STRUCTURAL AND GEOMETRICAL DESIGN FOR MA'AN AIRPORT LANDING AREA

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Abstract

Jordan consider one of the most popular tourist countries in the Arab world, because of its middle location in the Arab world, which led to an increase in the number of flocking tourists to the various regions of the Kingdom due to the limited number of airports in Jordan I decided to design an airport in the Governorate of Ma'an, which is one of the largest provinces of the Kingdom and contain the most important tourist city such as the city of Petra which has been chosen as one of the seven wonders.At educational level Al-Hussein Bin Talal university is the only university in Ma'an, there are another Educational institution (e.g. College of Shoubak, Ma'an University College). The airport at Ma'an city was proposed as "Runway design and the structural design of Airfield pavement "is a region specific project work that's aims to geometrically design the runway and orient it considering all the factors that affect including the environmental norms and regulation. All the factors affecting site selection are considered and cross checked with the proposed site conditions and location. Enviroware's Wind Rose PRO3 software is used to analyze and plot the raw wind data often year duration graphically as a wind-rose diagram and using Revit for 3D structural Design for pavement layers and for viewing the landing area component . Federal aviation administration (FAA) guidelines and design criteria are strictly followed in the design and orientation of the runway.

Keywords: Airport landing Area, Geometrical Design.

الملخص

تعتبر الأردن من أكثر الدول السياحية شعبية في الوطن العربي ، وذلك بسبب موقعها المتوسط في الوطن العربي ، مما أدى إلى زيادة أعداد السياح المتوافدين على مختلف مناطق المملكة. وبسبب قلة عدد المطارات في الاردن حاول الباحث تصميم نموذج مقترح لمطار في محافظة معان التي تعد من أكبر محافظات المملكة وتحتوي على أهم المدن السياحية كمدينة البتراء التي تم اختيارها كواحدة من عجائب الدنيا السبع بالاضافة الى وجود مؤسسات تعليمية في المحافظة كجامعة الحسين بن طلال وكليتي الشوبك ومعان الجامعية. استخدم الباحث المنهج الوصفي التحليلي لتصميم المدرج والتصميم الإنشائي لرصيف المطار بشكل معماري وتوجيهه مع مراعاة جميع العوامل التي تؤثر فيه بما في ذلك المعايير والقواعد البيئية. تم أخذ جميع العوامل التي تؤثر على اختيار الموقع في الاعتبار ومراجعتها مع ظروف الموقع والموقع المقترح. تم استخدام برنامج Wind Rose PRO3الخاص بـ Enviroware لتحليل بيانات الرياح الخام ورسمها في كثير من الأحيان على مدار العام بشكل بياني كرسم تخطيطي للرياح واستخدام Revit للتصميم الإنشائي ثلاثي الأبعاد لطبقات الرصيف ولعرض مكون منطقة الهبوط. تم اتباع إرشادات إدارة الطيران الفيدرالية (FAA) ومعايير التصميم بدقة في تصميم وتوجيه المدرج.

الكلمات المفتاحية: منطقة هبوط المطار، التصميم الهندسي.

INTRODUCTION

The world became mainly depends on the technology and recent developments which have contributed to the development of different areas of life, including: industry, agriculture, transport and communications.

Development of transport depends on economic growth and the level of income of the country, so most of the countries concerned mainly transport, in order to provide safety, comfortable, convenient, economical and environmentally movement for people and goods instead of using trucks.

The Hashemite Kingdom of Jordan to the forefront of countries that focused on modes of transportation:

1- Highways
2- Airways
3- Railways

From the airways side there are three airports in Jordan for commercial flights, two of them in the capitalAmman, and one in Aqaba city. The main air career is Royal Jordanian. The Queen Alia Airport is the largest one of them followed by king Hussein international airport in Aqaba and Amman civil airport.

There are several factor that we depend on to design the airport in Ma’ancity:

1- Agricultural factor
2- Educational factor

Ma'an located on the road to pilgrims, administratively divided into Ma'an city, Petra, Shoubak, which have many advantages, the most important is Petra region which is the first tourist destination in Jordan. At educational level Al-Hussein Bin Talal university is the only university in Ma'an, there are another Educational institution (e.g. College of Shoubak, Ma'an University College). On the agricultural level, town of shoubak is famous for its agricultural products, especially the cultivation of apples, in addition to, Ma'an development area Which has a lot of industrial output. In order to Development and support all of these aspects, an airport in the province will convey this new stage of development and will help overcome the problem of bad transportation network.

(<u>Brown, 1996</u>) the research is taking about the application of soil mechanics principles to the design of pavement foundation, the design of complete pavements and to their structural evaluation . Various tools have been used in the search result collection such as theoretical analysis , laboratory testing apparatus , field testing and full scale trials with appropriate instrument. The result give a better understanding for the resilient and permanent strain response of clays and granular material , the effective stress below the pavements and the application of recent theoretical work on saturated soils .

(<u>Middlebrooks et al., 1943</u>) It was a study of soil tests employed by the U.S engineer department and the aviation engineers for the design of flexible and rigid runway pavements. Because many soil test take a long time , such as California test and bearing tests . therefore this evaluation has been set up on the bases of field and simple laboratory test for quick classification of the soils.

(<u>Heukelom and Klomp, 1962</u>) The study is talking about the dynamic investigations of roads and runways enable the non-destructive observation of the properties in situ of the construction materials down to a considerable depth. The observations can be made at any stage of construction and can serve for recurring control. A survey is given of test results obtained with the road vibration machine on various soils and road constructions. Special attention is paid to the ratio between the modulus of elasticity of successive compacted layers of unbound granular matter.

(**<u>Rahim, 2005</u>)** the study is taking about the mechanistic pavement design procedures based on elastic layer theory require characterization of each material in the pavement structure in terms of elastic modules. Repeated triaxial load tests on cylindrical disturbed/undisturbed samples, yielding a resilient modulus, are frequently used for characterizing subgrade soil. Because of the complexities encountered with the test, *in-situ* and other laboratory tests would be desirable if a reliable correlation can be established. Relying on data from two-field test programs, correlation equations to predict M_R for fine- and coarse-grained (sandy) soils are proposed in this paper. Twelve test sections reflecting a range of typical subgrade soil materials of Mississippi are selected and tested. Undisturbed samples are extracted and tested in a repeated triaxial machine for M_R, employing AASHTO. Other soil index properties are also determined, facilitating soil classification according to AASHTO procedure. The results suggest two relations one for fine-grain and another for coarse-grained (sandy) soil in correlating laboratory M_R to soil index properties. These models include the most relevant factors that influence M_R values. For model verification, an independent set of data is used, observing good comparison between actual and predicted moduli. These models with the soil properties included could be used in levels 2 and 3 in the new 2002 AASHTO design.

