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RESEARCH IN AIRPORT PAVEMENTS

MAY 1977

SUMMARY REPORT

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Summary report of a conference held November 15-17, 1976, in Atlanta, Georgia.

16. Abstract

At the request of the Federal Aviation Administration, the Transportation Research Board conducted a conference on research in airport pavements to present the findings from recent research activities by FAA, to invite comments on the conclusions from these findings, and to address areas of future research needs. Based on presentations and discussions at the conference, research results that can now be implemented are in the following areas: (a) The pavement-aircraft compatibility study provides a basis for trade-offs between aircraft and pavement design; (b) aircraft distribution on airport pavements can be reasonably defined for design and rehabilitation purposes; (c) mix design and construction procedures for fibrous concrete are adequate to permit its use where appropriate; (d) mix design and construction procedures are adequate for porous friction courses and performance data demonstrate their suitability for in-service use; (e) suitable equipment and procedures are available for measuring pavement unevenness; and (f) statistical quality control and quality assurance procedures are well defined for use in pavement construction and rehabilitation. Areas needing further study are (a) documentation of pavement performance, especially the establishment of a framework and methodology for the systematic and continuous monitoring of pavement systems; (b) establishment of procedures for nondestructive testing and pavement evaluation; and (c) development of improved pavement design and rehabilitation procedures together with data for these procedures, including criteria for pavement unevenness for new surface construction, effects of frost on pavement performance, soil strength evaluation procedures, equivalency values for paving materials, and design criteria for continuously reinforced and prestressed concrete pavements.

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SUMMARY

At the request of the Federal Aviation Administration (FAA) the Transportation Research Board of the National Academy of Sciences appointed a program committee to plan, conduct, and summarize the Conference on Research in Airport Pavements. The objective of the conference was to present findings from recent research activities by FAA, to invite comments on the conclusions from these findings, and to indicate areas of future research needs.

The conference was held November 15-17, 1976, in Atlanta, Georgia. Topics of the five sessions were Pavement Management Systems, Pavement Design Considerations, Pavement Materials, Pavement Evaluation and Performance, and Performance Procedures and Summary of Federal Aviation Administration Research Program. The 227 participants were from 40 states and 14 foreign countries.

Based on presentations and discussions at the conference, research results that can be implemented now and require no further immediate research effort are in the following areas:

1. Pavement-aircraft compatibility,
2. Aircraft distribution on airport pavements,
3. Fibrous concrete mix design and construction procedures,
4. Porous friction courses,
5. Measurement of pavement unevenness, and
6. Statistical quality control and quality assurance procedures.

Those areas that were considered to be in need of further study are

1. Documentation of pavement performance, especially the establishment of a framework and methodology for the systematic and continual monitoring of pavement systems;
2. Establishment of procedures for nondestructive testing and pavement evaluation; and
3. Data for improved pavement design procedures including criteria for pavement unevenness for new surface construction, effects of frost on pavement performance, soil strength evaluation procedures, equivalency values for paving materials, and design criteria for continuously reinforced and prestressed concrete pavements.

The full proceedings of the conference will be published by the Transportation Research Board in Special Report 175.

INTRODUCTION

At the request of the Federal Aviation Administration, the Transportation Research Board planned and conducted the Conference on Research in Airport Pavements to present the results of research undertaken by FAA to update and revise its methodology for airport pavement design and rehabilitation and to provide feedback on airport pavement research needs.

The conference was held November 15-17, 1976, in Atlanta, Georgia. Included in the 227 participants were representatives of nearly all aspects of the profession including federal, state, and municipal governmental agencies, airport management and airport engineering agencies, aircraft manufacturing companies, educational institutions, and consulting firms. The participants were from 40 states and 14 foreign countries.

Conference sessions were on the following topics:

Pavement Management Systems;
Pavement Design Considerations;
Pavement Materials—Mix Design, Performance, and Quality Control;
Pavement Evaluation and Performance;
Performance Procedures and Summary of Federal Aviation Administration Research Program

At each session, which was approximately $\frac{1}{2}$ day in duration, several papers were presented and open discussions were conducted. Before the sessions began, each participant received a copy of FAA Report FAA-RD-74-35, Criteria for Airport Pavements.

This administrative report to FAA summarizes the session discussions, the conference overall, and the recommendations for implementation of research findings and research needs. The recommendations are those of the Program Committee prepared after all members had heard the conference presentations and the discussions that followed.

The full proceedings of the conference will be published by the Transportation Research Board in Special Report 175.

SUMMARY OF SESSIONS

Program Committee for the Conference on Research in Airport Pavements

PAVEMENT MANAGEMENT SYSTEMS

Primary discussions during this session centered on the development of pavement inspection and evaluation procedures and the incorporation of the results into pavement management systems. Particular interest was shown in developing pavement inspection programs and correlating observed distress to performance. Several questions were asked of speaker Arntzen regarding the cost of his inspection and pavement evaluation programs. He suggested that periodic (twice yearly) inspection and yearly nondestructive testing (NDT) and evaluation for six runways could be done for $25 000 to $30 000/year.

Questions submitted to speaker Hutchinson after the session indicated some confusion regarding the importance and implementation of the Aircraft-Pavement Compatibility Study. The discussion indicated that the introduction of the 680.4 to 907.2-Mg (1.5 to 2.0 million-lb) aircraft is not expected in the near future.

Several participants asked about runway grooving, particularly its effectiveness, performance, and durability. The ability to regroove or resurface over grooved concrete and asphalt-surfaced pavements was also discussed. None of the participants presented objective data on these subjects, but the consensus seemed to be that grooving was effective and was relatively long lasting especially in concrete runways. No particular problems were reported to have occurred during the regrooving or resurfacing of grooved pavements (either asphalt or concrete surfaced).

PAVEMENT DESIGN CONSIDERATIONS

Many questions and considerable discussion were directed to the equivalency factors presented for the various paving materials. Several participants stated that the equivalency values should not be constant and unique quantifiers of a material, but should reflect the influence of the pavement system and especially the properties of the subgrade soil on how various materials affect pavement performance. The effect of the frost design procedures on the relative equivalency values was questioned, but it was apparent that no objective information defining this relation is available. The thrust of these concerns and questions seemed to be that, if valid design procedures were developed, they should incorporate actual material properties so that the material properties would not need to be expressed in terms of the equivalency values.

