Report 96-010

Cessna 172

ZK-CGE

Mandeville

16 March 1996

Abstract

At about 1520 hours on Saturday 16 March 1996, Cessna 172 ZK-CGE took off from Mandeville Aerodrome on a private flight to Big Bay. The aeroplane did not gain sufficient altitude after take-off to clear a line of willow trees some 500 m from the departure end of the runway, and collided with the trees, killing the pilot. The three passengers sustained minor injuries. The aeroplane was found to have been operated at a weight 136 kg in excess of the maximum permitted all-up weight, which degraded the take-off performance sufficiently to cause the collision with the trees.

Transport Accident Investigation Commission

Aircraft Accident Report 96-010

Aircraft type, serial number and registration:	Cessna 172E, 17250965, ZK-CGE
Number and type of engines:	1 Continental O-300-C
Year of manufacture:	1964
Date and time:	15 March 1996, 1520 hours*
Location:	500 m west of Mandeville Aerodrome Latitude: 45° 59.3' S Longitude: 168° 48.2' E
Type of flight:	Private
Persons on board:	Crew: 1 Passengers: 3
Injuries:	Crew: 1 fatal Passengers: 3 minor
Nature of damage:	Substantial
Pilot-in-Command's Licence:	Private Pilot Licence (Aeroplane)
Pilot-in-Command's age:	57
Pilot-in-Command's total flying experience:	160 hours 35 on type
Investigator in Charge:	A J Buckingham

* All times in this report are in NZDT (UTC +13 hours)

1. Factual Information

1.1 On the day of the accident, the pilot flew ZK-CGE from an airstrip near his home in Balfour to Mandeville Aerodrome, where he had arranged to meet three passengers (a workmate and two of his friends) for a flight to Big Bay. He landed at Mandeville at 1453 hours, after earlier telephoning his passengers to say that he had been delayed by about three quarters of an hour. The purpose of the flight was a "hunting and fishing weekend" at Big Bay.

1.2 The passengers had been waiting at the local tea-rooms adjacent to the aerodrome, and made their way to the aerodrome after one of them noticed that the aeroplane had landed. They found the pilot pouring the contents of a 20-litre jerrycan into the left wing tank, after which he asked if one of them could pass up the fuel dipstick from the pocket in one of the front seats. He dipped the tank he had just filled and made a remark "that'll do us, she's full" or words to that effect. One of the passengers asked jokingly if he was using "that new stuff" (referring to the premium unleaded motor fuel which was the subject of a controversy at the time), but he assured them that he was not.

1.3 The pilot then began loading the passengers' baggage into the aeroplane's luggage locker, which was already partially occupied by items belonging to the pilot. The locker was unable to accommodate all the passengers' baggage, and the excess, together with the empty fuel container, was taken over to the tea-rooms for safekeeping. Although the locker was loaded to capacity (by volume), none of the items loaded was weighed.

1.4 One of the passengers was considerably heavier than the other two, and the pilot allocated him the front right-hand seat. The other two passengers occupied the rear seats. At some stage after the baggage had been loaded, one of the passengers saw the pilot push down on the tailplane as if testing for balance, and heard him remark to the effect that "we could still fit a horse in there".

1.5 When everybody was aboard, the pilot started the engine, and after a short period of idling, performed an engine run-up before taxiing for take-off. The engine run was carried out adjacent to the Croydon Aircraft Company's hangar, and was heard by an engineer in the hangar. He remarked that the engine run and magneto checks sounded normal.

1.6 The aeroplane was taxied for take-off on runway 27, which was consistent with the engineer's observation of the wind "straight down the strip at five to seven knots". The take-off was observed by the engineer and at least one other person in the hangar, and the point at which the aeroplane became airborne was noted.

1.7 Some 200 m after passing the western boundary of the aerodrome the aeroplane was seen by another aircraft engineer, from his home about 300 m south of the extended runway centreline. He saw the aeroplane in a nose-up attitude which he estimated to be 15°, and not climbing at all. The engine sounded to be running at full power and performing normally. The aeroplane was heading towards a stand of willow trees, in which there was a gap on or close to the extended centreline. The aeroplane disappeared from his sight, and he thought initially that it had flown through the gap, but then heard the sounds of the aeroplane striking the trees.

1.8 He immediately telephoned the Police to report what he had seen, and while he was still on the telephone, one of the passengers arrived at his house and confirmed that there had indeed been an accident. The passenger was able to provide further details to the Police, and emergency services were dispatched promptly to the scene.

1.9 The pilot was found to have sustained fatal head injuries, and the front seat passenger received a blow to the head and a wound to the chest. The two back-seat passengers escaped with minor

grazes, and both ran for help immediately the aircraft came to rest. The front-seat passenger endeavoured to follow them, but after a short distance, sat down to await help, as he felt dizzy and disorientated. He was subsequently hospitalised overnight for observation.

