FEASIBILITY CHECKS OF RUNWAY LENGTH AND ORIENTATION OF PROPOSED INTERNATIONAL AIRPORT AT PURANDAR, PUNE.

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Abstract – *In last decade air traffic in India has increased in multiple numbers taking it into consideration. Indian government has decide so have at least one airport in every district. Pune have already one airport which is situated at Lohegaon. But due to heavy air traffic Maharashtra Government has decided to have one more airport for traffic control purpose in Pune district. The elaborate design of runway of proposed international airport at Purandar Pune, Maharashtra, India.*

Key Words**:** Design of Runway, Orientation, Traffic Control

1. INTRODUCTION

The proposed **Purandar** International Airport which is named as **Chatrapati Sabhaji Raje** International airport it is 45km away from **Pune** city.

It is proposed **green field** airport to serve the city of **Pune India**. It will built near **Pune** in **Pune district** of the **Pune district** in the Indian state of **Maharashtra**. In 2016 it was announced that the proposed airport would spread over 2400 acres. The airport would be named as after the king of the **Maratha Empire, Sambhaji Maharaj,** who was born at **Purandar Fort**.

The **Airport Authority of India** conducted survey on various areas near **Pune** for a new airport for the city. Initially site near **Chakan** was chosen for the airport but due to opposition from local farmers and mountainous terrain taluka. As it was a flatter region compared to **Chakan**. The airport is planned to include a decided cargo terminal. The site is 18° 20′ 56″N 074°08′02″E. The average elevation of airport is 739m.

The number and orientation of the runway plays an important role in the overall arrangement of various components of an airport. The number of runway will depend on the volume of air traffic while its orientation will depend on the direction of the wind and sometimes on the extent area available for the airport development.

In general, the arrangement of the runway and connecting taxiway should comply with the following conditions:

(i) To avoid delay in the landing, taxiing and take off operations and to cause the least interference in these operations.

(ii) To grant the shortest taxi distance possible from the terminal area to the ends of the runway.

(iii) To make provision for adequate taxiway so that the landing aircraft can leave the runways as quickly as possible and follow routes as short as possible to the terminal area.

2. Methodology:

We have collect the information about "Place of the site, 10 years wind data from Indian Metrological Department (IMD), Elevation of site, and Distance of airport from city, Highway, River and Area of the site" by **Google Earth** for windrose diagram and runway length to our selected study area.

2.1 Runway orientation:-

(1) Preliminary information required:-

It is necessary to collect the following data before deciding the orientation of the runway:-

(i) Maps of the area in the vicinity of the airport showing contours at suitable intervals.

(ii) Records of direction, force and direction of the wind in the vicinity and fog characteristics of the area for as long a period as possible.

(2) Head wind:-

The runway is usually oriented in the direction of the prevailing winds. The head wind indicates the wind from the opposite direction of the head or nose of the aircraft while it is landing or taking off. The orientation of runway along the head wind grants the following two advantages:

(i) During landing, it provides a breaking effect and the aircraft comes to a stop in a short length of the runway.

(ii) During take off, it provides greater lift on the wings of the aircraft.

Thus the landing and take off operations take place in a shorter length of the runway due to the head wind than what it would have been, if the landing and take off were in the direction of the wind. The reduction in length of runway may be about 10% or so.

(3) Cross wind component:-

It is not possible to get the direction of opposite wind parallel to the center-line of the runway length everyday or throughout the year. For some period of the year at least, the may blow making some angle θ with the direction of the center-line of the runway length.

(4) Wind coverage:

The percentage of time in a year during which the cross wind component remains within the limit of 25 km/h. is called the wind coverage of the runway. The orientation of the runway should be such that the minimum wind coverage of about 95% is obtained. For busy airports, it is possible to obtain wind coverage up to 98% or even 100%.

(5) Wind rose:

For the airport, the average wind data of 5 to 10 years period are collected and represented graphically in the form of a chart known as wind rose. The diagram is given the name wind rose because of its irregular shape resembling a rose.

For this project, a type I and type II windrose diagram has been used, which gives the suitable wind direction and crosswind component.

The number and orientation of the runway play an important role in the overall arrangement of various components of an airport. The number of runways will depend on the volume of air traffic while orientation will depend on the wind and sometimes on the extent area available for the airport development.

