OAK RIDGE
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Nuclear Concrete Materials Database Phase I Development

February 20, 2012

Prepared by

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Light Water Reactor Sustainability Program

Nuclear Concrete Materials Database
Phase I Development

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TABLE OF CONTENTS

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ABSTRACT

The FY 2011 accomplishments in Phase I development of the Nuclear Concrete Materials Database to support the Light Water Reactor Sustainability Program are summarized. The database has been developed using the ORNL materials database infrastructure established for the Gen IV Materials Handbook to achieve cost reduction and development efficiency. In this Phase I development, the database has been successfully designed and constructed to manage documents in the Portable Document Format generated from the Structural Materials Handbook that contains nuclear concrete materials data and related information. The completion of the Phase I database has established a solid foundation for Phase II development, in which a digital database will be designed and constructed to manage nuclear concrete materials data in various digitized formats to facilitate electronic and mathematical processing for analysis, modeling, and design applications.

ACRONYMS

LWRS	Light Water Reactor Sustainability
NCMDB	Nuclear Concrete Materials Database
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
SMH	Structural Materials Handbook
UCAMS	Universal Computer Access Management System
XCAMS	External Computer Access Management System

1. INTRODUCTION

In FY 2010, a plan was drafted to outline the development of an advanced Nuclear Concrete Materials Database (NCMDB) that would support the Light Water Reactor Sustainability (LWRS) Program for life extension of the existing 104 domestic nuclear reactors [1]. The entire development was divided into two phases. In Phase I, a web-based electronic document database would be designed and constructed to manage the historical data files of nuclear concrete materials compiled in the Structural Materials Handbook (SMH), which was developed in the 1990s by the Oak Ridge National Laboratory (ORNL) under the sponsorship of the Nuclear Regulatory Commission's (NRC) Structural Aging Program [2] to cover the concrete components of the existing domestic nuclear reactors. In Phase II, a web-based digital database would be developed to manage historical as well as newly generated data and related information in various digitized data formats that would enable effective support to advanced information searching, processing, analysis, modeling, and simulation applications.

The Phase I development was initiated in the third quarter of FY 2010 and the accomplishments of the fiscal year were summarized in the FY 2010 project annual report [3]. In FY 2011, all the remaining Phase I activities were successfully undertaken to deliver the database. First, detail design of the database structure was reviewed and finalized after several revisions to provide the adequate data record layouts based on the draft data management schema developed in FY 2010. With the desired data record layout design, the basic database components were constructed. The structure of the database was then built using these basic components. Meanwhile, data documents were prepared in the Portable Document Format with search capability (searchable PDF) from the original SMH hardcopy as well as the historical electronic files. The searchable PDF documents were then uploaded into the database structure, and hypertext links were established to connect related data documents. To facilitate the database development and future release, an access control system was also designed and implemented to provide different browsing privileges for the developers and regular users. Lastly, testing of database operational functions and checking on database content error were conducted to ensure expected operation and to eliminate erroneous information, if any. A homepage was also designed for the database website.

This report summarizes the accomplishments in FY 2011 development and briefly discusses the considerations for Phase II development.

2. DETAIL DESIGN OF THE DATABASE STRUCTURE

In Phase I development, a major objective is to collect and organize the historical data files of nuclear concrete materials that were compiled in the SMH Project in the 1990s. The SMH was developed with a three-ring binder version and an electronic version. The data and related information were organized in a specific code system. Because the code system well categorized the nuclear concrete materials with adequate considerations of their constituents, it was highly likely that it could be utilized to facilitate the design of the digital data management schema in Phase II development. To establish a solid foundation for the Phase II database development as well as to provide quick access to the nuclear concrete data for users who were familiar with the SMH data structure, it was determined that the detail structure of the Phase I database should retain the original SMH architecture while enabling some basic database search capabilities. With this intention, the Phase I database was designed to largely reflect the original core data management structure in Volumes 1 ~ 3 of the SMH, as outlined in Table 1. Due to its considerable size, the detail database

structure design for Volumes 1 ~ 3 is documented the Appendix. It is apparent from the Appendix that this data management structure provides a full coverage of the nuclear concrete material system, including the areas where data were lacking therefore no existing information had been collected in the SMH. To ensure operational effectiveness, the data containers whose data availability is marked with "No" in the Appendix were not constructed in the Phase I database. With these non-constructed containers, the detail design in Appendix is expected to provide guidance for future data collection in a systematic manner. Once the lacking data are collected, the containers can be added to the database as designed.

Table 1: Data containers in correspondence with the SMH data management structure

Place in the SMH Code	Description	Structure Level	Data Container
The 1st and 2nd Characters of the Material Code	Two digits from 01 to 99	Chapter for Material System	Silver Color Folder
The 3rd Character of the Material Code	A capital letter	Group Index for Material Group	Gray Color Level 1 Subfolder
The 4th Character of the Material Code	A capital letter	Class Index for Material Class	Teal Color Level 2 Subfolder
The 5th, 6th, and 7th Character of the Material Code	Three digits from 001 to 999	Identifier for Concrete Mixture Type	Navy Color Record
The 1st character of the Property Code	One digit in the thousand place from 1000 to 9000	Material Property Code Group	Heading Prefix in Record
The 2nd, 3rd , and 4th Character of the Property Code	Three digits from 000 to 999	Descriptor of Material Property	Attribute Prefix in Record

It should be noted that the structure design in the Appendix only covers to the 4th character of the SMH Material Code hierarchy, which represents the Material Class as shown in the fourth row of Table 1. Designs of the further detailed structures are presented in Table 2 and Table 3, with the former for Volumes 1 and 2 and the latter for Volume 3 to cover the more refined different data structure characteristics of these volumes. The designs presented in Tables 2 and 3 were used for construction of records for concrete mixture type to cover the Property Code of the SMH data structure. Each row in the design was constructed as a data container that could hold a PDF document for corresponding Property Code(s). Unlike the construction at the Material Code levels that only included folders with available data, all the rows in Tables 2 and 3, regardless the data availability, were constructed in the database. Functionalities are provided in the database so that user can choose to hide the empty rows and display only the rows that hold a PDF document. If new data can be collected in the future to enable creation of a PDF document for an empty row, it can be conveniently uploaded into the empty row to expand the record.

