International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 01, January-2018

EXPERIMENTAL STUDY ON RUNWAY PAVEMENT

P. Lakshmi Kantha[1], P. Eswanth[2], B. Vinod Kumar[3]

[1] Student of Civil Engineering, G. Pulla Reddy Engineering College, Kurnool,
[2]Assistant Professor of Civil Engineering, G. Pulla Reddy Engineering College, Kurnool,
[3]Student of Civil Engineering, G. Pulla Reddy Engineering College, Kurnool,

ABSTRACT—The economic growth of country is dependent on increase in transportation methods. Air transportation has gained importance in the recent scenario because of reduction in travel time and increase in access to airports. Runway, a prominent part of airport is to be designed appropriately for better duration of airport and comfort to the passengers. "Runway design" is a region specific project work that aims to design the runway and orient it considering all the factors that affect, including the environmental norms and regulations. The dimensions of the runway vary on whether the airport is international or domestic. Considering the factors, Indian government has decided to have minimum of one airport in every district in India. Thus, runway design has become important aspect of growing airport industry. The present paper focuses on runway pavement, basic parameters.

KEYWORDS— Airport, Runway, Runway dimensions and pavements.

I. INTRODUCTION

Transportation plays a key role to determine economic status of a country. In country like India, railways are the second largest transportation in the world and fully developed highway transportation. Though connectivity is obtained by railways, people prefer airways when travel time associated is less which has resulted in growth of demand for air transportation. Demands for larger capacity and more facilities at the airports are increasing at a faster rate. The demand for larger capacity necessitates an increase in accommodating new airline offices and runways. An airport runway is defined as a rectangular area on a land prepared for the landing and take-off of aircraft. Runway essentially consist of pavement which is of two types namely

- Flexible pavement
- Rigid pavement

Flexible pavements: Flexible pavements are those which on the whole have low or negligible flexural strength and are rather flexible in their structural action under the loads. The flexible pavement layers reflect the deformation of the lower layers on to the surface of the layer. Thus if the lower layer of the pavement or soil subgrade is undulated, the flexible pavement surface also gets undulated. The flexible pavements consist of asphalt concrete surface built over a base course and they rest on subgrade.

Layered structure for flexible pavement

- Wearing course
- Binder course
- Sub base course
- Soil formation bed
- Natural ground surface

RUNWAY DIMENSIONS

Runway dimensions vary from as small as 245 m (804 ft.) long and 8 m (26 ft) wide in smaller general aviation airports, to 5,500 m (18,045 ft) long and 80 m (262 ft) wide at large international airports built to accommodate the largest jets. A runway of at least 1,829 m (6,000 ft) in length is usually adequate for aircraft weights below approximately 90,718 kg. Larger aircraft including wide bodies will usually require at least 8,000 ft (2,438 m) at sea level and somewhat more at higher altitude airports. International wide body flights, which carry substantial amounts of fuel and are therefore heavier, may also have landing requirements of 10,000 ft (3,048 m) or more and takeoff requirements of 13,000 ft (3,962 m). At sea level, 10,000 ft (3,048 m) can be considered an adequate length to land virtually any aircraft. The Federal Aviation Administration (FAA) has established a set of airport classifications known as the Airport Reference Code (ARC) to relate airport design criteria to the operational and physical characteristics of the most demanding airplane.

The ARC has two components relating to the design aircraft:

1. Aircraft approach category and
2. Airplane design group.

1) *AIRCRAFT APPROACH CATEGORY:* Designated by a letter (A – E), this component describes the operational characteristic of aircraft approach speed, with 'A' being the slowest and 'E' being the fastest.

Aircraft Approach Category:-

- Category A: airplane approach speed < 91 knots.
- Category B: airplane approach speed at least 91 knots but <121 knots.
- Category C: airplane approach speed at least 121 knots but <141 knots.
- Category D: airplane approach speed at least 141 knots but <166 knots.
- Category E: airplane approach speed of at least 166 knots.

2) *AIRPLANE DESIGN GROUP:* Designated by a Roman Numeral (I-VI), the second component relates to the physical characteristic of airplane wingspan with "I" being the shortest and "VI" being the longest.

- Airplane Design Group :-
- Group I: airplane wingspan up to but not including 49 ft.
- Group II: airplane wingspan at least 49 ft but <79 ft.
- Group III: airplane wingspan at least 79 ft but <118 ft.
- Group IV: airplane wingspan at least 118 ft but <171 ft.
- Group V: airplane wingspan at least 171 ft but < 214 ft.
- Group VI: airplane wingspan of at least 214 ft.

