Runway Pavement Design of a proposed Airport with the use of FAARFIELD Software

Amandeep Singh B. Bhalla, Amit A. Vankar, L. B. Zala

Abstract: ***The Fedara International Airport is a proposed international airport near Fedara in Gujarat state in India. This airport will be proposed in India with a total area of 7,500 hectares (85 km from Ahmedabad). The need for a new international airport was felt because of rising international passenger traffic at the existing airport at Hansol, which despite a new world-class international terminal, is expected to face expansion constraints in the future. In general, the soil type in the Fedara is fine (shrinkage and swelling characteristics) calcareous and mostly saline. Generally, construction of rigid structures on such soils is not deemed feasible. Even in the case of flexible structures, though the settlements occur uniformly, such heavy settlements are not permissible. The need for improving ground conditions prior to commencement in construction activity is extremely critical. The aim behind this paper is to evaluate the flexible pavement thickness analysis by testing subgrade soil using FAARFIELD software.***

Index terms: ***Dholera Special Investment Region, FAARFIELD, Runway Pavement Design, Soil Subgrade Improvement***

I. INTRODUCTION

Fedara is lying between 22°27′14″N and72°09′40″ E. The state Government identified the location for the proposed Airport and has earmarked the land. The site is about 80 kms from Ahmedabad and around 20 kms from Dholera SIR (Special Investment Region)[4]. In addition to the SIR and Ahmedabad city, this location is also ideally placed near the cities like Nadiyad, Bhavnagar, Vadodara and Rajkot. In general, the soil type in the Fedara is fine calcareous and mostly saline. The sub-soil is made up of the alternate layers of soft silty clay/clayey silt of medium to high plasticity and fine to medium grained sand. The magnitude of the settlement under the applied load will be 300 to 800 mm depending on the applied pressure intensity. **Table 1** indicates properties of the soil as reported in the DDP-DSIRDA (Development draft plan- Dholera Special Investment Region Development Association) and the soil tests which were performed in the laboratory. Generally, construction of rigid structures on such soils is not deemed feasible. Even in the case of flexible structures, though the settlements occur uniformly, such heavy settlements are not permissible.

The need for improving ground conditions prior to commencement in construction activity is extremely critical.

The Fedara having the most of the region covered with top black cotton soil. As the soil has liquid limit greater than 50% and this soil is classified as CH group (Inorganic clays of high plasticity, fat clays) according to IS: 1498-1970. **Fig. 1** shows the Map of soil deposits in Gujarat State.

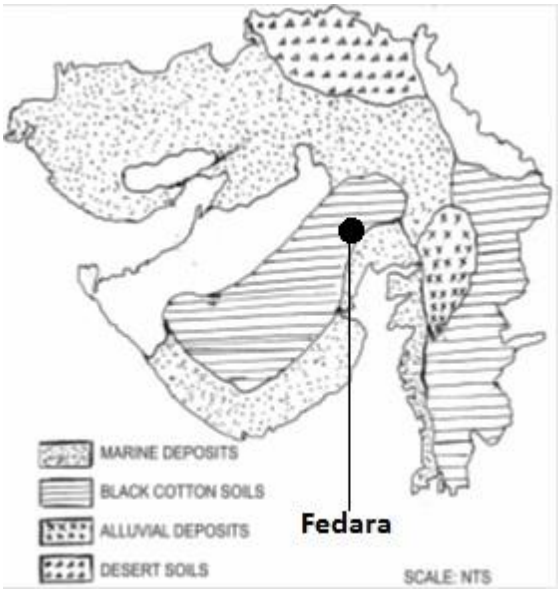

Fig.1 Map of soil deposits in Gujarat State

II. SOIL SUBGRADE IMPROVEMENT

Soil tests were carried out to get the CBR value of subgrade layer. The average value observed under soaked CBR was 1 -1.5%. **Table 2** show the CBR value as conducted. Hence requires improvement in the soil strength. Therefore it was decided to go for insitu soil stabilization. To stabilize the soil, tests were conducted with the addition of cement, lime and Flyash. Number of C.B.R tests was conducted to increase the strength of soil. Combination of the additives was also tried. Ultimately got the desired strength of C.B.R as 10.8.which is shown in Table 2. Hence the C.B.R of 10.8% was considered in the design. In **Table 2** C denotes cement, S soil, L lime and F Flyash. CS1, CS2, CS3, LS1, LS2, LS3 represents mixture of soil with cement and lime with 2%, 4%, 6% respectively. FS1, FS2, FS3 represents mixture of soil with 6%, 8%, 10% flyash. CF1, CF2 represents mixture of soil with 3% and 6% cement and flyash respectively. And CLF represent mixture of soil with 6% cement, 6% lime and 2% flyash.

