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GENERAL-AVIATION PILOT REACTIONS TO AND OPINIONS ON GROOVED RUNWAYS

by George E. Cranston

Prepared by
FLIGHT SAFETY FOUNDATION
Arlington, Va.
for Langley Research Center

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FLIGHT SAFETY FOUNDATION

SUMMARY

A survey and analysis study of general-aviation pilot reaction to and opinions on grooved runways was conducted by the Flight Safety Foundation. At the time the survey was performed, there were four commercial airports in the continental United States that had at least one grooved runway. Personal interviews were conducted between general-aviation pilots and aviation safety specialists at these sites by using a prepared questionnaire to obtain the data discussed in this paper. The results of the survey and study show that the grooving of runways has a pronounced beneficial effect and provides increased safety for high-speed general-aviation aircraft operations by the reduction of hydroplaning and increasing braking action during wet runway conditions. Pilots operating light, low-speed aircraft did not generally realize these benefits as the runway lengths and widths at these airports far exceeded their operational requirements under all anticipated circumstances involved with this problem.

INTRODUCTION

The Flight Safety Foundation (FSF) conducted a survey analysis study (under NASA Contract No. NAS1-8668) to determine the reactions and opinions of general-aviation pilots to grooved runways. A total of 1444 persons were contacted - 1404 pilots, 36 FAA airport air traffic controllers, and 4 airport managers. Of the 1404 pilots, 700 of them gave insufficient information to be used in this survey. This paper is a report on the results of this survey. The term "general aviation" covers all flight operations and activities except those conducted by scheduled air carriers and the military. At the time of this survey there were four major civil airports that had one or more grooved runways. These airports were John F. Kennedy (JFK) International, Washington National, Chicago Midway, and Kansas City Municipal. The diverse groove designs and runway surface materials at these airports provided a comparative base for determining whether runway grooving was practical on the hard surfacing materials commonly used in this country. (See table I).

The objectives of the study were: First, to obtain pilot opinions on the effectiveness of runway grooving towards improving braking action, directional control, and visibility of the runway details from the approach during wet runway surface conditions; second, to obtain pilot reactions as to whether they consider runway grooving a safety contribution to their flight operations; and, third, to find out whether they recommend the application of grooves to all runways. Several additional areas related to operating on the grooves - noise and vibration, tire wear, and aircraft damage - were covered; all 704 pilots interviewed thought grooving had no detrimental effect on aircraft operation in these areas. The interviews were conducted by a team of two specialists at each airport by using a prepared questionnaire. The questions were of the type that could be answered with a simple yes or no or a number. This approach proved to be an asset to the team in that the desired survey data could be obtained with little inconvenience to the busy pilots. A copy of the two-page questionnaire is included as Table II. Prior to embarking on the interview, campaign letters were sent to each airport manager, FAA area manager, and each fixed base operator at each of the four airports to solicit their support. This proved to be very helpful and contributed greatly to the success of the effort.

The program at the airport called for the team to visit the Airport Manager's office. The purpose of the survey was explained in detail and in discussions that followed with his staff, the technical and historical information concerning the runway grooving at the airport was gathered. The next step was to visit the FAA tower chief and arrange to interview as many controllers as he felt could provide useful inputs. The FAA personnel interviews involved two questions, the sole purpose of which was to establish a different source of information on the subject to reinforce the findings. The questions and the results are given in Tables III and IV.

The fixed-base, corporate, supplemental, and air-taxi operators were each visited and their pilots interviewed. Fixed-base operators were extremely cooperative in providing the team members with the use of their facilities for accomplishing the pilot interviews.

DISCUSSION

During the interview periods the initial attention was directed toward seeking the opinions and reactions of all pilots based at the airport. The rationale of this approach was that a better comparison could be realized from a pilot who operated consistently from the airport before and after the application of grooves. The probability of such a pilot

using the runway under wet or slushy conditions was also much greater than those of the transient. This group included local corporate, cargo, charter, air-taxi, commuter, flight training, business and private pilots. (See Figure 1, page 11.) In between and whenever available, transient pilots of all general-aviation categories were interviewed. The interviews would be terminated if the pilot could not answer the first two questions in the affirmative. This procedure was adopted to obtain only the best information from the available interviews rather than the largest total number. This theory was qualified in subsequent discussions with pilots who could not state they had knowingly experienced hydroplaning or poor braking, and, in addition, never heard of runway grooving. About 50 percent of the pilots contacted fell in this category with little or nothing to contribute to the survey.

