# Functional Condition Evaluation of Airfield Pavements Using Automated Road Survey System—A Case Study of a Small Sized Airport

**Pradeep Kumar and Madhavendra Sharma**

**Abstract** Airports are vital national resources. Airfield Pavements within an airport represents a large capital investment in infrastructural development made by a country. Timely and appropriate maintenance and rehabilitation of such in-service facilities are essential to provide an all-weather surface for safe and regular operations of the aircraft. Pavement maintenance is done based on functional and structural pavement condition evaluation. This paper presents a case study dealing with functional evaluation of airfield pavements of a small sized airport in India. The considered airport consists of two runway, seven link taxiways, three apron areas and an isolation bay with different surface types. Present paper reports the methodology adopted for the functional condition evaluation of the airfield pavements with help of Automated Road Survey System. Further, the evaluated pavement condition was quantified in terms of Pavement Condition Index (PCI) as per the ASTM D5340 with help of PAVER and GIS based software. GIS was used for preparing inventory database and base maps for the concerned pavements which were then used in PAVER software for determining the PCI. The airfield pavement network within the airport was divided into a four-level hierarchy consisting of the network, branch, section and sample. The obtained PCI rating shows that the overall condition of the airfield pavements within the considered airport is satisfactory to good, however some of the areas have distresses that needs to be repaired by localized maintenance.

**Keywords** Airfield pavement management system · Pavement condition index · GIS · PAVER

## 1 Introduction

Air transport is growing manifolds in terms of number of operations worldwide. As a result of growing air transport, new airfield infrastructure is being developed worldwide. Airports serves as a source of fast and reliable mode of transportation in present times. Airfield pavements are a major investment with a new runway typically

P. Kumar · M. Sharma (✉)
Pavement Evaluation Division, CSIR—Central Road Research Institute, New Delhi 110076, India



H. R. Pasindu et al. (eds.), *Road and Airfield Pavement Technology*, Lecture Notes in Civil Engineering 193, https://doi.org/10.1007/978-3-030-87379-0_13

costing between $100 M and $500 M to plan, design and construct, including all the associated infrastructure [1, 2]. These airfield pavements act as the backbone for economic development in the region, not only in developed countries but also in developing countries [3].

Immediately after the construction, airfield pavements begin a gradual deterioration attributable to weather and loading. With higher deterioration when pavements are in poor condition, the maintenance cost would increase manifolds as compared to pavements in good condition [4]. Airfield Pavement Management System (APMS) is employed for assisting the airport authorities in effective decision making in Maintenance and Rehabilitation (M&R) of pavements. Collection, assessment and reporting of present pavement condition are some of the major tasks to be performed while developing an APMS. Condition assessment of airfield pavements is done based on condition indicators obtained from visual distress survey. Visual distress surveys are usually performed by walking (Foot on Ground) or windshield method consuming time and labor.

This paper presents a methodology adopted for condition evaluation of the airfield pavements in India using Automated Road Survey System (ARSS). Use of ARSS for condition surveys of highway pavements is accepted worldwide but use of such techniques for airfield pavements is not widespread. One of the best practices in the state of the art in airport infrastructure management is maintenance management with a combination of Global Positioning System (GPS) and Geographic Information System (GIS) Technologies [5]. The work reported within the present paper incorporate both GPS and GIS for the functional condition evaluation of the airfield pavements.

APMS provides a consistent, objective and systematic procedure for establishing facility policies, setting priorities and schedules, allocating resources, and budgeting for pavement maintenance and rehabilitation [6]. APMS is widely used techniques for planning and assessment of airfield pavements around the globe [3, 7–10]. APMS uses the concept of Pavement Condition Index (PCI), Foreign Object Damage Potential (FOD Index), Structural Index and Friction properties of Airfield Pavements for condition assessment [11]. Determination of PCI is done based on pavement surface distresses as specified in ASTM D5340 [12]. FOD Index is determined based on subset of distresses mentioned in ASTM D5340 and can be calculated using the PAVER software. APMS as reported in different articles [8, 9, 11, 13–18], used FOG visual survey technique for distress survey of airfield pavements, however FAA guidelines [6] doesn't lay specific guidelines for the visual condition survey. Hence, to reduce the time and labor consumption, the present study used ARSS for condition survey.