In general, the arrangement of runway and the connecting taxiways should comply with the following conditions:

i. To avoid delay in the landing, taxiway and take off operations cause the least interference in these operations.

ii. To grant the shortest taxi distance possible from the terminal area to the ends of runway.

iii. To make provision for adequate taxiway so that the landing aircraft can leave the runway as quickly as possible and follow routes as short as possible to the terminal area.

iv. To provide adequate separation in the air traffic pattern.

Table -1: Grouped data of wind components in percentage.

Wind Direction				Total percentage of wind Blowing in each direction
	7-12 km/h	13-24 km/h	25-84 km/h	
N	0	0	0	0
NNE	0.05	0	0	0.05
NE	0.55	0.02	0	0.57
ENE	0.64	0.07	0.02	0.73
E	4.09	0.30	0.02	4.41
ESE	0.53	0	0	0.53
SE	0.32	0.02	0	0.34
SSE	0.02	0	0	0.02
S	0.07	0	0	0.07
SSW	0.02	0	0	0.02
SW	0.66	0.18	0	0.84
WSW	4.09	0.37	0.02	4.48
W	55.28	9.05	0.11	64.44
WNW	8.87	0.43	0	9.3
NW	0.64	0.05	0.02	0.71
NNW	0.09	0	0	0.09
Variable	0	0	0	0
Total	75.91	10.49	0.21	86.61

The study of wind rose helps in determining the most suitable orientation of the runway. It is also a useful device for estimating the runway capacity.

The plotting of the wind rose diagrams can be done in the following two ways:

Type 1: Showing direction and duration of wind.

Type 2: Showing direction, duration and intensity of wind.

Each of the above type of plotting will now be discussed.

Type 1 wind rose, direction and duration of wind: The radial lines indicate the wind direction and each circle represents the duration of wind to a certain scale. The total percentage of wind blowing in North is 6.10 and accordingly, this point is marked along North direction. Similarly, all other values are plotted and then Joined by the straight lines. The best direction of runway is indicated along the direction of the longest line on the wind rose diagram. WNW-ESE is the best orientation for the runway. This type of wind rose does not consider the effect of the cross wind component.

