Lecture 10

University of Anbar
Civil Engineering Department
MSc- Highway Engineering
Railway and Airport Engineering

Geometric Design of Airport

- Aircraft Data Needed for the Design of Airports
- Geometric Design

Instructor : Dr. Hameed Aswad Mohammed

Aircraft Data Needed for the Design of Airports

1- Size

2- Turning radius

3- Maximum takeoff weight

4- Aircraft capacity

5- Type of engine

6- Takeoff and landing distances

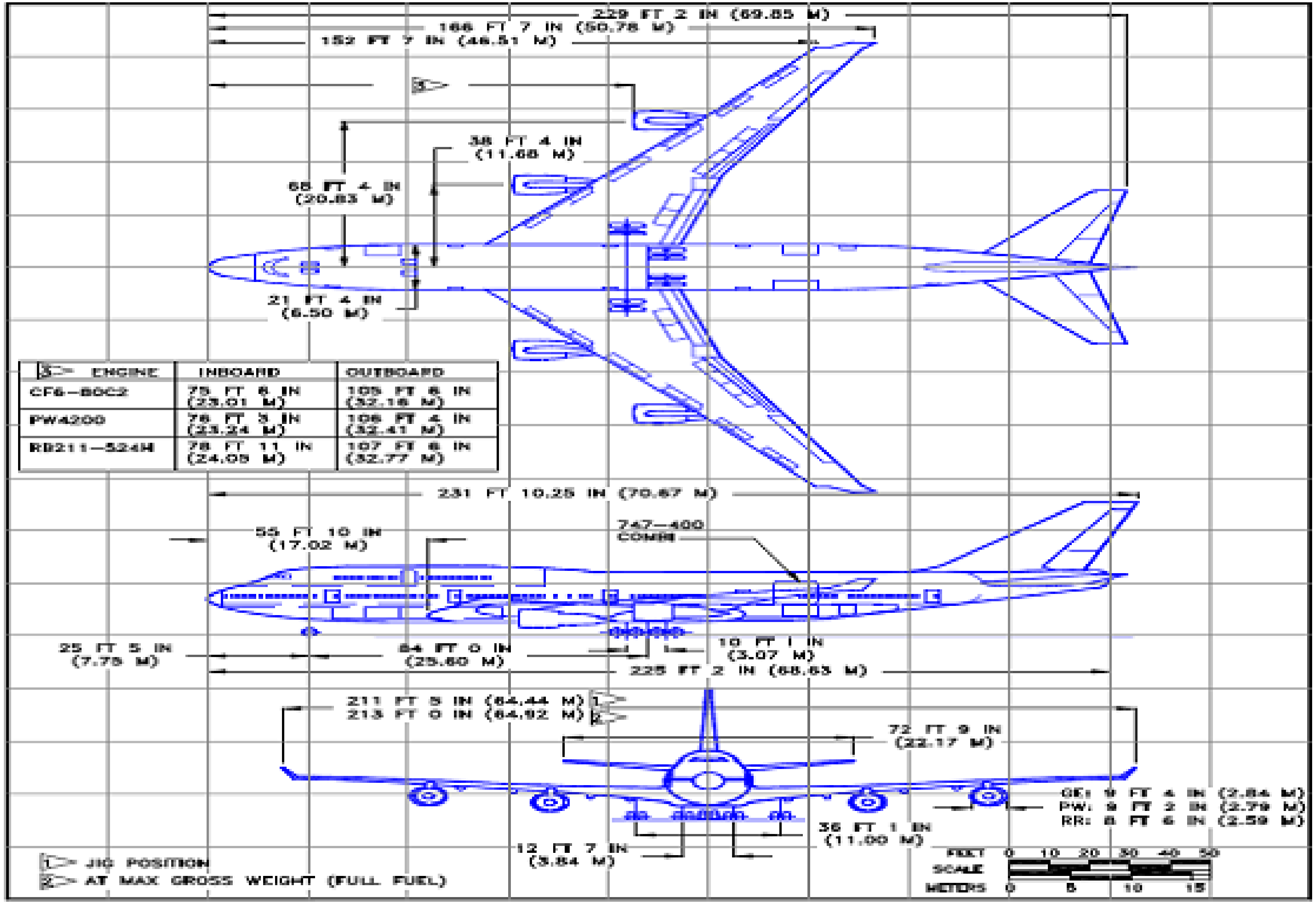
7- Landing gear configuration

Size:

