AIRPORT

Transportation System:

↳ 3 functional components.

- Fixed facilities – Runway, Terminal buildings, Hangers etc (maintenance and repair shed)
- flow entities – Airplane, Heli
- Control system – ATC, Runway markings, signs etc.

→ Safe & efficient travel of passengers & goods.

Comparison between different modes of transportation:

- Ubquitiy → Accessibility to the system.
- Mobility → speed or reliability of the system/or capacity.
- Efficiency → Ratio of output to the input.

Different modes: Roadways, Railways, Airway, waterways, pipe lines, conveyor belt, Ropeways etc.

Airport Engineering

↳ It is branch of transportation Engineering.
↳ planning, designing, construction, operation and maintenance of Airway (i.e. for landing, takeoff, Terminal facilities, cargo movement, Hanger etc.
→ For safe and efficient movement of goods and passengers.

As an airport Engineer your role :-

→ analyze wind direction for runway orientation.
→ Size of runway stripe.
→ Safety areas/clear zone.

→ Intermodality of transportation system (accessibility with roads / rails)
→ Parking zones.

History of Airway in Nepal :

1949 : Indian Ambassador Mr. Sarjit Singh landed at Gauchaur airport.

1955 : King Mahendra inaguraled Gauchaur airport and renamed it Tribhuwan Airport.

1957 : Grassy runway → concrete civil aviation department under Ministry of work, communication & Transport.

1958 : Royal Nepal Airlines started service.

1959 : RNAC under HMG|N →(His Magesty of Government|Nepal).

1960 : ICAO membership
1964 : Tribhuvan Airport renamed as TIA.
1975 : TIA runway expanded to 10,000 ft from 6600 ft

1977 : Nepal imprinted on Aeronautical world.

1993 : first civil Aviation policy. (CAAN)

1998 : Civil Aviation Authority of Nepal became an independent Nepali Government body.

2022 : Inagural of Gautam Buddha International Airport.

2023 : Inagural of Pokhara Int'l Airport.

Current Status :

- 53 Airports
  - → 3 International
  - → 2 Regional domestic
  - → 48 domestic.

→ 40 paved
→ 33 operating.
→ Bilateral agreement with 40 countries.
→ Annual used seat numbers - 3.46 million (43 %)

Development of New Airport:

1. Traffic forecast
2. Determination of capacity of existing airport.
3. Improvement of existing airport.
4. Planning of new airport.

1. Traffic forecast:

→ Area to be served
→ Origin and destination of residents and non residents.
→ Population growth
→ Economic character of the area
  - Income level per capita.
  - Types of business activities.
  - Trends in existing traffic.

2. Determination of capacity of existing airport:

↳ capacity of runways and taxiways is assessed.
↳ capacity of terminal buildings.
↳ Adequacy of Apron and servicing facilities.

3. Improvement of existing airport:

↳ Runway extension
↳ Parallel Runway.
↳ ~~Rearrangement~~ Rearranging Terminal building facilities.
↳ Rapid exit Taxiways.

4. Planning of new airports:

↳ If improvement of existing capacity cannot fulfill the demand then planning of new airport is done.

Planning of Airport:

→ for fulfilling current and future demand.

→ most efficient plan is that which provides the required capacity with maximum passenger, operator and staff at lowest capital and operating cost.

Master plan of Airport:

↳ Planners concept for development of airport

↳ graphical & report format.

Indudes:

↳ physical features of an airport.

↳ Land use plan for areas surrounding an Airport

↳ Environmental effect.

↳ Access requirement.

↳ Airport master plan are reviewed at least anually and modified every five years.

1) Policy Planning:

→ Setting project goals and objectives.

→ Preparing work programme schedules and budget.

→ Evaluation and decision making format.

→ Establishing monitoring procedures.

→ data management and information system.

2) Economic Planning :

→ Preparing market outlooks and market forecast.
→ Analysis of different alternatives.

3) Physical Planning :

→ Terminal building planning
→ Airport layout planning
→ Ground access system
→ Communication services development.

4) Environmental Planning :

→ EIA preparation.
→ view of neighbouring communities.

5) Financial planning :

→ sources of finance.
→ feasibility study.

Level of planning :

1) Strategic Planning

→ Long Term planning
→ Focus on civil aviation of whole country.
→ Aviation system planning
→ Works under goals and objectives of the CAAN.
→ National enplaned passenger.

2) Tactical planning

→ Medium / short term planning
→ focuses on particular airport.
→ Airport system planning.
→ Works under goals and objectives of a particular airport.
→ Enplaned passenger for a particular airport.

Forcasting for planning purpose :

→ To access the characteristics of future demand.

Factors affecting forecast of demand:

→ Local and regional socio-economic data.
→ demographics
→ geographical attributes
→ external factors such as fuel cost.
→ political developments.
→ Changes in security, airline delay, congestion.

Principles of forecasting:

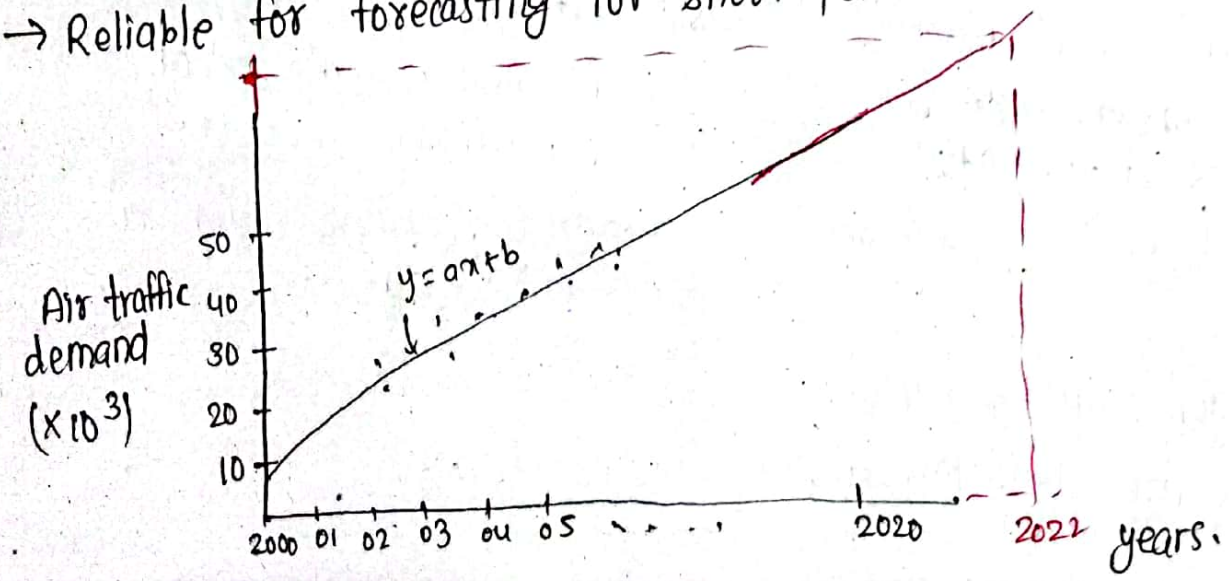
↳ Historical data is required at least 10 years.
↳ Long term → 10-20 years forecast.
Medium → 6-10 years forecast.
Short term → < 6 years forecast

→ > 20 years forecast is necessary for additional airport facility.
→ Forecasted data should be validated.

Methods of forecasting:

1) Trend Forecast:

→ Basic assumption: Travel pattern remains same.
→ Reliable for forecasting for short period.



2) Base forecast method:

→ Compute a ratio,

$$r = \frac{\text{Passenger per 1000 popn for airport}}{\text{Passenger per 1000 popn for nation}}$$

→ multiply this ratio with national forecasted volume.

3) Econometric Model:

→ In the form of multiple regression analysis.

→ Expressed as:

$$T = a_0 + a_1 x_1 + a_2 x_2 + a_3 x_3 + \dots + a_n x_n$$

where, T = no. of Trips / Traffic / Passengers

$a_0, a_1, a_2, a_3, \dots a_n$ = Regression coefficient.

$x_1, x_2, x_3 \dots x_n$ = Independent variable

- ↳ GDP
- ↳ Income level
- ↳ Import
- ↳ Export etc.

Qualitative Analysis:

4) Delphi Technique

↳ Ask the expert.

Forecasting Accuracy:

→ The validity of forecasting method depends on how accurately predictions can be made using that method.

→ One approach to estimate accuracy is to compare the actual results with those predicted by the models.

→ Another method is to fit the model only to part of data (Truncated analysis) and apply the model to rest of data to test accuracy.

Limitations of forecasting:

→ Doesn't consider the unforeseen events such as COVID.
→ Change in Technology (for eg: Internal combustion engine to electric vehicle)
→ Development of more advanced type of transportation system (eg: Maglev (Magnetic levitation (train movement)), Hyperloop) may affect forecast.

Airport site evaluation: Factors affecting airport site location:

Airport:

The area on land or water intended for the use of aircraft for landing & takeoff with other facilities (eg. terminal building, parking, cargo facilities etc.).

Factors:

1. Regional plan / policy
2. Wind direction (major prevailing wind, 6.4 km/hr → calm period, ≯23 kn → cross wind component)
3. Geological condition should be stable.
4. Area availability with consideration of future expansion.
5. Airport use (military, passengers, Helipads etc).
6. Accessibility to the other mode of transport.
7. Visibility criteria (Ground + air)
8. Economic consideration (for construction, operation.

Airport components — Airfield (movement of airplane or which facilitates its movement)
— Terminal (where movement of airplane doesn't take place)

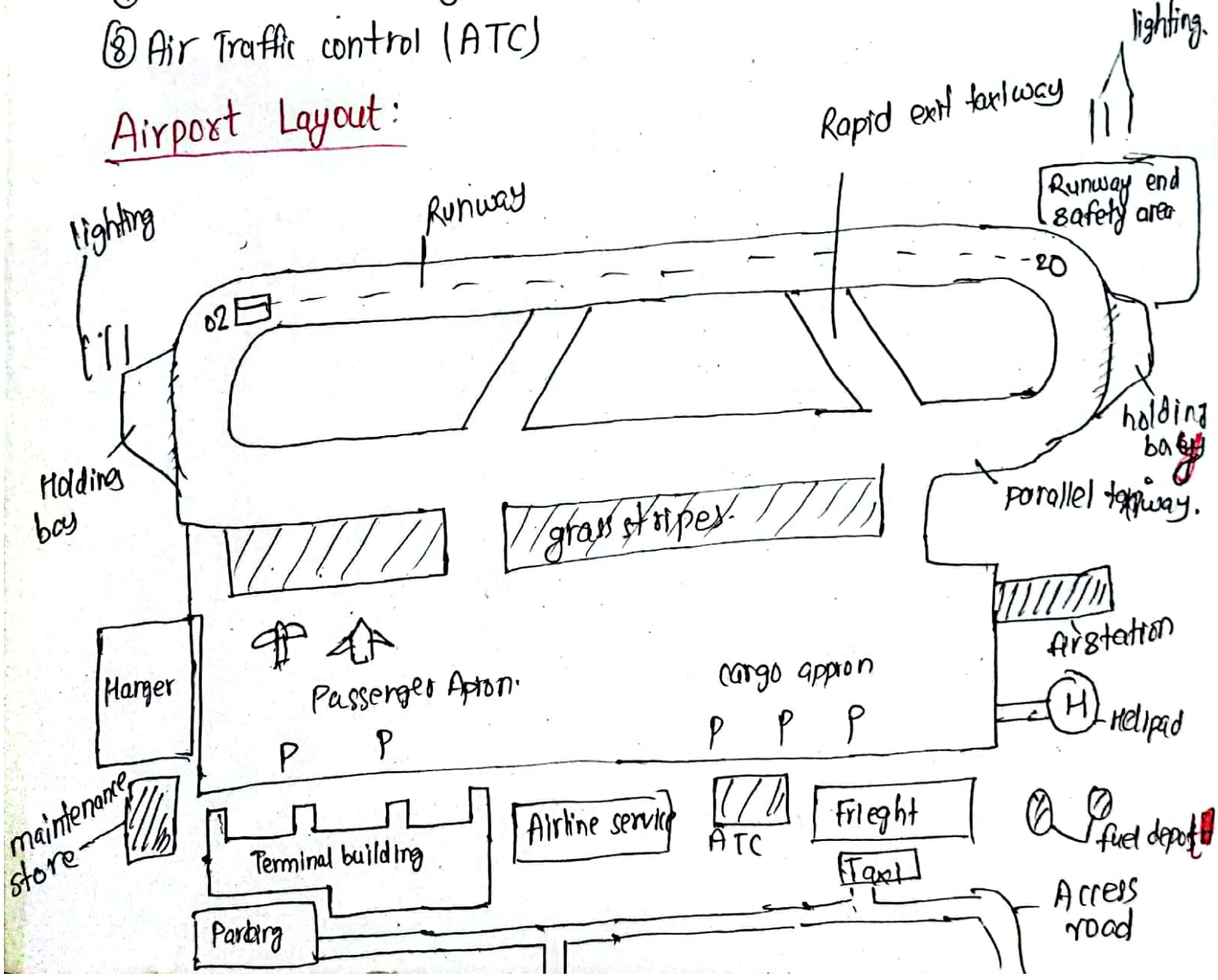
Airfield components:

1) Runway
2) Taxiway
3) Hanger
4) Navigational aids
5) Lightings
6) Fuel supply for aircraft
7) Weather reporting components (Hydrology / meterology)
8) Air Traffic control (ATC)

Terminal

1. Apron
2. Ground handling system
3. Passenger handling system
4. Gate system.

Airport Layout:



Factors for airport layout:

① Number and orientation of runway
② Number of Taxiway.
③ Size / Area of airport.
④ Expected airtraffic / passengers / cargo.
⑤ Obstacle to the airplane.
⑥ Meterological conditions.
⑦ Surrounding land use.

