FAA PAVEAIR, A NEW WEB-BASED PAVEMENT MANAGEMENT SOFTWARE AND A DISCUSSION OF ANOMALIES IN CALCULATING PAVEMENT CONDITION INDEX USING THE ASTM STANDARD

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INTRODUCTION

The Federal Aviation Administration has developed and continues to develop and refine Non-Destructive Testing (NDT) technologies to assess airport pavement condition. Recent advances in computer hardware and software and data acquisition systems have significantly improved NDT effectiveness and value. The FAA has developed back calculation software to collect and interpret data from Falling/Heavy Weight Deflectometer equipment. This software, titled BAKFAA, was developed by the FAA and has been available for several years. Results obtained from BAKFAA can provide information on the structural capacity of the pavement layers from measured deflection basins and assuming uniform layer thickness. In addition, the FAA has developed ProFAA, an airport pavement profile evaluation program. ProFAA and BAKFAA are both available to the public at no charge with access to the source code for local modification. The most recent FAA software program currently under development is an internet based computer program for use as an Airport Pavement Management System (APMS). This software is called FAA PAVEAIR and its development is discussed below.

PAVEAIR

The FAA originally became involved in the development of a computer based airport pavement evaluation program via collaboration with the US Army Corps of Engineers. The original version of the U.S. Army Corps of Engineers (USACOE) pavement evaluation program was called PAVER. Development of PAVER dates back to the 1960’s and was originally designed for use on a mainframe computer. This version and subsequent versions were also designed to evaluate airport, road, and parking lot pavements. A new version called MicroPAVER was then developed for use on personal computers. This version included refinements such as dividing pavements into uniform sections to comply with existing FAA Advisory Circular guidelines, computing and storing pavement evaluation history as Pavement Condition Index (PCI) as defined in ASTM D5340-04 Standard Test Method for Airport Pavement Condition Index Surveys, and including deflectometer results for overlay design [1]. The National Association of State Aviation Officials (NASAO) and the FAA agreed to partner to develop a system for sharing information to optimize available airport pavement funds. It was then agreed that the development of a web-based airport pavement program would be the optimum method to share this information. FAA Advisory Circular 150/5380-7A, Airport Pavement Management, requires the use of a Pavement Management System (PMS) [2]. PAVEAIR will satisfy the requirements of this Advisory Circular and comply with the U.S. Government section 508 accessibility requirements to ensure that people with disabilities have the same access to electronic and information technology as people without disabilities. Figure 1 below is a PAVEAIR screenshot of the PCI/ pavement distress page.

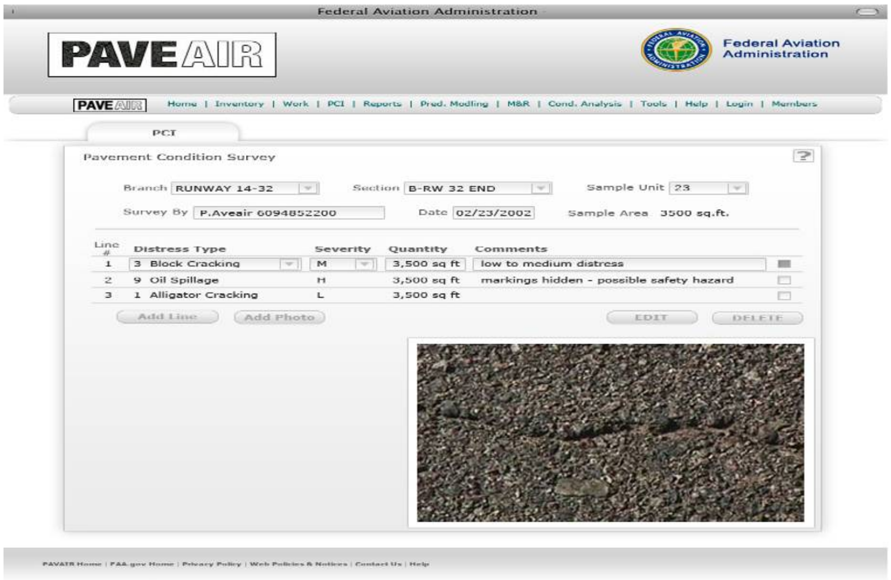


Figure 1.