Based upon the above aircraft design and groups, the maximum takeoff weight and landing weight are discussed below.

Maximum Takeoff Weight (MTOW) - The maximum certificated weight for the airplane at takeoff. Small Airplane- An airplane of 12,500 pounds or less MTOW. Large Airplane- An airplane of more than 12,500 pounds MTOW. Regional Jets (RJs)- For purposes of runway length recommendations, an RJ is a commercial jet airplane that carries fewer than 100 passengers.

Maximum landing weight (MLW):- the maximum weight authorised for landing of an aircraft. The MLW must not exceed the MTOW. Overweight landings require a structural inspection or evaluation of the touch down loads before the next aircraft operation.

II. LITERATURE REVIEW

In this chapter, the main algorithmic contributions for scheduling air-craft landings and takeoffs are discussed. The subsections are organized according to the main methodology used in the study. Essential methods used in the literature are dynamic programming, branch-and-bound and genetic algorithm. The combined aircraft landing and take-off problem have been discussed.

A. *THE AIRCRAFT LANDING PROBLEM*

In this section, applications of various optimization methods such as dynamic programming, branch and bound, branch-and-price, genetic algorithm, ant colony optimization and queuing theory in scheduling of aircraft landings have been reviewed.

B. *DYNAMIC PROGRAMMING*

Dynamic Programming (DP) is a general optimization technique for making sequential decisions. Almost all ALPs can be usefully modelled as DP problems because the algorithms can evaluate current partial solutions independently of the exact sequencing decisions used to form these solutions. Beginning with the early work of Psaraftis (1978), there have been several attempts to develop efficient dynamic programming algorithm for the ALP. In many of these studies, it is assumed that all aircraft within any weight class can be sequenced. Psaraftis (1978, 1980) considers a simplified version of the ALP in which all aircraft are available to land immediately. Bayenetal. (2004) propose a model that takes account of the time taken to complete a circuit in a holding stack. They assume that all aircraft belong to a single class. They develop a 5-approximation algorithm for the problem of minimizing the sum of landing time, and a 3-approximation algorithm for minimizing the landing time of the last aircraft.

C. *THE AIRCRAFT TAKE-OFF PROBLEM*

The ALP has attracted much greater research interest compared to the ATP for studies are quite scarce. The main reason is that take-off scheduling problem is highly correlated with taxi-out scheduling problem and they cannot be solved separately. Integration of these two sub-problems makes the problem complex and difficult to solve. Pujet et al. (1999) develop an alternative queuing model of the departure system. Their model is evaluated using the runway configuration and traffic data. The intention is to relieve the departure traffic congestion on the ground.

D. *COMBINED AIRCRAFT LANDING AND TAKE-OFF PROBLEM*

Trivizas (1998) introduces a dynamic programming approach for solving optimally the static runway scheduling problem for landings and take-offs based on the CPS concept. The mixed-mode, segregated-mode, and multiple-runway environments are considered. Bianco et al. (2006) introduce static and dynamic models for scheduling the landing and take-off of aircraft in the terminal manoeuvring area (TMA). The proposed deterministic job shop scheduling model can represent several operational constraints and different runway configurations.

III.STUDY AREA

An area has been selected for the study to check whether it is suitability for the airfield construction. The samples of the soil are taken at 5metre interval from the site and all the tests are conducted to check the standards of the soil.

IV. METHODOLOGY

The methodology for the current work involves various test on soil, aggregates, bitumen to evaluate the parameters and thus design the runway. Airport pavements are designed by two methods.

A. Westergaard's method

The method is based on the assumption that the pavement is an elastic plate supported on a heavy fluid base with a uniform reaction coefficient known as the K value. Experience has shown that the K values on which the formula was developed are not applicable for newer aircraft with very large footprint pressures.

B. California bearing ratio method

The method is an extrapolation of the original test results, which are not applicable to modern aircraft pavements or to modern aircraft landing gear. Some designs were made by a mixture of these two design theories. A more recent method is an analytical system based on the introduction of vehicle response as an important design parameter. Essentially it takes all factors, including the traffic conditions, service life, materials used in the construction, and, especially important, the dynamic response of the vehicles using the landing area into consideration. The current study is based on the usage of CBR method for design of runway. In order to evaluate strength parameters of water mix macadam, following tests were conducted.

