Research Status and Analysis of Residual Life of Airport Pavement

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Abstract: The remaining service life evaluation of airport pavement can well monitor the usage state of airport pavement concrete and provide basic information and safety data for the comprehensive evaluation of airport operation. The research status of the residual life of airport pavement at home and abroad is expounded and analyzed, and the research characteristics of the remaining life of the airport pavement are summarized.

Keywords: residual life; airport pavement; research status; prediction.

1. Introduction
In the entire air transport system, the airport is an important part of it. In the airport system, the activities of the airport need to be carried out around the airport road surface, which is the guarantee of the normal operation of the aircraft. Most airports have been built in our country are very early, many airports are built in 80s and 90s, the airport construction design theory is not perfect, in common aircraft loads and environmental factors, many of the airport pavement has been damaged obviously, seriously affected the normal operation of the airport. Moreover, with today’s peace and development becoming the theme of the world, many Military airports in China is also gradually turning to civil airports. The two will exacerbate the destruction of airports and reduce their service life after transformation because of the different service objects and design theories. If we do not pay attention to the performance of the airport road surface, it is likely to bring irreparable loss. Therefore, people urgently need to make a scientific and effective evaluation and prediction for the performance of airport pavement, and avoid huge losses caused by the deterioration of pavement performance.

At present, there is no unified method to study the residual life of the airport pavement at home and abroad. Most of the international civil aviation organization proposed the
residual life prediction of airport pavement according to the inverse process of airport pavement design method. With the development of finite element software, more and more people began to predict the residual life of airport pavement based on finite element software modeling.

2. Abroad Research Situations
The theoretical and practical research on the residual life of airport pavement is early in foreign countries. In the early 1970s, most of the Military airports built during the Second World War had been damaged, which affected the normal use of the airport. People needed to repair and rebuild the airport pavement. Therefore, the theory of airport pavement performance evaluation came into being. Because in the airport prediction on performance of surface before the road surface service performance theory research has made great progress and achieved many results, but the airport pavement and road surface in terms of structure, function and working environment has great similarity, therefore, the airport road surface performance study to a large extent from the road surface using performance evaluation results.
In 1870s, the American Institute of Architectural Engineering published the Research Report on the United States Air Force airport road surface maintenance management system. In the report, the establishment of road surface system performance evaluation system; on the runway of various types of damage are analyzed by statistics, the first calculation of pavement condition index (PCI) statistical methods; on the airport pavement damage condition of evaluation and analysis provides a theoretical basis for the later remaining life of airport pavement evaluation [1, 2]. On the basis of the famous pavement family theory, a method for determining the limit value of PCI is proposed in the MICRO-PAVER airport pavement residual life prediction system [3]. The IAPMS of Kennedy International Airport adopted the new pavement remaining life evaluation theory and predicted the remaining life by way of pavement family theory (PCI) and carrying capacity of pavement structure [4].
In the late twentieth Century, along with the development of science and technology, many achievements have been made in the field of aerospace. The new large aircraft, represented by the Airbus series and Boeing series, has appeared. It has put forward a severe test for the design and evaluation of airport pavement. For this reason, the National Airport Pavement Test Center (NAPTF) was set up in the United States. A series of experiments were carried out, and the LEDFAA design software based on the layered elastic system was compiled. The software is the first software that has the official authority of the United States. In 2004, NAPTF improved the LEDFAA software on the basis of full scale indoor test data. LEDFAA software not only has the design function to adapt to all kinds of large and medium-sized aircraft, but also evaluates and
predicts airport flexible, rigid pavement and composite structure pavement according to various parameters of airport pavement and calculates its remaining life [5]. Compared with other computing methods, LEDFAA software is more convenient, efficient, and not easy to make mistakes.

The inverse design method proposed by the International Civil Aviation Organization (ICAO) is a relatively mature method of calculation and has been widely accepted. The prediction method is: in the design of Airport Road, according to the airport operation and future development planning arrangements, determine the evaluation models of airport pavement types and related parameters, determine the number of function evaluation models using the total fatigue equations of concrete, then according to the calculation method of mechanical experience airport pavement thickness, until the meet the requirements by calculation; the remaining life of airport pavement inverse design method, we also need to determine the evaluation models, then obtain the relevant data of airport pavement according to the testing data of airport pavement design data or the scene, in the current concrete conditions, combined with the future traffic volume forecast, calculation of the remaining life span of the fatigue equation [6]. Many scholars based on the idea of reversion design method and applied the latest finite element software and the latest theory to build the residual life prediction model of airport pavement and have made many achievements.