Table 2: Design of the data record layout for concrete mixture type of SMH Volumes 1 and 2

Volume 1 and Volume 2 Data Record Layout
1000 GENERAL INFORMATION
2000 CONSTITUENT MATERIALS AND PLASTIC CONCRETE PROPERTIES
3000 MECHANICAL PROPERTIES
3602 Engineering Stress-Strain Diagram (Temperature Dependent)

Volume 1 and Volume 2 Data Record Layout	
3612	Modulus of Elasticity versus Time (Temperature Dependent)
3613	Dynamic Modulus of Elasticity versus Time
3614	Dynamic Modulus of Elasticity versus Time (Temperature Dependent)
3615	Modulus of Elasticity versus Fast Neutron
3617	Poisson's Ratio versus Time (Temperature Dependent)
3619	Dynamic Poisson's Ratio versus Time (Temperature Dependent)
3621	Ultimate Compressive Strength versus Time
3622	Ultimate Compressive Strength versus Time (Temperature Dependent)
3623	Ultimate Compressive Strength versus Fast
3631	Flexural Strength versus Time
3635	Splitting Tensile Strength versus Time (Temperature Dependent)
3636	Splitting Tensile Strength versus Fast
3642	Creep of Concrete in Compression (Temperature Dependent)
3651	Bond Stress versus Slip
3652	Bond Stress versus Slip (Temperature Dependent)
3662	Hardness versus Time (Temperature Dependent)
3672	Compressive Strength Ratio versus Temperature
3674	Modulus of Elasticity Ratio versus Temperature
3676	Tensile Strength Ratio versus Temperature
3678	Bond Strength Ratio versus Temperature
3701	Engineering Stress-Strain (Ambient Conditions)
3702	Engineering Stress-Strain (Temperature Dependent)
3711	Tensile Yield Strength versus Temperature
3712	Ultimate Tensile Strength versus Temperature
3721	Ultimate Tensile Elongation versus Temperature
3731	S-N Diagram
4000 THERMAL, PHYSICAL, AND OTHER PROPERTIES	
4631	Weight Change versus Time
4634	Porosity versus Time (Temperature Dependent)
4636	Shrinkage versus Time (Temperature Dependent)
4637	Length Change versus Time
4639	Weight Change versus Temperature

Table 3: Design of the data record layout for concrete mixture type of SMH Volume 3.

Volume 3 Data Record Layout
1000 GENERAL INFORMATION
1000-1999 General Information
2000 CONSTITUENT MATERIALS AND PLASTIC CONCRETE PROPERTIES

2000-2999 Constituent Materials and Plastic Concrete Properties
3000 MECHANICAL PROPERTIES
3000-3999 Mechanical Properties
4000 THERMAL, PHYSICAL, AND OTHER PROPERTIES
4000-4999 Thermal, Physical, and Other Properties

The structure of SMH Volume 4 is quite different from that of the previous 3 volumes. Volume 4 only contains Appendixes A ~ F without the data hierarchy in Volumes 1 ~ 3. Therefore no folder containers were designed and only the data record containers were constructed, with each record holding one appendix. Its data record layout design is also different from those for Volumes 1, 2 and 3, as shown in Table 4.

Table 4: Design of the data record layout for concrete mixture type of SMH Volume 4

Volume 4 Data Record Layout
COVER SHEET
Volume 4 Cover Sheet
TABLE OF CONTENTS
Volume 4 Table of Contents
INTRODUCTION
Volume 4 Introduction
APPENDIX
Appendix A Title
Appendix A File
Appendix B Title
Appendix B File
Appendix C Title
Appendix C Introduction
1000 GENERAL INFORMATION
1000-1999 General Information
2000 CONSTITUENT MATERIALS AND PLASTIC CONCRETE PROPERTIES
2000-2099 Cementitious Materials
2100-2199 Cementitious Material Properties
2200-2299 Aggregate and Fiber Reinforcing Materials
2300-2399 Aggregate and Fiber Reinforcing Material Properties
2400-2499 Concrete Admixtures, Water, Additives and Products
2500-2599 Concrete Admixtures, Water, Additive and Product Properties
2600-2799 Plastic Concrete Properties
3000 MECHANICAL PROPERTIES
3000-3099 Static Mechanical Properties of Nonmetallic Materials
3100-3199 Static Mechanical Properties of Metallic Materials

3200-3299 Dynamic Mechanical Properties of Nonmetallic Materials
3300-3399 Dynamic Mechanical Properties of Metallic Materials
3400-3499 Fracture Mechanics Properties
3500-3599 Charpy V-Notch Impact Test
3600-3699 Plots and Graphs of Mechanical Properties for Nonmetallic Materials
3700-3799 Plots and Graphs of Mechanical Properties for Metallic Materials
4000 THERMAL, PHYSICAL, AND OTHER PROPERTIES
4000-4099 Thermal Properties of Nonmetallic Materials
4100-4199 Thermal Properties of Metallic Materials
4200-4299 Physical Properties of Nonmetallic Materials
4300-4399 Physical Properties of Metallic Materials
4400-4499 Other Properties of Nonmetallic Materials
4500-4599 Other Properties of Metallic Materials
4600-4699 Plots and Graphs of Thermal, Physical, and Other Properties for Nonmetallic Materials
4700-4799 Plots and Graphs of Thermal, Physical, and Other Properties for Metallic Materials
5000 ADDITIONAL MATERIAL PROPERTIES
5000-5999 Additional Material Properties
CHEMICAL ELEMENT ABBREVIATION
Chemical Element Abbreviation
Appendix D Title
Appendix D File
Appendix E Title
Appendix E File
Appendix F Title
Appendix F File

3. CONSTRUCTION OF THE DATABSE

With the detail structural design, another two major elements were prepared to construct the Phase I database. The first one was the PDF documents containing the data and related information, and second one was the actual database structure constructed in a server machine that composed of various data containers, operational functionalities, and link mechanisms that would connect the related data records.