1) *OPTIMUM MOISTURE CONTENT FOR WATER MIX MACDAM:* The water bound macadam road construction technique was given by John Macadam. Aggregates, screeners and binders are used for WBM construction to provide proper stress distribution.

2) *CALIFORNIA BEARING RATIO FOR WMM:* Wet Mix Macadam is a pavement layer wherein crushed graded aggregates and granular material, like, graded course sand arc mixed with water in mixing plant and rolled to a dense mass on a prepared surface. It has many advantages over the WBM construction. These include superior gradation of aggregate, faster rate of construction, higher standard of densification that can be achieved, less consumption of water and stricter standards of quality achievable. The specification can be adopted for sub-base and base courses. The work may be done in many layers. The thickness of an individual layer shall not be less than 75 mm and can be upto 2(X) mm suitable type of compacting equipment is used.Fig.1 shows the apparatus of California Bearing Ratio.

Fig.1 CBR apparatus

3) *LIQUID LIMIT AND PLASTIC LIMIT:* These test methods are used as an integral part of several engineering classification systems to characterize the fine-grained fractions of soils and to specify the fine-grained fraction of construction materials. The liquid limit, plastic limit, and plasticity index of soils are also used extensively, either individually or together. The liquid and plastic limits of a soil and its water content can be used to express its relative consistency or liquidity index.Fig.2 shows the liquid limit and plastic limit apparatus.

Fig.2 liquid limit and plastic limit apparatus

V. RESULTS AND DISCUSSIONS

Four samples of wet mix macadam were tested for OMC and MDD and test results are shown in table 1. table 2 and table 4 shows the results corresponding to CBR for WSB and CBR for WMM with which thickness of pavement can be evaluated. Consistency limits of existing soil are shown in table 3, and table 5 shows the results corresponding to CBR for soils(soaked soil).

TABLE 1
OMC AND MDD FOR WET MIX MACADAM

Weight of the mould +compacted soil	7952		8208		8348		8302	
Container No.	24	41	49	S11	S27	15	23	11
Weight of the container + wet soil(g)	49.88	58.97	55.22	46.73	73.42	70.13	97.69	95.92
Weight of the container + dry soil(g)	48.97	57.18	53.14	45.28	69.15	66.58	92.79	90.64
Weight of the container(g)	22.08	25.24	22.40	22.72	25.43	23.89	38.92	32.24
Weight of water (g)	0.91	1.16	2.08	1.45	4.27	3.55	4.9	5.28
Weight of oven-dried sample(g)	26.89	32.57	30.74	22.56	43.72	42.69	53.87	58.44
Water content (%)	3.384	3.56	6766	6.42	9.766	8.315	9.09	9.034
Average water content (%)	3.472		6.59		9.04		9.062	
Bulk Density (g/cc)	2.455		2.57		2.647		2.62	
Dry Density(g/cc)	2.37		2.411		2.427		2.40	

OMC (%) = 9.04%

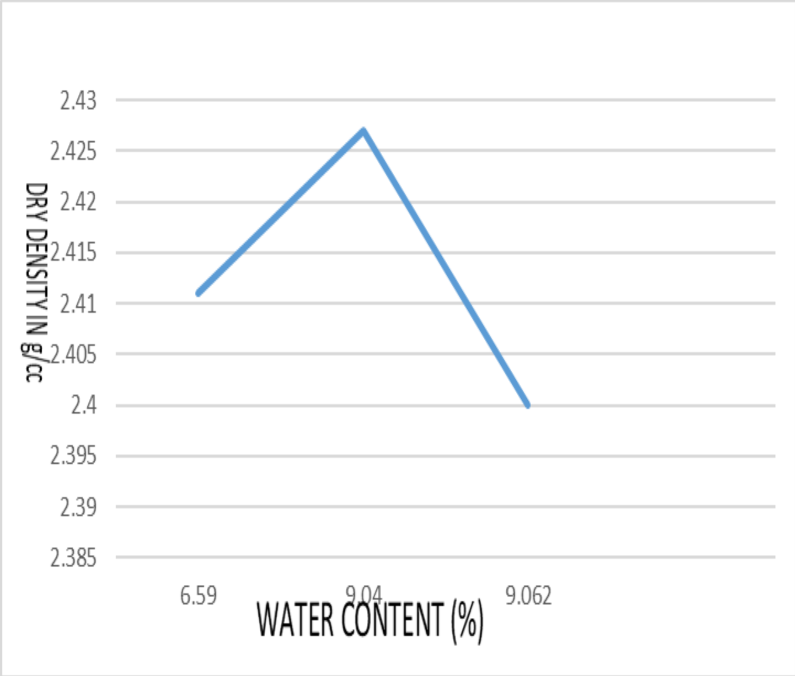

Fig.3: OMC graph for WMM

Table 1 shows the results of OMC and MDD for WMM and the graph is plotted between water content and dry density. Fig.3 shows the peak point of the compaction curve is the point with the maximum dry density. The above OMC value is suitable for the construction of the runway pavement.