PAVEAIR was originally devised to satisfy the requirements identified by NASAO and the FAA. Additional benefits of a web-based pavement evaluation and management program were subsequently determined and are discussed as follows: a method to manage system-wide dissemination and analysis of FAA sponsored pavement projects, a tool to tie volumes of existing airport pavement data together for project/construction comparison, and as a means to join existing FAA airport pavement design and evaluation computer programs together for ease of operation. PAVEAIR, in its' initial launch, will have the equivalent functionality of MicroPAVER version 5.3 and be designed to operate in Microsoft Internet Explorer version 6.0 and above web browser on the client side.

The primary MicroPAVER version 5.3 functionality includes: Inventory, Work, PCI, Reports, Prediction Modeling, Condition Analysis and Maintenance and Repair (M & R) Plan. Secondary functions such as List Selector, Import/Export Tools are all supporting tools for the above main functionalities. The following definitions of primary functionalities as defined in references by M. Shahin, U.S. Army Corps of Engineers are as follows [3], [4]:

Inventory - Inventory is a user interface to let users Add/Delete/Edit pavement information manually.

Work - Work is a user interface to let users enter pavement Work data for specific areas. Work data includes Required Work or History Work.

PCI - This function calculates the PCI value for an existing pavement inspection and creates a new inspection data entry that calculates its future PCI value.

Standard Reports - Generates a variety of Reports for a given Micro PAVER database. The list comprising Standard Reports includes; Section Condition Report, Branch Listing Report, Branch Condition Report, and Work History Report.

Prediction Modeling - is a process that identifies and groups in-service pavements sharing similar construction features. These pavements also share common environmental and traffic loading attributes. Based on the evaluation of a smaller sample of similar pavement, the user can predict the future condition of a larger sample of like pavements.

Condition Analysis - Condition Analysis is a feature that allows the user to quantify the state of the pavement based on the cause and rate of the pavement deterioration using pavement distresses with respect to time.

M&R Plan is a tool used to coordinate pavement evaluation with planning, scheduling, budgeting and optimal pavement maintenance and repair (M&R) activities. The M&R plan combines existing and anticipated PCI values using inventory data and provides the ability to assess various M & R options with the resulting pavement life.

PAVEAIR is being developed using Visual Studio 2008 and compiled to run using the most current Microsoft Windows operating system to support single-user and server class personal computers. Installation of PAVEAIR will be configured for use on a stand-alone personal computer, a private network, and the internet or an intranet. A user database will be created for each inventory (data owner), all work is performed on individual sections, and the database engine is Microsoft SQL server. The FAA anticipates hosting a server at the WJHTC as a repository for civil airport projects funded by the Airport Improvement Program (AIP). As with other FAA pavement programs, the PAVEAIR application will be made available for free download by users as a set of installation files, source code, and documentation for installation and operation. In addition, development of PAVEAIR will be done in accordance with existing industry standards such as; American Society for Testing and Materials (ASTM), FAA Advisory Circulars, and Federal Department of Transportation (DOT) and FAA Information Systems Security (ISS) requirements.

During development of PAVEAIR, the question of securing both the data owned and input by individual users and the data created by PAVEAIR was identified as a possible cause for concern. The FAA has resolved the user authentication and authorization portion of this task by development of registration functions, change password and reset password functions, and development of a logon user interface for registered users.

An additional issue identified when developing the statement of work for PAVEAIR was the extent to which data input and produced in PAVEAIR would be accessible to the public. To date, this issue has not been resolved pending the determination of FAA policy for data that could be judged to be proprietary. One solution would be to provide users the option of choosing the level of accessibility granted to the public. This specified level of accessibility could be further refined within an organization to include read and write privileges. Figure 2 below is the PAVEAIR registration page.

