreen Aviation primary use an European and a UK AGAT a manufacture, both companies with years of experience (one since 1983) within artificial/synthetic grass, especially for football fields. The European company has since 2000 been ISO 9001 certified.

The AGAT has been used for helicopter landings sites for years and for helicopters from small to medium size on a regular basis.

The latest installation installed by Evergreen Aviation has been at a hospital in Aabenraa and for a commercial helicopter company at Roedvig. The Roedvig installation is daily used and has within the first 2 months accumulated 350 operations and expect within a year to reach close to 3000 operations.



Picture of Roedvig installation 2018.

The testing was performed to show if the simulated landings performed with a defect landing gear system, where the wear pads have split due to wear, would have an effect on the AGAT and be a safety factor for the helicopter, crew and/or surroundings.

Test subject and reason for testing

Simulated defect wear pads or the bolts to hold the wear pads is part of the test to show the reaction of the AGAT during forced landings.

Physical testing – test one

TEST ONE

The first test was performed to simulate a defect landing gear, with bolts and slightly damaged “wear-pad like” metal parts. The test showed however no effect on the AGAT and modified more violent devises were hereafter manufactured to generate an effect on the AGAT.

The plan was to keep increasing pressure / design that would penetrate the straw, sand and fabric of the AGAT to see the effect of the rupture and to see the way the fabric behave/fold or split.

Even with several runs in the same path, the setup had none or minor effect on the AGAT installation. Due to the heat generated of the friction and the straight edge of the metal test part, left minor change to a small line in the AGAT, where straws had been cut/pulled apart due to friction. No rupture of the AGAT installation was seen. The first 4 pictures below show the first set of runs and the next 4 pictures show the result with maximum pressure applied vertically after several runs.




First test layout of simulated damaged wear-pad and result on the AGAT

TEST ONE continued

Additional pictures of the first test layout of simulated damaged wear-pad and result on the AGAT.

Severity						
	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Probabililty				

Test one risk factor for helicopter and surroundings. Severity 1, Probability 2-3 during full down auto rotation training.

TEST TWO

The second test was performed with a modification of the test two setup, to stress the AGAT installation with a modification of the same part, cut in 45 deg to generate a sharp object direct into the direction of the “impact” direction.
Result was the same as for test one, only a trail of removed straws, but no penetration, only a sliding run on top of the infill sand which cover approximately 2 cm of the 5 cm long straws.




Pictures of the second test layout of sharpened wear-pad and result on the AGAT.

Severity						
	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Probabililty				

Test two risk factor for helicopter and surroundings. Severity 1, Probability 2-3 during full down auto rotation training.

TEST THREE

Test three was performed to assure rupture of the AGAT.
The test was performed with a “dull” vertical metal part to determine the possibility to penetrate the sand and AGAT fabric and the result of the rupture over a longer distance. With an estimated 750-1000 kg vertical pressure, the pulled vertical metal part penetrated the installation fully, but left the installation in its position, just leaving a sliced installation as if it had been cut with a sharp knife.

Pictures of the third test layout of a vertical metal part.

Severity						
	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Probabililty				

Test three risk factor for helicopter and surroundings. Severity 2-3, Probability 1

Worst case

As the test during the first three test didn't show any medium to severe safety risks, an additionally separate test was performed to observe what would happen in the likelihood if the AGAT was penetrated and with high force was lifted and dragged/pushed to achieve a dangerous situation for the helicopter and/or surroundings. From test three the fine line cut in the AGAT was opened by a tool and the test equipment was manually driven into the hole and from here high force was used to drive toward the unbroken AGAT. Only with high force from the Volvo Valp (low gearing low shift), further penetration of the AGAT was possible and the AGAT at the end of a longer run would raise approx. ¼-½ foot.

This could theoretically escalate letting the AGAT fold in front of the "helicopter", but seen from the test a more cutting reaction of the AGAT was more likely. With the force required to perform the test, a helicopter landing performing a rupturing and full penetration of the AGAT with this force, would during landing on normal soil/grass result in a very high twisting torque resulting in a ground roll. Such a landing would most likely be catastrophic on any surface.

Worst case testing, result after executing the test of a setup pushing force below the AGAT with full test equipment structure below the AGAT.

Severity						
	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Probabililty				

Worst case test risk factor for helicopter and surroundings. Severity 4, Probability 0-1

Safety / conclusion

From a safety point of view, the test performed to show if the simulated landings performed with a defect landing gear system, where the wear pads have split due to wear, would have an effect on the AGAT and be a safety factor for the helicopter, crew and/or surroundings, the following comments reveal:

1. AGAT seem to have a positive characteristic to withstand helicopter landings with defect undercarriage/landing gear even if the defect landing gear impact the AGAT with a dull or sharp part.

2. A tendency to skid over the AGAT infill/straw would normally be the result of a landing with a defect undercarriage/landing gear.

3. AGAT cannot be recommended for continues full down running landings with helicopters with skid pads due to the friction which in the long run would wear the AGAT and would require renewal of the AGAT before the expected life limit time of AGAT.

4. Further test for damaged heavy helicopter landing gear landings have to be performed to show any unforeseen behavior of the AGAT in case of full penetration and dragging situations. This was a limitation to the test equipment to perform continued pushing force to the AGAT. However, with the force applied during the performed test, the likely hood of a different outcome of further test will be doubtful as the rupture was the normal outcome of the test and not a folding AGAT which could danger the tail rotor or other parts of the helicopter or surroundings.

Remarks

The AGAT helipad was reestablished with a new part of AGAT glued to the remaining installation close to the H-symbol in the middle of the installation. See the picture below and note the slightly difference in color due to the direction of the straw and the fading due to normal UV influence.

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