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Review of flexible pavement for light aircraft

[1]Rohit, [2]Sonam

[1]Research Scholar, Department of Civil, GITM, Jhajjar Haryana

[2]A.P. Department of Civil, GITM, Jhajjar Haryana

Abstract

Pavement is the durable surface material laid down on an area intended to sustain vehicular or foot traffic, such as a road or walkway. In the past, gravel road surfaces, cobblestone and granite setts were extensively used, but these surfaces have mostly been replaced by asphalt or concrete laid on a compacted base course. Road surfaces are frequently marked to guide traffic. Flexible pavement are preferred over cement concrete roads as they have a great advantage that these can be strengthened and improved in stages with the growth of traffic and also their surfaces can be milled and recycled for rehabilitation. The flexible pavements are less expensive also with regard to initial investment and maintenance. Although Rigid pavement is expensive but have less maintenance and having good design period. The economic part is carried out for the design pavement of a section by using the result obtain by design method and their corresponding component layer thickness.

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Keyword: Pavement, Flexible pavement, light aircraft

Introduction

Roads are the major channel of transportation for carrying goods and passengers. They play a significant role in improving the socio-economic standards of a region. Roads constitute the most important mode of communication in areas where railways have not developed much and form the basic infra structure for the development and economic growth of the country. The benefits from the investment in road sector are indirect, long-term and not immediately visible. Roads are important assets for any nation. However, merely creating these assets is not enough, it has to be planned carefully and a pavement which is not designed properly deteriorates fast. India is a large country having huge resource of materials. If these local materials are used properly, the cost of construction can be reduced.

Types of pavement: There are various type of pavements depending upon the materials used. A briefs description of all types is given here.

Flexible pavement: Flexible pavement can be defined as the one consisting of a mixture of asphaltic or bituminous material and aggregates placed on a bed of compacted granular material of appropriate quality in layers over the subgrade. Water bound macadam roads and stabilized soil roads with or without asphaltic toppings are examples of flexible pavements.

Rigid pavement: A rigid pavement is constructed from cement concrete or reinforced concrete slabs. Grouted concrete roads are in the category of semi-rigid pavements.The design of rigid pavement is based on providing a structural cement concrete slab of sufficient strength to resists the loads from traffic. The rigid pavement has rigidity and high modulus of elasticity to distribute the load over a relatively wide area of soil.

Review of literature

(Sultan, 2017) studied "Effect of aircraft dynamic loads on airport asphalt pavement" and found that rapid increase in the weight and number of aircrafts that use the existing airport asphalt pavements has focused the light on the ability of these pavements to serve efficiently. The fast deterioration of airport asphalt pavements in comparison with their design life encourages the researchers to evaluate the existing airport design methods. The objective of this research is to examine the current design methods by introducing the dynamic effects of aircraft loads on the airport flexible pavement. The effect of aircraft impact, aircraft movement, and aircraft braking forces on airport asphalt pavement were studied. It was found that all the known design methods of airport asphalt pavements are underestimate the actual dynamic effects of aircraft loads. When the impact factor is 1.5 of the actual wheel load, the wheel load factor for rutting criterion is from 3.96-4.49 for standard single wheel loads of 200-500 kN respectively. Also, when the braking forces are 50% of the standard single wheel loads, the wheel load factor for fatigue criterion is from 6.64-7.66 for single wheel loads of 133.6-334 kN respectively. The pavement structure optimization as recommended by most design methods should be re-considered due to the considerable effects of dynamic loads of aircraft maneuvers. New compaction techniques were recommended to increase the strength of airport asphalt pavement structure.

(Bazi, Mansour, Sebaaly, Ji, & Garg, 2019) studied "Instrumented flexible pavement responses under aircraft loading" and found that the FAA National Airport Pavement Test Facility (NAPTF) is a full-scale accelerated pavement testing facility located in Atlantic City

International Airport, New Jersey. Six flexible and three rigid test sections were built, instrumented and trafficked by Boeing 777 and 747 gears as part of construction cycle one. One flexible test section with an asphalt-stabilised base over a low-strength subgrade was considered in this study. All dynamic sensors, including pressure cells, strain gauges and multi-depth deflectometers were evaluated. A multistep procedure for evaluating the dynamic sensors was developed, and it included data reliability, repeatability, changes in the pavement responses under the Boeing 777 and 747 gears, and comparison with a three-dimensional (3D) finite element (FE) mechanistic model. The mechanistic model was found to predict the pavement responses with good reliability, whenever representative layer moduli are used. The study also found that 60% of the sensors produced acceptable or marginal responses and 40% produced unacceptable responses; therefore, it is recommended to consider this sensor survival rate when instrumenting future test sections. The rutting performance and pavement responses over time were evaluated; the test section was shown to have relatively similar performance and pavement responses under the Boeing 777 and 747 gears.