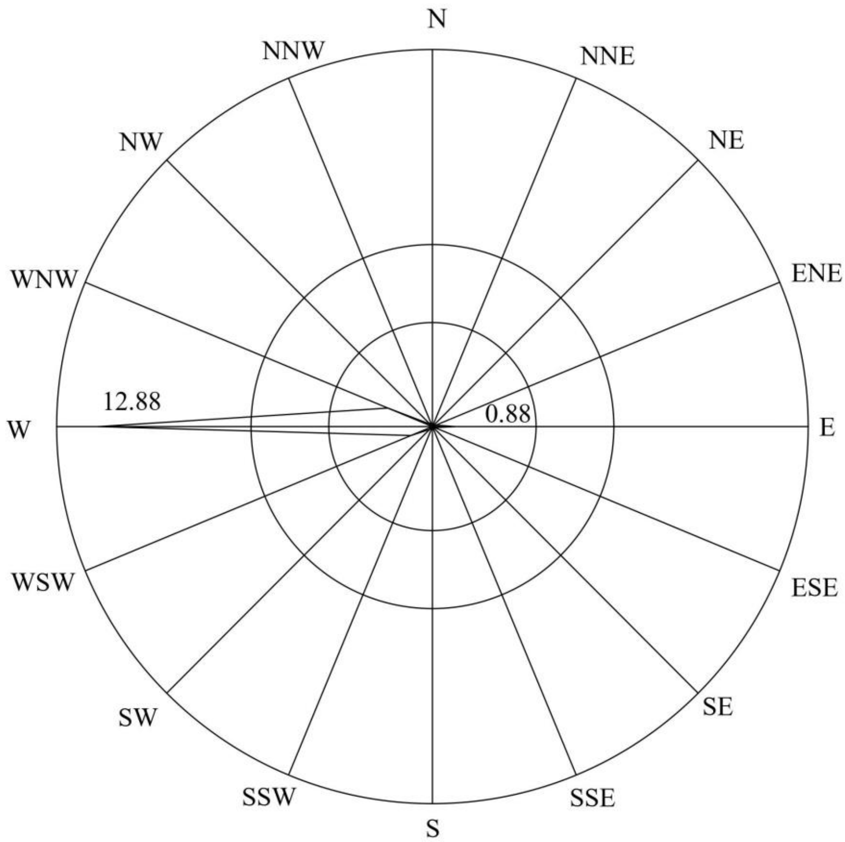


Fig: 1 Wind rose diagram type-1 showing direction and duration of wind

Type II wind rose, direction, duration and intensity of wind: That the percentage of time during which the wind velocity is less than 6 km/h. works out to (100-88) = 12. This period is called the calm period and it does not influence the operations of landing and take-off because of low wind velocity. Thus, the wind velocities below 6 km/h. have no effect on the fixing of orientation of a runway.

The construction and use of this type of wind rose diagram are illustrated following procedure is adopted:

(i) The concentric circles with radii corresponding to 6, 25, 50 and 80 km/h. to some scale are drawn. Thus, each circle represents the wind velocity to some scale.

(ii) Starting with center of the concentric circles, the 16 radial directions are shown on the outer circle. The mid-points of 16 arcs on the outermost concentric circle are marked and they are given the cardinal directions of compass like N, NNE, NE, ENE, E, etc.

(iii) The recorded duration of winds and expressed as percentage are shown for each cardinal direction in the sector pertaining to that direction. It may be noted that the cardinal direction is central to its sector. Taking the wind data for N direction, the duration of 6-25, 25-50 and 50-80 km/h. wind velocities are shown in 3 pertinent parts of the N direction sector as 4.6, 1.4 and 0.1%. Similarly, for NNE direction, the durations in the sector of NNE direction are shown as 3.4, 0.75 and 0.00%. The durations of wind velocities are thus shown in all the sectors to complete the wind rose diagram.

(iv) A transparent rectangular template or paper strip is taken. Its length should be slightly greater than the diameter of the wind rose diagram and its width should be greater than twice the allowable cross wind component i.e. (2 x 25) = 50 km/h. The scale for cross wind component should be the same as that of the concentric circles of the wind rose diagram. Along the center of the length of this template, a line is marked corresponding to the direction of runway. The two parallel lines, one on either side of the center-line, is drawn at a distance equal to the allowable cross wind component i.e. 25 km/h. from the center-line. In other words, the two parallel lines are 50 km/h. away from each other.

(v) The wind rose diagram is fixed in position on a drawing board. A hole is drilled in the center of the template and it is placed on the wind rose diagram such that its center lies over the center of the wind rose diagram. In this position, the template is fixed by a pin passing through its center so that the template can rotate about this pin as axis.

(vi) The template is rotated and is placed along a particular direction. In this position of the template, the duration of 6-25, 25-50 and 50-80 km/h. winds are read for the cardinal directions lying between the two extreme parallel lines marked on the template. The sum of all these durations is expressed as the percentage and it gives the total wind coverage for that direction.

(vii) The template is then rotated and is placed in the next direction. The total wind coverage is calculated and the process is repeated for all the directions.

(viii) The direction which gives the maximum wind coverage is the suitable direction for the orientation of the runway.

Following points should be noted:

(i) If the extreme parallel lines on the template cut some of the three significant parts of a sector for a cardinal direction, the values of the truncated portions of these parts lying inside the parallel line should be found by eye estimation. This is done on the assumption that the full part represents the percentage of duration marked on it.

(ii) The maximum wind coverage of a runway should be 95% on the assumption that the calms are 5%. If a single runway is not sufficient to provide the necessary coverage, two or more number of runways should be planned to get the desired coverage.

(iii) If proper wind data for an entirely new location are not recorded, the study of nearby measuring stations may be made. If the surrounding area is fairly level, the records of these stations may indicate the winds at the site of the proposed airport. If the area is however hilly, the wind pattern is often dictated by the topography and it will prove dangerous to utilize the records of stations situated some distance away from the site. In such cases, it will be advisable to study the topography of the region at least for one year and correlate the observations from the information gathered from the old residents of the locality.