JFK International Airport presented a peculiar problem in obtaining a cross section of general-aviation interviews as well as the predicted total number. The imposition of an unusually high landing fee base discouraged the use of JFK by all except supplemental carriers, air taxis, and some corporate activities. The air-taxi and commuter pilots, although highly experienced and knowledgeable on runway grooving, were unable to provide convincing information as to its beneficial effects because of the equipment they operated. Light twin-engine, single-engine, and STOL aircraft comprised the type equipment they operated. Braking was not usually required due to long runway length and aircraft performance. Occasionally pilots reported that crosswind conditions were more easily coped with on the grooved runway than on ungrooved runways, and some pilots reported more positive braking action on the grooves than that noticed on the taxiway after turnoff. A majority of pilots reported they had noticed no significant difference in seeing the runway markings from the approach during wet conditions. This was not a fair evaluation as most pilots stated they had not paid any particular attention to comparing the view wet or dry.

From the standpoint of actual experience and being able to relate the effect of runway grooving during wet runway conditions, the corporate jet pilots and the supplemental airline pilots provided the best information at each survey location. There is no doubt in the minds of these pilots that the grooving of hard-surfaced runways is a contribution to safer operations. (See Table V.) Their reactions to the interview on the subject was so enthusiastic that they would recite specific instances of accident prevention attributed to grooving.

While the team was on site at Kansas City during a heavy rain a pilot of a corporate jet was landing to the south and the first 2000 feet are not grooved. He intentionally touched down on the numbers and checked his brakes which were ineffective.

Having no reverse thrust he had just made up his mind to apply power and head for Mid-Continent International Airport when he heard the hum of the grooves. He tried the brakes and the effect was shocking. This pilot thought he had pulled the rubber off his main tires the grip was so strong. However, after his passengers departed he examined the tires and to his amazement they showed no excessive wear.

At Chicago Midway in two instances jet pilots enthusiastically discussed how they escaped from a certain overshoot accident. They both were fortunate enough to run onto the grooves 1000 feet from the fence. The braking action went from nothing to good so quickly that one pilot stated, "It almost put me through the windscreen." The runways are notoriously slick at Midway during wet conditions. With two runways to groove the procedure was to work on the runway that was inactive at the time. Grooving began at both ends working towards the middle. Consequently, the pilots' dilemma and remarks were understandable.

In discussions with airport managers and engineers the subject of grooving macadam versus concrete was raised. JFK International and Chicago-Midway Airports have concrete runways. Washington National Airport has macadam runways. Kansas City Municipal Airport has a combination of both concrete and macadam. The consensus of opinion is that at this date there is not much difference between the two surface materials grooved so far. Kansas City has concrete about 18 years old and macadam about four years old. The macadam had been thoroughly compacted and cured during the four years of use and took the grooving very well. After 18 months which included one winter, the grooving shows no deterioration. The concrete although satisfactory has shown some minor spalling and chipping.

At Washington National Airport the macadam was also cured well before grooving and is doing very well. In fact at the touchdown zones the impact of the heavy jets had moved the surface of the macadam so that the once straight cut grooves are now wavy. However, this did not destroy the function of the groove in any way. The grooves appear to purge themselves of debris and show little tendency toward clogging. Questions were raised about the effects that resealing concrete joints and patching would have on drainage, and the recommended cure time of each material before grooves should be cut. Since experience in these parameters is quite new, the answers were based on speculation with no serious problems predicted.