(Hveem, 1955) This paper entitled the factors underlying the rational design of pavements appearing in the 1948 proceedings of the highway research board. the original work indicated the importance of fatigue failures caused by resilience in the supporting soils. this paper describes the initial work of measuring deflections over a wide variety of pavements. examples are shown illustrating the load- deflection curves where pavements are showing signs of failure and on other sections where conditions are good or excellent. in general, the deflections are directly proportional to load, although not in all cases. the deflections were measured under both single-axle and tandem- axle loads and the relationship between these two types of loading are established for several types of pavement. laboratory methods are discussed including the design of a resiliometer for measuring the resilient characteristics of soil samples and the design of a fatigue testing machine for measuring the relative flexibility of pavements. the study indicates that a comprehensive design procedure must provide a pavement structure that will either be capable of surviving the fatigue resulting from continuous flexing or have sufficient stiffness to reduce the flexing to an acceptable value.

(Barker and Brabston, 1975)in this study A design procedure is presented for three types of flexible pavement: conventional, bituminous concrete, and chemically stabilized. These represent nearly all flexible pavements being constructed at this time. Designs are based on analytically determined strain values and experimental and laboratory determined material fatigue strengths. Thus, the procedure can handle in a rational manner the possible variations in the properties of different pavement materials. An adaptation of the cumulative damage concept permits the consideration of cyclic variation in bituminous materials due to variations in temperatures and the variation in sugarad strength resulting from freeze-thaw cycles.

(White, 2014) Grooving remains the most common approach to reducing the risk of skidding related incidents at Australian airports. Grooving does, however, introduce a number of risks and issues (White & Roadway 2014). Groove closure is not new but has occurred in a number of airports in recent times in Australia and around the world. Groove fretting or edge break is also not uncommon. As aircraft become heavier and their tire pressures continue to increase, the risks associated with grooving are expected to also increase. Traditional grooves are square cut to a width and depth of 6 mm. They are commonly spaced at 38 mm centres. It has long been considered likely that a trapezoidal groove would provide improved groove performance. Trapezoidal grooves are 6 mm wide at the base but have 45° sides, resulting in a 12 mm width at the surface. They are spaced at 57 mm to provide the same groove volume per pavement area. Until recently the ability to manufacture durable blades that can reliably cut trapezoidal grooves was unavailable. However, a blade with those capabilities has recently been developed and patented in the USA (Zuzelo 2014). These newly developed blades provide similar life to conventional blades.

(Packard, 1973) Longitudinal Steel , the amount of reinforcing steel required to control volume changes is dependent primarily on thickness of the slab, tensile strength of the concrete, and yield strength of the steel. Other factors that influence the amount of steel are contraction due to temperature drop, shrinkage due to drying, and modulus of elasticity of concrete and steel. The controlling factor is crack width. When insufficient steel is used, cracks become too wide, permitting intrusion of solids and water. Crack-width criteria have not been firmly established, but good performance has resulted when crack spacing average between 3 and 7 ft. Since crack spacing is directly related to crack width and is more readily observed, design of continuously reinforced pavement has indirectly become a matter of determining the amount of steel needed to obtain desirable crack spacing. Several theoretical equations have been developed for computing the amount of steel required; but in general, the amount is based on empirical data obtained from experimental pavements and pavements in service. It is usually the practice to specify the amount of steel at 0.6 percent of the gross cross-sectional area of the pavement and a minimum yield strength of 60,000 psi. In severe climates, where freezing and thawing occur, or where un- usually heavy traffic prevails, a somewhat higher percent- age, such as 0.7 or 0.8 percent, should be considered. The amount of steel should not be less than that indicated by the following formula. The formula is also used to compute minimum amount of steel based on special concretes or steels that may be selected.

(<u>Coughlan, 1992</u>) The study was Conventionally, paints which are formulated for use as markings on roads have also been used as markings on airport runways but have been found unsatisfactory since airport runway markings have special requirements .and Airport runway markings need frequent maintenance re-application of paint in order to obliterate the black markings left after contact with aircraft tires. Therefore The super-high opacity paint has the advantage that it can be sprayed on at very thin film thickness thereby minimizing the tendency of the buildup of thick smooth film to potentially hazardous levels.

(<u>Horonjeff and McKelvey, 1962</u>) While the concept of aircraft weight may be thought to be a simple one, the measurement of the weight of a given aircraft is actually relatively complex. An aircraft will in fact be measured with a certain number of weight measurements, depending on its level of loading with fuel, payload, and crew, and assigned maximum allowable weight values for takeoff, landing, and at rest. These various measurements of aircraft weight are important to airport planning and design, in particular the facilities such as ramps, taxiways, and runways that are designed to support the aircraft. While it is rare that any two aircraft, even those of the same model and configuration, have the same weight measurements (as there are almost always variations between aircraft in equipment, seating configurations, galleys, and other objects), most manufactures will assign typical weights to their aircraft for planning and design purposes.

(**Castor et al., 2001)**An airport surface movement guidance and control system (SMGCS) involving detection, integrated processing and graphical display of the relevant, in particular the safety-relevant, positions and movements of aircraft, and optionally, vehicles, on airside (runway, taxiways, apron) and in the relevant airport airspace. At least one radar detects the positions and movements between airborne and parked positions of the aircraft. The relevant data are displayed after data concentration on the monitor of at least one controller station in graphical form and/or letter or number form. As a result, the operational management of the surface movement can be planned and executed from the at least one controller station by means of solely the SMGC system

(**Patil and Patil, 2016)** Runway is a defined rectangular area on a land aerodrome prepared for the landing and takeoff of aircraft. Runways may be a man-made surface (often asphalt, concrete, or a mixture of both) or a natural surface (grass, dirt, gravel, ice, or salt), ICAO Runway Orientation Runway is usually oriented of prevailing winds. The direction of wind opposite to the direction of landing & take off which provides greater lift on the wings of the aircraft because of this aircraft rise above the ground much earlier & in shorter runway length. Thus Landing & Takeoff operations of the aircraft performs opposite to the wind directions. Cross Wind Component It is not possible to obtain the direction of the wind along the direction of the center line of runway throughout the year. Some time wind blow making certain angle with the center line of the runway. The normal component of the wind (90Degree) is called cross wind component and interrupts the safe landing and takeoff of the aircraft.

(Fox et al., 1964) Here , it was study Several methods to assess the sulfur status of soils On of the chemical measures used, water and phosphate extractions gave a better agreement with sulfur A values and total sulfur uptake by alfalfa from Nebraska soils. Water was an inefficient are derived of sulfate from a Hawaiian Latosol. Calcium phosphate solution was a more appropriate than extractant than KH2PO4 for both Nebraska and Hawaii soils.

(Uhlenhop and Wilkens, 1998) Here , it was study The side view three-dimensional plane information to leader the aircraft.Swinging in the middle across the screen laterally code responds to changes in the horizontal deviation of the aircraft so as to providing obvious point of view perspective of the pilot, This show is adaptation to all phases of the the trip, but is particularly helpful by the approach phase of the flight date. Favorite embodiment is a head-up display for the instrument flight conditions.