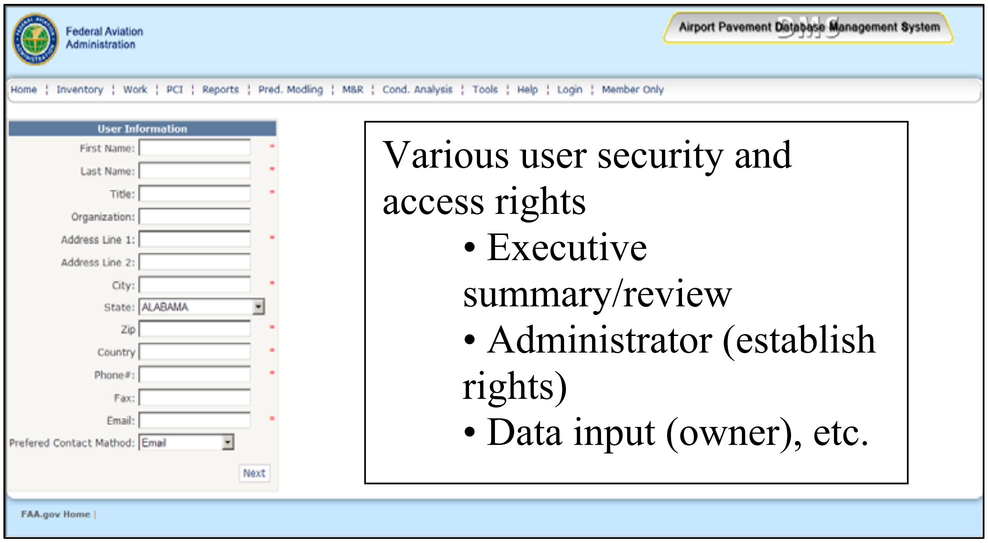


Figure 2. PAVEAIR Registration Form

Development of PAVEAIR has been ongoing for approximately eighteen months at the time of writing and progress has been significant. The reader is cautioned that the items that are shown below as complete are pending rigorous testing, review, and acceptance. The current status of PAVEAIR at the time of this paper is as follows:

- Prototype User Interface and master page template is complete.
- The database structure has been defined and implemented.
- MicroPAVER data import procedure completed.
- Logon and user profile modules completed.
- Inventory and Work modules completed.
- PCI module completed.
- Tentative first deployment is scheduled for September 2010.

Implementation of PAVEAIR is anticipated to take place by the FAA for AIP projects, by FAA regions for smaller airports, by state Department of Transportations for General Aviation airports, and by consulting and engineering firms in support of airports. Future enhancements include upgrading the Geographic Information System (GIS) for compliance with recent FAA requirements.

Finally, PAVEAIR is envisioned to be a central component in web enabling existing FAA pavement software applications such as: FAARFIELD, BAKFAA, COMFAA, and ProFAA. Figure 3 below describes the proposed configuration of linking the FAA pavement software programs.

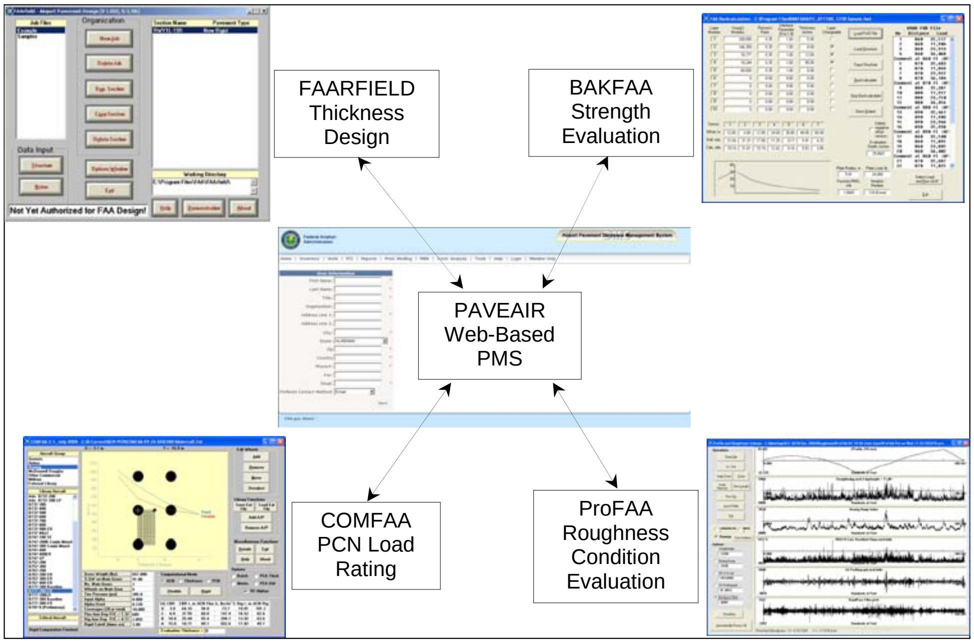


Figure 3.

