

## A REVIEW ON AIRPORT RUNWAY DRAINAGE SYSTEMS

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### ABSTRACT

In order to provide safe aircraft takeoff and landing in a variety of weather circumstances, airport runway drainage is an essential component of airfield construction and operation. By eliminating surface and subsurface water, effective drainage systems stop hydroplaning, pavement degradation, and interruptions to operations. Water ponding, subgrade deterioration, higher maintenance expenses, and even total runway closures during severe weather occurrences can result from poorly planned or maintained drainage. The types of drainage solutions, their components, and the engineering principles underlying their construction are all covered in this paper's thorough analysis of airport runway drainage systems. In addition to important design elements including rainfall intensity, catchment area characteristics, runoff coefficients, and soil permeability, international standards like ICAO Annex 14 and FAA AC 150/5320-5D are also reviewed. The study also emphasizes sustainability and environmental factors, such as sustainable urban drainage systems (SUDS), retention and detention basins, and oil-water separation. To demonstrate real-world issues and solutions, such as Operation Pravaah flood mitigation efforts, a case study of Cochin International Airport (CIAL), which have experienced significant flooding during the 2018 Kerala floods, is examined. The study concludes by examining the upcoming developments including intelligent IoT-based drainage monitoring, artificial intelligence-based predictive maintenance, and the incorporation of drainage design with GIS and BIM systems for sustainable and resilient airport infrastructure.

**Keywords:** Hydroplaning Prevention, Surface And Subsurface Drainage, Runway Safety, Sustainable Urban Drainage, And Airport Drainage.

### 1. INTRODUCTION

Airports are intricate facilities where good pavement performance is crucial to both safety and operational effectiveness. Drainage is one of the most important elements which affects the runway safety. In order to collect and release rainfall and subsurface water from airfield pavements, airport runway drainage systems are engineered networks of pipes, slopes, channels, and filtration structures. Good drainage keeps water from building up, which can lower pavement friction and lead to dangerous situations like hydroplaning, in which a small layer of water causes an aircraft tire to lose contact with the ground. There are significant concerns during landing and takeoff operations since even a tiny amount of standing water can negatively affect steering control, stopping distance, and braking efficiency. Moreover, poor drainage causes water to seep into the base and subgrade layers of pavement, hastening its degradation. Cracking, rutting, and structural collapse can result from water penetration followed by freeze-thaw cycles in cold areas. In addition to interfering with airport operations, poor drainage can result in expensive delays, cancelled flights, and lost income for operators.

International Civil Aviation Organization (ICAO) Annex 14 and Federal Aviation Administration (FAA) Advisory Circular AC 150/5320-5D are two examples of regulations that regulate airport drainage design globally. These standards specify pavement slopes, grading specifications, and hydraulic capacity requirements. Important design codes are also provided in India by the Bureau of Indian Standards (BIS). Despite these recommendations, severe rainfall, elevated groundwater levels, or inadequate maintenance can cause drainage issues at airports, particularly those located in monsoon-prone or flood-vulnerable regions.

The vulnerability of airfields situated in low-lying reclaimed regions with modified natural drainage was highlighted by the flooding of Cochin International Airport during the 2018 Kerala floods. Modern airport infrastructure requires an understanding of the reasons behind these failures and the implementation of robust, sustainable drainage systems.

The surface and subsurface types of airport drainage systems, as well as their components and design issues, are covered in this review study. It looks at typical issues brought on by inadequate drainage and how they affect airports financially. Sustainability and environmental issues are examined, with a focus on pollution prevention and environmentally friendly drainage techniques including bio-swales and permeable pavements. Along with examining cutting-edge technologies like smart sensors, artificial intelligence-based predictive maintenance, and integration with building information modelling (BIM) and geographic information systems (GIS), the paper also provides a real-world

case study of Cochin Airport's flood mitigation measures. Giving a thorough grasp of present procedures and potential future paths in airport runway drainage planning is the goal.

## 2. METHODOLOGY

Based on a thorough analysis of published literature, international aviation design rules, and actual airport drainage procedures, this paper offers a technical evaluation. Information was gathered from scholarly publications, technical reports, and authoritative standards like the Bureau of Indian Standards (BIS) drainage and pavement design guidelines, the Federal Aviation Administration (FAA) Advisory Circular AC 150/5320-5D, and the International Civil Aviation Organization (ICAO) Annex 14. In order to comprehend real-world difficulties, case studies of airports were also studied, particularly those from areas with high monsoon rains. Keywords like surface drainage systems, runway safety, hydroplaning prevention, airport drainage, and sustainable urban drainage systems (SUDS) were used to find the literature. In order to capture modern design advances, sustainability initiatives, and smart monitoring technologies, studies and publications published within the last ten years were given priority. To provide an overview of the various drainage system types, their components, design considerations, and performance in actual operational settings, the results were subjected to a methodical analysis.

## 3. MODELING AND ANALYSIS

Runway drainage systems can be broadly categorized into surface and subsurface drainage.

