GOVERNMENT OF PAKISTAN
MINISTRY OF COMMUNICATIONS
NATIONAL TRANSPORT RESEARCH CENTER
***

Evaluation Of Islamabad Runway Pavement

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Only for Reference

NTRC No.207

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EXECUTIVE SUMMARY

National Transport Research Centre (NTRC) was asked by the Civil Aviation Authority (CAA), to evaluate the Islamabad Runway Pavement in order to determine possible causes of surface distresses in the bituminous overlay, laid during 1994-95 for strengthening the existing rigid pavement. The length of the runway was also extended by 600 meters.

The evaluation carried out by NTRC can be divide into two parts;(a) Functional evaluation to judge the pavement surface condition for the safe operation of aircraft and (b) Structural evaluation of the pavement to assess the strength for bearing the imposed loads.

The methodology adopted for the evaluation of the runway pavement was along the lines proposed by Federal Aviation Administration (F.A.A) of USA and this consists of a visual survey by experienced Engineers, slipperiness and roughness measurement of the pavement surface, traffic analysis, alongwith detailed field and laboratory testing of materials.

The investigation has brought out a number of issues of considerable technical importance, relevant to most developing countries. Nevertheless, the main findings of the evaluation are given below:

1. Significant intensity of hair-line cracks in the wheel tracks, were observed from chainage 1+000 to 4+500 from 3-0 end of the runway.
2. The riding quality of the runway pavement as measured by a vehicle mounted Bump Integrator unit was found to be within standards.
3. The mean macrotexture depth value of the pavement surface is found to be less than 1.5 mm, which indicates that the runway is slippery as per FAA standards.
4. The development of surface distresses are due to the improper mix design and laying/compaction of bituminous mix.
5. The mix design problems are indicated as the bitumen content in wearing course is found to be less than the binder course.
6. The improper laying and compaction of the bituminous mix, is obvious due to very high air voids in the compacted mix, which has produced a rather brittle mixture, prone to cracking under heavy loading.
7. Thickness of the overlay is found to be adequate to accommodate the air traffic on Islamabad Airport for next twenty years.

RECOMMENDATIONS

The pavement other than the affected areas is currently OK and does not require any further strengthening etc. For the affected areas the following remedial actions can be adopted :

1. An additional asphaltic concrete can be overlaid. This however would be too expansive .
2. A triple surface treatment may be carried out. This would have the further advantage of reducing slipperiness. However, for a good and uniform surface dressing special care would require proper design and high quality control in laying. Beside this is time consuming and an expansive option.
3. Seal or patch cracked area wherever required, to prevent seepage of water in to lower layers, causing stripping. A useful precaution would be to apply an overall sand seal in those areas where cracking is evident.
4. Under the circumstances the last option seems to be most viable.

2: METHODOLOGY FOR EVALUATION OF ISLAMABAD RUNWAY

The methodology adopted for the evaluation of Islamabad runway pavement and to find out the possible cause of premature cracking, has been on the lines guided by US Federal Aviation Administration (FAA). The basic investigations described in following par's have been carried out for the evaluation:-

2.1 PAVEMENT SURFACE CONDITION

Pavement condition survey showing how the existing pavement is holding up traffic. The condition of the pavement in relation to any cracking, distortion and wear has been assessed. It is tried that failures due to traffic load shall be differentiated from failures due to climate, drainage etc.

2.2 ROUGHNESS SURVEY

Roughness survey with a vehicle mounted Bump Integrator carried out on the runway in order to accretion the riding quality of the pavement.

2.3 MACROTEXTURE TESTING

For determining the average macrotexture depth of Pavement surface, standard sand patch test has been used on selective locations of the runway.

2.4 AIR TRAFFIC ANALYSIS

An analysis of the traffic history of the Airport with regard to both weight of aircraft and number of operations associated with traffic has been excised.

2.5 SOIL SURVEY

A soil survey has been carried out in order to disclose variations in soil, its type and natural moisture content. Testing require will:-

-Sieve Analysis.
- Atterberg's Limits.
- Moisture-Density Relationship.
- California Bearing Ratio (CBR) Test.
- D.C.P. Testing(Deep Cone Penetrometer).

2.6 LAYERS THICKNESS CONFIRMATION

Verification of types and thickness of pavement sections have been carried out by the extraction of a number of cores from random locations and which have been tested to obtain the concrete flexural strength and to analyze bituminous overlaid material.

2.7 CONSTRUCTION & MAINTENANCE RECORD

The construction methods and practices of maintenance adopted for the Islamabad runway have been evaluate.

2.8 PAVEMENT DESIGN EVALUATION

After getting the all necessary information the structural design of the Islambad runway has been evaluated and try to determine the possible causes of pre-mature failure of the pavement.

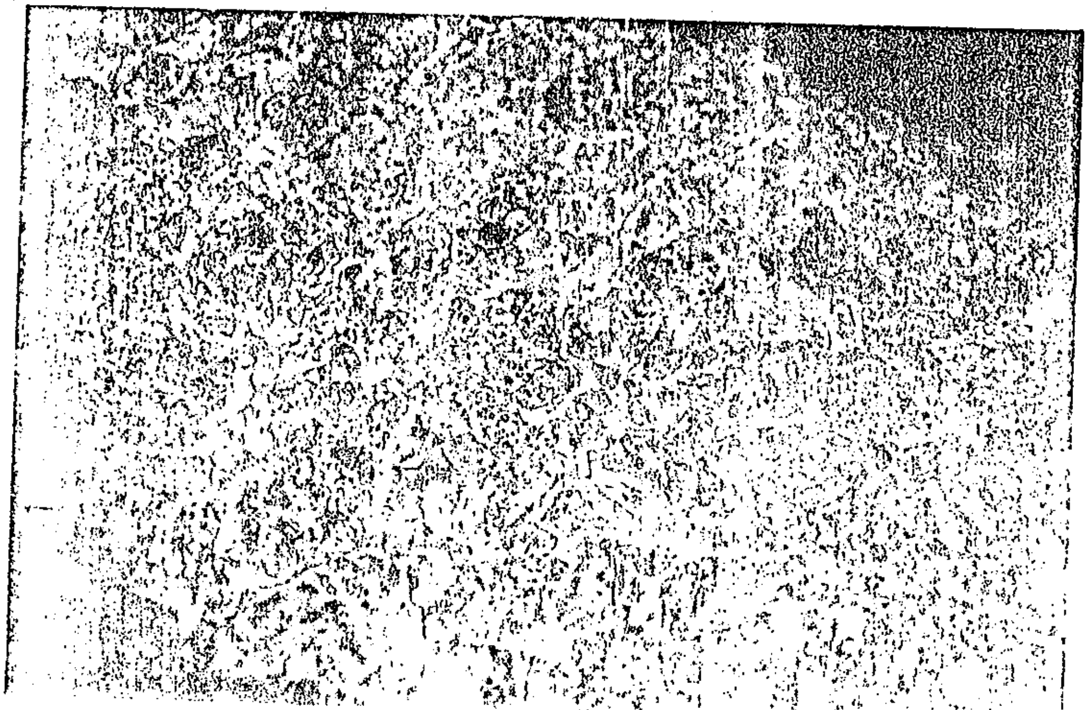


Plate- 4.2 Close view of cracked surface.

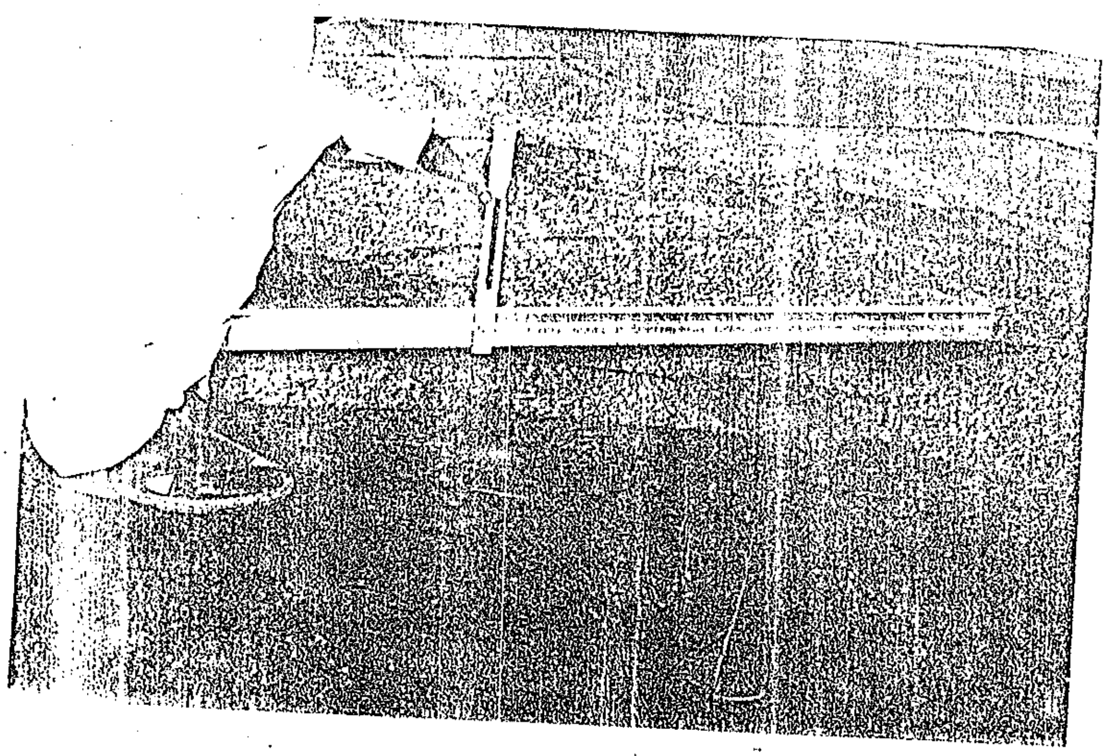


Plate- 4.3 Oservation of rutting more than 5 mm in wheelpaths under 3 meters straight edge.

while the detail of condition survey is presented in the table 4.1.

TABLE 4.1
PAVEMENT CONDITION SURVEY

Airport: Islamabad

Section: Main Runway

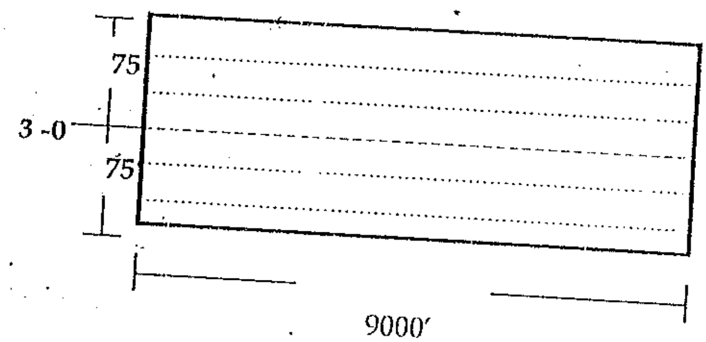
Observer : Eng. M.Feroz Akbar
Eng. Hameed Akhter

Location: From 3 - 0

Date: 15-10-97

Chainage		Asphaltic Concrete Surface			
From	To	Alligator Cracking		Rutting	
0+000	1+000	2	0	2	0
1+000	2+000	3	0	3	1
2+000	3+000	3	0	4	1
3+000	4+000	2	0	4	1
4+000	5+000	1	0	3	1
5+000	9+000	1	0	0	0

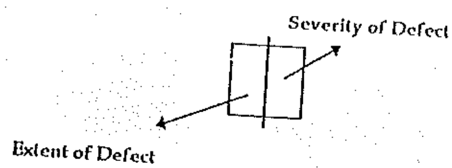
Location Plan



EXTENT OF DEFECT

0: None	0% of Area
1: Minor	>25% "
2: Moderate	26-50 % "
3: Major	51-70 % "
4: Extreme	<75 % "

Double Ratings



SEVERITY OF DEFECT

	Cracks	Rutting
0: None	> 3mm Wide	> 5mm deep
1: Minor	3 - 6 mm "	6 -10 mm "
2: Moderate	6 - 8 mm "	10 - 25 mm "
3: Major	< 8 mm "	

4.2 ROUGHNESS SURVEY: In order to get the riding quality of the runway, roughness (evenness) measurements have been carried out by a vehicle mounted Bump Integrator at a constant speed of 20 mile/hr. Road meter readings obtained have been converted in Bump integrator index, which measured the roughness in mm/km along the longitudinal direction. Results have incorporated in Table-4.2.

Table- 4.2 ROUGHNESS OF ISLAMABAD RUNWAY (mm/km)

	Left Bond			Right Bound		
	Slab 1	Slab2	Slab 3	Slab 1	Slab2	Slab 3
Reading Round 1	155	125	50	158	118	52
Reading Round 2	150	130	55	165	125	55
Reading Round 3	152	135	58	158	128	53
Avg. Reading	152	130	54	160	124	53
Length (m)	2743	2743	2743	2743	2743	2743
B.I Reading / Km	56	47	20	58	45	19
Roughness (mm/Km)	1109	1000	630	1148	969	625

4.3 SKID RESISTANCE OF ISLAMABAD RUNWAY: For the safety of the Aircraft's using the runway pavement, among various other factors, it is necessary to have a non-slippery Pavement surface. The slipperiness is dependent on both the Pavement surface texture and the condition of tires. Since these are two very different aspects, the functional evaluation of Pavement deals with Pavement surface texture only. There are two parts of the surface texture of a Pavement that contribute to the overall friction of a Pavement surface namely the Microtexture and the Macrotexture... ..

4.3.1 MACROTEXTURE TESTING: Standard volumetric method is adopted for measuring Pavement Macrotexture . Table- 4.3.1 presented the results obtained from sand patch testing :-

Table- 4.3.1 ISLAMABAD RUNWAY MACROTEXTURE TEST RESULTS
Volume of Sand used= 50000 cubic millimeter

LOCATION NO.1 AT CHAINAGE 1+000 RIGHT BOUND FROM 3-0, OFFSET 5'.

	TEST-1	TEST-2	TEST-3
Sand Patch Diameter Reading 1 in mm	280	285	240
Sand Patch Diameter Reading 2 in mm	280	290	245
Sand Patch Diameter Reading 3 in mm	281	288	248
Average Diameter of Sand Patch in mm	280.3	287.7	244.3
Average Macrotexture Depth in mm for the test	0.810	0.769	1.066
Average Macrotexture Depth in mm for Location No.1	0.882		

LOCATION NO.2 AT CHAINAGE 1+700 RIGHT BOUND FROM 3-0, OFFSET 60'.

	TEST-1	TEST-2	TEST-3
Sand Patch Diameter Reading 1 in mm	170	182	195
Sand Patch Diameter Reading 2 in mm	180	186	193
Sand Patch Diameter Reading 3 in mm	185	181	192
Average Diameter of Sand Patch in mm	178.3	183.0	193.3
Average Macrotexture Depth in mm for the test	2.00	1.90	1.70
Average Macrotexture Depth in mm for Location No.2	1.87		

LOCATION NO.3 AT CHAINAGE 3+000 LEFT BOUND FROM 3-0, OFFSET 10'.

	TEST NO.1	TEST NO.2	TEST NO.3
Sand Patch Diameter Reading 1 in mm	280	285	268
Sand Patch Diameter Reading 2 in mm	280	290	270
Sand Patch Diameter Reading 3 in mm	280	288	269
Average Diameter of Sand Patch in mm	280.0	287.7	269.0
Average Macrotexture Depth in mm for the test	0.81	0.77	0.88
Average Macrotexture Depth in mm for Location No.3	0.82		

LOCATION NO.4 AT CHAINAGE 4+000 RIGHT BOUND FROM 3-0, OFFSET 10'.