Aircraft size has a great effect on size of:

(1)- Parking apron (2)- Configuration of terminal building (3)- Width of Runway (4)- Width of Taxiway (5)- Distance between runway and the taxiway.

Aircraft Data Needed for the Design of Airports



Aircraft Data Needed for the Design of Airports

- **Turning Radius on the Ground**
  - ✓ Between 70 – 90 degree
  - ✓ Has an effect on 1- Apron 2- Radius of curves at the end of taxiway

- **Maximum Takeoff Weight**

  Used in structural design of pavements of:

  1- Runway

  2- Taxiway

  3- Apron

- **Aircraft Capacity**

1- Regarding fuel, passengers, cargo, …etc 2- Has an effect on: (A)- The fuel storage facilities (B)- Cargo handling facilities required

- Maximum Seating Capacity: The maximum number of passengers specifically certificated or anticipated for certification
- Maximum cargo volume: The maximum space available for cargo
- Usable fuel: Fuel available for aircraft propulsion

Aircraft Data Needed for the Design of Airports

- **Engine Type**

There are four types: 1- Piston engine 2- Turbo jet 3- Turbo propeller 4- Turbo fan

- **Landing Gear Configurations**

Affects the structural design of pavements (determination of pavement layers thicknesses).

Some Types of Landing Gear Configurations

1- Single conventional

2- Single tricycle

3- Twin tricycle

4- Single tandem tricycle

5- Twin tandem tricycle

6- Twin bicycle

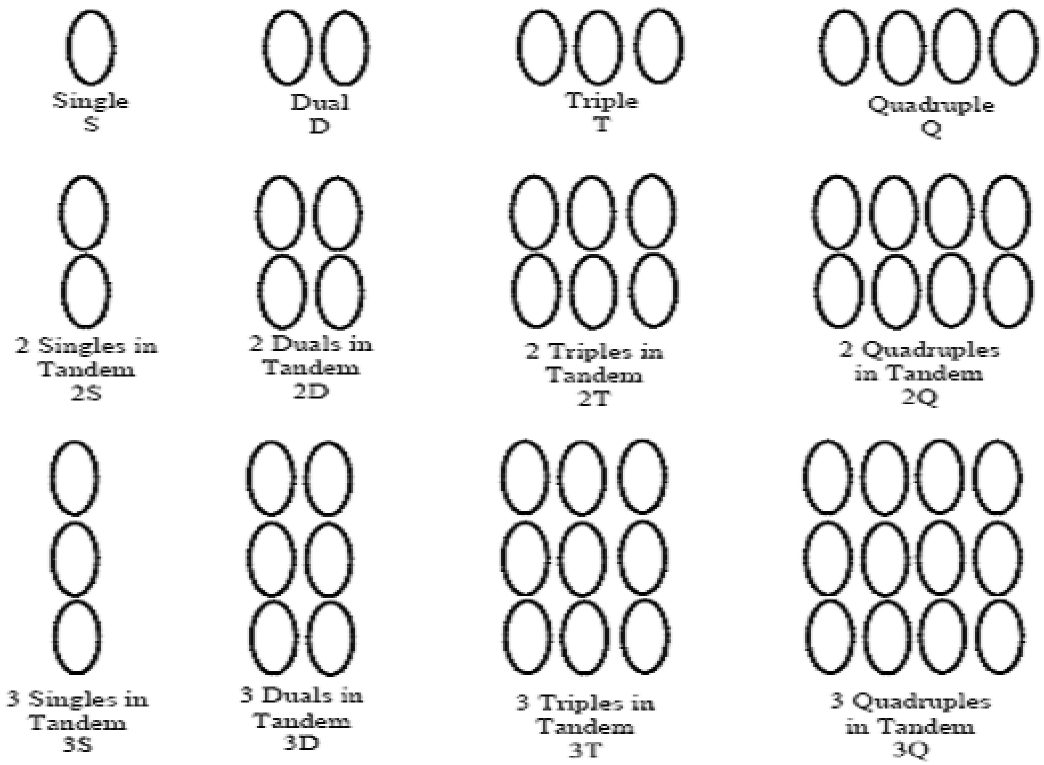
7- Twin twin bicycle

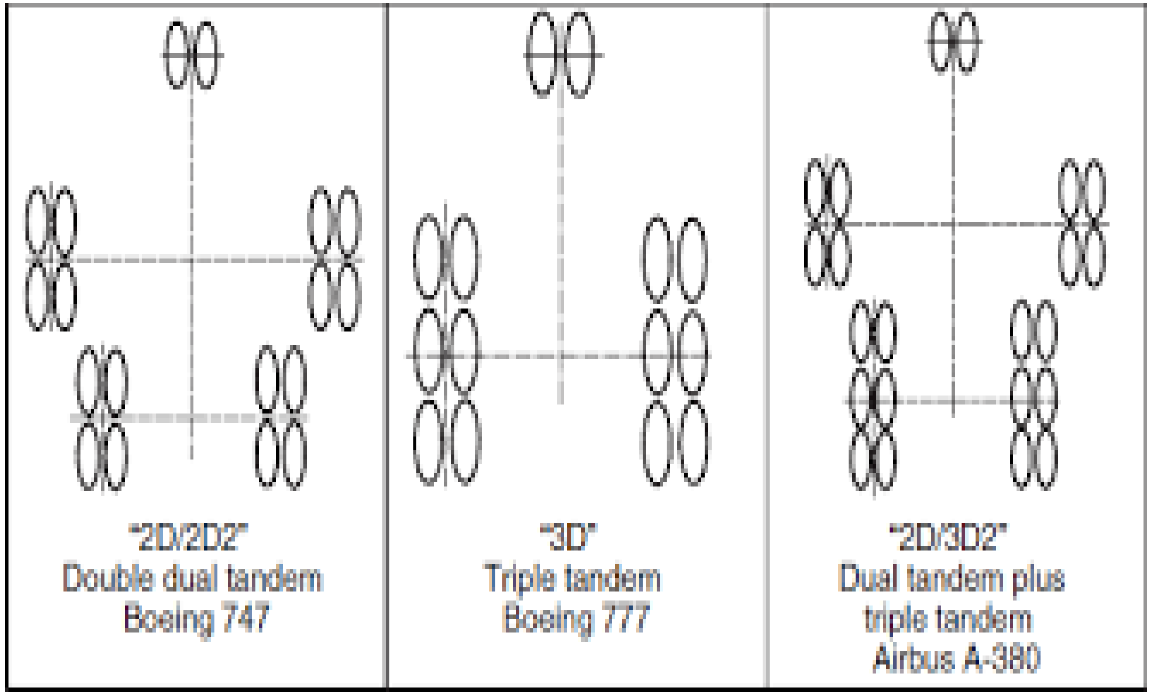
8- Dual twin tandem tricycle

9- Double twin tandem

Aircraft Data Needed for the Design of Airports

Examples of Landing Gear Configurations





Aircraft Data Needed for the Design of Airports

- **Aircraft Weight:**
- **Manufacturer's empty weight (MEW)** Also called Manufacturer's Weight Empty (MWE) or Licensed Empty Weight

  • It is the weight of the aircraft "as built" and includes the weight of the structure, power plant, furnishings, installations, systems and other equipment that are considered an integral part of an aircraft.

  • This excludes any baggage, passengers, or usable fuel.

- **Zero-fuel weight (ZFW)**

  • This is the total weight of the airplane and all its contents (including unusable fuel) but excluding the total weight of the usable fuel on board.

