The Second Meeting of the Asia/Pacific Aerodrome Design and Operations Task Force (AP-ADO/TF/2)

Video Teleconference, 26 to 29 January 2021

Agenda Item 2: Planning, Design and Construction of Aerodromes

PAVEMENT CONSTRUCTION IN ALTIPORTS OF NEPAL

(Presented by Nepal)

SUMMARY

This paper presents the empirical practice of pavement construction in Altiports of Nepal. FAARFIELD is a widely accepted software for the design of pavement thickness; both flexible and rigid. The thickness of asphalt concrete is minimum 100 mm when designed by using the software, and the thicknesses of standard Base and Sub-base are also calculated accordingly.

This paper also recommends the minimum thickness of pavement layers for altiports.

1. INTRODUCTION

1.1 The altiports of Nepal have a long history of operating in earthen and gravel pavements. It has not been more than 10 years since Civil Aviation Authority of Nepal (CAAN) started blacktopping the runway, taxiway and apron. Most of the altiports of Nepal are situated in rural Himalayas which have no road access to transport construction materials and equipment. Most of the construction were done using the local means, i.e manual labor and locally available raw material.

1.2 Nepal is a small country with huge difference in elevation from south to north, from 60 m to 8,848 m in only average aerial distance of 200 km. The access to cities becomes more and more difficult as the elevation increases. The earthen runway only serves in good weather conditions, i.e. in dry weather. In monsoon and the snowy winter, altiports remained non-operational for months. The only solution to this problem was to construct a paved runway.

1.3 The altiports were the only access to cities for the local community, and STOL aircrafts and helicopters were the only means of transport. CAAN planned a sequential construction of paved runway, taxiway and apron due to budgetary constraints. Lukla Airport was amongst the first altiports to be blacktopped. The cost of construction was very high compared to the capital city due to the difficulties in transportation of raw materials and equipment like bitumen, diesel, kerosene, cement etc. It was imperative to save construction cost without impairing safety and operation cost of aircraft.

1.4 Pavement thickness in altiports of Nepal:

S.No.	Airports	Runway Dimensions	Sub-base Thickness	Base Thickness	Asphalt Concrete Thickness
1	Lukla Airport	527*20 m	20 cm	15 cm	5 cm
2	Jumla Airport	675 *20 m	20 cm	15 cm	5 cm
3	Jomsom Airport	815*20 m	20 cm	15 cm	5 cm
4	Simikot Airport*	650*20 m	15 cm	15 cm	5 cm
5	Rara Airport*	570*20 m	20 cm	15 cm	5 cm
6	Bajura Airport	600*20 m	20 cm	15 cm	5 cm
7	Khanidanda Airport	590*20 m	20 cm	15 cm	5 cm
8	Juphal Airport	560*20 m	20 cm	15 cm	5 cm
9	Phaplu Airport	680*20 m	20 cm	15 cm	5 cm
10	Ramechhap Airport	530*20 m	15 cm	15 cm	5 cm
11	Salley Airport	580*20 m	15 cm	15 cm	5 cm
12	Taplejung Airport	900*30 m	20 cm	15 cm	5 cm
13	Thamkharka Airport	630*20 m	20 cm	15 cm	5 cm
14	Rumjatar Airport**	580*20 m	20 cm	15 cm	5 cm

*extra 20 cm of stone soling
** extra 25 cm of capping layer

1.5 The traffic data of the airports listed above is given below along with the age of pavement. Among these airports, Jumla, Jomsom and Simikot Airports have been recently overlayed with Hot Mix Asphalt Concrete. CAAN is planning to overlay the pavement of Lukla Airport as it has been more than 2 decades since the construction of the existing pavement.

