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Revised Concept of Nijgadh International Airport Using Endless Runway

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Abstract
Nepal is a country with high tourist potential. But due to lack of infrastructures, such as Airport meeting International standards, people face problems while visiting the country. Nepal Government had proposed an alternative site for construction of Second International Airport after the existing Tribhuwan International Airport (TIA). But due to excessive land coverage of the airport in location of forest has brought protest to the project. This research was carried out to find an alternative design that could fulfil the objectives of the airport with less environmental impact which led us to the burning concept of The Endless Runway.
Keywords: *Airport, Nepal, Endless Runway, Nijgadh.*
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I. Introduction

Nepal is a landlocked country where the major means of international connectivity is either through Roadway or Airway. As for travel time, Roadway takes a considerable time compared to Airway. Despite being a major tourist attraction nation, Nepal has got only one international airport, Tribhuvan International Airport (TIA).

The airport is confined with only one runway and is limited to its expansion due to uncontrolled urbanization. This has resulted in air-traffic congestion leading to flight delays which directly effects the socio-economic as well as tourism sector of the country.

According to the White Paper of CAAN, it has been cleared out the necessity of the Second International Airport due to the following reasons:

- TIA is being operated at its peak capacity and cannot be further expanded thus in need of modern fully functional Second International Airport.
- To enhance the Tourism Sector of the country.
- For ease of access to different European and Asian countries by use of larger planes with high passenger carrying capacity.
- Necessity of an Airport with well built Runway, Yard, Cargo Terminal and Parking for Cargo planes. (CAAN, 2010)

The then Nepal Government headed by Sher Bahadur Deuba directed a consulting firm called NEPICON/IRAD to access the feasibility of 8 sites for the Second International Airport in 1995. Among the 8 alternative sites, Nijgadh was found to be most feasible location due to its topography. The location has feasible area of 80 sq.km. to construct infrastructure for Airport equipped with modern facilities. The located site has easy access from East, West, North and South of the country.

The proposed plan of the SIA is to construct two parallel runways, taxiway, terminal, apron including all transportation and communication. This primitive design of runway occupies more area while providing less benefits. The Second International Airport has targeted to take care of 60 million air passengers annually. The total cost of the projected has been estimated about 6565 million US dollars. (Article33509)

According to 'Operational Forest Management Plan' in 1990s, the location consists of 3 types of trees; Sal, Terai-Hard wood and Khair-Sissoo. The location also consists of migration corridor for Asian Gigantic Elephants. This reason led to protest by environmentalists' resulting in halt of the project. The unavoidable massive destruction of the environment in the proposed site has forced the government to rethink about the plan of the airport. (CAAN, 2010)

Development isn't possible without affecting the environment. But while designing, one should be aware of its consequences and should work on minimizing them as far as practicable. We tried to revise the design of the airport so that the objectives planned for the airport are met with less destruction of the environment by using the Endless Runway Concept. Endless Runway is a noble and radical design for a runway: a circular track, circumventing the airport. This runway can be used for takeoff and landing from any

direction enhancing the feature of the runway. So, this concept mainly focuses on the space management equivalence to conventional airport with three or more runways with sustainable capacity.

II. METHODS AND MATERIALS

Study Area

The proposed site for the Nijgadh International Airport is in Bara district of Province 2. It is located South of Easr-West Highway, 8km from the Fast Track and 18km East of Pathlaiya. The site is trapezoidal in shape covering about 80 sq.km.

Topographic survey

The topographic survey was conducted with the help of GPS and GOOGLE MAPS. It gave us a broader vision of the proposed design of the government.

Techniques of Data Collection

Primary Data

The data required for this research was obtained by visiting the site and interviewing the Mr. Om Sharma, Chief of the Implementation Unit. Office. He provided us with adequate information about the ongoing conditions of the project. He provided information about the residents that had to be displaced when the airport is constructed. The territory of the site was allocated with the help of GPS considering the accuracy of the device.

Secondary Data

The reports, journals, guidelines, books and project documents were studied either online or offline regarding the airport design. Guidelines published by Aerospace Engineer Henk Hesselink and his team.