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Table 1 Properties of the Soil

ASPECTS OF SILTY CLAY OF HIGH PLASTICITY	PROPERTY REPORTED IN DSIR REPORT	REPORT OF SOIL TESTS IN LABORATORY			IS CODES
		PIT 1	PIT 2	PIT 3	
GRAVEL (%)	00-00	0	0	0	IS:1498-1970
SAND (%)	20-30	24	25.1	24.9	IS:1498-1970
SILT (%)	30-40	38	37	37.55	IS:1498-1970
CLAY (%)	30-40	38	37.9	37.55	IS:1498-1970
NATURAL MOISTURE CONTENT (%)	10-30	29.03	29.45	29.15	IS:2720 (Part II)-1973
ATTERBERG LIMITS					
LIQUID LIMIT (%)	55-70	48.5	50.1	51.4	IS:2720(Part -5)-1985
PLASTIC LIMIT (%)	30-40	28.24	30.02	31.77	IS:2720(Part -5)-1985
PLASTICITY INDEX (%)	20-30	20.26	20.08	19.63	IS:2720(Part -5)-1985
FREE SWELL INDEX (%)	70-135	20	10	15	IS:2720-Part -4
SPECIFIC GRAVITY	2.63-2.65	2.66	2.65	2.65	IS:2720-Part -3
DRY DENSITY(T/m^3)	1.40-1.80	1.78	1.75	1.75	IS:2720-Part -8

TABLE 2.C.B.R TEST RESULTS FOR THE IMPROVEMENT OF SUBGRADE

Type of Mixtures	CS1	CS2	CS3	LS1	LS2	LS3	FS1	FS2	FS3	CF1	CF2	CLF
Penetration(mm)	Observed Load Kg/cm2	Observed Load Kg/cm2	Observed Load Kg/cm2	Observed Load Kg/cm2	Observed Load Kg/cm2	Observed Load Kg/cm2	Observed Load Kg/cm2	Observed Load Kg/cm2	Observed Load Kg/cm2	Observed Load Kg/cm2	Observed Load Kg/cm2	Observed Load Kg/cm2
0	0	0	0	0	0	0	0	0	0	0	0	0
0.5	6.2	2.2	10	3	3.6	4	3.8	4.8	6	12	20	10
1	10.4	4.4	16.8	5.6	6.6	7	6.2	9.4	11	22.2	45.6	28
1.5	14	6.4	25.4	8.8	9.6	10	8.4	10.2	13.6	35	71	51
2	17.2	8.4	31.4	13.6	13.6	14	11	12.2	16.2	51	98	77
2.5	20	11	37.8	16.2	17	18.6	12.2	15	20	68	124	104
3	23	14	43.6	21	21.4	22	14	16.6	24.2	87	143	128
4	26.4	25	54.2	33.6	35	36	17	18.4	30.4	127	180	180
5	27.8	35.2	56.4	55	56	60	20.2	21.8	35.6	168	210	222
7.5	33	83	70.5	131.6	131.6	134	30	30.8	43	255	269	302
10	35.2	119	87	200.8	207	208	37	39	60	60	312	367
12.5	36	137	97	267	270.8	275	45	49.6	87	87	335	429
Soaked CBR @ 2.5 mm	1.46	0.8	2.76	1.18	1.24	1.36	0.89	1.09	1.46	4.96	9.05	7.59
Soaked CBR @ 5 mm	1.35	1.71	2.74	2.68	2.73	2.92	0.98	1.06	1.73	8.18	10.22	10.8

III. DESIGN TRAFFIC

The data of Airplanes is collected from the Sardar Vallabhbhai Patel International Airport. The Aircrafts which lands on Ahmedabad international airport are taken into the consideration for the design. The design considers three aircraft characteristics such as total gross load of aircraft, annual departures of the aircraft which is considered as 3 % from the annual budget report of airport

Annual budget report of airport. Table 3 shows the aircraft which lands on Ahmedabad international Airport.

Table 3 List of Aircrafts arrives at Ahmedabad International Airport.

Airlines	Aircraft Type
Air Arabia	A320
Air India	A310
Air India	B747
Air India	B777
Spice Jet	B738
Spice Jet	B737
Emirates	A310
Emirates	B777
Etihad Airways	B767
Fly Dubai	B737-800
Go Air	A320-200
Indigo	A320-200
Jet Airways	A330-200
Jet Airways	A330-300
Jet Konnect	B737-700
Jet Konnect	B737-800
Jet Konnect	B737-900
Qatar Airways	A320-200

Source: S.V.P International Airport.