S. No.	**Name of Airport**	**Paved year**	**Traffic data (no of movements) (ARR+DEP)**											**Remarks**
			2020	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	
1	Lukla Airport	2000	5,270	19,688	31,636	27,292	20,418	16,787	16,802	18,198	16,936	15,418	8,100	
2	Jumla Airport	2002	1,130	1,318	1,588	600	615	999	1,199	1,308	1,072	2,108	3,462	Overlay in 2018
3	Jomsom Airport	2000	330	4,154	3,209	3,222	3,222	2,804	3,855	2,666	4,070	4,696	4,754	Overlay in 2019
4	Simikot Airport*	2010	7,824	10,878	13,960	14,725	13,368	6,470	4,082	5,856	6,524	5,536	5,182	Overlay in 2020
5	Rara Airport*	2015	1,571	2,160	2,360	1,640	1,314	736	836	844	652	2,712	2,834	
6	Bajura Airport	2013	1,234	756	1,092	1,068	966	1,500	756	808	1,220	1,350	1,006	
7	Khanidanda Airport	2017	42	-	70	90	562	548	368	278	318	118	-	
8	Juphal Airport	2017	1,449	1,496	1,556	278	384	994	1,517	376	-	1,806	-	
9	Phaplu Airport	2014	1,955	2,541	3,297	2,965	3,326	3,828	374	1,350	2,746	2,190	2,100	
10	Ramechhap Airport	2017	686	6,958	1,304	628	260	378	1,532	1,704	1,736	2,116		
11	Salley Airport	2013	186	192	186	214	170	222	120	32	392	396	444	
12	Taplejung Airport	2016	286	435	299	334	334	90	180	66	110		42	
13	Thamkharka Airport	2015	220	116										
14	Rumjatar Airport**	2014	66	197	488	120	136	144	166	74	-	-	-	

1.6 Pavement Materials: Sub-base materials can be natural river bed material, gravel or crushed stone gravel. 50mm down aggregates are used with CBR of minimum 50 %. The Sub-base and Base material are well graded to ensure proper filling up of voids for good compaction. Base material are crushed stone aggregates with CBR of minimum 80%. The bitumen with Penetration grade 80/100 (Viscosity Grade (VG) 10 equivalent) have been used. Polymer modified, crumb rubber modified and other kinds of improvised bitumen can prolong the life of the pavement.

1.7 Maintenance plays a vital role in prolonging the life of pavement. The visible pavement distresses are identified and proper maintenance are done. Sealing of cracks can be easy but sealing of potholes can be difficult due to unavailability of heavy equipment. Small patch works are done with the help of plain cement concrete as an emergency maintenance. These concrete patches are later removed during asphalt overlay as contractors transport all necessary equipment at that period. It has been 5 to 10 or more years in some airports where maintenance is not required due to no significant pavement distress. Most of the pavement distresses were found to be due to construction defects rather than loading on pavement.

Construction Challenges

1.8 The problems faced during pavement strengthening works in altiports of Nepal are identified as follows. There have been significant improvements in the field of physical infrastructure in Nepal due to which some of the problems mentioned below have now been solved.

a. Lack of local skilled manpower
b. Lack of road access
c. Less time to work due to seasonal factors like rain and snow
d. Less time to work due to aircraft movement
e. Lack of electricity
f. Difficulty in transportation of fuel, equipment and raw material
g. Poor quality of locally available construction material
h. Conservation areas and wildlife reserves.

2. DISCUSSION

Pavement Design for STOLports

2.1 The ICAO STOLport manual (Doc 9150) does not have any content regarding STOLport's runway, taxiway and apron pavement thicknesses, neither does Aerodrome Design Manual (Doc 9157). In December 1976, FAA issued a book on Structural Design of Pavements for Light Aircraft. With the help of this book, a design for pavement of Simikot Airport has been done with following parameters:

a. Soil Subgrade Soaked C.B.R.: 4 %
b. Design Aircraft: Let-410
c. Max. Take off Weight: (Lbs) 12,500
d. Annual Departure: 13,960

2.2 The design result can be obtained as:

a. Thickness of Asphalt Pavement: 50 mm
b. Thickness of Base Layer: 150 mm
c. Thickness of Subbase Layer: 200 mm

(Refer to Annex-1 for the design Report)

2.3 Federal Aviation Administration (FAA) has issued a software called FAARFIELD which is freely available and widely accepted for design of pavements. The software have pre-defined set of standard materials like P-401, P-403 for Asphalt Surface Course, P-209, P-208, P-211 for Base Course, P-154 for sub-base etc. When we use the same design parameters following results were obtained.

a. Thickness of P-401/P-403 HMA Surface: 100 mm
b. Thickness of P-208 Cr Ag Base Layer: 150 mm
c. Thickness of P-154 UnCrAg Subbase Layer: 101.6 mm

(Refer to Annex-2 for the design Report)