  • As a flight progresses and fuel is consumed, the total weight of the airplane reduces, but the ZFW remains constant.

- **Operating empty weight (OEW)**

  • It is the basic weight of an aircraft including the crew, all fluids necessary for operation such as engine oil, engine coolant, water, unusable fuel and all operator items and equipment required for flight but excluding usable fuel and the payload.

Aircraft Data Needed for the Design of Airports

- **Payload**
  - It is the carrying capacity of an aircraft. It includes cargo, people, extra fuel. In the case of a commercial airliner, it may refer only to revenue-generating cargo or paying passengers.
- **Maximum takeoff weight (MTOW)**
  - This is the maximum weight at which the pilot of the aircraft is allowed to attempt to take off.
- **Maximum landing weight (MLW)**
  - This maximum weight at which an aircraft is permitted to land.
- **Maximum ramp weight (MRW)** also called maximum taxi weight (MTW)
  - It is the maximum weight authorized for maneuvering (taxiing or towing) an aircraft on the ground
- **Aircraft gross weight**
  - It is the total aircraft weight at any moment during the flight or ground operation. This decreases during flight due to fuel and oil consumption.

Geometric Design

- **Runway length**

As the first step, a basic length should be selected of a runway adequate to meet the operation requirement of the airplanes for which the runway is intended.

Table 18.2 Federal Aviation Administration Standards for Airport Design[a]

Item		Airports Serving Aircraft Approach Categories[b] A and B — Airplane Design Group[c]					Airports Serving Aircraft Approach Categories[b] C and D — Airplane Design Group[c]					
Length, ft		I[d]	I	II	III	IV	I	II	III	IV	V	VI
Runway[e]		2,800	3,200	4,370	5,360	6,370	5,490	6,370	7,290	9,580	10,700	12,000
Runway safety area	$<\frac{3}{4}$[f]	600	600	600	800	1,000	1,000	1,000	1,000	1,000	1,000	1,000
(beyond runway end)	$\geq\frac{3}{4}$[g]	240	240	300	600	1,000						
Runway object-free area	$<\frac{3}{4}$[f]	600	600	600	800	1,000	1,000	1,000	1,000	1,000	1,000	1,000
(beyond runway end)	$\geq\frac{3}{4}$[g]	240	240	300	600	1,000						
Width, ft.												
Runway	$<\frac{3}{4}$[f]	75	100	100	100	150	100	100	100	150	150	200
	$\geq\frac{3}{4}$[g]	60	60	75	100	150						
Runway safety area	$<\frac{3}{4}$[f]	300	300	300	400	500	500	500	500	500	500	500
	$\geq\frac{3}{4}$[g]	120	120	150	300	500						
Runway object-free area	$<\frac{3}{4}$[f]	800	800	800	800	800	800	800	800	800	800	800
	$\geq\frac{3}{4}$[g]	250	400	500	800	800						
Taxiway		25	25	35	50	75	25	35	50	75	75	100
Taxiway safety area		49	49	79	118	171	49	79	118	171	214	262
Taxiway object-free area		89	89	131	186	259	89	131	186	259	320	386
Taxilane object-free area		79	79	115	162	225	79	115	162	225	276	334
Minimum distance between, ft:												
Center lines of parallel[a] runways[h]		See Advisory Circular 150/5300-13, Chapter 2										
Center lines of runway and	$<\frac{3}{4}$[f]	200	250	300	350	400	400	400	400	400	450	600
center line of taxiway	$\geq\frac{3}{4}$[g]	150	225	240	300	400	300	300	400	400	450	600
Center line of runway and	$<\frac{3}{4}$[f]	400	400	400	400	500	500	500	500	500	500	500
aircraft parking area	$\geq\frac{3}{4}$[g]	125	200	250	400	500	400	400	500	500	500	500
Center line of taxiway and aircraft parking apron		45	45	66	93	130	45	66	93	130	160	193
Center line of parallel taxiways		69	69	105	152	215	69	105	152	215	267	324
Center line of runway to	$<\frac{3}{4}$[f]	875	875	875	875	875	875	875	875	875	875	875
building line or obstruction[i]	$\geq\frac{3}{4}$[g]	600	600	600	600	600	713	713	713	713	713	713
Center line of taxiway to obstruction		45	45	66	93	130	45	66	93	130	160	193
Maximum runway grades[j], %:												
Longitudinal		2.0	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5	1.5	1.5
Transverse[k]		2.0	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5	1.5	1.5

Geometric Design

- **Basic Runway:-** L_{BRW}

Is a runway length selected for airport planning purposes which are required for landing or takeoff under standards atmospheric conditions for; (according to ICAO).

