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Guidelines for Identification of Concrete in a Materials Property Database*

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ABSTRACT: Guidelines for the identification of concrete in a materials property database are presented to address the complex problem of distinguishing one concrete from another. These guidelines are based on a logical scheme for systematically organizing and subdividing data and information about concrete and its constituents; they reflect consensus recommendations for a multilevel material description and designation system. Aspects of the guidelines include a classification system used to establish a series of primary identifiers, methods for reporting constituent information and mixture proportions, fields describing the source of the concrete and its processing history, and recommendations for reporting baseline or reference properties.

KEY WORDS: classification system, concrete, database, guidelines, identifiers, material property, standards

Concrete is a composite material consisting essentially of hydraulic cement, water, and aggregates such as natural sand, gravel, or crushed stone particles. Other ingredients such as specialty cements, mineral and chemical admixtures, metallic and non-metallic fibers, and manufactured aggregates may be used to improve workability, durability, and strength. When properly proportioned and thoroughly mixed, these materials form a plastic mixture that can be cast into almost any size or shape. After concrete has been mixed, transported, placed, and consolidated, its strength increases as a result of cement hydration (i.e., the reaction of the cement with water). Concrete is a versatile building material that has been used throughout the world for over 150 years in highway, bridge, dam, foundation, and other building applications. During this time, its properties and characteristics have been collected and recorded based on evolving concrete technology. Scientific research, new discoveries, and inservice experience have contributed to advancements in the state of the art.

Historically, data on the properties of concrete have been recorded in laboratory notebooks, technical reports, scientific journals, text books, and other reference sources. Retrieving data from these sources for use in comparing the performance of one concrete with another is often difficult or impossible due to inconsistencies between data sets, differences in nomenclature and test methods, and use of conventional or customary units. A common name such as "Mixture A", "Lightweight Concrete", "3000 psi Concrete", or "50 MPa Concrete" may be reported for each concrete and used to facilitate communications among material suppliers, building subcontractors, authorized inspectors, and design engineers. These names are often established by the design engineer, concrete specifier, or material supplier. Although common names are useful identifiers, they do not provide enough information to establish meaningful differences between concretes in a materials property database.

Distinguishing one concrete from another can be complicated because a number of constituents (often as many as eight or more) can be combined in varying amounts resulting in an infinite number of mixture possibilities. Establishing a unique identifier for such a complex material requires information about the types of natural and manufactured constituents used to

make the concrete, mixture proportions, methods and procedures used to process the concrete, and properties of the fresh and hardened concrete. An effective concrete identification scheme needs to include a variety of information categories representing more than a single piece of information or common name. Whenever possible, standard terminology established by ASTM, the American Concrete Institute (ACI), and others should be used to describe concrete, its constituents, and its properties.

Guidelines for establishing the unique identity of concrete in a materials property database are described in the following sections. These guidelines are intended to aid in database design, facilitate data exchange, and encourage greater precision and completeness in data recording. Based on consensus recommendations for a multilevel material description and designation system [1], they provide for the reporting of essential and desirable information necessary for searching the database and locating concretes with similar features and characteristics [2]. The guidelines include a concrete classification system, recommendations for identifying and designating the supplier, composition, processing history, and mixture proportions of concrete, and guidance for reporting fresh and reference concrete properties.

Concrete Identification Guidelines

Identification parameters are an important part of a concrete materials property database. They are used by database developers to distinguish one concrete from another and by database users to search for concretes with desired compositions and properties. Information required to adequately identify a concrete may be placed into the following seven data categories.

- Concrete designation
- Concrete supplier
- Constituent designation
- Concrete mixture proportions
- Concrete processing

- Fresh concrete property
- Reference concrete property

Each data category is represented by a series of essential and desirable fields (Tables 1-7). Fields are used to store elementary units of a database. The order of the fields is not rigid and may be varied depending on the protocol of the database management system. However, it is important that the relationships among the fields and data categories be considered during the database design process.

Although one of the objectives of these guidelines is to encourage greater precision and completeness in data recording, some fields may not always be applicable, while additional fields may be required in some cases. When these situations arise, entries for non-applicable fields may be omitted or supplementary fields may be created to enhance the concrete identification process. However, to ensure equivalency between the data sets, it is suggested that entries be provided for all fields that are designated "essential" [2]. Data called for in essential fields are required to make comparisons of property data from different sources meaningful [3].

Concrete Designation

The concrete designation data category is used to report primary identifiers for each concrete in a concrete materials property database. These identifiers are based on a multilevel classification system that uses established terms and designations to classify and subdivide the concretes. This data category is represented by eight fields (Table 1). Fields considered "essential" are important because they can be used to separate concretes into groups having similar characteristics, compositions, or properties.