There were no complaints registered by pilots against the operational performance of the grooves, nor were there any derogatory comments on detrimental operational side effects from runway grooving. In most interviews the vibration and accompanying noise was described as a low level buzz or hum,

which was discernable, but far from annoying. Tire wear was reported as being normal with no perceptible increase in cuts or cracks. With the grooving of more runways more landings would be made on the grooves and what is now an acceptable circumstance could develop into a problem of excessive tire wear. The opinion of FSF is that the tire wear increase, if any, will still be acceptable and will be more than offset by the operational benefits.

At Kansas City Municipal Airport there were complaints from aircraft operators against the groove cutting procedure. It seems that the concrete dust and chips were not removed from the runway and arriving and departing traffic would raise clouds of dust when dry. When wet, debris would form a slurry that would splash into wheel and flap assemblage causing removal of lubricants, and clogging of micro switches and relays. One aircraft in particular on landing roll passed through a large puddle of the slurry and required considerable maintenance to remove the grit from critical areas.

One of the ancillary areas covered with the controllers was the size of spray patterns generating from the tires and reverse thrust during wet conditions. The purpose was to substantiate from another source how well the grooves did or did not drain standing water from the runway surface. In most instances the controllers felt there was some reduction in the amount of water spray since the grooving. At JFK the controller opinion was unusual by reason that the extreme distances involved made such observations virtually impossible. (See Table III.)

The other area covered was in runway traffic management during wet surface conditions. The majority of the controllers definitely felt that runway grooving aided most pilots in controlling their aircraft's landing roll with improved effectiveness and that the turnoff point from the wet grooved runway in most instances was identical to dry operations. This definitely improved runway traffic management and increased the acceptance rate over the original ungrooved surface.

CONCLUDING REMARKS

The opinions and reactions of the general-aviation pilots interviewed during the survey indicate a strong support in favor of the runway grooving program as a method of improving aircraft operations on wet or slushy runways. Although grooving the long runways has little beneficial effect for the light plane pilot, he is cognizant of the effect grooves would have on the short narrow strips which he more frequently uses and voiced his recommendations to consider grooving those strips. There were no detrimental effects noted to any type or size

aircraft operation on any of the four groove designs now in operation. Noise, vibration, or tire wear were not factors for complaint. The benefits derived from grooved runways extend beyond the cockpit inasmuch as shorter landing rolls and normal turnoffs on wet runways increased runway acceptance rates at a time when expeditious traffic handling is most needed. (See Appendix A for a complete correlation of answers against each question used in interviews.)

Runway grooving serves its intended purpose well and deserves consideration as a standard safety specification for all hard-surfaced runways.

TABLE I

AIRPORTS

	WASHINGTON NATIONAL	JFK	MIDWAY	KANSAS CITY
Runway grooved	18/36	4R/22L	31L/13R	18/36
Distance grooved, ft.	6870	8400	6500 6100	4000 (600 from 36 threshold or 2400 from 18 threshold.
Surface material	Macadam	Concrete	Concrete	Concrete and Macadam
Groove design	Rectangular groove 1/8" x 1/8" 1" apart	"V" groove 3/8" x 1/8" 1" apart	Rectangular groove 1/4" x 1/4" 1" apart	Rectangular groove 1/8" x 1/4" 1" apart

TABLE II

NASA GROOVED RUNWAY SURVEY

GENERAL AVIATION PILOT REACTION/OPINION QUESTIONNAIRE

DATE ____/____/ 1968
Month Day Year

AIRPORT JFK____ MDY____ DCA____ MKC____

RUNWAY DATA Direction____/____ Length_____ Ft.

Date Grooved____/___/____
Month Day Year

Type Groove_____

Distance Grooved_____

Runway Surface Material_____

ACTIVITY Supplemental Carrier Pleasure

Corporate Air Taxi/Charter

Business Training

Other_____

AIRCRAFT Jet____ Turbo-Prop____ Piston____

Number of Engines: 4____ 3____ 2____ 1____

Landing Gear: Tri-cycle____ Conventional____

Reverse Thrust: Yes____ No____

Anti-Skid Brakes: Yes____ No____

Nose Wheel Steering: Yes____ No____

TABLE II - Concluded

OPERATIONS

1. Have you experienced hydroplaning or poor braking on a wet or slushy runway?

   Yes_____No_____Wet_____Slushy_____No of times_____

2. Have you heard of Runway Grooving? Yes_____No_____

3. Are you aware that runway__/__is grooved? Yes_____No_____

4. How did you acquire that information?

   Tower Advisory_____Felt Vibration_____ Saw

   Grooves_____Noise_____Other_____

5. Have you landed on runway____/____prior to__/____/____

   How many times_____ Wet_____Day_____

6. Have you landed on runway___/___since it was grooved?_____

   If yes, how many times?_____Under what conditions?