	TEST NO.1	TEST NO.2	TEST NO.3
Sand Patch Diameter Reading 1 in mm	280	285	280
Sand Patch Diameter Reading 2 in mm	280	290	285
Sand Patch Diameter Reading 3 in mm	280	288	288
Average Diameter of Sand Patch in mm	280.0	287.7	284.3
Average Macrotexture Depth in mm for the test	0.81	0.77	0.79
Average Macrotexture Depth for Location No.4	0.79		

LOCATION NO.5 AT CHAINAGE 5+000 LEFT BOUND FROM 3-0, OFFSET 10'.

	TEST NO.1	TEST NO.2	TEST NO.3
Sand Patch Diameter Reading 1 in mm	240	255	268
Sand Patch Diameter Reading 2 in mm	240	250	270
Sand Patch Diameter Reading 3 in mm	238	248	275
Average Diameter of Sand Patch in mm	239.3	251.0	271.0
Average Macrotexture Depth in mm for the test	1.11	1.01	0.87
Average Macrotexture Depth for Location No.5	1.00		

5. STRUCTURAL EVALUATION

In order to access the strength of the existing pavement, the structural evaluation of a pavement is carried out. The method choose for the structural evaluation of Islamabad runway is defined as "Evaluation by Inversion of Design". The input required for this purpose are a) Soil Properties, b)Air traffic data, c) Layers thickness with its strength d) Pavement age and construction history.

5.1 SOIL ANALYSIS

Soil samples were collected from three locations along the runway at a depth of five feet. Soil auger was used for getting disturbed samples. As background data , information on the physical properties of the soil for the engineering classification, and strength tests for the soil as a pavement subgrade were carried out.

5.1.1 NATURAL MOISTURE CONTENT :- In order to get the moisture content condition under the pavement, samples were collected with the help of a boring kit at Chainage 5+000 on the right bound shoulder of the runway from 3-0 end. Results are presented in Table-5.1.1 :-

Table- 5.1.1 NATURAL MOISTURE CONTENT

S.No	Depth (ft)	Moisture Content (%)
1	3	5
2	5	18
3	10	21
4	20	30

5.1.2 SOIL GRADATION:- Soil samples from three locations along the runway, 5 feet away from the shoulders were collected for physical properties of the natural soil. Standard tests for wet preparation of soil samples for particle - size analysis and determination of soil constants (ASTM D-2217) were performed on each sample. Table 5.1.2 shows the result:-

Table- 5.1.2 SIEVE ANALYSIS OF SOIL SAMPLES

Chainage	% Passing Sieve No.								
	1/2"	3/8"	No.4	No.10	No.20	No.40	No.50	No.100	No.200
1+000 R	100	98	96	94	93	93	93	93	92
4+000 L	100	100	100	100	99	98	98	93	91
8+000 R	100	97	95	94	93	92	91	90	90

5.1.3 ATTERBERG'S LIMITS OF SOIL:- The liquid limit, plastic limit and plastic index of all three samples as per standard tests ASTM D-423, D-424 were determined and results are presented in Table- 5.1.3:-

Table 5.1.3 SOIL SAMPLES CLASSIFICATION

Chainage	Liquid Limit (%)	Plastic Limit (%)	Plastic Index	Unified Soil Classification	AASHTO Classification
1+000 R	33	20	13	CL	A-6
4+000 L	39	21	18	CL	A-6
8+000 R	30	18	12	CL	A-6

On the basis of results in Table-5.1.2 and Table-5.1.3 the soil samples according to Unified soil classification system are classified as CL, lean clay of low to medium plasticity.

LOCATION NO.6 AT CHAINAGE 8+000 RIGHT BOUND FROM 3-0, OFFSET 5'.

	TEST NO.1	TEST NO.2	TEST NO.3
Sand Patch Diameter Reading 1 in mm	268	292	291
Sand Patch Diameter Reading 2 in mm	270	290	292
Sand Patch Diameter Reading 3 in mm	270	290	290
Average Diameter of Sand Patch in mm	269.3	290.7	291.0
Average Macrotexture Depth in mm for the test	0.88	0.75	0.75
Average Macrotexture Depth for Location No.6	0.79		

4.3.2 SKID RESISTANCE :- Currently the Federal Aviation Administration (FAA) of USA and also CAA, Pakistan use the Mu-Meter to measure tire-pavement friction at their commercial airports. There have been developed tentative standards, by which a runway is rated. These standards are based upon a critical Mu number (MuN) describing the likelihood of an aircraft tire hydroplaning. These standards are shown in Table -4.3.2 for the guidance of Islamabad airport management to check runway friction:-

Table-4.3.2 HYDROPLANING POTENTIAL

MuN at 40 mph	Aircraft Braking Response	Hydroplaning Response
> 50	Good	No hydroplaning expected
40 to 50	Fair	Transitional (not well defined)
25 to 41	Marginal	Potential for hydroplaning
<25	Unacceptable	High Probability

However the modern research has proved that the MuN derived from Mu-Meter is predictable from low-speed locked wheel data. Therefore, it is not very sensitive to macrotexture and should be used in conjunction with an independent measurement of macrotexture. A high MuN from Mu-Meter, together with a high macrotexture depth, would thus indicate a level of Skid resistance adequate to ensure safety [5].

5.1.4 MOISTURE- DENSITY RELATIONSHIP :- In order to characterized the soil according to its compaction control during construction, standard test (ASTM D-1557) to determine the moisture density relations of the three soil samples were carried out. Results are tabulated in Table- 5.1.4, while detail results are placed at Annexure A :-

Table- 5.1.4 MOISTURE-DENSITY RELATIONSHIP OF SOIL SAMPLES

Chainage	Max.Dry Density (lb/cft)	Optimum Moisture Content (%)	Natural Moisture Content (%)
1+000 R	124	13	18
4+000 L	122	14	18
8+000 R	127	13	20

5.1.5 STRENGTH OF SOIL:- Soil classification for engineering purposes provides an indication of the probable behavior of the soil as a pavement subgrade. This indication of behavior is , however, approximate. Performance difference from that expected can occur due to a variety of reasons such as degree of compaction, degree of saturation, height of overburden, etc. The possibility of incorrectly predicting subgrade behavior can be largely eliminated by measuring soil strength. The strength of materials intended for use in flexible pavement structures is measured by the California Bearing Ratio (CBR) tests. Materials intended for use in rigid pavement structures are tested by the Plate-bearing method of test. For this particular study the bearing capacity of the existing pavement foundation has been worked by using the correlation available between the California Bearing Ratio (CBR) value and the Modules of subgrade reaction k value.

In order to work out the laboratory CBR values of the soil standard test (ASTM-D1883) has been used. Results are tabulated in Table 5.1.5-1 to Table 5.1.5-3 at Annexure A , while a summery of results in tabulated form is placed below:-

Table- 5.1.5-5 SUMMERY OF LABORATORY CBR TESTS OF SOIL SAMPLES

Chainage	Molding Density (lb/cft)			Optimum Moisture Content (%).	Soaked CBR Value (%)	Swell (%) @ 95 % MDD
	10 Blows	30 Blows	56 Blows			
1+000 R	105	119	124	13	17	0.62
4+000 L	101	118	120	14	20	0.60
8+000 R	107	120	124	13	20	0.60

For the assessment of in-situ CBR value of the subgrade, Deep Cone Penetrometer (DCP) had been deployed at the edge of existing pavement on top of shoulders. The results of DCP testing along with operating instructions of the equipment in detail are placed at Annexure -A. While a summery of results is placed below in Table-5.1.5-6 :-

Table- 5.1.5-6 IN-SITU CBR VALUES OF SOIL

Chainage	Depth Below Surface (mm)	In-situ CBR Value (%)
2+000 R	415	12
5+000 R	410	13
8+000 L	415	12

5.2 AIR TRAFFIC ANALYSIS OF ISLAMABAD RUNWAY

Air traffic data provided by the CAA is based on PIA traffic schedule for October 1992 placed at Annexure -B. All departures from Islamabad airport have been sorted and tabulated in the form of Table-5.2:-

Table - 5.2 ANNUAL DEPARTURES FROM ISLAMABAD AIRPORT

Aircraft Type	Gear Type	Max.Takeoff Weight (Kg)	Weekly Departures (Nos.)	Annual Departures (Nos.)
A-300-600R	Dual Tandem	171700	17	886
A-310-300	Dual Tandem	157000	9	469
B-707-320C	Dual tandem	152407	3	156
B-737-400	Dual	64864	34	1773
B-747-200	Double dual Tandem	395987	19	991
DHC	Dual	10600	24	1251
F-27	Dual	19777	81	4224
			Total	9751

* Source Civil Aviation Authority based on 1992-93 data.

5.2.1 DETERMINATION OF DESIGN AIRCRAFT:

A Pavement thickness is determined for each type of aircraft by using appropriate design curves provided in FAA deign manual for rigid pavement. Each wide body aircraft has been treated as a 136,100 kg dual tandem aircraft. The pavement input data like, k value, flexural strength have been kept constant, while annual departures for each type of aircraft has been used. Therefore the exercise produce the following results:-

Aircraft Type	Thickness (inch)
A-300-600R	9.25
A-310-300	8.50
B-707-320C	9.00
B-737-400	12.50
B-747-400	8.00
DHC	6.5
F-27	6.00

As 737-400 departures require the highest pavement thickness and thus it is the design aircraft for the calculation of Annual Equivalent Departures.

5.2.2 GROUPING OF AIR TRAFFIC INTO LANDING GEAR OF DESIGN AIRCRAFT:

In this case the design aircraft B-737-400 is equipped with a dual wheel landing gear so all the traffic must be grouped into the dual wheel configuration as presented in Table- 5.2.2:-

Table- 5.2.2 GROUPING OF TRAFFIC INTO LANDING GEAR OF DESIGN AIRCRAFT

Aircraft Type	Gear Type	Annual Departures	Dual Gear Departures
A-300-600R	Dual Tandem	886	1506
A-310-300	Dual Tandem	469	797
B-707-320C	Dual tandem	156	265
B-737-400	Dual	1773	1773
B-747-400	Double dual Tandem	991	1685
DHC	Dual	1251	1251
F-27	Dual	4224	4224
		Total	11501

5.2.3 CONVERSION OF AIRCRAFT DEPARTURES TO EQUIVALENT ANNUAL DEPARTURES OF THE DESIGN AIRCRAFT: After the aircraft mixture has been grouped into a common landing gear configuration, the equivalent annual departures of the design aircraft can be calculated as showing in the Table-5.2.3:-

Table-5.2.3 EQUIVALENT ANNUAL DEPARTURES OF DESIGN AIRCRAFT

Aircraft Type	Dual Gear Departures	Aircraft wheel load (kg)	Wheel load of design Aircraft (kg)	Eq. Annual Departures of Design Aircraft
A-300-600R	1506	20592	15407	4528
A-310-300	797	18646	15407	1556
B-707-320C	265	18101	15407	423
B-737-400	1773	15407	15407	1773
B-747-200	1685	16164	15407	2018
DHC	1251	2518	15407	18
F-27	4224	4698	15407	100
	11501			10417

*** Wheel load for wide body aircraft has been taken as the wheel load for a 136100 kg aircraft for Equivalent annual departure calculation.**

For this particular case the pavement would be assessed for 10500 annual departures of a dual wheel aircraft weighing 64864 kg.

5.3 CORING SURVEY

The evaluation of pavement structures for aircraft loading requires accurate information on the thickness of layers within the structure, and the physical properties of the materials in these layers. The most important process in any pavement evaluation is the core analysis, from cores the exact layer thickness are determined in order to run a proper back calculation program. The core also tested on composition and bound.

Cores from five locations along the length of the runway have been drilled out using a high speed portable drill capable of producing spindle speed of 300 to 500 rmp and a cutting bit with hand control to apply pressure. A water pump has been connected to the drill in order to wash out the cutting as coring progress and to avoid any damage to core. Cores mostly taken from the cracked areas in order to investigate whether cracking has propagated from top to bottom or vice versa. Core specimens were than preserve for testing in laboratory.

Plan placed at Fig. 5.3 shows the locations from where the Asphaltic as well as Cement concrete cores were drilled and other field testing was performed, while Table -5.3 provide the necessary information related to different layers of the existing pavement determined with the help of cores:-

Table - 5.3 DATA RELATED TO THICKNESS OF DIFFERENT LAYERS OF PAVEMENT

S.no	Chainage From 3 - 0 End.	Offset (feet)	Asp.Conc. Thickness (cms)	Cem. Conc. Base Thickness (cms)	Lean Conc. Base Thickness (cms)	Year of Original Const.	Year of Overlay	Surface Distress
1	1 + 400	10 right	17.4	N:A	N.A	1969	1994 - 95	Crazing
2	3 + 000	5 right	20.8	N.A	N.A	- do -	- do -	- do -
3	4 + 000	5 left	20.2	28.9	11.43	- do -	- do -	- do -
5	5 + 000	20 left	16.5	27.8	11.43	- do -	- do -	- do -
6	8 + 000	10 right	17.8	28.8	11.43	- do -	- do -	- do -

* N.A means Not Applicable as only Asphaltic Concrete Layers were cored from the location.

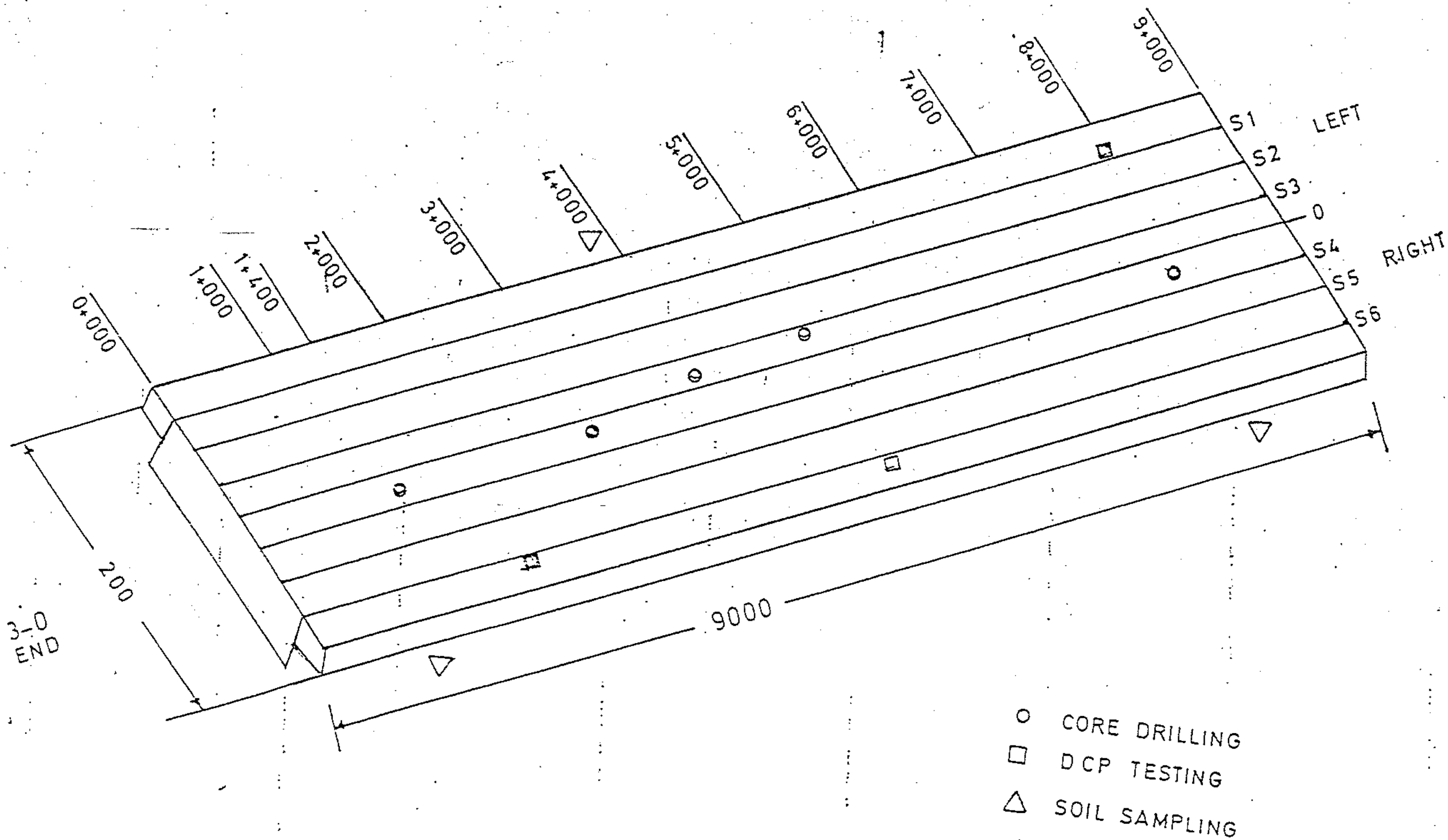


FIG 5.3 LOCATION OF FIELD TESTS

While Plate- 5.3.1, show the bore from where a core has been extracted and Plate - 5.3.2 show the picture of three extracted cement concrete cores.

