Design of Airport Runway Pavement with the Help of COMFAA and FAARFIELD

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Abstract— This project aims to calculate the Aircraft Classification Number (ACN) and Pavement Classification Number (PCN) for airports using the computer programs COMFAA (Computer Model for Feasibility Analysis and Operations Evaluation) and FARRFIELD (Federal Aviation Administration Rigid and Flexible Iterative Elastic Layered Design).

ACN and PCN are important parameters used in airport design and planning, as they help determine the maximum weight and size of aircraft that can safely operate on a givenrunway and taxiway.

COMFAA (computer program for FAA) is a software tool developed by the Federal AviationAdministration (FAA) that calculates the ACN for an aircraft based on its weight, landing gearconfiguration, and other factors. FARRFIELD (FAA Runway Analysis and Reporting Program) is another FAA program that uses the ACN data to calculate the PCN for the pavement surface of a runway or taxiway.

This project will involve inputting data about various aircraft types (B737-400, B777-300ER,B777-400, B747-400, A310-30 A321-100std) into the COMFAA program to generate ACN values. These values will then be used in FARRFIELD to calculate PCN values for different pavement types and conditions. The project will also involve evaluating the accuracy and reliability of the results obtained from the two programs.

The outcomes of this project such as unsoaked and soaked CBR by using Standard Proctor testas 4.34% and 2.91% respectively also unsoaked and soaked CBR by using Modified Proctor test which gives Evaluation thickness as 47.6 inches, 58.5 inches, 34.3 inches, 43.4 inches and various ACN and PCN number for different Aircrafts can be useful for airport operators and planners in determining the capacity of their runways and taxiways for various aircraft types. It can also help in assessing the need for pavement maintenance or upgrades to accommodate larger and heavier aircraft.[1].

Our proposed system, uses their health records in the form of general parameters and

INTRODUCTION

Our project is to design Airport Runway Pavement by ACN-PCN classification method using COMFAA and FAARFIELD Software. So, at first

What is ACN and PCN?

The Aircraft Classification Number (ACN):

The ACN expresses the effect of individual aircraft on different pavements by a single unique number, which varies according to pavement type and subgrade strength, without specifying a particular pavement thickness.

Pavement Classification Number (PCN):

PCN is an International Civil Aviation Organization (ICAO) standard used in combination with the Aircraft Classification Number (ACN) to indicate the strength of a runway, taxiway or apron. This helps to ensure that they are not subjected to excessive wear and tear, thus prolonging their usable life.

LITERATURE REVIEW

Krisana Chaleewong, Chaisak Pisitpaibool, Pavement Evaluation of Airport Taxiway and Effect of Increasing CAN to Pavement Remaining Life, 31 October 2018 This research evaluates the strength of the flexible taxiway pavement. The Cumulative Damage Factor (CDF), which is then expressed in the form of remaining life, is determined by applying the Layer Elastic Design (LED) theory. Strength of the pavement is evaluated by the Aircraft Classification Number - Pavement Classification Number (ACN-PCN) procedure, based on the CBR method. The remaining life of the taxiway causing by the increasing ACN is also evaluated. It is found that the taxiway area A5 provides the lowest remaining lifetime, which is

0.9 years. The taxiway area A2 provides the lowest PCN value, which is 130. It should be noted that, when the ACN aircraft is increase and the ACN/PCN ratio is equal or larger than 0.7-0.8, the pavement remaining life is reduced. In addition, when the ACN/PCN ratio is greater than 1.0 (ACN is overload), the remaining life decreases in the form of an exponential function. The remaining life should be taken into account in the procedure of pavement evaluation.