1.10 The aeroplane had come to rest inverted with little or no horizontal velocity, most of its energy having been dissipated in the passage through the trees. Several sizeable boughs, up to 30 cm in diameter were brought down by the aeroplane, and one of these had struck the windscreen area, crushing the coaming above the instrument panel and part of the panel itself. The pilot's side bore the brunt of the damage, the left-hand door frame also suffering vertical compressive deformation. Damage to the remainder of the cabin area was minimal, and it appeared that the two back-seat passengers, who were of short stature, had not even struck the headlining in the inverted impact. Each occupant was restrained by a lap belt only, there being no shoulder harnesses fitted to this aeroplane.

1.11 A notable feature of the on-site investigation of this accident was the large amount of baggage and supplies aboard the aeroplane, in the baggage locker. These were removed and weighed, and were found to total 103 kg. Two additional items found later brought the total to 105 kg. The baggage locker door carried a placard proclaiming the maximum weight to be carried in the locker as 120 pounds (54 kg).

1.12 It was intended, before moving the wreckage on 18 March, to pump out the fuel tanks via the drain cocks, but it was found that the contents had drained away through the filler caps over the intervening 42-hour period. The firewall fuel filter bowl, however, yielded a clean sample of 100/130 octane Avgas, and the remains of the fuel in the jerrycan was also determined to be of the same grade.

1.13 Two days before the accident, the pilot had picked up the aeroplane from its owner at Thornbury, and flown it to Balfour. The owner reported that the fuel tanks were full on departure from Thornbury. The pilot had recorded a flight time from Thornbury to Balfour of 35 minutes, and from Balfour to Mandeville, 17 minutes. Using an average consumption rate of 36 litres per hour, these two flights would have consumed about 31 litres, and the addition of 20 litres at Mandeville would have resulted in a fuel load on take-off of about 148 litres, or 106 kg.

1.14 All three passengers were weighed during their post-accident interviews, the front-seat passenger weighing in at 110 kg, and the other two at 61 and 63 kg. The pilot's weight at his last medical examination (on 22 January 1996) was 89 kg, to which a 3 kg allowance for clothing was added in the aircraft weight calculation.

1.15 The all-up weight of the aeroplane at the time of the accident was calculated to be 1179 kg, 136 kg (300 pounds) in excess of the maximum permitted take-off weight. The centre of gravity, however, was found to be inside the normal aft limit by 0.25 inches, primarily because of the weight distribution of the occupants. However, the normal aft limit is only valid at weights at or below the maximum permitted.

1.16 The flap lever was found in the second notch (corresponding to a flap extension of 20°) initially, but the flaps themselves were retracted. The retraction was attributed to impact disruption of the flap cable runs and the flaps themselves having been walked upon frequently during the time the aeroplane was inverted. After the aeroplane had been recovered from the site and righted, the front-seat passenger was asked if he could recall where the flap lever was set throughout the take-off. He set it without hesitation to the second notch, as he had been aware of the position of the lever in relation to his left knee.

1.17 All three passengers mentioned having heard the sound of a "horn or buzzer" (the stall warning horn), which came on briefly in the initial climb, then came on again and sounded continuously

for several seconds, up to the time the aeroplane struck the trees. The front-seat passenger thought that the horn first sounded as the aeroplane crossed the western boundary of the aerodrome. His estimate of the aeroplane's height at that point was 60 feet above the ground.

1.18 It was not practicable to test run the engine owing to damage sustained in the impact sequence, nor was it considered necessary to have it bulk stripped, as it had been heard, by an aircraft engineer, operating normally up to the moment of the collision with the trees. A leakdown check was performed, however, when evidence of an exhaust "blow" on number 2 cylinder was noted. The check revealed no abnormality except on number 3 cylinder, which had a high leakdown rate. The reason for this was found to be the inlet valve sitting slightly clear of its seat, and this was attributed to the ingestion of debris when the carburettor throat and the inlet manifold were fractured at impact.

1.19 Shortly after the accident, the staff at the aerodrome were able to mark the point of lift-off of ZK-CGE within a nine-metre range, and by identifying the aeroplane's wheel marks, were able to establish and mark the point at which the aeroplane lined up for take-off. The latter was close to the eastern end of the runway, i.e. the pilot used the maximum length available.

1.20 The ground roll was measured at 590 m, with lift-off occurring approximately 270 m from the upwind boundary of the aerodrome. The distance from the boundary to the trees with which the aeroplane collided was 485 m, and the height at which the aeroplane struck the trees was about 50 feet. The gap in the willow trees was large enough for the aeroplane to have flown through, but this was not readily apparent at first sight; through the gap the slopes of a small hill were visible. The hill was about 200 feet higher than aerodrome elevation and about 1000 m distant. The published take-off distance available on runway 27 was 830 m, based on a 1:20 obstacle clearance gradient.