IV. FAARFIELD SOFTWARE

The FAA Advisory Circular AC-150/5320-6E is used for the design of new airport pavements and for the rehabilitation of old ones that exhibit damage. This AC employs a finite elements method for rigid and flexible pavements; to facilitate the calculations for its users, it is accompanied by software called FAARFIELD (Federal Aviation Administration Rigid and Flexible Iterative Elastic Layered Design).

The FAARFIELD program is easy to use. In the case of a flexible pavement, the user inputs the thickness of the existing layers: concrete slabs, cement-treated base courses and granular layers, as well as the modulus of each. In the same way, the program must be supplied with some parameters that indicate the structural condition of the pavement to be treated. There are two parameters:

• CDF: Cumulative Damage Factor Used, which defines the amount of structural life that has been used by the existing pavement up to the time of the overlay.

• SCI: Structural Condition Index, derived from the Pavement Condition Index (PCI), using just 6 modes of distress: corner break; longitudinal, transverse and diagonal cracking; shattered slab; shrinkage cracks; joint spalling; and corner spalling. An SCI of 80 is the FAA definition of structural failure of a rigid pavement and is consistent with 50% of slabs in the traffic area exhibiting structural cracks.

The FAARFIELD program also requires information regarding the fleet of airplanes which the airport will receive. To facilitate the introduction of the fleet, with the departure frequency and projected annual growth rate, the program offers a library from which to select the most common aircraft models. For each model, the number of annual departures is introduced as well as the annual growth expected in the coming years. Finally, the design life of the project must be introduced; this is usually established in the coming years. Finally, the design life of the project must be introduced; this is usually established at 20 years. Based on this data and on the modulus of the layer, the program calculates by successive iterations the necessary thickness of the pavement.

V. PAVEMENT THICKNESS AND ITS COMPOSITION

By soil stabilization using various additives like cement, lime, fly ash improved the soil strength and designs the pavement thickness. Here the value of CBR = 10.8% is obtained with 6% cement + 6 % lime and 2 % fly ash is taken into the consideration. The design life of the pavement is proposed for 20 years. Table 4 shows the pavement structure information which is kept for design and Table 5 show the Aircraft information which is considered for the design.

FAARFIELD- Airport Pavement Design (V 1.302, 3/11/09)

Table 4 Pavement Structure Information by Layer, Top First

No.	Type	Thickness (in)	Modulus (MPa)	Poisson's Ratio(μ)
1	P-401/ P-403 HMA Surface	5.00	1379.5	0.35
2	P-401/ P-403 St (flex)	10.43	2759	0.35
3	P-209 Cr Ag	7.87	279.93	0.35
4	Subgrade	0.00	111.74	0.35

Total thickness to the top of the subgrade = 23.29 in (1 in = 25.4 mm) **Fig. 2 and 3** shows screenshots of the combination of aircraft and pavement characteristics that were introduced to the program during the design. The item P-209 Cr Ag, P-401, P-401/ P-403 St (flex), P-401/ P-403 HMA in Table 4 represents crushed aggregate base course, Plant mix Bituminous Pavements, Hot Mix Asphalt Base course respectively. Their gradations and compositions can be seen under the advisory circular AC 150_6320_6e and AC 150-_5370_10F.

Table 5 Aircraft Information

No.	Name	Gross Wt. lbs.	Annual Departures	Annual Growth (%)	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	A320 Bogie	162,922	365	3	0.00	0.00	0.71
2	A310-200	315,041	365	3	0.00	0.00	0.66
3	B747-SP	703,000	365	3	0.01	0.01	0.70
4	B777 Freighter (Preliminary)	768,800	365	3	0.78	0.79	0.51
5	B737-100	111,000	365	3	0.00	0.00	1.39
6	Adv. B737-200 QC	128,600	365	3	0.00	0.00	1.39
7	A310-200	315,041	365	3	0.00	0.00	0.66
8	B777-200 Baseline	547,000	365	3	0.01	0.01	0.52
9	B767-200	361,000	365	3	0.01	0.01	0.71
10	B737-800	174,700	365	3	0.00	0.00	1.33
11	A320-200 Twin std	162,922	365	3	0.00	0.00	1.33
12	A320-200 Twin opt	172,842	365	3	0.00	0.00	1.32
13	A330-200 std	509,047	365	3	0.10	0.10	0.75
14	A330-300 std	509,047	365	3	0.10	0.10	0.75
15	B737-700	155,000	365	3	0.00	0.00	1.34
16	B737-800	174,700	365	3	0.00	0.00	1.33
17	B737-900	174,700	365	3	0.00	0.00	1.33
18	A320-200 Twin std	162,922	365	3	0.00	0.00	1.33

