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"Design of Runway for Navi-Mumbai International Airport"

Bhushan Shinde[1], Manjunath Sajjan[2], Rajat Telure[3], Shailesh Thorat[4], Prof. Vibhor Patil[5], Prof. Reshma Shaikh[6]

[1,2,3,4]*Under Graduate, Dept. of Civil Engineering, DRIEMS Neral.*
Professor, Dept. of Civil Engineering, DRIEMS Neral, Maharashtra, India.

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Abstract - *This Project includes the design of the runway for the proposed Navi-Mumbai International airport site which is located at Panvel. The data required for the designing part is taken from the competent authority 'City Industrial Development Corporation' (CIDCO). The responsibility for construction of airport comes under CIDCO. The runway is to be designed by international standards following the design procedure given by the 'International Civil Aviation Organization' (ICAO). Wind velocity and temperature is given by Indian Metrological Department (IMD) Physical characteristics of the runway and its sections have been studied in depth and design will be made according to the standards. Along with the runway length calculation of its pavement, marking, and lighting, is also calculated. Images have been provided for better understanding. . The methodology and their references have been specified clearly.*

***Key Words*: Runway, Aircraft, Length Calculation, Pavement, Lighting and Marking.**

1. INTRODUCTION

Transportation plays an important role in the development of the country. Social and economic development of any country or region mainly takes places due to development in transportation. No one can imagine a country or region without any mode of transportation. Transportation helps to connect the remotest part and helps to connect the remotest part and helps in its progress.

Out of the 3 modes of transportation i.e. airways are widely used in the country. Although, Transportation through this routes is cheap but it takes heavy tool of time.

All transportation is little expensive than other modes but it's very quick and reliable. It helps to you cover 100kms with a couple of hours. The air transportation possess a few distinct advantages as compared to other modes of transportation. They or listed below.

1. Rapidly: - All transportation maintain is the highest speed design have been finalized for super-sonic jets which travel faster than sound.
2. Continuous Journey: - Air transportation is continuous over land and water without losses of the time unlike other mode of transportation.
3. Accessibility: - Air Transportation had the unique ability to open up any region that is inaccessible by other means of transportation.

Due to increase in Air transportation in Air transportation it is essential to maintain a proper balance in its essential to maintain a proper balance in its growth. ICAO (International Civil Aviation Organization) keeps a control over planning and also monitors and coordinator all the aspects related to civil aviation.

Navi-Mumbai International Airport: - Is the secondary airport for Mumbai region. It is situate of in Navi Mumbai at Ulwe-Panvel and is Besides the National Highways 4B. The geographical coordinators at the airport a latitude 1 59' 40" and longitude 7343"E.It is nearly about 35-40 km away from existing chhatrapati Shivaji Maharaj International Airport – Mumbai. This prospect Airport is easily accessible from the mankhurd Belapur – Panvel rail corridor from khandeshwar Railway Station and from the Targhar Railway Station on the Nerul- URAN Railway line which is in progress.

In the last few years Mumbai has been a drastic increase in the population to fulfill This has increased the burden on the present " Chhatrapati Shivaji International Airport " to reduce passengers burden from the airport and also to make transportation mode easier to the people leaving at the bounding of Mumbai i.e. Thane , Navi Mumbai , Raigad. Etc.

2. DESIGN OF THE RUNWAY

Design of runway done by following the below listed points:-

1) Aircraft Specification
2) Runway Orientation
3) Runway Geometric Design

4) Runway Pavement design
5) Runway Marking
6) Runway lighting

2.1 Aircraft Specification

This Airport of Navi-Mumbai international Air is to be designed so that it can easily accommodate world's largest passenger carrying Aircraft. We have selected "Boeing 747-800" for the design calculation. All the required specification for the B-747-8 was acquired from manufacturing Website.

1) Take Speed = 297 km/hr.
2) Minimum Take of length required
   = 2915 m
   $\simeq$ 2950 m (assumed)
3) Minimum landing distance required
   = 2300 m

2.2. Runway orientation

Runway orientation means directions of the runway with respect to North and south direction Runway is usually oriented in the direction of prevailing winds. The head wind i.e. the direction of wind opposite to the direction of loading and take off provides a greater lift on the wings of the air craft when it is taking off.

All the necessary data like wind velocity, direction, intensity, duration etc. required for the designing purpose was obtained from INDIAN METROLOGICAL DEPARTMENT Navi- Mumbai

Wind Data

From fig 1 & 2, as some Topographical obstruction are present in W-NW. We have decided to orient our runway in 83^0 E-NE and 263^0 W-SW. The crosswind component at the runway is 10.3 m/s.