In preparation of the PDF documents, both the three-ring binder hardcopy and the electronic files of the SMH were used as the data source. Although the hardcopy has been preserved in a relatively good condition, as shown in Figure 1, and most of the pages can be directly scanned into PDF files of visually acceptable quality, a trial Optical Character Recognition (OCR) operation to create the desired searchable PDF document indicated potential problems in accurate conversion of numeric numbers and math equations, particularly in symbols for number zero and letter o, number one and letter l, and so on. To avoid such problems which could introduce serious error into the database, the

electronic files were used as the major source for PDF document preparation, with the hardcopy as a backup for verification and confirmation when needed during the electronic conversion process. Because the electronic files had originally been created using software that was no longer available, furthermore, a large amount of math equations in those electronic files had been generated using the obsolete software in a semi-manual fashion, several attempts at automated file processing and conversion using modern software failed. Some unique procedures had to be developed to convert the electronic files to searchable PDF documents, and consequently the process took longer than initially expected. However, the painstaking processing was paid off by the good quality of the final product. The prepared PDF documents were searchable with satisfactory accuracy. Some errors in the original source were also identified and corrected. The high quality searchable PDF documents are expected to facilitate effective use of the database, furthermore, to provide a convenient data source for the digital database development in Phase II since the "Copy and Paste" operation can be conducted to easily extract the needed digital data.

In construction of the actual database structure, the designs discussed in Section 2 were used as the blue print to build all the needed components. The construction was carried out in a server machine located in the Universal Computer Access Management System (UCAMS), which is the ORNL internal network, for convenient developer and evaluator access. All the prepared PDF documents were integrated into the database structure, as shown in Figure 2. Preliminary testing of the system proved that the design and construction were successful, and all the functionalities could perform as expected. Further testing and database content reviewing are currently being conducted.

