

Analysis of the causes and prevention of runway excursions

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Analysis of the causes and prevention of runway excursions

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Abstract. The incidence of flight accidents 96% occurred on the runway. Where, 80% of accidents due to excursions result in death. Excursion is the improper exit of the aircraft from the runway. The plane got out because it couldn't stop after it reached the end of the runway. Data for the last 16 years, in Indonesia there have been 3 accidents due to excursions which claimed many lives and materials. So it is necessary to study with the aim of knowing the dominant factors that cause excursions and finding recommendations for handling them. This paper is a literature review. The analysis uses secondary data taken from several articles in journals and other sources. Based on the discussion of the results of the data analysis, it was found the dominant factors that caused the excursion. Furthermore, based on the impact, a discussion was conducted with several references to obtain recommendations for appropriate treatment. The study results show that the dominant factor causing the excursion is the runway which is wet or inundated by water, in addition to the condition of the aircraft components. The recommendation to reduce incidence is to make good drainage, so that there is no stagnant water on the runway surface. In addition, inspection of aircraft components must be carried out carefully and strictly so that they can function properly.

Keywords: Runway excursions; flight accidents; drainage factors; aircraft condition

1. Introduction

According to the Flight Safety Foundation, 96% of accidents between 1995 and 2007 occurred on runways. And 80% of these accidents are excursions that result in death. Runway excursions are a common type of landing accident. This situation occurs when the aircraft leaves the runway either by turning sideways or by crossing the end of the runway [1]. So that the aircraft leaves the runway inappropriately. The aircraft got out because it couldn't stop after it reached the end of the runway.

The excursion (overrun) is influenced by weather, aquaplaning and the adequacy of the runway length. Aquaplaning due to standing water on the runway is dangerous for landing. Therefore, various studies have been carried out to determine drainage capacity in relation to rainfall and runway

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characteristics, such as texture depth and runway geometry. The water level that exceeds the depth of the surface texture is an indication of standing water on the runway. This can reduce the friction ability of the wheels with the runway[1].

There are many accidents due to excursions. In the past 16 years, there have been at least 13 times worldwide. Three of them are in Indonesia. In this regard, this study aims to determine the dominant factors that influence excursions and find recommendations for their treatment.

2. Method

This paper is the result of a literature review. The analysis uses secondary data taken from several sources, both articles in journals and other related publications. The dominant factors that influence the excursion are determined from the discussion based on the analysis results from these references. Based on the impact, a discussion was conducted to obtain recommendations for appropriate treatment. Figure 1 the approach taken to obtain the study objectives.

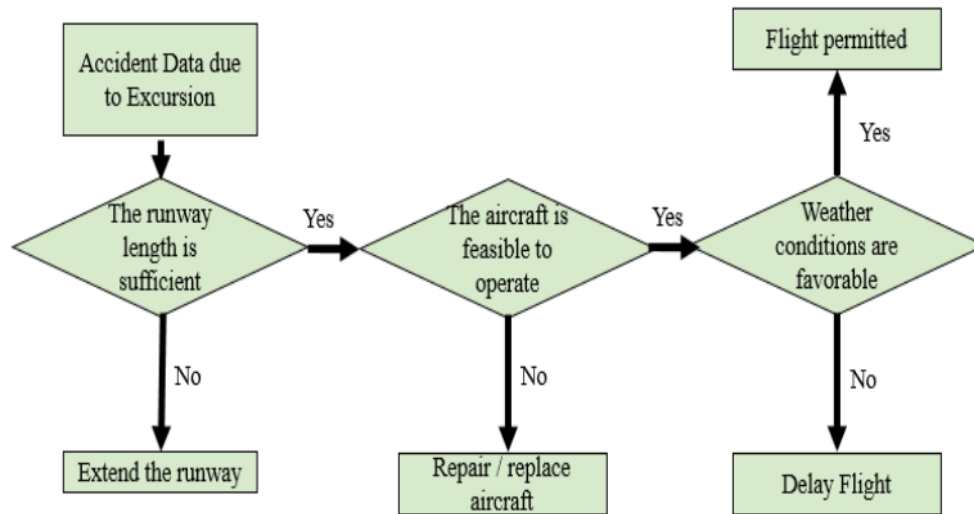


Figure 1. Flowchart of the study approach

The approach in this study is carried out through data collection, data analysis and discussion to determine the dominant factors that affect excursions and find treatment solutions as recommendations.