Aircraft component parts:

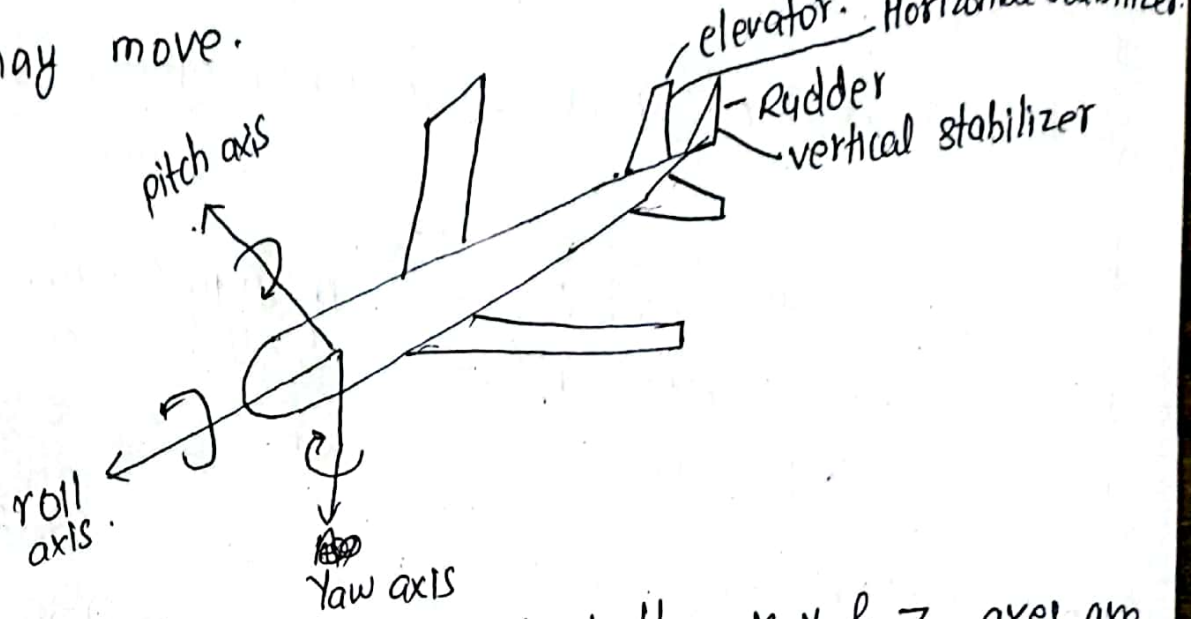
① Engine
② Propeller
③ Fuselage.
④ Wings
⑤ Three controls
⑥ Flaps
⑦ Tricycle under carriege.
↓
number of wheel configuration
↓
Pavement design.

① Engine : ① Piston Engine
② Jet Engine
③ Rocket
→ speed of aircraft
↓
landing & take off distance.
④ Turbo engine.

② Fuselage: → It is a main body of aircraft where other components are attached.

Wings: It produces lift that allows plane to fly. It also supports engine of aircraft.

3 controls: These are the axes which an aircraft in space may move.

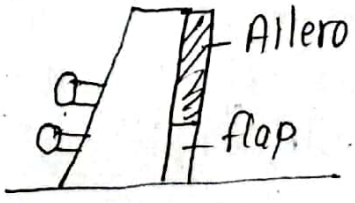


→ The movement of aircraft about the x, y & z axes are called lateral (rolling), pitching and yawing movements respectively.

i) Elevator: It consists of two flaps capable of moving up and down through an angle of 50 to 60°. It controls pitching movement.

ii) Rudder: It consists of streamlined flap hinged to a vertical fin provided at the tail and can move left to right at an angle of 30°. It is utilized for yawing movement.

iii) Aileron: It is a hinged flap which is fixed in the trailing edge of the wing near the wing tip. It is used for rolling movement.



Tricycle undercarriage:

It is a structure to support the aircraft while it is in contact with the ground.

① To absorb the shock while take off & landing.

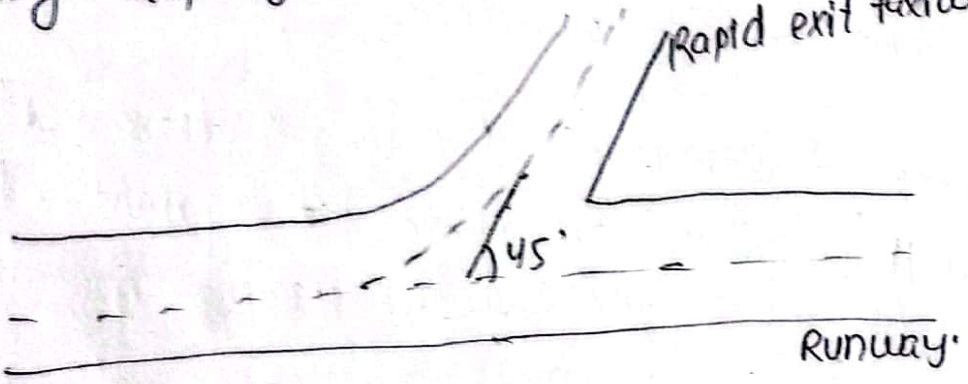
② To distribute the wheel load to wider area.

Taxiway:

Taxiways are the path on the airfield surface for taxing of an aircraft and are intended to provide linkage between runway and apron.

Rapid exit taxiway:

→ A rapid exit taxiway is a taxiway connected to a runway at an acute angle ($>25°, <45°$) and are designed to allow landing airplanes to turn off at higher speeds thereby minimizing runway occupancy time.



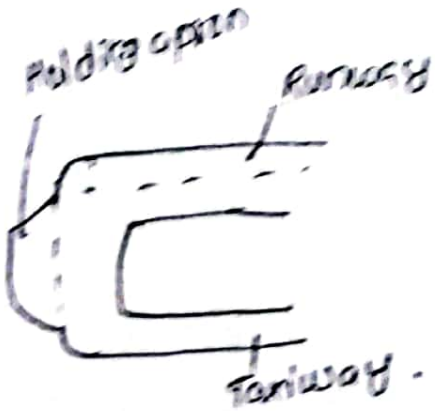
Apron:

→ An airside area intended to accomodate aircraft for the propose of loading and unloading passengers, cargo, maintenance or fueling etc. is called apron.

→ It is classified according to its function.

→ Location and size depends upon:-
1) Number of aircraft & Types
2) Size of aircraft
3) Shape of terminal.
4) Area available
5) Clearance required
6) Ground access.

1) Holding apron:



→ Holding bays / aprons are placed adjacent to the ~~one~~ ends of runway where aircraft park briefly before takeoff.
→ Used when runway is busy, engine warming up, cockpit and instrument check before takeoff.

2) Passenger Apron:
→ Space dedicated to the boarding and ~~unloading~~ unboarding of passengers and can also be used for fueling, general check up of aircraft.
→ Shape deperds upon the type of terminal building, Type of boarding gate.

3) Parking Apron:
→ Space used for parking of an aircraft.
→ It may be used for overnight parking or for maintenance purpose.

4) Cargo apron:
→ Seperate space for air craft carrying cargo.
⇒ Should be near to cargo terminal building.

→ Should be equiped with cargo lifting facilities.

5) Service apron / Hanger Apron:
→ for maintenance of aircraft.

Terminal :

It is a building provided for passengers and cargo.

Functions:

① Change of mode for airways to other mode (roadways, metros)
② Passenger processing facilities (security check, ticketing etc)
③ Cargo facilities.
④ Recreational activities (Shopping, Restaurants) for passengers.
⑤ Provide waiting facilities, Restroom, internet
⑥ facilities, drinking water.

Types of Terminal:

① Passenger Terminal
② Cargo Terminal.

Airport Capacity:

→ Airport capacity refers to the ability of an airport to handle a given volume of traffic (demand) within a specified period of time.
→ can be discussed under four headings..
① Airspace
② Airfield
③ Terminal capacity.
④ Ground access.

Factors affecting airport capacity :-

→ number of runways, spacing, orientation of runway.
→ Presence of rapid exit taxiway.
→ Apron gates, boarding bridge.
→ Amount of aircraft, size of aircraft.
→ Weather condition (fog, Rain, Hailstone, storm)
→ Wind direction.
→ Efficiency of cargo handing system.
→ Demand of passenger of peak period.

Runway capacity:

Gate capacity

Factor affecting runway capacity:

Numerical:

Q. If an aircraft occupies a gate for an average 30 min. What is the capacity of the gate?

Soln

Capacity of gate = 1 aircraft / 30 min / gate
= 2 aircraft / hr / gate.

Q. If there are 10 gates available with following aircraft mixes, Determine the capacity of gate.

Aircraft class	Percent mix	Average occupying time
1	10	20 min
2	30	40 min
3	60	60 min

Soln

$$\text{Capacity of a gate} = \frac{1}{0.1 \times 20 + 0.3 \times 40 + 0.6 \times 60}$$

$$= 0.02 \text{ aircraft / min / gate}$$

$$= 1.2 \text{ aircraft / hr / gate.}$$

There are 10 gates;

$\therefore$ Capacity of gate $= 10 \times 1.2 = 12$ aircraft / hr.

Factors causing delay:

Airfield characteristics:

- higher runway ocupany time
- Higher taxing of airplanes
- lacking of parking facilities
- Inefficient air traffic controlling.

Air space characteristics:

- nearby airport
- obstacle.

Meterological characteristics:

- presence of fog, snow, Heavy rain, storm etc.

Demand characteristics:

- As demand reaches its capacity, delay ocurs.

4.2.2.6: Environment Related

Aircraft Noise:

The noise that is generated by the aircraft operation (takeoff and landing) is called aircraft noise.

Factors:

1) Type of aircraft
2) Type of engine.
3) Time of a day of its operation (i.e day & night)
4) Meterological factors (rain, fog, wind etc)
5) Operation procedure of an aircraft.

Effect:

→ can be divided into two broad categories:-

1) Behavioural Characteristics / effict: annoyance / irritation, interference with communication, mental disrest, sleep etc.

2) Health / Psychological effect:
Loss of hearing, cardiovascular diseases, panic heart attack.

Air pollution:

→ It can be defined as the presence of unwanted particles on the air or the interference of natural composition of air. Hub airport with considerable amount of commercial aircraft contributes to air pollution.

Contributing factors of air pollution by aircraft:

① Type of engine
② Idling condition of aircraft (इंजीन on बसा राखने condition)
3. Presence of dust particles on the runway.

4) Unpaved shoulder.

Effects:

↳ Respiratory difficulties, unhygenic environment, eye and nose irritation.

Water pollution:

→ Water is the scarced resource on earth.
→ Mixing of unwanted chemicals on the water is called water pollution.

Causes of water pollution:

1) Washing of rubber deposit from runway during rain.
2) Washing of fuel spilled on the Apron or runway that get mixed on the water resources.
3) Washing of chemicals due to deicing of aircraft in snow covered areas.

Effects:

1) Water gets polluted and becomes less usable.
2) Ground water/aquifier cannot be recharged. due to low impermiability of airport infrastructure.
3) Heavy Runoff during rain causing flash floods.
4) Aquatic life at the downstream of natural stream gets affected.

Global environmental problem arising from airport use:-

→ Airports of all sizes have an impact of some kind on the environment, both locally and globally.

→ This can include:-

1) Emissions from aircraft and ground vehicles, as well as from power use in buildings, all contribute to climate change and local air quality loss.
2) Global warming.
3) Potential damage to local wildlife and habitats.
4) Disposal of an aircraft after it's servicable life.

These effects can be controlled by adopting some control measures:-

1) Investing on renewable energy that helps to minimize the degredation of air quality.
2) Encouraging airlines to use energy efficient aircraft or quieter aircraft through charges or incentives.
3) Increase airport efficieny i.e. by reducing the duration of aircraft idling, unnecessary taxing.
4) Developing biodiversity strategies that balance the need to protect aircraft safety but maintain a positive natural environment.
5) Should develop the proper strategy for better waste disposal.