1) Sea level elevation.
2) Standard sea level temperature 59 F (15C^{o}).
3) Zero percent of effective gradient.

- **Factors that influence required runway length:**

1- Performance characteristics of aircraft using airport.

2- Landing & takeoff gross weight of the aircraft.

3- Elevation of the airport.

4- Air temperature.

5- Runway gradient.

6- Humidity. 7- Wind. 8- Natural & condition of runway surface.

Geometric Design

$$\text{reference field length} = \frac{\text{planned or existing field length}}{F_e \times F_t \times F_g}$$

$$F_e = 0.07 \times E + 1$$

where E = airport elevation (thousands of feet)

$$F_t = 0.01[T(°C) - (15 - 1.981E)] + 1$$

$$F_g = (0.10G + 1)$$

Correction to Basic Runway length due to:

1) Correction due to Elevation:

Standard lengths must increase by 7% per each 1000 ft of elevation above sea level.

$$L_{RW} = L_{BRW} + L_{BRW} * 0.07 * E$$

Standard lengths must decrease by 7% per each 1000 ft of elevation below sea level.

Geometric Design

2) Correction due to Temperature:

- Standard lengths must increase by 0.5 % for each 1 F which the mean temperature at the site for the no hot month of the year.
- Standard temperature site is obtained by reducing the standard sea level temp. of 59 F o at the rate of 3.566 F per 1000 ft elevation.

T_s=59-3.566 *E (elevation greater than 1000 (above or down M.S.L))

$\Delta T = T_m - T_s$

$L_{RW} = L_{RW} + L_{RW} * \Delta T * 0.005$

$C^o = 5/9 * (F^o - 32)$

Geometric Design

3) Correction due to Effective Gradient:-

The effective runway gradient is found by dividing the max. different in elevation by the total length of the runway, should be noted that the developed as the result of experience with many different types on takeoff and landing.

$$L_{RW} = L_{RW} + L_{RW} * G\% * 0.2$$

Example:-

Pre limiting investigation indicates that aircraft to service a particular town will require a truck line airport with runways 4100 ft long under standard conditions. The airport site is located 2700 ft above M.S.L, the av. Temp. during the hottest month is 67 F° and the effective gradient is 0.18 % . Find the required length of runways.

Solution:-

L_{BRW}=4100ft

1) Correction due to Elevation:

$L_{RW} = L_{BRW} + L_{BRW}*0.07*E = L_{BRW}*1.07$

$=4100 + 4100*(2700/1000)*0.07 = 4875$ ft.

2) Correction due to Temperature:

$T_s = 59 - 3.566*(2700/1000) = 49.4$ F°

$\Delta T = T_m - T_s = 67 - 49.4 = 17.6$ F°

$L_{RW} = L_{RW} + L_{RW}*\Delta T*0.005$

$L_{RW} = 4875 + 4875*17.6*0.005 = 5304$ ft.

Geometric Design

3) Correction due to Effective Gradient:

$L_{RW} = L_{RW} + L_{RW} * G\% * 0.2$

$L_{RW} = 5304 + 5304 * 0.18 * 0.2 = 5495$ ft . =5500 ft.