(Marks, 1964) Here , it was study Their lines aircraft which constitute at airports, whether in the air or on the ground, is the the biggest source of delay in the civil air transport Actions. Complex study of these lines from the fact that the times when aircraft are waiting lists to join are not independent, and also by the a large diurnal the vagaries of traffic.Forms used assume that the arrival times waiting lists are the result of the pattern due to the disordered through the aircraft being a separate in the early or late. This degenerates access to the Poisson process if contradictions and very broad operation, but in fact was much different. Recognized simulation results than 300,000 takeoffs and landings process.

Software

Runway orientation

Wind rose

A wind rose is a graphic tool used by meteorologists to give a succinct view of how wind speed and direction are typically distributed at a particular location. Historically, wind roses were predecessors of the compass rose (found on maps), as there was no differentiation between a cardinal direction and the wind which blew from such a direction. Using a polar coordinate system of gridding, the frequency of winds over a time period is plotted by wind direction, with color bands showing wind speed ranges. The direction of the longest spoke shows the wind direction with the greatest frequency.

structural Design

FAARFIELD

is a computer program for airport pavement thickness design. It implements both layered elastic based and three-dimensional finite element-based design procedures developed by the Federal Aviation Administration (FAA) for new and overlay design of flexible and rigid pavements. The thickness design procedures implemented in the program are the FAA airport pavement thickness design standards.

Design information is entered by means of two graphical screens, one for the structure and one for the traffic. Default values and ranges for the various input parameters have been set so that the thickness designs produced by FAARFIELD are generally compatible with designs produced by previous generations of the FAA design procedures.

FAARFIELD represents a significant departure from previous FAA standards that were in place from the 1960's through 2009. Apart from the procedures being implemented as a computer program instead of as nomographs, the main change in pavement design from the user's perspective is that the "design airplane" concept has been replaced by design for fatigue failure expressed in terms of a "cumulative damage factor" (CDF) using Miner's rule. Also, the major material property of the pavement layers is now uniformly expressed as an elastic modulus instead of the previous CBR (California Bearing Ratio) for flexible pavements or k value for rigid pavements. Formulas for transforming CBR and k values to modulus values are provided where appropriate in the documentation. Automatic conversion is provided in the program.

FAARFIELD belongs to the category of mechanistic-empirical (M-E) design procedures, meaning that it combines an engineering-mechanical structural analysis (layered elastic or finite element) with empirical failure models. While FAARFIELD is more rational than previous procedures, a considerable amount of engineering judgment is still required to produce valid designs. Designs pr. It is the designer’s responsibility to use the program and the advisory circular in conjunction with each other.

A complete description of the design procedures and program structure is not possible within the confines of a user’s manual, and these descriptions can be found in other publications. The main intent of the user’s manual is to provide sufficient information for operating the program, selecting input data values such as annual departure of air planes types, and interpreting the output data such as the thickness of the layers and the type of each layer.

Problem Statement

In a previous graduation project that have been designed by students in Al-Hussain Bin Talal university "Site selection for airport using GIS based multi-criteria analysis and design the terminal to support the tourism and agriculture in Ma'an governorate" the terminal area for the airport have been designed without designing the runway with it , so in this project we are going to design the landing area for the airport (runway and taxiway with its component).

research objective

This research aims to design the landing area for Ma'an airport which consist of (runway and taxiway) structurally and geometrically.

research question

How to design the landing area for Ma'an airport structurally and geometrically?

Scope and Limitation

writing this research encountered a lot of difficulties, start by identifying the information needed to design the pavement for the airport and identify the source of this information the difficulty to find previous studies related to the subject matter, in addition to that some of them need to buy,one of the most important problems faced the writing of this research is the communication between the team members to schedule meetings for the completion of the work required and the time was short and not enough.

research significant

The runway is a major element of the airport. It is clearly defined area of an airport prepared for landing and takeoff of aircraft. Landing area consist of(Runways and taxiways) should be designed in relations to other major operating elements such as terminal area, aprons air traffic services and parking. Runways are normally identified by the principal elements (safety area, blast pads, and displaced thresholds)

Runway location and orientation are of the most importance to aviation safety, comfort and convenience of operation, environment impacts, and the overall efficiency of the airport.

An airport in Ma'an governorate will drive development and the economy in the region and Jordan generally, So it will be a major gateway to the region of the world to Import the necessary industrial inputs and export products Ma'an Development Area, and it will opens new markets for these products and Reduces costs of transportation and shipping.

research layout

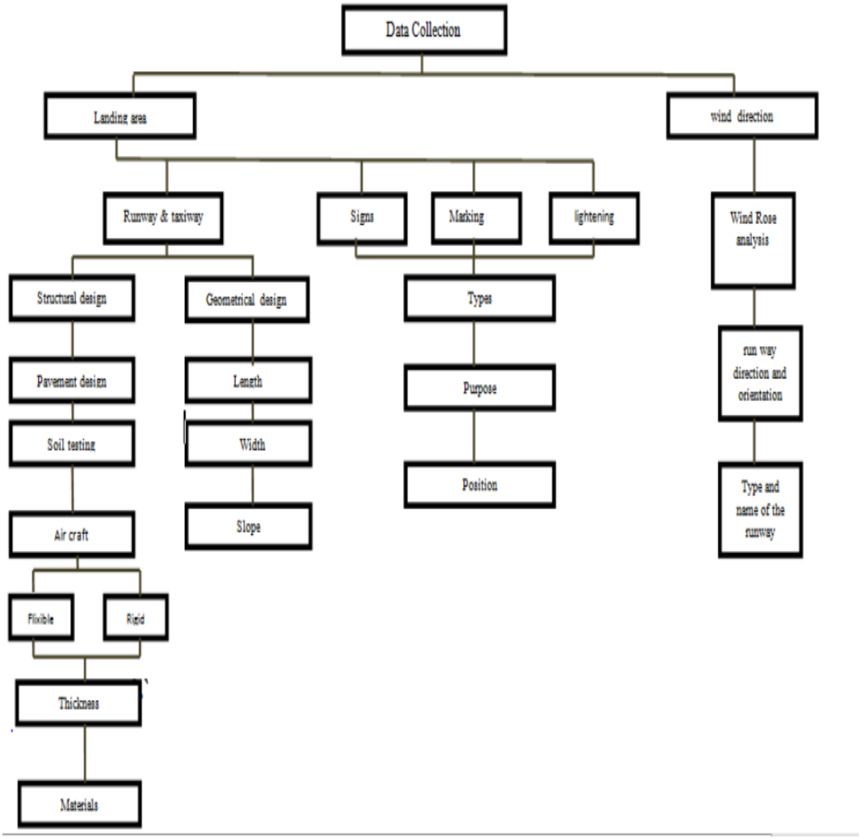
Chapter one presents an introduction about the structural and geometrical design of an airfield landing area,the objective of that research and it's significant. Chapter two presents the literature review that consist the past studies related to the subject and chapter three presents methodology consists of the flow chart, primary and secondary data, tools, materials, codes and software needed for the design (WindRose and Reivet).