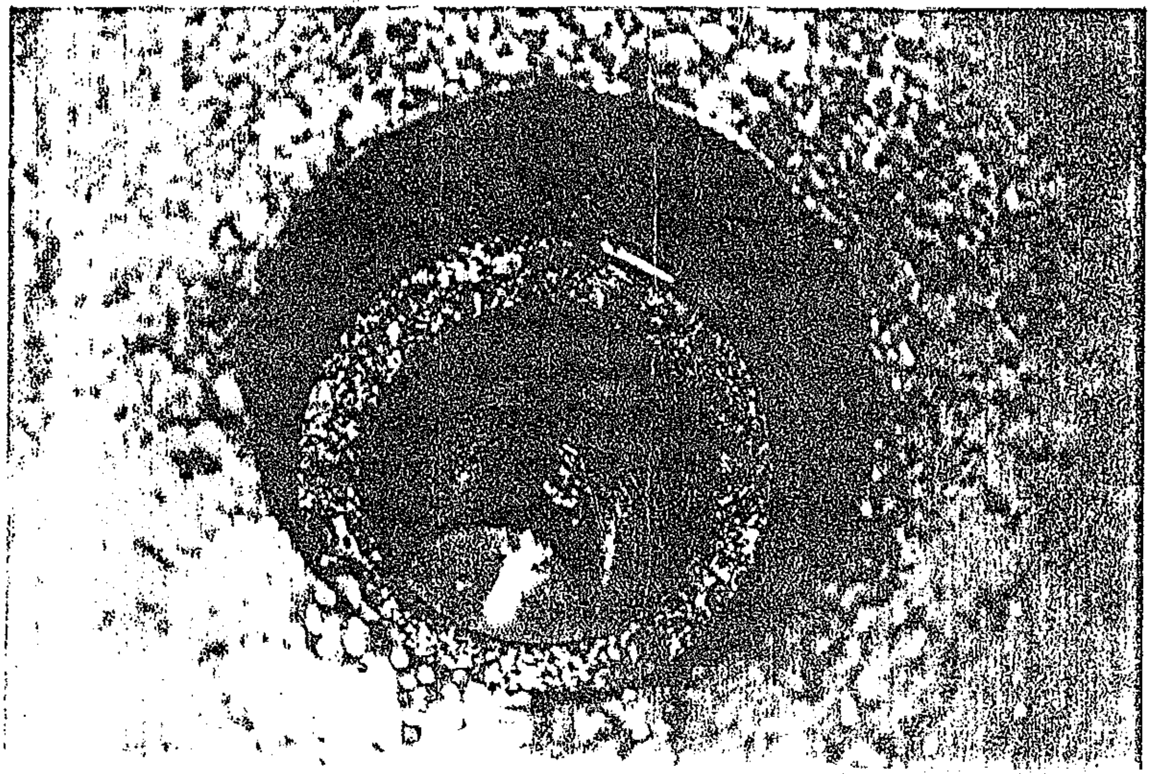


Plate - 5.3.1 View of location from where a Cement Plus Asphaltic Concrete core has been drilled.

Plate - 5.3.2 View of three cement concrete cores.

Plate- 5.3.3 show the view of a bore hole from where an Asphaltic concrete core has been drilled out, similarly Plate 5.3.4 show the close view of Asphaltic concrete 6 inches cores.

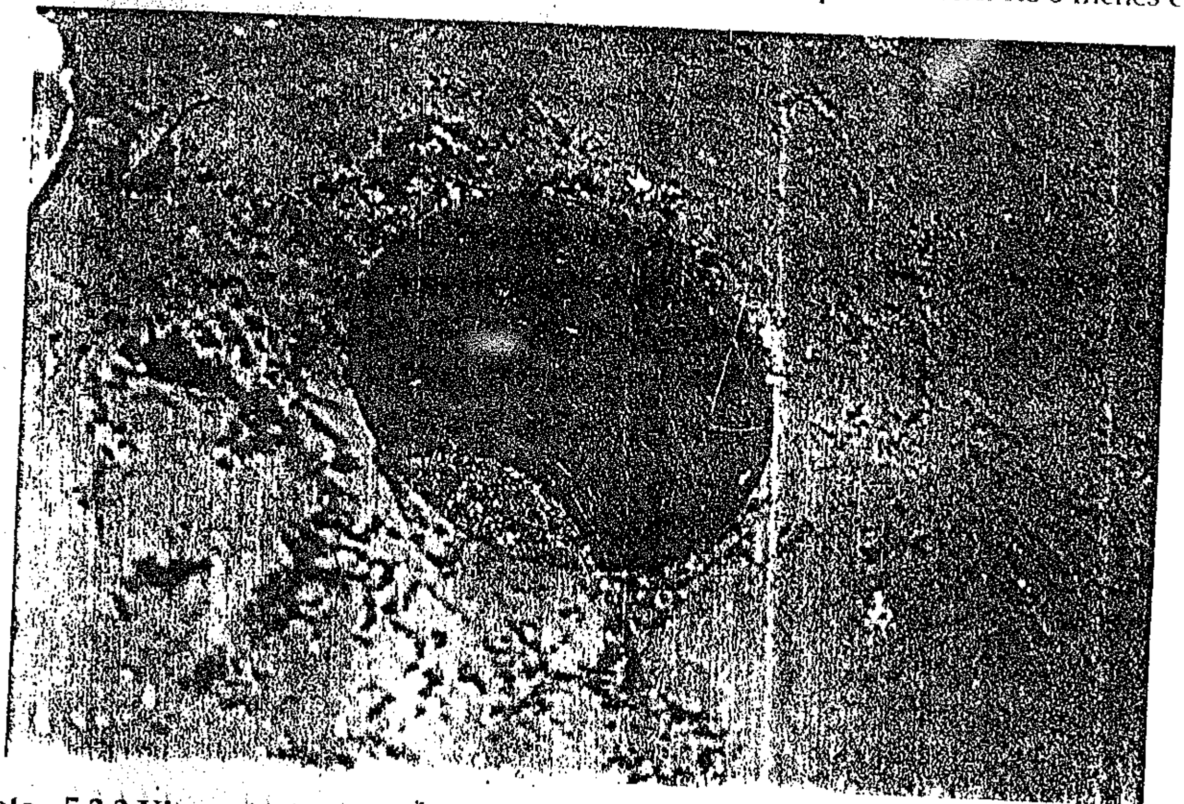


Plate - 5.3.3 View of bore hole from where Asphaltic Concrete core has been drilled.

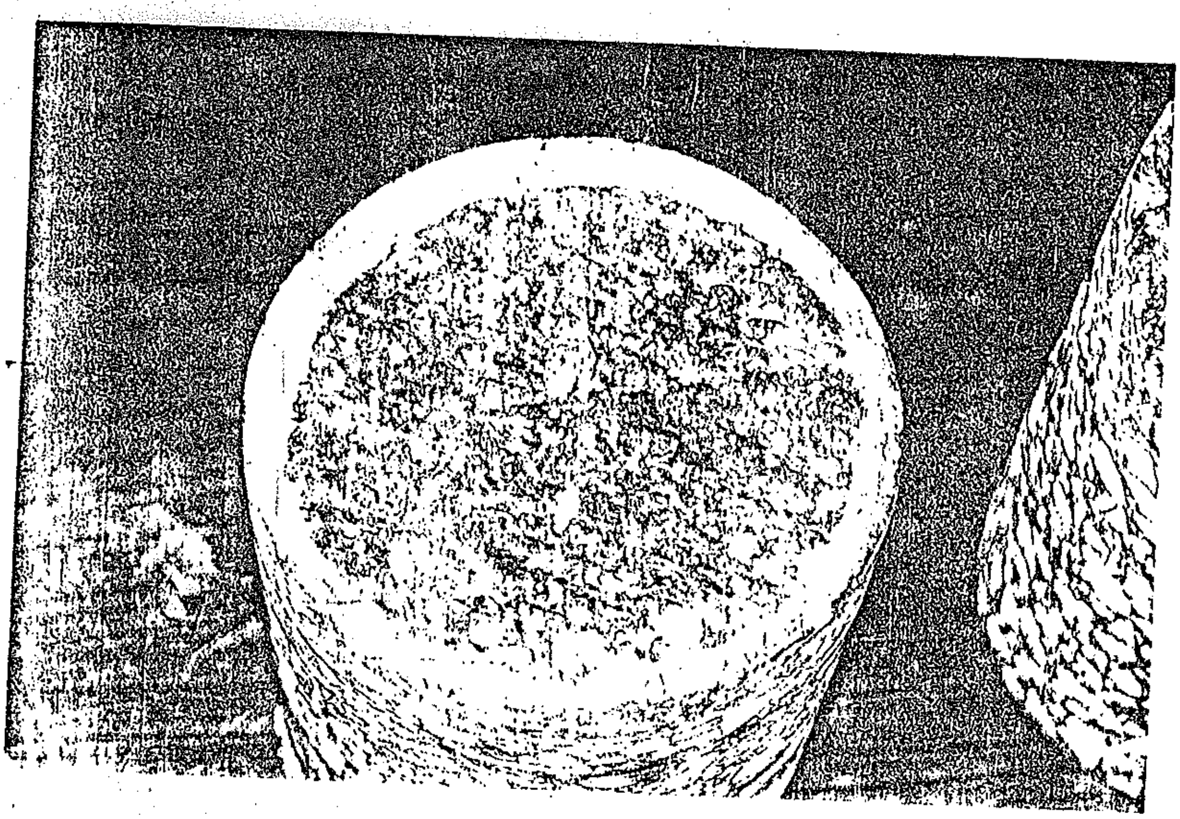


Plate. 5.3.4 Close view of Asphaltic Concrete Core.

5.4 ANALYSIS OF OVERLAY DESIGN

To establish the thickness of bituminous overlay over an existing rigid pavement, in the Federal Aviation Association (FAA), U.S.A design method, it is first necessary to determine the single thickness of rigid pavement to satisfy the design conditions in terms of subgrade strength and air traffic using the runway.

5.4.1 STRENGTH OF EXISTING CEMENT CONCRETE:- The required thickness of concrete pavement is related to the strength of the existing concrete. Concrete strength is assessed by the flexural strength method as the primary action of a cement concrete slab is flexure. In this particular study, for the assessment of compressive strength of existing concrete, cores from three locations were drilled out conforming thickness from 28.9 cms to 27.8 cms of the existing cement concrete pavement and then were tested by an apparatus name "Pundit" [6]. The apparatus derives its name from the initial letters of the full title of "Portable Ultrasonic Non-destructive Tester". It generates low frequency ultrasonic pulses and measures the time taken from them to pass from one transducer to the other through the material interposed between them. The pulse velocity method of testing may be applied to the testing of plain, reinforced and prestressed concrete. The measurement of pulse velocity may be used to determine the quality of concrete in relation to specified standard requirement, which generally refer to its strength.

All three cement concrete cores have been tested for compressive strength with the help of Pundit and result drawn are tabulated in Table 5.4.1, while the correlation used between the crushing strength and the Pulse velocity is placed at Annexure-B:-

Table - 5.4.1 Compressive Strength of Cement Concrete

Location	Core (cms)		Ultrasonic Pulse (μ sec)	Pulse Velocity (Km/sec)	Compressive Strength (psi)
	Dia	Thickness			
4+000 L	9.84	28.9	71.41	4.05	4000
5+000 L	9.83	28.5	66.45	4.30	4800
8+000 R	9.83	27.8	61.40	4.53	5000
				Average Strength	4600

Therefore an average cylindrical crushing strength of the old concrete has been worked out as 4600 psi. For the calculation of Flexural strength of the concrete, the relation R= 9 * f 'c ^0.5 has been used. Which gives a value of 675 psi for the 90-day Flexural strength of the concrete in the design.

5.4.2 MODULES OF SUBGRADE REACTION k VALUE:- The k value is, in fact, a spring constant for the material supporting the rigid pavement and is indicative of the bearing value of the supporting material. Therefore taking socked CBR value equal to 20, as the strength of the subgrade as determined in section 5.1, the equal value of k is equal to 200 lb/cu.inch has been adopted for design.

5.4.3 GROSS WEIGHT OF AIRCRAFT: The gross weight of the design aircraft worked out in section 5.2 is 64864 kg.

5.4.4 ANNUAL DEPARTURE OF DESIGN AIRCRAFT: The fourth input parameter is the annual departures of the design aircraft, which is worked out as 10500 of dual wheel aircraft weighing 64864 kg as per section 5.2.3.

5.4.5 TOTAL PAVEMENT THICKNESS: The total thickness required is determined using the nomograph placed at Annexure B, extracted from FAA design manual. The effect of the stabilized sub-base (lean concrete)is reflected in the foundation modules. Presence of 4 inch lean sub-base would likely increase the foundation modules from 200 pci to 300 pci. Thus the total thickness worked out for the design is equal to 33.65 cms.

5.4.6 BITUMINOUS OVERLAY THICKNESS: The overlay thickness worked out in above para is to modify by a factor F which controls the degree of cracking which has been present in the existing concrete. The factor F in effect is indicating that the entire concrete single slab thickness determined from the design curves is not needed because a bituminous overlay pavement is allowed to crack and deflect more than a conventional rigid pavement. The value of F adopted for the analysis is equal to 0.91 as guided by fig.4-64 placed at Annexure B.

The effective thickness of the existing rigid pavement is also adjusted by a condition factor C_b. The determination of the proper C_b value is a judgment decision for which only general guidelines can be provided. A C_b value of 1 should be used when the existing slabs contain nominal initial cracking and 0.75 when the slabs contain multiple cracking. Therefore the value assumed for C_b in this exercise is 0.75 , as the cracking was observed in all cores drilled from the existing pavement.

After the F factor, condition factor C_b, and single thickness of rigid pavement have been established, the thickness of the bituminous overlay is computed from the following formula :

$$t = 2.5\,(F\,h - C_b\,h_e)$$

Where t = thickness of bituminous overlay, cm.

F = factor which controls the degree of cracking in the base pavement.

h = single thickness of rigid pavement required for design conditions, cms. use the exact value of h ; do not round off.

C_b = condition factor for base pavement ranging from 1.0 to 0.75

h_e = thickness of existing rigid pavement in cm.

Therefore t = 2.5 (0.91 x 33.65 - 0.75 x 29.0)

= 22.0 cms.

5.5 ANALYSIS OF BITUMINOUS MIX

In order to analyze the mix properties of the overlay material, cores from five locations along the length of the runway were drilled by a core drilling machine. pavement overlay samples have been prepared for testing carefull removing all particles of base material or other foreign matter. All broken or damged edges of chunk samples for testing have been carefully trimmed from the sample. All the Asphaltic concrete cores have been split at the interface of layers prior to testing. Splitting cores at the interface of construction layers have been accomplished by sawing with a stone saw. Standard tests like the measurement of bulk specific gravity and density of the compacted mix (ASTM D-2726), measurement of theoretical maximum specific gravity of the loose paving mixture (ASTM D-2041), determination of bitumen content (ASTM D-2172), recovery of Bitumen (ASTM D-1856) and Voids analysis (ASTM D-3203) were carried on each sample.