2.1. Required data

The data used for analysis purposes are secondary data, namely:

- a) Accident data, including event, year, location, and description
- b) Data on the causes of accidents can be taken from the accident description data

2.2. The analysis data

The analysis carried out is:

- a) The percentage of accidents

- b) Analysis of casualties and losses due to accidents
- c) Analysis of the causes of accidents due to excursion

2.3. Discussion on the results of the analysis

The discussion is to find out:

- a) The dominant factors affecting the excursion and
- b) Recommendations for handling.

3. Results

The incidence of accidents on the runway starting from 2004, resulting in death, aircraft destruction, or changes or improvements to aviation safety [2], is shown in Table 1.

Table 1. Incidents of accidents on the runway from 2004 to 2020 [2]

No	Even, year and loaction	Description
1	Lion Air Flight 583 (2004) Adisumarmo International Airport, Surakarta, Indone sia	While landing in wet weather, the McDonnell Douglas MD-82 overran the runway due to hydroplaning and poor aircraft braking performance. After leaving the runway, the aircraft struck an embankment and split into two sections. 25 of the 153 people on board were killed.
2	Southwest Airlines Flight 1248 (2005) Midway International Airport, Chicago, Illinois, U.S.	A Boeing 737-700 overran the runway while landing in a snowstorm and crashed into automobile traffic, killing one person on the ground.
3	Air France Flight 358 (2005) Toronto Pearson International Airport, Toronto, Canada	An Airbus A340 overran the end of the runway and came to rest in a ravine. 43 people were injured, and the aircraft was destroyed by a post-crash fire.
4	S7 Airlines Flight 778 (2006) Irkutsk International Airport, Irkutsk, Russia	The Airbus A310 overshot the runway and struck a concrete barrier at high speed, causing the aircraft to break apart and igniting a massive fire. 125 of the 203 occupants were killed.
5	Garuda Indonesia Flight 200 (2007) Adisutjipto International Airport, Yogyakarta, Indon esia	During landing, the Boeing 737-400 departed the runway, crashed into a rice field and burst into flames. Of the 140 occupants, 21 were killed.
6	TAM Airlines Flight 3054 (2007) São Paulo–Congonhas Airport, São Paulo, Brazil	An Airbus A320 overran the runway while landing in rain, and crashed into a warehouse. All 187 people on board, and 13 people on the ground, were killed.
7	Sriwijaya Air Flight 62 (2008)	The Boeing 737-200 overran the runway due to a hydraulics malfunction of the aircraft and crashed into a house. There

² ICST conference, December 14th 2020, published online: June 1st 2021

	Sultan Thaha Airport, Jambi	were no fatalities out of the 130 passengers and crew on board the aircraft, but one person inside the house was killed. The aircraft received substantial damage and was written off. ^[9]
8	American Airlines Flight 331 (2009) Norman Manley International Airport, Kingston, Jamaica	A Boeing 737-800 landing in rain and a tailwind touched down more than 4,000 feet from the start of the runway. Unable to stop in the remaining distance, it broke apart on rocks near the shoreline. No one was killed, but 85 people were injured and the plane was destroyed.
9	Air India Express Flight 812 (2010) Mangalore International Airport, Mangalore, India	The Boeing 737-800 overshot the end of the runway, went through a 300 feet (91 m) sand arrestor bed meant as excursion protection, then slid down a steep hillside. 158 of the 166 occupants were killed.
10	Caribbean Airlines Flight 523 (2011) CheddiJagan International Airport, Georgetown, Guyana	A Boeing 737-800 overran the runway while attempting to land in rainy weather. All occupants survived, but the aircraft was irreparably damaged and seven people were injured.
11	Pegasus Airlines Flight 8622 (2018) Trabzon Airport, Trabzon, Turkey	A Boeing 737-800 ran off the left side of the runway during landing and slid down a cliff, stopping short of the water. No one was killed, but the aircraft was destroyed.
12	Pegasus Airlines Flight 2193 (2020) SabihaGökçen International Airport, Istanbul, Turkey	A Boeing 737-800 overran the runway while landing in heavy rain and high winds, and broke into several pieces. 3 of the 183 people aboard were killed.
13	Air India Express Flight 1344 (2020) Calicut International Airport, Kerala, India	A Boeing 737-800 overran the tabletop runway, skidding off the end of the runway and crashing into a gorge. The aircraft was carrying 190 people including 6 crew members. A total of 20 people, including both pilots, were killed in the crash.

Based on Table 1, it can be seen that the accidents that occur on the runway are mostly caused by excursions (overran). Data in the last 16 years [1], in Indonesia there have been 3 accidents due to excursions, out of around 13 incidents around the world. In accidents due to excursions, there were many fatalities.