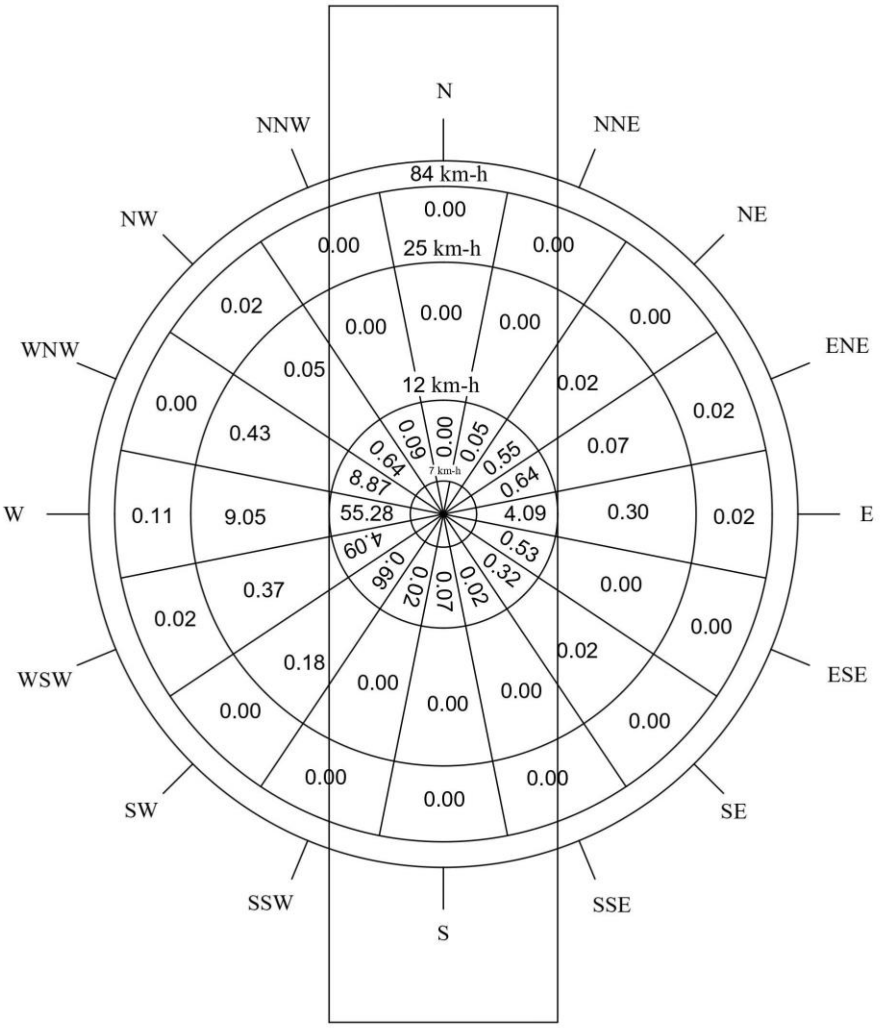


Fig: 2 Wind rose diagram type-2 showing direction, duration and intensity of wind

CHANGE IN DIRECTION OF RUNWAY:-

The ideal orientation decided from the study of the wind rose diagram may have to be slightly altered or changed because of the following factors:

1. Excessive grading: If the orientation of runway demands excessive grad and earthwork, it will have to be suitably modified even though it might have been satisfactory with respect to the safe approaches and the wind coverage.

2. Noise nuisance: The location of runway should be such that it does not obstruction create excessive noise nuisance to the surrounding developed residential areas and public places of importance. This factor may also sometimes cause the change in direction of the runway as decided by the wind rose diagram.

3. Obstruction: The absence of obstruction in the layout of the runway is more important than the consideration of the permissible cross wind component. Hence, the runway direction providing fewer obstruction in the approach zone is preferred to one having greater wind coverage.

2.2 Runway Length:-

2.2.1 Basic runway length:-

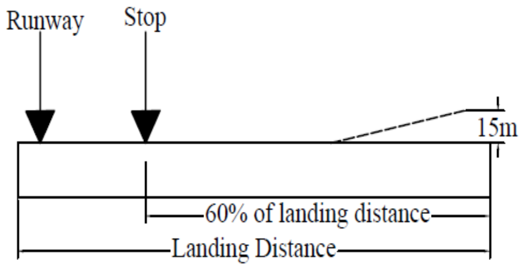
The length of runway based on the following assumed condition is known as the basic runway length:

i. No wind is blowing on the runway.
ii. The aircraft is loaded to its full loading capacity.
iii. The airport is situated at sea-level.
iv. There is no wind blowing on the way to the destination.
v. The runway is levelled in the longitudinal or in other words. It has zero effective gradient.
vi. The standard temperature is maintained along the way.
vii. The standard temperature of 15°C exists at the airport.

