BAe 146-200, G-JEAW

AAIB Bulletin No: 1/99 Ref: EW/C98/7/3 Category: 1.1

Aircraft Type and Registration:	BAe 146-200, G-JEAW
No & Type of Engines:	4 Lycoming ALF 502-R5 turbofan engines
Year of Manufacture:	1986
Date & Time (UTC):	22 July 1998 at 1810 hrs
Location:	Belfast City Airport, Northern Ireland
Type of Flight:	Public Transport
Persons on Board:	Crew - 5 - Passengers - 97
Injuries:	Crew - Nil - Passengers - Nil
Nature of Damage:	Nil
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	12,836 hours (of which 7,000 hours were on type)
	Last 90 days - 61 hours
	Last 28 days - 37 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft and crew were planned to operate a scheduled passenger flight from London (Gatwick) to Belfast (City) Airport. The aircraft was serviceable and the First Officer (FO) was the handling pilot for the flight. He had 3,473 hours experience on this type of aircraft. As the aircraft approached the top of descent point for Belfast (City) the flight crew obtained the latest Automatic Terminal Information Service (ATIS) which reported: surface wind 060°/06 kt, visibility 5,000 metres in rain, cloud scattered at 600 feet and overcast at 1,100 feet. The surface temperature and dew point were coincident at +13°C and the QNH was 1003 mb. The ATIS also identified Runway 22 as the runway in use for landing aircraft. This runway has a concrete surface with an available landing distance of 1,767 metres. The runway is served by high intensity approach lights, threshold

and stop end lighting and runway edge lighting, the PAPIs are set to 3° and all lighting was serviceable.

The crew contacted Belfast approach at 1800 hrs and were given radar vectors for the ILS to Runway 22. The aircraft was established on the localiser at 10 nm from touchdown at an altitude of 1,700 feet and was handed over to the tower frequency at 1805 hrs. On initial contact with the tower frequency the controller passed the current surface wind of 040°/07 kt and the runway state as "WET WITH WATER PATCHES"; this transmission was acknowledged by the crew. At this stage the FO questioned the wisdom of continuing the approach to land given the combination of a tailwind and water on the runway, however, the commander elected to continue. At 1807 hrs the aircraft was cleared to land and passed the current surface wind of 060°/10 kt. This surface wind was subsequently updated to 080°/10 kt and then 070°/12 kt by the tower controller during the remainder of the approach. These later wind velocities equate to a tailwind component of 8 kt and 10 kt respectively when using Runway 22.

The crew could see the runway lighting, including the PAPIs, from glideslope intercept at 1,700 feet and the approach was stabilised on the glideslope throughout. At about 500 feet the indicated airspeed was 12 to 14 kt greater than the required approach speed of 122 kt. This discrepancy was corrected by the use of speedbrake and by about 300 feet the crew were satisfied that the airspeed was now at the correct value. At the "10 feet" radio altimeter call the commander assessed that the aircraft was directly above the touchdown zone markers and the PAPIs were changing from two red and two white lights to one red and three white lights. The FO initiated the flare but the aircraft did not contact the runway and continued to float. After a short time the commander told the FO to place the aircraft on the runway and nudged the control column forward to ensure ground contact. Once on the ground the commander selected the spoilers whilst the FO commenced braking. After a further short period of time the commander also began braking and applied maximum pressure to the brake pedals. He became aware that the remaining runway appeared to be covered in standing water and believed that aquaplaning occurred as he continued to apply maximum braking pressure. As the aircraft approached the threshold of Runway 04 the commander realised that the aircraft was not going to stop so he used the nosewheel steering to turn to the left in an attempt vacate the runway by the taxyway. The aircraft went off the end of the runway and came to a halt on a heading almost 90° to the runway centreline and embedded in the mud about 7 metres from the runway surface. The commander realised that the aircraft was undamaged and confirmed with the cabin supervisor that there were no injuries to the passengers. He therefore decided not to initiate an emergency evacuation but instead commenced the normal shutdown checklist.

As soon as the tower controller realised that the aircraft had left the runway surface he sounded the crash alarm and the airfield fire and rescue services responded immediately. When they arrived at the aircraft the commander spoke to the fire chief through the direct vision (DV) window and requested steps be made available to allow disembarkation of the passengers. Fire and ambulance services from off the airfield also attended at the scene and remained available until all of the passengers had been moved to the passenger terminal and the aircraft had been handed over to the local aircraft engineers who organised the subsequent recovery of the aircraft. The airfield remained closed until 2019 hrs.