## 2 Materials and Methods

The methodology adopted for the study make use of technologies like Geographic Information System (GIS), Global Positioning System (GPS), Remote Sensing systems in form of Automated Road Survey System (ARSS) and PAVER.

### 2.1 *Airfield Pavement Network Definition*

For the purpose of the inspection and evaluation, airfield pavements within the airport are divided in a hierarchical structure of network, branches and sections which is considered to be the first step in establishing a APMS [12, 19]. The inventory data was obtained from the airport authority. The obtained data was used as secondary data for preparation of GIS map and classification of considered pavements into network, branch and section. The pavements within the considered airport were classified into three different network, one each of runway (RW), taxiway (TW) and Apron (AP). Pavement within network were divided further into branch and section based on crust and surface characteristics. Pavement area distribution within airport as per use and surface type is presented in Figs. 1 and 2 respectively. The inventory GIS map prepared is presented in Fig. 3.

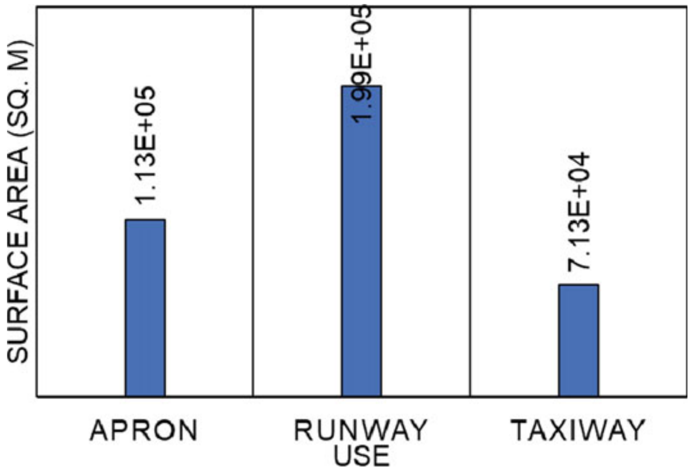



**Fig. 1** Pavement area distribution as per use

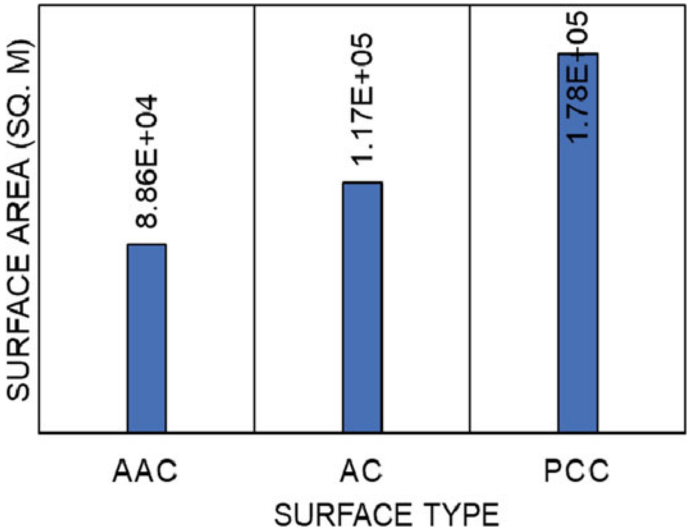



**Fig. 2** Pavement area distribution as per surface type

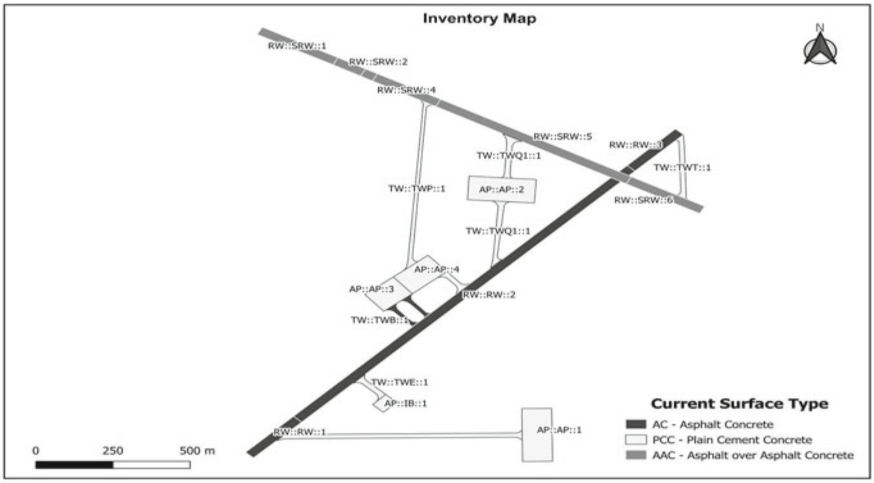



**Fig. 3** Prepared inventory map in GIS of airfield pavements

## *2.2 Airfield Pavement Distress Condition Evaluation*

Airfield Pavement Distresses and condition were surveyed in accordance with the methods outlined in FAA Advisory Circular 150/5380-6C and ASTM D 5340—18 using Automated Road Survey System (ARSS). The procedure is based on the identification and measurement of distress at the pavement surface.