Concrete Supplier

The concrete supplier data category is used to report the origin of the concrete. It is represented by four fields (Table 2). These identifiers are particularly valuable when concretes with similar or identical mixture proportions are provided by more than one supplier.

Constituent Designation

The constituent designation data category is used to identify each constituent contained in a concrete mixture. This data category is represented by ten fields (Table 3) that are repeated for each cement, aggregate, chemical admixture, mineral admixture, other solid constituent, and other liquid constituent used to make the concrete. For completeness, the properties and characteristics of these constituents should also be included in the database using guidelines established for each material class.

For concretes used in research applications, the data sets tend to include more information about the constituents compared to commercial concretes made with standard constituents. This information is especially important when new constituents such as specialty cements or chemical admixture formulations are being investigated or when the effects of similar constituents on concrete performance are being evaluated.

Concrete Mixture Proportions

The concrete mixture proportions data category is used to report the amount of each constituent contained in a given volume of concrete. This data category is represented by four fields (Table 4). Each field is considered essential because the compositional characteristics of the concrete are significantly influenced by the amount of each constituent included in the mixture.

This data category is intended to be repeated for each constituent in the mixture. Consequently, the relationship between the mixture proportion entries and the corresponding constituent needs to be maintained. Because the relationships among the constituents and the mixture proportions are important concrete identification parameters, they should be given priority consideration when establishing the database management system.

Concrete Processing

The concrete processing data category is used to report information related to batching,

mixing, transporting, placing, consolidating, finishing, and curing of concrete. It is represented by eight fields (Table 5). Processing information can be an important identifier. For example, when all other factors are identical, the mechanical properties of concrete specimens that have been moist cured for one month may be significantly different from companion specimens that have been moist cured for only one week.

Fresh Concrete Property

The fresh concrete property data category is used to report the properties of freshly mixed concrete. These properties may be obtained from tests such as slump, unit weight, and air content that are conducted on the fresh concrete or determined by calculation from the mixture proportions or related information. Entries based on calculations may include the water-cement ratio, water-cementitious material ratio, or cement factor. This data category, which is repeated for each fresh concrete property, is represented by nine fields (Table 6).

Reference Property

The reference property data category is used to report any concrete property that is to be used as a reference property. Properties obtained from a test conducted on the fresh concrete or a sample of the hardened concrete are often used for this purpose. Other types of entries that may be reported in this data category include reference property values, acceptance criteria, or strength requirements such as the design compressive strength of the concrete. This data category, which is repeated for each reference concrete property, is represented by ten fields (Table 7).

Format Standards

Format standards for the identification of concrete in a materials property database have not yet been published, but ACI Committee 126 on Concrete Material Property Database Formats is currently involved in their development. The mission of the committee is to develop and maintain standard database formats for use in computerization of the properties of concrete, concrete

materials, and related materials. Documents currently being developed include: a guide for recommended formats for the identification of concrete in a materials property database; guides for recommended formats for cements, aggregates, chemical admixtures, and mineral admixtures; a guide for recommended formats for processing of concrete; and a guide for recommended formats for properties and performance of concrete. The recommended formats in these documents are intended to be consistent with the principles laid down in the guides that have been prepared by ASTM Committee E-49 on Computerization of Material and Chemical Property Data.

References

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TABLE 1--Concrete designation data category.

Field Name	Field Type	Suggested Use
Material Class	Essential	To distinguish one broad group of materials from another. Materials within each class typically have common compositional traits and similar characteristics or features. Metals and alloys, ceramics, polymers, composites, and wood are considered material classes. The class of materials covered by these guidelines is concrete.
Binder Type	Essential	To subdivide concrete into types which contain the same binder. Many types of binders such as portland cement, blended hydraulic cement, expansive hydraulic cement, and masonry cement may be used to make concrete. Terms used as database entries should conform to established concrete terminology whenever possible.
Concrete Category	Essential	To categorize each type of concrete based on its bulk density. The bulk density of concrete is significantly influenced by the densities of the aggregates and the void content of the concrete. Lightweight, structural lightweight, normal-weight, and heavyweight are terms that represent ranges of concrete bulk density.
Concrete Group	Desirable	To indicate the end-use or application of the concrete or other types of unique features or characteristics. Terms such as plain, structural, precast, prestressed, reinforced, or fiber-reinforced may be used as database entries in this field.
Processing Group	Desirable	To distinguish concretes of the same type, category, and group from one another. The processing group identifier generally reflects the procedure or manufacturing technique used to process the concrete. Terms such as ready-mixed, prepacked, pumped, and roller-compacted used as database entries should conform to established concrete terminology whenever possible.
Concrete Identification Number	Desirable	To report a unique alphanumeric concrete identifier. This combination of numbers and letters is generally established by the organization that prepares the concrete specification and its is used by the database manager to represent the concrete in the materials property database. It should be noted that a standardized numbering system for concrete has not yet been developed.
Common Name	Essential	To report a unique designation for the concrete. This name is often provided by the concrete supplier and used by the database manager to represent the concrete in the materials property database. "Mixture A", "Lightweight Concrete", "3000 psi Concrete", and "50 MPa Concrete" are examples of common concrete names.
Concrete Designation Notes	Desirable	To report descriptive information or notes about the concrete.

