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Guide to Recommended Format for Concrete in Materials Property Database

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This guide presents recommended formats for concrete materials property data for entry into computerized databases. The purpose of this guide is to facilitate efficient storage and retrieval of information about concrete and its constituents with a computer and allow meaningful comparison of data from different sources. It is intended for use by those responsible for planning and maintaining a concrete materials property database as well as those who enter data. Recommended formats are provided for organizing and subdividing information about hydraulic cements, aggregates, chemical admixtures, mineral admixtures, fibers, water, concrete processing, and concrete properties and performance suitable for use in developing a computerized database. ACI Committee 126 developed this guide to be consistent with the principles of ASTM Committee E-49, Computerization of Material and Chemical Property Data. Before computers can replace laboratory notebooks and published reports as a more efficient means for storing and retrieving concrete materials property data, recording standards are needed. The recommended formats in this guide are a first step toward fulfilling this need.

Keywords: admixtures; aggregates; cements; concretes; database management; fibers; materials property database; recommended format.

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CHAPTER 1—SCOPE

1.1—Introduction

Concrete has been used worldwide as a construction material for at least 100 years. Scientific research, new discoveries, and in-service experience have contributed to many advances in the state of the art. The key to continued advancement in this field is to provide a means of accurately reporting and widely distributing new information about concrete in an organized and rapid manner. The means to this end is a computerized database of concrete material properties.

Currently, printed materials, such as journals and textbooks, are the most prevalent means of sharing information regarding concrete. Comprehensive reports, such as the Portland Cement Association's report on long-term performance of cement in concrete (Klieger 1957, Wood 1992) are published from time to time, but too infrequently to be an efficient way of disseminating information. The information in notebook databases (Rumble 1993) developed in laboratories is invaluable to the specific project for which they are developed, but is not always sufficiently detailed, or even published at all, for use in future projects. As a result, the information recorded in these databases is often used only once, and is not as useful as it could be to the industry as a whole.

A computerized database can provide ready access to countless analyses of concrete materials property data, thereby eliminating the need for lengthy testing and analysis that may have already been performed by another group. This guide addresses the task of developing a standard format for recording and retrieving information in a database that would most benefit its users and the concrete industry at large.

1.2-Objective

A concrete materials property database is a collection of data files in which properties of concretes and their constituents are organized and stored. Each data file is unique because it only contains information for one particular concrete. For example, ACI Committee 207, Mass Concrete, has developed such a collection. ACI 207.1R contains data files for 30 concretes used in dams located throughout the world. The usefulness of such databases depends on the types and amount of data that they contain.

Accessing the information in a concrete materials property database can be difficult or impossible if the database management system poses constraints or if there are inconsistencies in format and completeness among data files. To consistently report all of the properties that may be available for a particular concrete, a comprehensive set of guidelines should be followed. The guidelines should address concrete identification and include guidance for presenting constituent information; processing parameters; and data on mechanical, thermal, and physical properties.

This document is a guide for establishing the content of a comprehensive concrete materials property database. Recommended formats for categorizing information about concrete constituents including hydraulic cements, aggregates, chemical admixtures, mineral admixtures, fibers, and water; concrete processing; and concrete properties and performance are provided. The information is organized into data segments and data elements suitable for use in developing a computerized database. If needed, data segments and data elements for other constituents may be developed using the recommended formats presented in this guide as an example. Constituents that may be used in concrete production but are

not covered in this guide include binders such as asphalt, gypsum, sulfur, and polymers; solids such as metal shot, pigments, carbon black, and redispersible powders; and liquids such as latex and other chemical solutions.

Recommendations in this guide are consistent with the principles of ASTM Committee E-49, Computerization of Material and Chemical Property Data. Guides prepared by ASTM E-49 for metals (ASTM E 1309 and E 1338); composite materials (ASTM E 1471); database terminology (ASTM E 1443); and data records (ASTM E 1313) were used in preparing this document. Although compliance with the recommended formats is considered essential for efficient computerization of concrete properties, this guide is not intended to replace reporting requirements established in consensus standards or contractual agreements, nor is it intended to serve as a step-by-step manual for use in database management or computer implementation.