2.4 From the Nepalese experience, we can see the thickness of HMA surface recommended by FAARFIELD is much higher than required. As a second trial, same elastic modulus has been used as that of P-401/P-403 HMA Surface i.e 1378.96 but as a user defined material, we get the following result.

a. Thickness of HMA Surface: 50.8 mm
b. Thickness of P-208 Cr Ag Base Layer: 150 mm
c. Thickness of P-154 UnCrAg Subbase Layer: 139.5 mm

(Refer to Annex-3 for the design Report)

2.5 The thickness of the pavement is subject to change with respect to soaked C.B.R. of the subgrade. The subgrade stabilization works or separate capping layer may be required if the C.B.R. is lower, whereas for high C.B.R subgrade the design is safe.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper;

b) discuss any relevant matters as appropriate; and

c) include the following thickness of pavement layers as minimum requirement for altiports in draft Regional Guidance for the design and operations of altiports and aerodromes in constrained environment.

   i) Thickness of Asphalt Pavement: 50 mm
   ii) Thickness of P-208 Cr Ag equivalent Base Layer: 150 mm
   iii) Thickness of P-154 UnCrAg equivalent Subbase Layer: 200 mm

ANNEX-1

Airfield Pavement Design for Simikot Airport
1. Subgrade CBR
Adopted Subgrade CBR = 4 % (Soaked CBR)

2. Annual Aircraft Departures
(from 2018 data)"
Design Aircraft: Let-410
Conversion of aircraft departures to Equivalent Annual Departures (EAD) for design aircraft (EAD) is as per FAA AC 150/5320-6E.

$$\log R_1 = \log R_2 \times \left(\frac{W_2}{W_1}\right)^{\frac{1}{2}}$$

Where,
R1 = equivalent annual departures by the design aircraft
R2= annual departures expressed in design aircraft landing gear
W1 = wheel load of the design aircraft
W2= wheel load of the aircraft in question

Aircrafts	Fleet Mix	MTOW (lbs)	MTOW (kg)	Departures	Gear type	EAD for Design Aircraft
Cessna C208	5%	8,000	3,269	695	Single-Wheel	128
Dornier 228	35%	14,495	6,575	4,865	Single-Wheel	4,786
DHC-6	35%	12,500	5,670	4,865	Single-Wheel	2,614
Let-410	25%	14,551	6,600	3,475	Single-Wheel	3,475
			Sum	***13,900***		***11,003***

The 6,950 number of annual departures from 2018 data has been doubled for use in pavement design due to the central link taxiway configuration in the airfield in question. This configuration results in two passes of an aircraft along the runway for a single departure operation in contrast to a single pass for single departure in case of parallel taxiway.

Table 1

Minimum Thickness Requirements

Gross Weight, kips	100-CBR Base Pavement	100-CBR Base Base	80-CBR Base Pavement	80-CBR Base Base	50-CBR Base Pavement	50-CBR Base Base
			Single-Wheel Aircraft			
4.0	ST	4	MST	4	MST	6
8.0	MST	4	MST	4	1-1/2	6
12.5	1-1/2	4	2	4	2	6
16.0	2	4	2	4	2-1/2	6
20.0	2	6	2	6	3	6
			Dual-Wheel Aircraft			
10	ST	4	MST	4	MST	6
15	MST	4	MST	4	1-1/2	6
20	1-1/2	4	2	4	1-1/2	6
25	2	6	2	6	2	6
30	2	6	2	6	2-1/2	6

3. Minimum Thickness Requirements
Minimum thickness of surfacing = 2 inches ~ 50 mm
Minimum thickness of base = 4 inches ~ 100 mm
However, 150 mm base thickness is adopted in line with prevalent practice due to size of maximum nominal size of aggregate.