4. Analysis Data

4.1. Excursion Accidents

Analysis of the data in Table 1, results in the composition of the number of incidents within and outside Indonesia, as well as the causes of their occurrence, as shown in Figure 2.

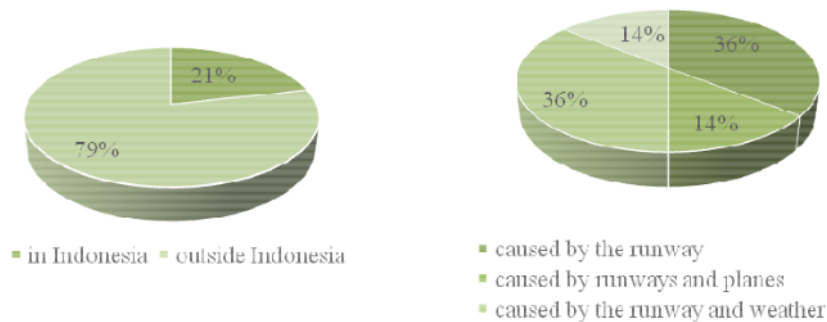


Figure 2. Number of Excursions from 2004 to 2020

4.2. Casualties and losses due to the incident

Table 2 shows the casualties and losses incurred by each incident at an airport in Indonesia. Meanwhile, Table 3 shows the victims and losses caused by each incident at an airport outside Indonesia.

Table 2. Victims and losses due to excursions in Indonesia

Type of aircraft, Airline Name and Flight Number	Accident victim	Accident loss
McDonnell Douglas MD-82	25 were killed out of the 153 people on board.	The plane split into two parts. The front of the plane was torn apart [3]
Lion Air Flight 583 Boeing 737-400 Garuda Indonesia Flight 200	21 were killed, out of the 140 on board	The plane caught fire.
Boeing 737-200 Sriwijaya Air Flight 62	There were no fatalities from the 130 passengers and crew. One person in the house died	The plane was badly damaged

Table 3. Victims and losses due to excursions at outside Indonesia

Type of aircraft, Airline Name and Flight Number	Accident victim	Accident loss
Boeing 737-700 Southwest Airlines Flight 1248	killing one person on the ground.	loss report not found
Airbus A340 Air France Flight 358	43 people were injured, and the.	aircraft was destroyed by a post-crash fire
Airbus A310 S7 Airlines Flight 778	125 of the 203 occupants were killed.	loss report not found
Airbus A320 TAM Airlines Flight 3054	All 187 people on board, and 13 people on the ground, were killed.	loss report not found
Boeing 737-800 American Airlines Flight 331	No one was killed, but 85 people were injured and the plane was destroyed.	loss report not found

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Boeing 737-800 Air Express Flight 812	India	158 of the 166 occupants were killed.	loss report not found
Boeing 737-800 Caribbean Airlines Flight 523		All occupants survived, but seven people were injured.	the aircraft was irreparably damaged
Boeing 737-800 Pegasus Airlines Flight 8622 (2018)		No one was killed	aircraft was destroyed
Boeing 737-800 Pegasus Airlines Flight 2193		3 of the 183 people aboard were killed.	loss report not found
Boeing 737-800 Air Express Flight 1344	India	The aircraft was carrying 190 people including 6 crew members. A total of 20 people, including both pilots, were killed in the crash.	loss report not found

4.3 Causes of Excursion

Table 4 shows the location of the incident in Indonesia and the predicted causes. Meanwhile, Table 5 shows the causes of excursion accidents outside Indonesia.

Table 4. Causes of excursion in Indonesia

Type of aircraft, Airline Name and Flight Number	Airport and Year of occurrence	Cause
McDonnell Douglas MD-82 Lion Air Flight 583	Adisumarmo International Airport, Surakarta, Indonesia 2004	Landing in wet weather. There was hydroplaning on the runway. Poor aircraft braking performance. After leaving the runway, hit the embankment.
Boeing 737-400 Garuda Indonesia Flight 200	Adisutjipto International Airport, Yogyakarta, Indonesia 2007	On landing, it left the runway, hit rice fields and caught fire.
Boeing 737-200 Sriwijaya Air Flight 62	Sultan Thaha Airport, Jambi 2008	Past the runway. Due to aircraft hydraulics damage. Hit a house.