(White, 2019) studied "RIGID AND FLEXIBLE AIRCRAFT PAVEMENTS" and found that the construction and maintenance costs, as well as the residual value, were calculated for structurally equivalent rigid and flexible airfield pavements for a range of typical commercial aircraft and a range for typical subgrade conditions. Whole of life cycle cost analysis was performed for a range of analysis periods, from 40 years to 100 years. For the standard 40-year analysis period and a residual value based on rigid pavement reconstruction, the rigid pavements had a 40-105% higher whole of life cost than equivalent flexible pavements. However, longer analysis periods had a significant impact on the relative whole of life cost, although the rigid pavements always had a higher cost than the flexible pavements. The assumed condition of the rigid pavement at the end of the design life was the most influential factor, with a 60-year service life resulting in the rigid pavements having a lower whole of life cost than the flexible pavements, but assuming a requirement for full expedient reconstruction resulted in the rigid pavements costing approximately 4-6 times the flexible pavements over the 40- year analysis period.

(Wang, Li, Garg, & Zhao, 2018) studied "Multi-wheel gear loading effect on load-induced failure potential of airfield flexible pavement" and found that this study aimed to investigate the effect of multi-wheel loading gear configuration on loading-induced failure potential of airfield flexible pavements. Field response testing was conducted in the National Airport Pavement Test Facility (NAPTF) using different multi-wheel gear configurations. Three-dimensional (3-D) finite element (FE) models were developed to simulate multi-wheel loading along with non-uniform tyre contact stresses. The 3-D FE models were validated by tensile strains measured from response testing. The effects of wheel loading configurations and magnitudes on different strains responses were compared for two pavement sections with different asphalt layer thicknesses. Analysis results showed that six-wheel gear configuration caused the greater pavement responses. The critical shear strains were found greater than critical tensile strains at the same loading condition and pavement structure, especially for thick asphalt pavements. This is consistent with top-down cracks observed at field sections after traffic testing. On the other hand, shear strains increase more rapidly as the load level increases as compared to tensile strains; while thin asphalt layer is more sensitive to loading magnitude as compared to thick asphalt layer. The multi-wheel effect on fatigue life is more significant for thick pavement due to the load superposition effect under different wheels.

(Gill, Singhal, Mani, & Srivastav, 2015) studied "To Study and Design of Airport Runway Pavement" and found that the structural design of airport runway pavements are material design and thickness design. Material design deals with the selection of suitable materials for various pavement layers and mix design of bituminous materials Pavements are designed and constructed to provide durable all-weather travelling surfaces for safe and speedy movement of people and goods with an acceptable level of comfort to users. These functional requirements of pavements are achieved through careful considerations in the following aspects during the design and construction phases: (a) types of pavement (b) grading of material (c) design of pavement thickness. Airport facility requirements include runways, taxiways, pavement condition, navigational aids, lighting systems, and aircraft parking apron, hangars, fixed base operator (FBO) facilities, aircraft fuelling, automobile parking, utilities and surface access.

Flexible pavement for light aircraft

Pavement for light aircraft is deemed by the Federal Aviation Administration as pavement intended to serve aircraft with gross weights of less than 30,000 pounds. With the Lake Mathews Airport being an AII-BII category airport, the maximum gross weight that the airport

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can serve is 12,500 pounds. This gross aircraft weight would put the Lake Mathews Airport in the light aircraft category.

Flexible pavement for light aircraft is composed of hot mix asphalt surfacing, base course, subbase, and prepared subgrade. The hot mix asphalt surface is responsible for preventing water to seep into the base course. In addition, the hot mix asphalt must provide a smooth, well-bonded surface free from loose particles that pose a potential threat to aircraft or persons using the airport. The base course is the primary load carrying component of the flexible pavement. The subbase course is usually required for flexible pavement, except for those with a CBR value of 20 or greater. However, with a CBR value of 4 for the Lake Mathews site, a subbase course is needed.