Tiago Barreto Tamagusko, Airport Pavement Design, February 2020 Three scenarios are presented, maintaining current operation with aircrafts up to 6.4 tons and autonomy of 1000 km, operating aircrafts up to 23 tons and 2500 km range, and aircraft up to 82.2 tons and 6000 km range. In the first scenario, the existing pavement must be reinforced with an overlay that can vary between 5.5 and 7.0 cm. In the second, a new 1800 m runway was designed, with 15.0 cm of the granular layer, 13.0 cm of bituminous layer, and 10.5 cm wear layer. In the final scenario, the new runway should be 2500 m. This pavement should have a structure with 29.5 cm of the granular layer, 13.0 cm of bituminous layer and 10.5 cm of the wear layer. It was also foreseen the possibility of construction of this runway in two stages, the first being precisely the same as the previous project (1800 m in length and a total thickness of 38.5 cm), then the runway should reach the final characteristic, with 2500 m and structural capacity for aircraft up to 82.2 tons. This was possible with a 9.5 cm overlay on the 38.5 cm structure (previous structure).

Michael J. Roginski, Present and Future Work Items of the ICAO Pavement Sub-Group September 1-5-2014 For D type aircraft the results derived from Alizé-LCPC and FAARFIELD correlate quite well across all subgrade strengths. For 2D and 3D aircraft, the difference between Alizé-LCPC and FAARFIELD become quite significant. For high subgrade strengths, FAARFIELD is close to current aircraft ACN's (typically lower) while Alizé-LCPC leads to higher ACNs. For low subgrade strengths both are significantly higher than current ACNs. Incorporate the Alize method of looking at multi-axle loading. Faarfield uses a pass/coverage approach whereas Alize uses a multi-peak integration approach. This will effect the CDF computation significantly and the ACN computation slightly. Rigid pavements need to be addressed- currently assumed not to be as discrepant as the flexible pavement failure models. Consider different reference structures and coverage levels for ACN determination.

Laboratory Procedure and Equipment Required to Perform the tests

Various tests are performed in Laboratory such as Standard Proctor Test, Modified Proctor Test, Unsoaked and Soaked CBR on the basis of Standard Proctor Test, Unsoaked and Soaked CBR on the basis of Modified Proctor Test also Atterberg limit test we find the strength of Subgrade and also for classification of soil.

The following tests were carried out on various soil samples with treated and untreated soil

1. Atterberg's Limits Test

a) Liquid Limit

b) Plastic Limit

2 Standard Proctor Test

3. C.B.R Test

4.Unconfined Compression Test

Results of test that was Carried out for Input in Software

Standard Proctor Test

Container Number	S2 (Sample1)	V2 (Sample2)	P1 (Sample3)	S1 (sample4)	N2 (Sample4)	G4 (sample6)
Water Content %	4	8	12	14	16	18
Weight of soil + Container weight in gm	5204	5336	5444	5439	5368	5401
Wet density (gm/cc)	2.001	2.133	2.24	2.23	2.16	2.19
Wet soil +Container weight	204	228	233	261	295	320
Dry soil + Container weight	190	207	207	221	248	266
Empty Weight of container	51	50	52	51	50	51
Moisture lost	14	21	26	34	47	54
Dry weight of soil	139	157	155	176	198	215