1.3—Use of guide

This guide is intended for use by those responsible for planning a database management system, entering data into a concrete materials property database, or preparing tables of concrete properties for use by others. It should be of particular use to those who wish to share data with others, either within the same organization or between organizations. When necessary, users of this guide may expand the number of data segments or create different data elements so that the required information is included in the database. The order of the data elements is not rigid and can be varied, depending on the protocol of the database management system. It is important, however, that the relationships among the data elements and data segments be considered during the database development process.

Database development begins with a list of essential and desirable data elements to be included in the database. These data elements form the basis for a data dictionary. A data dictionary is a guide for understanding the information in a database and has features similar to those in a language dictionary (Begley 1993). In the data dictionary, one can find a description, the origin, and the usage of each specific piece of data presented in the database. It also provides information describing the relationship of a given piece of data to all other pieces of data, including the format that best fits the data. The data dictionary is a framework on which the database schema is built. A database schema is a perspective, a way of seeing the information in the database (Begley 1993). The schema provides a transition from the data elements to the user's viewpoint.

CHAPTER 2—GENERAL DATABASE TERMINOLOGY

A concrete materials property database consists of data files that are composed of data segments and data elements. These terms, along with others used to describe the components of a concrete materials property database, are presented in this section. It is essential that standardized terminology related to materials databases be developed (Newton 1993). Terms and definitions provided here are intended to complement those already provided in ACI 116R

and ASTM C 125, C 219, E 1013, and E 1443. Relationships among the individual components of a concrete materials property database are shown in Fig. 2.1.

Concrete materials property database—A collection of data files in which properties of concretes and its constituents are organized and stored.

Data—The set of scientific or technical measurements, observations, or facts that can be represented by numbers, tables, graphs, models, text, or symbols used as a basis for reasoning or calculation.

Data dictionary—A guide for understanding all of the essential and desirable data about concrete and its constituents that are included in the database.

Data element—One individual piece of information used in describing a material or to record test results; for example, a variable name or test parameter (ASTM E 1313). Each data element in this guide is represented by a data element number, data element name, data element type, and data element format. Certain data elements included in this guide are essential for unique concrete identification. Entries for these particular data elements may be recorded at various locations throughout a data file.

Data element format—The presentation style used to report information or data. Alphanumeric, floating-point, and special-entry formats are specified in this guide for use in reporting information, unit designations, numerical values, and text. Details concerning date and time are presented in Section 3.4.

Data element name—A descriptive term or title that designates the type of information or data to be reported in the data element.

Data element number—A four- or six-digit number used to denote an individual data element. These numbers represent the entire set of information in a particular data element. Data element numbers are considered a functional part of the database and may be used for data element reference. Data element numbers are not, however, considered data. The first digit in the data element number is used as a cross reference. Assigned ranges of data element numbers are presented in Table 2.1.

Data element type—A designation that reflects the significance of the data element entry. All data element entries are considered either essential or desirable. Data elements are considered essential if they are required to make a meaningful comparison of property data from different sources. A comparison of data from different sources may still be possible if essential information is omitted, but the value of the comparison may be greatly reduced. Nonessential or desirable data elements are used to report supplementary information.

Data file—A complete set of concrete materials property database entries or data records that contain information and properties for a particular concrete.

Data record—The collection of data elements used to describe a material or the results of a specified test in their entirety (ASTM E 1313).

Data segment—A category of information that is used to subdivide and designate sets of related data elements. Certain

data segments may be used a number of times to report constituent information and properties for a particular concrete.

Database scheme—A way of representing the information in the database so that the data are meaningful and useful.

Desirable data element—A data element in a record that provides supplementary information necessary to make the record comprehensive or complete.