FAA PAVEAIR SUMMARY

The need for accurate and timely airport pavement evaluation and management has been established. The anticipated increase in air travel in the United States has made pavement management more critical as existing airport infrastructure is tasked with serving more flights. At issue is the ability of airport engineers to provide data to airport managers to maximize pavement use and optimize maintenance and repair funds. This report describes the development of a FAA computer program to be used to evaluate and manage airport pavement.

This application will be developed using available existing standards for airport pavement maintenance and repair such as; applicable FAA Advisory Circulars, American Society for Testing and Materials (ASTM) standards, and federal Information Technology requirements.

Anomalies in Calculating PCI in Rigid and Flexible Pavements in ASTM D5340

During the development of the FAA PAVEAIR program, questions arose for PCI calculation in ASTM D 5340-04; Standard Test Method for Airport Pavement Condition Index Surveys. The questions are a result of the procedures in ASTM D5340 for the calculation of PCI. It assumes that for pavement units with equal Deduct Values but a different number of distresses, the pavement with the least number of distresses will *always* have a lower PCI. No references are available in ASTM D5340 to support the above assumption but a logic anomaly has been discovered.

The following example is presented on pages 7 and 8, in pavement units 10 and 11 of ASTM D5340 to illustrate a synopsis of the methodology from ASTM D5340:

Eight distresses are observed and quantified for a 20-slab pavement unit as shown in Figure 4 of this paper (Figure 7 from ASTM D5340). The deduct values of PCI for all distresses can be obtained in the curves given in D5340. For example, longitudinal/transverse/diagonal cracks, distress type 3, were measured in five slabs or 25% of the 20 slabs with medium severity. Therefore, the corresponding deduct value of PCI due to the medium longitudinal/ transverse/diagonal cracks is 32 and this was obtained in Figure 5 of this paper (Figure X4.3 from D5430). The detailed steps for determination of the pavement unit PCI are given in Figure 6 (Figure 8 from D5340).

<u>Step one for calculating the results in line one.</u> The total number of distresses is eight. All Deduct Values (DVs) are input into line one and the sum of DV = 89.3. Only seven of these have a DV value greater than five, therefore, q = 7 is used in line one and seven steps will be taken to determine the final pavement unit PCI. The corrected deduct value (CDV) 56 can be obtained using Figure 7 of this paper (Figure X4.16 from D5340) based on the sum 89.3. Therefore, the pavement unit PCI in line one is 100 – 56 = 44.

<u>Step two for calculating the results in line two.</u> All steps are the same except the lowest DV = 6 is replaced by 5.0 and q is defined as 6 – six steps are still left for final PCI determination. The sum of DV = 88. The CDV is calculated using the curve q = 6 in Figure 7 so it is 58. The pavement unit PCI in line two = 100 – 58 = 42.

<u>Steps three to six are similar to step two.</u>

<u>Step seven for calculating the results in line seven.</u> All steps are still the same as step two. The sum of DVs is 63.3. Since q = 1, the CDV should be equal to the sum of DVs 63.3 without correction. Then the pavement unit PCI = 100 – 63.3 = 36.7.

<u>Final determination of the pavement unit PCI.</u> The maximum Corrected Deduct Value establishes the PCI of this pavement unit: Therefore, the maximum CDV in this example is 63.3 and the corresponding PCI = 100 – 63.3 = 36.7.

In Figure 6 of this paper (Fig. 8 in ASTM 5340), line one indicates a pavement section with the eight surveyed distresses and the corresponding deduct values obtained from Figures X4.1

through X4.15 of ASTM 5340. Line seven is a section with artificially modified Deduct Values with the following DVs: 32 for medium Longitudinal/Transverse/Diagonal cracking, 1.3 for low severity joint spalling and 5 for all the others. The DVs due to medium Longitudinal/Transverse/Diagonal cracking and low severity of joint spalling are the same between the two pavement units in line one and seven. And for all the other types of distresses, the pavement in line one has DVs higher than the pavement in line seven respectively. Therefore, the pavement PCI in line one must be logically lower than that of the pavement PCI in line seven. However, the calculated pavement unit PCI in line one is 100-56 = 44 and the PCI in line seven is 100 – 63.3 = 36.7. Or, the pavement unit that is more seriously deteriorated in terms of distresses has a higher PCI. This can not be logically correct. Therefore, PCI = 36.7 that was calculated for the modified pavement in line seven is artificially defined (or forced) to be the PCI of the pavement unit in line one. This procedure defined in ASTM D5340 as a "correction" may create confusion for pavement engineers.