1.21 The take-off performance graph in Supplement D to the Approved Flight Manual showed that, at maximum all-up weight, in the prevailing conditions, ZK-CGE should have been able to take off (to 50 feet) in a total distance of about 580 m. The graph was based on take-off with flaps up. The Cessna 172 Owner's Handbook contained the following information on the use of flap for take-off:

> "Normal and obstacle clearance take-offs are performed with wing flaps up. The use of 10° flaps will shorten the ground run approximately 10%, but this advantage is lost in the climb to a 50-foot obstacle. Therefore the use of 10° flap is reserved for minimum ground runs or for take-offs from soft or rough fields with no obstacles ahead."

1.22 The pilot, since he began flying training in 1978, had flown to Big Bay many times, and he generally based himself there for the duration of every whitebait season. His logbook showed that in the last five years however, he had flown only about 12 hours, logging only one dual flight in 1995, with the last recorded flight before that in March 1993. His last recorded flight on the Cessna 172 type was on 23 March 1991. He completed a biennial flight review (BFR) on 4 March 1996, after having renewed his Class 2 Medical Certificate in January.

1.23 The instructor who performed the BFR was mindful of the type of operation the pilot was most likely to be involved with and his lack of recent flying experience, and discussed with him the possibility of doing a flight from Gore to Big Bay and return as the BFR. The pilot readily agreed, and the flight was undertaken in a PA 28-181. In conjunction with the BFR, the instructor also spent an afternoon discussing flight theory with the pilot, the discussion including take-off and landing performance. The instructor reported that the pilot had responded well to the flight and ground phases of the review, and had in fact done a "self-critique" of the flight, which showed that he understood his personal limitations and areas that may have needed improvement.

2. Analysis

2.1 It was clear early in the investigation that the aeroplane was overloaded by a significant amount, i.e. 13% over the permitted maximum. Even without the contents of the baggage locker, the aeroplane would have been 31 kg over the limit. The effect on the take-off was readily apparent - the aeroplane lifted off after a ground roll equating to the total distance it should have taken, at maximum all-up weight, to reach 50 feet at 1.2 V_S[1]

2.2 Considering the passenger and external eyewitness observations, it is likely that the aeroplane lifted off at an airspeed marginally above the stall speed (which would be higher than normal at the increased weight) and climbed to about 50 feet. It remained at this height, at an angle of attack close to the stall, with consequent high total drag.

2.3 The initial climb would have been assisted by ground effect, a phenomenon experienced by aircraft when within a height corresponding to approximately one wingspan above the ground, which has the effect of improving the lift/drag ratio of the wing. This is due to the effect of the ground on the airflow over the wings, in particular the upwash in advance and the downwash to the rear, both of which are more pronounced towards the tips because of the presence of tip vortices. Close to the ground, tip vortices do not develop as fully as at altitude, resulting in a reduction in the modification of the airflow by the vortices. A full explanation of ground effect was published in "New Zealand Flight Safety" Vol 9, No 5 (1982).

2.4 Once out of ground effect, the aeroplane required clear airspace in which to accelerate to a suitable climb speed, but with the willow trees ahead, this was not available. Aiming for the gap in the trees, close to the extended runway centreline was a possible option, but from the pilot's perspective, the slopes of a small hill about 1000 m ahead were visible through the gap. This may have influenced his decision to continue towards the trees, or he may have been expecting to clear them in any case. To do so would have required only another 10 to 20 feet of height.

2.5 The use of 10° flap on take-off on this aircraft type will result in an earlier lift-off, but will increase the overall take-off distance (to the 50-foot point). While the use of flap will increase the lift coefficient of the wing, it also increases drag, and the overall effect is to decrease the lift/drag ratio, in turn adversely affecting climb performance. This effect will be more pronounced with a flap setting of 20°. The use of flap is appropriate for take-off from soft or rough fields, but sufficient obstacle-free space is required for acceleration after lift-off to normal climb speed. The take-off graph in Supplement D to the Approved Flight Manual is based on "flaps up" take-offs.

2.6 No adequate explanation could be found for the pilot's overloading of the aeroplane, particularly in view of his recent BFR, during which several aspects of aircraft operation were discussed. There was no evidence of any attempt to calculate an accurate weight, although the placement of the passengers indicated a possible attempt to keep the centre of gravity within limits. There remains the possibility that he had carried similar loads successfully in the past, and therefore expected to do so on this occasion.