**Fig. 4** Automated Road Survey System (ARSS) used for survey of Airfield Pavements

Traditionally, Pavement condition surveys have been conducted using foot-on-ground (FOG) approach on the airfields where inspectors walk on the pavement sections and collect the detailed distress data [9, 11, 21]. In this study, the pavement condition surveys have been conducted using Pavement Surface Imaging System (PSIS) installed in Automated Road Survey System (ARSS).

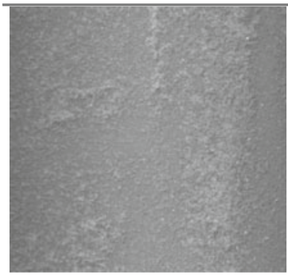
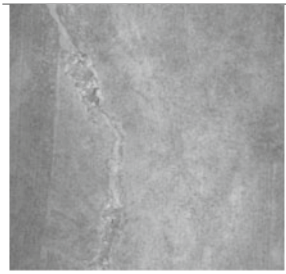
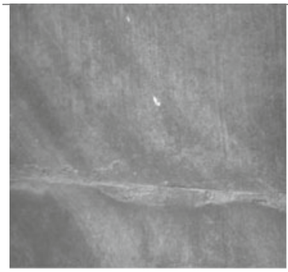
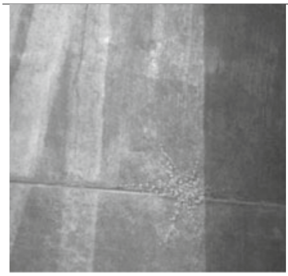
ARSS used in present study as shown in Fig. 4 is based on the latest survey techniques utilizing Global Positioning System and pavement surface imaging systems. Using PSIS of ARSS condition survey is conducted while travelling at speeds up to 80 kmph.

PSIS of ARSS involve the use of two pavement cameras as shown in Fig. 4. These cameras were used to generate the calibrated images (with known length and width) of the pavement surface. The measurement of various surface defects viz. cracking, raveling, and potholes was done by processing the captured calibrated pavement surface images, using the Image Processing software. To fulfill the objective of this study, emphasize were made on GPS data and pavement surface distress. Some of the prominent distresses observed in the study are presented in Table 1.

## 2.3 *Preparation of Distress Dataset*

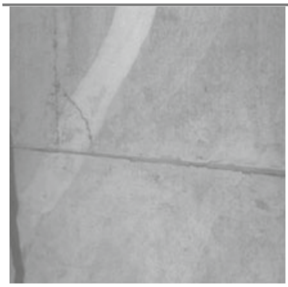
As per the ASTM D 5340—18, for the calculation of Pavement Condition Indices; the pavement area needs to be divided into small inspection samples. The considered sample area for the flexible pavements was 450 ± 200 $m^2$ and for rigid pavements was 25 ± 10 slabs. Hence, the base maps in the GIS were divided into samples using small polygons. The ARSS data collected was further processed frame by frame using image processing technique to quantify the distresses observed on the airfields in terms of distress type, distress severity and extent as shown in Table 1.