METHODOLOGY

Introduction for methodology

There are several factors and steps will be taken into account during the structural and geometrical design for the landing area of the airport which consist of runway with its component and taxiway, These factors will be explain and clarify in this chapter.

Flow Chart



Data collection

This project consist of tow phase , the first phase is determining the wind direction and strength in the selected site of the airport using wind rose the second phase is the landing area design .

Wind direction and strength

The runway orientation, direction and strength is an important consideration in airport planning, design the correct runway orientation increase yearly using of the runway through landing and takeoff .The data of the wind direction and strength will be collected from Royal Jordanian Geographic Center, reference to Federal Aviation

Administration after determining the air direction one type configuration of the runway will be selected as shown in figure(3-1)

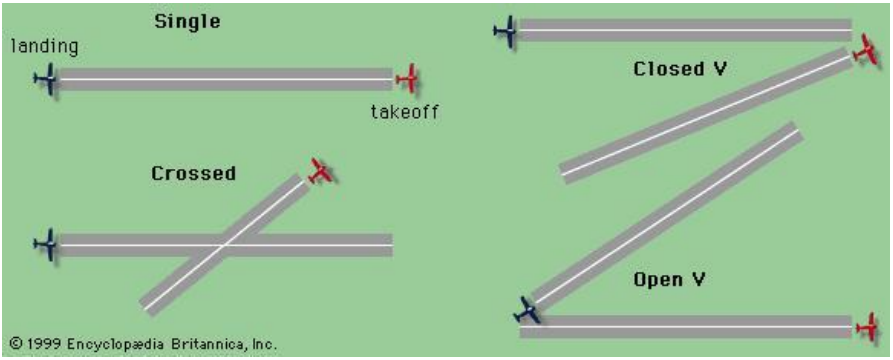


Fig3-1. Runway configuration(FAA)

- single runway which is the simplest runway configurations, the hourly capacity for this type in visual flight rule (VFR) is (50-100) operation, and in instrument flight rule (IFR) is (50-70) operation.
- parallel runway, two and four parallel runways are most common. as shown in figure (3-2) the spacing between close runway (700-2500 ft), the intermediate (2500-4300ft) and far (4300ft and more).

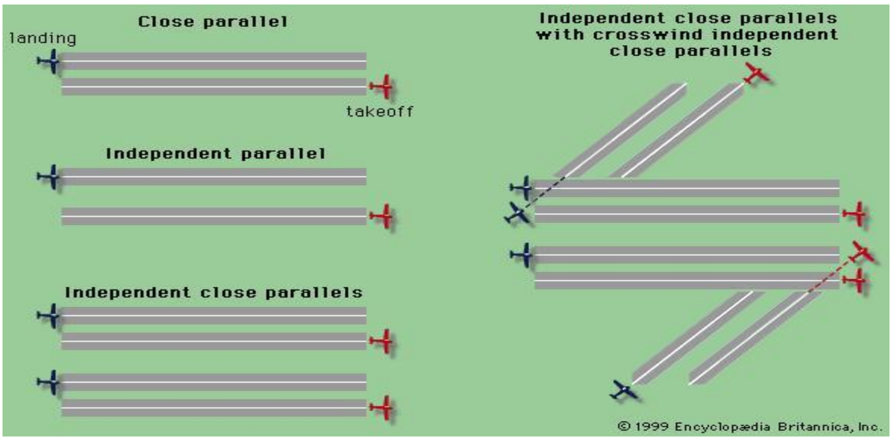


Fig3-2. Parallel runway (FAA)

- intersecting runways and open-V runways, many of airports have two or more runway in different direction crossing each other. they are necessary when relatively strong winds blow from more than direction. strong winds (only one can be used), light winds (both can be used).

Landing area design

This section will be talking about collecting the data for designing the landing area structurally and geometrically, for the structural design three points will be focused on an explained which listed below

1-Soile test

2-Selecting aircraft

3-Pavement design (runway , taxiway)

For soil testing several tests will be done (atterbing limit test, California bearing test, marshal, moisture content, specific gravity, compaction test) to determine the strength of the soil, physical properties, provide and estimate its behavior under various condition, then the aircraft will be selected taking in consideration several factors such as:

a) Load

Which is the maximum anticipated takeoff weight of the aircraft, the design procedure assumes 95 percent of the gross weight is carried by the main landing gears and 5 percent is carried by the nose gear.

b) Landing Gear Type and Geometry as shown in figure (3-3) referenced to (FAA)

(1) Single Gear Aircraft.

(2) Dual Gear Aircraft.

(3) Dual Tandem Gear Aircraft.

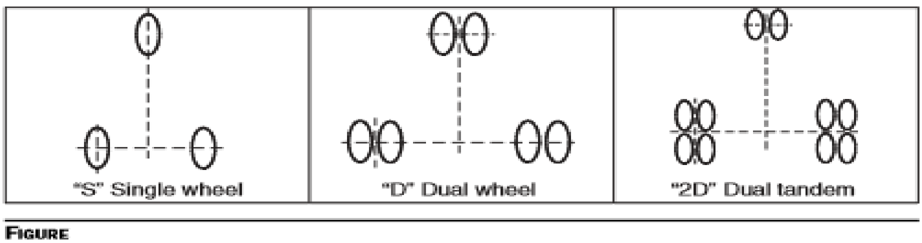


Fig3-3-a. Landing gear configuration(FAA)

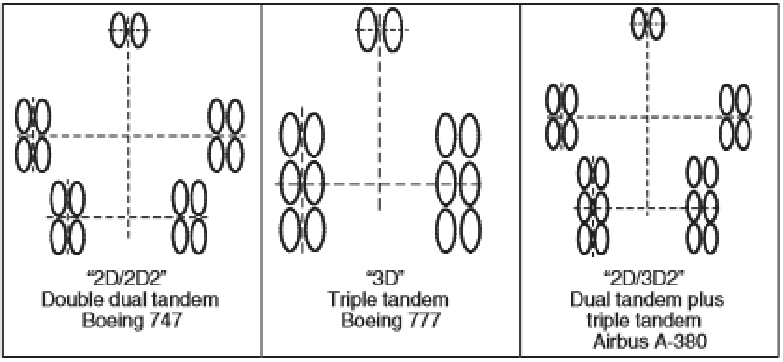


Fig3-3-b. Landing gear configuration(FAA)

C) Tire Pressure.

Tire pressure varies between 75 and 200 PSI depending on gear configuration and gross weight for the air craft.

D) Traffic Volume.