The Origin of the Question

The above anomaly is caused by using Figure 7 in this paper (Figure X3.19 and Figure X4.16 in ASTM D5340). These curves were generated based on the assumption the pavement deterioration degree not only depends on the total deduct values of PCI, but also depends on the number of distress types. In accordance with ASTM D5340, if the total DVs are the same, the pavement with the lower number of distresses will have more serious deterioration than pavement with the same DV and a higher number of distresses. As an example, assume the following rigid airport pavement unit one has a single type of distress A with a DV = 60 and pavement unit two also has distress A with DV = 30 plus another type of distress B with DV = 30. Therefore the total DVs of the two pavements have the same value of 60. The model for determining the final PCI in ASTM D5340 assumes that though pavement unit two has the "face" total DV = 60, same as pavement unit one, it is less deteriorated than the pavement unit one. Therefore, q = 2 curve, rather than q=1 curve in Figure 7 should be used to obtain the final DV for the unit two. This assumption may be explained by the following rationale: the distress from the first pavement with a distress A with DV = 60 in pavement unit one may cause the pavement unit to be deteriorated quicker in the future than in pavement unit two. Therefore, the DV = 60 in pavement unit two should be considered equivalent to CDV=52 (Figure X4.16, curve q = 2, ASTM D5340). The same DV = 60 in pavement unit one should be still equal to CDV = 60 (Figure X3.19, curve q = 1, ASTM D5340).

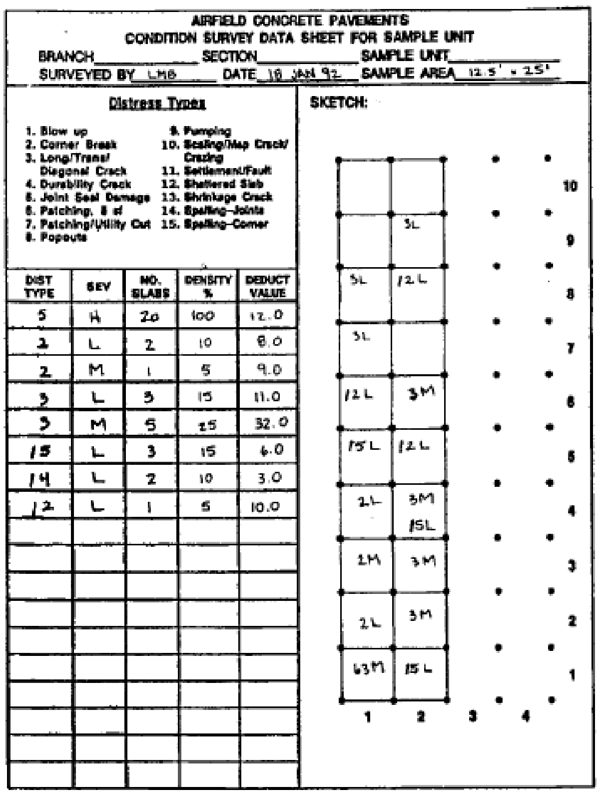
A similar assumption has also be adopted in ASTM D5340 in cases with q = 3. For example, if a third pavement unit has three types of distresses at DV = 20 each for a total DV = 60, the CDV will be 46 if the pavement unit is in a rigid pavement. Unfortunately, the above logic can be broken by changing the Deduct Value distribution.

Considering a fourth pavement unit with three types of distresses: distress A with DV = 40, distress B and C with DV = 10 each for a total DV = 60. Since the distress A with DV = 40 in pavement unit four is higher than the distress A with DV = 30 in pavement unit two, the final PCI of the pavement unit four should be lower than that in pavement unit two following previous logic. Unfortunately, the final PCI of the pavement unit four is still equal to that of the pavement unit three following ASTM D5340, and higher than the final PCI in pavement unit two. Or, a logical anomaly exists between the cases with same total DV but different distribution of DVs.

We believe that the final PCI correction model in ASTM D5340 and its assumption was developed based on some case observations in field. However, the conflicts discovered using the CDV curves indicates that further study is necessary to resolve the issues identified in this paper. Another reason to evaluate the corrected deduct value model would be to control the values of final DV always below 100.

Our Suggestion

This paper does not request a revision to an existing time-tested ASTM standard and we respect that it has been popularly used in practice for many years. However, with a better understanding of the methods used to calculate PCI, is it now in the best interests of airport pavement engineers to revisit the procedures for calculating PCI? Should we start the consideration on improving the existing ASTM method for calculating PCI?