5.5.1 DENSITY OF COMPACTED MIX: Density data has been obtained from cored specimens and chunk samples by adopting standard method (ASTM D-2726) and tabulated in Table - 5.5.1.for consultation:-

Table - 5.5.1 Mix Density (lb.cft) at Different Locations

Location	Mix Density (lb/cft) @ 25 o C			
From 3-0	Layer 1	Layer 2	Layer 3	Layer 4
1+400 R	151	151	151	151
3+000 R	151	152	n.a	n.a
4+000 L	150	152	153	154
5+000 L	143	146	148	149
8+000 R	133	134	134	134

5.5.2 BULK SPECIFIC GRAVITY OF COMPACTED MIX : In order to find out bulk specific gravity of the compacted mix cores were cut in to four slices in order to get information related to each layer . Result are tabulated in Table-5.5.2:-

Table - 5.5.2 Bulk Sp.Gravity of Mix at different locations

Location	Bulk Specific Gravity @ 25 o C			
From 3-0	Layer 1	Layer 2	Layer 3	Layer 4
1+400 R	2.423	2.426	2.428	2.431
3+000 R	2.431	2.442	n.a	n.a
4+000 L	2.410	2.442	2.452	2.469
5+000 L	2.294	2.342	2.382	2.394
8+000 R	2.142	2.150	2.154	2.155

5.5.3 THEORETICAL MAXIMUM SPECIFIC GRAVITY OF LOOSE MIX:- Theoretical maximum specific gravity of the loose mixture by standard Rice's method (ASTM D-2041 - 90) has been calculated for the Top and bottom layers of Asphaltic overlay and result are placed in Table-5.5.3:-

Table - 5.5.3 Theoretical Maximum Specific Gravity Of Loose Mixes.

Location	Th. Maximum Specific Gravity of Loose Mix	
From 3-0 End	Top Layer	Bottom Layer
5+000	n.a	2.498
8+000	2.502	n.a

5.5.4 AIR VOIDS ANALYSIS:- With the help of Table- 5.5.2 and 5.5.3 , Air voids in mixes at different locations have been worked out using the following relation as per ASTM D 3203-88 and result are tabulated in Table- 5.5.4 :-

Percentage Air Voids In Compacted Mix = 100 (1- (bulk sp.gravity / theoretical maximum sp.gravity)

Table - 5.5.4 % Air Voids By Mix at Different Locations

Location	Air Voids In Compacted Mix (%)			
From 3-0	Layer 1	Layer 2	Layer 3	Layer 4
1+400 R	4	3	3	3
3+000 R	3	2	n.a	n.a
4+000 L	4	2	2	1
5+000 L	8	6	5	4
8+000 R	14	14	13	13

5.5.5 BITUMEN CONTENT IN THE MIX: In order to confirm the Bitumen content in different layers of overlay, at different locations of runway, standard test for recovery of Bitumen (ASTM D- 2172) have been carried out . Result are presented in Table - 5.5.5 for consultation:

Table 5.5.5 Bitumen Content of Compacted Mix

Location	Bitumen Content By Mix (%)			
From 3-0 End	Layer 1	Layer 2	Layer 3	Layer 4
1+400 R	4.30	4.42	5.40	5.41
3+000 R Chunk	4.20	n.a	n.a	n.a
3+000 R Chunk	4.67	n.a	n.a	n.a
4+000 L	4.13	4.08	4.79	5.4
8+000 R	4.15	4.20	5.30	5.32

5.6.5 GRADATION OF EXTRACTED MIX: Overlay mix samples have also been examined by recording the gradation of extracted aggregates, results are presented in Table - 5.6.5 for consultation:

Location From 3-0 End	% Passing Sieve No.								
	1"	3/4"	1/2"	3/8"	No.4	No.10	No.50	No.100	No.200
1+400 R									
Layer 1	100	100	93	77	56	30	17	8	7
Layer 2	100	98	74	63	46	23	11	5	5
Layer 3	100	95	81	70	45	31	13	8	5
Layer 4	100	93	72	65	44	39	20	12	8
3+000 R C-1	100	100	93	76	53	31	13	9	7
3+000 R C-2	100	100	93	74	50	36	13	8	7
4+000 L									
Layer 1	100	99	88	77	53	36	14	8	6
Layer 2	100	95	83	69	45	33	13	8	7
Layer 3	100	98	78	67	47	36	15	9	7
Layer 4	100	93	73	64	48	39	21	11	9
8+000 R									
Layer 1	100	100	83	70	44	30	12	9	5
Layer 2	100	100	82	69	45	31	13	9	6
Layer 3	100	98	78	66	48	35	18	10	8
Layer 4	100	92	77	67	46	38	20	10	8

6. ANALYSIS OF RESULTS & DISCUSSION

Results of field and laboratory testing of the Islamabad Runway pavement in detail have been presented in previous chapters of the report. This chapter deals with analysis of these results along with their interpretation:

6.1 VISUAL INSPECTION: The visual inspection has revealed that the surface distress in the form of fine hair like cracks are present at all over the pavement surface. Its severity and intensity is more visible on wheel tracks as compared to other areas. Also the rutting of more than 5 mm under a three meters straight edge was observed specially from chainage 2+000 to 4+000 from 3-0 end.

6.2 PAVEMENT ROUGHNESS: As per Table- 4.2 the maximum value of roughness recorded is 1200 mm/km at a constant speed of 32 km/hr. According to the road standards the riding quality of the pavement is classed as very good. However, for the runway pavement as such standard is not available with CAA. Therefore it is not possible to categorized, runway with respect to roughness or evenness.

6.3 SKID RESISTANCE: As per Table 4.3.1 at most of the locations on Islamabad runway mean macrotexture depth value of pavement surface as tested by standard sand patch test is found less than 1.5 mm. Therefore according to FAA standards the runway is found to be more slippery.

6.4 SOIL ANALYSIS: The field and laboratory testing of the soil at Islamabad Runway, reveals that the water table is at 20 feet depth. Similarly the soil has been categorized as CL (lean Clay) by Unified Soil Classification system and as A-6 by AASHTO classification. The Optimum Moisture Content of the soil has been observed between 13-14%, while the maximum dry density has been found between 122-124 lb/cft. The strength of the soil in the form of socked CBR has been observed between 17-20%. Similarly the deep cone penetrometer (DCP) testing performed on the top of existing shoulders and at the edge of pavement, reveals that the in-situ CBR under the shoulder is between 12-13%. Also the swell potential of soil has been found as per the allowable limits that is less than 1 % for 96 hours socking.

6.5 **AIR TRAFFIC ANALYSIS:** Airport traffic analysis was carried out on the 1991-92 data of the weekly departures from Islamabad Airport as provided by CAA. It shows that annual departures from the runway are around 10,000. While the equivalent annual departures of the design aircraft (B737-400) are found to be 10,500. Therefore the thickness of overlay has been assisted on the basis of 10,500 equivalent annual departure of B737-400 aircraft.

6.6 **CORING SURVEY:** Cores drilled from five locations have confirmed that the thickness of old cement concrete is between 27.8 to 28.9 cms, and it has cracks running through all over the depth. While the thickness of asphaltic overlay is found to be between 17.8 to 20.8 cms.

6.7 **OVERLAY DESIGN ANALYSIS:** After getting the all needed information, the overlay design was evaluated as per the F.A.A. runway pavement design charts. An overlay thickness required for design inputs has found to be 22.0 cms. This confirms that the present thickness of the overlay is adequate for the existing air traffic on Islamabad Airport runway.

6.8 **MIX DESIGN ANALYSIS:** As per CAA the asphaltic concrete for the overlay on Islamabad Runway was designed on the basis of asphalt institute recommendation (MS2) or Marshal Method for mix design.

Keeping in view the requirement of the mix, the cores drilled from the existing pavement were divided in to slices and tested by standard tests. It can be observed from the Table- 5.6.1 that the maximum value of the density recorded is 152 lb/cft, while the minimum is 134 lb/cft, showing a huge difference in values. Locations from chainage 1+000 to 4+000 has been found extraordinary compacted. This cause the reduction of air voids in the mix as low as 1% in bottom layer at chainage 4+000 , on the other hand the density of compacted mix has been found as low as 134 lb/cft at chainage 8+000, where the air void content is found to be as high as 14%. It is seen that the current density (cores) is not constant and the voids relationship are outside the acceptable ranges. As per AASHTO's latest recommendations, the pavement should attain a uniform density at the time of compaction equivalent to 94% of the theoretical maximum density, therefore the requirement of compacted density. In this case was (2.509x62.4x0.94= 147 lb/cft), whereas a value of compacted density as low as 134 lb/cft has been achieved at the Islamabad runway pavement.

For getting the information related to bitumen content and gradation at different locations and in different layers, cores drilled from the existing pavement were divided in to slices and than extracted by standard method. Consulting Table- 5.6.5, which shows the value of bitumen content in different layers. It can be seen that in the top layer the bitumen content ranged from 4.13% to 4.67 %, while in the bottom layer its value found to be nearly 5.4% at all locations.

It is worth mentioning that the value of added bitumen content in top layer is 4.8+-0.45% as per job mix formula, while in the bottom its value is 5.4 +-0.3% as per job mix information provided by CAA. It is really amazing that in the wearing course the designer has decreased the bitumen content value from 5.4 % to 4.8%. While it is a general practice in mix design to keep the higher bitumen content in top layer. While the gradations of aggregate obtained from extraction of Asphaltic cores, generally match the requirement of the job mix formulae.

Hence the picture emerges from the exercise is like that the compaction in the mix was not achieve properly initially, leaving very high air voids in the mix (13 to 14%), plus very low bitumen content (4.4% by mix) specially in the top layer has made the mix very brittle as it permits air and water to circulate in the mix. Causing very early cracking emerging on the surface of overlay. On the other hand the secondary compaction due to very heavy loads has decreased the air voids in the body of the mix, resulting plastic flow in the mix and causing channalization on the surface of the runway specially from chainage 1+000 to 4+000 from 30 end.

7 CONCLUSIONS & RECOMMENDATIONS

This investigation has proved of considerable technical interest, raising issues which are important in pavement engineering not only in the country but throughout the developing countries.

7.1 CONCLUSIONS :The main conclusions draw from the study are given below :

- Surface distresses in the form of interconnected hair-line cracks called crazing and rutting (depression) in the wheel tracks, have been observed from chainage. 1+000 to 4+500 from 3-0 end of the runway.
- The maximum value of roughness (evenness) recorded on the runway is 1200 mm/km at a constant speed of 32 km/hr. by a vehicle mounted Bump Integrator Unit.
- On most of the locations of the runway, the mean macrotexture depth value of the pavement surface, as tested by standard sand patch method is found to be less than 1.5 mm therefore as per F.A.A. standards the runway is found to be more slippery.
- Thickness of the overlay is found to be adequate to accommodate the existing and future air traffic on Islamabad Airport.
- The cracking in the overlay is happening from the top of the pavement and moving downwards.
- Reasons of very early development of surface distresses at the runway pavement are related to the improper design and laying of bituminous mix, supported by the density data of the compacted mix, together with air voids analysis of samples obtained from five different locations of the runway and discussed in detail in the main report.
- In the mix design of top layer the conventional remedy to enhance the stability of mix by reducing the nominal bitumen content was adopted, as the bitumen content had been dropped

from 5.4% by mix in job Mix-1 to 4.8 % by mix in job Mix-2. But unfortunately without the necessary improvement in the grading of the aggregate this produced a rather brittle mixture prone to crack under very heavy loading.

7.2 PROGNOSIS AND REMEDIES: The pavement is clearly very strong and currently in no need of further strengthening. But on those areas where cracking is evident, there is need for an overall treatment to seal the cracks to prevent the entry of surface water and to arrest any surface reveling which may develop. There is no doubt that the ideal treatment would be a surface dressing. This would have the further advantage of providing a rough surface on existing asphaltic concrete which is rather smooth and slipping when wet. But good surface dressing requires resources of expertise and technology which may well not be currently available in the country and because of this, surface dressing cannot be recommended.

It would be unnecessarily expansive to add a further overlay of asphaltic concrete. The procedure recommended therefore is to continue to seal or patch cracking wherever it occurs. The resultant surfacing may not look good. But it will retain its good riding quality, and with this treatment, should have a service life very short of the intensions in the design. A useful precaution would be to apply an overall sand seal in those areas where cracking is evident.

7.3 RECOMMENDATIONS : Asphaltic concrete mixture are extremely sensitive to small changes in both bitumen content and the grading of aggregate. When traffic loads are very heavy such as air fields, grate care is necessary both in designing and in controlling its manufacturing, so that the material as laid confirms continuity with quite narrow specifications limits. Few fundamental recommendations for future work are as follows:

1. The design air voids content should be based on theoretical maximum density of the voidless mix, as determined by Rice test (ASTM D-2041). This test is relatively fast. A major plus is that it accounts for asphalt absorption by the aggregates. It also eliminates the error that

can occur by trying to calculate a maximum specific gravity based on the percentages and specific gravities of the component aggregates.

2. Similarly compaction specifications can be based on meeting percentages of maximum density of voidless mix, laboratory density or test strip density. Which ever specification is used, acceptance levels should be set so that after rolling, the mat will have an air void content of 6 to 8 %, or a density of 92 to 94 % of maximum density of voidless mix. The AASHTO recommends a requirement of 94 percent of theoretical maximum density, based on the mean five tests with no test below 91 percent .

References

[1] International Civil Aviation Organization, (ICOA), " Aerodrome Design Manual", Part 3 Pavements, second Edition 1983, Montreal, Quebec Canada.

[2] William D.O & Thomson Scullion "Information Systems for Road Management", The World Bank Policy Planning and Research Staff Report INU-77, The World Bank Washington D.C, U.S.A, September 1990, pp.29-31.

[3] Lary K. Lanke and R.A.Craul, " Development of Runway Rubber Removal Specifications using Friction measurements and Surface Texture", published in ASTM special Technical Publication STP-929. Philadelphia. USA.

[4] Federal Aviation Administration FAA, design method for Evaluation and Pavement Design, " Aerodrome Design Manual", Part 3 Pavements, second Edition 1983, Montreal, Quebec Canada.

[5] Manual of "Flexible Pavements section II" E.02, U.S.Army Engineer School for Believer, Virginia , USA.

[6] The American Association of State Highway & Transportation Officials (AASHTO), "Report of AASHTO joint Task Force on Rutting" , published by AASHTO Washington D.C, U.S.A, February 1989.