The selected length would normally be multiple of 100 ft

4) % of correction = (planned length-basic length) / basic length *100%

= 5500-4100/4100*100%

= 34% < 35% O.K

Geometric Design

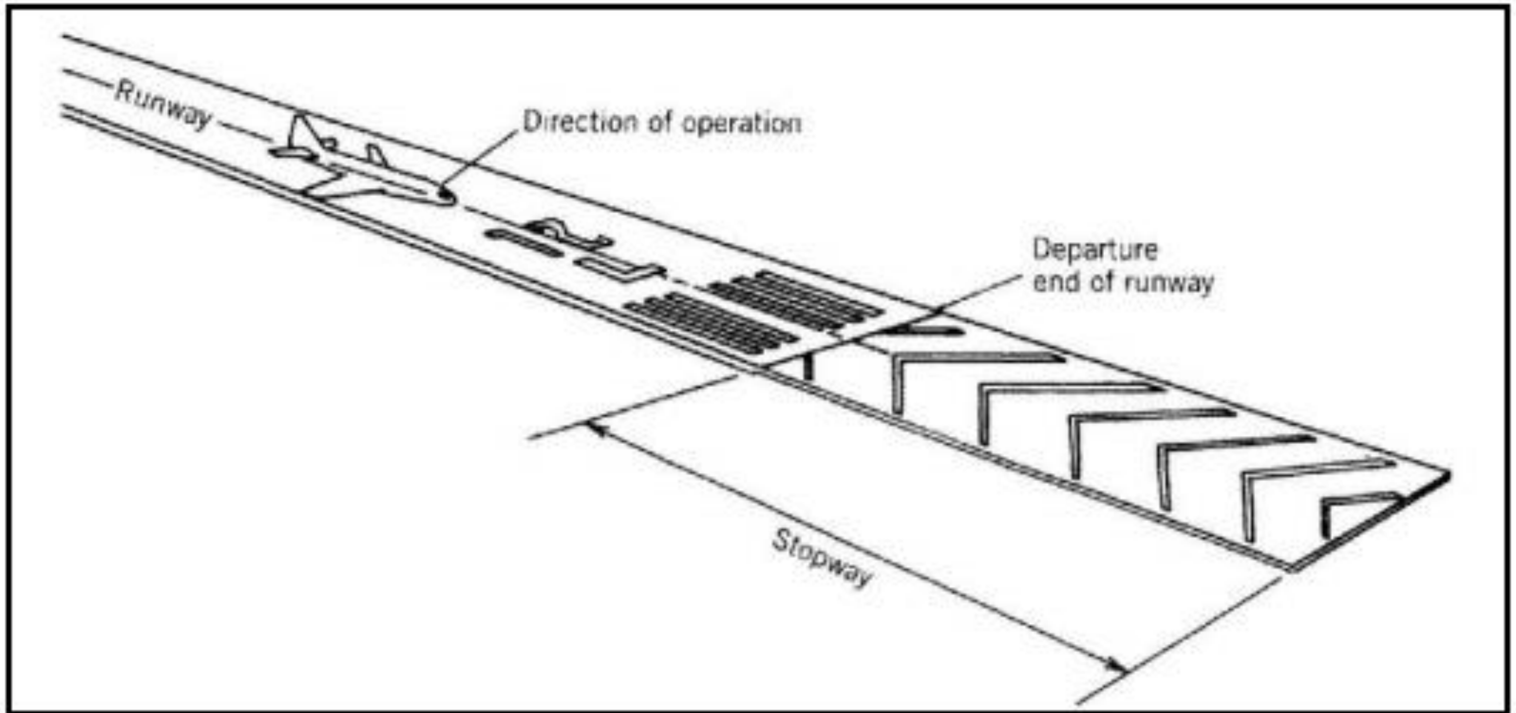
- Field runway required based on the

1) Aircraft characterize.

2) Safety regulation.