Forecasts of annual departures by aircraft type are needed for pavement design the information on aircraft operations can be collected from the major airport forecasts ,then the design aircraft will be selected on the basis of the one requiring the greatest frequency and pavement thickness. The design aircraft is not necessarily the heaviest aircraft in the forecast which is in our case Boing 747-400. According to the Boing company the dimensions and performance will be shown in figure(3-4) and tables (3-1) (3-2) .

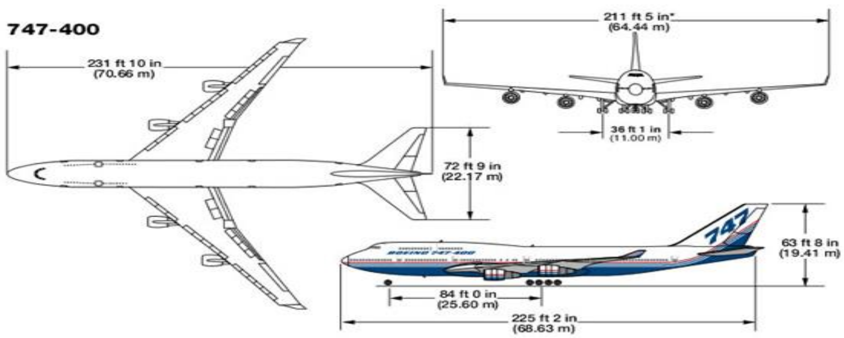


Fig 3-3. Dimension of boing747-400

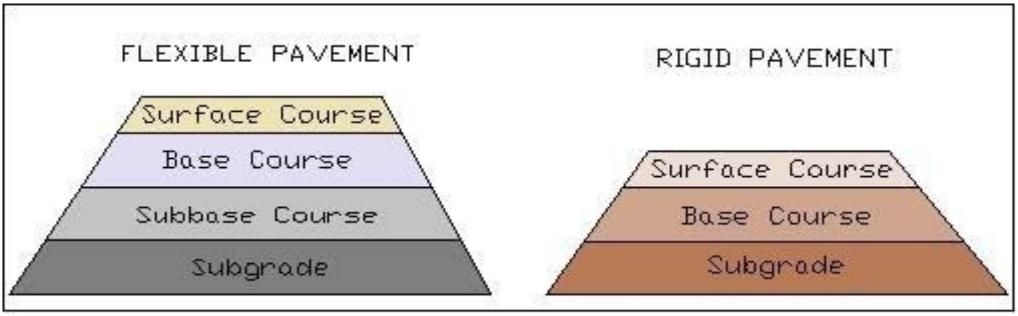
Table 3-1

Dimensions	
Overall length	72.72 m
Cabin length	49.90 m
Fuselage width	7.14 m
Max cabin width	Main deck: 6.5 m Upper deck: 5.8 m
Wing span (geometric)	79.75 m
Height	24.09 m
Track	14.34 m
Wheelbase	31.88 m

Table 3-2

Performance	
Range	15200 km
Max ramp weight	577 tones
Max take-off weight	575 tones
Max landing weight	394 tones
Max zero fuel weight	369 tones
Max fuel capacity	320000 liters

After collecting the data from the soil tests and choosing the correct air craft the structural and geometrical design will take a place, starting with the structural design (flexible and rigid pavement design) and ending with the geometrical design (length, width, slop, markings, signs and lightening). Layers of flexible and rigid pavement referenced to ASHTO are listed below in Fig (3-5)



a- flexible structural pavement design

1- Runway structural design

There are many types of method used to design flexible pavement of the runway:

1- CBR method of design for flexible airport pavement.
2- pavement design using elastic layer theory.
3- load classification number procedure.
4- FAA design procedure for flexible airport pavement
5- ICAO(CAN/ PCN) Procedure

Flexible Pavement design is based upon the CBR method, an essentially empirical method.

The Design assumes that 95%of the gross aircraft weight is carried on the main landing gear assembly and 5% on the nose gear assembly.

The step used to design the flexible pavement according to FFA:

1- obtain forecasts of annual departures for all aircraft type.
2- Determine for each type the required pavement thickness using the appropriate design curve with the forecast number of annual departures for the aircraft ,always using the CBR for the subgrad .

The appropriate design curve is chart have incorporated the effects of load repetitions, landing gear assembly configuration, and the "wandering" (lateral distribution) effect of aircraft movements. With subgrade CBR, gross weight, and total equivalent annual departures of design aircraft input, the total pavement thickness required can be read from the appropriate chart.

3- Select the aircraft requiring the greatest pavement thickness as the design aircraft.
4- Convert the annual departures of all aircrafts to equivalent annual departures of the design aircraft by the following formula:

Log Req = log (Ri x F i) x {Wi /W}0.5

5- convert the type of landing gear for all aircraft to the type of the landing gear of the aircraft design
6- computing the summation of the equivalent annual depart by design aircraft (Req).

7- using the appropriate curve for the aircraft design and the CBR for the subgrad and total equivalent annual depart to find the total thickness for the pavement .
8- using the CBR for the subbase course to find the thickness for the base course and surface layer.

The thickness of the base course layer must be larger than the minimum thickness which can determine by the Minimum base course thickness requirement.

2- Taxiway structural design

The same method will use as the runway structural design. Using CBR method and determine the total thickness for the taxiway, but in fact the thickness of the taxiway is greater than the thickness of the runway. But the runway and taxiway are designed the same way in mathematical model.

b- Rigid structural pavement design on the other side runway design mainly used rigid pavement but on this project a flexible pavement will be used on the top of a rigid one, this is due to the ease of maintenance of flexible pavement after the occurrence of corrosion due to long period of use and this explain the difference between rigid and flexible pavement.

Rigid pavement have a history of successful construction , good performance and can with stand large load capacity due to using reinforced concrete in the shape of small slaps and joints.

The final base of the project is adding marking, signs and lightning to the landing area which largely effect the runway efficiency and provide much more safety to the flight operation and users of aircraft, they play a guidance rule to the pilot and passengers through landing and takeoff. all runways licensed for night use must have lighting which at least defines the extent of the runway. This is referred to as Edge Lighting, Threshold Lighting and Runway End Lighting, other types of lighting may also be provided. according to (FAA) the most important type of marking ,signs and lighting will be shown in table (3-3) .