Table 5. Causes of excursion outside Indonesia

Type of aircraft, Airline Name and Flight Number	Airport and Year of occurrence	Cause
Boeing 737-700 Southwest Airlines Flight 1248	Midway International Airport, Chicago, Illinois, U.S. 2005	overran the runway while landing in a snowstorm and crashed into automobile traffic.
Airbus A340 Air France Flight 358	Toronto Pearson International Airport, Toronto, Canada 2005	overran the end of the runway and came to rest in a ravine.
Airbus A310 S7 Airlines Flight 778	Irkutsk International Airport, Irkutsk, Russia 2006	The overshot the runway and struck a concrete barrier at high speed, causing the aircraft to break

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Airbus A320TAM Airlines Flight 3054	São Paulo-Congonhas Airport, São Paulo, Brazil2007	apart and igniting a massive fire. overran the runway while landing in rain, and crashed into a warehouse.
Boeing 737-800American Airlines Flight 331	Norman Manley International Airport, Kingston, Jamaica2009	A landing in rain and a tailwind touched down more than 4,000 feet from the start of the runway. Unable to stop in the remaining distance, it broke apart on rocks near the shoreline.
Boeing 737-800Air India Express Flight 812	Mangalore International Airport, Mangalore, India 2010	The overshot the end of the runway, went through a 300 feet (91 m) sand arrestor bed meant as excursion protection, then slid down a steep hillside.
Boeing 737-800Caribbean Airlines Flight 523	CheddiJagan International Airport, Georgetown, Guyana 2011	A overran the runway while attempting to land in rainy weather.

Table 5. Causes of excursion outside Indonesia (continued)

Type of aircraft, Airline Name and Flight Number	Airport and Year of occurrence	Cause
Boeing 737-800Pegasus Airlines Flight 8622 (2018)	Trabzon Airport, Trabzon, Turkey 2018	A ran off the left side of the runway during landing and slid down a cliff, stopping short of the water.
Boeing 737-800Pegasus Airlines Flight 2193	SabihaGökçen International Airport, Istanbul, Turkey 2020	A overran the runway while landing in heavy rain and high winds, and broke into several pieces.
Boeing 737-800 Air India Express Flight 1344	Calicut International Airport, Kerala, India 2020	overran the tabletop runway, skidding off the end of the runway and crashing into a gorge.

5. Discussion

The discussion is limited based on the causal factors in Table 4. In this case, there are things that must be met for aircraft landing activities. This is the adequacy of the runway length, the operational feasibility of the aircraft and the puddle on the runway when it rains, due to suboptimal drainage. As for the location of the incident, it is limited to 3 airports in Indonesia, namely: Adisumarmo International Airport, Adisutjipto International Airport and Sultan Thaha Airport.

5.1. Adequacy of runway length

Requirement of Runway Length minimal was stated as Airplane Reference Field Length (ARFL) standard. ARFL is a drink runway that the aircraft needs to take off, at the time of maximum take off

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weight, sea level elevation, standard atmospheric conditions, conditions without blowing wind, runway without slope [4].

Table 6. Requirement of runway length

Type of aircraft, Airline Name and Flight Number	Airport and Year of occurrence	Runway length
McDonnell Douglas MD-82 Lion Air Flight 583	Adisumarmo International Airport, Surakarta, Indonesia 2004	2150 m
Boeing 737-400 Garuda Indonesia Flight 200	Adisutjipto International Airport, Yogyakarta, Indonesia 2007	2200 m
Boeing 737-200 Sriwijaya Air Flight 62	Sultan Thaha Airport, Jambi 2008	2220 m

The runway length required to serve the landings of type B 737-400 aircraft requires a minimum of 2,100 m[5]. The Airbus A330-200 requires a runway length of 2,753 m and the A330-300 requires 3100 m[6].

Data for 2004 when the incident was not found, then the assumption of the minimum runway length at the time of the accident was 2150 meters. This refers to the AdiSoemarmo runway data for 1987, which was planned to be extended 350 meters to 2150 meters. With the target of serving wide-body aircraft of various types of Boeing or Airbus A320 [7]. Until 2018 it is 2,600 meters long, at that time it is planned to be 3,000 meters [8].

The runway length of Adisucipto Airport at the time of the incident was 2200 meters. It was still in the planning stages of extending the runway by 300 meters (980 feet) to the east, bringing it to 2,500 meters (8,200 feet) [9].

The length of the runway at the time of the incident at Sultan Thaha Jambi Airport, based on 2007 data, was 2220 meters. Runway width of 30 meters. Managed by PT AngkasaPura II, the largest aircraft served is the A320 [10]. The plane that crashed was a Boeing 737-200, meeting the requirements for landing.