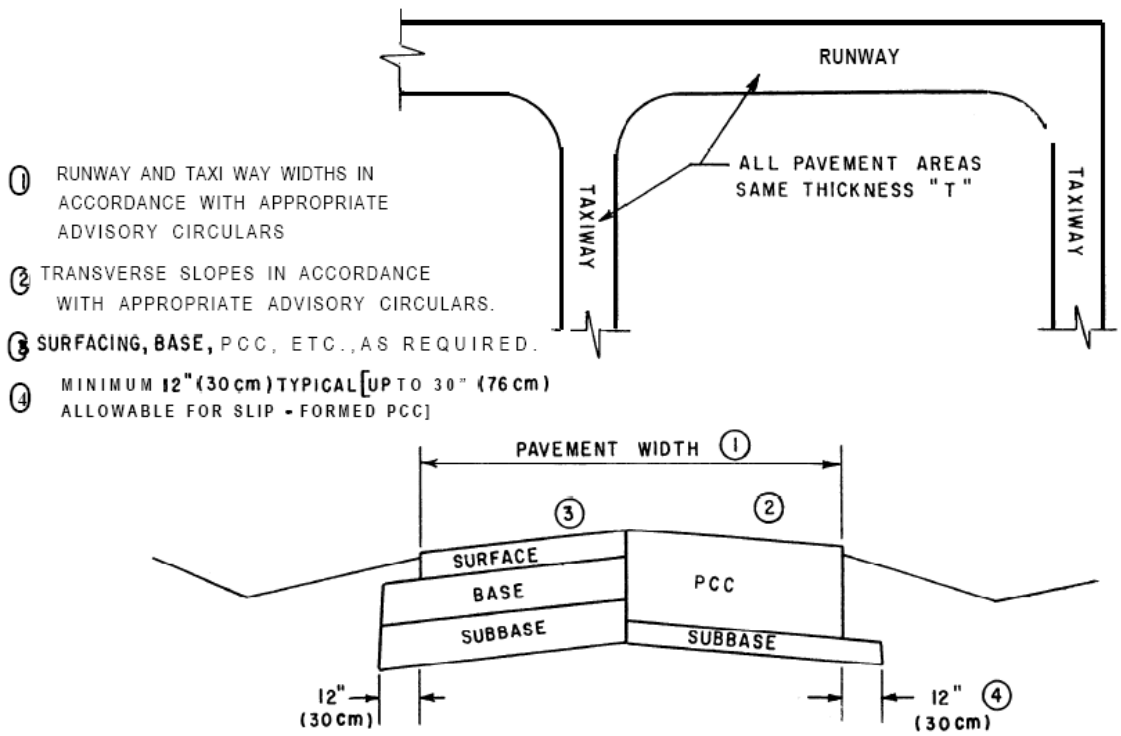

Figure: Typical sections for light aircraft pavement per AC 150/5320-6D.

Overall Pavement Thickness

The pavement thickness of 14 inches, which was determined previously, must be used upon all areas of airport pavement according to the Federal Aviation Administration.

Surfacing and Base Thickness

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According to the Federal Aviation Administration, to find the surfacing and base thickness, the CBR 20-line is used. Using the chart provided by the Federal Aviation Administration, the thickness of the surfacing and base can be found. Using a CBR value of 20, as instructed by the Federal Aviation Administration, and a maximum aircraft gross weight of 12,500 pounds, a value of four and a half inches is obtained for the thickness of the surfacing and base. This thickness value is rounded up to five inches in order to be conservative and also because this base is, in essence, the structural element of the pavement. Figure 4.5 represents how the thickness for the surfacing and base was generated

Subbase Thickness

The difference between the total pavement thickness required and the CBR 20-line thickness yields the thickness of the subbase. With a total pavement thickness of 14 inches and a surfacing and base thickness of five inches, the total subbase thickness is required to be nine inches.

Subgrade

The subgrade materials need to be compacted to a specific percentage depending upon whether the soil is noncohesive or cohesive and the design aircraft gross weight. For the Lake Mathews Airport, with cohesive soil and a maximum gross aircraft weight of 12,500 pounds, it was determined that the subgrade needs to be compacted to 85 percent for eight to twelve inches or 90 percent for four to eight inches in depth.

Final Flexible Pavement Design:

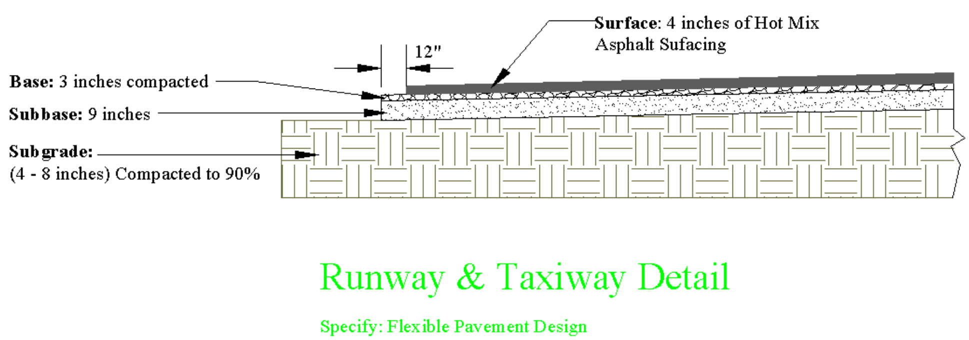

Figure: Expansion Cross-section of flexible pavement (Total Thickness).

Conclusion

Flexible pavement for light aircraft is composed of hot mix asphalt surfacing, base course, subbase, and prepared subgrade. The hot mix asphalt surface is responsible for preventing water to seep into the base course. In addition, the hot mix asphalt must provide a smooth, well-bonded surface free from loose particles that pose a potential threat to aircraft or persons using the airport. The base course is the primary load carrying component of the flexible pavement. The subbase course is usually required for flexible pavement, except for those with a CBR value of 20 or greater. However, with a CBR value of 4 for the Lake Mathews site, a subbase course is needed. It is observed that flexible pavements are more economical for lesser volume of traffic. The life of flexible pavement is near about 15 years whose initial cost is low needs a periodic maintenance after a certain period and maintenance costs very high.

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