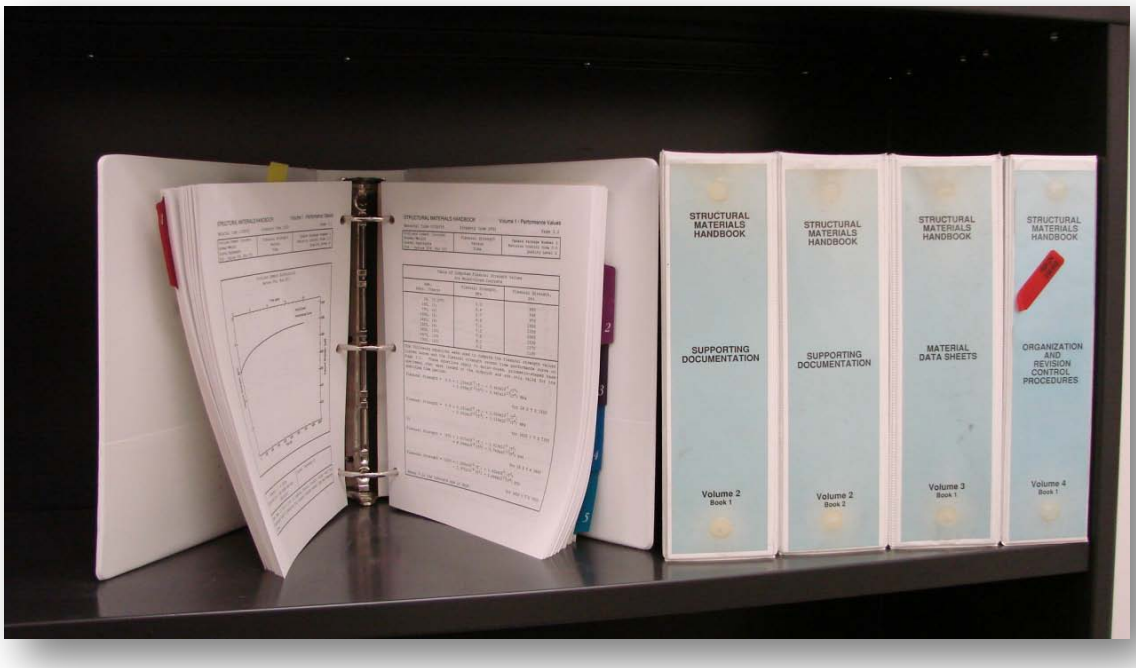

Figure 1: Hardcopy of the SMH used as reference for database file preparation

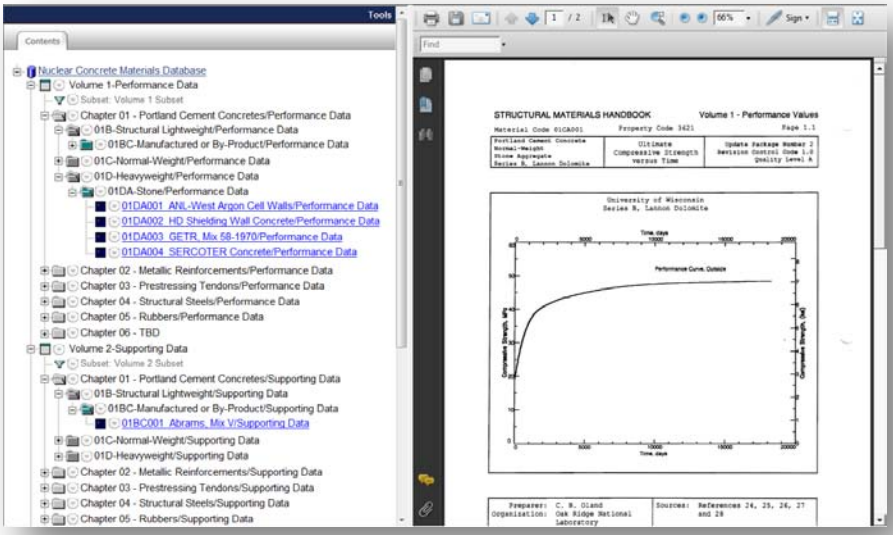

Figure 2: A display of the constructed Nuclear Concrete Materials Database

To prepare database release for external user access, a homepage was design for the database website as shown in Figure 3. Once the database passes all the testing and evaluation, it will be duplicated to a server machine located in the ORNL External Computer Access Management System (XCAMS). A domain name will be created for the database website and the homepage will be integrated into the system as the first displayed image with a login icon for users to perform the identification authentication. An access control system will be design and implemented to meet the LWRS Program requirements for external users.

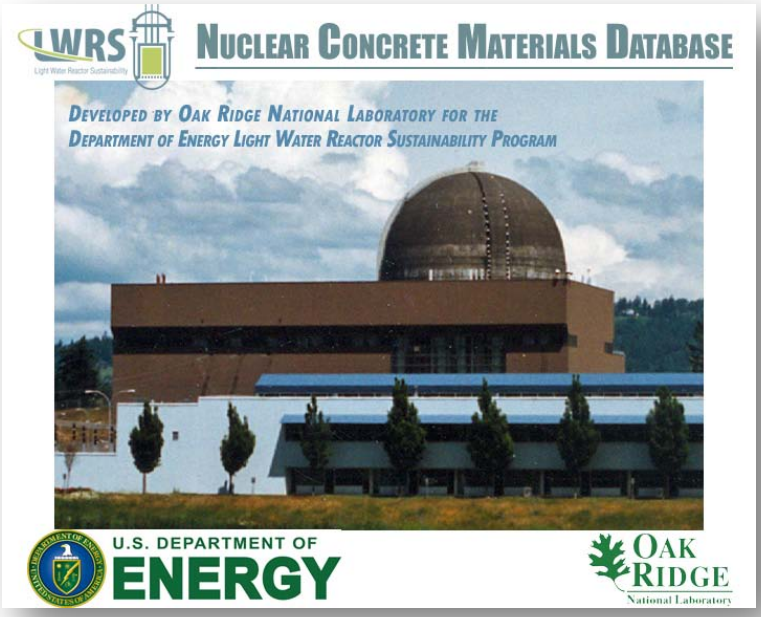

Figure 3: Homepage for the Nuclear Concrete Materials Database

4. OPERATION OF THE DATABASE

As it was planned, the Phase I database has been constructed as a simple system to manage the PDF documents created from the SMH in a well organized fashion. Subsequently its operations are also simple, without any training requirements for regular computer users. Therefore no development of a user manual is needed.

As shown in Figure 4 a), there are four volume icons in the left window pane, corresponding to the four volumes of the SMH. When a record is opened, its contents are displayed in the right window pane. The hypertext links in the record are the entry points for PDF documents. User can click on the link to open a desired document in a new window to review it, as shown in Figure 4 b).