EXAMPLE	TYPE OF SIGN	PURPOSE	LOCATION/CONVENTION
4 - 22	Mandatory: Hold position for taxiway/ runway intersection.	Denotes entrance to runway from a taxiway.	Located L side of taxiway within 10 feet of hold position markings.
22 - 4	Mandatory: Holding position for runway/runway intersection.	Denotes intersecting runway.	Located L side of rwy prior to intersection, & R side if rwy more than 150' wide, used as taxiway, or has "land & hold short" ops.
4 - APCH	Mandatory: Holding position for runway approach area.	Denotes area to be protected for aircraft approaching or departing a runway.	Located on taxiways crossing thru runway approach areas where an aircraft would enter an RSA or apch/ departure airspace.
ILS	Mandatory: Holding position for ILS critical area/precision obstacle free zone.	Denotes entrance to area to be protected for an ILS signal or approach airspace.	Located on twys where the twys enter the NAVAID critical area or where aircraft on taxiway would violate ILS apch airspace (including POFZ).
⊖	Mandatory: No entry.	Denotes aircraft entry is prohibited.	Located on paved areas that aircraft should not enter.
B	Taxiway Location.	Identifies taxiway on which the aircraft is located.	Located along taxiway by itself, as part of an array of taxiway direction signs, or combined with a runway/ taxiway hold sign.
22	Runway Location.	Identifies the runway on which the aircraft is located.	Normally located where the proximity of two rwys to one another could cause confusion.
	Runway Safety Area / OFZ and Runway Approach Area Boundary.	Identifies exit boundary for an RSA / OFZ or rwy approach.	Located on taxiways on back side of certain runway/ taxiway holding position signs or runway approach area signs.
	ILS Critical Area/POFZ Boundary.	Identifies ILS critical area exit boundary.	Located on taxiways on back side of ILS critical area signs.
J →	Direction: Taxiway.	Defines designation/direction of intersecting taxiway(s).	Located on L side, prior to intersection, with an array L to R in clockwise manner.
↖ L	Runway Exit.	Defines designation/direction of exit taxiways from the rwy.	Located on same side of runway as exit, prior to exit.
22 ↑	Outbound Destination.	Defines directions to take-off runway(s).	Located on taxi routes to runway(s). Never collocated or combined with other signs.
FBO ↘	Inbound Destination.	Defines directions to airport destinations for arriving aircraft.	Located on taxi routes to airport destinations. Never collocated or combined with other types of signs.
NOISE ABATEMENT PROCEDURES IN EFFECT 2300 - 0500	Information.	Provides procedural or other specialized information.	Located along taxi routes or aircraft parking/staging areas. May not be lighted.
	Taxiway Ending Marker.	Indicates taxiway does not continue beyond intersection.	Installed at taxiway end or far side of intersection, if visual cues are inadequate.
7	Distance Remaining.	Distance remaining info for take-off/landing.	Located along the sides of runways at 1000' increments.
EXAMPLE	**TYPE OF MARKING**	**PURPOSE**	**LOCATION/CONVENTION**
	Holding Position.	Denotes entrance to runway from a taxiway.	Located across centerline within 10 feet of hold sign on taxiways and on certain runways.
	ILS Critical Area/POFZ Boundary.	Denotes entrance to area to be protected for an ILS signal or approach airspace.	Located on twys where the twys enter the NAVAID critical area or where aircraft on taxiway would violate ILS apch airspace (including POFZ).
	Taxiway/Taxiway Holding Position.	Denotes location on taxiway or apron where aircraft hold short of another taxiway.	Used at ATCT airports where needed to hold traffic at a twy/twy intersection. Installed provides wing clearance.
	Non-Movement Area Boundary.	Delineates movement area under control of ATCT, from non-movement area.	Located on boundary between movement and non-movement area. Located to ensure wing clearance for taxiing aircraft.
	Taxiway Edge.	Defines edge of usable, full strength taxiway.	Located along twy edge where contiguous shoulder or other paved surface NOT intended for use by aircraft.
	Dashed Taxiway Edge.	Defines taxiway edge where adjoining pavement is usable.	Located along twy edge where contiguous paved surface or apron is intended for use by aircraft.
4 - 22 4 - 22	Surface Painted Holding Position.	Denotes entrance to runway from a taxiway.	Supplements elevated holding position signs. Required where hold line exceeds 200'. Also useful at complex intersections.
	Enhanced Taxiway Centerline.	Provides visual cue to help identify location of hold position.	Taxiway centerlines are enhanced 150' prior to a runway holding position marking.
↖ T	Surface Painted Taxiway Direction.	Defines designation/direction of intersecting taxiway(s).	Located L side for turns to left. R side for turns to right. Installed prior to intersection.
B	Surface Painted Taxiway Location.	Identifies taxiway on which the aircraft is located.	Located R side. Can be installed on L side if combined with surface painted hold sign.

All runways licensed for night use must have lighting which at least defines the extent of the runway. This is referred to as Edge Lighting, Threshold Lighting and Runway End Lighting, other types of lighting may also be provided. Factor effecting airport lighting

1- Airport classification
2- Amount of traffic
3- Availability of power
4- Nature of aircraft using the airport
5- Type of night operation plans

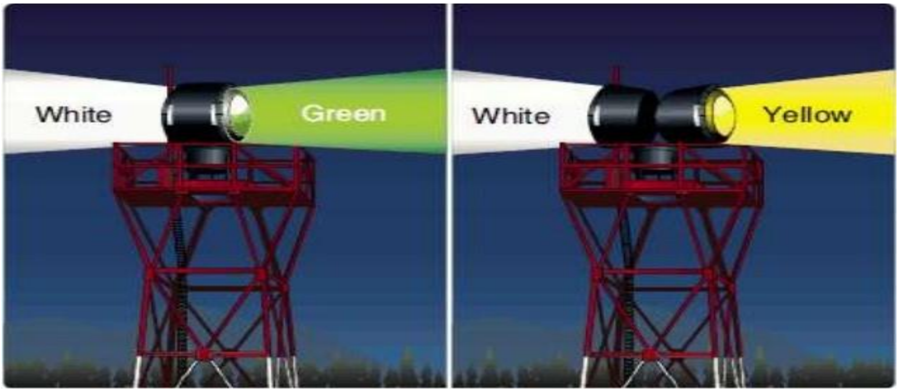
Element of airport lighting

1- Airport beacon
2- Approach lighting
3- Apron and hangar lighting
4- Boundary lighting
5- Lighting of landing direction indication
6- Lighting of wind direction indication
7- Runway lighting
8- Taxiway lighting
9- Threshold lighting

Type of lighting used in landing area referenced to (FAA) :

1-Airport beacon

Beacon strong beam of light used to indicate any geographical location situated slightly above the horizontal rotated to produce flashing light to an observer.It gives out white and green flashes are visible in the horizontal direction 180 apart flashes are visible Pilot from any direction of approach and it indicates the approximate situation of an airport equipped of the night operation, as shown in picture (3-1)



Picture (3-1)

2- Approach lighting

It takes before runway begins sequence of high intensity lighting arrangement for a length of 900m and helps pilots to check if the aircraft is centered correctly or not, And gives way to touchdown zone light from threshold of the runway, as shown in picture (3-2)

Picture (3-2)

3- Boundary lighting

Entire boundary of the airfield is provided with lights At a c\c distance of about 90m with height of about 75cm from the ground,the boundary lights are provided with red marker light, as shown in picture (3-3)

Picture (3-3)

4- Lighting of landing direction indicator

The landing direction indicator is illuminated with suitable lighting arrangement so that the airport can be used at night also, as shown in picture (3-4)

Picture (3-4)

RESULT AND CALCULATION

soil test result

After conducting the necessary tests for the soil, it was found that the soil was not suitable for the building and therefore needed to strengthen its structure through the so – called stabilization .