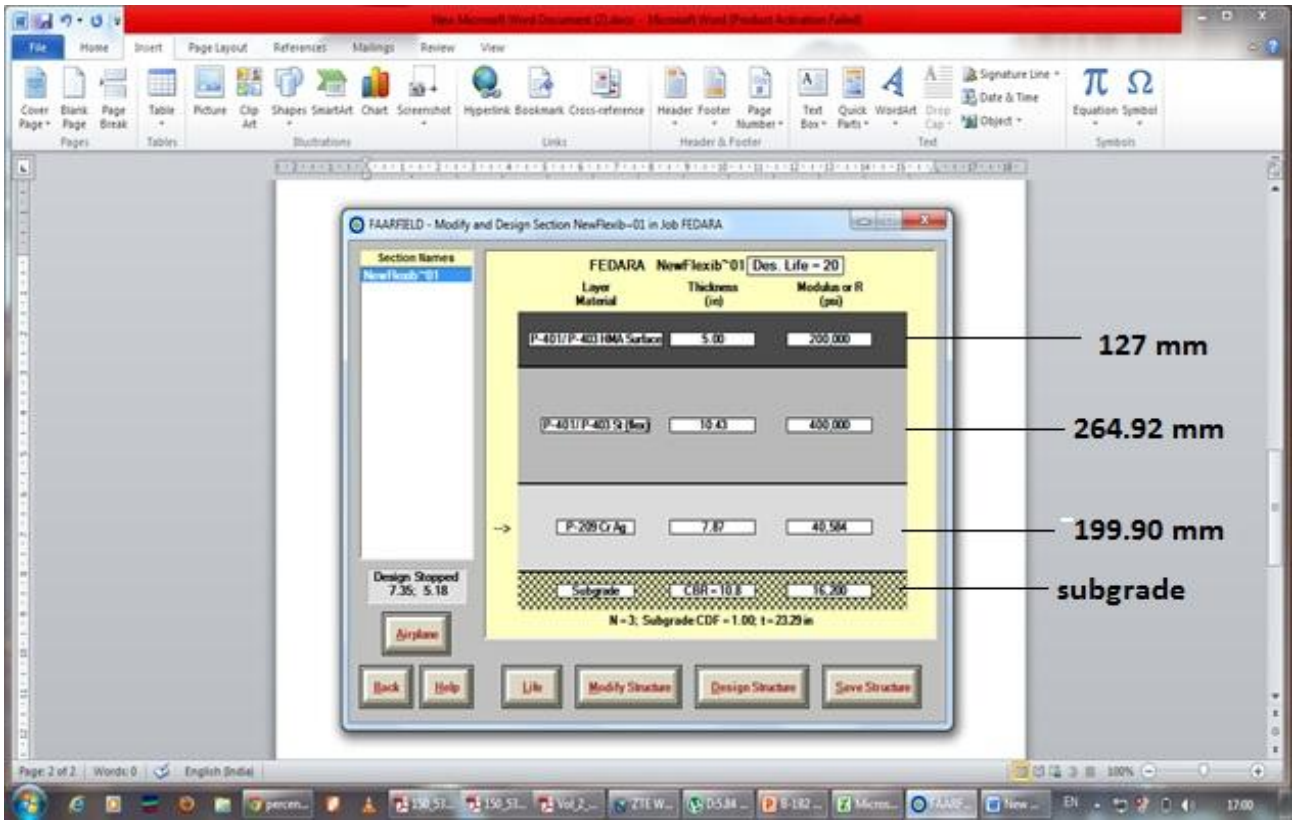

Fig. 2 FAARFIELD. Pavement Thickness of various Layers.