With regard to the revised design procedures for flexible pavements that are under development and were summarized by Barker, questions were added concerning validation procedures and methods of evaluating paving material and subgrade properties for inclusion therein. Most questions related to implementation and use of the procedure rather than to the basic approach, although concern was expressed that the procedure seemed somewhat oversimplified for a comprehensive rational design. The point that the proposed procedure was a first iteration of a possible multiple iterative approach seemed to be missed by most participants.

The number of comments and questions about fibrous concrete indicated a high degree of interest in this subject. The questions or comments did not seem to question fibrous concrete as a potential paving material, but indicated a need to develop performance history for the material under realistic service conditions.

Several questions about the effects of frost and permafrost on design and performance went unanswered, suggesting a need for further studies in this area.

There were several comments and questions concerning FAA's change to the Unified Soil Classification System. An essential point made by Horn was that the unified system is intended to classify soils only insofar as their susceptibility to frost and moisture, but that the actual pavement design would be based on an evaluation of the strength of the subgrade soil.

PAVEMENT MATERIALS—MIX DESIGN, PERFORMANCE, AND QUALITY CONTROL

The major discussion in this session centered on the statistical quality control procedures and especially the typical values developed for limiting the variability of the materials. Great concern was expressed over the assignment of penalties for inferior quality material. A question was posed as to whether the suggested penalties were reflective of the potential loss in performance of the total pavement system or were arbitrary values. It was pointed out that there is a basic difference between quality control and quality assurance testing and that these concepts should be kept separate. The thrust of the discussion was that the concept of statistical procedures for quality assurance is good, but the participants were not willing to accept either the levels of variability indicated in the presentations or the penalties suggested. More data are obviously needed to justify the suggested values before these procedures can be applied.

There were several questions and some discussion about the effectiveness of the porous friction course (PFC) and the problems of tire rubber buildup and removal. The performance and cost-effectiveness of the PFC have been reported to be generally good, but further study is needed of rubber removal and procedures for overlaying pavements having PFC surfaces.

The edge curling of fibrous concrete slabs was discussed and, although the phenomenon was never fully explained, it appears there may be a need to observe and analyze curling in thin fibrous concrete overlays and the effect of curling on the performance of these systems.

PAVEMENT EVALUATION AND PERFORMANCE

The discussion in this session included questions related to the framework for evaluation and performance of pavements presented by Witczak. These questions focused on the effect of subgrade properties on the evaluation procedure and the relative importance of sampling versus nondestructive testing. Witczak believes that some sampling tests will always be needed to complement NDT evaluation.

The discussion of commercial aircraft gear loads brought out two facts: (a) Dynamic wheel loads in excess of the static wheel loads can occur during takeoff and landing, and (b) most aircraft operations are concentrated nearer the centerline of the pavements than was previously believed. This suggests the use of keel (thickened center) sections as a practical approach to new pavement design. It was brought out that thicker overlays near the center of the pavements would be over the areas with the most frequent traffic loading. It was noted, however, that with some pavements there would have to be a waiver of the maximum transverse slope in order to use a nonuniform overlay.

The lack of a criterion for tolerable runway unevenness was discussed, but no consensus was reached regarding the need for such a criterion. Some suggested that pavement unevenness may lead to fatigue failure of aircraft components, but this was disputed by representatives of aircraft manufacturers, who pointed out that, since aircraft spend so much more time in motion in the air than on the ground, any cumulative structural damage during ground operations is insignificant.

PERFORMANCE PROCEDURES AND SUMMARY OF FEDERAL AVIATION ADMINISTRATION RESEARCH PROGRAM

In this session, and to some extent in the preceding one, there were some lively discussions on the merits and validity of nondestructive testing and evaluation of pavements and the procedures for doing so. The questions centered on two main topics: (a) Can results from NDT be used to determine pavement rehabilitation requirements? and (b) Which of the NDT procedures and corresponding methods of pavement evaluation is best? Correlative questions dealt with whether NDT procedures can stand alone in evaluating pavements or whether other forms of sampling and tests are also required. The consensus was that much can be done to improve the nondestructive testing and evaluation procedures to make them more self sufficient, but that some form of sampling and testing is necessary to define critical properties of paving materials and pavement sections. Much interest was shown in the development of validation procedures for NDT and pavement evaluation. It was noted that at this time all validation is made strictly on the basis of correlation with results from earlier pavement evaluation procedures. There were several suggestions that NDT and evaluation procedures should be on a more fundamental basis.

Another point of discussion dealt with whether a method of NDT and pavement evaluation should be selected from the two presented at the conference and currently being applied on an experimental basis or whether the development of more techniques should be encouraged. This question was not satisfactorily resolved: The "fundamentalists" appeared to favor development of more and improved procedures, and the operational people appeared to favor selecting one or two procedures and approving them for application and implementation. It is apparent that more research is needed on the NDT procedures and the concomitant pavement evaluation.

SUMMARY OF CONFERENCE

Carl L. Monismith, University of California, Berkeley, conference chairman

The emphasis at the outset of the conference was that pavement design and rehabilitation should be considered within a management framework and that the results of research presented at the conference should add specific information to facets of this overall management system. It is worthwhile to reiterate this point. Fortunately, to think of a specific airport within this context is easier as compared to a highway network because of the limited range in soil conditions and a reasonably constant environment.

Material presented by Arntzen on performance evaluation including the measurement of pavement structure response represents an example at Chicago O'Hare Airport of some of the data that must be obtained on a systematic and continuing basis to ensure that the management system will work effectively.

Material presented by Ledbetter indicates that for smooth pavements the aircraft dynamic load effect is not a problem. However, it is possible that rough pavements may contribute to increased loads, which will accelerate the pavement deterioration process. His data also indicate that turning movements should receive additional consideration because of the increase in load on the gear of the aircraft during the turning process.