Annexure "A"

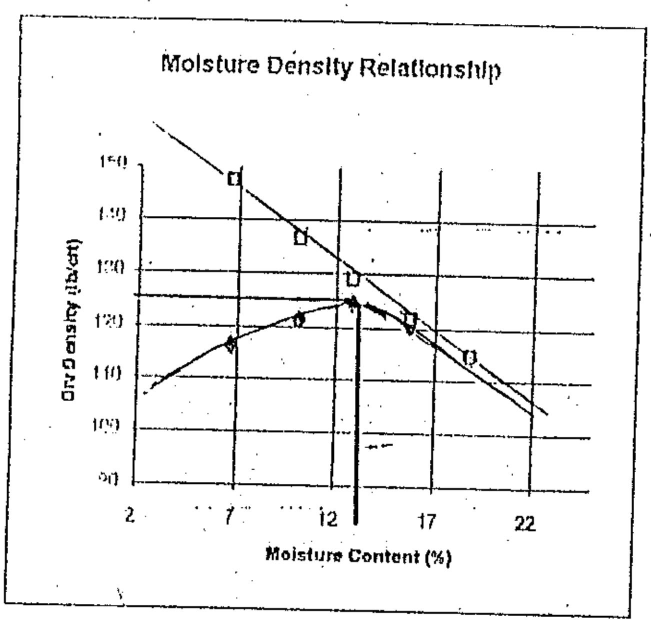
MOISTURE DENSITY RELATION

Sample Pickup Date: 23/10/97
Sample No : 1
Description of Material: Dark Brown Lean Clayey Soil.
Processing Time (hrs): 4 Hours
Client : CIVIL AVIATION AUTHORITY

LOCATION: Islamabad Runway 1+000
Processing Date: 3/11/97

SPECIFICATIONS
STANDARD ADOPTED : ASTM Modified .
COMPACTED BY MACNINE OR NOT: Yes.
SPECIFIC GRAVITY OF MATERIAL: 2.80

DETAIL	1	2	3	4	5
1. Wt. Wet Soil + Mold (lbs)	16.37	17.09	17.58	17.52	17.34
2. Wt. of Mold (lbs)	7.13	7.13	7.13	7.13	7.13
3. Net Wt.Soil (1)-(2) (lbs)	9.24	9.96	10.45	10.39	10.21
4. Volume of Mold (cu.ft)	0.0747	0.0747	0.0747	0.0747	0.0747
5. Wet Unit Wt.(3)/(4)lb/cu.ft	123.69	133.33	139.89	139.09	136.80
6. Wt. Wet Sample + Container (gms)	106.50	88.90	92.10	101.60	110.20
7. Wt. Dry Sample + Container (gms)	100.90	82.20	83.50	90.00	95.40
8. Wt. Of Moisture (6) - (7) (gms)	5.60	6.70	8.60	11.60	14.80
9. Wt. Of Container (gms)	16.60	15.80	16.30	16.20	16.60
10. Net Wt. Dry Sample (7)-(9)(gms)	84.30	66.40	67.20	73.80	78.80
11. Moist. Cont [(8)/(10)]*100 (%)	7	10	13	16	19
12. D.Ut.Wt.(5)/[1+(11*)]lb./cu.ft	115.99	121.11	124.02	120.20	114.33
13. Zero Air Voids Density (lb/cu.ft.)	147.32	136.23	128.63	121.32	114.50



Maximum Density
lb./cu.ft. 124

Optimum Moisture
(%) 13

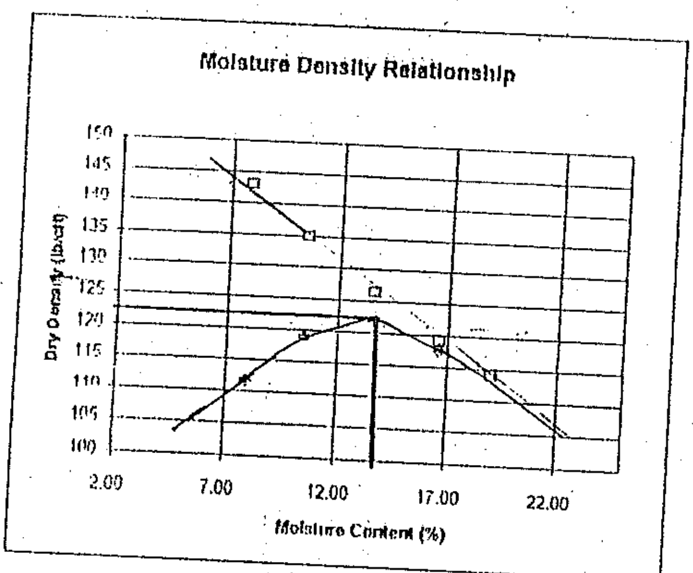
MOISTURE DENSITY RELATION

Sample Pickup Date: 23/10/97
Sample No : 2
Description of Material: Dark Brown Lean Clayey Soil.
Processing Time (hrs): 4 Hours
Client : CIVIL AVIATION AUTHORITY

LOCATION: Islamabad Runway RD 4+000
Processing Date: 6/11/97

SPECIFICATIONS
STANDARD ADOPTED : ASTM Modified
COMPACTED BY MACNINE OR NOT: Yes.
SPECIFIC GRAVITY OF MATERIAL: 2.80

DETAIL	1	2	3	4	5
1. Wt. Wet Soil + Mold (lbs)	16.14	16.94	17.48	17.38	17.24
2. Wt. of Mold (lbs)	7.13	7.13	7.13	7.13	7.13
3. Net Wt.Soil (1)-(2) (lbs)	9.01	9.81	10.35	10.25	10.11
4. Volume of Mold (cu.ft)	0.0747	0.0747	0.0747	0.0747	0.0747
5. Wet Unit Wt.(3)/(4)lb/cu.ft	120.62	131.33	138.55	137.22	135.80
6. Wt. Wet Sample + Container (gms)	73.30	104.00	110.00	121.20	116.00
7. Wt. Dry Sample + Container (gms)	69.10	95.70	98.80	106.20	100.00
8. Wt. Of Moisture (6) - (7) (gms)	4.20	8.30	11.20	15.00	16.00
9. Wt. Of Container (gms)	16.20	16.80	16.70	16.10	15.80
10. Net Wt. Dry Sample (7)-(9)(gms)	52.90	78.90	82.10	90.10	84.20
11. Moist. Cont [(8)/(10)]*100 (%)	8	11	14	17	19
12. D.Unit.Wt.(5)/[1+(11)]lb./cu.ft	111.74	118.83	121.92	117.63	114.12
13. Zero Air Voids Density (lb/cu.ft.)	142.94	134.97	126.43	119.17	114.04



Maximum Density lb./cu.ft. 122

Optimum Moisture (%) 14

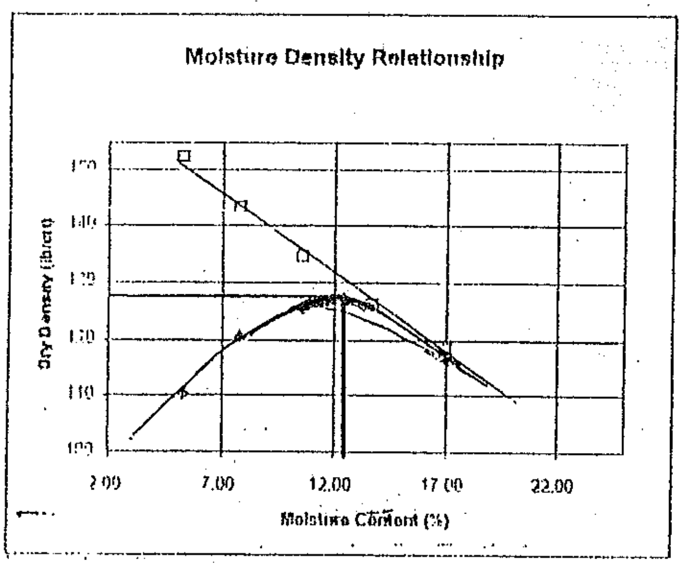
MOISTURE DENSITY RELATION

Sample Pickup Date: 23/10/97
Sample No : 3
Description of Material: Dark Brown Lean Clayey Soil.
Processing Time (hrs): 4 Hours
Client : CIVIL AVIATION AUTHORITY

LOCATION: Islamabad Runway RD 8+000
Processing Date: 5/11/97

SPECIFICATIONS
STANDARD ADOPTED : ASTM Modified
COMPACTED BY MACNINE OR NOT: Yes.
SPECIFIC GRAVITY OF MATERIAL: 2.80

DETAIL	1	2	3	4	5
1. Wt. Wet Soil + Mold (lbs)	15.81	16.82	17.50	17.83	17.45
2. Wt. of Mold (lbs)	7.13	7.13	7.13	7.13	7.13
3. Net Wt.Soil (1) (2) (lbs)	8.68	9.69	10.37	10.70	10.32
4. Volume of Mold (cu.ft)	0.0747	0.0747	0.0747	0.0747	0.0747
5. Wet Unit Wt.(3)/(4)lb/cu.ft	116.18	129.72	138.76	143.29	135.80
6. Wt. Wet Sample + Container (gms)	93.90	112.40	87.00	92.10	104.40
7. Wt. Dry Sample + Container (gms)	90.00	105.40	80.20	82.90	91.60
8. Wt. Of Moisture (6) - (7) (gms)	3.90	7.00	6.80	9.20	12.80
9. Wt. Of Container (gms)	15.90	15.90	16.20	15.80	16.30
10. Net Wt. Dry Sample (7)-(9)(gms)	74.10	89.50	64.00	67.10	75.30
11. Moist. Cont [(8)/(10)]*100 (%)	5	8	11	14	17
12. D.Ut.Wt (5)/[1+(11*)]lb./cu.ft	110.38	120.31	125.43	126.02	116.07
13. Zero Air Voids Density (lb/cu.ft.)	152.28	143.33	131.66	126.25	118.38



Maximum Density
lb./cu.ft. 127

Optimum Moisture
(%) 13

Table-5.1.5-1 CALIFORNIA BEARING RATIO DETERMINATION (CBR)

Sample Pickup Date: 23/10/97 Sample No.1
Location: Islamabad Runway RD 1+000 Right from 3-0 end
Description of Material: Dark Brown Lean Clayey Material.
Processing Time (hrs): 4 Hours
Processing Date: 15/11/97
Client : CIVIL AVIATION AUTHORITY

SPECIFICATIONS

CBR @ 95 % Of Max.Dry Density =124 lb/cu.ft
& OPTIMUM MOISTURE COTENT = 13 %.
AASHTO COMPACTION BY MACNINE: T-180 MAX.AGG.SIZE =NO.4
SURCHARGE LOAD =10 lbs. SOCKING TIME=96 HOURS
CBR TEST PROVING RING FACTOR = 5.80
SPECIFIC GRAVITY OF SOIL= 2.80
MOULD = 4.57" X 6"

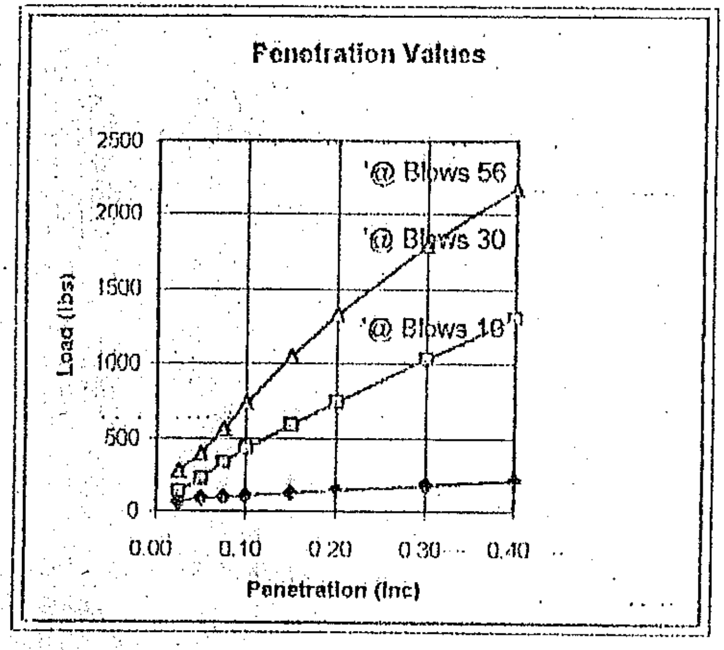
PENETRATION (inches)		At Blows Guage	10 Load	At Blows Guage	30 Load	At Blow Guage	56.00 Load
0.025	50	11	63.8	23	133.4	48	278.4
0.050	100	15	87.0	39	226.2	68	394.4
0.075	150	17	98.6	56	324.8	97	562.6
0.100	200	19	110.2	73	423.4	126	730.8
0.150	300	22	127.6	102	591.6	180	1044.0
0.200	400	25	145.0	128	742.4	228	1322.4
0.300	600	31	179.8	176	1020.8	309	1792.2
0.400	800	37	214.6	224	1299.2	374	2169.2
0.500	1000						
SWELL (Gauge Reading)			96.00		61.00		31.00
SWELLING (%)			2.10		1.33		0.68

DRY DENSITY DETERMINATION @ COMPACTION

	At Blows	At Blows	At Blows 56
Soil + Tat,Wet (gms)	126.6	110.8	96.5
Soil + Tare, Dry (gms)	113.9	100.1	87.5
Tare (gms)	16.1	16.7	16.4
Water Content (%)	13	13	13
Mold + Soil, Wet (gms)	11522	12072	12252
Mold wt. (gms)	7477	7485	7503
Mold Volume (cu.cm)	2122	2122	2122
Bulk Density (g/cu.cm)	1.91	2.16	2.24
Dry Density (gm/cu.cm)	1.69	1.92	1.99
Dry Density (lb/cft)	105.28	119.55	123.96

DRY DENSITY DETERMINATION AFTER SOCKING

	At Blows	At Blows	At Blows 56
Soil + Tare,Wet (gms)	107.9	130.0	105.1
Soil + Tare, Dry (gms)	92.8	114.2	94.7
Tare (gms)	16.2	16.3	16.1
Water Content (%)	20	16	13
Mold + Soil, Wet (kg)	11.8	12.2	12.3
Mold wt. (kg)	7.480	7.485	7.503
Mold Volume (cu.ft)	0.075	0.075	0.075
Bulk Density (lb/cu.ft)	128.0	138.7	140.8
Dry Density (lb/cu.ft)	106.9	119.5	124.3
Socked Density(lb/cu.ft)	104.7	117.9	123.5
Saturation Wt.Content	24	17	15
Degree of Saturation(%)	83	94	89



SUMMERY OF CBR TEST

Pen	Standard	Load (lb)			CBR (%)				
(inch)	Load (lbs)	@ Blows 10	@ Blows 30	@ Blows 56	@ Blows 10	@ Blows 30	@ Blows 56	Socked Den	CBR (%)
0.10	3000	174.00	435.00	556.80	5.80	14.50	18.56	104.7	6
0.20	4500	214.60	655.40	846.80	4.77	14.56	18.82	117.9	15
								123.5	19

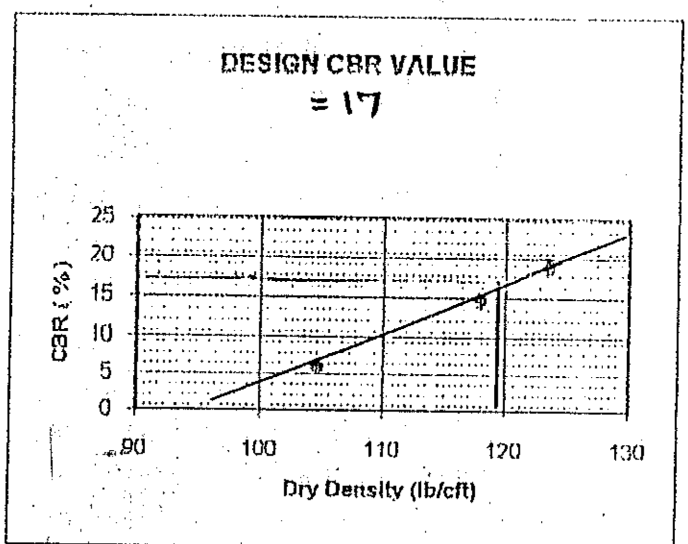


Table-5.1.5-2 CALIFORNIA BEARING RATIO DETERMINATION (CBR)

Sample Pickup Date: 23/10/97 Sample No.2
Location: Islamabad Runway RD 4+000 Left from 3-0 end
Description of Material: Dark Brown Lean Clayey Material.
Processing Time (hrs): 4 Hours
Processing Date: 10/11/97
Client : CIVIL AVIATION AUTHORITY