- **Stop way:**

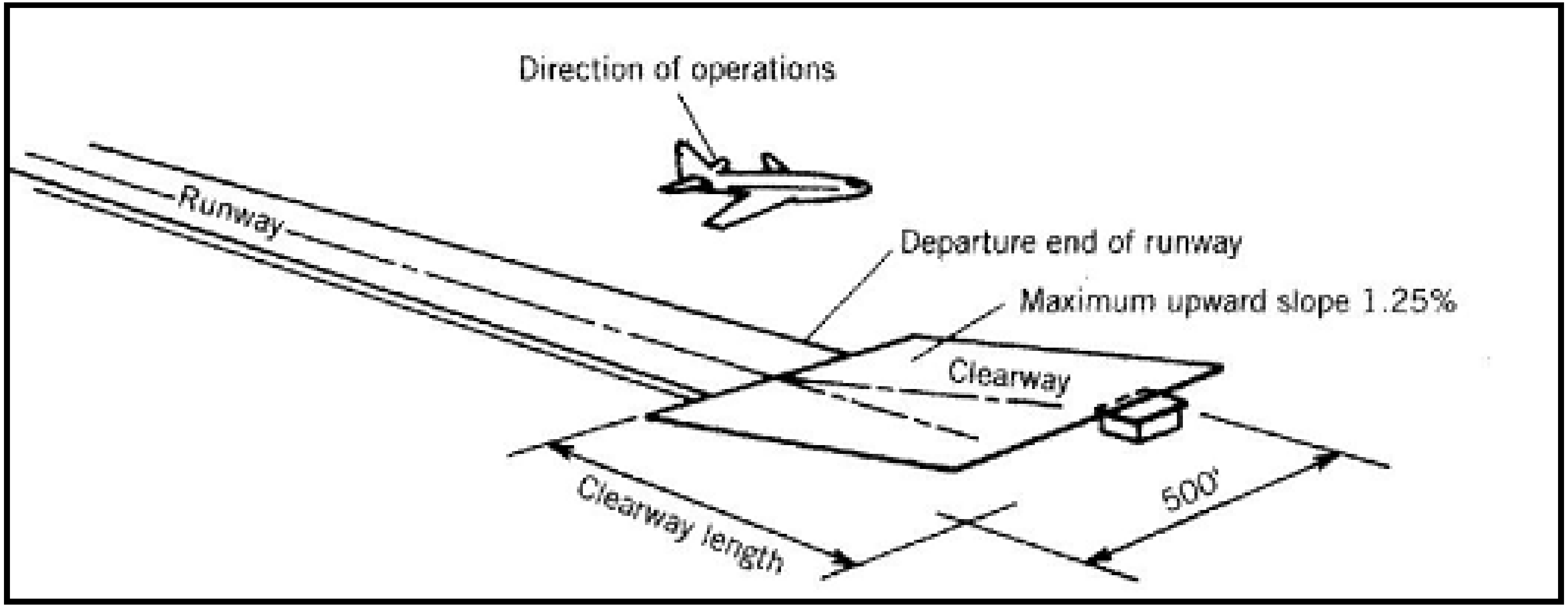
An area beyond the runway not less in width than the width of the runway and designed by the airport authorities for use in decelerating the aircraft during on aborted takeoff to be considered as such the stop way must be capable of supporting the aircraft without in during structural.



Geometric Design

- **Clear way:**

An area beyond the runway not less than 500 centrally located about the extended center line of the runway and under control of the airport authorities.

