Circular Runway

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Abstract - *This paper presents an innovative concept for airport operations in the long-term future, based on a radically new airport design encompassing a circular circumventing runway. The Endless Runway project, mostly funded by the European Commission during the Framework Programmed 7 (FP7), aims at evaluating the benefits and identifying the constraints associated to this kind of airport. The possibility to operate the airport whatever the wind direction and for every aircraft type, the optimization of air and ground aircraft trajectories through the use of the best runway section, as well as the compact airport footprint are part of the observed gains. Those must be balanced with the high runway construction cost, additional safety issues in gusty winds and the impossibility to extend the runway system if additional capacity is desired. A foreseen application could be a small airport dedicated to unmanned aircraft operations or a large hub airport with limited traffic mix and high reliability of operations.*

Key Words: Runway, airport design, aircraft, Airport capacity

1. INTRODUCTION

One of the scenarios of the European Research Establishments in Aeronautics (EREA) Air Transport System (ATS) 2050 study [1], the Unlimited Skies scenario, imagines an explosive growth of air traffic. If this happened, the lack of capacity at airports would be a major constraint to growth, as recognized by ACARE, the Advisory Council for Aeronautics Research in Europe. Airports form already a major bottleneck in the air transport system. If nothing is done, part of the demand may not be accommodated. Extending existing airports or building new ones might be a solution. However it usually faces the opposition of inhabitants and takes many years between the first identification of the need and the completion of the construction. For instance, making a runway longer to accommodate larger aircraft or departures if the runway was specialized for arrivals, adding a tangent runway to an existing runway system in order not to close the airport in high crosswind, extending the airport outside of its current limits, are all measures that may encounter the refusal of the local residents.

While airport capacity needs to be increased, authorities ask for optimized trajectories in order to reduce fuel consumption, emissions and possibly noise. Current aircraft routes based on standard procedures in the departure and approach phases are far from being direct: an aircraft flying from Toulouse-Blagnac to ParisOrly, on a day of Autan wind (coming from the south east), will take off facing the wind from runway 14L or 14R almost in the opposite direction of its destination.

1.1 OBJECTIVES:-

When we plan an airport, all type of aircraft's landing and take-off operations take place including bigger and smaller aircraft. In case of circular runway we can't classify the runway for particular aircraft. So we designing here considering the design parameters for the largest aircraft BOING 474. So our main objectives are as under

- To find out the Radius of circular runway for safe operations.
- To find the exact bank angle for safe ground rolling.
- Apply the circular runway concept to existing major hub airport in India and to compare it.

To find the feasibility of the concept in India

1.2 Concept of Circular Runway

A. Description of Circular Runway

The circular runway is an innovative concept for airport operations in the long term future which is based on a radically new airport design encompassing a circular circumventing runway.

In order to allow to sufficient number of landing and take-off at a time, the runway inner radius is set to more than 1500 meters. The minimum length for circular runway thus should be 10,000 meters comparable three times more than a straight runways, which is long enough to allow multiple simultaneous landing and take-off on the runway and to build the airport infrastructure inside the circular runway while keeping the airport compact.

Due to higher centrifugal forces for a narrower runway the runway width is set to be 140 meters for avoidance of discomfort of passengers. To limit the effects of centrifugal forces, the outside of runway is banked with increasing angle.

As the aircraft accelerates for take-off, it moves from the flat inner part of runway to towards the other outer banked part until aircraft reaches the lateral position on the runway where the bank angle is fits its lift-off speed. The same applies during landing operations.

B. Design of Circular Runway

The basis airport design principles are presented in Figure 1.1 The taxiway system consists of an outer and an inner taxiway ring between the runway and the terminals area. The outer taxiway, operated in the same direction(s) as the runway, is connected to runway access points through high-speed exit taxiways, where one aircraft can hold if needed. The inner taxiway is operated in the opposite direction to the outer one. Taxiways between the airport's buildings link the inner circular ring to the inner airfield area. Finally, a dual taxiway system is available on the inner part of the terminals. This taxiway design aims at avoiding bottlenecks and at providing a short routing between the aircraft stands and the runway entry or exit point

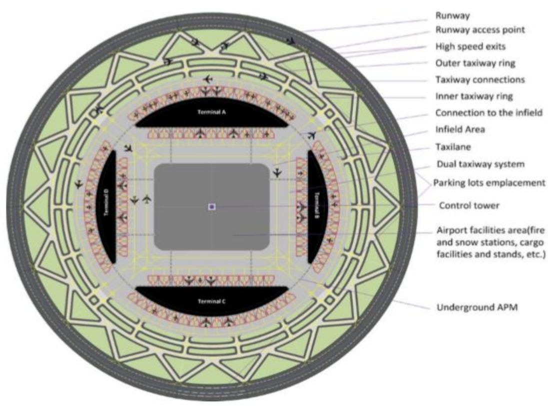

Fig. 1.1: Basis airport design

C. Flying to and from a circular runway

The project objective is to define two concepts of airports with circular runways: one for a hub and one for a seasonal airport. In both cases, the geometrical properties of the runway are identical. The runway inner radius is set to 1500 meters. Thus the total runway length, of about10 000 meters, is long enough to operate several aircraft simultaneously on the runway and to build airport infrastructures inside, while keeping the airport compact. The runway width that can be used by aircraft is set to 140 meters as a compromise between discomfort due to higher centripetal acceleration for a narrower runway and the cost of a wider runway.