The term ‘stabilization’ is the process whereby the natural strength and durability of a soil or granular material is increased by the addition of a stabilizing agent. In addition, it may provide a greater resistance to the ingress of water. There are many types of stabilizer that can be used, each with its own advantages and disadvantages. The type and quantity of stabilizer added depends mainly on the strength and performance that needs to be achieved.

Soil stabilization, in the broadest sense, is the alteration of any property of a soil to improve its engineering performance. It also comprises of any process which increases or maintains the natural strength of the soil. Stabilization techniques could be mechanical or chemical (addition of cementitious additives).

mechanical stabilization

Soil stabilization can be achieved through physical process by altering the physical nature of native soil particles by either induced vibration or compaction or by incorporating other physical properties such as barriers and nailing.

COMPONENTS OF STABILIZATION

Soil stabilization involves the use of stabilizing agents (binder materials) in weak soils to improve its geotechnical properties such as compressibility, strength, permeability and durability. The components of stabilization technology include soils and or soil minerals and stabilizing agent or binders (cementitious materials).

Soils:

Most of stabilization has to be undertaken in soft soils (silty, clayey peat or organic soils) in order to achieve desirable engineering properties. According to Sherwood (1993) fine-grained granular materials are the easiest to stabilize due to their large surface area in relation to their particle diameter. A clay soil compared to others has a large surface area due to flat and elongated particle shapes. On the other hand, silty materials can be sensitive to small change in moisture and, therefore, may prove difficult during stabilization (Sherwood, 1993). Peat soils and organic soils are rich in water content of up to about 2000%, high porosity and high organic content. The consistency of peat soil can vary from muddy to fibrous, and in most cases, the deposit is shallow, but in worst cases, it can extend to several meters below the surface (Pousette, et al 1999; Cortellazzo and Cola, 1999; Åhnberg and Holm, 1999). Organic soils have high exchange capacity; it can hinder the hydration process by retaining the calcium ions liberated during the hydration of calcium silicate and calcium aluminate in the cement to satisfy the exchange capacity. In such soils, successful stabilization has to depend on the proper selection of binder and amount of binder added (Hebib and Farrell, 1999; Lahtinen and Jyrävä, 1999, Åhnberg et al, 2003).

Stabilizing Agents

These are hydraulic (primary binders) or non-hydraulic (secondary binders) materials that when in contact with water or in the presence of pozzolanic minerals reacts with water to form cementitious composite materials. The commonly used binders are:

o cement
o lime
o fly ash
o blast furnace slag

Cement

Cement is the oldest binding agent since the invention of soil stabilization technology in 1960's. It may be considered as primary stabilizing agent or hydraulic binder because it can be used alone to bring about the stabilizing action required (Sherwood, 1993; EuroSoilStab, 2002). Cement reaction is not dependent on soil minerals, and the key role is its reaction with water that may be available in any soil (EuroSoilStab, 2002). This can be the reason why cement is used to stabilize a wide range of soils. Numerous types of cement are available in the market; these are ordinary Portland cement, blast furnace cement, sulfate resistant cement and high alumina cement. Usually the choice of cement depends on type of soil to be treated and desired final strength.

Hydration process is a process under which cement reaction takes place. The process starts when cement is mixed with water and other components for a desired application resulting into hardening phenomena. The hardening (setting) of cement will enclose soil as glue, but it will not change the structure of soil (EuroSoilStab, 2002). The hydration reaction is slow proceeding from the surface of the cement grains and the center of the grains may remain unhydrated (Sherwood, 1993). Cement hydration is a complex process with a complex series of unknown chemical reactions (MacLaren and White, 2003).

However, this process can be affected by

- presence of foreign matters or impurities
- water-cement ratio
- curing temperature
- presence of additives
- specific surface of the mixture.

Depending on factor(s) involved, the ultimate effect on setting and gain in strength of cement stabilized soil may vary. Therefore, this should be taken into account during mix design in order to achieve the desired strength. Calcium silicates, *C3S* and *C2S* are the two main cementitious properties of ordinary Portland cement responsible for strength development

(Al-Tabbaa and Perera, 2005; EuroSoilStab, 2002). Calcium hydroxide is another hydration product of Portland cement that further reacts with pozzolanic materials available in stabilized soil to produce further cementitious material (Sherwood, 1993). Normally the amount of cement used is small but sufficient to improve the engineering properties of the soil and further improved cation exchange of clay. Cement stabilized soils have the following improved properties:

• decreased cohesiveness (Plasticity)

• decreased volume expansion or compressibility

• increased strength.

- What is the best type of stabilizer uses for the airport field ?

By laboratory test on the soil the best type is cement stabilization , the type of soil classification A-7

TABLE 9.1. Admixture

	Type	Admix	Primary Mechanics of Stabilization	Use	Situations Best Suited	Approximate Quantity by Weight
Increase Strength by Cementing Action	Cementing agents[b]	Portland cement	Principally hydration Some modification of clay minerals	Base and subbase	Sandy soils or lean clays	A-7 9–15% to A-2 5–9%
		Lime	Change water film, floccula-tion, chemical	Some base and subbase, shoulders	Granular materials or lean clays	2–5%
		Lime flyash	Pozzolanic ac-tion of lime and silica, some modification of clay minerals	Some base and subbase, shoulders	Granular materials or lean clays	2–5% lime 10–20% flyash
		Bitumen		Base and subbase	Granular	2–5%

STABILIZATION METHOD

In–Situ Stabilization

The method involves on site soil improvement by applying stabilizing agent without removing the bulk soil. This technology offer benefit of improving soils for deep foundations, shallow foundations and contaminated sites. Planning of the design mix involves the selection and assessment of engineering properties of stabilized soil and improved ground. The purpose is to determine the dimensions of improved ground on the basis of appropriate stability and settlement analyses to satisfy the functional requirements of the supported structure (Keller Inc.). The technology can be accomplished by injection into soils a cementitious material such cement and lime in dry or wet forms. The choice to either use dry or wet deep mixing methods depend among other things; the in-situ soil conditions, in situ moisture contents, effectiveness of binders to be used, and the nature of construction to be founded. Depending on the depth of treatment, the in situ stabilization may be regarded as either deep mixing method or mass stabilization.