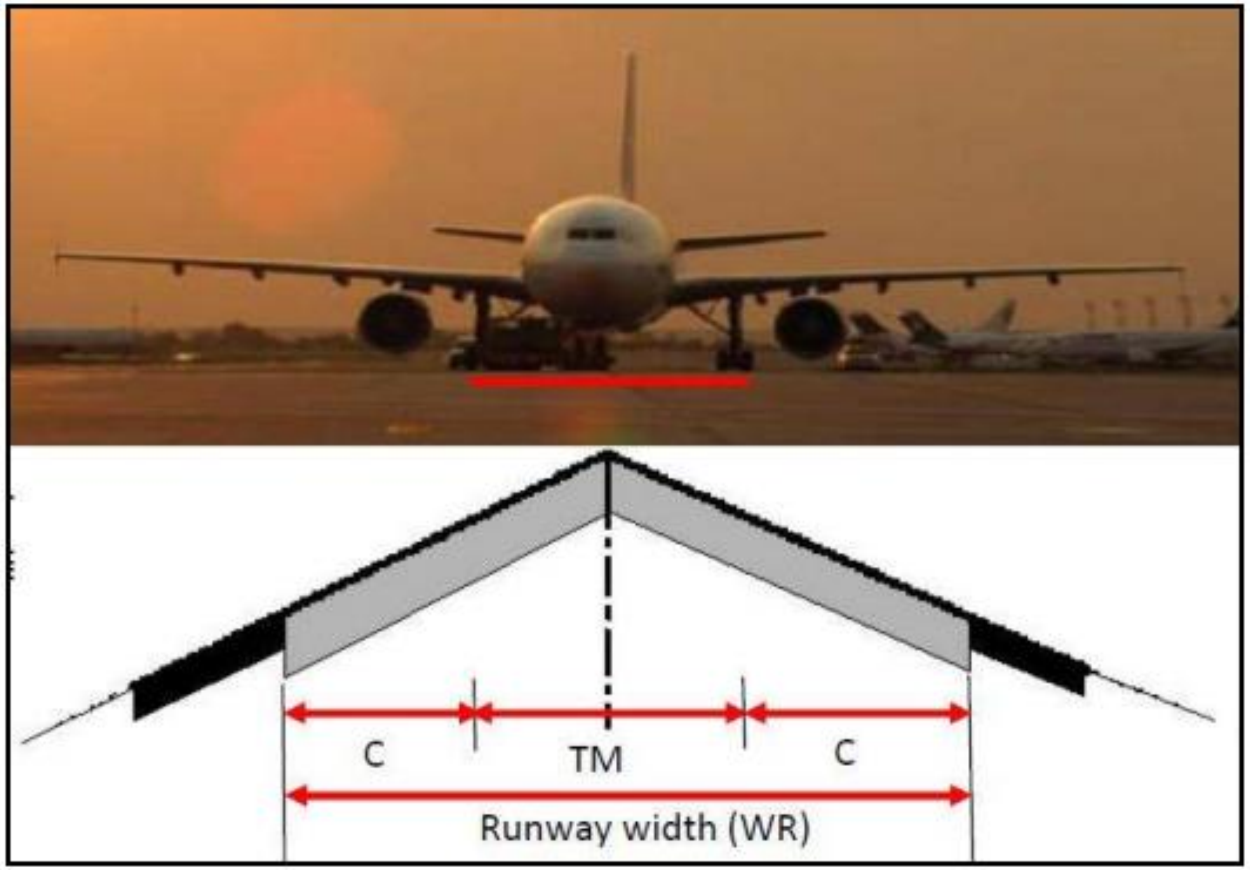


Note:

*The field length includes the runway length plus the stopway and/or clearway lengths, if provided.

Geometric Design

2-Runway Width:



WR=TM+2C

Where;

TM= Outer main gear wheel span.

C= Clearance between the outer main gear wheel and the runway edge.

Geometric Design

2-1-Runway Width Requirements:

- The width of a runway is one of the elements that is affected by several geometrical characteristics of airplanes:

✓The distance between the outside edges of the main gear wheels.

✓The distance between wing mounted engines and the longitudinal axis of an airplane.

✓The wing span. However, the required runway width is also affected by the operational elements:

  - The approach speed of the airplane.
  - The prevailing meteorological conditions.

Lack of sufficient width will cause constraints on the operations.

Under normal conditions, the width of a runway should ensure that an airplane does run off from the side of the runway during the take-off or landing, even after a critical engine failure causing the aircraft to yaw towards the failed engine.

Geometric Design

Minimum runway width

Code number	Code letter					
	A	B	C	D	E	F
1/x	18 m	18 m	23 m	-	-	-
2/x	23 m	23 m	30 m	-	-	-
3	30 m	30 m	30 m	45 m	-	-
4	-	-	45 m	45 m	45 m	60 m

x/ The width of a precision approach runway should be not less than 30 m where the code number is 1 or 2.

Example : Baghdad International Airport (WR=60 m)