**Table 1** Prominent distresses observed on airfield pavements

| Distress image | Pavement surface type | Distress type | Distress severity |
|---|---|---|---|
|  | AC | Weathering | Low |
|  | PCC | Longitudinal cracking | Medium |
|  | PCC | Joint spalling | Medium |
|  | PCC | Joint Seal damage | High |

(continued)

**Table 1** (continued)

| Distress image | Pavement surface type | Distress type | Distress severity |
|---|---|---|---|
|  | PCC | Corner break | Low |

The distress data prepared in such a way is a GPS enabled dataset having locations of distresses in terms of latitude and longitude which was further included in the GIS database at sample level in accordance with the ASTM D 5340—18. Figure 5 shows the schematics of the process followed in GIS for preparation of base map.

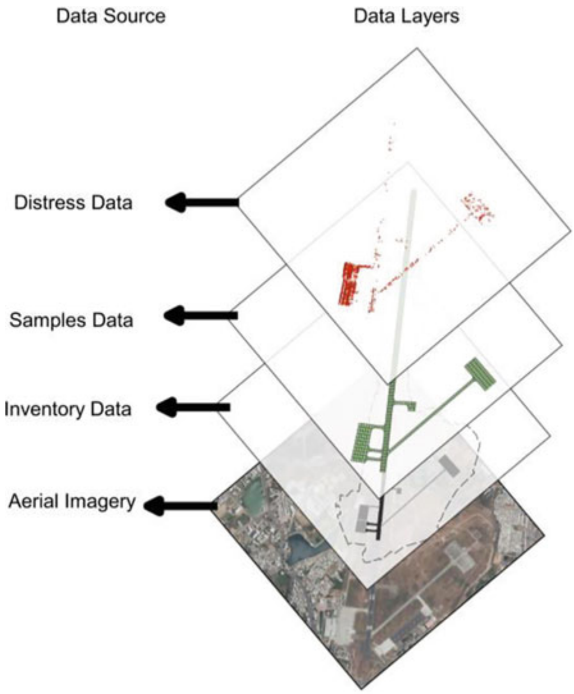



**Fig. 5** Schematic diagram for distress database preparation in GIS

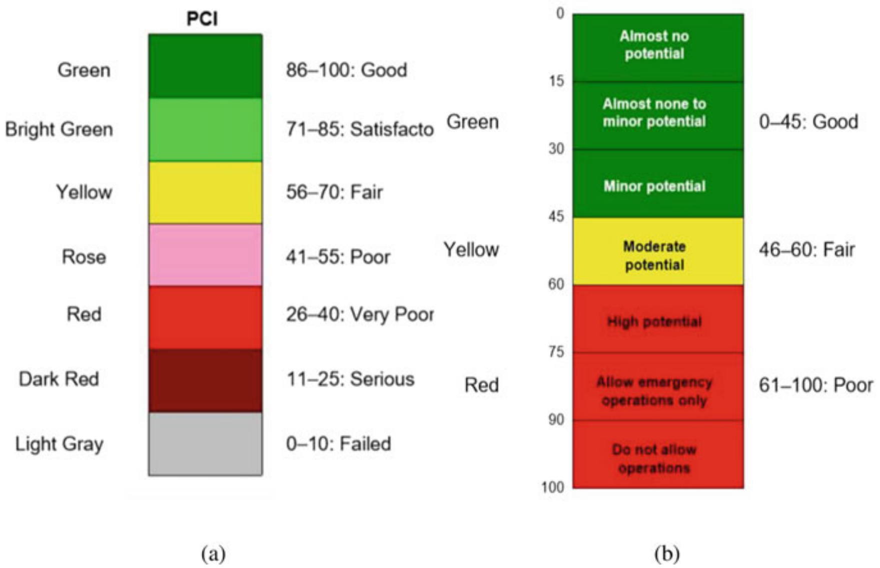



**Fig. 6** Representation of condition indices; **a** Pavement condition index, **b** FOD potential index [23]

# 3 Result

As a part of functional condition evaluation two types of functional indices a) Pavement Condition Index (PCI) and b) Distress based Foreign Object Damage (FOD) Potential Index, were determined in the present study to quantify the present functional condition of the airfield pavements.