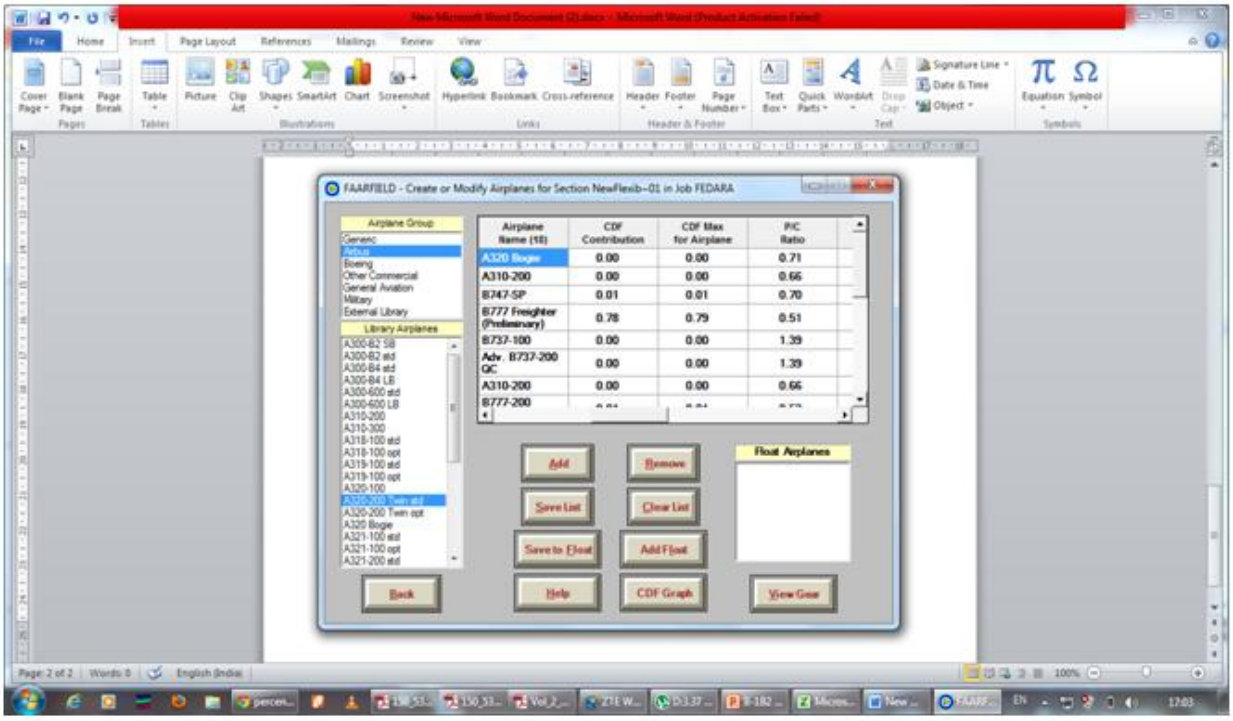

Fig. 3 FAARFIELD Represent the CDF & P/C RATIO.

VI. CONLUSIONS

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

• To study the characteristics of soil and classification for proposed Airport.
• Improved CBR of soil with addition of Cement, Lime and Fly ash and various mixes such as cement + lime, cement + fly ash, cement + lime + fly ash.
• A method was proposed, based on the FAARFIELD (Federal Aviation Administration Rigid and Flexible Iterative Elastic Layered Design) program for the estimation of thickness in airport pavements.
• To identify the Aircraft class and its thickness as per its wheel load/ gross weight.
• Thickness without soil improvement is 2170.43 mm and with improved soil comes out to be 591.57 mm

REFERENCES

1. Airport Pavement Design and Evaluation Federal Aviation Administration Advisory Circular 150/5320 – 6E
2. CRISIL analysis, Gujarat Infrastructure Development Board, Chapter 8 Airports, Dec 2008
3. CRISIL analysis Gujarat Infrastructure Development Board, Vol 1 August, 2009
4. DDP-DSIRDA (Development draft plan- Dholera Special Investment Region Development Association)
5. Norman J Ashford, Saleh A Mumiaz, PH Wright, Airport Engineering, 4th Edition, John Wiley & Sons INC.
6. Robert Horenjeff, Francis X Mckelvey, William J Sproulle, Seth B young Planning and Design of Airports, 5th Edition, McGraw Hill.
7. S.K. Khanna, M.G. Arora, S.S. Jain, Airport Planning and Design, 6th Edition, Nemchand & Bros.
8. Standards for Specifying Construction of Airports Federal Aviation Administration Advisory Circular 150/5370-10 F
9. http://articles.timesofindia.indiatimes.com/2010-03-30/ahmedabad/28132955_1_new-airport-third-runway-airports-authority
10.]http://articles.timesofindia.indiatimes.com/2009-01-18/ahmedabad/28020640_1_changi-greenfield-airport-fedara
11.]http://articles.timesofindia.indiatimes.com/2009-02-08/ahmedabad/28031061_1_ahmedabad-airport-airport-project-fedara
12. http://en.wikipedia.org/wiki/Fedara
13. http://www.gidb.org/cms.aspx?content_id=156
14. http://www.gidb.org/cms.aspx?content_id=158

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