   Dry_____Wet_____Slushy_____

7. Have you landed on other grooved runways? Yes_____No_____

8. Did you notice any improvement landing on a grooved runway in:

   Braking Action? Yes_____No_____Wet_____Dry_____

   Crosswind Directional Control? Yes_____No____Wet____Dry___

   Reducing Landing/Takeoff Roll? Yes_____No____Wet____Dry___

   Visibility During Reverse Thrust? Yes_____No_____

   Seeing the Runway During Approaches?

   Day/VFR Yes___No___Day/IFR Yes___No___

   Night VFR Yes___No___ Night/IFR Yes___No___

9. In your opinion, do you think Runway Grooving helps you to operate your aircraft more safely?

   Yes_____ No_____

10. Do you recommend grooving for all runways? Yes_____No_____

    A._____ B._____

TABLE III

WATER SPRAY OBSERVATIONS

Question: Do you notice any reduction in the size spray patterns of aircraft operating on grooved runways versus those not grooved?

	WASHINGTON NATIONAL	JFK	MIDWAY	KANSAS CITY
FAA airport traffic controllers				
No change	2	(a)	2	0
Less	8	(a)	3	10
Pilot visibility		No noticeable effect		

(a) The distances between the control tower and the grooved runway were considered too far to permit observations of spray within reasonable accuracy.

TABLE IV

RUNWAY TRAFFIC MANAGEMENT

Question: Do you notice any significant improvement in runway traffic management during adverse conditions on grooved runways?

	WASHINGTON NATIONAL	JFK	MIDWAY	KANSAS CITY
FAA airport traffic controllers				
No change	1	2	2	0
Less	9	9	3	10

TABLE V

REDUCED HYDROPLANING AND IMPROVED BRAKING

PILOT ACTIVITY	YES		NO	
	NUMBER	PERCENT	NUMBER	PERCENT
SUPPLEMENTAL	23	3.3	5	0.7
CORPORATE	235	33.4	60	8.5
AIR TAXI	113	16	51	7.2
BUSINESS	37	5.3	65	9.2
PRIVATE	29	4.1	35	5
TRAINING	5	.7	18	2.6
OTHER	19	2.7	9	1.3
TOTAL	461	65.5	243	34.5