SPECIFICATIONS
CBR @ 95 % Of Max.Dry Density =122 lb/cu.ft
& OPTIMUM MOISTURE COTENT = 14.0 %.
AASHTO COMPACTION BY MACNINE: T-180 MAX.AGG.SIZE--NO.4
SURCHARGE LOAD =10 lbs: SOCKING TIME=96 HOURS
CBR TEST PROVING RING FACTOR = 5.80
SPECIFIC GRAVITY OF SOIL= 2.80
MOULD = 4.57" X 6 "

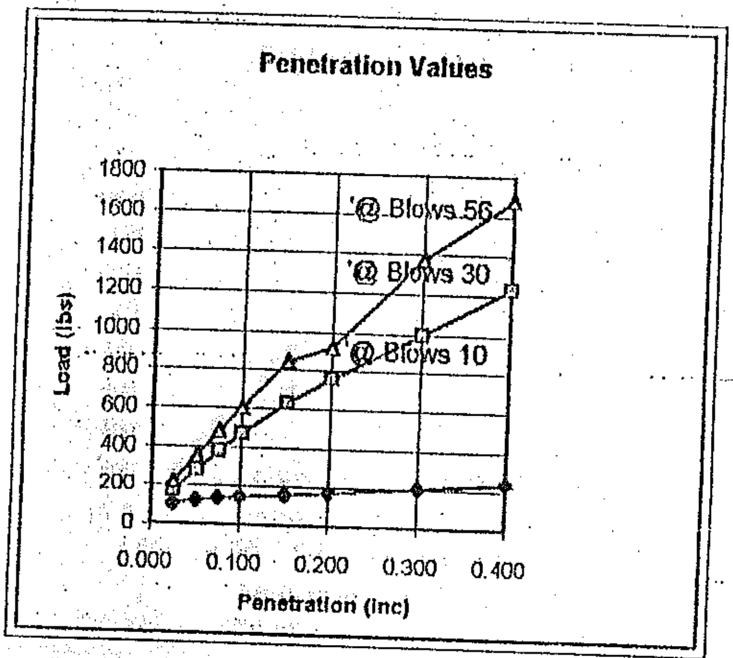
PENETRATION (inches)		At Blows 10 Guage	Load	At Blows 30 Guage	Load	At Blow 56.00 Guage	Load
0.025	50	20.00	116.0	23.0	133.4	30.0	174.0
0.050	100	25.00	145.0	45.0	261.0	60.0	348.0
0.075	150	28.00	162.4	62.0	359.6	80.0	464.0
0.100	200	30.00	174.0	75.0	435.0	96.0	556.8
0.150	300	34.00	197.2	95.0	551.0	124.0	719.2
0.200	400	37.00	214.6	113.0	655.4	146.0	846.8
0.300	600	43.00	249.4	139.0	806.2	179.0	1038.2
0.400	800	48.00	278.4	162.0	939.6	205.0	1189.0
0.500	1000						
SWELL (Gauge Reading)			96.00		61.00		29.00
SWELLING (%)			2.10		1.33		0.63

DRY DENSITY DETERMINATION @ COMPACTION

	At Blows 10	At Blows 30	At Blows 56
Soil + Tar.Wet (gms)	113.8	90.0	112.1
Soil + Tare, Dry (gms)	101.7	80.8	100.0
Tare (gms)	16.4	16.1	16.5
Water Content (%)	14	14	14
Mold + Soil, Wet (gms)	10459	12070	12160
Mold wt. (gms)	7480	7503	7485
Mold Volume (cu.cm)	2122	2122	2122
Bulk Density (g/cu.cm)	1.40	2.15	2.20
Dry Density (gm/cu.cm)	1.23	1.88	1.92
Dry Density (lb/cft)	76.72	117.58	120.07

DRY DENSITY DETERMINATION AFTER SOCKING

	At Blows 10	At Blows 30	At Blows 56
Soil + Tar.Wet (gms)	125.0	92.3	109.0
Soil + Tare, Dry (gms)	104.3	79.5	96.0
Tare (gms)	15.9	16.2	16.3
Water Content (%)	23	20	16
Mold + Soil, Wet (kg)	11.8	12.1	12.2
Mold wt. (kg)	7.480	7.503	7.485
Mold Volume (cu.ft)	0.075	0.075	0.075
Bulk Density (lb/cu.ft)	125.3	134.8	138.3
Dry Density (lb/cu.ft)	101.5	112.2	118.9
Socked Density(lb/cu.ft)	99.4	110.7	118.2
Saturation Wt.Content	27	21	17
Degree of Saturation(%)	87	98	95



SUMMERY OF CBR TEST

Pen (inch)	Standard Load (lbs)	Load (lb) @ Blows 10	@ Blows 30	@ Blows 56	CBR (%) @ Blows 10	@ Blows 30	@ Blows 56	Socked Den	CBR (%)
0.10	3000	139.20	464.0	603.20	4.64	15.47	20.11	102.3	5
0.20	4500	168.20	754.00	916.40	3.74	16.76	20.36	107.9	17
								119.1	20

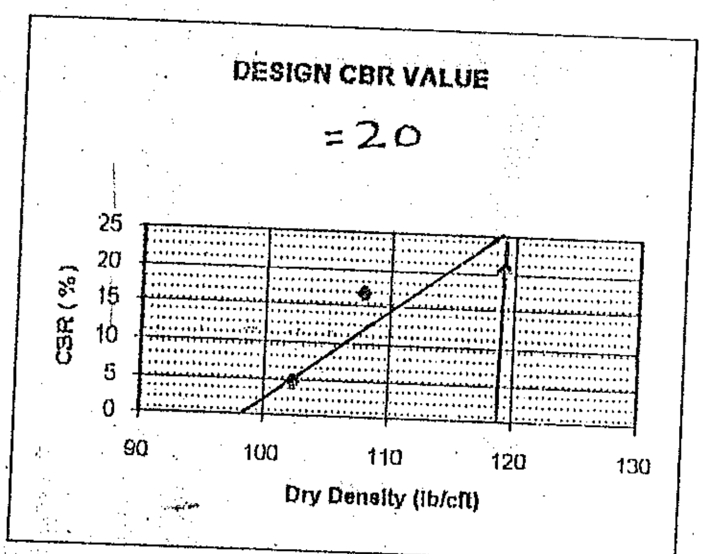


Table-5.1.5-3 CALIFORNIA BEARING RATIO DETERMINATION (CBR)

Sample Pickup Date: 23/10/97 Sample No.3
Location: Islamabad Runway RD 8+000 Right from 3-0 end
Description of Material: Dark Brown Lean Clayey Material.
Processing Time (hrs): 4 Hours
Processing Date: 10/11/97
Client : CIVIL AVIATION AUTHORITY

SPECIFICATIONS

CBR @ 95 % Of Max.Dry Density =127 lb/cu.ft
& OPTIMUM MOISTURE COTENT = 13 %.
AASHTO COMPACTION BY MACNINE: T-180
SURCHARGE LOAD =10 lbs.
CBR TEST PROVING RING FACTOR = 5.80
SPECIFIC GRAVITY OF SOIL= 2.80
MOULD = 4.57" X 6 "
MAX.AGG.SIZE =NO.4
SOCKING TIME=96 HOURS

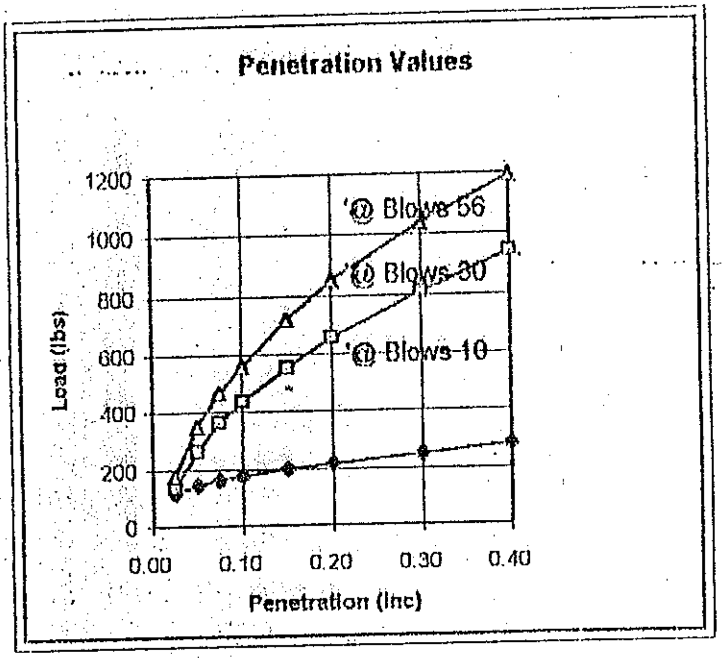
PENETRATION (inches)		At Blows	10	At Blows	30	At Blow	56.00
		Guage	Load	Guage	Load	Guage	Load
0.025	50	18	104.4	29	168.2	37	214.6
0.050	100	21	121.8	48	278.4	61	353.8
0.075	150	23	133.4	65	377.0	83	481.4
0.100	200	24	139.2	80	464.0	104	603.2
0.150	300	27	156.6	108	626.4	145	841.0
0.200	400	29	168.2	130	754.0	158	916.4
0.300	600	35	203.0	171	991.8	236	1368.8
0.400	800	41	237.8	211	1223.8	290	1682.0
0.500	1000						
SWELL (Gauge Reading)			96.00		61.00		29.00
SWELLING (%)			2.10		1.33		0.63

DRY DENSITY DETERMINATION @ COMPACTION

	At Blows 10	At Blows 30	At Blows 56
Soil + Tar,Wet (gms)	146.1	110.5	101.2
Soil + Tare, Dry (gms)	131.6	99.5	91.5
Tare (gms)	16.0	16.1	16.2
Water Content (%)	13	13	13
Mold + Soil, Wet (gms)	11600	12173	12207
Mold wt. (gms)	7487	7548	7460
Mold Volume (cu.cm)	2122	2122	2122
Bulk Density (g/cu.cm)	1.94	2.18	2.24
Dry Density (gm/cu.cm)	1.72	1.93	1.98
Dry Density (lb/cft)	107.47	120.16	123.66

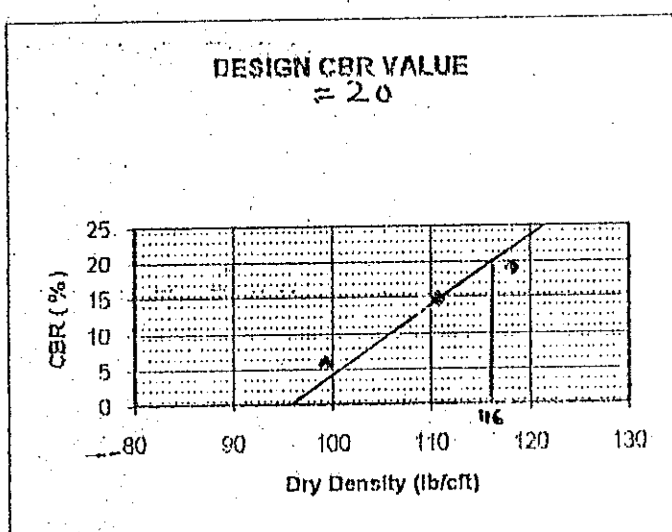
DRY DENSITY DETERMINATION AFTER SOCKING

	At Blows 10	At Blows 30	At Blows 56
Soil + Tar,Wet (gms)	156.5	97.2	122.7
Soil + Tare, Dry (gms)	132.0	84.0	108.0
Tare (gms)	16.0	16.1	16.2
Water Content (%)	21	19	16
Mold + Soil, Wet (kg)	11.8	12.0	12.2
Mold wt. (kg)	7.487	7.548	7.460
Mold Volume (cu.ft)	0.075	0.075	0.075
Bulk Density (lb/cu.ft)	126.5	130.6	139.0
Dry Density (lb/cu.ft)	104.5	109.3	119.8
Socked Density(lb/cu.ft)	102.3	107.9	119.1
Saturation Wt.Content	25	22	17
Degree of Saturation(%)	84	88	96



SUMMERY OF CBR TEST

Pen (inch)	Standard Load (lbs)	Load (lb) @ Blows 10	@ Blows 30	@ Blows 56	CBR (%) @ Blows 10	@ Blows 30	@ Blows 56	Socked Den	CBR (%)
0.10	2000	174.00	435.00	556.80	5.80	14.50	18.56	99.4	6
0.20	4500	214.60	655.40	846.80	4.77	14.56	18.82	110.7	15
								118.2	19



... Cone Penetrometer

...11.97 — Data file : isL

...	Islamabad Runway	Date	20/10/97
...tion no.	2	Start layer	Asphaltic Concrete
...t no.	2	Condition	Fair
...	2+000	Zero error (mm)	0
...tion/lane	Right Bound from 3-0	Surf thick (mm)	0
...tion/offset	At Edge of Pavement	Extens @ line	0

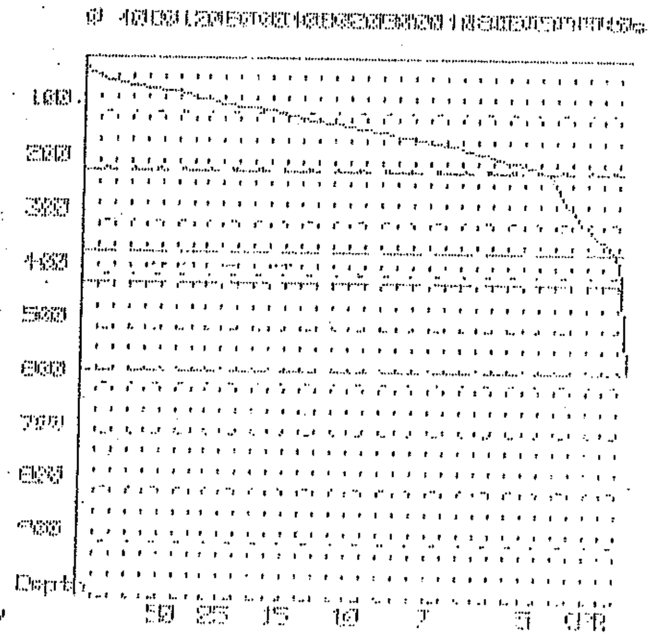
	Blw	Rdng		Blw	Rdng		Blw	Rdng		Blw	Rdng		Blw	Rdng
1	-	16	11	100	60	21	200	89	31	300	115	41	410	144
2	10	29	12	110	62	22	210	91	32	310	118	42	420	146
3	20	34	13	120	64	23	220	93	23	320	122	43	430	150
4	30	42	14	130	68	24	230	95	34	340	126	44	440	152
5	40	44	15	140	72	25	240	97	35	350	128	45	450	154
6	50	49	16	150	75	26	250	100	36	360	131	46	460	157
7	60	51	17	160	77	27	260	104	37	370	133	47	470	160
8	70	54	18	170	81	28	270	106	38	380	136	48	480	164
9	80	56	19	180	85	29	280	110	39	390	138	49	490	169
10	90	58	20	190	87	30	290	113	40	400	142	50	500	173
51	510	171	61	605	244	71	655	328	81	690	510	91		
52	520	177	62	610	252	72	660	333	82	691	535	92		
53	530	182	63	615	263	73	665	339	83	692	540	93		
54	540	185	64	620	274	74	670	345	84	693	555	94		
55	550	189	65	625	285	75	675	355	85	694	565	95		
56	560	193	66	630	293	76	680	372	86	695	575	96		
57	570	197	67	635	302	77	685	415	87			97		
58	580	200	68	640	309	78	687	454	88			98		
59	590	205	69	645	315	79	688	475	89			99		
60	600	227	70	650	321	80	689	502	90			100		