Procter Cylinder details

Diameter = 10cm Height =12.7cm Volume=997.5cub.cm

Proctor Hammer Details

Weight Of Hammer =2.6 kg

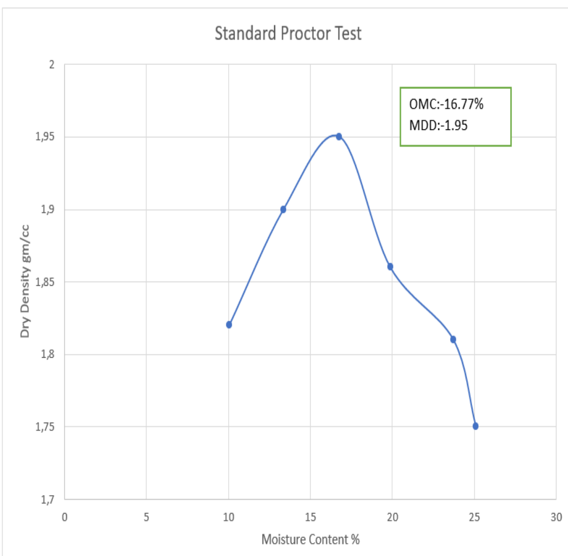


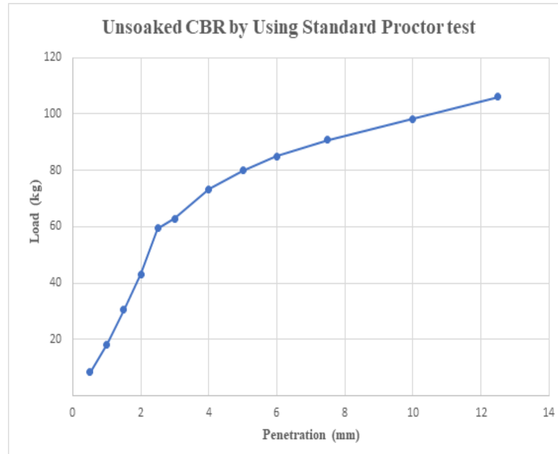
Fig 6. Graph for Standard Proctor Test showing OMC and MDD

The procedure for Modified Proctor test is same as standard Proctor test only the rammer weight which was used is 4.67kg.

Unsoaked CBR by Using Standard Proctor test

Penetration mm	Proving Ring	Load (Kg)
0.5	26	8.46
1.0	56	18.25
1.5	94	30.59
2.0	133	43.13
2.5	170	59.55
3.0	193	62.90
4.0	224	73.26
5.0	245	79.99
7.5	280	90.81
10.0	304	98.22
12.5	329	106.04

Results of Unsoaked CBR by Using Standard Proctor test

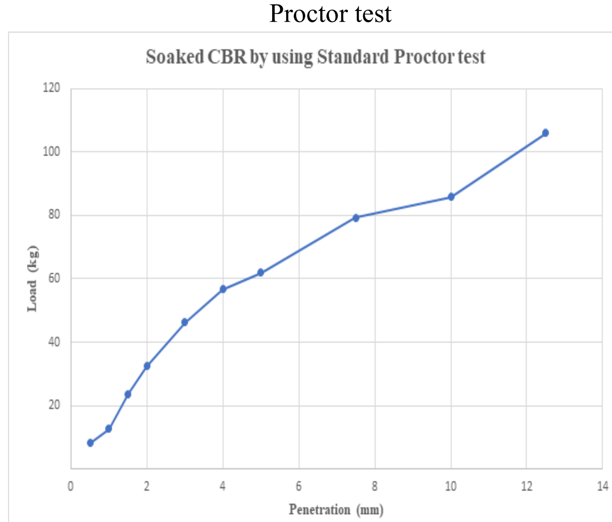


Graph representing the Curve of Unsoaked CBR by using Standard Proctor test

Soaked CBR by Using Standard Proctor test

Penetration (mm)	Proving Ring	Load (kg)
0.5	25	8.17
1.0	39	12.74
1.5	73	23.75
2.0	100	32.52
3.0	143	46.29
4.0	175	56.79
5.0	190	61.89
7.5	243	79.33
10.0	264	85.85
12.5	284	106.04

Results of Soaked CBR by using Standard Proctor test



Graph representing the Curve for soaked CBR by using standard Proctor test

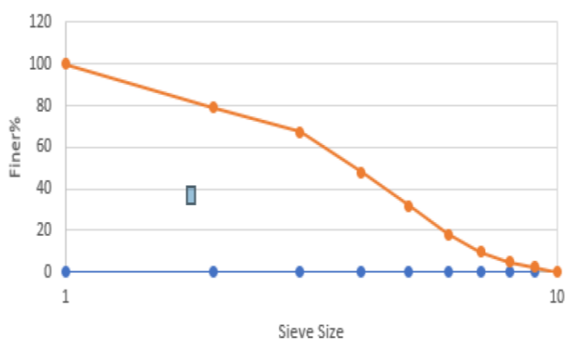
For both Unsoaked and Unsoaked CBR Using Modified Proctor test the Hammer weight will Change.