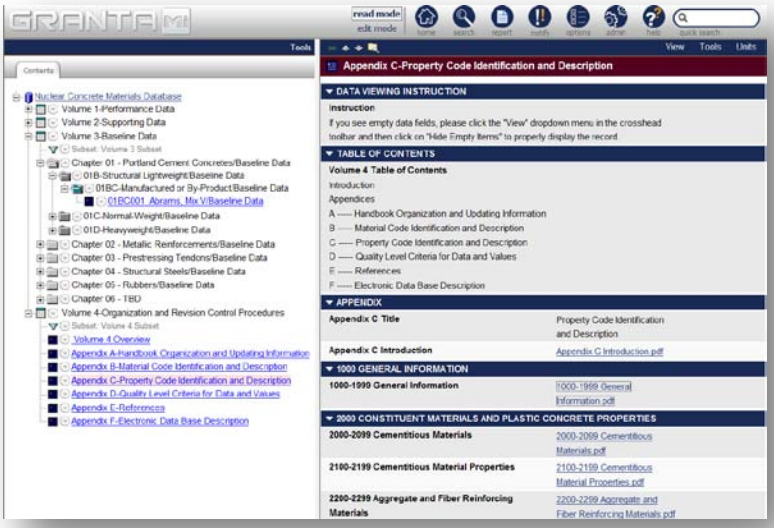

Figure 4 a): Four volumes in the database corresponding to those in the SMH

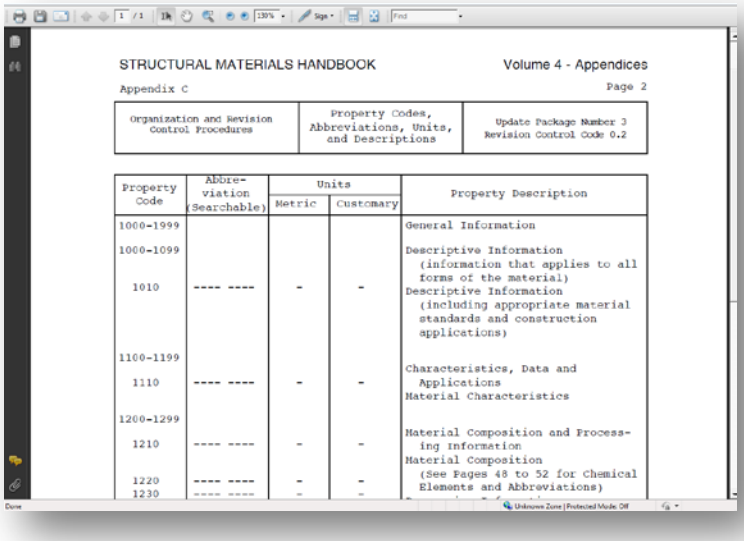

Figure 4 b): Display of an opened PDF document for review and download

Although the Phase I database is constructed as a simple file management system, it is still designed with some basic features of a relational database that maintains the relations between datasets. In the original SMH structure, information for a specific material property is separately presented in Volume 1 with performance data, Volume 2 with supporting data, and Volume 3 with baseline data. The Phase I database provides hypertext links to connect these three related datasets. As shown in the record title on the upper right side of Figure 5, the performance data record of "*02AC005_ASTM A 615, Gr. 60/**Performance Data***" is displayed. The location of this record in the database is indicated by the pink highlight of the record title in the left window pane. In the displayed record contents in the right window pane, there are two hypertext links under the heading RELATED RECORDS, one for its supporting data record and the other for its baseline record. A click on the supporting data link immediately displays the "*02AC005_ASTM A 615, Gr. 60/**Supporting Data***" record, and the location of this supporting data record in the database is automatically marked by the pink highlight in the left window pane, as shown in Figure 6. It should be noted that in Figure 6 the displayed "*02AC005_ASTM A 615, Gr. 60/**Supporting Data***" record also provides two hypertext links, of which one of the links connects the record back to the "*02AC005_ASTM A 615, Gr. 60/**Performance Data***" record. By maintaining these relations between the datasets, the database enables the user to browse through the system and conveniently trace pedigree of the information as needed.

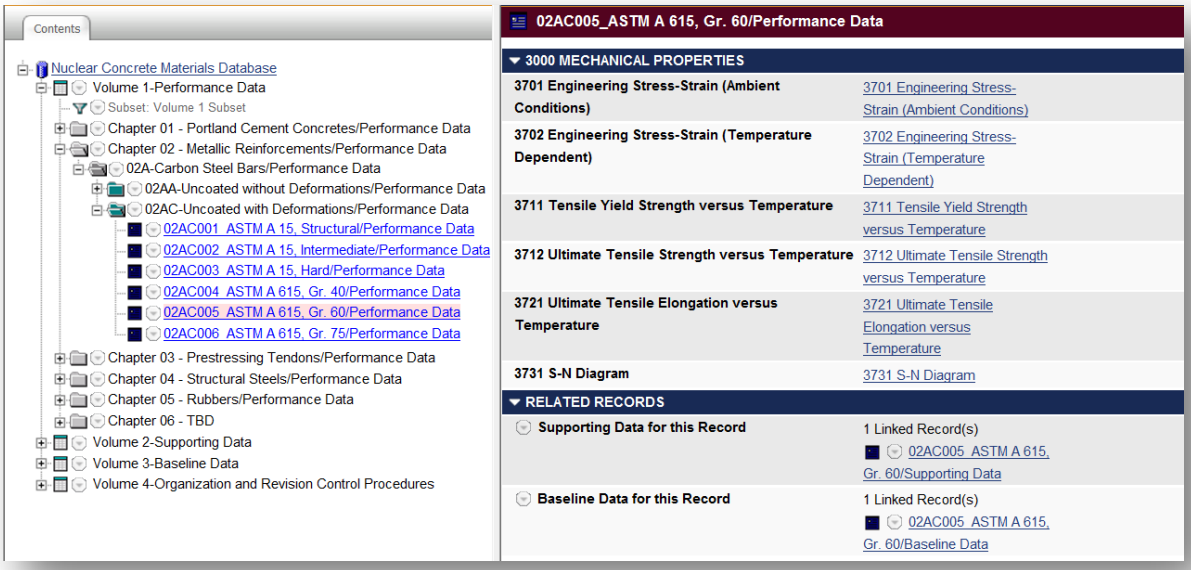

Figure 5: Hypertext links under the heading RELATED RECORDS that connect related information in the database (Note the brown heading indicates this is a Performance Data record.)

In addition to tracing the relations between datasets, the database also provides some basic search capabilities. Any word that is contained in the record name or the Property Code can be used as a key word to conduct the search operation. An example is given in Figure 7. In Figure 7 a), a click on the search icon activates the search window pane. A key word string "Compressive Strength Ratio" is typed into the upper search field and the search results are displayed in the left window pane as shown in Figure 7 b), in which the upper section shows that a total of 14 records are found in Volumes 1 and 2, with 7 records in each volume. The lower section shows that, of the 14 records, there are 3 records containing the key word string with a 100% matching rate. A click on a record

with 77% matching rate shows in Figure 7 c) that Property Code 3622 contains a partial key word string "Compressive Strength" without the last word "Ratio." Obviously, the 3 records with the 100% matching rate are the records containing the complete key word string.

Because the Phase I database does not manage all the information in digital data formats but in searchable PDF documents created in the preparation discussed in Section 3, key words contained inside a given PDF document can only be searched using the PDF search function when that document is open, as shown in Figure 8.