Land use planning :

→ Land use planning and management is an effective means to ensure that the activities nearby airports are compatible with aviation. It's main goal is to minimize the population affected by the aircraft noise and accidents by introducing land use zoning around airports.

→ Locate new airports at an appropriate place such as away from noise-sensitive areas.

→ Define zones around the airports associated with different noise levels such that other facilities (i.e. hospitals, schools etc.) can be planned accordingly.

→ Approach zones for landing and takeoff should be properly defined.

→ Ensure that reader-friendly information on aircraft operations and their environmental effects to communities near airport.

#Ch-1

There are different national and international agency working for betterment of civil aviation :-

① MoCTCA
② CAAN
→ National

③ ICAO
④ FAA
⑤ ADG
→ International

MoCTCA :

→ Ministry of Tourism came into existence in 1978 A.D.
→ 1982 AD, civil aviation was merged and ministry of tourism and civil aviation was formed.
→ In 2000 AD, culture sector was also integrated and called ministry of culture, Tourism and civil aviation.
→ In 2008 A.D., MoCTCA was divided into ministry of Tourism and civil Aviation and ministry of culture and state restructuring.
→ In 2012, culture sector has been integrated with the tourism and became MoCTCA.
→ It consists of 4 divisions :-
1) Tourism Division
2) Administration and planning Division
3) Culture Division
4) Civil Aviation Division.

Role of MoCTCA :

→ Aircraft design and construction, operation and maintenance, Airport construction and operation, air navigation service and civil aviation training → monitoring and permission.
→ Airfare, Airport charge, air navigation service → pricing & monitoring
→ Airservice operation policy → permission.
→ Development of civil aviation policy, rules and regulation and monitoring.
→ Permission for professionals and business related to aircraft and airports.

→ Air Traffic services
→ Airspace management.
→ Information regarding meterological conditions.
→ Civil aviation rescue.
→ Aircraft accident study.
→ Ultralight, paraglyding etc → development of policies.

Civil Aviation Authority of Nepal (CAAN):

→ GoN introduced first ever civil aviation policy in 1993 A.D. This policy made the provision of transformation of Department of Civil Aviation into an autonomous civil Aviation Authority.
→ Accordingly CAAN was established as an autonomous regulatory body on 31st Dec. 1998 under civil Aviation Act 1996.
→ CAAN is a regulator of civil Aviation as well as the service provider in the areas of air navigation service and aerodrome services.

Mission:
Ensuring safe, efficient, secured, standard and quality of service in civil aviation.

Vision:
Making air service an effective vehicle of high economic growth though wide scale tourism promotion and accessibility

Functions:
1) Permitting airlines operation.
2) Airworthiness certification and manpower Licensing/Rating.

3) Regulating air transport, air navigation on services and aerodromes as per ICAO.
4) Constructing, operating and maintaining airports.
5) Equipping and maintaining air ports with neressary communication and navigational facilities.
6) Operation of safe, efficient and expeditious flight.

Income Sources:

→ Landing, parking, over-flying navigation charges.
→ Charter charges, passenger service charges,
→ vehicle entry-parking charges.
→ Advertisement charges.
→ Terminal Rent
→ Land Rent
→ Royalty
→ Cargo charges
→ Regulating fees.
→ Ground handling charges etc.

International Civil Aviation Organization (ICAO):

→ The ICAO concept was formed during a conference of 52 nations held in Chicago in 1944. This conference was by an invitation of united states to consider matters of mutual interest in the field of air transportation.
→ It is the most important international agency concerned for airport development.
→ It is a specialized agency of the UN with headquarters in Montreal, Canada.
→ There are 193 member countries as of 2019.

Objectives:

1) Ensure the safe and orderly growth of international aviation throughout the world.
2) Encourage the arts of aircraft design and operation for peaceful purpose.
3. Encourege development of airways, airports and air navigation facilities.
4) Meet the needs of people for safe, regular, efficient and economical air transport.
5) Prevent uneconomical waste by unreasonable competition.

Economic Role of airports

→ Generation of employment opportunities.
→ Attracts investments in the area.
→ Air transport contributes to world trade.
→ Air transport stimulates tourism.
→ Air transport is a significant tax payer.

Social Role:

→ provides access to remote areas.
→ Delivers humanitirian aids.
→ Improve quality of life.
→ Poverty alleviation through employment, trade & tourism
→ Rescue operation.
→ Time & cost saving.

Political Role:

→ Exchange of culture and social values.
→ Exchange of technology.
→ Generates trade opportunities
→ Decentralization.

4.2.3. Geometric design of Runways:

Runway:

A runway is a rectangular area on the airport surface prepared for take off and landing of aircraft.

→ An airport may have one or more runway which are sited, oriented and configured in a manner to provide for the safe and efficient use of airport under a variety of conditions

Aerodrome:

An aerodrome is a part of an airport used by an aircraft.

Aerodrome Reference code:

→ A system of code numbers and letters selected for aerodrome planning purpose in accordance with the characteristics of the airplane for which aerodrome facility is intended.

Code No	Reference field length, m	Code letter	Wing span (m)	Distance between outside edges of main wheel gear (m)
1	<800	A	<15	<4.5
2	800-<1200	B	15-<24	4.5-<6
3	1200-<1800	C	24-<36	6-<9
4	>1800	D	36-<52	9-<14
		E	52-<65	9-<14
		F	65-<80	14-<16

↳ As per ICAO.

For eg :-

Airport	Reference code	Critical Aircraft
TIA	4E	Airbus 330
Biratnagar	3C	ATR 72
Nepalgunj	3C	ATR 72
Jomsom	1B	DHC 6
Lukla	1B	D228

Factors affecting location, orientation and number of runways:

↳ Local weather condition, particularly wind distribution and visibility.

↳ topography of the airport and surrounding areas.

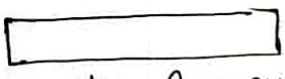
↳ Volume of air traffic that a particular airport is supposed to handle.

↳ Aircraft noise.

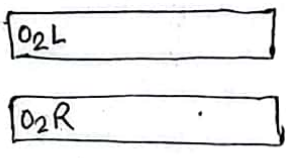
Runway configuration:

→ Refers to the number and relative orientation of one or more runways. The basic configuration are:

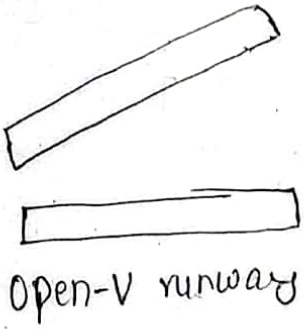
1) Single runway
2) Parallel runway
3) Intersecting runways
4) Open-V Runway.



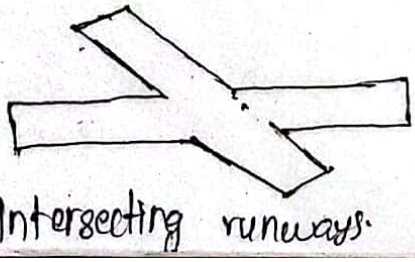
Single Runway.



Parallel runway.



Open-V runway



Intersecting runways.

Runway orientation

→ The orientation of runway is defined by the direction, relative to magnetic north, of the operations performed by aircraft on the runway.

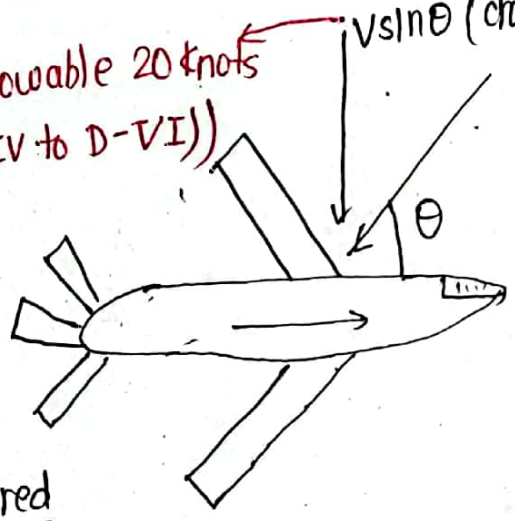
→ Runway is oriented based on local wind condition.

Runway orientation: Wind factor

① **Head Wind**: is a wind which is coming from the front side that is just opposite to the movement of aircraft.

② **Tail Wind**: is a wind which is coming from the tail side.

③ **Cross wind**: The normal component of the wind ($V\sin\theta$) acting at Right angle to the direction of aircraft is called cross wind. Aircraft will drift from the runway if cross wind is high.



↳ Requires greater width of runway as aircraft drifts.

Head wind

→ Takes shorter length of runway

→ Increases lift while takeoff

→ while landing increases resistance.

Tail wind

→ Increases the required length of runway for take off and landing.

→ FAA recommends that runway should be oriented so that aircraft may be landed at least 95 percent of the time with allowable cross wind components.

Wind Rose Diagram:

→ It is a graphical representation of wind data (direction, duration and Intensity)

→ Two types of wind Rose:

(i) Type-I (Direction and Duration)

(ii) Type-II (Direction, duration & intensity)

→ Wind data should be taken for a period of 5-10 years.

→ Gives orientation of runway with respect to True North.

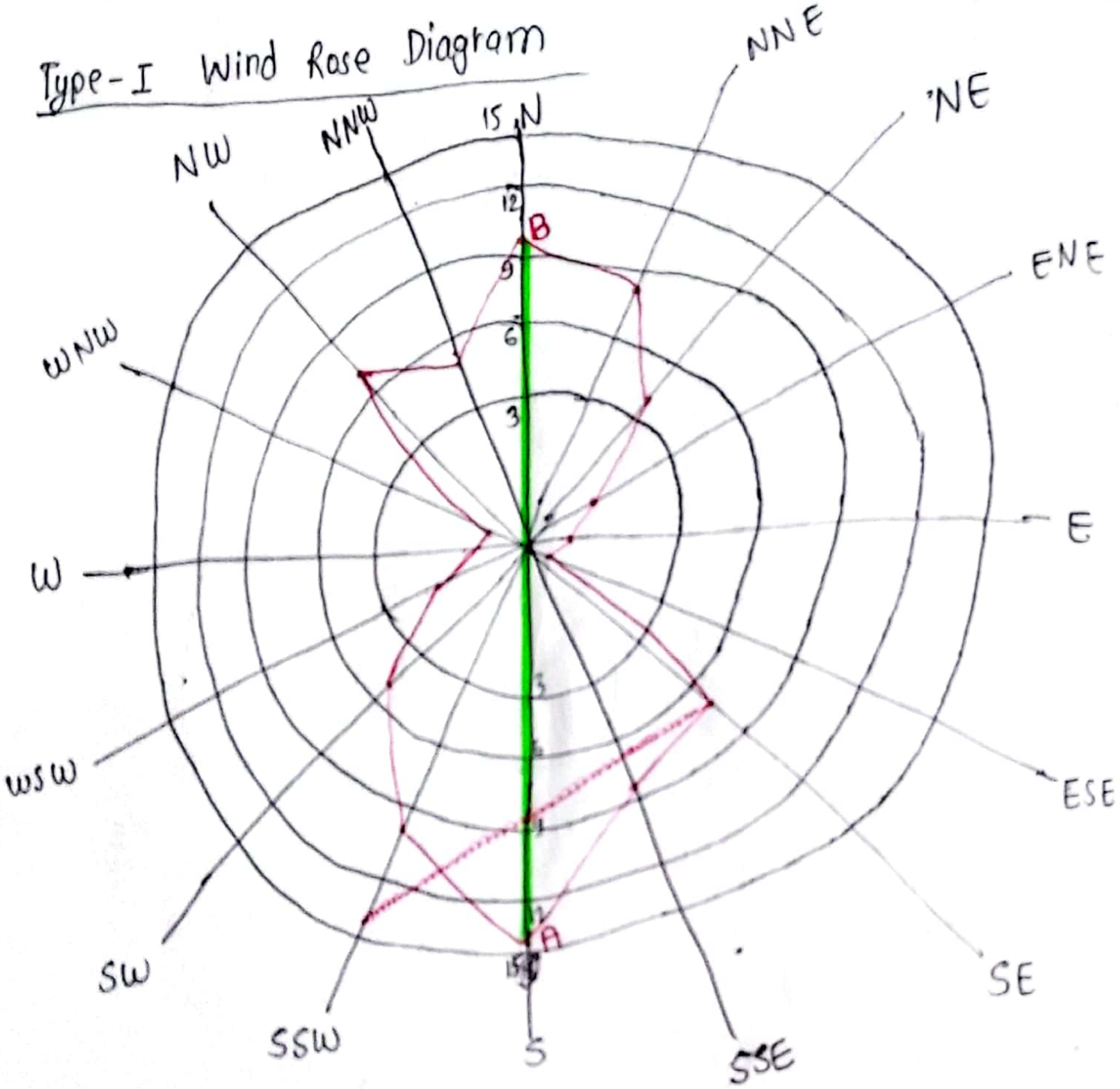
Direction	Duration of wind (%)			Total % of time wind blew betn 6-60 kmph
	6-25 kmph	25-40 kmph	40-60 kmph	
N	7.4	2.7	0.2	10.3 = 7.4 + 2.7 + 0.2
NNE	5.7	2.1	0.3	8.1 = 5.7 + 2.1 + 0.3
NE	2.4	0.9	0.6	3.9
ENE	1.2	0.4	0.2	1.8
E	0.8	0.2	0	1
ESE	0.3	0.1	0	0.4
SE	4.3	2.8	0	7.1
SSE	5.5	3.2	0	8.7
S	9.7	4.6	0	14.3
SSW	6.3	3.2	0.5	10
SW	3.6	1.8	0.3	5.7
WSW	1	0.5	0.1	1.6
W	0.4	0.1	0	0.5
WNW	0.2	0.1	0	0.3
NW	5.3	1.9	0	7.2
NNW	4	1.3	0.3	5.6
			Total =	86.5

Type-I

100 - 86.5 = 13.5 % of time.