4. Pavement Design (20 years design life)
Using adopted CBR and annual departures (S.N. 1 & 2),
Total Pavement thickness = 15 inches ~ 400 mm (above subgrade)
Subbase thickness = 400 – 50 – 150 = 200 mm (using S.N. 3)

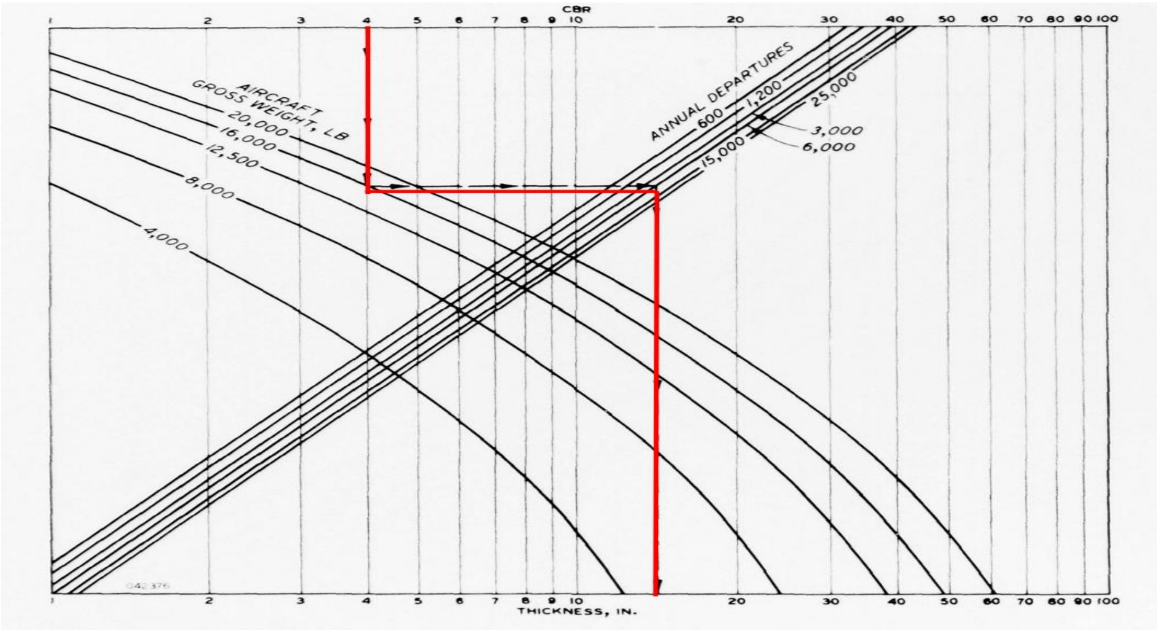
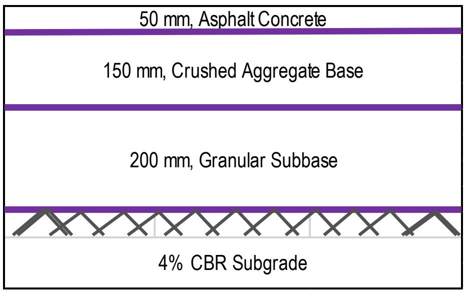


Figure 3. Flexible pavement design curves for light-load aircraft, single-wheel gear



Design Reference: FAA-RD-76-179, Structural Design of Pavements for Light Aircraft December 1976, by Ladd, Parker, Percira; ADA-04 l-300. This document has been included under "Related Reading Material" of FAA AC 150/5320-6F.

ANNEX-2

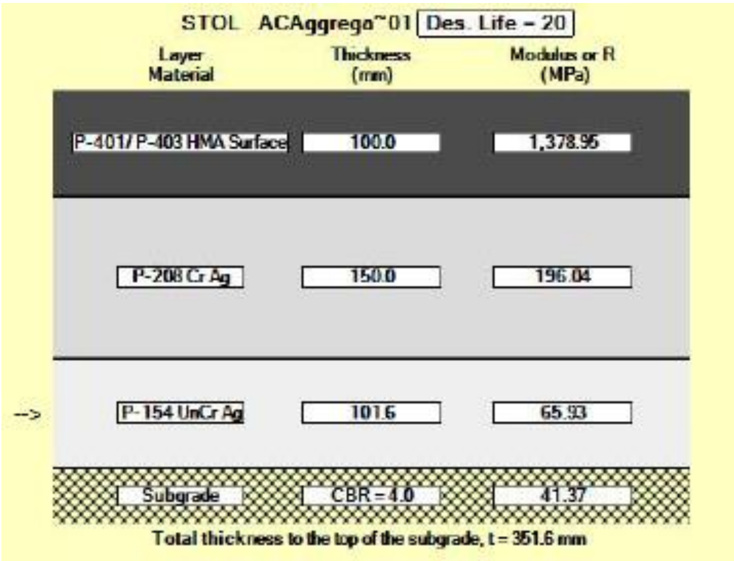
Airfield Pavement Design for Simikot Airport