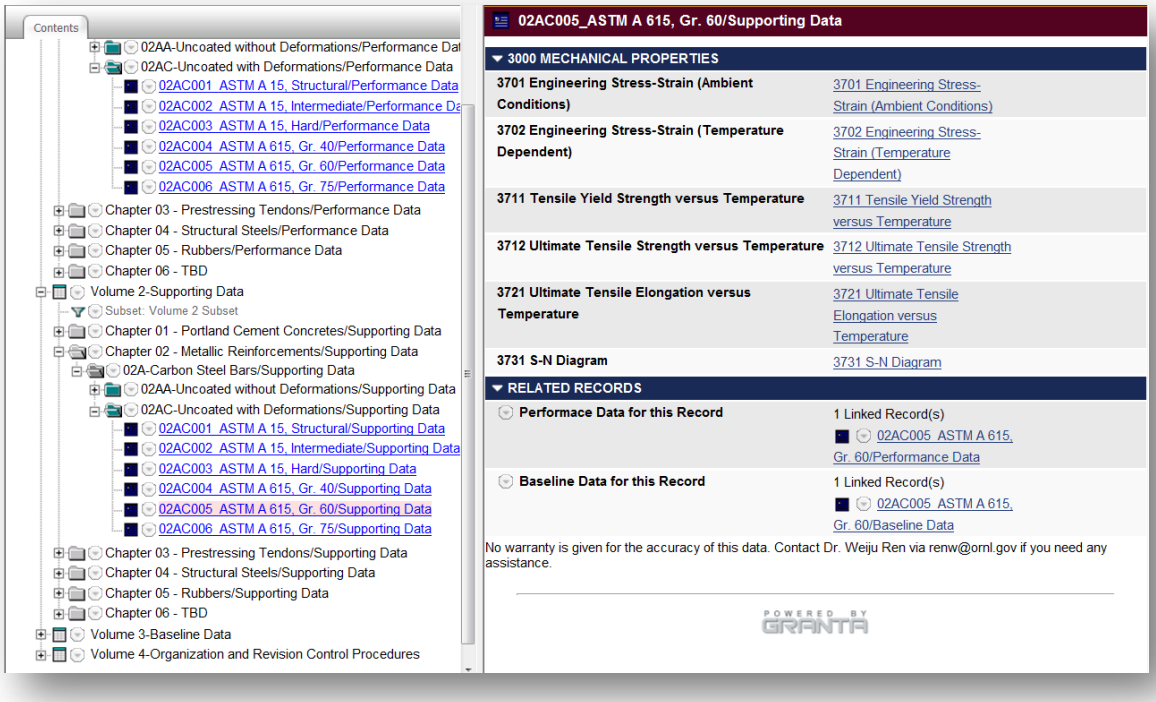

Figure 6: Display of a related record and its location in the database by a click on the link (Note the brown heading indicates this is a Supporting Data record.)