**Surface Drainage Systems:** In order to avoid ponding and hydroplaning, surface drainage deals with the quick evacuation of rainfall from the top layer of the pavement. To guarantee that water flows away from the centerline, runways are built with longitudinal slopes of 1% to 1.5% and transverse slopes of 1.5% to 2%. To prevent depressions that could hold water, these slopes need to be precisely maintained both during construction and over the course of the pavement's life.

Important elements consist of:

**Side Drains and Open Channels:** Sheet flow is collected and diverted away from operational zones by lined ditches along the runway's margins.

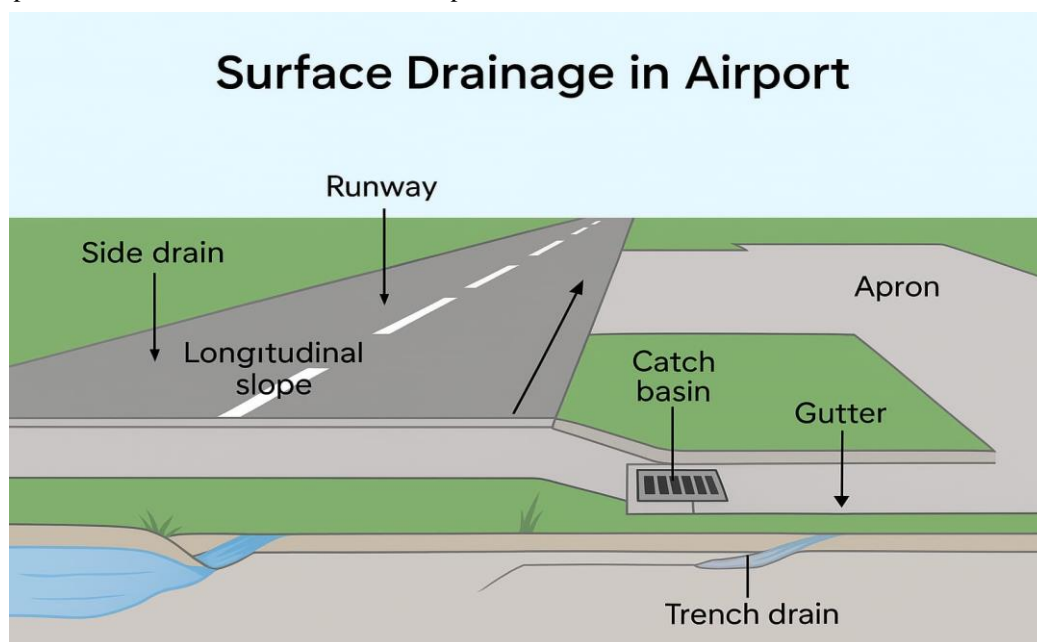
In order to direct surface runoff into inlets, curbs and gutters are utilized in apron and terminal regions.

Water is collected and moved into subterranean drainage pipes by inlets and catch basins, which are box-shaped structures with grates.

Transport collected water to treatment facilities, retention ponds, or natural rivers using stormwater pipes and culverts.

Trench drains and grated channel drains are examples of advanced designs that efficiently intercept sheet flow.

Permeable pavements are often used in low-traffic apron areas to minimize runoff.



**Figure 1:** Surface Drainage Systems

**Subsurface Drainage Systems:** In order to prevent the base course and subgrade from deteriorating, subsurface drainage regulates the water beneath the pavement layers. It is crucial in regions where rainfall infiltration can weaken building integrity, have a high water table, or have poor soil permeability.

Important elements consist of:

Perforated collector pipes, also known as underdrains or subdrains, are gravity-flow pipes that have holes in them to catch seepage and groundwater.

French Drains: Perforated pipes covered in geotextile filters and graded gravel-filled trenches.

Geotextile Filter Fabrics: Prevent soil particle penetration while maintaining permeability.

Sand and gravel filter layers: Provide channels for water to flow away from the subgrade.

Manholes and inspection wells: Give access for upkeep, monitoring, and flushing.

Unique and Long-Term Solutions

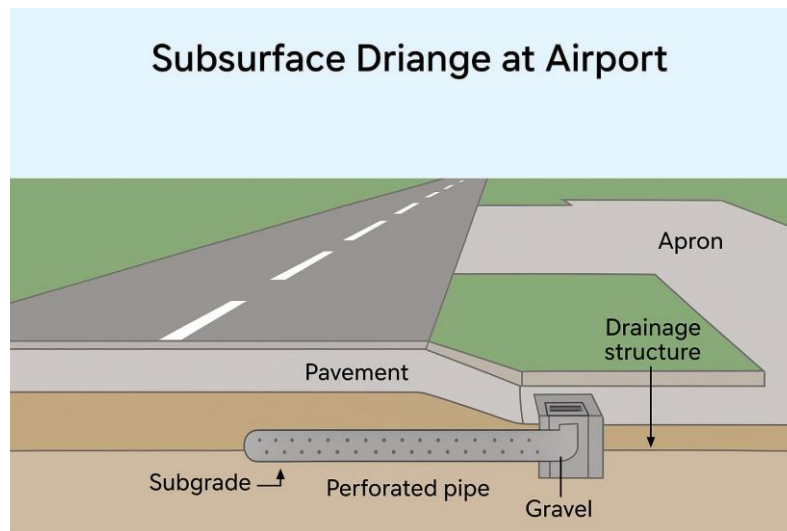
Airports are becoming more integrated:

Aprons with oil-water separators to remove pollutants.