↳ calm period. (Speed of wind < 6 kmph for 5th period in this example)

Type-I Wind Rose Diagram



→ Here, concentric circles represent wind duration and radial lines represent direction

→ The total % duration of wind is plotted along respective directions and the points are joined to form closed figure.

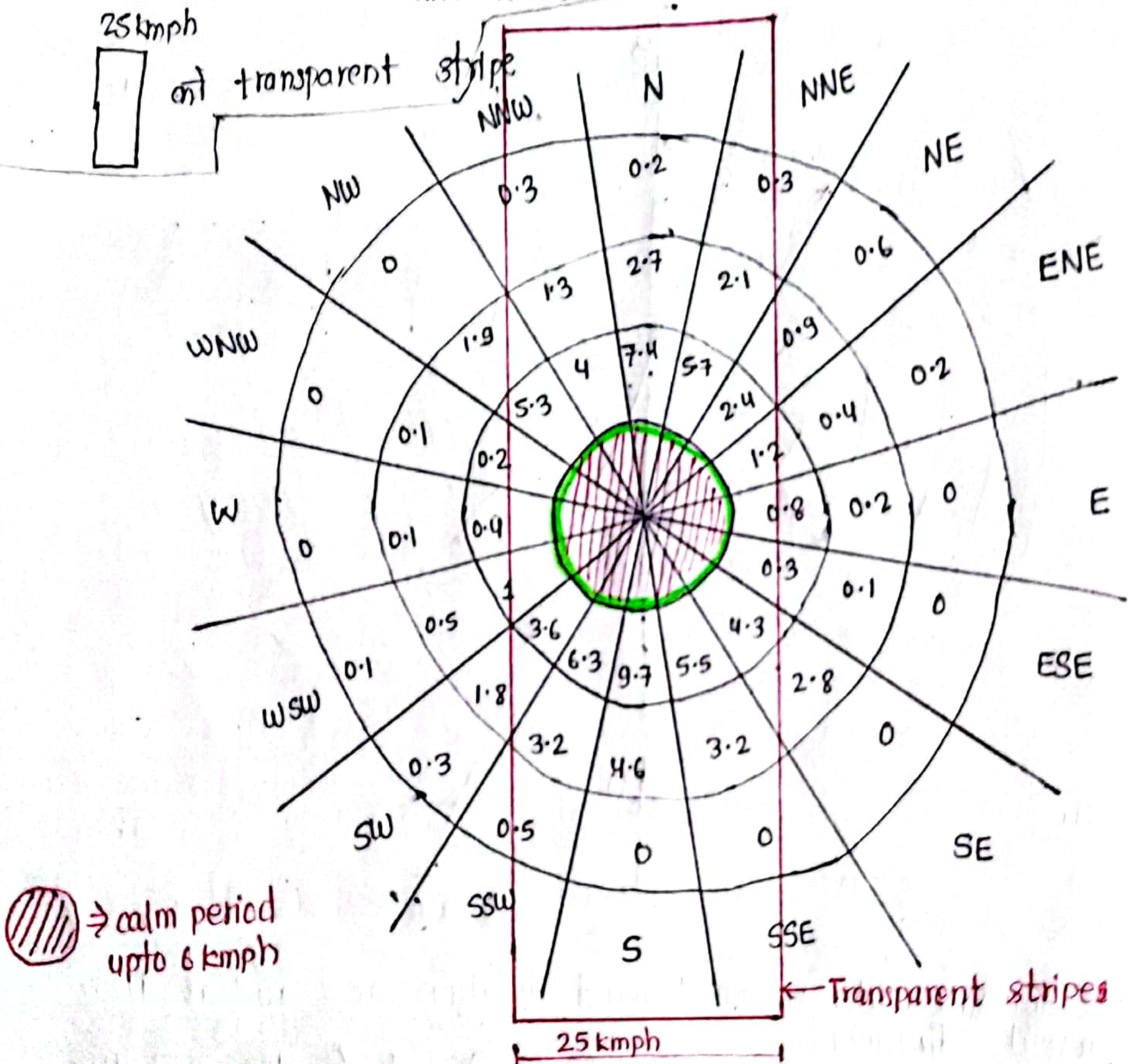
→ Runway is oriented along the longest line joining the two end of plotted figure.

→ In the above diagram, AB is the longest line joining the two end of plotted figure. So, the orientation of Runway is (North-South) direction.

Type II (Exam मा सोधेको)

Allowable cross wind component = 25 kmph.

95 % भन्दा बढी आउने मान लिने। (max. value) → gives orientation)



→ Here, concentric circle represents wind speed/Intensity and Radial wind coverage area shows the direction.

→ In each segment, the duration of wind is written which is called wind coverage area.

→ Allowable cross-wind component for mixed size aircraft is 25 kmph. So, 25 kmph width transparent strip (at same scale) is placed along a direction.

→ (The wind coverage percentages superimposed by the strip + Calm period) is added to get total wind coverage. The strip is rotated for each direction and wind coverage for each direction is calculated.

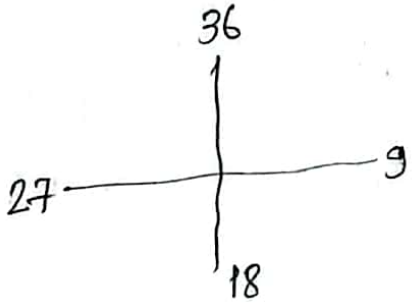
→ The orientation of runway is the direction with max^{m} wind coverage which shouldn't be <95%

Runway Designation:

→ Because true north is used for published wind data, this bearing usually will be different from that used in numbering runways since runways are designated based on magnetic bearing.

Steps:

① Convert to degrees
② Adjust to magnetic variance
③ Divide the bearing by 10
④ Round to the nearest whole number.
(if the answer is 0. Use 36)



Q. From a wind Rose diagram a proposed runway is determined to be N 54° 30' W, with a magnetic variance of 14° 45' west. Designate the runway.

Soln

Bearing w.r.to True North = N 54° 30' W = 305.50°

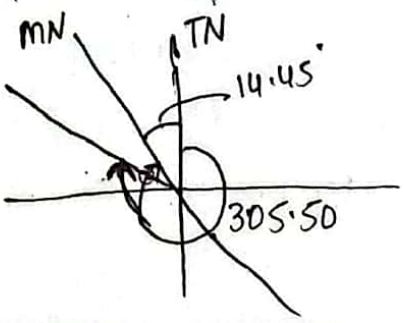
Magnetic variance = 14° 45' west

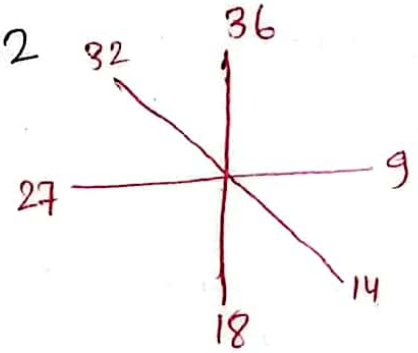
⇒ Bearing w.r.to Magnetic North = 305.50 + 14° 45'
= 320.25°

⇒ Divide the bearing by 10 = $\frac{320.25}{10}$ = 32.025

⇒ Round off to the nearest whole no. = 32

⇒ 32 − 14 ← (32 − 18 = 14)





Basic Runway Length:

→ It is the runway length under following conditions:
- Airport altitude is at sea level
- Temperature at airport is standard (i.e. 15°C)
- Runway is levelled in longitudinal direction.
- No wind is blowing on runway.
- Aircraft is loaded to it's full capacity
- No wind is blowing en-route to the destination
- En-route temperature is standard.

Factors affecting Basic Runway length

① Aircraft characteristics:
↳ Power and propulsion system
↳ Gross take-off weight.
↳ Type of aircraft

2) Safety Requirements
↳ Normal landing case
↳ Normal take off case
↳ Abandoned landing and take off case.

3) Environmental Characteristics:
↳ Elevation
↳ Temperature
↳ Gradient

Corrections for Basic Runway length:

① Elevation Correction:
↳ ICAO recommends that basic runway length should be increased @ 7% per 300 m rise in elevation above MSL.
↳ Elevation correction factor $(K_h) = \left(1 + 0.07 \times \frac{H}{300}\right)$

where H = elevation of highest point of airport.

2) Temperature correction :

→ ICAO recommends that basic runway length after elevation correction should be further increased @ 1 % for every 1°C rise of airport reference temperature.

→ Temp^r correction factor (K_t) = $1 + 0.01 \times (t_{ar} - t_{at})$

where,

→ t_{ar} = aerodrome reference temp^r = $t_a + \left(\frac{t_m - t_a}{3}\right)$

→ t_{at} = Standard atmospheric temp^r at given elevation
= $15 - 0.0065 \times H$

→ t_a = monthly mean of average daily temp^r of the hottest month of a year

→ t_m = monthly mean of max^m daily temp^r.

(% change in)

* Runway length after elevation and temp^r correction should be less than 35 % of basic Runway length.

→ If > 35 % then further specific study is required.

3) Gradient correction :

→ As per FAA, the runway length having corrected for elevation and temperature be further increased by 20 % for each 1 % of effective runway gradient.

→ Gradient correction factor, $(K_g) = 1 + 0.2 \frac{(RL_{max} - RL_{min})}{L} \times 100$.

where,

L is the runway length after elevation & temp^r correction.

Q. The runway length required for landing at sea-level in standard atmospheric condition is 3000 m. The effective runway gradient is 0.5%, H = 200 m, $t_m = 43.73°C$, $t_a = 26.21°C$
Find the corrected runway length.

Soln

Correction of Basic runway length for elevation

Elevation correction factor (K_h) $= 1 + 0.07 \times \frac{H}{300}$

$= 1 + 0.07 \times \frac{200}{300}$

$= 1.046$

corrected runway length $= 3000 \times K_h$
$= 3000 \times 1.046$
$= 3140$ m

Correction for temp^r:

$t_{art} = t_a + \frac{t_m - t_a}{3} = 26.21 + \frac{43.73 - 26.21}{3}$

$= 32.05°C$

$t_{at} = 15 - 0.0065 \times H = 15 - 0.0065 \times 200$
$= 13.7°C$

$K_t = 1 + 0.01 (t_{art} - t_{at})$
$= 1 + 0.01 (32.05 - 13.7)$
$= 1.18$

Corrected Runway length $= 3140 \times K_t = 3140 \times 1.18$
$= 3705$ m

% change of Runway length $= \frac{3705 - 3000}{3000} \times 100\% = 23.5\%$

$\because$ 23.5% < 35% (as recommended by FAA)

Correction for gradient.

$$K_g = 1 + 0.2 \left(\frac{RL_{max} - RL_{min}}{L} \right) \times 100 \rightarrow 0.5\%$$

$$= 1 + 0.2 \times 0.5$$

$$= 1.1$$

∴ Corrected length = 3705×1.1

$= 4075$ m

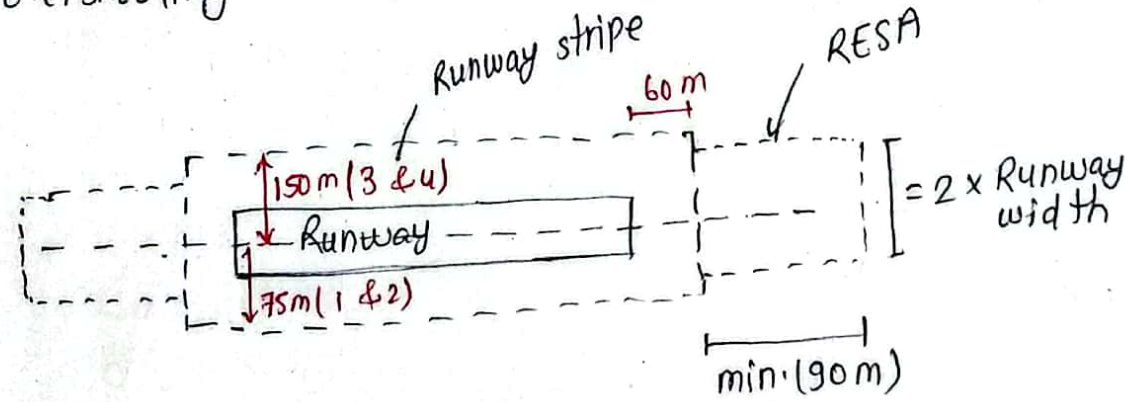
Turnpad on Runways:

→ Turn-pads are provided at the end of runway to turn a moving aircraft safely by 180°

→ Provided where there is no end taxiway.