Particle Size Distribution Test:

Sr.No	Sieve Size	Weight of soil	Cumulative %	% finer
1	10 mm	0	0	100
2	6.3 mm	21	21	79
3	4.75mm	11.5	32.5	67.5
4	2.36mm	19.4	51.9	48.1
5	1.18mm	16.3	68.2	31.8
6	600 microns	13.8	82	18
7	300 microns	8.1	90.1	9.8
8	150 microns	5.1	95.2	4.8
9	75 microns	2.5	97.7	2.3
10	Finer	2.3	100	0

Table no. 8: -Results showing Particle Size Distribution of soil

Remark: -Here the Cu is 2.70 i.e. in between 1 &3 and Cc is 9.72 i.e. greater than 6 hence it is well graded Sand



Plastic limit observation table:

1	Observation number	1	2	3
2	Weight of Container (kg)	34.52	36.61	3416
3	Weight of Container +Weight of soil(kg)	43.2	46.96	42.89
4	Weight of container + Oven dry soil(kg)	41.73	45.09	40.72
5	Weight of water (kg)	1.47	1.87	1.67
6	Weight of oven dry soil(kg)	7.21	8.48	6.56
7	Moisture content (%)	20.38	22.05	25.45
8	Average plastic limit (%)	22.42		

Table no.9: -Result Showing plastic Limit of Soil

Liquid limit observation table:

Sr. No	Description	Sample1	Sample2	Sample3
1	Number of Blows (No.)	16	25	32
2	Weight of container (kg)	35.07	35.06	33.78
3	Weight of container + Weight of wet soil (kg)	49.35	54.35	46.69
4	Weight of container + Weight of oven dry soil(kg)	44.8	48.8	43.3
5	Weight of Water (kg)	4.55	5.55	3.39
6	Weight of oven dry soil(kg)			
7	Moisture Content (%)	46.76	40.39	35.60
8	Liquid Limit from the graph (%)	46.76		

Table no. 10: -Result Showing Liquid Limit of Soil

Shrinkage Limit observation table:

Sr. No	Description	Sample1
1	Container Id	S1
2	Mass of container + Wet soil(kg)	56.23
3	Mass of container + Dry soil(kg)	94.90
4	Mass of dry soil(kg)	25.27
5	Mass of water(kg)	13.4
6	Moisture content(%)	53.02
7	Volume of soil V1 (cu.cm)	24.28
8	Volume of dry soil (cu.cm)	12.54
9	Shrinkage Limit (%)	6.56%

Table no.11: -Result Showing Shrinkage Limit of Soil

IS Classification of Soil:

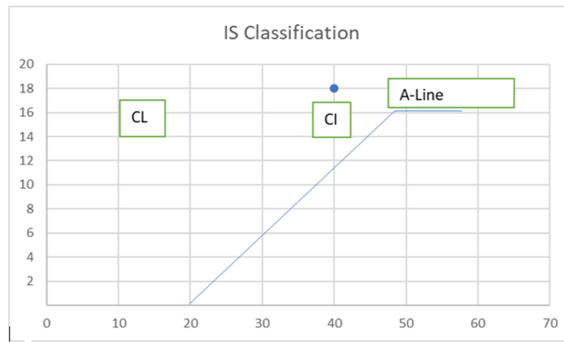


Figure 14: -Graph Representing the Classification of Soil

IP (Plasticity Index) =0.73(wL – 20)

The plasticity index (PI) is a measure of the plasticity of a soil and is determined by subtracting the liquid limit (LL) from the plastic limit (PL). The plasticity index can be used to classify soils into different groups based on their engineering properties.

If the plasticity index of a soil is 17.77%, it falls in the category of a low to medium plasticity clay, according to the Unified Soil Classification System (USCS). The USCS classifies soils into several categories based on their physical properties, and the plasticity index is an important parameter used in this classification.

Remark: -So, the remark for the classification of soil with a plasticity index of 17.77% would be that it is a low to medium compressibility clay soil.