Wind Data

Direction	[illegible]	5.1-23.5 (m/s)	[illegible]	%	%	%	Total %
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0
ENE	23	8	0	6.28	2.19	0	8.47
E	0	0	0	0	0	0	0
ESE	30	0	0	8.20	0	0	8.20
SE	0	0	0	0	0	0	0
SES	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	38	53	1	10.38	14.48	0.27	25.14
WNW	143	70	0	39.07	19.13	0	58.20
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0

Fig. 1
Windrose Diagram

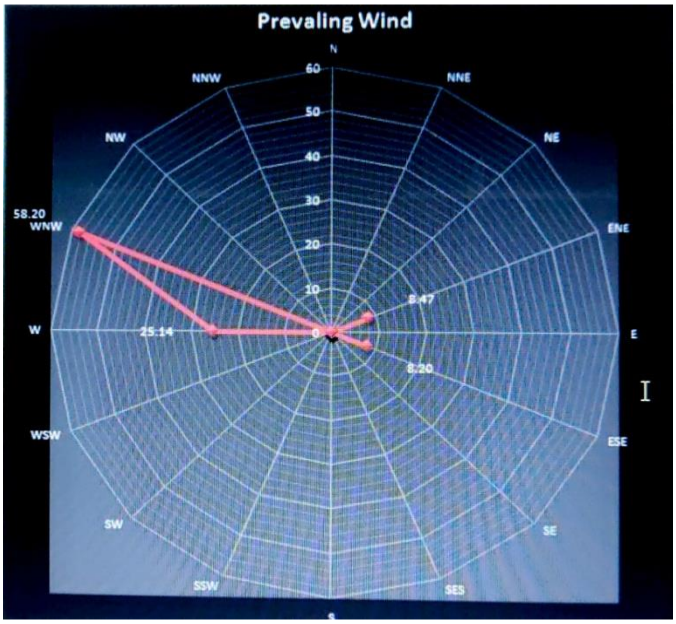


Fig. 2

2.3. Runway Geometric Design

The runway for Navi Mumbai. International airport is to be designed to make it capable for landing and take – off operation of B-747-800. This aircraft is presently world's biggest passenger carrying aircraft. The runway is been categorized and its corresponding length and width is defined by ICAO (International Civil Aviation Association)as per ICAO recommended categories the aircraft B-747-800 fall under category '4E' and the minimum take of length required is 2950 m. and the width of the runway to accommodate this aircraft is 60 m.

The length of the runway is fixed after calculation of two constraints;

1. Basic runway length.
2. Actual runway length.

2.3.1. Basic runway length

The length of the runway is calculations under the following assumed conditions at the airport.

1. Airport altitude is at sea level.
2. Temperature at the airport is standard.
3. Runway is levelled in longitudinal direction.
4. No wind is blowing on runway.
5. Aircraft is loaded no its full capacity.
6. There is no wind blowing enough to the destination.
7. Enright temperature is standard.

The basic runway length is determined from the performance charactstic of aircraft using the airport. The following cases are considered

Case 1;

If one of the critical engines of the aircraft fails, the pilot has to make the decision whether to continue the run or to abort the takeoff. After the aircraft has attained a certain speed, which is called decision speed. If the pilot makes the decision to abort the takeoff then the takeoff run should be equal to shop distance shop distance. If both shop distance and take off run is equal then the total length is called balanced field length.

Take of speed (v) = 297 km/hr.
The decision speed is less than or equal to take all speed.

Decision speed $\leq$ Take off speed.

Hence decision speed VF = 297 km/hr.

Velocity: $\frac{297 \times 1000}{3600} = 82.5$ m/sec

The acceleration to be assumed as 1m/sec

Time: $\frac{\text{Velocity}}{\text{Acceleration}} = \frac{82.5}{1} = 82.5$ sec

Now actual velocity is the difference between final velocity and initial velocity

Hence, va = $\frac{(vf\text{-}vi)}{2} = \frac{8450}{2}$ = 41.15 mlsec

Hence the total take of run = 4125 X 84.5

= 3403 m

Case 2;

When all the engines of aircraft are functioning

115% of take of run = $\frac{115}{100}$ X 3403

Considering the maximum value of (A) and (B)

Take off run of aircraft = 3403 m

Now the minimum landing length required = 2300 m

3403 > 2300 …….. Safe

2.3.2. Actual running length calculation:-

The basic runway length as discussed above is for mean sea level elevation having standard atmospheric condition Necessary correction are therefore applied for any change in elevation temperature and gradient for the actual site of construction.

Following correction are made to basic length to calculate actual runway length.

a) Correction for elevation

b) Correction for temperature

c) Correction for gradient.

a) Correction for elevation:

To achieve speed longer length of runway is required ICAO recommends that the basic runway length should be increased by 7 percent per 300 m rise in elevation above the mean sea level.