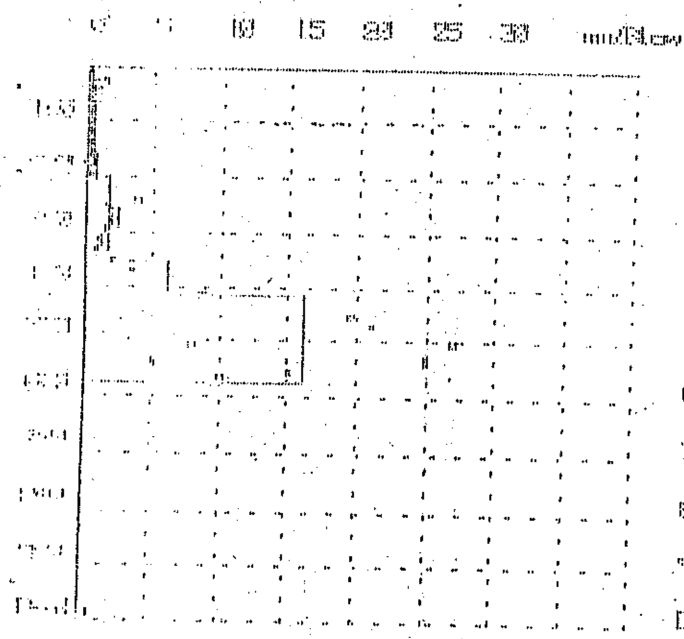
E2 : 0.80 E3 : 2.00 E4 : 5.00 EN : 2.00

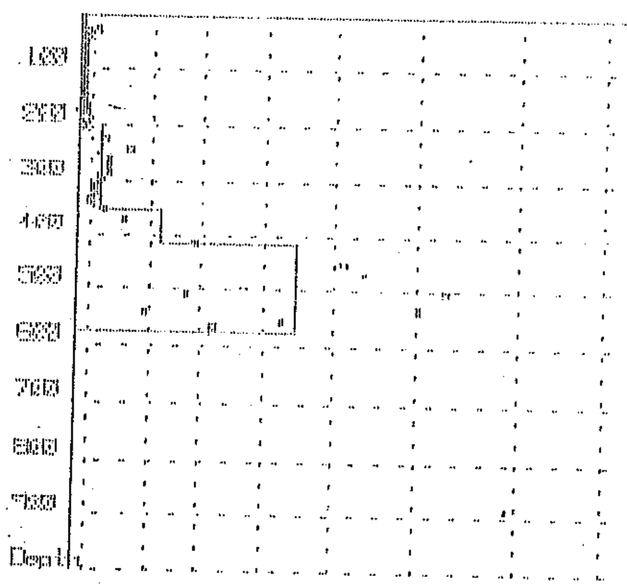
Layer	Strength mm/blow	CBR	Thick mm	Depth mm
1	0.32	1840 (200)	189	205
2	1.76	207 (156)	150	355
3	6.00	43	60	415
4	16.00	12	160	575

...equation - log10(CBR) = 2.632 - 1.28 * log10(STRENGTH)

Data file : isb2
Site : Islamabad Runway
Section no. : 2
Test no. : 2
Chainage : 2+000
Direction/lane : Right Bound from 3 0
Position/offset : At Edge of Pavement
Date : 20/10/97
Start layer : Asphaltic Concrete
Condition : Fair
Zero error (mm) 0
Surf thick (mm) 0







Dynamic Cone Penetrometer — Data file : run1

10/97

	Islamabad Runway	Date	22/10/97
Location no.	5	Start layer	Asphaltic Concrete
Site no.	4	Condition	Fair
Chainage	5+000	Zero error (mm)	0
Direction/lane	Right Bound from 3-0	Surf thick (mm)	0
Position/offset	At Edge of Payment	Extens @ line	0

Blw	Rdng		Blw	Rdng		Blw	Rdng		Blw	Rdng		Blw	Rdng
1		12	11	100	55	21	200	74	31	300	114	41	400	140
2	10	31	12	110	56	22	210	82	32	310	117	42	410	142
3	20	36	13	120	56	23	220	87	33	320	122	43	420	143
4	30	40	14	130	62	24	230	90	34	330	122	44	430	147
5	40	42	15	140	62	25	240	95	35	340	124	45	440	151
6	50	46	16	150	63	26	250	97	36	350	126	46	450	154
7	60	48	17	160	65	27	260	102	37	360	130	47	460	160
8	70	50	18	170	67	28	270	103	38	370	131	48	470	163
9	80	51	19	180	68	29	280	106	39	380	133	49	480	168
10	90	53	20	190	72	30	290	110	40	390	135	50	490	172
51	500	174	61	600	232	71	650	320	81	689	502	91	699	626
52	510	176	62	605	246	72	655	326	82	690	515	92	700	639
53	520	177	63	610	253	73	660	331	83	691	530	93	701	652
54	530	180	64	615	262	74	665	335	84	692	540	94	702	667
55	540	183	65	620	272	75	670	342	85	693	554	95	703	684
56	550	186	66	625	282	76	675	357	86	694	566	96	704	702
57	560	192	67	630	289	77	680	373	87	695	577	97	705	720
58	570	200	68	635	295	78	685	410	88	696	588	98	706	737
59	580	209	69	640	305	79	687	450	89	697	600	99	707	754
60	590	223	70	645	314	80	688	477	90	698	613	100	708	772

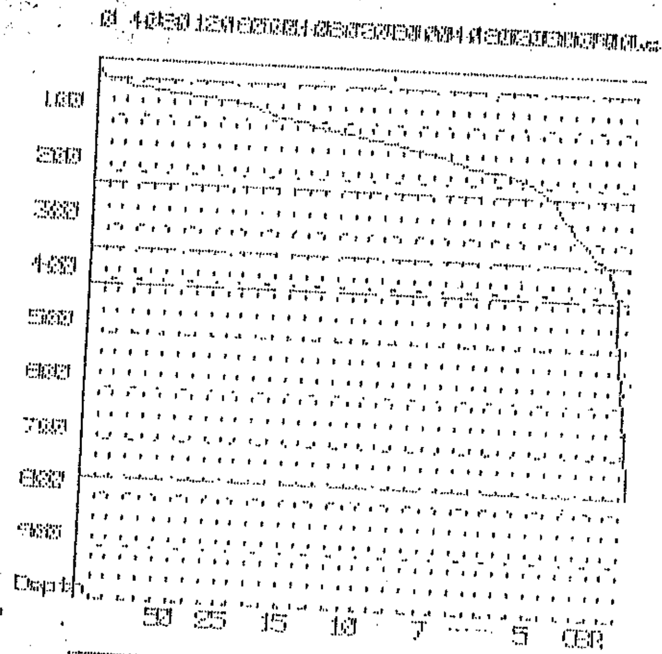
E1 : 0.25 E2 : 0.80 E3 : 2.00 E4 : 5.00 EM : 2.00

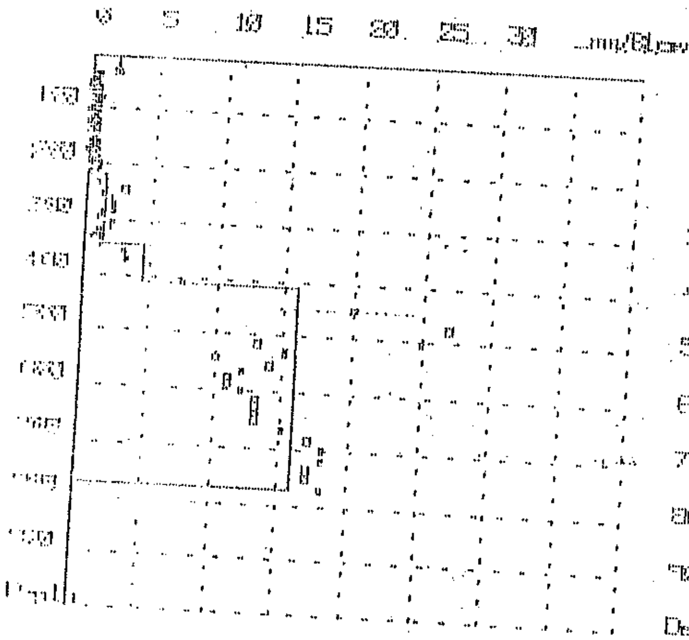
Layer	Strength mm/blow	CBR	Thick mm	Depth mm	Layer
Trans	1.90	188 (150)	19	31	Base
1	0.33	200 (150)	192	223	Base
2	1.49	200 (150)	119	342	Base
Trans	4.53	62	68	410	Subbase
3	15.74	13	362	772	Subgrad

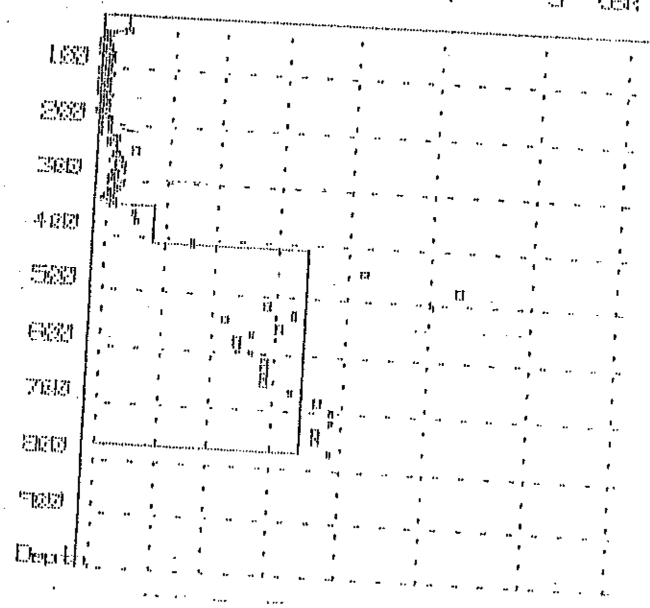
Correlation - log10(CBR) = 2.632 - 1.28 * log10(STRENGTH)

Surface 0.000 Base 1.947 Subbase 0.499 Subgrad 1.788 Total 4.144

Data file Run4
Site Islamabad Runway
Section no. 5
Test no. 4
Chainage 5+000
Direction/lane Right Bound from 3 0
Position/offset At Edge of Pav.& Shl
Date 22/10/97
Start layer Surface Treated
Condition Fair
Zero error (mm) 0
Surf thick (mm) 0
Structural no 4.144022







[illegible] Penetrometer

Data file : isb1

1/97

Test no.	8	Date	21/10/97
No.	3	Start layer	Asphaltic Concrete
Chainage	8+000	Condition	Fair
Section/lane	Left Bound from 3-0	Zero error (mm)	0
Location/offset	At Edge of Pavement	Surf thick (mm)	0
		Extens @ line	0

Blw Rdng | Blw Rdng | Blw Rdng | Blw Rdng | Blw Rdng

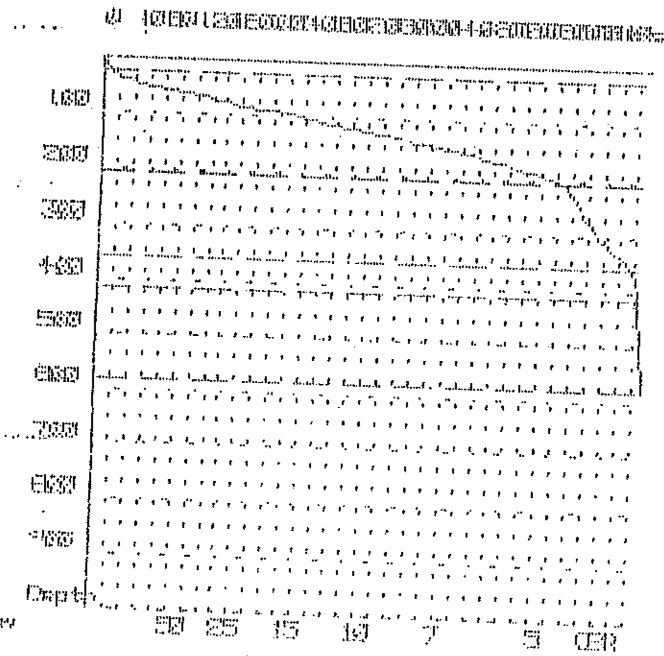
1	[illegible]	4	11	100	60	21	200	89	31	300	115	41	410	144
2	10	25	12	110	62	22	210	91	32	310	118	42	420	146
3	20	32	13	120	65	23	220	93	33	320	122	43	430	150
4	30	40	14	130	68	24	230	95	34	340	126	44	440	152
5	40	41	15	140	72	25	240	97	35	350	128	45	450	154
6	50	49	16	150	75	26	250	100	36	360	131	46	460	157
7	60	51	17	160	77	27	260	104	37	370	133	47	470	160
8	70	54	18	170	81	28	270	106	38	380	136	48	480	164
9	80	56	19	180	85	29	280	110	39	390	138	49	490	169
10	90	59	20	190	87	30	290	113	40	400	142	50	500	173
51	510	174	61	605	240	71	655	329	81	690	515	91		
52	520	177	62	610	252	72	660	333	82	691	535	92		
53	530	182	63	615	263	73	665	338	83	692	545	93		
54	540	185	64	620	274	74	670	345	84	693	555	94		
55	550	188	65	625	285	75	675	355	85	694	568	95		
56	560	192	66	630	295	76	680	370	86	695	580	96		
57	570	197	67	635	305	77	685	415	87			97		
58	580	200	68	640	310	78	687	458	88			98		
59	590	205	69	645	315	79	688	478	89			99		
60	600	220	70	650	321	80	689	504	90			100		

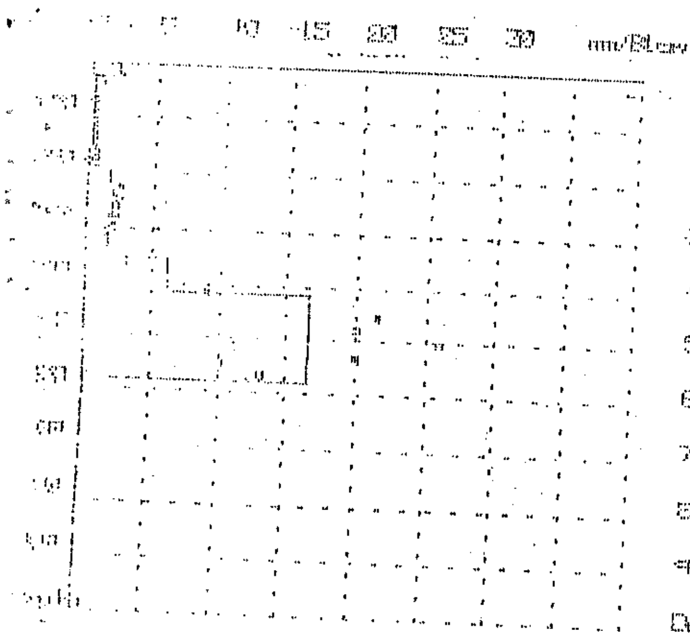
0.35 E2 : 0.80 E3 : 2.00 E4 : 5.00 EM : 2.00

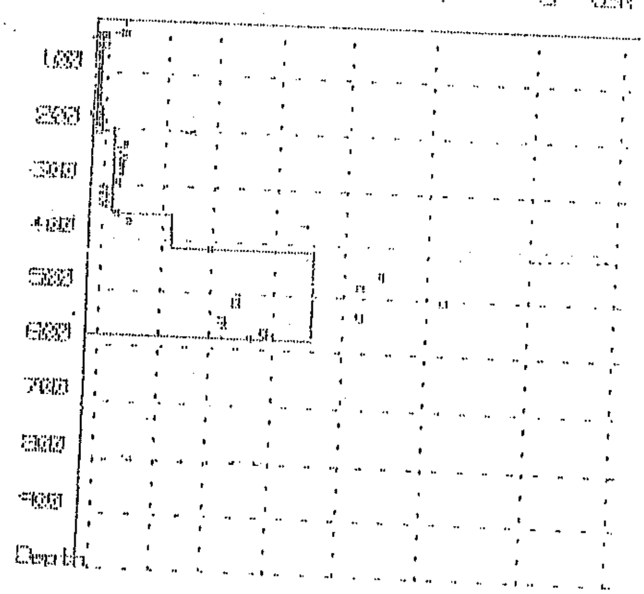
Layer	Strength mm/blow	CBR	Thick mm	Depth mm
[illegible]	2.10	166 (155)	21	25
	0.31	1916 (150)	180	205
	1.76	207 (150)	150	355
[illegible]	6.00	43	60	415
	16.50	12	165	580

[illegible] equation - log10(CBR) = 2.632 - 1.28 * log10(STRENGTH)

Data file	isb1
Site	Islamabad Runway
Section no.	8
Test no.	3
Chainage	8+000
Direction/Lane	Left Bound from 3 @
Position/Offset	At Edge of Pavement
Date	21/10/97
Surface layer	Asphaltic Concrete
Condition	Fair
Correction (mm)	0
Surf thick (mm)	0







Annexure "B"

Departures Data of Islamabad Airport for 1992.