Table 2
CBR TEST RESULTS FOR GSB

S.L No.	Penetration dial (in Div.)	Penetration(mm)	Proving ring dial readings (in Div.)	Load(Kgs)
1	50	0.5	15	86.094
2	100	1	28	160.708
3	150	1.5	53	304.198
4	200	2	75	430.47
5	250	2.5	84	482.126
6	300	3	130	746.148
7	350	3.5	165	947.034
8	400	4	200	1142.92
9	450	4.5	245	1406.202
10	500	5	300	1721.88
11	600	6	345	1980.162
12	700	7	400	2295.84
13	800	8	495	2841.102
14	900	9	505	2898.49
15	1000	10	615	3529.854

C.B.R. Value @ 2.5 mm (%) = 35.19%

C.B.R. Value @ 5.0 mm (%) = 83.79%

C.B.R. Value (%) = 83.79%

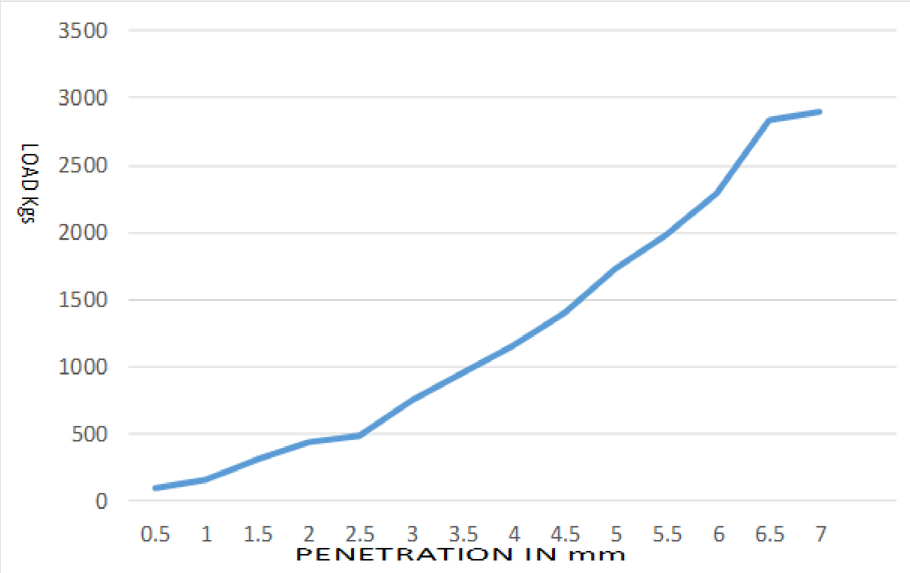

Fig.4: CBR graph for granular subbase coarse

The results of CBR for GSB is shown in table.2 and the graph is plotted between penetration and load. The test is penetration test is used for the evaluation of subgrade strength of roads and pavements. This method is mostly used for the flexible pavements. From fig.4 the CBR value is taken @2.5 and 5mm penetrations. For pavements, CBR value @5mm penetration considered for pavement design. The values of liquid limit, plastic limit, plasticity and flow index are shown in table 3.

TABLE 3
TEST RESULTS OF LIQUID LIMIT AND PLASTIC LIMIT

DESCRIPTION	**LIQUID LIMIT**								**PLASTIC LIMIT**	
Number of Blows	18		15		26		27			
Container No.	16	15	25	1	9	S11	22	24	49	41
Weight of container +wet soil(g)	34.90	34.99	49.60	47.55	29.51	35.08	33.68	31.60	29.56	35.18
Weight of container + dry soil(g)	32.24	32.08	46.81	43.90	27.26	31.97	31.35	29.18	28.30	33.39
Weight of container(g)	24.64	23.08	38.74	33.19	20.42	22.68	24.41	22.07	22.40	25.28
Weight of water(g)	2.66	2.91	2.79	3.65	2.25	3.11	2.33	2.42	1.26	1.79
Weight of oven dried sample(g)	7.57	8.28	8.07	10.71	6.84	9.29	6.94	7.11	5.9	8.11
Water content (%)	35.13	35.14	34.57	34.08	32.89	33.47	33.57	34.03	`21.35	22.07
Average water content (%)	35.135		34.325		33.18		33.8		21.71	