Design procedures that can be implemented were presented by Parker, for thickness selection for continuously reinforced concrete, fibrous concrete, and prestressed concrete pavements. In addition, guidelines for mix design for the fibrous concrete have been suggested. The problems of cost and long-term performance of this material, however, still have to be addressed.

McKeen presented guidelines for improved procedures to analyze and "design" pavements to be constructed on swelling soils. Implementation of these procedures awaits the results of additional studies.

The change to the Unified Soil Classification System represents a step forward in FAA methodology. In addition, the requirement that a soil strength California bearing ratio (CBR) be used for pavement thickness selection is an important addition to the design requirements.

Layer equivalencies that have been developed from field tests for various treated materials at the U.S. Waterways Experiment Station were suggested by Hammitt. The specific values presented raised questions among the participants; accordingly, these values should be examined carefully before use.

Pavement design for frost and permafrost conditions has been updated, as reported by Johnson. He noted, however, that research is still required in this area, particularly when stabilized layers are to be considered as part of the pavement structure.

Improved methodology being developed by the Waterways Experiment Station for FAA was introduced by Barker. The material he presented is the first iteration in the development of an improved design procedure. It is important to emphasize the point made by Hutchinson that this improved methodology is useful for structural rehabilitation as well as new design. As a matter of fact, applicability to rehabilitation may overshadow the usefulness in new design, particularly in the next few years. Although the Waterways Experiment Station has selected specific criteria for this improved methodology, other criteria are also in use, e.g., those developed by Shell and the Asphalt Institute for design of airfield pavements. (Recent developments by a number of groups in improved design and rehabilitation methodology will be presented and described at the Fourth International Conference on the Structural Design of Asphalt Pavements in August 1977 at Ann Arbor, Michigan.)

Data presented at the conference indicate that the porous friction course is a suitable alternative to grooving asphalt concrete pavements to reduce the potential for hydroplaning. White presented guidelines for both mix design and construction for this open-graded asphalt concrete. Although there has been tire rubber buildup at the pavement surface on a number of porous friction course surfaces, the minimal amount of reverted rubber at the Salt Lake City Airport suggests, as reported by Duggan, that it may be desirable to consider larger maximum-size aggregate (19.1 versus 12.7 mm or $^3/_4$ versus $^1/_2$ in) for these mixes. With the larger maximum size, it may be necessary, however, to consider modified asphalts such as the rubberized material used at Salt Lake City.

The performance of overlays in porous friction courses has raised some question as to what should be done to these porous mixes prior to overlays. For example, water might accumulate in this pervious layer. As temperatures in the overlay increased, the moisture or moisture vapor in the porous layer could have a deleterious effect on the overlay. Additional studies of field performance appear warranted.

E. R. Brown, Reid H. Brown, and Wathen emphasized that statistical quality control should be used as soon as practicable in airfield construction. Although the values reported by E. R. Brown may serve as a guide, the tolerances to use for specific jobs should be developed on the basis of experience in a particular area. This point was emphasized by a number of discussants.

The need for rational evaluation of performance of existing pavements was emphasized. Moreover, the necessity for obtaining quantitative as well as subjective measures of performance was stressed. The use of the concept of functional failure as noted by Witczak as a part of the management framework provides a reasonable basis for making decisions as to when to undertake rehabilitation. It would appear that the response of aircraft to pavement roughness may be a useful method for defining this functional failure, e.g., the methodology described by Gerardi. Specific criteria have not been defined as yet according to Sonnenburg. The laser profilometer provides a quick tool for determination of runway profile and should prove to be useful in the evaluation process.

Nondestructive testing provides an improved procedure for evaluating structural performance. Although the procedures developed by Hall and Yang and presented at this meeting have received support from FAA, it must be recognized that there are other procedures, e.g., those discussed by Barenberg. A number of groups have been using such procedures for several years.

As noted at the outset of this summary, it is imperative that performance data be developed on a systematic and continuing basis. Data feedback to the design and rehabilitation process is absolutely essential. Fortunately, the management system concept provides a framework within which this can be accomplished.

It is strongly recommended that airport engineering staffs conduct performance evaluations now even though FAA guidelines are not yet available. Sufficient experience is available to permit such evaluations. The indications from those who have already undertaken such evaluations are that the procedures are cost effective. As a part of this process, it is important to verify the performance of overlays as well. When airfields are evaluated, it may be desirable, as Witczak noted, to establish different rehabilitation criteria for runways and taxiways.

All conference speakers emphasized that engineering judgment is required. One must be careful to heed this advice and not expect everything to be written in simple statements. In effect, FAA circulars must be viewed in this light in that they are advisory and provide guides that, when used with judgment, will permit effective use of resources for airfield pavements. The research and development effort sponsored by FAA and presented at this conference provides engineers concerned with the design and rehabilitation of airfield pavement systems a way to improve their capabilities for better engineered structures.

RESEARCH RECOMMENDATIONS

Program Committee for the Conference on Research in Airport Pavements

The Program Committee evaluated the conference presentations and discussions, giving special attention to those research results presented that were acceptable by conference participants as requiring no immediate further research and to those that were not altogether in accord with the views of the participants. If these differences could not be reconciled by available information, then the committee concluded that more research is needed.

RESEARCH RESULTS THAT CAN BE IMPLEMENTED

Pavement-Aircraft Compatibility

Results of the Aircraft-Pavement Compatibility Study provide a basis for trade-offs between aircraft and pavement design. It is now apparent that aircraft in the 680.4 to 907.2-Mg (1.5 to 2.0 million-lb) category, the possibility of which led to this FAA study, will not be introduced in the foreseeable future. Thus, any further effort along these lines would have little immediate return.

Aircraft Distribution on Airport Pavements

Results from the study of aircraft distribution on airport pavements were well accepted, and these findings should be incorporated into the design methodology. To take full advantage of the findings in pavement overlay design will require a review of the limiting criteria for transverse slopes for airfield pavements. In the design of new or replacement sections, the results of this research should also permit thickness changes in the transverse direction of runway pavements.