Mc Nerney. M.T developed a new method for calculating the remaining life of airport pavement, which is called flow cytometry. Firstly, according to the actual testing data of Denver International Airport, it is proved that the original PCI computing method is problematic based on the actual data of Denver International Airport. Secondly, the Mc Nerney. M.T four different road surface based on the decay phenomenon, including fatigue, alkali silica reaction (ASR), cracking, spalling, developed a prediction model of the four decay modes of airport pavement based on residual life prediction model, the number of replacement can significantly save cement concrete pavement [7-9]. Shahin in the airport road surface prediction, the "road surface family" method is proposed. This method divides the pavement performance data that is basically similar into a family for overall regression analysis and obtains a single pavement performance curve by parallel moving method. On this basis, the remaining life of pavement is evaluated [10, 11]. Cook according to the road surface family theory, the proportion of incremental single pavement performance prediction value, but due to bear the load of aircraft panel is not uniform, and the existence of random factors, so its performance is still there is a big difference, the results are not accurate [12, 13].
3. Domestic Research Status

Compared with the research on the remaining service life of airport pavement abroad, China's theory and practice research is relatively late. But after many scholars' unremitting efforts, our country has also formed many mature theories and has been proved in practice. The first study of the remaining service life of the airport pavement in China is the Tongji University. Ling Jianming et al. Based on China civil aviation airport pavement design method, absorbing foreign outstanding research results and referring to the inverse design method proposed by the International Civil Aviation Organization (ICAO), we built the airport's residual life prediction and prediction model for the first time [14, 15]. But in China's civil aviation airport pavement design process, calculation of pavement thickness by the method of mechanical experience, easy to cause the design result is conservative; at the same time, at the airport in the design process, the evaluation models of thought, the operation frequency conversion of different aircraft into the evaluation model to simplify the operation, ignoring the different plane of airport pavement damage is not the same facts. Therefore, the inverse design method is a problem.

At present, the study of the remaining life of the airport pavement is mainly based on the construction of the prediction model based on the different parameters. Generally, mathematical algorithm is adopted. Meanwhile, based on the finite element software and combined with the measured data of airport pavement, a residual life prediction model for airport pavement is built according to different pavement indexes. Cai Liangcai and Chen Wenlai believe that the distribution of wheel tracks on airport pavement is not distribute uniformly on the width, but according to the distribution of normal function curves, so the theory of traffic coverage is introduced [16]. Taking full account of the stress distribution on the pavement panel under the action of aircraft load and selecting the location of the maximum stress on the pavement panel, combined with the track distribution curve of the aircraft, a residual life prediction model based on the cumulative damage is established [17]. Li Le, Cen Guoping and others believe that the calculation method of the residual service life belongs to the method of fixed value of the airport cement concrete pavement design method of inverse standard are not reliable; therefore Miner law and reliability based on science, put forward the concept of surface fatigue damage degree, the pavement reliability calculation program, finally proposes the prediction method of residual life of airport rigid pavement, comparison of cement concrete pavement design method and with the standard in [18]. Through the improved grey theory, Wang Guanhu constructed the residual life prediction model of the airport cement concrete pavement with the criterion of pavement breakage. He believes that the pavement damage degree can reflect the
strength of road surface, damage degree of 0.15 airport cement concrete pavement reaches a critical point; accumulated after processing the raw data into the grey model, thus eliminating the error of original data; after the actual test, the model predicts the damage degree error is less than 2.5% [19].

4. Analysis of the Research Status

The present situation of the residual life assessment and prediction of airport pavement at home and abroad is integrated, and the characteristics of the research on the remaining life of the airport pavement are summarized as follows:

1) The prediction and analysis of the residual life of rigid airport pavement is mainly based on two aspects, one is calculated in accordance with the inverse design method, modeling and analysis based on field test data, the result accords with the actual situation of concrete pavement; on the other hand is based on the Miner law, considering the aircraft damage accumulation of concrete the remaining life prediction model of rigid pavement, the method accords with the actual situation of the concrete effect of aircraft.

2) Scholars at home and abroad are analyzed by using the finite element software, and based on the theory of physical and mathematical algorithms, such as fuzzy AHP, the cumulative damage theory, grey model and linear mixed effect, to study the decay law of airport pavement performance, according to different indicators, the residual life prediction model of different road surface.

3) The current research focuses on the assessment and prediction of the structural residual life of the airport pavement, and the research on the functional residual life of the pavement is relatively small. The prediction of pavement functional residual life are: negative exponential curve model and S curve model, double exponential curve model, S inverse power series model, airport road surface functional residual life prediction method in present criterion proposed is based on double exponential curve model of anti S.

4) At present, there is no unified opinion on the residual life prediction model of airport pavement. Many prediction models and research programs have subjectivity. Some model parameters are based on engineering experience and probability calculation, and the accuracy needs to be checked. There is little accumulation of test data for airport pavement performance, and no continuous and systematic database can be formed. Therefore, it is difficult to verify the remaining life of pavement. At present, there is no relevant research on the airport pavement of special environment (cold area, high cold and so on), and the research is lack of pertinence.
5. Conclusion

The assessment of the remaining service life of the airport pavement can be used to monitor the use of the concrete on the airport pavement well. Through evaluation, we can know the structural performance and apparent performance of airport pavement concrete, and prevent the inevitable damage caused by larger diseases such as airport pavement panel breakage. The research status of the residual life of airport pavement at home and abroad is expounded and analyzed, and the research characteristics of the remaining life of the airport pavement are summarized.

References