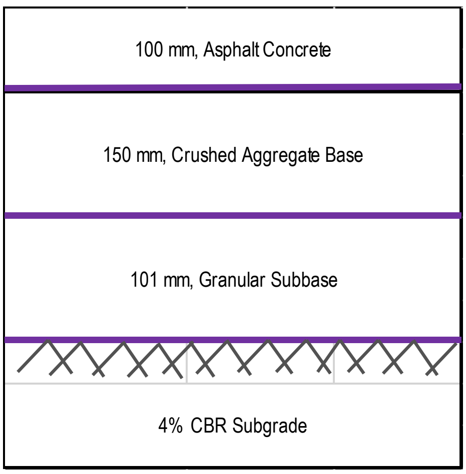
1. Subgrade CBR
Adopted Subgrade CBR = 4 % (Soaked CBR)

2. Annual Aircraft Departures (from 2018 data)"

Aircrafts	Fleet Proportion	MTOW (lbs)	MTOW (kg)	Annual Dep.	Gear type
Cessna C208	5%	8000	3269	700	Single-Wheel
Dornier 228	35%	14495	6575	4800	Single-Wheel
DHC-6	35%	12500	5670	4800	Single-Wheel
Let-410	25%	14551	6600	3600	Single-Wheel
			Sum	***13900***	

3. FAARFIELD v 1.42 - Airport Pavement Design





ANNEX-3

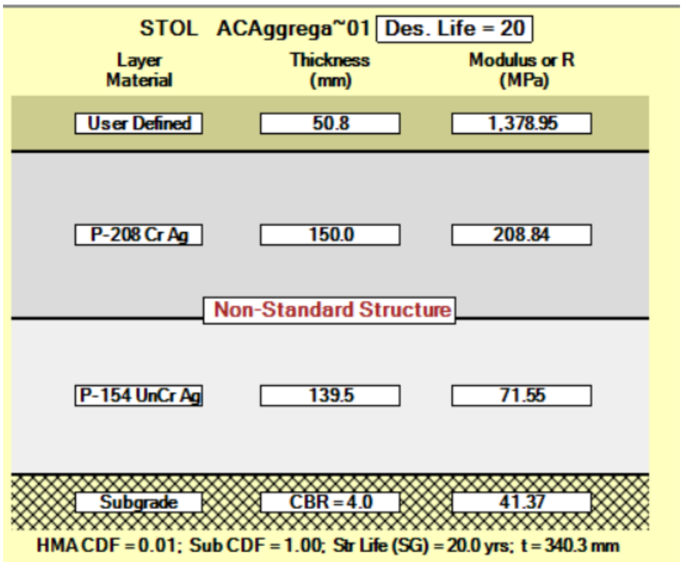
Airfield Pavement Design for Simikot Airport

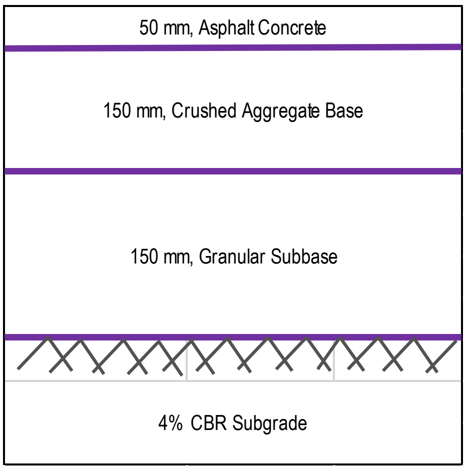
1. Subgrade CBR
Adopted Subgrade CBR = 4 % (Soaked CBR)

2. Annual Aircraft Departures (from 2018 data)"

Aircrafts	Fleet Proportion	MTOW (lbs)	MTOW (kg)	Annual Dep.	Gear type
Cessna C208	5%	8000	3269	700	Single-Wheel
Dornier 228	35%	14495	6575	4800	Single-Wheel
DHC-6	35%	12500	5670	4800	Single-Wheel
Let-410	25%	14551	6600	3600	Single-Wheel
			Sum	***13900***	

3. FAARFIELD v 1.42 - Airport Pavement Design





— END —