Fibrous Concrete

Mix design and construction procedures for fibrous concrete appear adequate, and only long-term performance data are needed before design and construction standards are established for the material.

Porous Friction Courses

Mix design, construction procedures, and performance data on porous friction courses appear adequate to justify implementation of this technology. Some additional information on optimum aggregate size and gradation and on maintenance and rehabilitation procedures is needed, but it is believed that this can best be obtained from in-service installations of this material.

Pavement Unevenness

Procedures for measuring pavement unevenness appear well advanced, and relating runway profile data to an aircraft response model appears to provide a meaningful way to evaluate pavement unevenness. Acceptable pavement unevenness criteria for aircraft operations are not available, and there are some serious questions as to whether such criteria are needed or desirable. For construction acceptance, criteria for new pavement and pavement overlays appear to be desirable and should be pursued further.

Statistical Quality Control and Quality Assurance

Application of statistical procedures for quality control and quality assurance testing is well accepted by the profession. Typical values indicating levels of material variability and limit[illegible]ues for acceptability and penalties are function[illegible]ection and construction procedures. It is r[illegible]ded that the statistical control and assurance [illegible] be implemented but that the basis and crite[illegible]ssigning penalties be reviewed before implementation.

FURTHER RESEARCH REQUIRED

Three areas appear to require additional investigations: documentation of pavement performance, validation of nondestructive test procedures, and improved pavement design. Some of the studies listed in one area will overlap into other areas.

Documentation of Pavement Performance

The most critical need in the area of documenting pavement performance is the establishment of a framework and the methodology for systematic and continual monitoring of pavement systems. Among the items that must be established are

1. Frequency of visual inspection;
2. Frequency of pavement evaluation tests such as nondestructive, roughness measurements, and skid measurements;
3. Descriptors of what to look for and how to identify and describe pavement distress and its causes; and
4. Traffic count procedures including estimation of critical wheel loads and traffic patterns.

In addition, studies should be initiated to

1. Incorporate the findings from the traffic distribution study into the pavement design and evaluation procedures,
2. Document the performance of pavements with fiber reinforced concrete, and
3. Document the performance of porous friction courses (PFC) and establish procedures for maintenance and rehabilitation of pavements with PFC surfaces.

Validation of Nondestructive Testing Procedures

Evaluation of the structural response of pavements by nondestructive testing procedures has the potential to provide important data to assist paving engineers in the management of airport pavement systems. Currently there are a number of NDT methods and associated procedures for pavement evaluation.

1. WES 16k vibrator operated in the load sweep mode (a static load superimposed by a sinusoidal dynamic load of varying amplitude at a constant frequency);
2. WES 16k vibrator operated in the frequency sweep mode (a static load superimposed by a sinusoidal dynamic load of constant amplitude but at varying frequency);
3. Air Force 9k vibrator, which has loading capabilities similar to those of the WES 16k vibrator but with a lower static load and a smaller maximum capacity;
4. Road rater, which can be custom made with a wide range of load and frequency capacities that even approach those of the WES vibrator;
5. Dynaflect test machines;
6. WES heavy-load vibrator, which is a nonmobile tester with the potential for high load amplitudes;
7. Cox vibrator, which is van mounted, applies a sinusoidal dynamic load to the pavement with a range of load amplitudes and frequencies, and differs from the WES, Air Force, road rater, and Dynaflect equipment in that it does not apply a static load on the pavement being tested but uses a trailer-mounted, remotely supported mass as a reaction for the applied loads;
8. Falling-weight deflectometer (introduced by the French and further developed by the Royal Dutch Shell Company), which applies a load most nearly approximating a moving aircraft load;
9. Wave-propagation techniques, which involve the use of vibratory equipment at the pavement surface to generate waves and the measurement of the rate of wave propagation in the pavement components rather than the measurement of pavement response to load as with the other test procedures;
10. Benkelman beam, which is a well-known method for measuring pavement surface deflections under slow-moving vehicles and is highly developed for use on highway pavements; and
11. Pavement deflection signature equipment, which is an expansion of the Benkelman beam in that the deflection-measuring equipment is mounted on the test vehicle and claims to measure the pavement surface deflection throughout the deflection basin under loads moving at low speeds.

At this conference only the procedures associated with the WES 16k vibratory load were discussed since this equipment has been developed with support from FAA. The Program Committee recognizes that many techniques are available and agrees with the conference comments that NDT should not be limited by FAA to nondestructive vibratory testing with the 16k equipment.

Thus, because of the diversity of equipment and procedures available and the potential new NDT procedures not yet put forth, the question arises as to whether validation procedures should be developed for one or two of the more advanced tests and evaluation procedures or guidelines developed for validation procedures that might be applicable to a broad range of NDT equipment and pavement evaluation methodologies. The committee recommends that the latter course be followed.

Since the procedures and criteria would have broad implications for and impact on the management of airport pavement systems, the committee recommends that an advisory panel be appointed to establish recommended procedures and criteria and to evaluate the results of validation studies using the various equipment. In the development of the validation procedures the committee recommends that the advisory panel consider the following:

1. Definition of the role and limitations of NDT,
2. Testing of existing pavements rather than specially instrumented test sections, and
3. Incorporation of climatic and environmental factors as part of the evaluation process.

To validate any of the NDT procedures will require performance data for existing pavements including those with overlays, and obtaining those data will require time. Therefore, so that the process may begin as soon as possible, the committee recommends that the procedures provide a measure of the stiffness characteristics of the various pavement components, particularly for subgrade materials, to permit comparisons to be obtained.

The burden of defining the potential usefulness of any new methods that are proposed lies with the developer. Promising procedures, after review by the advisory panel, could receive additional support for further development.

Improved Pavement Design

Before additional iterations for improvement in the design procedures can be developed, additional studies are needed in the following areas.

Pavement Unevenness

Some unevenness criteria are needed as a basis for control over construction operations. The current straightedge criterion is not consistent with the functional requirements of airport pavements. Thus, for unevenness of new pavement surfaces, new criteria are needed that can be related to the pavement functional requirements and to the latest technology for measuring runway roughness.