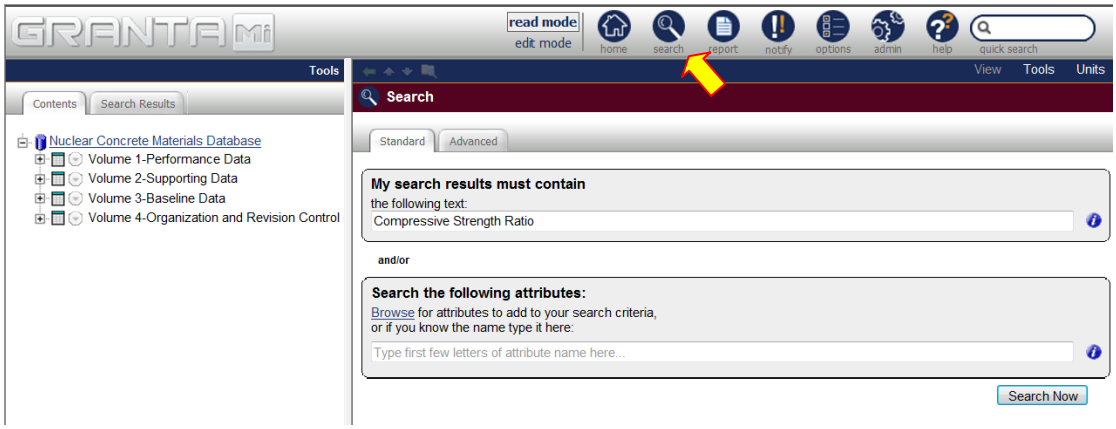

Figure 7 a): Activation of search functionality and input key words

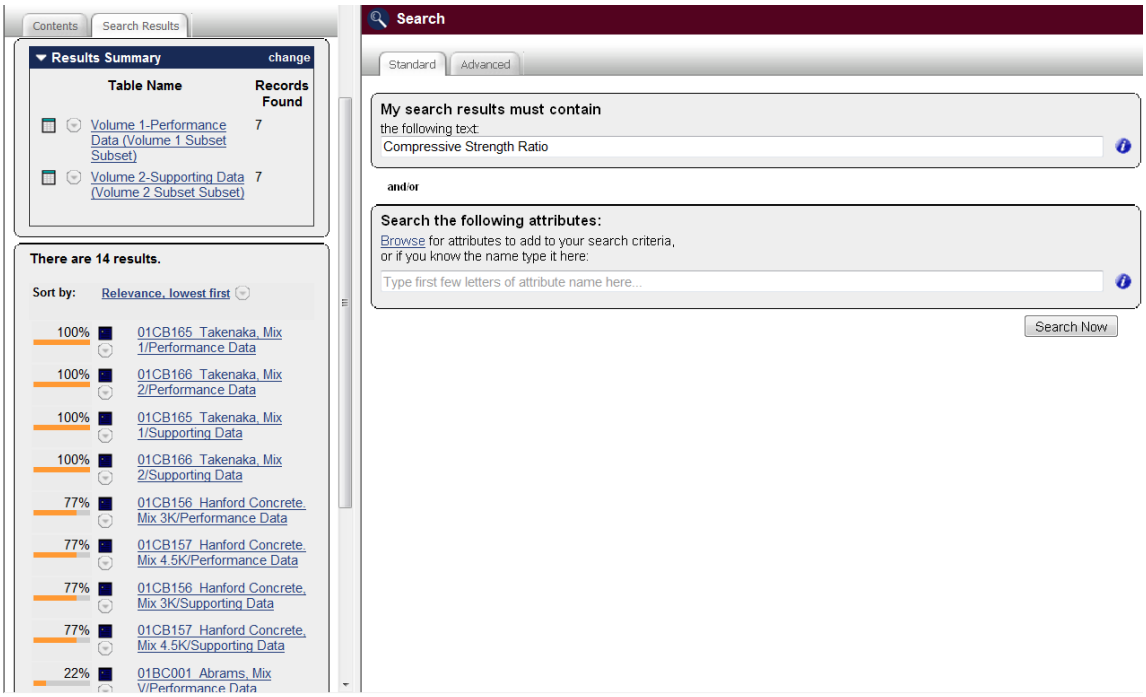

Figure 7 b): Search results displayed with matching rate in percentage

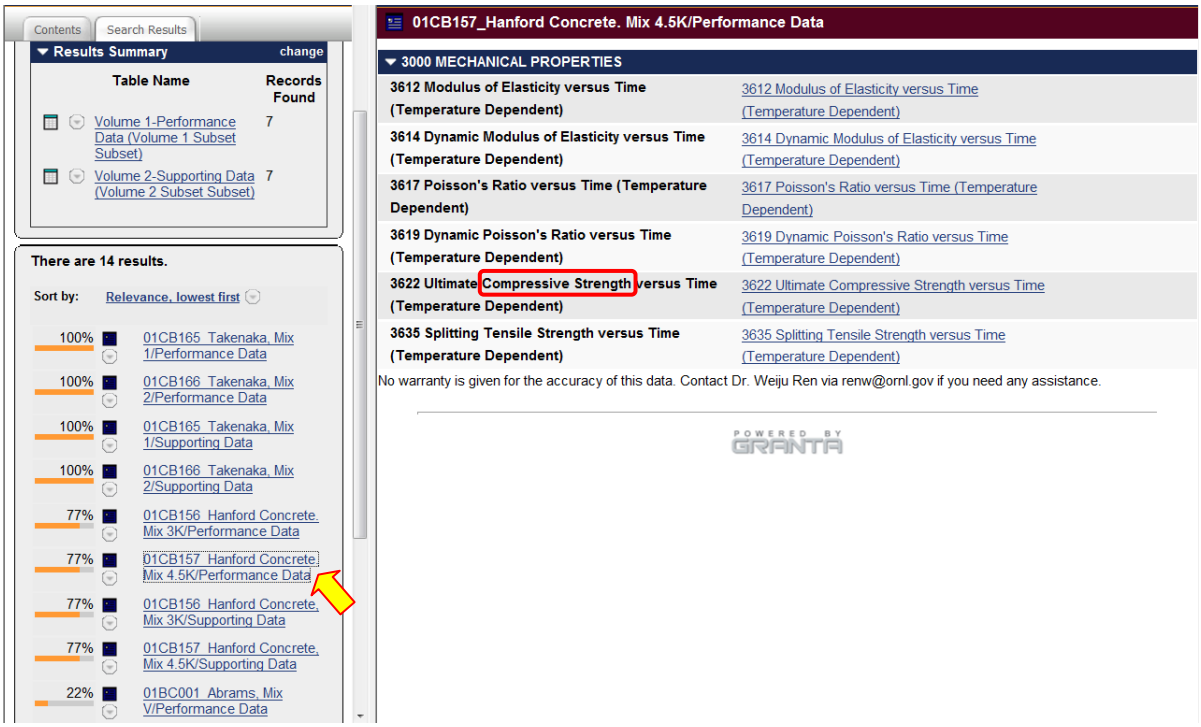

Figure 7 c): A record with less than 100% matching rate contains partial key word string