Liquid Limit = 33%

Plastic limit = 22%

Plasticity Index = 33 – 22 = 11%

Flow Index = 4.9

TABLE 4
TEST RESULTS FOR WMM

S.L No.	Penetration dial (In Div.)	Penetration(mm)	Proving ring dial readings (In Div.)	Load(Kgs)
1	50	0.5	3	17.21
2	100	1	7	40.177
3	150	1.5	11	63.135
4	200	2	13	74.614
5	250	2.5	17	97.573
6	300	3	20	114.792
7	350	3.5	23	132.01
8	400	4	26	149.229
9	450	4.5	30	172.188
10	500	5	33	189.406
11	600	6	40	229.584
12	700	7	46	264.021
13	800	8	56	321.417
14	900	9	66	378.813
15	1000	10	78	447.688

C.B.R. Value @ 2.5 mm (%) = 6.93%

C.B.R. Value @ 5 mm (%) = 9.24%

C.B.R. Value (%) = 9.24%

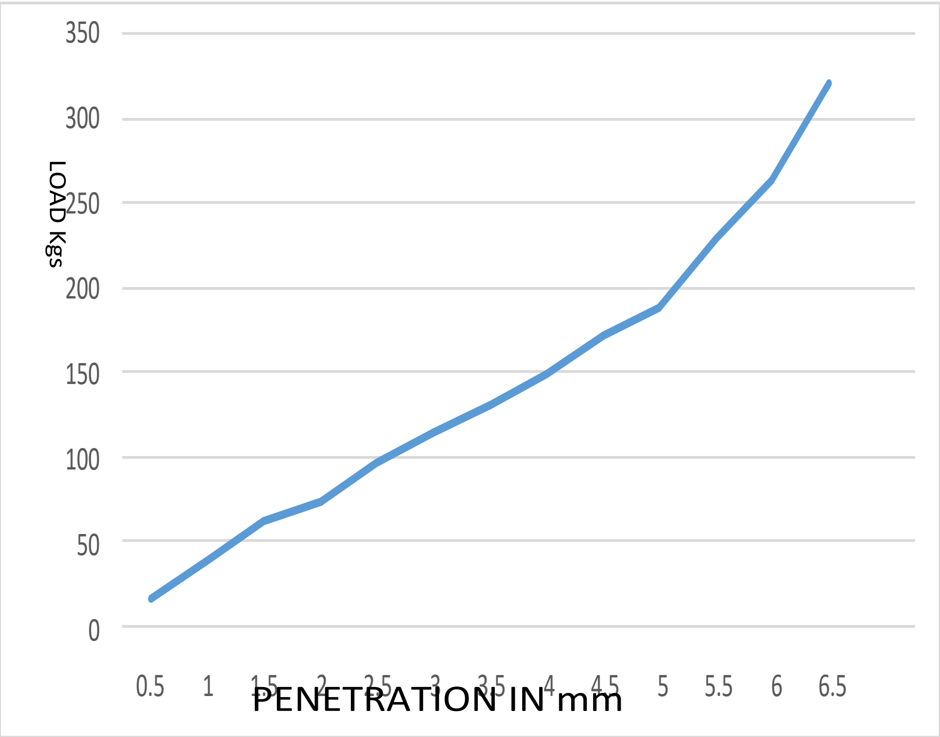

Fig.5: CBR graph for wet mix macadam

The CBR values are usually calculated for penetration of 2.5mm and 5mm. Table.4 shows the results of CBR for WMM. Generally the CBR value of 2.5mm will be greater than that of 5mm in such case it is taken for design purpose. If CBR value exceeds for 5mm that for 2.5mm, the test should be repeated. If the same results follow, penetration of 5mm should considered for design purpose. The values obtained from fig.5 are suitable for the pavement design.