Runway elevation considered at the elevation is 3m

= $\frac{(3403 \times 0.07 \times 3)}{300}$ + 3403

= 3405.38m

= 3406m

b) Correction for temperature

1% for every 1°C rise of airport reference temperature above the standard atmosphere temperature at that elevation this correction should be made on corrected length of elevation as per ICAO recommendation

Corrected take off length for temperature =

(Take of rum X (ART - Standard Temperature) x 0.01) + Take off run.

ART = Aerodrome reference temperature

ART = ta + (Tm-Ta) % 3

Where,

Ta = mean of average daily temperature for hottest month of the year

Tm = mean of max daily temperature for hottest month of the year

Standard temperature for the respective elevation is found out by the interpolation method from table

Table 1

Altitude	Temperature
0	15.0
500	11.75
1000	8.50

It was observe that April was the that month of 2017 so, max and min temperature data is shown in table 2

Table 2.1

Date	Temperature	
	Min	Max
16 April 2017	35	26
17 April 2017	33	26
18 April 207	36	27
19 April 2017	34	27
20 April 2017	38	27
21 April 2017	33	27
22 April 2017	33	28
23 April 2017	38	28
24 April 2017	32	28
25 April 2017	33	26
26 April 2017	37	25
27 Aprll 2017	33	26
28 April 2017	36	25
29 April 2017	33	23
30 April 2017	38	25

Table 2.2

Date	Temperature	
	Min	Max
1 April 2017	31	25
2 Appril 2017	33	25
3 April 2017	34	25
4 April 2017	36	26
5 April 2017	33	27
6 April 2017	33	27
7 April 2017	37	25
8 April 2017	33	21
9 April 2017	36	23
10 April 2017	35	23
11 April 2017	35	27
12 April 2017	34	26
13 April 2017	34	24
14 April 2017	34	27
15 April 2017	35	28

From table (1 and 2 .1 & 2.2)

We get = Ta = 30.15^0 C

Tm = 34.45^{0}C

Standard Temperature = 14.98^{0}C (by interpolation)

$$ART = Ta + \frac{Tm - Ta}{3} = 31.58^0\ C$$

corrected runway length for temperature

= (3406 x (31.58 - 14.98) X 0.01) + 3406

= 3971.396 m

c) Correction of gradient

ICAO does not recommends any specific correction for the gradient FAP recommends that runway length after have been corrected for elevation and temperature should be further increased at the rate of 20% for every 1% effective gradient's Where runway length a move than 900m.

Total runway length is divided in four parts

Where slope of 1st and 4th part is zero

Where the slope for 2nd part is 1.25%

Where the slope for 3rd part is 0.35 %

For second quarter

$$\frac{Dy}{Dx} \times 100 = 1.25$$

$$\frac{Dy}{900} \times 100 = 1.25$$

Elevation at second quarter is =11.25 elevation for third quarter :-

$$\frac{Dy}{Dx} \times 100 = 0.35$$

$$\frac{Dy}{900} \times 100 = 0.35$$

Dy = 3.15

Elevational at third quarter = 3.15

Total elevation = 3.15 + 11.2

= 14.4

$$\text{Slope} = \frac{\text{max.elevation - min . elevation}}{\text{length of runway}}$$

$$= \frac{14.4 - 0}{3972}$$

= 0.36%

Corrected runway length for gradient

= (3972 X 0.36 X 0.2) + 3972

= 4257.98m

= 4258m

Total length of runway to be provide is 4258m

Width of the Runway

The runway is designed for B-747-800 aircraft which comes under E category. Therefore width of runway to be provide is 60m

Runway Shoulders

The shoulders are usually unpaired as they are used abnormally emergency i.e. when there is some abnormally in the aircraft operation They may at the most prepared of established soil or be furthered . Another advantage of providing shoulder on either side of the runway is that they impart sense of apples to the pilot and improve his psychology during landing and takeoff. ICAO recommends width of safely area to be at least 78m for D and E types of runway.

Width of shoulder: - 9m on each side of runway.

2.4. Runway pavement design

The pavement are mainly classified in two categories they are flexible and Rigid pavement Which depends on their structural action. The Pavement which has gravel Water bound macadam and also has black top surface is known as flexible is mainly grouped as rigid pavement Flexible pavement are known for the deformation of subgrade and their subsequent lays.

rigid pavement has the characteristic which are associated which bending strength or beam action. Flexible pavement has flexible strength which is however negligible when compared with rigid pavement

Runway for Navi Mumbai international Airport is to designed as flexible pavement This pavement is designed by CBR method. The test was performed in geotechnical laboratory of "Vishwaniketan College at Khalapur", The CBR value at subgrade was found to be 15% (In which soil was stabilized). The pavement thickness is calculated by the below shown graph and considering wheel load as 27.4X 10^3 kg.