The manner in which an aircraft actually performs the landing and take-off will decide to a large extent the length of a runway.

Following three cases will be considered:
(1) Normal landing
(2) Normal take off
(3) Stopping in emergency.

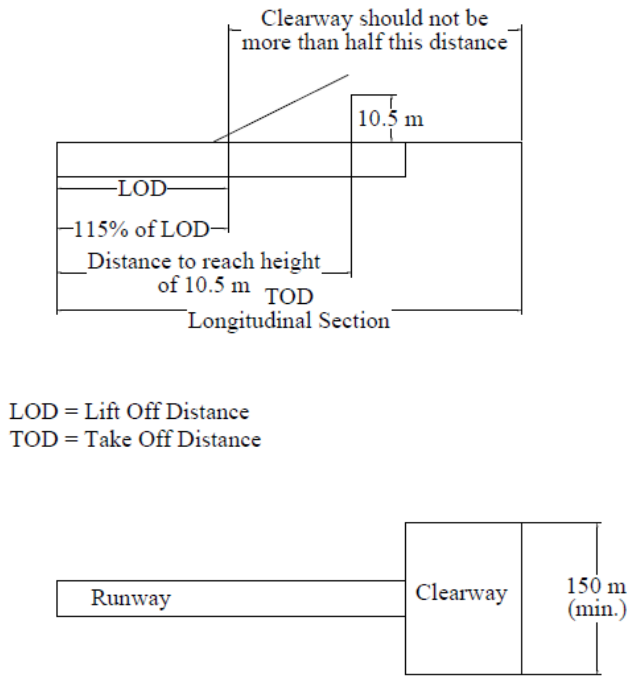
(1) Normal landing: The aircraft should come to a stop Within 60 per cent of the landing distance assuming that the pilot makes an approach at the proper speed and crosses the threshold of the runway at a height of 15 m. The beginning of the runway portion to be used for landing is known as the threshold. The runway of full strength pavement is provided for the entire landing distance.



Normal Landing
Fig. 3

(2) Normal take off: The take-off distance (TOD) must be, for a specific weight aircraft. 115 per cent of the actual distance the aircraft uses to reach a height of 10.5 m. The distance to reach the height of 10.5 m should be equal to 115 per cent of the lift-off distance (LOD).

The normal take off requires a clearway which is defined as an area beyond the runway not less than 150 m wide, centrally located about the extended center-line of the runway and under the control of the airport authorities. It is expressed in terms of a clearway plane extending from the end of the runway with an upward hit me slope not exceeding 1.25 per cent. It is to be seen that the clearway is free from any obstruction. The clearway should not be more than one-half the difference the between 115 per cent of the LOD and TOD.



Normal take off
Fig. 4

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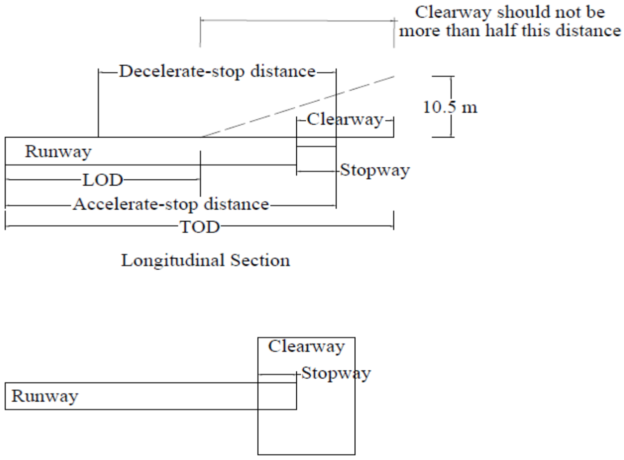
(3) Stopping in emergency: For the engine failure case, the TOD is the actual distance required to reach a height of 10.5 m with no percentage applied. It also incidentally recognizes the infrequency of occurrence of the engine failure. In case of an engine failure, sufficient distance should be available to stop the airplane rather than continue the take-off. This distance is known as the accelerate-stop distance.