AIRFIELD CONCRETE PAVEMENTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH______ SECTION______ SAMPLE UNIT______

SURVEYED BY LMB DATE 18 JAN 92 SAMPLE AREA 12.5' × 25'

Distress Types

1. Blow up
2. Corner Break
3. Long/Trans/ Diagonal Crack
4. Durability Crack
5. Joint Seal Damage
6. Patching, ≤ 5 sf
7. Patching/Utility Cut
8. Popouts
9. Pumping
10. Scaling/Map Crack/ Crazing
11. Settlement/Fault
12. Shattered Slab
13. Shrinkage Crack
14. Spalling–Joints
15. Spalling–Corner

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE
5	H	20	100	12.0
2	L	2	10	8.0
2	M	1	5	9.0
3	L	3	15	11.0
3	M	5	25	32.0
15	L	3	15	6.0
14	L	2	10	3.0
12	L	1	5	10.0

SKETCH:

FIG. 7 Example of a Jointed Rigid Pavement Condition Survey Data Sheet

Figure 4 an Example in ASTM D5340

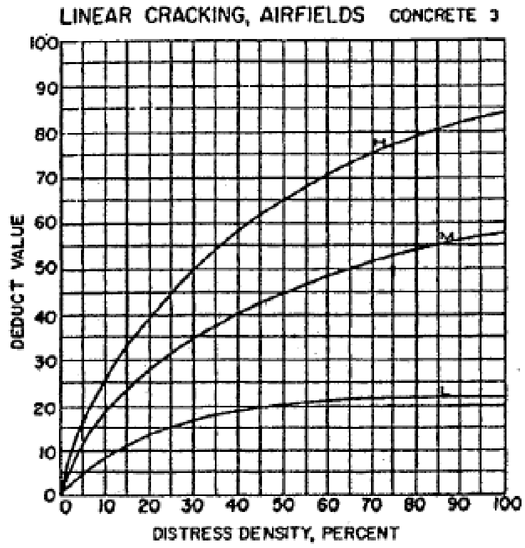


FIG. X4.3 Linear Cracking

Figure 5 Deduct Values for Linear Cracking

#	Deduct Values										Total	q	CDV
1	32.0	12.0	11.0	10.0	9.0	6.0	6.0	1.3			89.3	7	56.0
2	32.0	12.0	11.0	10.0	9.0	8.0	5.0	1.3			88.3	6	58.0
3	32.0	12.0	11.0	10.0	9.0	5.0	5.0	1.3			85.3	5	58.0
4	32.0	12.0	11.0	10.0	5.0	5.0	5.0	1.3			81.3	4	58.0
5	32.0	12.0	11.0	5.0	6.0	5.0	5.0	1.3			76.3	3	57.0
6	32.0	12.0	5.0	5.0	5.0	5.0	5.0	1.3			70.3	2	61.0
7	32.0	5.0	5.0	5.0	5.0	5.0	5.0	1.3			63.3	1	63.3
8													
9													
10													

Max CDV = 63.3

PCI = 100 − Max CDV = 36.7

RATING = POOR

FIG. 8 Calculation of Corrected PCI Value—Jointed Rigid Pavement

Figure 6 Detailed Steps on Determination of Pavement unit PCI

D 5340 – 04ε1

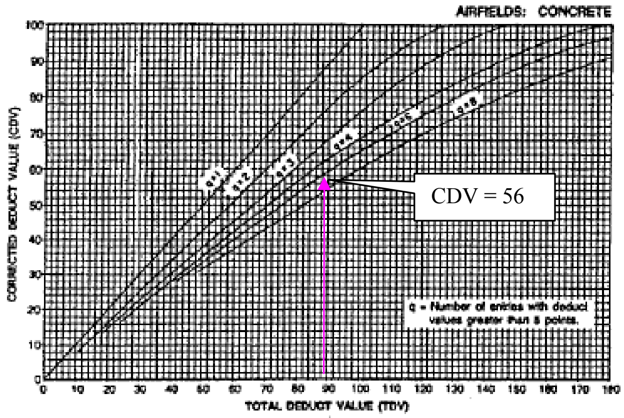


FIG. X4.16 Corrected DVs for Jointed Rigid Airfield Pavements

Figure 7 Correct Parameter for Determining Deduct Value for Different Number of Distress Types

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