Runway End Safety Area (RESA):

→ An area symmetrical about the extended runway centre line and adjacent to the end of the stripe primarily intended to reduce the risk of damage to an airplane undershooting or overshooting the runway.



→ RESA is located after the runway stripe.

→ Minimum length to be provided is 90 m where as recommended length is 240 m.

→ Width of RESA should be two times runway width.

→ No objects should be situated in RESA that may endanger planes.

Runway width:

→ It depends upon type of airport and the biggest aircraft in operation

$$W_R = T_m + 2C$$

where, T_m = outer main gear wheel span.
C = clearance between outer main gear wheel and edge of Runway.

Code NO	Code letter					
	A	B	C	D	E	F
1	18	18	23	-	-	-
2	23	23	30	-	-	-
3	30	30	30	45		-
4	-	-	45	45	45	60

↳ TIA

all are in m.

Runway Shoulder:

→ Provide sense of openness to the pilot
→ Lesser strength pavements and are provided on both sides of runway.
→ Runway shoulders are paved to resist the jet blast.
→ About 7.5 m on both sides.

Longitudinal slope:

→ The difference between maximum and minimum elevation along the length of a runway and shoulder should not exceed:-
→ 1% where code number is 3 or 4.
→ 2% where code number is 1 or 2.

Transverse slope:

→ The runway is cambered to promote rapid drainage of water.
→ 1.5 % where code letter is C, D, E & F.
→ 2 % where code letter is A & B.

Runway stripes:

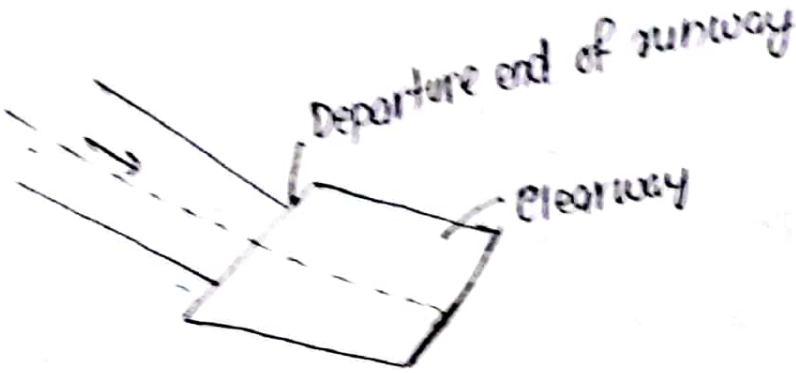
→ A defined area including runway and stopway is provided intended :-
- to reduce the risk of damage to aircraft running off the runway.
- to protect aircraft flying over it during landing & takeoff.

→ Length of runway strip shall extend before the threshold and beyond the end of runway or stopway for a distance of at least 60m.
→ Width of Runway strip from center line of runway in both sides.
- 150 m for code 3 & 4
- 75 m for code 1 & 2.

Clearway:

A defined rectangular area on the ground under the control of appropriate authority, selected or prepared on a suitable area over which on airplane may make a portion of initial climb to a specified height.
→ The origin of clearway should be at the end of take off run available.
→ Length of clearway should not exceed half the length of take-off run available.

→ Width of at least 75 m from centre line of runway.
→ Constructed at an upward slope of 1.25 %.

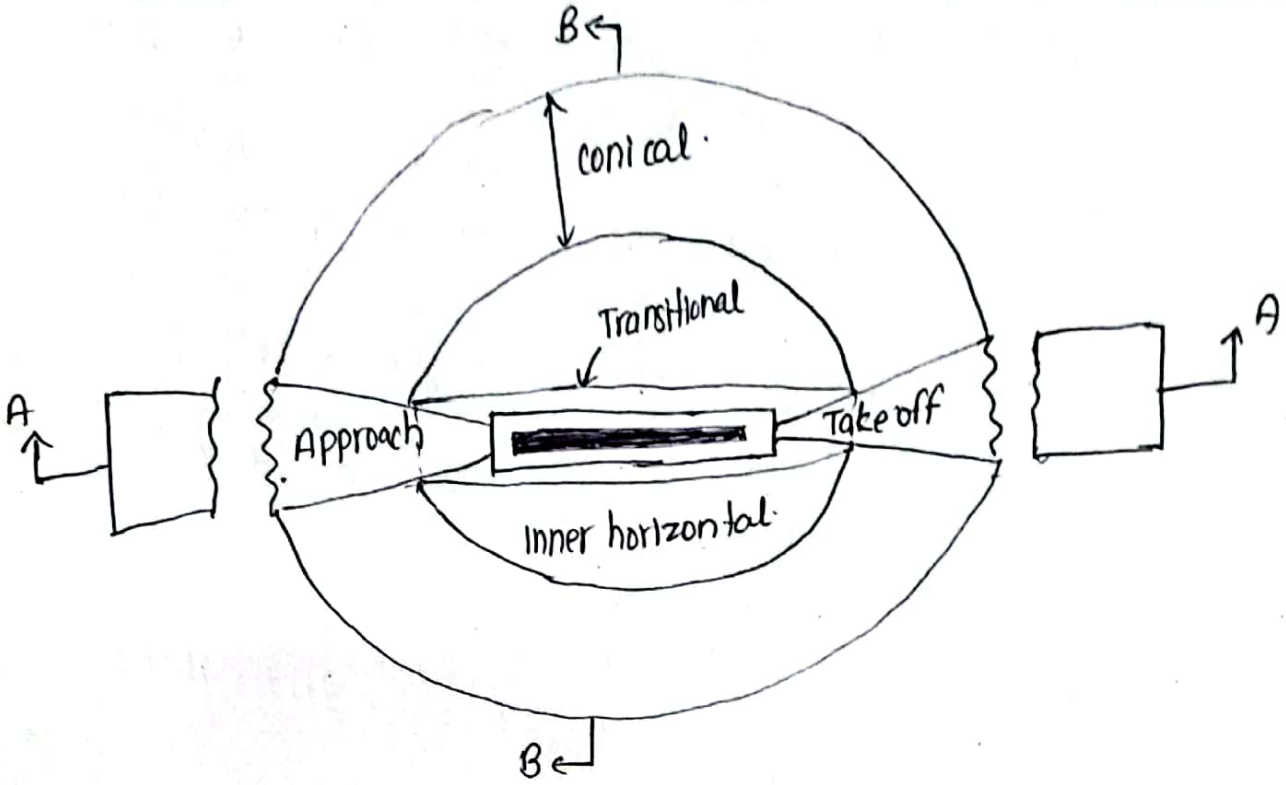


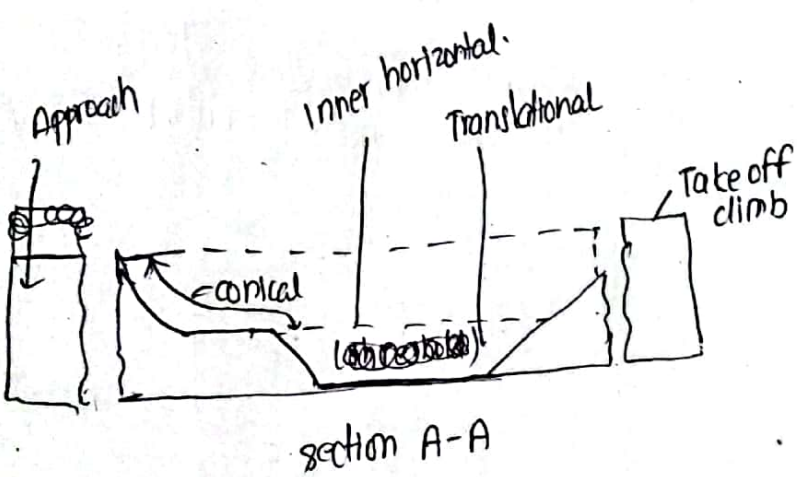
Stopway :

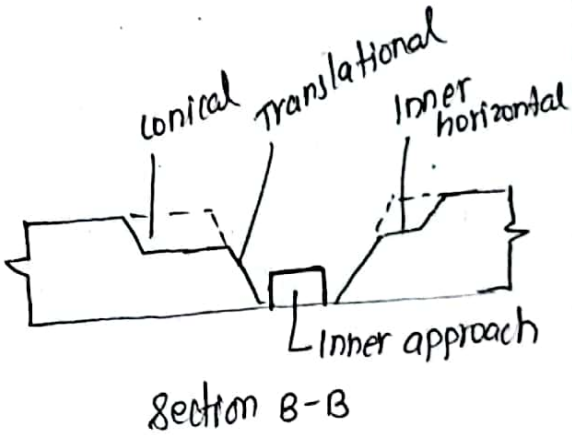
→ A defined rectangular area on the ground at the end of take-off run available prepared as a suitable area in which an aircraft can be stopped in the case of abandoned take off.
→ Width of stopway same as runway width.
→ Provided with yellow markings.

Obstacle limitation surface (OLS):

→ The airspace around aerodromes to be maintained free from obstacles so as to permit the intended airplane operations at the aerodromes to be conducted safely and to prevent the aerodromes from becoming unusable by the growth of obstacles around the aerodromes.
→ fixed obstacles (eg. high rised buildings)
→ movable obstacles (eg: cranes).







Design of taxiway, aprons and holding bays:

Functional / Principle requirements of taxiway:

→ The components of the taxiway system should serve to link the aerodrome functions and are necessary to develop optimum aerodrome utilization.

→ The taxiway system should be designed to minimize the restriction of aircraft movement to and from the runways and apron areas.

→ For any given aerodrome, the taxiway system should be able to accomodate (without significant delay) the demand of aircraft arrival and departures on the runway system.

→ Taxiway should be developed to operate at the highest level of both safety and efficiency.
→ Taxiway route should be as simple as possible in order to avoid pilot confusion and need of complicated instructions.
→ Straight runs of pavement should be used i.e avoid curves as possible.
→ Taxiway crossing the runway should be avoided for safety.
→ Designed to minimize taxiing time and cost.
→ All sections of taxiway should be visible from ATC.

Taxiway width:

→ Taxiway width are based on adding clearance distance from wheel to pavement edge to the maxm outer main gear wheel span.

Code letter	A	B	C	D	E	F
minimum width	7.5	10.5	18 15	23 18	23	25
minimum clearance required	1.5	2.25	4.5 3	4.5	4.5	4.5

Taxiway curves:

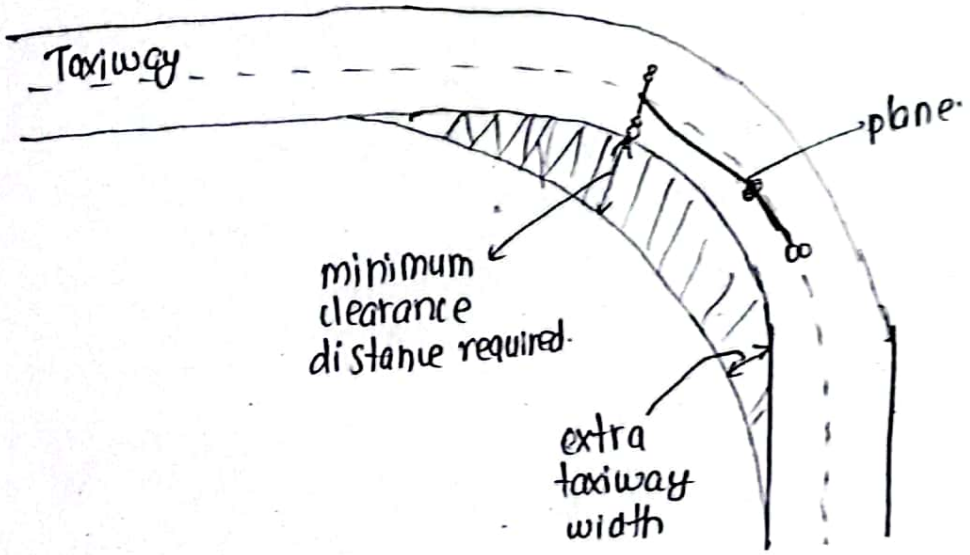
→ Changes in direction should be as few as possible.
→ The design of curve should be such that when the cockpit remains over taxiway center line marking, the clearance shouldn't be less than as specified in above table.