Domestic Departures

Day	Flight No.	Airline	Aircraft	Origin/Destination
WED	349	PIA	A-300	ISB-KHI
WED	373	PIA	A-300	ISB-LEH-KHI
TUE	301	PIA	A-300	ISB-KHI
TUE	313	PIA	A-300	ISB-KHI
TUE	309	PIA	A-300	ISB-KHI
THU	325	PIA	A-300	ISB-QET-KHI
SUN	373	PIA	A-300	ISB-LH-KHI
SUN	313	PIA	A-300	ISB-KHI
SUN	309	PIA	A-300	ISB-KHI
SUN	325	PIA	A-300	ISB-UET-KHI
MON	301	PIA	A-300	ISB-KHI
MON	313	PIA	A-300	ISB-KHI
MON	325	PIA	A-300	ISB-UET-KHI
	13			
WED	373	PIA	A-310	ISB-LH-KHI
SUN	373	PIA	A-310	ISB-LH-KHI
SAT	359	PIA	A-310	ISB-KHI
SAT	363	PIA	A-310	ISB-KHI
	4			
WED	365	PIA	B-707	ISB-UET-KHI
TUE	325	PIA	B-707	ISB-UET-KHI
FRI	325	PIA	B-707	ISB-UET-KHI
	3			
FRI	313	PIA	B-737	ISB-KHI
FRI	319	PIA	B-737	ISB-KHI
FRI	387	PIA	B-737	ISB-LHE-MUX
FRI	381	PIA	B-737	ISB-LHE
FRI	383	PIA	B-737	ISB-LHE
MON	319	PIA	B-737	ISB-KHI
MON	381	PIA	B-737	ISB-LHE
MON	377	PIA	B-737	ISB-LHE
MON	383	PIA	B-737	ISB-LHE
MON	451	PIA	B-737	ISB-GIL
SAT	313	PIA	B-737	ISB-KHI
SAT	319	PIA	B-737	ISB-KHI
SAT	387	PIA	B-737	ISB-LHE-MUX
SAT	381	PIA	B-737	ISB-LHE
SAT	383	PIA	B-737	ISB-LHE
SUN	319	PIA	B-737	ISB-KHI
SUN	345	PIA	B-737	ISB-LHE-SKZ-KHI
SUN	381	PIA	B-737	ISB-LHE
SUN	383	PIA	B-737	ISB-LHE
THU	313	PIA	B-737	ISB-KHI
THU	319	PIA	B-737	ISB-KHI
THU	345	PIA	B-737	ISB-LHE-SKZ-KHI
THU	381	PIA	B-737	ISB-LHE
THU	383	PIA	B-737	ISB-LHE
TUE	319	PIA	B-737	ISB-KHI
TUE	345	PIA	B-737	ISB-LHE-SKZ-KHI
TUE	381	PIA	B-737	ISB-LHE
TUE	383	PIA	B-737	ISB-LHE
WED	313	PIA	B-737	ISB-KHI
WED	319	PIA	B-737	ISB-KHI
WED	387	PIA	B-737	ISB-LHE-MUX

Day	Flight No.	Airline	Aircraft	Origin/Destination
WED	381	PIA	B-737	ISB-LHE
WED	383	PIA	B-737	ISB-LHE
	33			
WED	311	PIA	B-747	ISB-KHI
TUE	301	PIA	B-747	ISB-KHI
TUE	309	PIA	B-747	ISB-KHI
SUN	309	PIA	B-747	ISB-KHI
SUN	361	PIA	B-747	ISB-KHI
MON	301	PIA	B-747	ISB-KHI
MON	311	PIA	B-747	ISB-KHI
FRI	311	PIA	B-747	ISB-KHI
	8			
FRI	441	PIA	DHT	ISE-PEW
FRI	423	PIA	DHT	ISB-RAZ
FRI	427	PIA	DHT	ISB-MFG
MON	423	PIA	DHT	ISB-RAZ
MON	425	PIA	DHT	ISB-MFG-RAZ
MON	427	PIA	DHT	ISB-MFG
SAT	423	PIA	DHT	ISB-RAZ
SAT	429	PIA	DHT	ISB-RAZ
SAT	427	PIA	DHT	ISB-MFG
SUN	421	PIA	DHT	ISB-DHT
SUN	423	PIA	DHT	ISB-RAZ
SUN	425	PIA	DHT	ISB-MFG-RAZ
SUN	427	PIA	DHT	ISB-MFG
THU	431	PIA	DHT	ISB-MID-LHE
THU	423	PIA	DHT	ISB-RAZ
THU	429	PIA	DHT	ISB-RAZ
THU	427	PIA	DHT	ISB-MFG
TUE	423	PIA	DHT	ISB-RAZ
TUE	429	PIA	DHT	ISB-RAZ
TUE	427	PIA	DHT	ISB-MFG
WED	421	PIA	DHT	ISB-DHT
WED	423	PIA	DHT	ISB-RAZ
WED	425	PIA	DHT	ISB-MFG-RAZ
WED	427	PIA	DHT	ISB-MFG
	24			
FRI	385	PIA	F-27	ISB-LHE
FRI	603	PIA	F-27	ISB-LHE-BHP
FRI	632	PIA	F-27	ISE-SDT-PEW
FRI	611	PIA	F-27	ISB-LHE
FRI	688	PIA	F-27	ISB-DSK-LHE
FRI	684	PIA	F-27	ISB-PEW-DSK
FRI	630	PIA	F-27	ISB-PEW
FRI	607	PIA	F-27	ISB-LYP
FRI	657	PIA	F-27	ISB-LYP
FRI	401	PIA	F-27	ISB-GIL
FRI	405	PIA	F-27	ISB-GIL
MON	385	PIA	F-27	ISB-LHE
MON	603	PIA	F-27	ISB-LHE-BHP
MON	640	PIA	F-27	ISE-SDT-CJL
MON	632	PIA	F-27	ISE-SDT-PEW
MON	611	PIA	F-27	ISB-LHE
MON	682	PIA	F-27	ISB-PEW-DSK
MON	688	PIA	F-27	ISB-DSK-LHE
MON	630	PIA	F-27	ISB-PEW

Day	Flight No.	Airline	Aircraft	Origin/Destination
MON	607	PIA	F-27	ISB-LYP
MON	657	PIA	F-27	ISB-LYP
MON	401	PIA	F-27	ISB-GIL
SAT	385	PIA	F-27	ISB-LHE
SAT	603	PIA	F-27	ISB-LHE-BHP
SAT	640	PIA	F-27	ISE-SDT-CJL
SAT	632	PIA	F-27	ISE-SDT-PEW
SAT	611	PIA	F-27	ISB-LHE
SAT	682	PIA	F-27	ISB-PEW-DSK
SAT	630	PIA	F-27	ISB-PEW
SAT	607	PIA	F-27	ISB-LYP
SAT	657	PIA	F-27	ISB-LYP
SAT	401	PIA	F-27	ISB-GIL
SAT	405	PIA	F-27	ISB-GIL
SAT	407	PIA	F-27	ISB-GIL
SUN	601	PIA	F-27	ISB-LHE-HD-KHI
SUN	385	PIA	F-27	ISB-LHE
SUN	603	PIA	F-27	ISB-LHE-BHP
SUN	632	PIA	F-27	ISE-SDT-PEW
SUN	611	PIA	F-27	ISB-LHE
SUN	684	PIA	F-27	ISB-PEW-DSK
SUN	670	PIA	F-27	ISB-MUX
SUN	630	PIA	F-27	ISB-PEW
SUN	607	PIA	F-27	ISB-LYP
SUN	657	PIA	F-27	ISB-LYP
SUN	401	PIA	F-27	ISB-GIL
SUN	411	PIA	F-27	ISB-GIL
THU	601	PIA	F-27	ISB-LHE-HD-KHI
THU	385	PIA	F-27	ISB-LHE
THU	603	PIA	F-27	ISB-LHE-BHP
THU	632	PIA	F-27	ISE-SDT-PEW
THU	611	PIA	F-27	ISB-LHE
THU	684	PIA	F-27	ISB-PEW-DSK
THU	670	PIA	F-27	ISB-MUX
THU	630	PIA	F-27	ISB-PEW
THU	607	PIA	F-27	ISB-LYP
THU	657	PIA	F-27	ISB-LYP
THU	401	PIA	F-27	ISB-GIL
THU	413	PIA	F-27	ISB-GIL
TUE	601	PIA	F-27	ISB-LHE-HD-KHI
TUE	385	PIA	F-27	ISB-LHE
TUE	603	PIA	F-27	ISB-LHE-BHP
TUE	632	PIA	F-27	ISE-SDT-PEW
TUE	611	PIA	F-27	ISB-LHE
TUE	684	PIA	F-27	ISB-PEW-DSK
TUE	630	PIA	F-27	ISB-PEW
TUE	607	PIA	F-27	ISB-LYP
TUE	657	PIA	F-27	ISB-LYP
TUE	401	PIA	F-27	ISB-GIL
TUE	403	PIA	F-27	ISB-GIL
WED	385	PIA	F-27	ISB-LHE
WED	603	PIA	F-27	ISB-LHE-BHP
WED	632	PIA	F-27	ISE-SDT-PEW
WED	611	PIA	F-27	ISB-LHE
WED	682	PIA	F-27	ISB-PEW-DSK
WED	630	PIA	F-27	ISB-PEW

Day	Flight No.	Airline	Aircraft	Origin/Destination
WED	607	PIA	F-27	ISB-LYP
WED	657	PIA	F-27	ISB-LYP
WED	401	PIA	F-27	ISB-GIL
WED	403	PIA	F-27	ISB-GIL
WED	405	PIA	F-27	ISB-GIL
WED	407	PIA	F-27	ISB-GIL
	81			
International Departures				
MON	940	PIA	A-300	DUBAI
TUE	1215	PIA	A-300	LHE-JEDDAH
FRI	1215	PIA	A-300	LHE-JEDDHA
WED	1945	PIA	A-300	LHE-DHAHRAN
	4			
MON	2040	PIA	A-310	KHI-PAR-N.Y
SAT	645	PIA	A-310	COPENHEG
FRI	630	PIA	A-310	LHE-BANKOK
SUN	725	PIA	A-310	BEJ-TOKOYO
SAT	1145	PIA	A-310	DUBAI
	5			
MON	1100	PIA	B-737	TASHKANT
	1			
TUE	1030	PIA	B-747	DIB-MANCHESS
THU	1030	PIA	B-747	DUB-MANCHESS
SAT	230	PIA	B-747	DUB-LOND
SUN	115	PIA	B-747	DAMS-FRANC-N
SUN	830	PIA	B-747	MAS-LONDON
THU	1430	PIA	B-747	LHE-RIYADE
TUE	1800	SAUDIA	B-747	DHRAN-RIYADE
THU	1800	SAUDIA	B-747	RIYADE-JEDDHA
SUN	1800	SAUDIA	B-747	RIYADE-JEDDHA
TUE	800	B.AIRW	B-747	MANC-LONDON
FRI	800	B.AIRW	B-747	MANC-LONDON
	11			

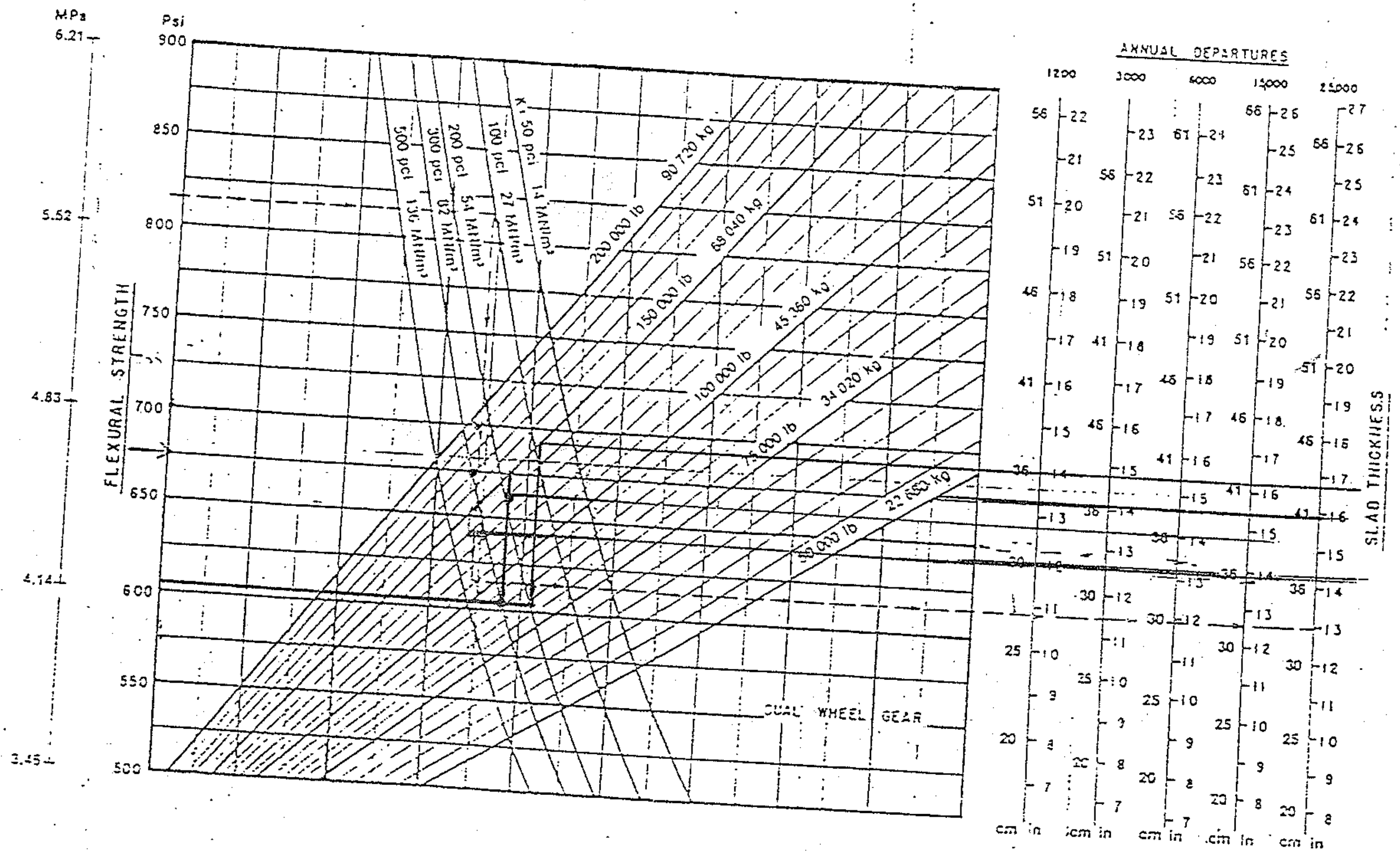


Figure 4-47. Rigid pavement design curves - dual wheel gear