Based on the results of the discussion, all airport runways have a sufficient length for the aircraft to carry out the landing process. However, inadequate aircraft conditions or unfavorable weather can result in accidents. For example, Adisumarmo Airport has a sufficient runway length, but the braking system is poor, resulting in overrun. Likewise, the Adisutjipto Airport. Except for Sultan Thaha Airport, runway length is not the cause.

5.2. Aircraft operational feasibility

Minimizes risk and ensures aircraft airworthiness so that it is easy to maneuver, including the braking system. Table 7 shows the events caused by aircraft conditions [11].

Tabel 7. Aircraft condition

Type of aircraft, Airline Name and Flight Number	Airport and Year of occurrence	Aircraft Condition
McDonnell Douglas MD-82 Lion Air Flight 583	Adisumarmo International Airport, Surakarta, Indonesia 2004	The aircraft is not suitable for operation. Poor aircraft braking performance.
Boeing 737-400	Adisutjipto International	There was damage to the aircraft

Garuda Indonesia Flight 200	Airport, Yogyakarta, Indonesia 2007	
Boeing 737-200 Sriwijaya Air Flight 62	Sultan Thaha Airport, Jambi 2008	The aircraft is not suitable for operation, there is damage to the aircraft hydraulics.

5.3. Aquaplaning on the runway

Weather can be an obstacle in the plane landing process. Fog can reduce visibility, while rain causes the runway to flood water. Especially when the drainage is not smooth. This can result in aquaplaning symptoms. Table 8 and Table 9 show the problems associated with puddle water.

Tabel 8. Runway drainage conditions

Type of aircraft, Airline Name and Flight Number	Airport and Year of occurrence	Kondisidrainase
McDonnell Douglas MD-82 Lion Air Flight 583	Adisumarmo International Airport, Surakarta, Indonesia 2004	There was hydroplaning on the runway, an indication that the surface water was not flowing smoothly due to inadequate drainage
Boeing 737-400 Garuda Indonesia Flight 200	Adisutjipto International Airport, Yogyakarta, Indonesia 2007	Drainage is not the cause
Boeing 737-200 Sriwijaya Air Flight 62	Sultan Thaha Airport, Jambi 2008	Drainage is not the cause

Tabel 9. Weather conditions

Type of aircraft, Airline Name and Flight Number	Airport and Year of occurrence	Cuaca
McDonnell Douglas MD-82 Lion Air Flight 583	Adisumarmo International Airport, Surakarta, Indonesia 2004	The runway is wet from rain
Boeing 737-400 Garuda Indonesia Flight 200	Adisutjipto International Airport, Yogyakarta, Indonesia 2007	Weather is not the cause
Boeing 737-200 Sriwijaya Air Flight 62	Sultan Thaha Airport, Jambi 2008	Weather is not the cause

5.4. Prevention of excursion

Table 10 shows the causes of excursions at 3 airports in Indonesia, namely: 1) Landing in rainy conditions, when there is a pool of water on the runway that causes hydroplaning (aquaplaning); 2) The condition of the aircraft is not optimal for operation, such as poor aircraft braking performance or due to aircraft hydraulics damage.

Based on these causative factors, precautions that can be taken are: 1) extending the runway so that it is safe when it rains; 2) all aircraft navigation and control systems must be in proper condition

and functioning properly; 3) runway drainage functions to channel water so that it does not flood the runway surface when it rains. The precautions taken as recommendations are shown in **Table 10**.

Table 10. Causes of excursion in Indonesia

Airport and Year of occurrence	Cause	Prevention
Adisumarmo International Airport, Surakarta, Indonesia 2004	Landing in wet weather. There was hydroplaning on the runway. Poor aircraft braking performance.	Stabilization of the runway surface and drainage, overwriting Hydroplaning is caused by uneven runway surface conditions and inadequate drainage. Certainty of aircraft operational feasibility
Adisutjipto International Airport, Yogyakarta, Indonesia 2007	On landing, it left the runway, hit rice fields and caught fire.	Ensuring the adequacy of the runway length and the aircraft's feasibility, considering that the dry runway overran is caused by the sufficient length of the runway and the condition of the aircraft
Sultan Thaha Airport, Jambi 2008	past the runway. due to aircraft hydraulics damage. hit a house.	Certainty of aircraft feasibility, given that the overran on the runway with sufficient runway length is caused by the condition of the aircraft

6. Conclusion

Based on the discussion conducted on the results of the analysis, the conclusions are:

- The dominant factor causing the excursion is the runway which is wet or inundated by water,
- The condition of the aircraft components.
- The recommendation to reduce incidence is:
 - to make good drainage, so that there is no stagnant water on the runway surface.
 - inspection of aircraft components must be carried out carefully and strictly so that they can function properly.

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