Collection of Data

Data regarding the air-traffic in TIA was collected by meeting the respective personnel and interviewing them.

Analysis and interpretation of data

The data were analyzed and the results obtained are represented in graphical form or by different charts and tables.

III. RESULTS AND DISCUSSIONS

Endless Runway

The Endless Runway is a noble and radical design for a runway; a circular track, circumventing the airport. This runway supports take-off and landing from any direction offering the unique characteristic of being operational under any wind condition through the possibility for an aircraft to operate always with headwind during take-off and landing. (Dupeyrat & Aubry, 2014)

The circle should be large enough to provide enough space for infrastructure. The radius of circle proposed in 1.5 kilometers and the total length of runway would be about 10,000 meters, long enough to operate several aircraft simultaneously on the runway. The width of the runway that can be used by aircraft is 140 meters.

In order to limit the effects of centripetal force, the circular runway lateral profile needs to be banked with increasing angle from inwards to outwards. 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.

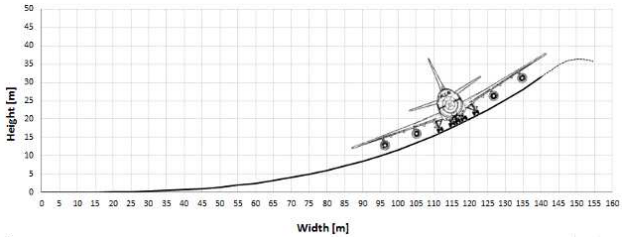

Fig: Runway Profile

Runway profiles for provision of super elevation can be determined form different approach. Linear speed distribution is selected as most promising solution.

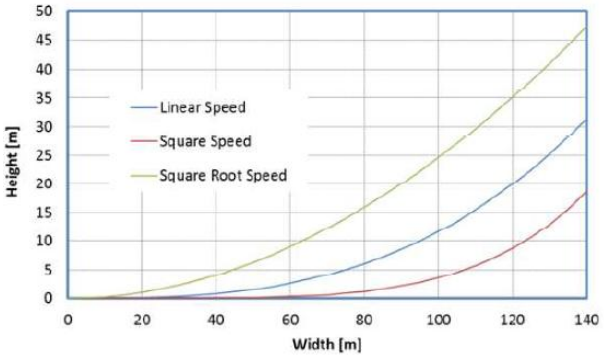

Fig: Runway profile with different speed distribution

- Take off distance = 3100 m
- Average lateral acceleration = 0.37 ms^{-2}
- Average steering angle = 2.4^{O}
- Take off distance = 3050 m
- Average lateral acceleration = 0.38ms^{-2}
- Average steering angle = 3.8^{O}

According to the simulations carried out in FlightGear for runway of this geometry, it is possible to make takeoff and landings even with old and heavy aircraft like a B747. The distance between aircraft elements like the engines or the wingtips and the ground is reduced compared to a flat runway, and finally passengers experience a lateral acceleration up to 1ms^{-2} which is acceptable compared to the limit commonly accepted in rail transportation in bend set to 1.2ms^{-2}. (Hesselink, 2014)

Well-connected airport

For the layout of a hub, most facilities for aircraft, passengers, baggage, freight, airport operator and ATC are located inside the circular runway. Access from the outside to inside facilities is provided to employees and suppliers through tunnels passing under the runway, and to passengers through an APM (Automated People Mover) connecting the main terminal to the intermodal station located outside. (Hesselink, 2014)

Optimized Operations

From the Air Traffic Management (ATM) perspective, the circular runway is seen in contiguous segments: an aircraft will use a set of contiguous runway segments for take-off and landing, and several aircraft will be authorized to use the distinct runway strips simultaneously (Hesselink, 2014).
The whole runway is divided into 18 segments, the length of one segment is about 550 meters.
Eighteen segments were chosen as a good compromise: low enough to minimize the taxiway construction and maintenance costs, movement area design and traffic complexity, and high enough to optimize throughput, runway occupancy time and route efficiency. (Hesselink, 2014)