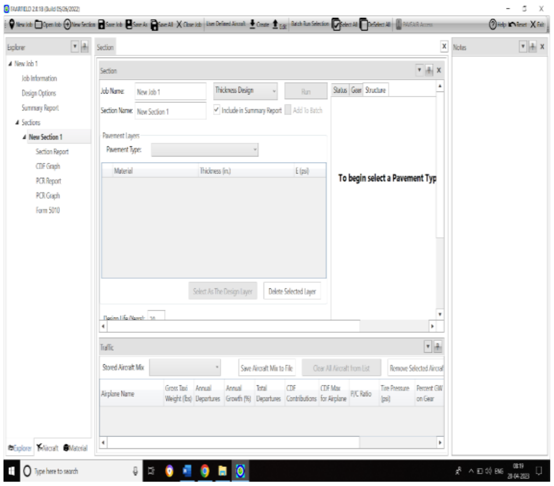
Software Details that are used in this Study:

We need two Software's for our project, first FAARFIELD to calculate pavement thickness and second COMFAA to evaluate ACN and PCN Number and to design aircraft runway.

COMFAA & FAARFIELD are free of cost to download from the official website of Federal Aviation Administration:

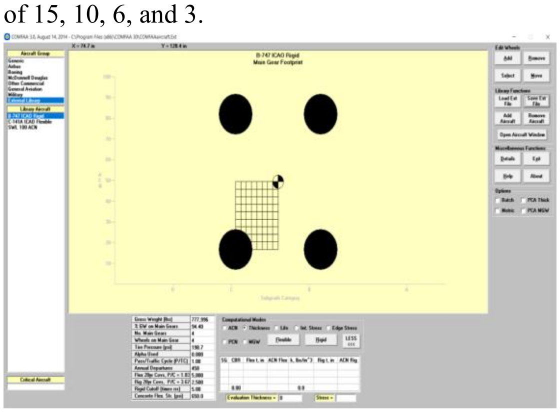
https://www.faa.gov/airports/engineering/airport_technology/airport_design/

1. FAARFIELD: "FAARFIELD is the FAA airport pavement thickness design program."
FAARFIELD superseded LEDFAA 1.3 as the standard design procedure in FAA Advisory Circular (AC) 150/5320-6E. It is officially released in September 30, 2009.
We are using FAARFIELD Version 2.0.18



FAARFIELD Opening Interface

2. COMFAA: "COMFAA is a program for computing flexible and rigid Aircraft Classification Numbers (ACNs) and pavement thickness."
The program runs under Windows 2000, XP, and higher.
Main Features:
- Calculates the ACN number for aircraft on flexible pavements.
- Calculates the ACN number for aircraft on rigid pavements.
- Calculates flexible pavement thickness based on the California Bearing Ratio (CBR) method in Advisory Circular (AC) 150/5320-6D for default values of CBR of 15, 10, 6, and 3.



COMFAA Opening Interface

Procedure to perform FAARFIELD
Step 1: Pavement Selection
Give Job Name and Section Name and Select Pavement Type. If you want to add any other material in pavement layer you can add it from material section.
Step 2: Aircraft Selection
Select Aircraft models as per your requirement. You can also change Aircraft Specifications.
Step 3: Run
Step 4: Results: In this step we will find Evaluation Thickness.

Procedure to perform COMFAA
Step 1: Inputs: Provide Inputs such as CBR and Evaluation Thickness.

Step 2 Select Aircraft: Select Aircraft as per Requirements

Step 3: Result
Result of performed test (Standard Proctor Unsoaked CBR) in COMFAA
Flexible pavement design by COMFAA for standard Proctor unsoaked CBR:
This file name = PCN Results Flexible
Units = English
Evaluation pavement type is flexible and design procedure is CBR.
Alpha Values are those approved by the ICAO in 2007.
CBR = 4.34 (Subgrade Category is C 6)
Evaluation pavement thickness = 47.60 in
Pass to Traffic Cycle (PtoTC) Ratio = 1.00
Maximum number of wheels per gear = 6
Maximum number of gears per aircraft = 4
At least one aircraft has 4 or more wheels per gear. The FAA recommends a reference section assuming
5 inches of HMA and 8 inches of crushed aggregate for equivalent thickness calculations.