Design for Frost Effects

New design criteria have recently been developed for pavements in areas of frost penetration. Questions raised at the conference regarding the effect of stabilized layers on the frost design criteria could not be resolved within the current state of the art. Further studies are needed to fully understand the effects of frost action on pavement systems with stabilized materials.

Soil Classification and Soil Strength Measurement

The discussion on soil classification and its relation to pavement design indicated some confusion about the relative roles of soil classification versus soil strength evaluation. The Program Committee believes that the unified system is an effective scheme for classification of soils for moisture and frost susceptibility. Needed for evaluating the soil strength parameters are improved procedures that can be incorporated into the pavement design procedure. Ideally, soil strength measurement procedures should provide soil strength parameters that are consistent with pavement design procedure and pavement evaluation when NDT procedures are used. This requirement suggests that the soil evaluation test procedures should include dynamic testing, for most soils have significantly different properties under static and dynamic loads. Studies to develop procedures for measuring soil strength parameters for pavement design and evaluation are strongly recommended and should be given a high priority in any future research program.

Equivalency Values

Equivalency values for paving materials have great appeal because of the manner in which such parameters simplify the design procedure when one deals with a number of different paving materials. However, because the physical characteristics of many of these materials are different, the modes and causes for pavement distress are often different. Consequently, some severe constraints must be placed on the use of any equivalency value assigned to any paving material.

The equivalency values presented at the conference raised many questions. A number of participants pointed out that a different equivalency ratio between any two materials must exist for almost every significant change in subgrade support, loading, environment, use in the pavement system, and even time of loading. With this many variables, either a range of equivalency values must be given for each material or the conditions for which the equivalency values are valid must be carefully spelled out.

A question was raised as to whether equivalency values are even necessary. If procedures are developed to incorporate real properties of component paving materials into the design process, there should be no need to develop equivalency values for the various materials. If it is determined that such parameters are necessary, studies must be undertaken to carefully delineate appropriate equivalency values for each paving material and the constraints under which such values are valid.

Continuously Reinforced and Prestressed Concrete Pavements

Both continuously reinforced concrete and prestressed pavements appear to have potential for excellent performance at reasonable costs. Design criteria are lacking, however, and it is impossible to optimize the design of these pavement systems. Additional design criteria, based on parameters such as allowable stresses and strains in the pavement components, allowable deflections, and allowable subgrade strains, are needed before the designs can be optimized. The committee recommends that further studies to develop the additional information needed to establish realistic design criteria be given high priority.

CONFERENCE PAPERS AND PRESENTATIONS

PAVEMENT MANAGEMENT SYSTEMS

1. Background of Federal Aviation Administration Research Program, Charles L. Blake, Federal Aviation Administration
2. Introduction and Pavement Management Procedures, Carl L. Monismith, University of California, Berkeley
3. Airport Pavement Management Procedures, Donald M. Arntzen, Chicago Department of Public Works
4. Airport Pavement Compatibility Study, Ronald L. Hutchinson, U.S. Army Engineer Waterways Experiment Station

PAVEMENT DESIGN CONSIDERATIONS

1. Design of Pavement With High-Quality Structural Layers, George M. Hammitt II, U.S. Army Engineer Waterways Experiment Station
2. Introduction of Improved Methodology for Pavement Design, Walter R. Barker, U.S. Army Engineer Waterways Experiment Station
3. Concrete Pavement Design Considerations: Fibrous Concrete, Continuously Reinforced Concrete, Prestressed Concrete, Frazier Parker, Jr., U.S. Army Engineer Waterways Experiment Station
4. Pavement Design for Frost and Permafrost Conditions, Thaddeus C. Johnson, U.S. Army Engineer Cold Regions Research and Engineering Laboratory
5. Pavement Design for Swelling Soils, R. Gordon McKeen, University of New Mexico
6. Soil Classification, Frederick Horn, Federal Aviation Administration

MATERIALS: MIX DESIGN, PERFORMANCE, AND QUALITY CONTROL

1. Development of Statistical Quality Control Requirements, E. R. Brown, U.S. Army Engineer Waterways Experiment Station
2. Material Variability, R. H. Brown, Vulcan Materials Company
3. Application of Statistical Quality Control at Space Shuttle Facility, T. R. Wathen, U.S. Army Engineer Southern Pacific Division
4. Mix Design, Construction, and Performance of Porous Friction Courses, Thomas D. White, U.S. Army Engineer Waterways Experiment Station
5. Effectiveness, Skid Resistance, and Antihydroplaning Potential of Porous Friction Courses, Leo F. Duggan, Airport Operators Council International, Inc.
6. Mix Design and Performance of Fibrous Concrete, Frazier Parker, Jr., U.S. Army Engineer Waterways Experiment Station
7. Fibrous Concrete Construction at Reno and Las Vegas, Robert Lowe, McCarran International Airport

PAVEMENT EVALUATION AND PERFORMANCE

1. Framework for Evaluation and Performance, Matthew W. Witczak, University of Maryland
2. Commercial Aircraft Gear Loads: Static and Dynamic, R. C. O'Massey, Douglas Aircraft Company
3. Aircraft Wheel-Path Distribution on Pavements, Victor A. HoSang, Howard, Needles, Tammen and Bergendoff
4. Dynamic Load Effects, Richard H. Ledbetter, U.S. Army Engineer Waterways Experiment Station
5. Aircraft Response to Unevenness, Anthony Gerardi, U.S. Air Force Flight Dynamics Laboratory
6. Pavement Unevenness: Measurement and Criteria, Paul N. Sonnenburg, U.S. Army Construction Engineering Research Laboratory
7. Nondestructive Testing: Dynamic Stiffness Measurements, James W. Hall, Jr., U.S. Army Engineer Waterways Experiment Station
8. Nondestructive Testing: Frequency Sweep, Nai C. Yang, Consultant, Katonah, New York