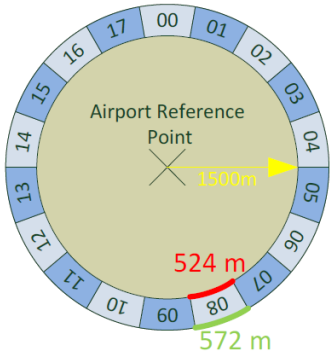

Fig: Runway segments

For each of the 18 runway segments, arrival and departure routes have been defined. Departure routes start at the end of the respective runway segment climbing straight out to a height of 5000 feet with an angle of 5°. Arrival routes end at the beginning of a runway segment with a straight path coming from a height of 3000 feet and a glide path angle of 3°. The starting point of the arrival routes and the end point of the departure routes are indicated by TMA (Terminal Maneuvering Area) entry and exit points. (Haider, Rawat, & Jaysawal, 2018)

Technology used

i. Radio navigation: A highly accurate ground-based reference can be made available at the airport to provide correction signals for high accuracy of the navigation performance. Systems like GBAS (Ground Based Augmentation System) can provide this information for curved approaches.

ii. Visual Guidance: To assist the pilots in the final phase of the approach, suitable guidance must be available. A first approach is the use of single controlled lamps that are available on every runway segment.

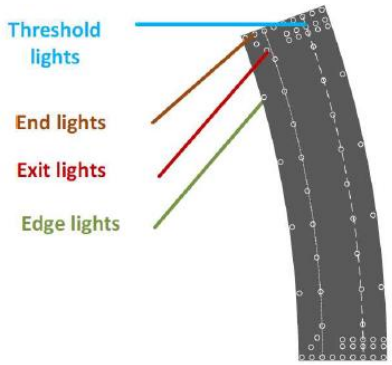

Fig: Lighting Classification

Dependent on the position of the segment in the temporary runway strip, the color of the lamp is changed as guided by current ICAO recommendations.

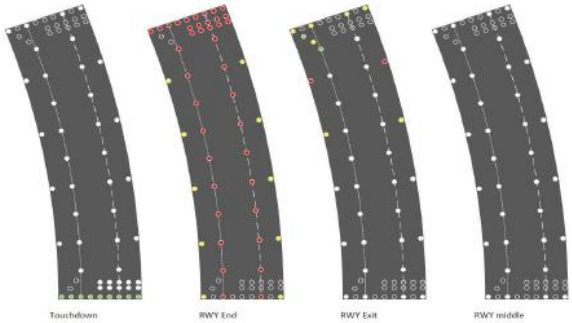

Fig: Single controlled lamp concept – coloring dependent on segment position

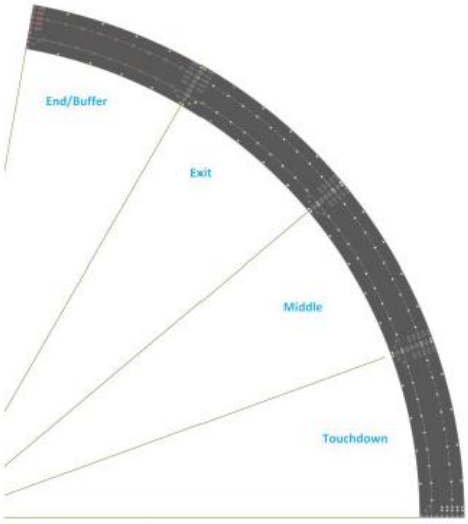

Fig: Lamp control for temporary runway strip

Feasibility Study

As the environmental subject has played the major role in development of the SIA and it may also be the stopping factor for the execution of it. The disturbances caused by the proposed Second International Airport (SIA) is tremendous and is very tough task to mitigate the problems brought by the SIA. The only corridor of the endangered species "Asiatic Giant Elephant" happens to be disturbed by the proposed SIA while many other flora and fauna are found to be harmed equally.

The endless runway airport is estimated to resolute almost 75 % of the existing problems that are caused by the SIA. The only migration corridor to the endangered species "Asiatic Giant Elephant" remains unharmed and the land area covered by the SIA reduces by 70% which is a strongest point to protect the nature.