TABLE 5
TEST RESULTS FOR CBR (SOAKED SOIL)

S.L No.	Penetration dial (In Div.)	Penetration(mm)	Proving ring dial readings (In Div.)	Load(Kgs)
1	50	0.5	23	27.616
2	100	1	46	55.232
3	150	1.5	77	92.453
4	200	2	110	132.077
5	250	2.5	138	165.696
6	300	3	166	199.316
7	350	3.5	190	228.133
8	400	4	222	266.555
9	450	4.5	255	306.178
10	500	5	290	348.203
11	600	6	330	396.231
12	700	7	375	450.262
13	800	8	410	492.287
14	900	9	448	537.913
15	1000	10	485	582.339

C.B.R Value @ 2.5 mm (%) = 12.09%

C.B.R. Value @ 5 mm (%) =16.98%

C.B.R. Value (%) = 16.98%

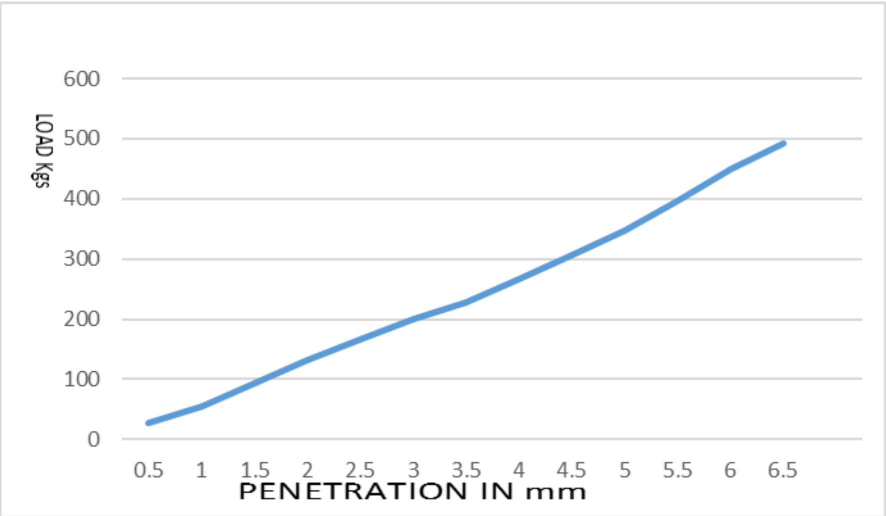

Fig.6: CBR graph for soaked soil

Table.5 shows the CBR results for soaked soils. Fig.6 is the graph plotted between penetration and load. The test is penetration test is used for the evaluation of subgrade strength of roads and pavements. The results obtained by the tests are used with the empirical curves to determine the thickness of pavements. The CBR test is conducted for soaked state. It is used for pavement layers. The value is suitable for the construction of pavement.

VI. Conclusions

Test results which are conducted for the samples taken from the selected site for considering runway shows that the values are within the range of specifications and all results satisfied the standards. Based on the results obtained it can be concluded that the location is suitable for further construction of runway pavement. The tests conducted is suitable for construction of runway pavement at the selected location.

REFERENCES

[1] Bayen, A. M., Tomlin, C. J., Ye, Y., and Zhang, J. (2004). *An Approximation Algorithm for Scheduling Aircraft with Holding Time*. In 43rd IEEE Conference on Decision and Control, Atlantis, Paradise Island, Bahamas.
[2] Bellman, R. (2003). *Dynamic Programming*. Princeton University Press.
[3] Beasley, J. E., Krishnamoorthy, M., Sharaiha, Y. M., and Abramson, D. (2004). *Problem and Dynamically Scheduling Aircraft Landings*. Journal of the Operational Research Society, 55:54–64.
[4] Bennell, J. A., Mesgarpour, M., and Potts, C. N. (2011). *Invited Survey: Airport Runway Scheduling*. 4OR, 9(2):115–138.
[5] IS: 2720 (1985): Methods of test for soils, PART.4-Grain size analysis.
[6] IS: 2720 (1985): Methods of test for soils, PART.5-Liquid Limit and Plastic Limit
[7] IS: 2720 (1980): Methods of test for soils, PART.7-Water Content - Dry density using light compaction
[8] IS: 2720 (1985): Methods of test for soils, PART.8 Water content - Dry density relation using heavy compaction
[9] IS: 2720 (1983): Methods of test for soils, PART.3-Water content (moisture content)
[10] IS: 2720 (1980): Methods of test for soils,PART.3-Specific gravity of fine grained soil
[11] IS: 2720 (1974): Methods of test for soils, PART.28-Dry density of soils, in place by the sand replacement method.
[12] IS: 2720 (1975): Methods of test for soils, PART.29-Dry density of soils, in place by the core cutter method.