FDR information

The Flight Data Recorder, a PV1584, and the Cockpit Voice Recorder, a Fairchild A100, were removed and replayed at the AAIB. Figure 1 shows selected parameters from the approach and landing at Belfast. The recorded data show that landing flap of 33° was selected at 750 feet at 136 KIAS and by 500 feet the airspeed was stabilised at 130 KIAS, at 35 feet the aircraft was at 128 KIAS. The engine power was then reduced from 60% N1 to around 40% N1 at 15 feet and the aircraft touched down 9 seconds later at 111 KIAS. There was no evidence of any windshear on the approach or during the flare. Calculations indicate that the total ground roll from touchdown to a complete stop was 975 metres. The spoilers were deployed between one and three seconds after touchdown (it is not possible to be more precise since this discrete parameter is only sampled every two seconds). Only the green spoiler discrete was functioning on this aircraft. Once the spoilers were deployed, at approximately 110 KIAS, the aircraft began to decelerate at a rate of about 0·2g. The deceleration remained fairly constant throughout the ground roll until the aircraft entered the turn to the left. Braking parameters are not recorded by the FDR so it was not possible to determine the level of braking applied.

Technical examination

The tyre marks on the runway showed that as the aircraft entered the loop at the threshold end of Runway 04 an attempt had been made to turn to the left; this was unsuccessful and the aircraft rolled onto the grassed overrun area and came to rest approximately 7 metres beyond the paved area. Whilst the tyres showed abrasions produced by the sideslip they had experienced before leaving the runway, there were no indications of scald marks or rubber reversion normally associated with aquaplaning.

Subsequent checks showed that the Yellow and Green hydraulic system pressures, and aircraft main and nose wheel tyre pressures were satisfactory. A functional check of the ASIs against calibrated test equipment showed no discrepancies up to 130 kt, and a maximum of 4 kt discrepancy between 130 kt and 180 kt. Brake pressure tests and an anti-skid functional test were carried out with no faults found. The aircraft did not carry any relevant Acceptable Deferred Defects, and the technical log had no brake, anti-skid, ASI or spoiler defects reported in the previous three months.

Runway details

Runway 22 is the preferred landing runway at Belfast (City) whilst 04 is the preferred departure runway. This preference is dictated by the location of the passenger terminal situated close to the threshold of Runway 04 coupled with the absence of a parallel taxyway. The associated traffic pattern for taxying aircraft allows for minimal operational delays which would occur if aircraft were required to backtrack the runway in use.

From the point of glideslope origin on the runway surface, as defined by both the ILS glideslope and the PAPIs, 1,509 metres of runway length is available for Runway 22. The runway width is 61 metres which is considerably wider than the runways at all other scheduled destinations for this operator which have runways that are 45 or 46 metres wide. The runway edge lights mark the full width of the runway and there are no indented markings to indicate a normal runway width. During the flare the pilot was thus faced with a short runway that is unusually wide.

The runway is surfaced with large concrete blocks with a rubberised sealant between the blocks. In any heavy precipitation there is the possibility of water pooling in these blocks if there is any misalignment between them. This was seen to occur the day after the accident following some heavy rain showers and may explain the commander's perception of extensive areas of standing water during the landing rollout. There are also two short sections of grooved asphalt surface approximately 290 metres and 80 metres long starting approximately 140 metres and 550 metres respectively from the Runway 22 threshold. However, the aircraft touched down beyond these grooved areas.

A runway friction classification of this runway had been performed on 29 January 1998. The average readings for the runway were well above the maintenance planning requirements (average 0·75, maintenance planning level 0·63). It was noted during this friction classification that whilst the runway generally had good high speed friction qualities there was a marked deterioration when crossing the painted touchdown zone markers which are displaced 10·5 metres from the runway centreline. It was recommended that action to improve the readings on these painted surfaces should be considered. Rubber deposits were described as light in the touchdown area of Runway 04.

Wind information

There are two anemometers at the airport. Site 1 is adjacent to the threshold of Runway 22 and Site 2 is adjacent to the threshold of Runway 04. Each unit records the maximum, minimum and mean values for the wind velocity over each 10 minute period. This mean value is then used for the ATIS information and the instantaneous wind for landing aircraft is derived from the relevant site.

Reporting of wet runways

ATC had informed the pilot that the runway state was "WET WITH WATER PATCHES" and this transmission was acknowledged by the crew. The Manual of Air Traffic Services Part 1, Section 9-3, Chapter 2 defines the manner in which water on a runway is to be reported. The information passed to the crew on this occasion is issued "When the surface is soaked and significant patches of standing water are visible".

Calibrated runways are discussed in the same chapter where it states:

> "Wet surface friction characteristics of the runways at certain aerodromes have been calibrated to ensure that they are of an acceptable quality. If the quality deteriorates below an acceptable level the particular runway will be notified as liable to be slippery when wet. When a runway, other than one notified as liable to be slippery when wet, is reported as 'damp' or 'wet' pilots may assume that an acceptable level of wet runway wheel braking friction is available. When a runway is reported as having 'water patches' or being 'flooded' it can be expected that pilots will make the necessary operational adjustments as wheel braking and control may be affected by aquaplaning."