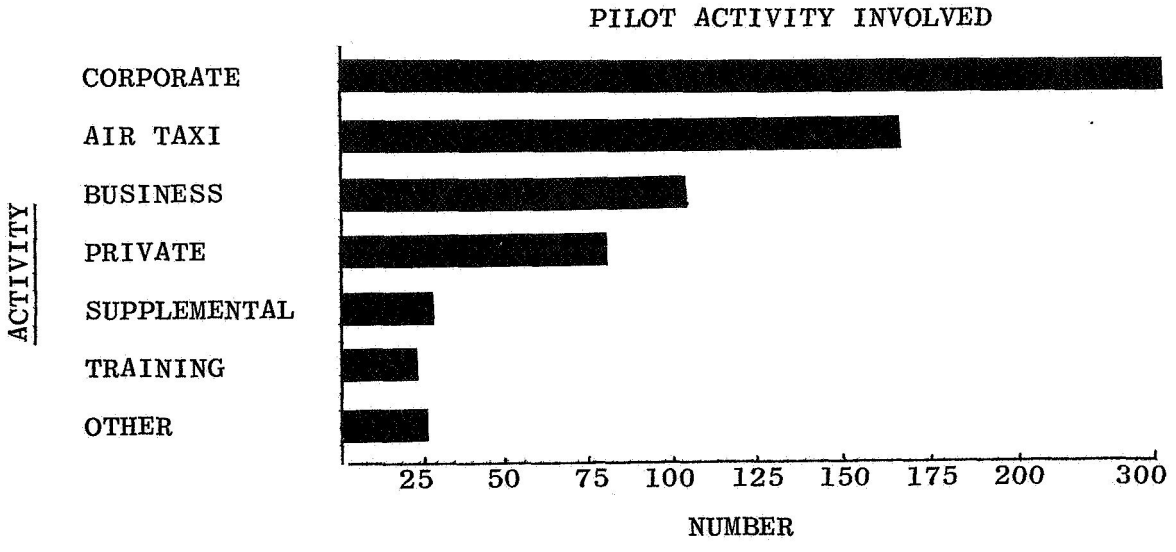

Figure 1.

APPENDIX A

CORRELATION OF ANSWERS FROM QUESTIONNAIRE

PART I, PILOT QUESTIONNAIRES

Question #1

Have you experienced hydroplaning or poor braking on a wet or slushy runway?

Yes_____No_____Wet_____Slushy_____No of times_____

NUMBER OF PILOTS

		PISTON	TURBO-PROP	JET	TOTAL
YES		361	93	177	631
NO		72	--	1	73
WET		359	93	177	625
SLUSHY		151	55	98	304
No. of Times	Few	196	34	57	287
	Several	120	42	95	257
	Many	45	17	25	87

Questions # 2 and 3

Have you heard of Runway Grooving? Yes_____No_____

Are you aware that runway___/____is grooved? Yes____No____

NUMBER OF PILOTS

		PISTON	TURBO-PROP	JET	TOTAL
Question Two	YES	406	91	177	674
	NO	27	2	1	30
	TOTAL	433	93	178	704
Question Three	YES	336	67	138	541
	NO	97	26	40	163
	TOTAL	433	93	178	704

Question #4

How did you acquire that information?

Tower Advisory_____Felt Vibration_____Saw

Grooves_____Noise_____Other_____

NUMBER OF PILOTS

	PISTON	TURBO-PROP	JET	TOTAL
TOWER ADVISORY	23	7	20	50
OBSERVATION	206	47	77	330
CONVERSATION	34	9	8	51
PUBLICATIONS	188	55	104	347
OTHER	48	11	23	82
TOTAL*	499	129	232	860

*A pilot may acquire information from more than one source.

Question #5

Have you landed on runway____/_____prior to____/ /_____

How many times_____Wet_____Dry_____

NUMBER OF PILOTS

RUNWAY	DCA	MDY	MKC	JFK	TOTAL
YES	182	199	157	9	629
NO	10	8	39	18	75
FEW	19	24	16	6	65
SEVERAL	51	25	64	36	176
MANY	112	150	77	49	388
WET	154	171	141	85	551
DRY	172	183	151	90	596

Question #6

Have you landed on runway__/__since it was grooved?____

If yes, how many times?_____Under what conditions?

Dry_____Wet_____Slushy_____

NUMBER OF PILOTS

		PISTON	TURBO-PROP	JET	TOTAL
	YES	417	92	177	686
	NO	16	1	1	18
No. of Times	FEW	102	31	78	211
	SEVERAL	161	44	62	267
	MANY	154	17	37	208
Runway Condition	DRY	410	90	169	669
	WET	296	66	146	508
	SLUSHY	61	15	5	81

Question #7

Have you landed on other grooved runways? Yes_____No_____

Under what conditions? Wet_____Dry_____Slushy_____

If yes, where?_____No.of times_____

NUMBER OF PILOTS

	PISTON	TURBO-PROP	JET	TOTAL
NO	356	49	75	480
YES	77	44	103	224
WET	53	25	72	150
DRY	61	40	93	194
SLUSHY	4	-	4	8
JFK	19	17	30	66
MDY	20	20	41	81
DCA	37	20	54	111
MKC	12	7	7	26
FEW	32	21	45	98
SEVERAL	23	21	45	89
MANY	20	2	10	32

Question #8

Part 1. Did you notice any improvement landing on a grooved runway in:

Braking Action? Yes____No____Wet____Slushy____

Part 2. Crosswind Directional Control? Yes___No___Wet___Dry___

Part 3. Reducing Landing/Takeoff Roll? Yes___No___Wet___Dry___

Part 4. Visibility During Reverse Thrust? Yes_____No_____

Part 5. Seeing the Runway During Approaches?