PERFORMANCE PROCEDURES AND SUMMARY OF FEDERAL AVIATION ADMINISTRATION RESEARCH PROGRAM

1. Summary Comparison of Nondestructive Testing Methods, Ernest J. Barenberg, University of Illinois at Urbana-Champaign
2. Field Performance of Airport Pavements, Ronald L. Hutchinson, U.S. Army Engineer Waterways Experiment Station; Matthew W. Witczak, University of Maryland; Donald M. Arntzen, Chicago Bureau of Engineering; and Joseph P. Bellanca, Tippetts-Abbett-McCarthy-Stratton
3. Implementation of Results of FAA Research Program, Edward Aikman, Federal Aviation Administration
4. Current and Future Programs in Pavement Research: Design, Hisao Tomita, Federal Aviation Administration
5. Current and Future Programs in Pavement Research: Airport Development Air Program Support, Carl L. Schulten, Federal Aviation Administration

CONFERENCE PARTICIPANTS

Aikman, Edward, Construction Standards Branch, Federal Aviation Administration

Anderson, Robert L., Division of Aeronautics, Wisconsin Department of Transportation, Madison

Argue, Glen H., Airside Surfaces Section, Transport Canada, Ottawa

Arntzen, Donald M., Airport Programs Section, Chicago Bureau of Engineering

Barenberg, Ernest J., University of Illinois at Urbana-Champaign

Barker, Walter R., Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi

Barksdale, Richard D., School of Civil Engineering,

Georgia Institute of Technology, Atlanta
Barnett, Carl J., Airports Authority of Jamaica, Kingston
Beale, Edward L., Washington Airports District Office, Falls Church, Virginia
Bellanca, Joseph P., Tippetts-Abbett-McCarthy-Stratton, Washington, D.C.
Berge, C. Frederick, Kansas City Aviation Department, Missouri
Blake, Charles L., Airport Division, Federal Aviation Administration
Boothroyd, James D., Hoyle Tanner and Associates, Inc., Manchester, New Hampshire
Boyer, Robert A., Toltz, King, Duvall, Anderson and Associates, Inc., St. Paul, Minnesota
Boyett, Verney, Bureau of Aeronautics, Tennessee Department of Transportation, Nashville
Breihan, Erwin R., Horner and Shifrin, Inc., St. Louis
Briggs, Robert C., Civil Engineer (Instruction), Federal Aviation Administration Academy, Aeronautical Center, Oklahoma City
Brown, E. R., Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi
Brown, W. J., Project Management Branch, Transport Canada, Ottawa
Brown, James L., Texas State Department of Highways and Public Transportation, Austin
Brown, Reid H., Vulcan Materials Company, Birmingham, Alabama
Buchanan, R. H., Canada Department of National Defence, Ottawa
Bufford, John, Bureau of Aeronautics, Tennessee Department of Transportation, Nashville
Bushee, James W., Airports Engineering Division, Federal Aviation Administration

Carstens, Clifford W., Federal Aviation Administration, Des Plaines, Illinois
Carter, Archie F., Southern Roadbuilders, Inc., Augusta, Georgia
Cawley, Martin L., CRC Group, Associated Reinforcing Bar Producers, Chicago
Chambers, Charles F., Piedmont Engineers, Greenville, South Carolina
Chen, Hsien Lin, Construction Department, Taoyuan International Airport, Taipei, Taiwan
Childs, Walter R., Bristol, Childs, Crowder and Associates, Inc., Coral Gables, Florida
Chiu, Chang-Hsien, Construction Department, Taoyuan International Airport, Taipei, Taiwan
Clemens, David E., Planning and Design Branch, Southern Region, Federal Aviation Administration
Colony, David C., University of Toledo
Coppens, M. H. M., Fugro-Cesco Consultants, Arnhem, Netherlands
Cote, Michael, Civil Engineering Service, Paris Airport, France
Cram, Milton B., Federal Aviation Administration, Burlington, Massachusetts

Danielski, Jeff, Engineers Testing Laboratories, Inc., Phoenix
Davidson, Cram M., Engineering Section, Federal Aviation Administration, Los Angeles
Davis, John R., Massachusetts Port Authority, East Boston
Dehn, Ervin N., Jr., Sverdrup and Parcel and Associates, Inc., Silver Spring, Maryland
Denayer, Joseph R., Regie Des Voies Aeriennes, Brussels
Desmarais, Michel, Ciment Independant Inc., Montreal
Devasenapathy, C., International Civil Aviation Organization, Montreal

DiRenzo, John P., Production and Technical Services, Highway Materials, Inc., King of Prussia, Pennsylvania
Dixon, Donald E., Law Engineering Testing Company, Atlanta
Douglas, Charlie, CMI Corporation, Oklahoma City
Dray, Frank L., Potter's Industries, Inc., Apex, North Carolina
Drechsel, Ralph H., Howard, Needles, Tammen and Bergendoff, Milwaukee
Dresser, J. D., Jacksonville Port Authority, Florida
Drobny, Dennis P., Portland Cement Association, Atlanta
Duggan, Leo F., Airport Operators Council International, Washington, D.C.
Dykes, J. W., Phillips Fibers Corporation, Greenville, South Carolina

Eck, Carl F., Air Line Pilots Association, Washington, D.C.
Edelen, William F., Jr., Law Engineering Testing Company, Jacksonville, Florida
Emery, Donald K., Jr., Georgia Department of Transportation, Atlanta

Finn, Fred N., Ben Lomond, California
Flosdorf, Herbert W., MCA Engineering Corporation, Newark, Delaware
Foster, Charles R., National Asphalt Pavement Association, Riverdale, Maryland
Franklin, Albert, KZF Environmental Design Consultants, Inc., Cincinnati
Frauenshuh, Ray R., G. J. Paving Company, St. Paul
Fripp, John L., Georgia Department of Transportation, Atlanta

Gillespie, Samuel S., Office of Chief of Engineers, U.S. Department of the Army
Goetz, W. H., Purdue University, West Lafayette, Indiana
Gomez, Ernest, Jr., Federal Aviation Administration, Seattle
Greene, James L., Federal Aviation Administration, College Park, Georgia
Greer, Wilbur Charles, Jr., Law Engineering Testing Company, Atlanta
Grice, Bobby R., Florida Department of Transportation, Chipley
Griffith, Richard W., Airports Division, Federal Aviation Administration, Anchorage, Alaska
Grimaldi, Alfred, Port Authority of New York and New Jersey, New York
Grossell, Armin J., Metropolitan Airport Authority, Moline, Illinois
Guinnee, John W., Transportation Research Board, Washington, D.C.
Guth, Herbert J., Transportation Research Board, Washington, D.C.