→ If curves are unavoidable, the radii should be compatible with maneuvering capability and normal taxiing speed.

Junctions and Intersections:

→ To ensure the minimum wheel clearance distances specified are maintained, fillets or extra taxiway width should be provided at junctions and intersections of taxiways with runways, aprons and other taxiways.

→ The strength of fillet should be same as taxiway pavement.



Rapid Exit Taxiways (RET):

→ A RET is a taxiway connected to a runway at an acute angle and designed to allow landing airplanes to turn off at the higher speeds than those achieved on other taxiways thereby minimizing runway occupancy time.

→ As different types of aircraft require different locations for RETs, the expected aircraft fleet mix will be an essential criteria for location.

→ The threshold speed, braking ability and operational turn-off speed of the aircraft will determine the location of exits.

→ Three segment method can be used to identify the location of RETs, based on 4 classes of aircraft from group A to group D (based on speed: 169 to 306 kmph)

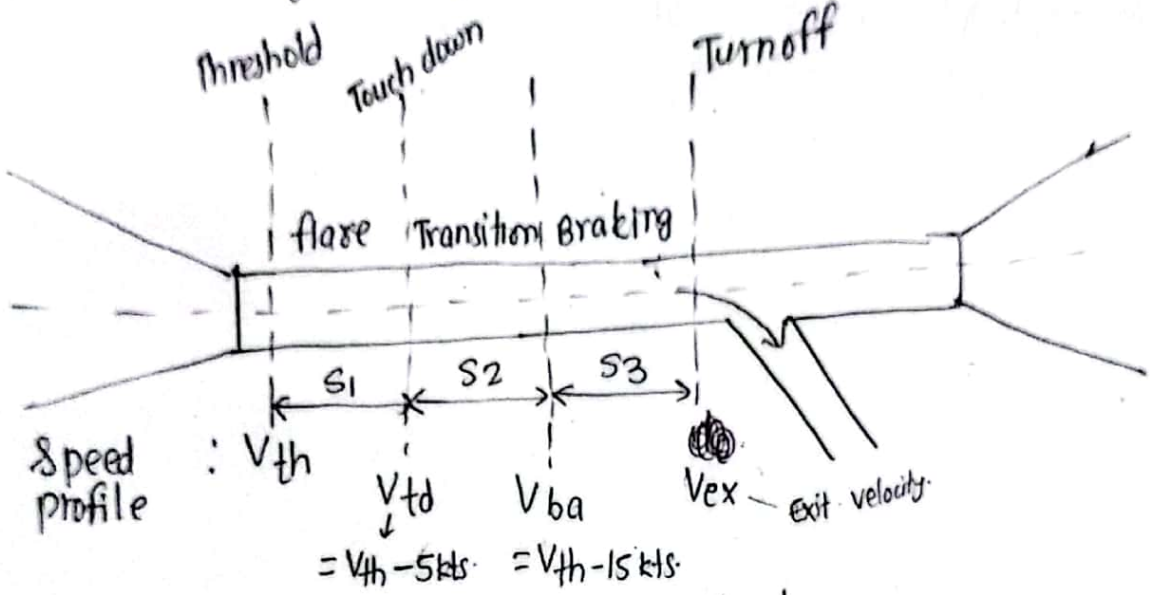


fig: 3- segment method

Passenger Terminal Apron:

→ A parking area of an aircraft for boarding and unboarding of passengers to and from aircraft.

→ Should be located near passenger terminal facility.

→ Can be used for fueling and minor inspection of aircraft.

Cargo Terminal Apron:

→ Space for loading and unloading of cargo's.

→ Should be located near cargo terminal facility provided with all necessary equipments to handle, transport and store goods.

Design Requirements of Aprons:

① Safety:

→ Should take into account safety procedures for aircraft maneuvering on the apron.
→ Should maintain specified clearance between fixed facilities
→ Pavement should slope away from terminal buildings.

② Efficiency:

→ Should contribute to a high degree of efficiency to aircraft movements.
→ Minimum taxing distance and delay.

3) Geometry:

→ Should consider aircraft size, clearance requirement, number of aircraft expected.

4) Flexibility:

→ ~~Expla~~ Expansion capability.
→ Range of aircraft.

Size of Apron:

→ The size and maneuvering characteristics of aircraft.
→ Volume of air traffic
→ clearance requirements.
→ Terminal layout
→ Aircraft ground handling requirements.
→ Taxiway and Roadway Service.

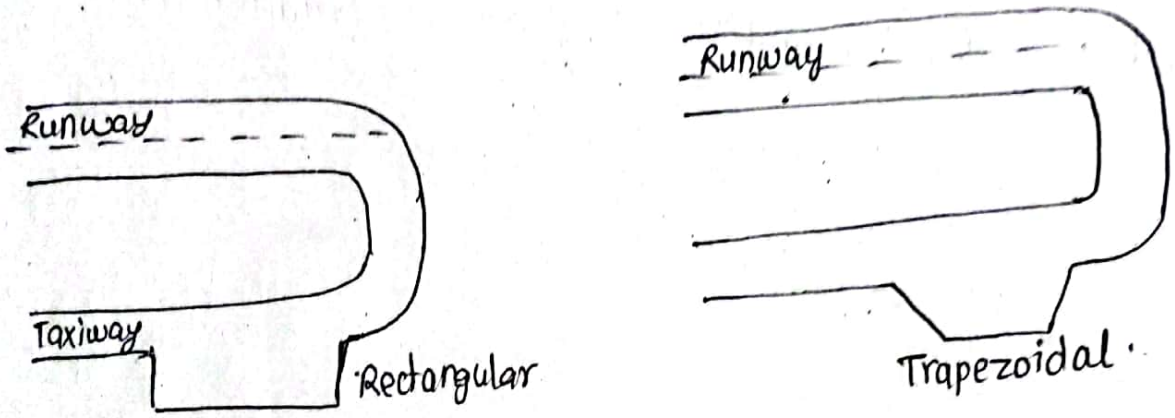
Need of Holding bays and Bypasses:

→ will allow a degree of flexibility in generating departure sequence.
→ This provides air traffic services units with greater flexibility in adjusting the take-off sequence to overcome undue delays, thus increasing the capacity of an aerodrome.
→ Engine warmup of piston engines.
→ Holding bays can be utilized if pilot discovers any fault in the aircraft before takeoff.

Types of by-passes:

1) Holding bays:

A defined area where aircraft can be held or bypassed.



2) Dual Taxiway:

→ A second taxiway or a taxiway bypass to the normall parallel taxiway.

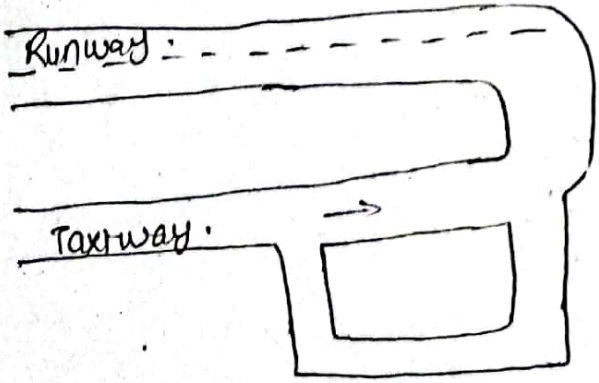


fig: Dual Taxiway Bypass

3) Dual Runway Entrance:

→ A duplication of the taxiway entrance to the runway.

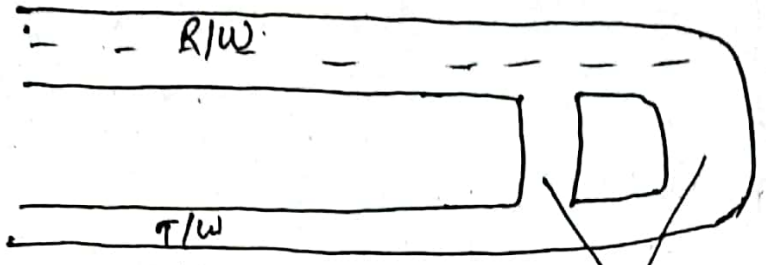


fig: Dual Runway Entrance bypass

Dual Runway entrance.

Size and location of Holding Bays:

→ The space required for a holding bay depends on the number of aircraft position to be provided, size of aircraft to be accomodate and the frequency of their utilization.

→ The dimension must allow for sufficient space between aircraft to enable them to maneuver independently.

→ Most advantageous location for a holding bay is adjacent to the taxiway serving the runway end.

→ The distance between holding bay and center line of runway should not be less than 30 m for code 1.

Isolated Parking Bay:

→ An isolated parking position shall be designated area for the parking of an aircraft which is known or believed to be the subject of unlawful interference, or which for other reasons needs isolation from normal aerodrome activities.

Recommendation for isolated parking Bays:

→ Should be located at a maximum distance practicable and in any case should not be less than 100 m from other parking position, buildings or any other public areas.

→ There should be taken to ensure that the position is not located over the underground utilities such as gas and aviation fuel supply, electrical and communication cables.

STOLPort and Heliport

STOLPort: A stolport is an airport designed with stol (short take-off and landing) operations usually for an aircraft of small weight and size.

→ The infrastructures are developed to support safe and effective public air transport in and out of densely populated urban areas and remote areas.

→ Designed with reference field length of less than 800m.

Importance of STOLPort in the context of Nepal:

→ Majority of the country's land is mountain. The rugged terrain and fragile geology has made road transport unsafe and time consuming as well as construction and maintenance cost are high.

→ So, stolports are being effective mode of transport in otherwise inaccessible part of the country.

→ Promoting internal as well as international tourism.

→ Generation of employment opportunities.

→ Poverty alleviation through employment.

→ Rescue operation and delivery of humanatirian aids.

→ Enhance Trade to and from urban areas to remote areas.

→ Ensures the presence of government in remote areas.

→ Exchange of social and cultural values.

Physical characteristics of stolport:

Runway:

The length of stolport runway should be based on take-off and landing data obtained from aeroplane flight manual of stolport design aeroplane and considered together following factors:

- whether the approaches are open or restricted
- elevation of the site.
- Aerodrome temperature.
- Visibility condition.
- nature of runway surface.

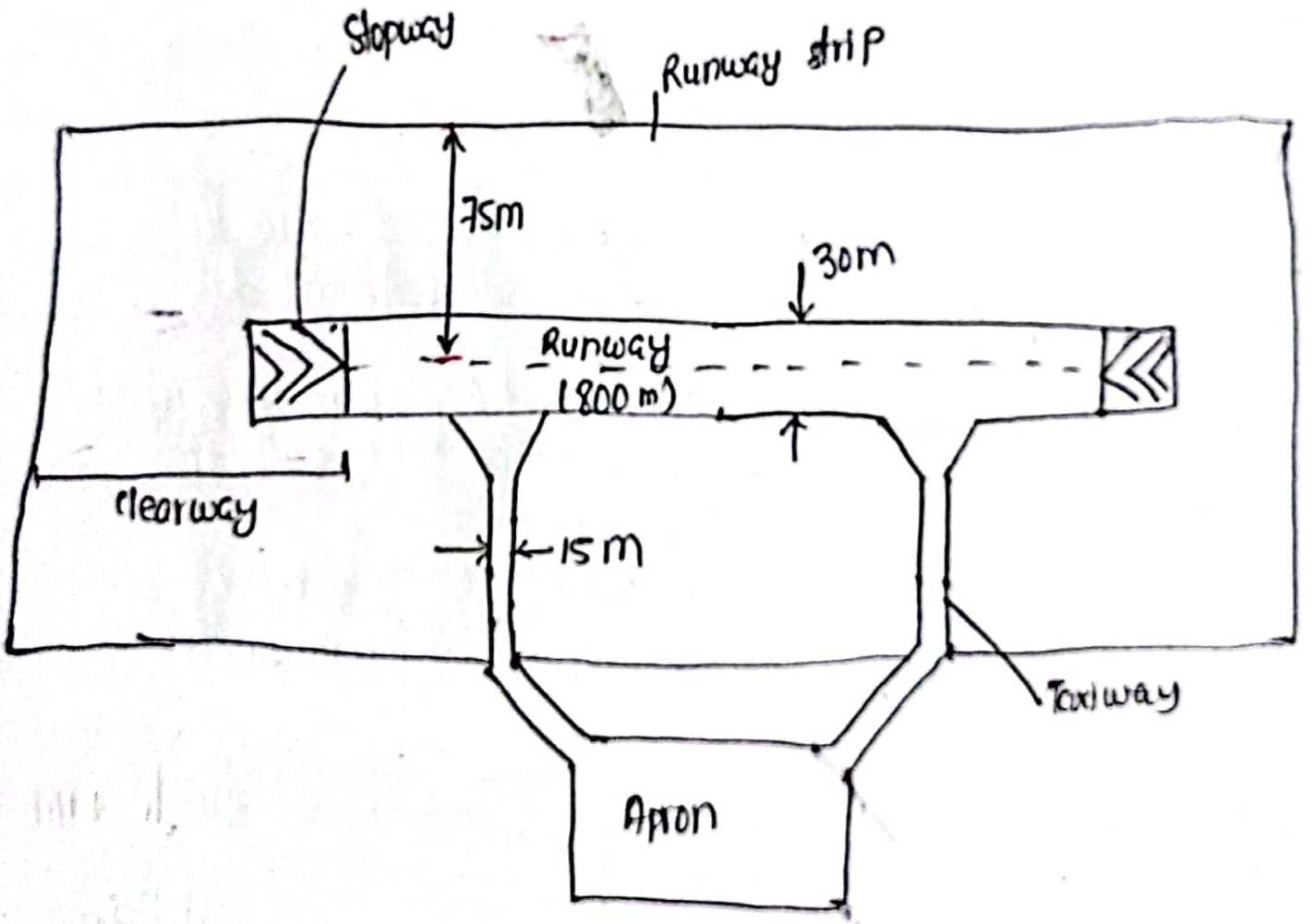


Fig: General layout of stolport

Runway width:

→ A runway width of 23 m has been considered suitable for airplanes for use in visual meterological condition.
→ However the width of precision approach runway for such and airplane should not be less than 30 m.