Essential data element—A data element in a record that must be completed to make the record meaningful in accordance with the pertinent guidelines. Failure to complete an essential data element may render the record unusable in a database or in data exchange. Comparison may still be possible if essential information is omitted, but the value of the comparison may be greatly reduced.

Material class—Any of several broad groups of materials into which a given material may be classified; for example, metals, ceramics, composites, or energetic materials (ASTM E 1443). The class of materials covered by this guide is concrete.

Property—A measurable or derivable attribute of a material. A property of a given material may take different values as influenced by one or more independent variables. It is therefore often referred to as a dependent variable (ASTM E 1443). In this guide, a concrete property is any property of the concrete. A constituent property is any property determined by testing to quantify the effects a constituent has on the properties and performance of concrete made using the constituent.

Property class—Any of several broad groups of properties; for example, physical, mechanical, or chemical properties (ASTM E 1443).

CHAPTER 3—GENERAL FORMATS

The recommended formats for concrete in this guide are represented by individual data elements that cover all aspects of concrete materials technology. Data elements that address similar topics are grouped together to form data segments. The following chapters identify the data segments and data elements developed specifically for hydraulic cements, aggregates, chemical admixtures, mineral admixtures, fibers, water, processing, properties and performance, and concrete identification. Each of these data categories includes a table that contains sets of data elements that, together, create the recommended format for concrete.

This chapter defines general formats that are used repeatedly for each category of the database.

3.1—Units

Numerical values that represent data, such as length and stress, have historically been reported using units that reflect local customs and practices. To minimize the possibility for misunderstanding and confusion associated with use of customary units, use of the International System of Units (SI) is essential. The following three data elements are recommended for use whenever a numerical value representing such measurement is reported in a concrete materials property database.

Customary units designation—The customary units that correspond to the reported numerical value. Example entries include in. and psi.

SI units designation—The units in the International System of Units (SI) that correspond to the reported numerical value. These designations should conform to requirements provided in IEEE/ASTM SI 10. Example entries include mm and MPa.

Customary to SI units conversion factor—A conversion factor required to convert customary units to SI units. This number is reported as a floating point decimal. For example, the conversion factors for in. to mm and psi to MPa are 25.4 and 0.006894757, respectively.

3.2—Standards-producing organization information

Requirements for concrete constituents and techniques for determining concrete properties are routinely provided in standardized material specifications and test methods. These documents may be issued by companies and industries as well as national and international organizations. Information that identifies and defines an applicable standard is a meaningful part of a concrete materials property database. The following four data elements are recommended for use whenever a standard specification, material property, or test result is reported in a concrete materials property database.

Standards organization—A name or title of the company, industry, or national or international organization that issued the applicable standard. ASTM is an example of an organization that issues standard specifications and test methods for concrete.

Standard number—The number of the standard issued by the organization reported previously. C 39, C 78, C 138, C 143, C 173, and C 293 are examples of ASTM test method standard numbers that correspond to test methods for determining properties of concrete.

Standard designation—A designation, if any, within the standard reported. Type I, Type A, and Class F are examples of standard designations for certain ASTM material specifications. Standard designation entries may not be applicable for test methods and standard specifications that do not include such designations.

Standard version—A version is usually a number that represents the year of issue.

3.3—Temperature

Although the SI unit for temperature is Kelvin (K), wide use is also made of degrees Celsius (C), which is the SI unit used for expressing Celsius temperature and temperature intervals. To minimize the possibility for misunderstanding and confusion, it is recommended that temperature and temperature interval values be reported in a concrete materials property database using degrees Celsius (C). If temperature and temperature interval values are reported using degrees Fahrenheit (F), then equivalent values in degrees Celsius (C) should also be reported.

3.4—Date and time

For consistency, special formats are provided for use in reporting date and time-of-day data in a concrete materials property database. The YYYYMMDD (year:month:day) format should be used to report the date. The first four digits of this format represent the year, the next two digits represent the month, and the last two digits represent the day. For example, 19941024 represents October 24, 1994.