[1] V_S is the stalling speed, in this case in the take-off configuration

3. Findings

3.1 The pilot was appropriately licensed and rated for the planned flight.

3.2 The aeroplane had a valid Certificate of Airworthiness and Maintenance Release.

3.3 The aeroplane was capable of normal operation until the moment of impact with the trees.

3.4 The aeroplane was loaded to a weight 136 kg in excess of the maximum authorised.

3.5 Take-off performance was degraded by the excess weight.

3.6 The flap setting of 20°, although ensuring a positive lift-off, resulted in a longer take-off distance to 50 feet.

3.7 There was sufficient take-off distance available for the aircraft had it been loaded to its maximum permitted all-up weight.

3.8 A combination of overloading and inappropriate use of flap on take-off resulted in a climb performance which was inadequate to ensure obstacle clearance after take-off.

21 August 1996

M F Dunphy
Chief Commissioner

Glossary of Aviation Abbreviations

AD	Airworthiness Directive
ADF	Automatic direction-finding equipment
agl	Above ground level
AI	Attitude indicator
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
amsl	Above mean sea level
AOD	Aft of datum
ASI	Airspeed indicator
ATA	Actual time of arrival
ATC	Air Traffic Control
ATD	Actual time of departure
ATPL (A *or* H)	Airline Transport Pilot Licence (Aeroplane *or* Helicopter)
AUW	All-up weight
^{o}C	Degrees Celsius
CAA	Civil Aviation Authority
CASO	Civil Aviation Safety Order
CDI	Course Deviation Indicator
CFI	Chief Flying Instructor
C of A	Certificate of Airworthiness
C of G (*or* CG)	Centre of gravity
CPL (A *or* H)	Commercial Pilot Licence (Aeroplane *or* Helicopter)
DME	Distance measuring equipment
E	East
ELT	Emergency location transmitter
ERC	Enroute chart
ETA	Estimated time of arrival
ETD	Estimated time of departure
^{o}F	Degrees Fahrenheit
FAA	Federal Aviation Administration (United States)
FL	Flight level
ft	Foot/feet
g	Acceleration due to gravity
GPS	Global Positioning System
h	Hour
HF	High frequency
hPa	Hectopascals
hrs	Hours
HSI	Horizontal Situation Indicator
IAS	Indicated airspeed
IFR	Instrument Flight Rules
IGE	In ground effect
ILS	Instrument landing system
IMC	Instrument meteorological conditions

in	Inch(es)
ins Hg	Inches of mercury
kg	Kilogram(s)
kHz	Kilohertz
KIAS	Knots indicated airspeed
km	Kilometre(s)
kt	Knot(s)
LAME	Licenced Aircraft Maintenance Engineer
lb	Pounds
LF	Low frequency
LLZ	Localiser
Ltd	Limited
m	Metre(s)
M	Mach number (e.g. M1.2)
°M	Degrees Magnetic
MAANZ	Microlight Aircraft Association of New Zealand
MAP	Manifold absolute pressure (measured in inches of mercury)
MAUW	Maximum all-up weight
METAR	Aviation routine weather report (in aeronautical meteorological code)
MF	Medium frequency
MHz	Megahertz
mm	Millimetre(s)
mph	Miles per hour
N	North
NDB	Non-directional radio beacon
nm	Nautical mile
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board (United States)
NZAACA	New Zealand Amateur Aircraft Constructors Association
NZDT	New Zealand daylight time (UTC + 13 hours)
NZGA	New Zealand Gliding Association
NZHGPA	New Zealand Hang Gliding and Paragliding Association
NZMS	New Zealand Mapping Service map series number
NZST	New Zealand Standard Time (UTC + 12 hours)
OGE	Out of ground effect
okta	Eighths of sky cloud cover (e.g. 4 oktas = 4/8 of cloud cover)
PAR	Precision approach radar
PIC	Pilot in command
PPL (A *or* H)	Private Pilot Licence (Aeroplane *or* Helicopter)
psi	Pounds per square inch
QFE	An altimeter subscale setting to obtain height above aerodrome
QNH	An altimeter subscale setting to obtain elevation above mean sea level
RNZAC	Royal New Zealand Aero Club
RNZAF	Royal New Zealand Air Force
rpm	revolutions per minute
RTF	Radio telephone or radio telephony

s	Second(s)
S	South
SAR	Search and Rescue
SSR	Secondary surveillance radar
°T	Degrees True
TACAN	Tactical Air Navigation aid
TAF	Aerodrome forecast
TAS	True airspeed
UHF	Ultra high frequency
UTC	Coordinated Universal Time
VASIS	Visual approach slope indicator system
VFG	Visual Flight Guide
VFR	Visual flight rules
VHF	Very high frequency
VMC	Visual meteorological conditions
VOR	VHF omnidirectional radio range
VORTAC	VOR and TACAN combined
VTC	Visual terminal chart
W	West