Structural design

Flexible structural pavement design

1- Runway structural design

From the soil test the CBR for the subgrad = 7%

Assume:

Subbase CBR= 30%

Base course CBR = 80%

According to FFA these charts use to determine the thickness:

Single wheel gear

Chart (4-1)

Dual wheel gear

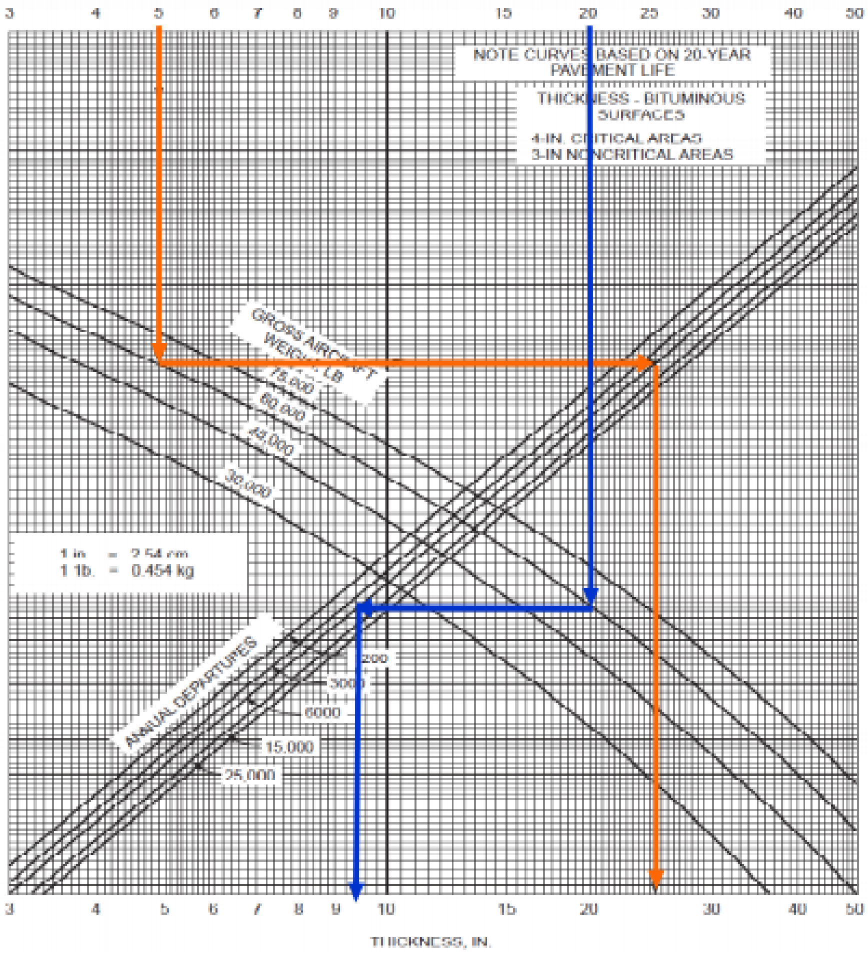
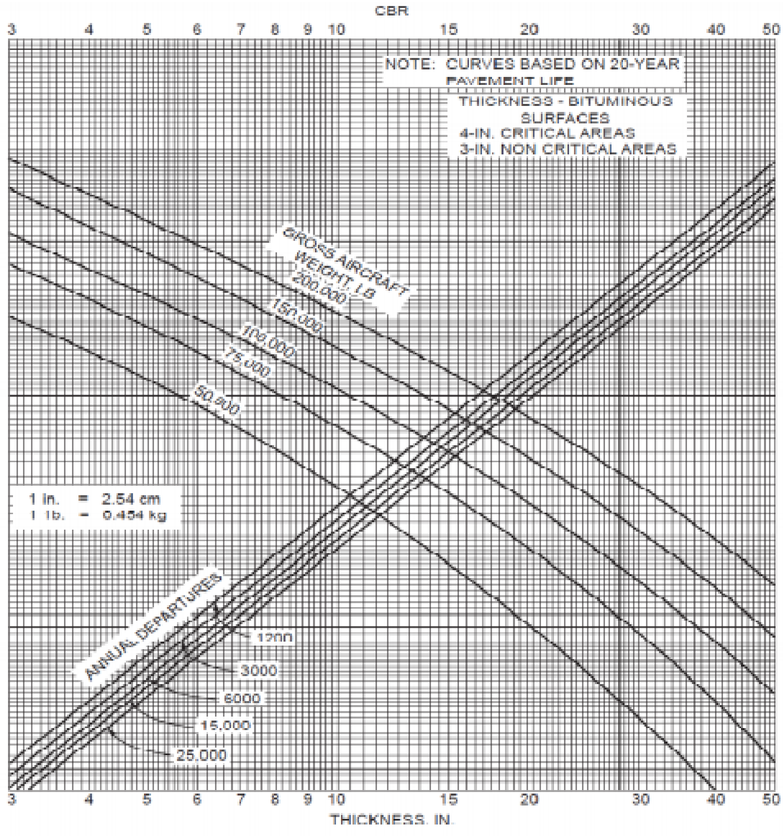


Chart (4-2)



discussion ,conclusion and recommendation

Discussion

The designer's task is always to choose the best compromise to meet the various conflicting requirements put upon him. This task is eased when these requirements and ways of meeting them are expressed precisely in numbers, which is so in most performance work, but rarely true of safety or reliability.

Designing the landing area for the airport took several steps and was very precise, starting with the structural design which after doing the calculation and using FAARFIELD software to be more accurate the result was a PCC over rigid pavement type with a thickness of 62 in . After that process of determination the runway length and width has been done and the result was a runway with 3033.6 m in length and 60 m in width which in compare to the standard FAA values were very reasonable.

The 3033.6 m length and 60 m width runway is capable of accommodating the requirements of all current aircraft and provides flexibility in accepting different aircraft in the future.

According to FAA and ICAO regulations the runway coverage must be 95% and higher, the designed runway gave a wind coverage of 95% which meet the standard, insure the safety and maximizes the possible use of the runway throughout, the year accounting for a wide variety of wind condition .

Conclusion

The information regarding the above mentioned runway airport is presented in a systematic manner as a feasibility report and also it covers what is needed for a detailed project report in which the airport planning, site selection and related surveys, airport design standards, environmental guidelines are incorporated as one part. The other part concentrates on the design aspects of runway and its structural design which includes the region specific and real time collection of field data, computerized wind analysis and Orientation of the runway. Computerized system of design is discussed and solutions are arrived in detail. The runway is designed for the current trend new large aircrafts by considering their future increase in the number of annual departures. This is one of the comprehensive effort to focus the preliminary report preparation of a typical airport's runway design.

Runway geometry and orientation along with the structural design of the flexible airfield pavement are obtained successfully by using software tools which are strictly in accordance with the ICAO design criteria and FAA guidelines (Advisory Circular).

Recommendation

- Before deciding to develop a new airport runway, full consideration should be given to the possibility of improving the existing airport capacity so as to make it suitable for the increased future air traffic.
- Efforts should be made to accommodate new types of pavement material likely to ply in the near future so the maintenance process doesn't needed to be done frequently.
- make sure to select the correct and most effective site for the runway in terms of wind (strength and direction) ,and the quality of the soil for the selected area.

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