1) Results of Performed Test in Software:
Results of Performed Test in FAARFIELD for Unsoaked CBR by using Standard Proctor test:

Federal Aviation Administration FAARFIELD 2.0 Section Report

FAARFIELD 2.0.18 (Build 05/26/2022)

Job Name: Project

Section: Standard Unsoaked CBR

Analysis Type: New Flexible

Last Run: Thickness Design 2023-04-20 12:59:02

Design Life = 20 Years

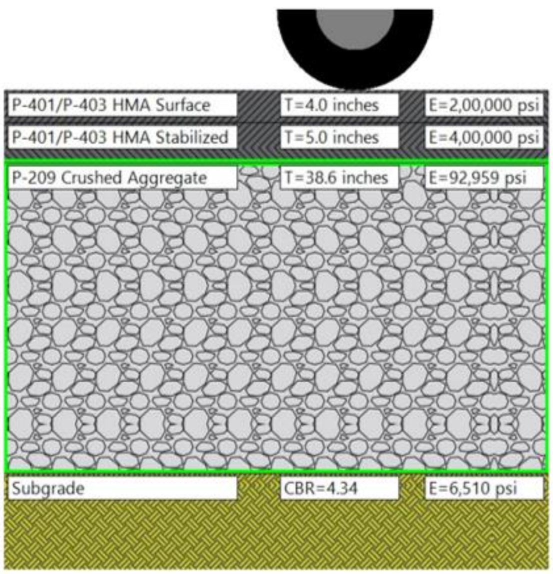
Total thickness to the top of the subgrade = 47.6in.

Pavement Structure Information by Layer

No.	Type	Thickness (in.)	Modulus (psi)	Poisson's Ratio	Strength R (psi)
1	P-401/P-403 HMA Surface	4.0	2,00,000	0.35	0
2	P-401/P-403 HMA Stabilized	5.0	4,00,000	0.35	0
3	P-209 Crushed Aggregate	38.6	92,959	0.35	0
4	Subgrade	0	6,510	0.35	0

Airplane Information

No.	Name	Gross Wt. (lbs)	Annual Departures	% Annual Growth
1	A310-300	3,15,041	1,200	0
2	A321-100 std	1,83,875	1,200	0
3	B737-400	1,50,500	1,200	0
4	B747-400	8,77,000	1,200	0
5	B747-400 Belly	8,77,000	1,200	0
6	B777-300 ER	7,77,000	1,200	0
7	B777-200 LR	7,68,000	1,200	0



This report shows the structure of evaluation thickness and also the various thickness of material such as p-401/p-403 HMA surface thickness is 4.0 inches
p-401/p-403 HMA stabilized thickness is 5.0 inches
p-209 Crush Agregate thickness is 38.6 inches
hence we got the total thickness of 47.6 inches

2)Results of Performed Test in COMFAA for Unsoaked CBR by using Standard Proctor test:
Result of performed test (Standard Proctor Unsoaked CBR) in COMFAA
Flexible pavement design by COMFAA for standard Proctor unsoaked CBR:
This file name = PCN Results Flexible
Units = English
Evaluation pavement type is flexible and design procedure is CBR.
Alpha Values are those approved by the ICAO in 2007.

CBR = 4.34 (Subgrade Category is C (6)
Evaluation pavement thickness = 47.60 in
Pass to Traffic Cycle (PtoTC) Ratio = 1.00
Maximum number of wheels per gear = 6
Maximum number of gears per aircraft = 4

At least one aircraft has 4 or more wheels per gear. The FAA recommends a reference section assuming 5 inches of HMA and 8 inches of crushed aggregate for equivalent thickness calculations.

RESULTS AND DISCUSSION

1.For calculation of results in COMFAA and FAARFIELD we have to provide the CBR value of the subgrade and annual departures, wheels per gear, tire pressure, list of Aircraft all this data will give you the ACN and PCN number
2. We have performed I.S classification of soil in which we have find out the liquid limit, plastic limit and shrinkage limit.
3.We got the liquid limit by Using Casagrande apparatus by filling the soil sample in apparatus and then taking no. of blows and collecting that sample in container after keeping that sample in oven find out the moisture content and the moisture content at 25 number of blows will be the liquid limit.
4.We have calculated plastic limit by rolling the soil sample over the glass and making the thread of approximate 3mm diameter and then collecting the soil sample in the container and keeping it in oven for 24 hours and then calculating moisture content and the averages of the sample is plastic limit
5.We have calculated Shrinkage limit by taking sample in mould then keeping it in 24 hours after taking out the sample calculated the volume by using mercury.
formula = [weight of water at the stage when sample ceases to shrink]/ [Dry weight of sample]
6. We have performed Standard proctor test by adding different percentage of water content in the mould having volume of 997.67 cm^2 and filling the soil sample in it by using 2.69 kg of hammer and then taking out the sample from the mould and collecting the soil sample from three layers top, middle and

bottom portion after that keeping it in oven for 24 hours and then calculating optimum moisture content and maximum dry density. It was found to be 16.77% and 1.95gm/cc respectively