TABLE 2--Concrete supplier data category.

Field Name	Field Type	Suggested Use
Supplier Name	Essential	To report the name of the concrete producer, research organization, or contractor that supplied the concrete.
Supplier Address	Essential	To report the address of the concrete producer, research organization, or contractor that supplied the concrete.
Supplier Plant Location	Desirable	To report the location of the concrete supplier's plant. An address, a batch plant designation, or another type of identifier may be entered in this field.
Supplier Identification Number	Desirable	To report an alphanumeric designation. This number may be the same as the one used by the concrete supplier for identification purposes.

TABLE 3--Constituent designation data category^a.

Field Name	Field Type	Suggested Use
Constituent Class	Essential	To distinguish one broad class of constituents from another. Materials within each class typically have common compositional traits or chemical formulations and similar characteristics or features. Cement, aggregate, chemical admixture, mineral admixture, other solids, and other liquids are examples of classes of constituents.
Common Name	Essential	To report a common name for the class of constituents reported in the previous field. Portland cement, crushed limestone (coarse), crushed limestone (fine), fly ash, air-entraining admixture, water-reducer, steel fibers, and water are examples of common names for constituents.
Producer Name	Essential	To report the name of the company that produced or supplied the constituent.
Producer Plant Location	Essential	To report the address where the constituent was produced or the location where the constituent was obtained.
Producer Identification Number	Essential	To report an alphanumeric designation assigned by the producer or supplier to distinguish one lot or batch of material from another.
Specification Organization	Desirable	To report the company, industry, or national or international organization that issued the standard specification with which the constituent complies. ASTM is an example of an organization that issues standard specifications for constituents of concrete.
Specification Number	Desirable	To report the number of the standard specification issued by the standards organization reported above. For example, the ASTM standard specification number for portland cement is C 150.
Specification Version	Desirable	To report the version of the standard specification reported above. A version is usually a number that represents the date of issue.
Specification Designation	Desirable	To report the designation, if any, within the standard specification reported above. Type I, Type A, and Class F are examples of ASTM standard specification designations.
Notes	Desirable	To report notes and comments about the constituent.

^aRepeat this set of fields for each constituent in the concrete mixture.

TABLE 4--Concrete mixture proportions data category^a.

Field Name	Field Type	Suggested Use
Constituent Quantity per Unit Volume of Concrete	Essential	To report the quantity (mass or volume) of a constituent that is used to prepare a unit volume of concrete. This number is reported as a floating point decimal.
Customary Units Designation	Essential	To report the customary units that correspond to the number reported above. Example entries include pounds / cubic yard, fluid ounces / cubic yard, kilograms / cubic meter, and milliliters / cubic meter.
SI Units Designation	Essential	To report the units in the International System (SI) of units that correspond to the number reported above. These designations should conform to ASTM Standard Practice for Use of the International System of Units (E 380). Example entries include kilograms / cubic meter and milliliters / cubic meter.
Customary to SI Units Conversion Factor	Essential	To report the conversion factor that is used to convert customary units to SI units. This number is reported as a floating point decimal. As an example; the factor for converting pounds / cubic yard to kilograms / cubic meter is 0.5932764.

^aRepeat this set of fields for each constituent in the concrete mixture maintaining the relationship between the mixture proportion entries and the corresponding constituent.

TABLE 5--Concrete processing data category.