## *3.1 Pavement Condition Index (PCI)*

Pavement Condition Index (PCI) as shown in Fig. 6a, is a score from 0 (failed) to 100 (good) that rates the ability of a pavement to perform its function effectively and safely [22].

## *3.2 Foreign Object Damage (FOD) Potential Index*

The loose material resulting from surface distresses can cause damage to aircraft propellers and is called Foreign Object Damage (FOD). A FOD potential rating scale as shown in Fig. 4b ranging from 0 to 100 is used to indicate the potential for FOD problems [23].

In the present study PAVER software was used for determination of PCI and FOD potential index. Subsequent sections summarize the process of PCI and FOD potential determination using PAVER.

The distress data at sample level was imported in the PAVER database after preparation of airfield database. Distress data was imported using inspection wizards within the PAVER for rigid and flexible pavement sections as shown in Figs. 7 and 8 respectively.

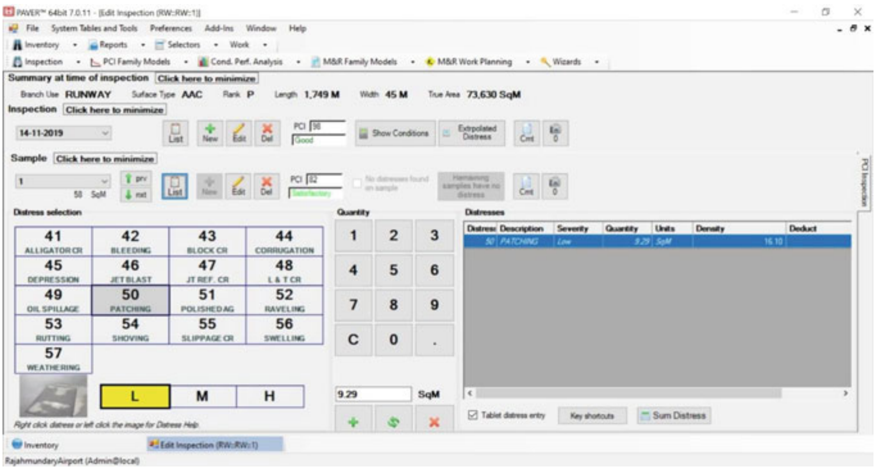



**Fig. 7** Rigid Pavement Surface Inspection Import wizard

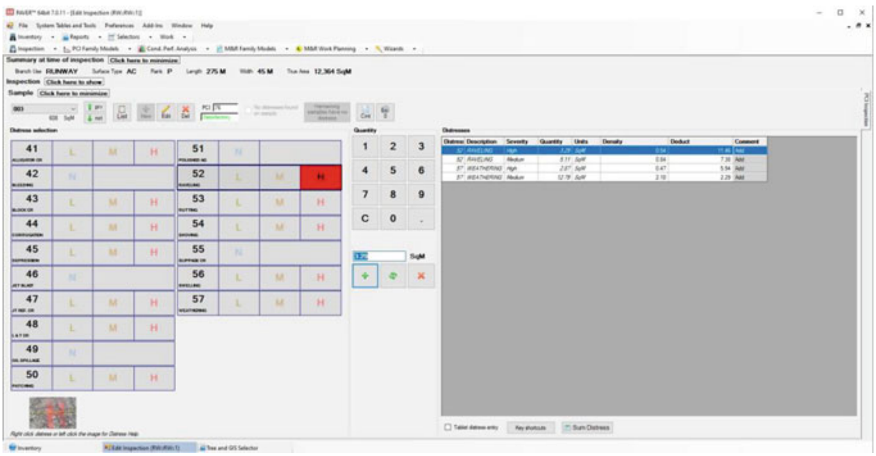


**Fig. 8** Flexible pavement surface inspection import wizard

## 4 Conclusion and Discussions

Pavement Condition Data collection is considered to be the most expensive and time consuming task in establishing a Pavement Management System (PMS) [24]. To save time and labor in collecting condition data for airfield pavements, presented study worked on using ARSS for collecting condition data. Based on inspected sample data, the FOD Potential Rating and PCI were calculated using the PAVER condition analysis wizard. Section wise results are presented in Figs. 9 and 10.