Day/VFR Yes___No___Day/IFR Yes___ No___

Night/VFR Yes___ No___Night/IFR Yes___ No___

NUMBER OF PILOTS

	PISTON	TURBO-PROP	JET	TOTAL
PART 1*				
YES	239	69	153	461
WET	80	15	59	154
DRY	32	6	16	54
NO	194	24	25	243
PART 2				
YES	130	47	108	285
WET	40	10	52	102
DRY	17	3	14	34
NO	249	39	54	342
NOT SURE	54	7	16	77
PART 3				
YES	149	47	119	315
WET	53	10	52	115
DRY	24	3	17	44
NO	218	33	34	285
NOT SURE	66	13	25	104

Question #8 (Continued)

NUMBER OF PILOTS

	PISTON	TURBO-PROP	JET	TOTAL
PART 4				
YES	2	22	32	56
NO	48	19	61	128
NOT SURE	383	52	85	520
PART 5*				
DAY/YES	109	31	77	217
VFR/NO	324	62	101	487
PART 6*				
DAY/YES	85	30	76	191
IFR/NO	348	63	102	513
PART 7*				
NIGHT/YES	58	29	69	156
VFR/NO	375	64	109	548
PART 8*				
NIGHT/YES	33	27	68	128
IFR/NO	400	66	110	576

*The answer "Not Sure/No Comment" was considered negative.

Question #9

In your opinion, do you think Runway Grooving helps you to operate your aircraft more safely?

Yes_____ No_____

NUMBER OF PILOTS

	PISTON	TURBO-PROP	JET	TOTAL
YES	374	90	164	628
NO	37	1	2	40
NOT SURE	22	2	12	36
TOTAL	433	93	178	704

Question #10

Do you recommend grooving for all runways? Yes_____No_____

NUMBER OF PILOTS

	PISTON	TURBO-PROP	JET	TOTAL
YES	386	89	171	646
NO	22	--	1	23
NO OPINION	25	4	6	35
TOTAL	433	93	178	704

BASIC QUESTIONNAIRE DATA

PART II, TOWER PERSONNEL QUESTIONNAIRE

Question #1

Do you notice any reduction in the size spray patterns of aircraft operating on grooved runways versus those not grooved?

Yes_____ No_____

Describe: Considerable_____

Some_____

Little_____

AIRPORT CONTROL TOWER SPECIALIST

AIRPORT	KANSAS	D.C. NATIONAL	CHICAGO MIDWAY	NEW YORK KENNEDY	TOTAL	PERCENT*
YES	10	8	3	0	21	58.3
NO	0	2	2	11	15	41.7
CONSIDERABLE	9	2	3	0	14	38.9
SOME	1	2	0	0	3	8.3
LITTLE	0	4	0	0	4	11.1
NONE	0	2	2	11	15	41.7

*Of total tower personnel (36) interviewed.

Question #2

Do you notice any significant improvement in runway traffic management during adverse conditions on grooved runways?

Yes_____ No_____

Describe: Considerable_____

Some_____

Little_____

AIRPORT CONTROL TOWER SPECIALIST

AIRPORT	KANSAS	D.C. NATIONAL	CHICAGO MIDWAY	NEW YORK KENNEDY	TOTAL	PERCENT*
YES	10	9	3	2	24	66.7
NO	0	1	2	9	12	33.3
CONSIDERABLE	7	6	2	0	15	41.7
SOME	3	1	1	2	7	19.4
LITTLE	0	2	0	0	2	5.6
NONE	0	1	2	9	12	33.3

*Of total tower personnel (36) interviewed.

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