7. We have performed Modified proctor test by adding different percentage of water content in the mould having volume of 997.67 cm^2 and filling the soil sample in it by using 4.536 kg of hammer and then taking out the sample from the mould and collecting the soil sample from three layers top, middle and bottom portion after that keeping it in oven for 24 hours and then calculating optimum moisture content and maximum dry density. It was found to be 16.03% and 2.365gm/cc respectively

8.We have performed two types of CBR, unsoaked and soaked CBR for two types of proctor test standard and modified proctor test. for calculating CBR we use to take 6kg of soil sample and filling it by hammer of 2.69 for soaked and unsoaked CBR by using standard proctor test and 4.536 for soaked and unsoaked CBR by using Modified proctor test

9.For soaked CBR by using Standard and Modified proctor test the mould have to be kept under water for 96 hours and after that the mould have to kept under loading machine with at least capacity of 5000kg and taking the readings at 0.5,1,1.5, 2,3,4,5,7.5,10,12.5 mm then the results have to be interpolated with the table and the load at 2.5 mm and 5mm is to be find out. after that by using formula

For 2.5 mm = (load at 2.5 mm/standard load at 2.5mm) x 100

For 5 mm = (load at 5 mm/standard load at 5mm) x 100

(Standard loads are given at table no.4)

10.From all above we found the results as 4.34% and 2.91% at unsoaked and soaked CBR by using standard proctor test also for 6.97% and 4.95% at unsoaked and soaked CBR by using Modified proctor test. which shows that unsoaked CBR by using Modified proctor test gives maximum CBR and required evaluation thickness is less as comparative to others

11. All this data is being provided into the software and the evaluation thickness is find out and also ACN and PCN number is find out and used by the airport authority

12.Hence this is the overall discussion on the results

CONCLUSION

1.This thesis has demonstrated how the ACN and PCN numbers can be calculated using COMFAA and FAARFIELD by available data on aircraft characteristics and pavement strength

2.we found liquid limit of soil is 46.76% and plastic limit is 22.62% and shrinkage limit is 6.56% from this data we have classified over soil and plotted over the graph. From graph we find out that soil is fine grained and clay of medium compressibility

3.From Standard proctor test we got the MDD and OMC as 1.95 and 16.77% over these results we have performed Unsoaked CBR and got the result as 4.34%. after providing this data to software such as FAARFIELD and COMFAA we got the Evaluation thickness of 47.6 inches and ACN, PCN number for different Aircrafts

4.From Standard proctor test we got the MDD and OMC as 1.95 and 16.77% over these results we have performed soaked CBR and got the result as 2.91%. after providing this data to software such as FAARFIELD and COMFAA we got the Evaluation thickness of 58.5 inches and ACN, PCN number for different Aircrafts

5.From Modified proctor test we got the MDD and OMC as 2.365 and 16.03% over these results we have performed Unsoaked CBR and got the result as 6.97%. after providing this data to software such as FAARFIELD and COMFAA we got the Evaluation thickness of 34.3 inches and ACN, PCN number for different Aircrafts

6.From Modified proctor test we got the MDD and OMC as 2.365 and 16.03% over these results we have performed soaked CBR and got the result as 4.95%. after providing this data to software such as FAARFIELD and COMFAA we got the Evaluation thickness of 43.8 inches and ACN, PCN number for different Aircrafts

7.However, further research is needed to evaluate the long-term performance of these pavements under different environmental conditions and traffic loads. Overall, the findings of this thesis provide valuable insights into the design of runway pavement and highlight the importance of using standardized approaches such as ACN and PCN in airport engineering