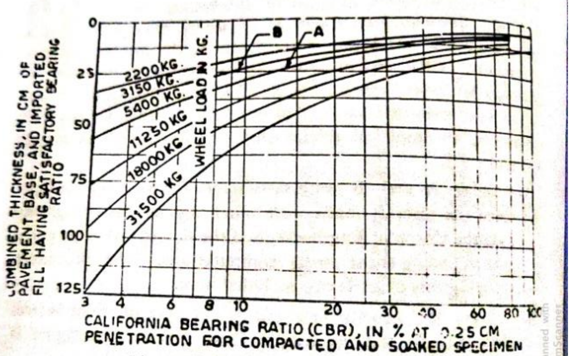


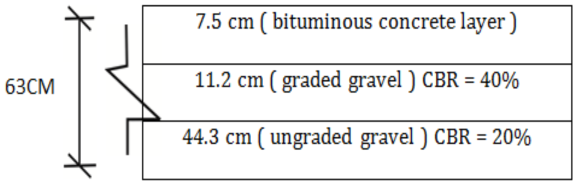
Figure 9.2 CBR Design Chart

Total thickness of pavement for subgrade CBR value 15% = 63cm

Thickness sub-base ungraded gravel of CBR value 20% = 44.3cm

Thickness of base coarse which consist of graded gravel 40% = 11.2cm

The pavement has bituminous concrete layer of the top surface which is 7.5cm thick



(Cross section of the road pavement)

2.5. Runway Marking

Marking helps the pilot of distinctly identify the laying area. Which indirect the laying area. Which indirectly helps the pilot in aircraft operations.

2.5.1. Runway threshold marking

Runway threshold marking is indicated by the series of parallel lines starting from a distance of 6m. From runway end.

Number of strips = 14

Length of each strip = 45m

Width of each strip = 1.80m

Gap between two strips = 1.80m

2.5.2. Aiming point marking

It consist of rectangular strip on either side of center line

Distance from thersold = 300m

Length of each strip = 50m

Width of each strip = 10m

Gap between each strip = 20m

2.5.3. Touch Down zone marking

It is indicated by number strips parallel to center line of Runway.

Number of Strips on both side = 4

Length of each strip = 25m

Width of strip = 3m

Gap between each strip = 1.5m

Lateral spacing between strips on either side = 20m

2.5.4. Center line marking

Length of each strips = 40m

Width of Strip = 0.5m

Gap between each strip = 35m

2.5.5. Runway strip marking

30m from the center line of Runway

Width of each strip = 1m

2.6. Runway lightning

2.6.1 Runway identifier lights (REIL)

Unidirectional lights which faces approach direction or omnidirectional pair of synchronized flashing lights. This lights are installed at the runway thereshold ,one on each side.

2.6.2 Runway and lights

This lights are pair of four lights on each side of the runway on the precision instrument runways. This lights extends along full width of runway. These lights can be seen in green colour by approaching aircraft and red when seen from runway.

2.6.3. Runway edge lights

These are the white elevated lights that runs the lengths of the runway on either side. The color of light changes to amber in the last 610 m of the runway or last one-third of runway whichever is less on precision instrument runways.

2.6.4 Runway centerline lighting system (RCLS)

These are the lights which are embedded in the pavement surface of the runway. This are installed at the interval of 15m along the centerline. Some of the precision instrument runway. They have

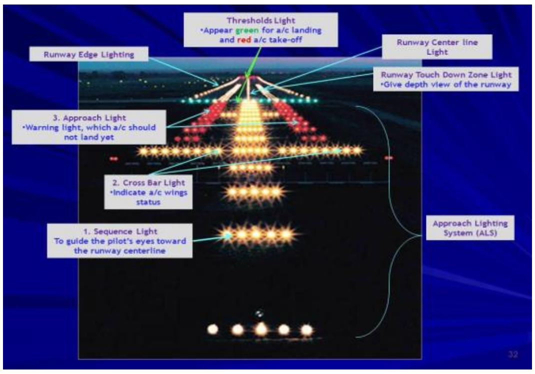
White light except last 900m

Alternate white and red for next 600m

Red for last 300m

2.6.5 Touchdown Zone lighting (TDZL)

These are lights of rows of white light bars of a intervals of 30 to 60m at either side of center line for 900m.



3. CONCLUSIONS

1. Runway is oriented in 83^0 E-NE & 263^0 W-SW.
2. Total actual length of the runway is 4258 m.
3. Width of the runway is 60m.
4. Width of the shoulder is 9m on each side of runway.
5. Total Depth of the pavement is 63cm.

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