While considering Pavement Condition Index (PCI), Runway pavements were found to be in satisfactory to good condition. While the condition of apron was

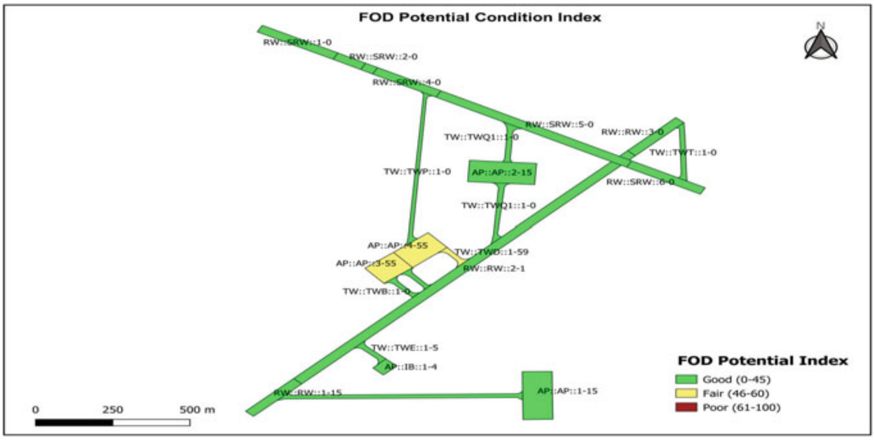



**Fig. 9** Observed FOD Potential Index for different airfield pavement sections

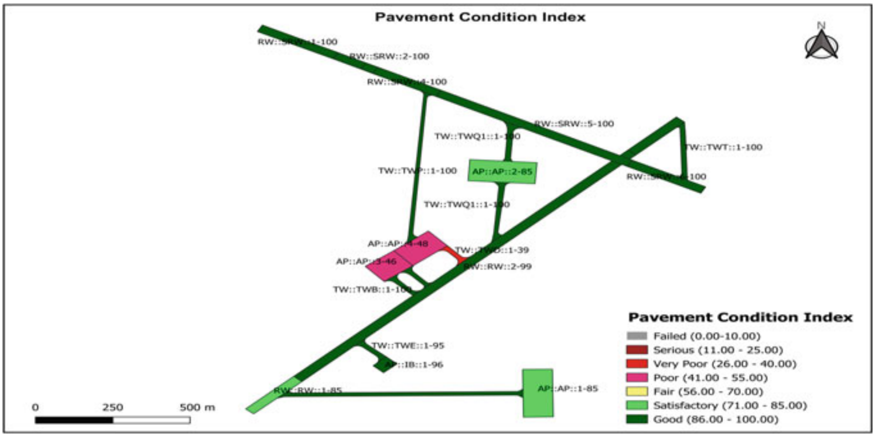



**Fig. 10** Observed Pavement Condition Index (PCI) for different airfield pavement sections

found to be in very poor and poor condition. In case of FOD potential, all pavements are in fair to good condition as seen in Fig. 9.

The study performed was aimed at the use of ARSS as a fast measure of evaluating airfield pavements for functional aspects. The salient conclusions that can be drawn from the present study are as follows:

- The use of ARSS and GIS subsequently has greatly reduced the effort for visual inspection and processing of distress data.
- There are several advantages observed with use of PSIS (ARSS) over the use of FOG approach in the present study including minimum interruption to aircraft operations.
- Earlier the location of a distress needs to be measured from a benchmark point, using tape and compass method. While in the present study the geotagged images of pavement were obtained with use of GPS technology in ARSS, significantly reducing the manual effort.
- Use of GIS to prepare inventory and GPS to subsequently mark distressed locations will further help in preparing spatial temporal pavement condition data.
- The use of ARSS, helped in reducing the subjective factor linked with traditional methods, hence improving productivity and repeatability.