Hall, James W., Jr., Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi
Hammitt, George M., Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi
Harr, Milton E., School of Civil Engineering, Purdue University, West Lafayette, Indiana
Harvey, Walter Blair, Airports Division, Federal Aviation Administration, Fort Worth
Hayman, Donald M., Australia Department of Transport, Melbourne
Hewett, Ronald N., Airports Authority of Jamaica, Kingston

Higgins, James L., Airports District Office, Federal Aviation Administration, Memphis
Hokanson, Lawrence D., Institute of Technology, U.S. Air Force, Wright Patterson Air Force Base, Ohio
Horn, Fred, Federal Aviation Administration
HoSang, Victor A., Howard, Needles, Tammen and Bergendoff, Alexandria, Virginia
Huntzinger, Harold S., Salt Lake City International Airport
Hutchinson, Ronald L., Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi

Jay, Elton E., Airports District Office, Federal Aviation Administration, Jackson, Mississippi
Jaycox, Claude E., Municipal Testing Laboratory, Hicksville, New York
Johnson, Thaddeus C., U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire
Jonas, Ernest, Tippetts-Abbett-McCarthy-Stratton, New York
Jones, Dennis, Amax Resource Recovery Systems, Inc., Smyrna, Georgia
Jones, Michael P., Naval Facilities Engineering Command, Alexandria, Virginia
Jordan, Jerry M., City of Birmingham, Alabama

Kaiser, Richard B., United Air Lines, Chicago
Keckler, A. R., Burns and McDonnell Engineering Company, Kansas City, Missouri
Kemahli, Ali S., Louisiana Department of Highways, Baton Rouge
Kerlin, T. R., Atlanta Airport Engineers, College Park, Georgia
Kimbrough, Duke S., Florida Department of Transportation, Fort Lauderdale
Klenk, Richard F., Plant and Structures Division, Port Authority of New York and New Jersey, Jamaica, New York
Knoblock, George C., WNKBS-Envirodyne, Chicago
Knop, Carl O., Professional Engineering Consultants, Wichita
Korzeniowski, Bohdan N., Philadelphia Division of Aviation

Lacroix, Didier, Service Techniques des Bases Aeriennes, Paris
Lamb, D. W., Acres American, Inc., Buffalo
Land, Frederic A., Pavement Systems, Inc., Landenberg, Pennsylvania
Larson, Rick E., W. J. Reese and Associates, Inc., Rock Island, Illinois
Ledbetter, Richard H., Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi
Lednak, John J., Federal Aviation Administration
Leo, Nick, Airports District Office, Federal Aviation Administration, Miami, Florida
Lesage, Maurice, Ciment Independent Inc., Montreal
Lowe, Robert A., McCarran International Airport, Las Vegas
Lynch, Edward T., G. J. Payne, Carson, California

Madison, Dan O., City of Tuscaloosa, Alabama
Magid, Lou, Federal Aviation Administration, Miami, Florida
Maguire, Robert B., Hillsborough County Aviation Authority, Tampa
Mahns, Henry L., Metropolitan Washington Airports, Federal Aviation Administration, Gravelly Point, Virginia
Martinez, Fernando, Restrepo Y, Uribe, Ltda., Bogota
Matsumoto, Daniel S., Airports Division, Pacific Asia Region, Federal Aviation Administration, Honolulu
McAleese, Thomas L., Milwaukee County Airport Planning and Construction
McDowell, Thomas H., Raleigh-Durham Airport Authority, North Carolina
McGill, William J., Airports Division, Southern Region, Federal Aviation Administration, Atlanta
McKeen, Gordon, Civil Engineering Research Facility, University of New Mexico, Albuquerque
McKeogh, C. A., Southern Region, Federal Aviation Administration, Atlanta
McLeod, Norman W., McAsphalt Engineering Services, Toronto
McMahon, T. F., Office of Research, Federal Highway Administration
McQueen, Roy D., Federal Aviation Administration, Jamaica, New York
Medico, Chris, Porous Concrete, Inc., Sarasota, Florida
Medico, John J., Jr., John J. Medico, Jr., Inc., Sarasota, Florida
Melendez, Edgar C., Costa Rica Ministry of Public Works and Transportation, San Jose
Melick, David E., Ohio Department of Transportation, Columbus
Melville, Phillip L., Federal Aviation Administration
Metternick, Larry, Williams and Works, Inc., Grand Rapids, Michigan
Michaluk, Ernest E., Transport Canada, Winnipeg, Manitoba
Mills, William H., William H. Mills and Associates, Atlanta
Mitronovas, F., Acres American, Inc., Buffalo
Monismith, Carl L., Department of Civil Engineering, University of California, Berkeley
Moore, Raymond K., Department of Civil Engineering, Auburn University, Alabama
Morin, W. J., Lyon Associates, Inc., McLean, Virginia

Parker, Frazier, Jr., Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi
Parr, Lloyd B., Missouri Department of Transportation, Jefferson City
Paschina, Ricardo, Rome Airport, Italy
Patteson, William T., Sr., Louisville and Jefferson County Air Board, Kentucky
Pavlovich, R. D., Asphalt Institute, College Park, Maryland
Perko, Lawrence, Port of Portland, Oregon
Petit, Richard G., Port of Seattle,
Pfister, Richard Hofmann, U.S. Steel Corporation, Pittsburgh
Plentl, Willard G., Jr., Division of Aeronautics, North Carolina Department of Transportation, Raleigh
Pulera, Vito Anthony, Federal Aviation Administration, Valley Stream, New York
Pumphrey, Robert L., Metropolitan Washington Airports, Federal Aviation Administration, Gravelly Point, Virginia