Benefit

The major benefit of this concept is the reduction in the area destroyed for the construction of the airport without compromising the objectives of the proposed airport. As area acquisition was the major issue for the execution of the airport, endless runway concept overcomes the challenge by reducing the area to one-third of the total proposed site preserving the nature as well as the corridor.

Endless runway also serves as a benefit as it can handle more than 7 domestic planes at a time or 3 giant Boeings at a time. The current design of Nijgadh International Airport is to construct a single runway which won't be enough to handle the air traffic. The delay in the air traffic causes a lot of fuel consumption which is nullified using endless runway. A Boeing 747 consumes approximately

1 gallon (4 litres) every second where as a domestic plane consumes 111 ml fuel per second. The cost due to air time delay in sense of fuel and compensation is saved. (ERP) Considering the 3 international and 7 domestic flight delay per day, the compensation to the passengers for the accommodation by airport is saved.
The development of the airport cities around the airport also supports the economy of the nation which improves the socio-economic standard of the peripheral area. (Norman J. Ashford, 2011)

Cost Benefit Analysis

A cost analysis was done based on a basic cost model, which distinguishes several cost factors. The analysis tries to estimate only the cost and benefits of an Endless Runway airport relatively to a conventional hub airport with four runways. No absolute Cost Benefit Analysis (CBA) can be provided as there are too many uncertainties and unknowns in respect to the airport concept, the needed technologies and the cost of materials, energy and workers in nearby future.

Estimations had to be made, like the cost of constructing the banked runway. Where no absolute figures would be available, a low and a high estimate have been made. The following types of costs have been considered: development, operational, recurring and non-recurring costs. This methodology is good enough to get a general feeling about the costs of an Endless Runway airport compared to a conventional airport.

Figure compares the costs between a standard airport and a minimum and a maximum estimate for the Endless Runway airport. It appears that an Endless Runway airport would be between 1.04 and 1.48 times more expensive than a conventional one.

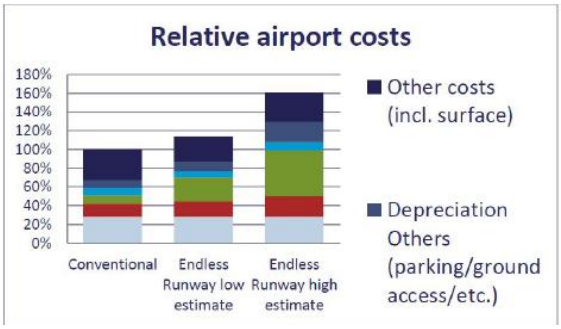

Fig: Relative airport development costs

On the benefits side, smaller ground acquisition costs due to the compactness of the infrastructure and shorter flying and taxi times leading to more efficient flights and less fuel consumption are in favor of the Endless Runway concept.

The expected total costs and revenues for a conventional airport is €1.87 Billion. The expected total cost for an Endless Runway airport is therefore €1,87 Billion * [104%-148%] = [€1,94 Billion - €2,76 Billion]. The difference is between €0.07 and €0.90 Billion per year of higher airport costs per airport when operating an Endless Runway airport. Return on investment can therefore be expected in between two and forty years.
Development, operational and non–recurring cost = €2.76 billion (max)
With FOS using PPP cost = €4.14 billion (≈NRs. 5,38,20,00,00,000/-)
Rehabilitation cost = NRs.1,81,80,87,383/-
Forest Plantation = NRs.2,67,18,00,000/-
Total Cost = NRs 5,42,68,98,87,383/-

IV. Conclusion

Endless Runway has been found as a feasible concept to be applied in Nijgadh International Airport to overcome the environmental issues that has hindered the project of national pride. It supports the feature of a transit hub as planned in its proposal with less environmental impact. A proper feasibility study should be carried out at Nijgadh with this concept that could revolutionize the concept of whole Airport engineering.

Recommendations

1. Fast Track should be completed within its time limit.
2. Sapahi Road should be black topped which will be access road.
3. The construction of airport city should be well planned and be carried out side by side.
4. Buffer Zone should be provided by providing the wildlife corridor in natural movement area.

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