Retention/Detention Basins to regulate the highest levels of stormwater.

Permeable pavements, infiltration trenches, and bio-swales are examples of Sustainable Urban Drainage Systems (SUDS).

Subterranean storage tanks to control heavy precipitation



**Figure 2:** Subsurface Drainage System

#### 4. RESULTS AND DISCUSSION

For pavement lifespan and operating safety, effective drainage is essential. Inadequate system management results in high maintenance expenses, subgrade deterioration, and hydroplaning occurrences. Hazardous landings can result from even thin water layers that drastically reduce friction and lengthen braking distances. When clayey or silty subgrades are weakened by infiltrated water, cracking, rutting, and settling occur, increasing maintenance downtime and financial loss.

Even though standards like ICAO Annex 14 and FAA AC 150/5320-5D provide guidelines for slope and hydraulics, real-world issues like subpar construction, long-term settlement, and missed inspections usually reduce performance.

Case Study: Cochin International Airport (CIAL), India

During the August 2018 Kerala floods, CIAL, which was constructed on reclaimed paddy fields next to the Periyar River, had heavy flooding that resulted in a 14-day shutdown and significant damage to airside, navigation, and lighting equipment. The ability to convey floods was limited by the narrowing of natural channels, such as Chengal Thodu, during development. The low-lying airport was overrun by heavy rain and dam releases upstream. In order to prevent flooding in the future, Operation Pravaah (2021) included:

Canals, Chengal Thodu's expansion and deepening.

Peripheral drains are cleaned and desilted.

Constructing diversion canals, culverts, and bridges to reroute surplus water.

After renovations, the airport avoided any problems during the 2020 monsoon. New bridges and flow controls will be part of a Phase 2 expansion (2024–2025) to improve resilience. This example demonstrates the necessity of regional hydrology-based planning and the expense of retroactive flood mitigation.



**Figure 3:** Cochin International Airport during flood 2018

#### ENVIRONMENTAL AND SUSTAINABILITY ASPECTS:

Eco-friendly drainage systems are now a priority for airports. Apron runoff contamination is avoided with sediment traps and oil-water separators. By delaying stormwater flow, retention and detention basins lessen flooding downstream. Permeable pavements and bio-swales are examples of SUDS techniques that naturally filter water and reduce runoff. Green infrastructure helps airports meet environmental standards and encourages long-term sustainability.

#### FUTURE TRENDS IN RUNWAY DRAINAGE:

IoT-Based Sensors: Monitoring moisture and water level in real time.

Predictive AI maintenance involves early repairs and failure forecasts based on data.

Integration of GIS and BIM: Digital twin modeling for asset management and design optimization.

Climate-Resilient Systems: Adaptive infrastructure and outlets with greater capacity to manage erratic, heavy rainfall.

#### 5. CONCLUSION

Effective runway drainage is crucial for performance, safety, and operational continuity. When integrated surface and subsurface systems are built in compliance with ICAO and FAA regulations, hydroplaning, pavement degradation, and costly delays are prevented. The case of Cochin Airport highlights the dangers of inadequate drainage planning and the expense of retroactive improvements. Future airport drainage will gradually incorporate engineering concepts with intelligent monitoring, AI-driven maintenance, and sustainable infrastructure to provide climate resilience and environmental compliance.

#### 6. REFERENCES

- [1] Abhishek Kumar, "Design of airfield pavement drainage system – case studies," Int. J. Civ. Eng. Technol. (IJCET), vol. 9, no. 4, pp. 102–110, 2018.
- [2] Federal Aviation Administration (FAA), Advisory Circular 150/5320-5D: Surface Drainage Design, U.S. Department of Transportation, Washington, DC, USA, 2008.
- [3] Horonjeff, R. and F. X. McKelvey, Planning and Design of Airports, 5th ed., New York, NY, USA: McGraw-Hill Education, 2010.
- [4] International Civil Aviation Organization (ICAO), Annex 14 – Aerodrome Design and Operations, Volume I, 8th ed., Montreal, Canada: ICAO, 2018.
- [5] Indian Meteorological Department (IMD), Rainfall Intensity–Duration–Frequency (IDF) Data for Kerala Region, Tech. Circular Series Vol. 5, New Delhi, India: IMD, 2018.
- [6] Ministry of Civil Aviation, Govt. of India, Airport Design and Planning Manual, Vol. 3 – Airfield Engineering Standards, New Delhi, India: MoCA, 2015.
- [7] National Transportation Safety Board (NTSB), Runway Excursion and Hydroplaning Accident Reports, Vol. 7 – Airport Safety Series, Washington, DC, USA: NTSB, 2015–2020.