In order to limit the effects of the centripetal force, the circular runway lateral profile is banked with increasing angles from inwards to outwards, as shown on Fig. 1.2 In this manner, it is possible not to have lateral friction between the aircraft tires and the runway surface at all .As the aircraft accelerates to take off, it moves from the flat inner part of the runway towards the outer banked part until it reaches the lateral position on the runway whose bank angle fits its lift-off speed. The same applies the other way around during landing.

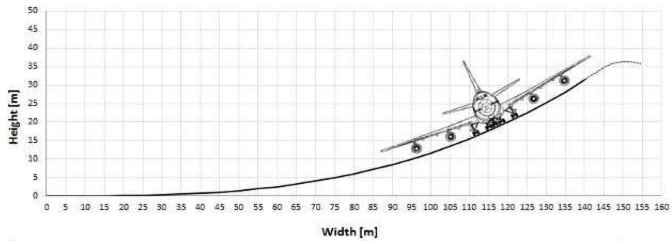

Fig. 1.2: Runway profile

2. CALCULATION AND ANALYSIS

2.1 Design and calculation Constraints as per ICAO and FAA

- Design Speed;- An aircraft of larger size need minimum 285-290 km per hour, and smaller 155-160 km per hour.
- Radius:- An aircraft need minimum radius of 180 m for turning.
- Width;- Width of runway varies from 55 m to 80 for small and bigger size of airport respectively.
- Bank Angle;- The minimum bank angle for aircraft is 6 degree and maximum recommended by ICAO is 60 degree at which in case of emergency a craft can work.
- Elevation;- Elevation of runway should be such that the wings of craft should not be in touch with ground, minimum clearance should be 0.73m and maximum should be 5.3m .
- Sight Distance;- Sight distance for pilot recommended is 500 m to 950 m. some time sight distance not obtain in that case pilot done operations with the help of central marking line.

Table -1: Current Atmosphere of Pune area

Altitude	201 m
Temperature	40
Friction	0.35
Wind speed	6kmph – 75kmph
Rain condition	7.5 cm

Since the distances are given on the standard condition of temperature which is 15°C, pressure (sea level), slope (null), a dry runway and in absence of wind, some correction factors need to be applied. After the all correction provided by ICAO and FAA, we also may correct the length

Fa=1+0.07a/300

Ft=1+0.01(tr−tsh)

FS=1+0.1s

Where;

Fa = correction in altitude

Ft = correction as a function of temperature

Fs = correction as a function of slope

a = altitude

tr = reference temperature

tsh = corresponding standard atmosphere to every altitude

s = slope

Value of equation Fa×Fs× Ft should be greater than 1.35.

Calculation:

As we know

Altitude (a) = 201

Reference temperature of Land Area = 40 0C

Standard atmosphere to every altitude by FAA = 250C

Slope (max) of runway by recommended by ICAO = 0.07

Now from equation (A) (B) & (C) we have,

Correction as a function of slope Fs = 1+ s = 1+0.07

FS = 1.07

Correction in Altitude Fa = 1+ 0.07*a

Fa = 1.0469

Correction as a function of temperature = 1+ 0.01

(tr –tsh)

ft = 1.15

From the equation 5, 6 & 7 we have the value of equation,

Fa×Fs× Ft = 1.07 × 1.0469 × 1.15 =1.67

2.1 Analysis

The output of the runway scheduler is a flight plan, with a detailed description of the every single flight. With increasing demand, the runway system is not able to handle the traffic anymore without delaying some of the flights. This delay is recorded and can be used as a parameter to determine the runway capacity.

Table -2: Output Of The Runway Scheduler

Traffic ratio	Number of flights	Max fligts per hour	Average delay with wake rule (h:min:s)	Max delay with wake rule (h:min:s)
100.0%	1570	110	00:00:21	00:04:16
110.0%	1727	121	00:00:33	00:07:18
120.0%	1887	127	00:01:16	00:09:23
130.0%	2042	131	00:03:41	00:20:11
140.0%	2198	146	00:12:53	00:41:58
150.0%	2365	150	00:27:31	01:04:09
200.0%	3140	179	02:37:43	05:11:33

3. CONCLUSION

A concept for operating a circular runway has been evaluated from various perspectives: the aircraft, the airport, and the operations. The Endless Runway has proven to be a feasible concept at least in the nominal conditions studied in the project timeframe, even though some particular aspects should be further studied (amongst others: flight dynamics near the runway especially in gusty conditions, safety procedures in case of go around, accurate navigation systems usable for circular landings). The main benefits of circular airports are their compactness and the reduction of ground and air trajectories, but they must be balanced with a moderate capacity, a high construction cost, a lack of flexibility in the inner infrastructure and the impossibility to operate some future aircraft configurations (like the blended wing body). In the course of the project, focus was made on hub airports, however, with these findings, it appears that circular airports could find a better application in the long term for RPAS airports with a small radius (for example 400 meters), little infrastructure in the middle and less constraint on the maximum tolerable lateral acceleration, or for large hub airports where arrival and departure streams are more uniform and separated, making best use of the route network structure through less conflict.

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