Longitudinal and Traverse slope:

→ The longitudinal slope of a stolport runway should be held to 1 % or less, not to exceed 2 %.
→ In cases where longitudinal slope exceeds 2 %, it may be necessary to advise the operators that operations are restricted to landing uphill and taking off downhill.
→ Traverse slope should not exceed 2 %

Runway strip:

→ A runway strip of at least 45 m from centre line of runway on either side is adequate at day time operation.
→ However for operation in night time or instrumental conditions, a width of 75 m on either side of runway center line is recommended.
→ A stolport runway strip length of 60 m beyond the end of runway (after stopway) is recommended.

Taxiways:

→ The likely configuration of a stolport in a single runway served by a single taxiway.
→ If end taxiway are not provided, runway should be provided with turning pad for turning of airplane,
→ The clearance distance between the pavement edge and outer main gear should not be is than 3m.

Apron:

→ It will be necessary to provide an apron to permit the loading and unloading of passengers and cargo as well as aircraft servicing without interfering stolport traffic.

→ Should be of sufficient size to accomodate the expected traffic in the stolport.

** Heliport: * *

→ An aerodrome or defined area on a structure intended to be used wholly or in part for the arrival, departure and surface movement of helicopters.

Site selection of Heliports:

→ Possible air traffic conflicts betn helicopters using a heliport and other air traffic should be avoided.

→ The selected site should be conveniently situated as regards to ground transport access and adequate vehicle parking facilities.

→ Site should be away from high structures such as high rised building, that might create wind turbulence.

→ High terrain or other obstacle especially power lines, in the vicinity of heliport should be avoided.

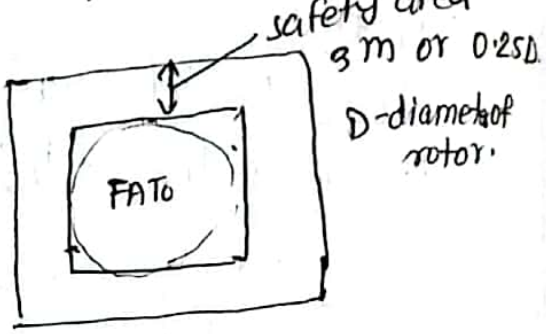
Physical characteristics of Heliport:

1) Final Approach and Take-off area (FATo):

→ A defined area over which final phase of the approach manoeuver to hover or landing is completed and from which the take-off is commenced.

→ All final approach should terminate at FATO.

→ FATO may be of any shape but it must be able to accomodate a circle whose diameter is at least equal to the diameter of rotor for which heliport is intended.



→ The slope should not exceed 3% at any direction.

→ Should be free from irregularities and have sufficient bearing strength.

2) Touch down and lift-off areas (TLOFs):

→ It is the designated area inside FATO where the helicoptor is supposed to touch the surface.

→ Slope should not exceed 2%.

→ Should be free from irregularities and have sufficient strength.

Safety areas:

→ Area surrounding the FATO for safety provision of helicopters that might get affected by wind turbulence.

→ At least, 3 m or 0.25 D whichever is greater.

→ Should be obstacle free and free from dust particles.

Helicopter ground taxiway:

→ Intended to permit the movement of wheeled-helicopters on the surface under it's own power.

→ Width should not be less than 7.5 m.

→ Longitudinal slope should not exceed 3%.

→ Should be provided with shoulders.

Air Taxiway :

→ Intended for use by helicopters which do not have wheels.
→ Movement of helicopters above ground surface with speed less than 37 km/hr.
→ Width of air ~~taxiway~~ ~~shoul~~ taxiway should be a least 2 times the greatest overall width of helicopters.
→ The surface beneath the air taxiway shall be resistant to the effects of rotor downwash and shall be suitable for emergency landing.

Obstacle limitation Surface & Requirements:

→ Permit the intended helicopter operations at the heliports to be conducted safely and to prevent the heliports becoming unusable by the growth of obstacle ~~around there~~ around them.

→ This can be achieved by establishing a series of OLS that defines the limit to which object may project into the airspace.

Requirements :

1) Take-off climb surface.
2) Approach surface.
3) Transitional surface.
4) Conical surface.

(fig: same as previous) of OLS.

Airport Drainage

→ An airport drainage system for the removal of surface & sub-surface water is vital for the safety of aircraft and for the longer life of pavement.

→ Improper drainage results in the formation on puddles on the pavement surface, which can be hazardous to aircraft taking off and landing.

Purpose of drainage:

1) Interception and diversion of surface and ground water flow originating from ~~adjusting~~ adjoining lands.
2) Removal of surface runoff.
3) Removal of surface flow from airport.

2080-06-11
Thursday

Focus on chapter 1 & 2 for loksewa exam.

* Design storm for surface runoff :-

→ FAA recommends that for civil airports, the drainage system should be designed for a storm whose probability of occurence is once in 5 years.

→ The design should be, however, checked with a storm of lesser frequency (10 to 15 years). In Nepal, it is taken as 10 years.

* Components of Airport Drainage system :-

i) Surface hydrology
ii) Pavement surface drainage
iii) Design of culvert / Drainage structure
iv) Design of channel

} Surface drainage

v) Sub-surface drainage

* Determination of surface Runoff (FAA Recommendation)

→ The FAA analysis of surface drainage is based on rational method.

i.e. $Q = CiA$

Q → ft^3/s, i → mm/hr, A → Acre

where,

$$C = \frac{\Sigma C_i A_i}{\Sigma A_i}$$

* Assumptions of rational method :-

1. Intensity of rainfall (i) is uniform throughout the area.
2. Suitable for area less than 200 acre.

→ The Kerby-Kirpich method is used to calculate time of concentration.

$$t_c = t_{ov} + t_{ch}$$

t_c → time of concentration
t_{ov} → " " overland ~~overflow~~
t_{ch} → " channel flow

→ Kerby eqⁿ for time of overland flow :

$$t_{ov} = K(LN)^{0.467} S^{-0.235}$$

K → unit conversion coefficient
= 1.44 for SI unit
= 0.0828 for ft

L → Overland flow length in ft or m used as in K
N → dimensionless retardance coefficient
S → Slope of terrain

* Type of surface (for N value)

Pavement	~~0.02~~ 0.02
Smooth, bare, pacted soil	0.1

→ Kirpich method is used to determine time of channel flow :

$$t_{ch} = K L^{0.770} S^{-0.385}$$

where,
K = 0.0195 for SI
= 0.0078 in ft
L, S → Length & slope of channel

Therefore, t_c can be written as:

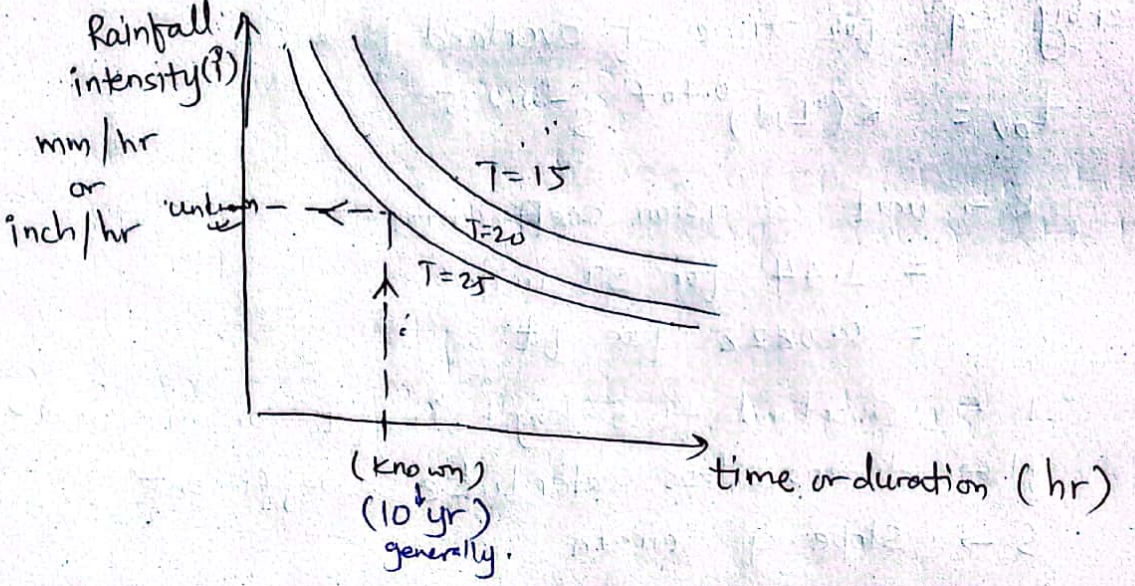
$$t_c = 0.0078\, L^{0.77} \left(\frac{L}{H}\right)^{0.385}$$

where,

L → Horizontal distance of drain inlet from farthest point in catchment area (ft)

H → Elevation difference of drain inlet at same point in catchment area (ft)

↳ i is computed from IDF curve



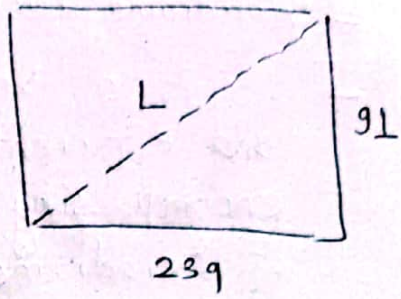
Q. Determine the quantity of runoff for a channel flow for a paved ~~chann~~ apron 239 * 91 sqm. The IDF curve for 10 year period has been determined to be rainfall intensity, I = in mm/hr = $590 * (\text{Duration in minutes})^{-0.17}$

The max^m length of flow is diagonal of the area and elevation difference is 2.557 m.

P.T.O.

Soln:-

Step (1) : Calculate t_c from eqn



Step (2) : Calculate

$$I = 590 * (\text{Duration in min}^m)^{-0.67}$$

Step (3) : $$Q = \frac{CIA}{360}$$

Take $C = 0.85 - 0.9$

Convert A in Ha.

Design of channel / Hydraulic design :-

→ Flood frequency = 10 years

→ channel geometry (Trapezoid or Rectangular)

→ Free board (15 to 30 cm)

→ Side slope should not be steeper than 2.5H : 1V

→ Permissible velocity = 1.5 m/s

→ Use manning's formula $V = \frac{1}{n} R^{2/3} S^{1/2}$

Sub-surface drainage :-

↳ To cut the capillary rise

↳ To lower down the seepage line

↳ " " GWT

(see notes for further details)

Aerodrome certification

→ It is a proven and effective way of ensuring safe and efficient aerodrome operations, through a defined encompassing process which examines various components of aerodromes, with an aim to verify their compliance with that of International standards and recommended practices.

→ During certification process, aerodrome regulators and operators verifies that aerodrome facilities, design, equipment and operational procedure comply with standards.

* Why certify aerodrome ?

→ management of aerodromes differ between states
→ Without certification, necessary level of standardization is not possible.
→ enhances safety
→ ICAO Chicago Convention, Article 15 – certification is compulsory.

* ICAO requirements of certification

→ Each state agrees to provide airports and air traffic services in conformance with standards and practices established under the convention.
→ Each state agrees to implement in their national regulations the International standards and Recommended Practices (SARPs) and procedures adopted by ICAO in order to ensure the highest practicable degree of uniformity.
→ Each state is required to notify ICAO immediately if it finds it impracticable to comply in all respects with SARPs.

