International Civil Aviation Organization

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Agenda Item 5: State's/Aerodrome Operator's update and best practices on – ACR-PCR Method of Reporting Aerodrome Pavement Bearing Strength

RIGID PAVEMENT DESIGN AND EVALUATION METHOD IN CHINA

(Presented by CHINA)

SUMMARY

This paper presents the airport rigid pavement design and evaluation methodology independently developed by China under the ACR-PCR framework. It describes the structural characteristics of rigid pavements in China, the theoretical basis and key features of China's rigid pavement design and evaluation method, a comparison with the FAARFIELD method, and its practical application.

1. INTRODUCTION

1.1 The ACN-PCN method has been in use for more than 40 years; however, its simplified model cannot reflect the cumulative damage effect of mixed traffic and lacks consistency with modern design procedures. The International Civil Aviation Organization (ICAO) adopted the ACR-PCR method in 2020, and it came into full effect in November 2024.

1.2 In response to ICAO's transition requirements, the Civil Aviation Administration of China (CAAC) organized a series of activities: improving the pavement design and evaluation calculation methods; developing pavement design and evaluation software; organizing data collection at transport airports nationwide and selecting representative airports for trial calculations and validation; completing the revision of relevant standards; organizing all transport airports nationwide to complete PCR calculations on schedule; updating aeronautical information; and conducting industry-wide training. Currently, China has successfully achieved a safe and smooth transition from ACN-PCN to ACR-PCR.

2. DISCUSSION

<u>China's Rigid Pavement Structural Calculation Model</u>

2.1 The CAAC rigid pavement design method and the FAARFIELD method share a common theoretical foundation and essentially the same basic logic. However, there are significant differences between the two in several key aspects. Specifically, the CAAC method adopts a K foundation model, while the FAA method uses an E foundation model. In terms of structural modeling, in the CAAC method, a two-layer (or three-layer) slab model is adopted, and the subbase course is not included in the combined modeling of the base and surface courses. The FAA method, by contrast, incorporates the subbase course together with the base and surface courses into a three dimensional finite element model for overall analysis. As for the Chinese practice, the typical pavement structure consists of the surface, upper base, lower base, subbase, and subgrade. In the calculation process, the reaction modulus at the top of the subgrade is input. Based on lookup tables and corresponding formulas, the reaction modulus at the top of the pavement bed can be obtained; the courses above the pavement bed are then incorporated into the two layer (or three-layer) slab finite element model for computation.

Load-Stress Database

2.2 The CAAC method constructs a load-stress database based on finite element calculation results under various working conditions, which significantly improves computational efficiency while maintaining accuracy. The database is built by categorizing parameters of pavement structure design into multiple graded levels. For example, the surface thickness has four levels, resulting in a total of 3,840 working conditions. Currently, a total of 1,520,640 data entries are involved in the database construction, and the load-stress database for general aviation aircraft is still being supplemented. During the database establishment, the ABAQUS script interface is employed, with Python scripts written for automation. A two-dimensional data table of the load-stress database is formed in the software. Since the working conditions in the load-stress database are finite, multi-dimensional interpolation is required to determine the load stress under specific working conditions when using the database. Evaluations have shown that the accuracy of the interpolation method can meet practical application requirements.

Revision Principles for the Fatigue Equation

2.3 The CAAC method revised the fatigue equation based on FAARFIELD, taking into account the structural features of pavements in China. The revision principles include:

a) Data for the fatigue equation are primarily based on structural fatigue test data.
b) Thickness trial computations are performed for the proposed fatigue equation, and the equation is then adjusted in light of engineering experience, taking into account the practical performance of cement concrete pavements used in China.
c) The deviation between the design thickness obtained by the adopted new fatigue equation and that based on the former code should be kept within a reasonable/acceptable range.

Selected Fatigue Equation

2.4 Three methods were tried to improve the fatigue equation. Method 3 was finally adopted.

a) Modification Method 1: Use the test data from the FAA fatigue equation, and adopt a 60% confidence level in the statistical regression.
b) Modification Method 2: The test data from the FAA fatigue equation are cleaned, applicable data are added, and the original regression approach is retained.
c) Modification Method 3: The data points and regression method from the FAA fatigue equation are retained; however, the parameter K0D is incorporated into the expressions for coefficients a and c.

Applications

2.5 Design and evaluation constitute an inverse pair of processes. Therefore, based on the same model foundation, both design and evaluation functions can be performed simultaneously. This integrated approach ensures seamless continuity from design to evaluation. As for the evaluation function, its core task is to determine the maximum aircraft mass that a pavement can sustain given known pavement structural conditions. The following describes the application of the ACR-PCR method and its specific implementation procedure, taking the evaluation work as an example. The evaluation procedure of the CAAC-PCR technique is as follows: determine the pavement structural parameters and the traffic parameters of aircraft types during the evaluation period → calculate the maximum cumulative fatigue damage CDFmax on the pavement induced by all aircraft types → determine the critical aircraft based on damage contribution ratio → determine the maximum allowable mass for the critical aircraft by referring to the thickness calculation method in the design specification → the corresponding ACR is the PCR, rounded to the nearest multiple of 10. This procedure applies the design method in a reverse manner for evaluation within a unified model framework, thereby ensuring consistency between evaluation results and design logic. Through practical evaluation and verification, the PCR conclusions obtained by CAAC-PCR are generally consistent with those of the FAA, with only minor differences, which further validates the reasonableness and reliability of the method.

Outlook for Future Work

2.6 Building on its existing work, China will continue to improve the methodology system for pavement design and evaluation. Key research directions include: clarifying the thickness calculation method for asphalt pavement structures in China's design specifications (currently under revision); developing the technical evaluation and calculation procedure for flexible pavement PCR and implementing it in the CAAC-PCR software; conducting application validation at multiple flexible pavement airports and completing the PCR evaluation software for both rigid and flexible pavements; and advancing the development of evaluation methods for complex structural forms such as asphalt overlay pavements and composite pavements. At the same time, China stands ready to strengthen exchanges and cooperation with ICAO Member States and international research institutions, share methodology development experience and validation data, and actively participate in technical coordination and standardization efforts for various national methods under the ACR-PCR framework. Together with the international community, China aims to promote the continuous improvement and coordinated development of the global airport pavement strength reporting system.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note that the ACR-PCR method allows States to use any design/evaluation method of their choice, and that the methodology developed by China, which is based on the Winkler foundation model and an improved fatigue equation, produces reasonable and reliable calculation results.

b) encourage Member States to exchange best practices in pavement design and evaluation methods, in particular experience in the development and application of States' own methods under the ACR-PCR framework.

c) encourage Member States and research institutions to cooperate in advancing the research and development of evaluation methods for complex pavement structures.

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