Roedell, Floyd J., Wichita Airport Authority, Kansas
Rath, John, Glasgow Quarry, Inc., King of Prussia, Pennsylvania
Raymond, Richard P., Federal Aviation Administration
Reese, John F., W. J. Reese and Associates, Inc., Rock Island, Illinois
Richards, Robert W., Howard, Needles, Tammen and Bergendoff, Atlanta
Rixman, A. Edward, CMI Corporation, Oklahoma City

Robinson, Howard M., Airports District Office, Federal Aviation Administration, College Park, Georgia
Rowan, Ronald E., Ralph H. Burke, Inc., Park Ridge, Illinois

Sanborn, Albert F., SITE Engineers, Inc., Cherry Hill, New Jersey
Sanders, Carroll R., Williams, Hatfield and Stoner, Inc., Fort Lauderdale, Florida
Saxena, Surendra K., Civil Engineering Department, Illinois Institute of Technology, Chicago
Schulten, Carl L., Airport Pavement Branch, Federal Aviation Administration
Selvik, Rolf, Aerodrome Division, Norway Directorate of Civil Aviation, Oslo
Sharma, Jatinder, Florida Department of Transportation, Tallahassee
Sheftel, David J., Systems Research and Development Services, Federal Aviation Administration
Shuler, Scott, Engineers Testing Laboratories, Inc., Phoenix
Slatten, J. L., Sahuaro Petroleum and Asphalt Company, Phoenix
Smith, Cecil B., Delta Air Lines, Inc., Atlanta
Smith, L. Beale, III, Howard, Needles, Tammen and Bergendoff, Miami, Florida
Smith, Larry E., HTB, Inc., Oklahoma City
Smith, Lawrence L., Tampa International Airport
Spaine, L. F., Transportation Research Board, Washington, D.C.
Sparks, Craig A., Rocky Mountain Region, Federal Aviation Administration, Aurora, Colorado
Spencer, Herbert G., Amax, Inc., Avondale Estates, Georgia
Springett, R. E., British Airways, Hounslow, Middlesex, England
Stoner, E. W., Williams, Hatfield and Stoner, Inc., Fort Lauderdale, Florida
Strandberg, Roy A., Boeing Commercial Airplane Company, Seattle
Studebaker, Robert, Laserplane Corporation, Dayton
Styron, Robert W., Amax Resource Recovery Systems, Inc., Atlanta
Sweetapple, Gordon J., Manchester International Airport Authority, England

Takeshi, Jotani, All Nippon Airways, Burbank, California
Tatro, Leo F., Jr., Florida Department of Transportation, DeLand District Office, DeLand
Taverner, G. G., Defence Construction, Ltd., Ottawa
Taylor, Marvin B., Division of Aeronautics, Illinois Department of Transportation, Springfield
Tenneson, H. Gunnar, San Francisco Airports District Office, Federal Aviation Administration, Burlingame, California
Thompson, Marshall R., University of Illinois at Urbana-Champaign
Tomita, H., Federal Aviation Administration
Truax, Dan A., CMI Corporation, Oklahoma City
Tuccillo, S., U.S. Naval Civil Engineering Laboratory, Port Hueneme, California
Turner, Elonza T., Federal Aviation Administration, Beckley, West Virginia
Tveter, Asle, A S Sigurd Hesselberg, Kongensgate 1, Oslo, Norway

Van Den Broeck, Frans A., Regi Des Voies Aeriennes, Brussels, Belgium
Van der Laarse, J. D., Aircraft Engineering, Fokker VFW and AECMA, Schipol-Oost, Netherlands
Van Noortwijk, H., Civil Engineering Service Bureau, Engineering Department, Schiphol Airport Authority, Amsterdam, Netherlands
Visser, W., Shell Research Amsterdam, Koninklijke Shell Laboratorium, Amsterdam, Netherlands
Vitale, William V., Office of Airports Programs, Federal Aviation Administration
Vittas, George P., Airport Planning, American Airlines, Inc., New York

Wadlington, V. B., Civil Engineering Department, Bovay Engineers, Inc., Spokane
Waldner, Frederick A., Airports District Office, Federal Aviation Administration, Camp Hill, Pennsylvania
Ward, William T., Airports District Office, Federal Aviation Administration, College Park, Georgia
Wathen, T. R., Engineering Division, U.S. Department of the Army, San Francisco
Weder, C. J., Schiphol Airport Authority, Amsterdam, Netherlands
Weisz, C. Phillip, Air Transport Association, Washington, D.C.
Wester, K., Study Center for Road Construction, Arnhem, Netherlands
White, Thomas D., Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi
Will, Kenneth J., Bureau of Aviation, Florida Department of Transportation, Tallahassee
Williams, George A., Florida Department of Transportation, Barton
Wilk, Willy, Betonstrassen AG, Wildegg, Switzerland
Wilson, Barrett J., Port Authority of New York and New Jersey, New York
Wilson, James A., City of Birmingham, Alabama
Wilson, John G., Pullman Swindell Ceramic Division, Pittsburgh
Wilson, T. E., III, Southern Roadbuilders, Inc., Augusta, Georgia
Witczak, Matthew W., Department of Civil Engineering, University of Maryland, College Park
Witteveen, Norman D., Watson and Company, Tampa
Worch, Richard J., Federal Aviation Administration

Yang, Nai C., Yang, Stevens, Fabian Engineers, New York City
Yoder, Eldon J., Purdue University, West Lafayette, Indiana

PROGRAM COMMITTEE FOR THE CONFERENCE ON RESEARCH IN AIRPORT PAVEMENTS

Carl L. Monismith, chairman: Donald M. Arntzen, Ernest J. Barenberg, Richard D. Barksdale, Leo F. Duggan, Ronald L. Hutchinson, Richard B. Kaiser, Carl L. Schulten, and Matthew W. Witczak. L. F. Spaine, John W. Guinnee, and Herbert J. Guth, Transportation Research Board staff.