It is required to provide a clearway or a stop way or both in this case. The stop way is defined as a rectangular area at the end of runway and in the direction of take-off. It is a paved area in which an aircraft can be stopped after an interrupted take off due to engine failure. Its width is at least equal to the width of runway and the thickness of pavement less than that of the runway, but yet sufficient to take the load of aircraft without failure. The clearway should not be more than one-half the difference between TOD and LOD. All the above three cases are considered for the jet engine aircrafts. For the piston engine aircrafts, only the first and the third cases are considered. The case giving the longest runway length is finally recommended.



Plan
Stopping in emergency
Fig.5

Basic runway length-

Take off speed of plane (V) = 290 km/h.

Decision speed (V_f) = 290 km/h.

Velocity = (290X1000)/3600 = 81m/s.

The acceleration is assumed as, (a) = 1 m/s.

Actual velocity is difference between final velocity and final velocity.

$V_a = (V_f-V_i)/2 = (81-0)/2 = 40.5\ m/s^2$.

Hence,

(a) Total distance (Take off run) = 40.5X81 = 3280m.

When all the engines are operating,

(b) 115% of take-off run = (115X2915) = 3352m.

Taking the maximum value of case (a) and (b)

Take off run from aircraft performance is 3352m.

To get actual length of the runway, the following three correction are to be applied to the calculated basic runway length:-

1) Correction for elevation.
2) Correction of gradient.
3) Correction for temperature.

(1)Correction for elevation:-As per the recommendation of ICAO, the basic runway length should be increased at the rate of 7 per cent 300 m rise in elevation of airport above mean sea level. This correction is required because the air density reduces s the elevation increases which in turn reduce the lift on the wings of the aircraft. These, the aircraft will require more ground speed to rise to the air for achieving more speed, the longer length of runway will be required.

The basic length selected for runway should be increased at the rate of 7% per 300m elevation.

Runway elevation at the aerodrome = 12m.

Elevation of Purandar airport is 739m.

Runway take off length corrected for elevation

= ((7/100) X (739/300) X3352) +3352)

=3929.99≈**3939m.**

(2) Correction for temperature:-The rise in airport reference temperature has the same effect as that of the increases in its elevation above mean sea-level. After the basic length is corrected for the elevation of airport, it is further increased at threat of 1% rise in airport reference temperature above the standard atmospheric temperature at the elevation. The airport reference temperature is worked out by the following expression:

Airport reference temperature = $(T_1 + (T_2 - T_1)/3)$

Where,

T_1= Monthly mean of the average daily temperature for the hottest month of the year.

T_2= Monthly mean of the maximum daily temperature for the same month.

The standard temperature at the airport site can be determined by reducing the standard mean sea-level temperature of 15°C at rate of 6.5°C per thousand meter rise in elevation.

= [Take of run X (ART-Standard temperature) X 0.01) +Take off run.

ART = Aerodrome reference temperature.

ART= 38.33°C

Standard temperature at 739m. Elevation at 15°C

= [3930X (38.33-15) X0.01] +3930

=4846.86≈**4847m.**

(3) Correction for gradient: - As the gradient becomes steep, more consumption of energy takes place and longer length of the runway will be required to attain the desired ground speed. The ICAO does not give any specific recommendation for the increase in length due to the effective gradient.

The maximum difference in elevation between the highest and lowest points of runway divided by the total length of runway is known as the effective gradient. According to FAA (Federal Aviation Administration) of U.S.A., the runway length after being corrected for elevation and temperature should further be increased at the rate of 20% for every 1°C of effective gradient.

Effective gradient = 0.5%.

Applying correction for the effective gradient at the rate of 20% for each 1°C effective gradient.

= (20/100X4847) X (0.5/100) +4847

=4.84+4847

=4851.84≈**4852m.**

3. CONCLUSIONS

The most important points of this study can be summarized as follows:-

i. From the wind data the orientation of the runway is provided West to East direction.
ii. For the proposed airport, the runway length is 4852 meter.

REFERENCES

[1] https://earth.google.com/
[2] Khanna, S. K., and M. G., Arora. Airport: Planning and Design. Nem Chand, 1976.
[3] S. C., and P. C., Rangwala., Airport Engineering. Charotar, 1992.