Operator's procedures

The Company Operations Manual Part 9 includes information on the recommended procedure for the approach and landing. This information is in agreement with that produced by the aircraft manufacturer. It requires that the aircraft should be flown at a constant IAS (Vref+ 5 kt) during the approach, where Vref is the target threshold speed for the selected flap setting. This speed is reduced after decision height to achieve Vref over the threshold, and then by a further 7 kt at touchdown.

The estimated landing weight for this aircraft was 35,636 kg. This equates to an approach speed of 122 kt (Vref + 5 kt) and an associated touchdown speed of 110 kt. Allowing for a wet runway and a 10 kt tailwind this requires a factored landing distance of 1590 metres which the commander had extracted from his published documents prior to the landing. A factor of 1·92 is applied to landing performance for turbo jet aircraft without thrust reversers to allow for minor operating inaccuracies and a factor of 1·5 is applied to any tailwind component.

Landing on contaminated runways is discussed at Part 9, Section 4, Chapter 9 of the company Operations Manual where a runway is described as contaminated 'when more than 25% of the length and width to be used is covered with ice, standing water, slush or wet snow to a depth exceeding 3 mm'. The maximum permitted tailwind for operations on such a runway is defined as 5 kt. Furthermore, when landing on a contaminated runway the pilot is required to plan and execute the approach and landing as for a 'short field' landing. This initially requires the maintenance of a normal glideslope at an airspeed of Vref + 5 kt, then, during the final stage of the approach the speed brakes should be extended and speed reduced to cross the threshold at Vref at a height of about 30 feet. The pilot should then aim to touchdown in the first 500 feet of the runway and is specifically warned not to let the aircraft float.

Aircraft performance

After the incident the aircraft manufacturer used its performance data to calculate an unfactored stopping distance in the actual conditions, ie the distance that the aircraft would use to stop from a touchdown speed of 110 KIAS, using wheel brakes, immediate selection of spoilers and with a 10 kt tailwind. The unfactored stopping distance was produced for both a wet runway surface and one that was wet with standing water. No factor was applied to the tailwind. With continuous, maximum application of wheelbrakes the unfactored stopping distance was 687 metres on the wet surface and 1,254 metres on the surface that was wet with standing water. The calculated ground roll from touchdown to a complete stop was 975 metres which falls between these two figures and appears to validate the assessment made by ATC of the runway state as "WET WITH WATER PATCHES". In such conditions it is not possible to define precisely the runway friction characteristics for the full length of the runway since these will vary depending upon the particular circumstances. It is also unlikely that maximum braking was applied immediately on touchdown although the crew were clear that maximum braking was applied very shortly afterwards.

Summary

The flight crew accepted the preferred runway, Runway 22, as their landing runway despite the reported tailwind. Landing on this runway was their normal routine and their published landing figures allowed for a landing with a 10 kt tailwind on a wet surface. Even after the FO expressed doubts about the tailwind the commander was satisfied that it was safe to continue the landing for Runway 22.

ATC had informed the pilot that the runway was "WET WITH WATER PATCHES" because the runway surface was soaked and significant patches of standing water were visible. ATC therefore expected that the pilots would realise that wheel braking and control might be affected by aquaplaning since

this information is available in the UK Aeronautical Information Publication (AIP). However, the crew were unaware of the implications of this description of the runway surface since the definition of a contaminated runway published in their Operations manual specifies "more than 25% of the length and width to be used is covered with.... standing water....to a depth exceeding 3 mm". Therefore, the crew did not consider that they were approaching a contaminated runway and did not apply the associated limiting tailwind of 5 kt nor did they brief for the short field landing technique.

As the result of a number of incidents which have occurred to aircraft when landing on wet or contaminated runways the CAA believed that there was a need to further enhance the consistency of information relating to the various classifications of runway surfaces; the aim being to ensure that both air traffic controllers and pilots have access to the same information. The CAA is currently producing an AIC on this subject, there will also be an associated amendment to the AIP.

Once landing flap of 33_ had been selected at 750 feet the aircraft was stabilised at a speed of 130 KIAS for the remainder of the approach and at 35 feet it was at 128 KIAS. At the estimated landing weight the correct approach speed was 122 kt (Vref + 5 kt) with an associated speed at the threshold of 117 kt. The landing performance for this aircraft is predicated upon achieving an accurate speed schedule during the approach and landing. It is therefore imperative that flight crews ensure that this speed schedule is followed when making an approach to land on a limiting runway.

Once established in the flare the handling pilot did not place the aircraft on the ground but allowed it to float until prompted, both physically and verbally, by the commander. This misjudged flare may have been caused by the handling pilot misinterpreting the visual cues provided by the unusually wide runway. This error was exacerbated by the 10 kt tailwind.

The aircraft finally touched down with approximately 968 metres of runway remaining at an indicated airspeed of 111 kt with a 10 kt tailwind and on a surface that was "WET WITH WATER PATCHES". During the braking there was no evidence, from the physical examination of the tyres, of any aquaplaning. The performance of the aircraft during the ground roll, with the spoilers extended and maximum braking applied, was as expected on a surface that was wet with standing water.