## Referenes


1. White G, Kitchen R (2019) Parametric comparison of the whole of life cycle cost of rigid parametric comparison of the whole of life cycle. In: Eighteenth annual international conference on pavement engineering, asphalt technology and infrastructure. Liverpool, England
2. Grothaus JH, Helms TJ, Germolus S et al (2009) ACRP report 16: guidebook for managing small airport
3. Irfan M, Khurshid MB, Iqbal S, Khan A (2015) Framework for airfield pavements management—an approach based on cost-effectiveness analysis. Eur Transp Res Rev 7. https://doi.org/10.1007/s12544-015-0165-5
4. FAA (2006) AC 150/5380-7A, airport pavement management program (PMP)
5. McNerney MT (2000) Airport infrastructure management with geographic information systems: state of the art. Transp Res Rec 58–64. https://doi.org/10.3141/1703-08
6. FAA (2014) AC 150/5380-7B, airport pavement management program (PMP)
7. Weso M, Iwanowski P (2020) APCI evaluation method for cement concrete airport pavements in the scope of air operation safety and air transport participants life. 1–14. https://doi.org/10.3390/ijerph17051663
8. Fuselier GK, Orandello BJ, Arze JM (2001) Customizing work planning with micropaver and paver-GIS Washington Dulles international airport case study. Proc - Int Air Transp Conf 181–191. https://doi.org/10.1061/40579(271)15
9. Butt AAD, Shahin MYD, Grovetti MR (1993) Airfield pavement management system. Proc Infrastruct Plan Manag 207–211
10. McNerney MT, Keegan KA (2011) The benefits of using a geospatial airport pavement management system at Denver and Tampa International Airports. TDI Congr 2011 Integr Transp Dev a Better Tomorrow - Proc 1st Congr Transp Dev Inst ASCE 255–270. https://doi.org/10.1061/41167(398)26

11. Greene J, Shahin MY, Alexander DR (2004) Airfield pavement condition assessment. Transp Res Rec J Transp Res Board 1889:63–70. https://doi.org/10.3141/1889-08
12. ASTM D 5340 (2018) Standard test method for airport pavement condition index surveys
13. Lam JC, Bryce JM, Priddy LP, Flintsch GW (2013) Development of infrastructure management strategies for small and mid-size airfields. Airf Highw Pavement 2013 Sustain Effic Pavements - Proc 2013 Airf Highw Pavement Conf 597–608. https://doi.org/10.1061/9780784413005.048
14. Noruzoliaee M, Zou B (2019) Airfield infrastructure management using network-level optimization and stochastic duration modeling. Infrastructures 4:2. https://doi.org/10.3390/infrastructures4010002
15. Hein DK, Aho B (2011) Preserving our airfield pavements. TDI Congr 2011 Integr Transp Dev a Better Tomorrow - Proc 1st Congr Transp Dev Inst ASCE 244–254. https://doi.org/10.1061/41167(398)25
16. Rada GR, Schwartz CW, Witczak MW, Rabinow SD (1992) Integrated pavement management system for Kennedy International Airport. J Transp Eng 118:666–685. https://doi.org/10.1061/(ASCE)0733-947X(1992)118:5(666)
17. Chen W, Yuan J, Li M (2012) Application of GIS/GPS in Shanghai airport pavement management system. Procedia Eng 29:2322–2326. https://doi.org/10.1016/j.proeng.2012.01.308
18. Yanti, Sunarjono S, Riyanto A, et al (2019) Visual assessment deterioration analysis of runways at Sultan Aji Muhammad Sulaiman Sepinggan Airport Balikpapan. AIP Conf Proc 2114. https://doi.org/10.1063/1.5112445
19. Shahin MY (2005) Pavement management for airports, roads, and parking lots, second. Springer US, Boston, MA
20. FAA (2014) AC 150/5380-6C: guidelines and procedures for maintenance of airport pavements
21. Shahin MY, Kohn SD, Lytton RL, Japel E (1981) Development of a pavement maintenance management system. Maint Manag
22. Freeman TJ, Borowiec JD, Wilson B, et al (2016) ACRP report 159 - pavement maintenance guidelines for general aviation airport management
23. AFI32-1041 (2017) Pavement evaluation program
24. Cafiso S, Di Graziano A, Goulias DG, D'Agostino C (2019) Distress and profile data analysis for condition assessment in pavement management systems. Int J Pavement Res Technol 12:527–536. https://doi.org/10.1007/s42947-019-0063-7