* Nepal requirements of certification on Aerodromes :-

→ The operator of airport that may be used for public purpose as per the national needs must obtain airport certificate.

→ The airport certificate must be obtained to operate international public air transport.

→ An aerodrome certificate shall be obtained if the maximum passenger seating capacity of the aircraft employed in the operation exceeds 30 seats.

Audit and inspection :-

→ As part of certification issuing process, a verification is done. State CAA must verify aerodrome operators compliance with established standards which include established test and inspection procedure to ensure safe operations.

* Types of audit and inspection

- Audit : ↳ periodic and special audits
  ↳ Review of published aerodrome data
- Inspection
  ↳ Initial / verification
  ↳ Periodic
  ↳ Special
  ↳ Surveillance

* Inspection phase :

→ Preparation for the inspection
→ Pre-inspection breifing
→ Administrative inspection
→ Movement Area "
→ Rescue & fire fighting "
→ Fuel facilities "
→ Night inspection
→ Post inspection briefing and → Follow up & paper work

State Safety Programme (SSP)

→ It is defined as the integrated set of regulation and activities aimed at improving safety.

→ To support fulfillment of responsibilities concerning safe and efficient delivery of aviation activities

→ SSP Nepal has been developed in accordance with ICAO SSP framework that consists of 4 components and 14 elements :-

1) State safety policy, objective and resources :-
   - → Primary aviation legislation
   - → Specific operating regulation
   - → State safety and functions
   - → Qualified technical personnel
   - → Technical guidelines, tools and provision

2) State safety Risk management :-
   - → Licensing, certifications and authorization
   - → Safety management system
   - → Accident and incident investigation
   - → Hazard identification and risk assessment
   - → Management of safety risk

3) State safety Assurance
   - → Surveillance
   - → State Safety performance

4) State safety Promotion
   - → Internal communication and dissemination of safety infrmth
   - → External ,, ,, ,,

Safety Management System (SMS)

→ Organization-wise procedure designed to manage the safety risk involved in the workplace.
→ Manage safety to acceptable level
→ Provide for ongoing monitoring and assessment of safety programme.
→ Make continuous improvements to the level of safety.
→ Develop and maintain safety culture within the organizatio
→ Consists of 4 components and 12 elements:

1. Safety Policy and objectives
2. " risk managements
3. " assurance
4. " Promotion

— *** —

Visual Aids for Navigation :-

* Operational factors (4C's)

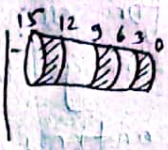
i) Configuration
→ This concerns the location of components and spacing of lights and markings within the system.

ii) Colour
→ To help identify the different lighting systems of the aerodromes, to convey instructions and information.

iii) Candelas
→ It is the illumination at the observer's eye produced by the light.

iv) Coverage
→ Refers to light characteristics essential to the proper functioning of configuration and colour.

* Operating requirements :
  - → Airport location
  - → " identification
  - → Landing information
    - ↳ Wind direction
    - ↳ Runway designation



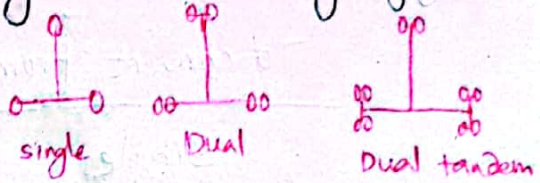
  - → Circling guidance
  - → Final approach guidance to touchdown
    - ↳ Runway edge
    - ↳ Threshold location
    - ↳ Approach slope guidance
    - ↳ Aiming point "
    - ↳ Running centerline
  - → Roll-out guidance
    - ↳ Runway centerline delineation
    - ↳ Runway edge "
    - ↳ Exit taxiway location
    - ↳ Runway end indication
  - → Taxiing guidance
    - ↳ Taxiway centerline
    - ↳ Taxiway edge marking
    - ↳ Information signs
  - → Departure information
  - → Take-off guidance

* * *

FAA recommended CBR method of flexible pavement design

→ Design charts are available for gross aircraft wt of 30,000 lbs or more for single, Dual and Dual tandem aircrafts

→ 95 % of aircraft load is carried by main landing gear and 5 % by nose gear.



→ Data required :-

i) Sub-grade strength (CBR)
ii) Design aircraft (Gear type, gross load)
iii) Traffic (Annual departures)

Design steps :-

Step (1) : Determine the design aircraft

→ Select aircraft requiring largest thickness as design aircraft.

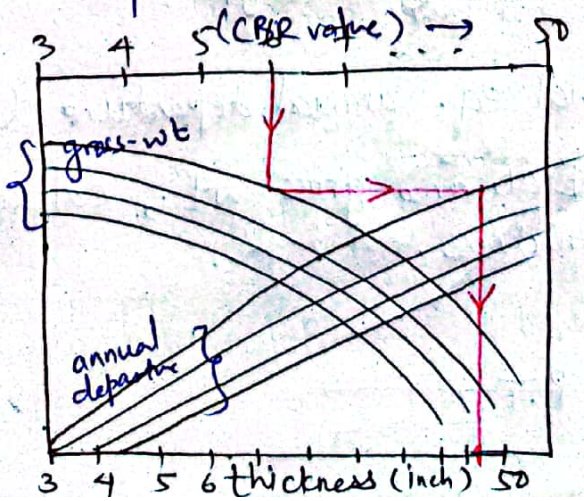
→ Design aircraft is not necessarily the heaviest aircraft in the forecast.

~~Step (2) :~~

Q. Determine the design aircraft from following data :-

	Aircraft	Gear type	Annual Departures	Max. take off wt (Lbs)
1)	727 - 100	Dual	3760	160,000
2)	727 - 200	Dual	9080	190500
3)	707 - 320 B	Dual tandem	1500	327000
4)	DC-9-20	Dual	5800	108000
5)	CV 880	Dual tandem	400	184500
6)	737 - 200	Dual	2650	115500

Soln :-



Graphs provided for single, dual & dual tandem respectively.

Assuming 6 % CBR. we get following respective thickness :-

	(inch)
1)	33.5 in
design aircraft 2)	38.2 in
3)	38
4)	27
5)	26
6)	26.6

Step (2): Conversion into same landing gear type as the design aircraft

Eg:- (Factors are provided in sheet)

To convert from	TO	Multiply departures by
Single	Dual	0.8
single	Dual tandem	0.5
Dual	"	0.6
Dual Tandem	"	1
"	Single	2
"	Dual	1.7
Dual	single	1.3

Step (3): Determination of equivalent annual departures by the design aircraft.

$$\log R_1 = \log R_2 \sqrt{\frac{W_2}{W_1}}$$

where,

R_1 → Equivalent annual departures by the design aircrafts

R_2 → " " " expressed in design aircraft landing gear

W_1 → Wheel load of design aircraft

W_2 → " " of aircraft

Step (4): Calculate total eq. annual departure (EAD)

Step (5): With CBR, EAD and gross wt., calculate the pavement thickness.

PTO

previous question continued..

CBR of subgrade = 6 %

" " sub base = 20 %

Min. bituminous surface = 4"

Design the pavement thickness.

Dual tandem to dual conversion factor

Sol":-

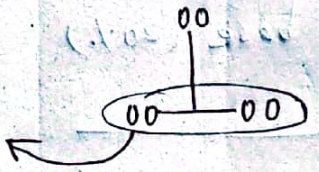
Aircraft	Gear type	Annual Departures	Take off weight (lbs)	Eq. dual gear departure (R_2)	wheel load (W_2)	EAD (R_1)
727-100	D	3760	160000	3760	38,000	1890
727-200	D	9080	190500	9080	45,224 (W_1)	9080
707 320	DT	1500	327000	1500 * 1.7 = 2250	38831	1432
DC-9	D	5800	10800	5800	25650	682
CV-880	DT	400	184500	400 * 1.7 = 680	21909	94
737-200	D	2650	115500	2650	27431	463

Total :- 13,641

W_2 calculations :-

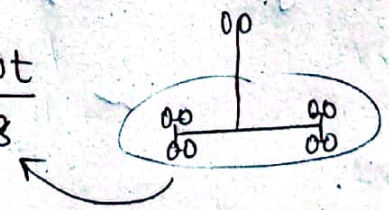
* For dual gear

$$W_2 = 0.95 \times \frac{wt}{4}$$



* For dual tandem,

$$W_2 = 0.95 * \frac{wt}{8}$$



EAD calculations :-

$$\log R_1 = \log R_2 \sqrt{\frac{W_2}{W_1}}$$

eg. i) $\log R_1 = \log 3760 \sqrt{\frac{38000}{45224}}$

$\therefore R_1 = 1890$

PTO

Thus,

Total EAD = 13,641

Gross wt = 190500

Sub-grade CBR = 6 %.

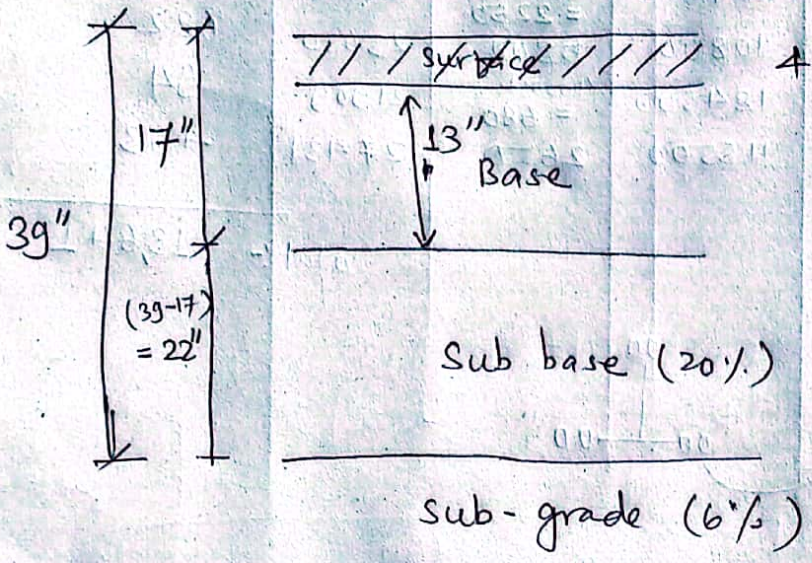
From design chart, thickness = 39 in

Sub-base CBR = 20 %.

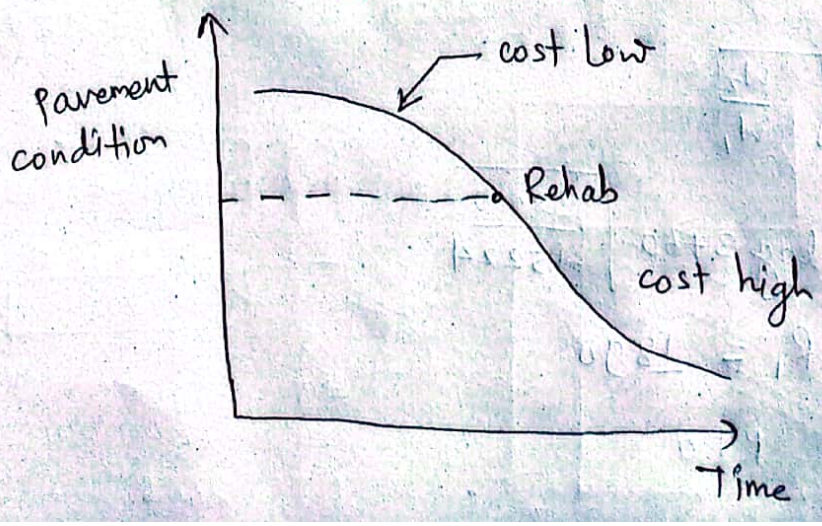
from design chart, thickness = 17 in

min. thickness of surface course = 4 in

" " base = 17 - 4 = 13 in



Pavement management system (PMS)



→ Defined as mechanism for providing consistent, systematic procedure for evaluating pavement condition and for determining the priorities and schedules of pavement maintenance and rehabilitation within available resource and budget.

* Pavement evaluation :

→ It is done to identify the present condition of pavement.

i) Structural evaluation

→ To check the structural ability of pavement

→ Use of BDD, falling wt. deflectometer, coring, boring

↑ Benkelman Beam method

ii) Functional evaluation

→ To check the performance of pavement

→ Use of SDI, PCI, IRI, etc.

* SDI → Surface Distress Index
* PCI → Pavement Condition "
* IRI → International Roughness "

Aircraft Classification Number (ACN)

→ It is a number expressing relative effect of an aircraft on a pavement for specified sub-grade strength.

Pavement condition Number (PCN)

→ A number expressing the bearing strength of a pavement.

↳ FAARFIELD software

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