Field Name	Field Type	Suggested Use
Processing Date	Essential	To report the date the concrete was mixed (or batched).
Batching Process	Desirable	To report the batching process used for measuring the constituents for a batch of concrete. Manual weight batching, semiautomatic weight batching, automatic weight batching, cumulative automatic weight batching, individual automatic weight batching, and volumetric batching are examples of concrete batching processes.
Mixing Equipment	Desirable	To report the type of mixer used for blending the constituents. Colloid mixer, horizontal shaft mixer, nontilting mixer, open-top mixer, pan mixer, paddle mixer, continuous mixer, tilting mixer, transit mixer, and vertical shaft mixer are examples of types of mixers used to prepare a batch of concrete.
Transporting and Placing Equipment	Desirable	To report the type of equipment used for transporting the concrete from the mixer to the point of discharge and the type of equipment used for placing the concrete. Wheelbarrow, buggy, chute, dump bucket, truck with agitator, truck without agitator, conveyor belt, portable conveyor, feeder or series conveyor, spreading conveyor, radial spreader, straight line spreader, piston pump, pneumatic pump, and squeeze pressure pump are examples of transporting equipment. Scoops, shovels, buckets, hoppers, chutes, tremie, paving equipment, and slipforming equipment are examples of placing equipment.
Consolidating Equipment	Desirable	To report the type of equipment used to consolidate the concrete. Spades, hand tampers, rods, power tampers or rammers, internal vibrators, external vibrators, surface vibrators, and table vibrators are examples of consolidating equipment.
Surface Finish	Desirable	To report the final surface finish of the concrete. Exposed aggregate, trowelled, broomed, rubbed, floated, screeded, polished, grooved, and formed are examples of surface finishes.
Curing Technique	Desirable	To report the curing procedure or technique. Curing with water and curing by moisture retention are two techniques that are typically used to cure concrete members.
Concrete Processing Notes	Desirable	To report processing-related notes and comments.

TABLE 6--Fresh concrete properties data category^a.

Field Name	Field Type	Suggested Use
Fresh Concrete Property Designation	Essential	To report the name of the fresh concrete property being reported. Slump, unit weight, air content, water-cement ratio, and water-cementitious material ratio are examples of fresh concrete properties.
Standards Organization	Desirable	To report the company, industry, or national or international organization that issued the standard method of test used in determining the fresh concrete property. ASTM is an example of an organization that issues test methods for determining fresh concrete properties.
Standard Number	Desirable	To report the number of the standard test method issued by the organization reported above. For example, the number of the ASTM test method standard for determining concrete slump is C 143.
Standard Version	Desirable	To report the version of the standard test method reported above. A version is usually a number that represents the date of issue.
Property Value	Essential	To report the property value obtained from the standard test method or evaluation. This number is reported as a floating point decimal.
Customary Units Designation	Essential	To report the customary units that correspond to the property value reported above. Example entries include inches and pounds.
SI Units Designation	Essential	To report the units in the international system of units that correspond to the property value reported above. These designations should conform to requirements of ASTM E 380. Example entries include millimeters and kilograms.
Customary to SI Units Conversion Factor	Essential	To report the conversion factor that is used to convert customary units to SI units. This number is reported as a floating point decimal. For example, the factor for converting inches to millimeters is 25.4.
Notes	Desirable	To report notes and comments about the fresh concrete property.

^aRepeat this set of fields for each fresh concrete property in the database.

TABLE 7--Reference concrete properties data category^a.

Field Name	Field Type	Suggested Use
Reference Property Designation	Essential	To report the name of the concrete property being reported. Unit weight, air content, slump, compressive strength, modulus of rupture, and splitting tensile strength are examples of properties that could be considered reference properties.
Standards Organization	Desirable	To report the company, industry, national, or international organization that issued the standard method of test used in determining the fresh concrete property. ASTM is an example of an organization that issues test methods for determining fresh concrete properties.
Standard Number	Desirable	To report the number of the standard test method issued by the organization reported above. For example, the number of the ASTM test method standard for determining the compressive strength of cylindrical concrete specimens is C 39.
Standard Version	Desirable	To report the version of the standard test method reported above. A version is usually a number that represents the date of issue.
Property Value	Essential	To report the property value obtained from the standard test method or evaluation. This number is reported as a floating point decimal.
Customary Units Designation	Essential	To report the customary units that correspond to the property value reported above. Example entries include inches and pounds / square inch.
SI Units Designation	Essential	To report the units in the international system of units that correspond to the property value reported above. These designations should conform to requirements of ASTM E 380. Example entries include millimeters, megapascals, and gigapascals.
Customary to SI Units Conversion Factor	Essential	To report the conversion factor that is used to convert customary units to SI units. This number is reported as a floating point decimal. For example, the factor for converting pounds / square inch to megapascals is 0.006894757.
Concrete Age (days)	Essential	To report the age of the concrete at the time the reference property was determined. This number is reported as a floating point decimal and the units are usually days.
Notes	Desirable	To report notes and comments about the reference property such as environmental exposure conditions, ambient temperature, and relative humidity.

^aRepeat this set of fields for each reference concrete property in the database.