The HH:MM (hour:minute) format should be used to report the time of day. The first two digits represent the hour of the day and is based on a 24 hr clock. The last two digits represent minutes. For example, a data entry of 14:30 represents 2:30 p.m.

CHAPTER 4—CONCRETE IDENTIFICATION

Essential and desirable data elements necessary for the unique identification of a concrete in a materials property database are provided herein. Distinguishing one concrete from another is difficult to accomplish with a single database entry. Most data elements for concrete identification serve a dual role as concrete identifiers and data elements for other data categories. Data elements for the concrete designation data segment, however, are used solely for concrete identification. Data segments and corresponding data elements for concrete identification are listed in Table 4.1. Although it is not necessary for every data element to be used for every concrete, it is suggested that entries be provided for each essential data element.

Data elements for concrete identification are organized into six data segments. The corresponding data elements are listed following each data segment description.

4.1—Concrete designation

The concrete designation data segment includes descriptive identifiers for each concrete in a concrete materials property database. These identifiers are based on a multilevel classification system that uses established terminology and designations to categorize the concrete.

- *Material class*—The class of materials covered by this guide is concrete.
- *Binder type*—Suggested entries for this data element are provided in Table 4.2.
- *Concrete category*—These entries are based on bulk density. Suggested entries for this data element are provided in Table 4.2.
- *Concrete group*—These entries indicate the end use or application of the concrete or other types of unique features or characteristics. Suggested entries for this data element are provided in Table 4.2.
- *Processing group*—These entries distinguish concretes from the same class, type, category, and group from one another. The processing group identifier generally reflects the procedure or manufacturing technique used to process the concrete. Suggested entries for this data element are provided in Table 4.2.
- Concrete identification number—A unique alphanumeric concrete identifier generally established by the organization that prepares the concrete specification and may be used by the database manager to represent the concrete in the materials property database. A unified numbering system (UNS) for metals and alloys has been developed and is described in ASTM E 527, but a standardized numbering system for concrete has not vet been developed.

- *Common name*—The common name is often provided by the concrete supplier and may be used by the database manager to represent the concrete in the materials property database. Mixture A, Lightweight Concrete, and 3000 psi Concrete are examples of commonly used concrete names.
- *Concrete designation notes*—These entries contain any additional information that may be useful in establishing a unique identifier for the concrete. A similar data element is used in each constituent category.

4.2—Concrete supplier

The concrete supplier data segment is used to report information that reflects the origin of the concrete. This data segment is included in concrete processing described in Chapter 11.

- *Concrete supplier name*—The name of a concrete producer, research organization, or contractor may be used as an entry in this data element.
- Concrete supplier address
- *Concrete supplier plant location*—An address, batch plant designation, or other type of identifier may be entered in this data element.
- *Concrete supplier identification number*—This entry is an alphanumeric designation provided by the concrete supplier to distinguish one concrete batch or mixture from another.

4.3—Constituent designation

The constituent designation data segment includes descriptive identifiers for a constituent in a concrete mixture. This data segment is repeatedly for each constituent used in the concrete. Data elements for a generic constituent are listed in Table 4.1. Data elements that provide descriptive identifiers intended specifically for hydraulic cement, aggregate, chemical admixture, mineral admixture, fibers, and water designation are presented in Chapters 5 to 10, respectively.

- *Constituent class*—Cement, aggregate, chemical admixture, mineral admixture, fibers, and water are examples of constituent classes.
- *Constituent common name*—Portland cement, crushed limestone (coarse), crushed limestone (fine), fly ash, air-entraining admixture, water-reducer, and water are examples of common names for constituents.
- Constituent producer name
- Constituent producer plant location
- *Constituent producer identification number*—This alphanumeric designation is assigned by the producer or supplier.
- *Constituent designation notes*—This entry includes any additional information that may be useful to create an identifier for the constituent.

4.4—Concrete mixture proportions

The concrete mixture proportions data segment is used to report the amount of each constituent in a given volume of concrete. Data elements in this data segment are included in concrete processing described in Chapter 11. Because this