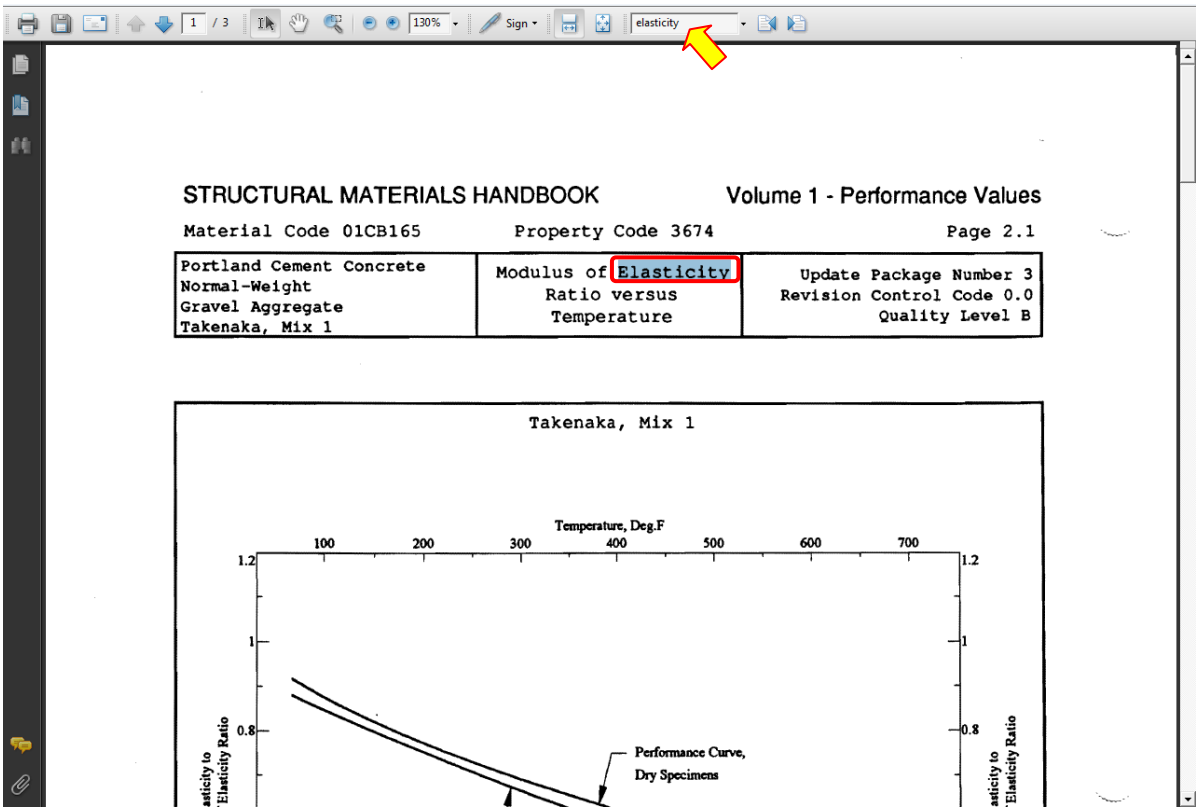

Figure 8: A key word search inside the stored PDF document

5. CONSIDERATIONS FOR PHASE II DEVELOPMENT

The development of the Phase I database has enabled internet access to the nuclear concrete materials data compiled in the SMH. In addition, the data accessibility has further been enhanced by the basic search capability and pedigree traceability introduced into the database. To provide a preliminary data support to the LWRS Program in a relatively short period of time, the completion of the Phase I database has successfully achieved its goal.

However, because the Phase I development aimed at retaining and providing quick internet access to the historical data files of nuclear concrete materials compiled in the SMH, the database has been developed as a document management system without taking full advantage of the advanced digital data management functionalities provided in the ORNL materials database infrastructure established for the Gen IV Materials Handbook. With the worldwide expanding trend of utilizing more analytical techniques and software tools in nuclear component design and construction, access to concrete materials data in various digital formats will become increasingly necessary and important. Therefore, the Phase II development must be carefully planned to enable digital data management of the nuclear concrete materials information so that it can be used to most effectively support the modern analytical and design techniques for development of nuclear concrete components as well as nuclear concrete materials per se.

In detail planning for the Phase II development, it must be considered that most of the modern concrete components are designed and fabricated as composite structures. With given properties of the constituents, the combined properties of a composite structure can vary considerably depending on various factors affected by constituents as well as fabrication procedures. The Phase II digital database must be designed with an ingenious schema so that data on properties of the matrix, the reinforcement, and various constituent combinations can be well organized and managed with accurate pedigree traceability and effective search ability. Factors that affect the final product properties, such as the processing and fabrication methods and parameters, and factors that determine the interpretation of data, such as the testing methods, must all be managed and be conveniently traceable from the related property data. Furthermore, the digital database must allow any constituent property data to be efficiently retrieved and extracted for processing, analysis, modeling and simulation using internal computational tools and external software packages. Up to data, such digital database schemas for concrete materials have not been developed in the Gen IV Materials Handbook system and are not known to exist anywhere else either. The closest experience that can be drawn upon is the design of the database schemas for polymeric and metallic composites. These schemas were designed in a draft stage for the Gen IV Materials Handbook development and can be utilized as a starting point for developing the nuclear concrete digital database schemas. To successfully design the desired schemas for effective nuclear concrete materials digital data management, expertise in concrete materials and a good understanding of concrete material properties as well as concrete component design and analysis needs and requirements are required.

6. REFERENCES

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2. "Structural Materials Information Center for Presentation of the Time Variation of Materials Properties," ORNL/NRC/LTR-90/22, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September 1990, C. B. Oland and D. J. Naus.
3. "Implementation Plan and Initial Development of Nuclear Concrete Materials Database for Light Water Reactor Sustainability Program", ORNL/TM-2010/177, U. S. Department of Energy Light Water Reactor Sustainability Program, U. S. Department of Energy, September 30, 2010, Weiju Ren, Dan Naus, and Barry Oland.

APPENDIX

DETAIL DATABASE STRUCTURE DESIGN FOR VOLUMES 1 TO 3

The mirrored database schemas of Volumes 1, 2, and 3 are the same except the suffixes are Performance Data, Supporting Data, and Baseline Data, respectively.

Data Container and Content	Data Availability
Volume 1-Performance Data	
Chapter 01 - Portland Cement Concretes/Performance Data	Yes
01A-Insulating/Performance Data	No
01AA-Stone/Performance Data	No
01AB-Gravel/Performance Data	No
01AC-Manufactured or By-Product/Performance Data	No
01B-Structural Lightweight/Performance Data	Yes
01BA-Stone/Performance Data	No
01BB-Gravel/Performance Data	No
01BC-Manufactured or By-Product/Performance Data	Yes
Yes	Data
01C-Normal-Weight/Performance Data	Yes
01CA-Stone/Performance Data	Yes
01CA001_Series B, Lannon Dolomite/Performance Data	Yes
01CA002_Series B, Red Granite/Performance Data	Yes
01CA003_Nasser and Chakraborty, 1981/Performance Data	Yes
01CA004_CANMET, Limestone Mix 1/Performance Data	Yes
01CA005_CANMET, Limestone Mix 2/Performance Data	Yes
01CA006_CANMET, Limestone Mix 3/Performance Data	Yes
01CA007_CANMET, Dolostone Mix 4/Performance Data	Yes
01CA008_CANMET, Dolostone Mix 5/Performance Data	Yes
01CA009_CANMET, Dolostone Mix 6/Performance Data	Yes
01CA010_PCA - Series 356, Mix XL1/Performance Data	Yes
01CA011_PCA - Series 356, Mix XL2/Performance Data	Yes
01CA012_PCA - Series 356, Mix XL3/Performance Data	Yes
01CA013_PCA - Series 356, Mix XhL1/Performance Data	Yes
01CA014_PCA - Series 356, Mix XhL2/Performance Data	Yes
01CA015_PCA - Series 356, Mix XhL3/Performance Data	Yes
01CA016_Midland, Mix E-2/Performance Data	Yes

	01CA017_Midland, Mix C-1/Performance Data	Yes
	01CA018_Nasser and Lohtia, 1971/Performance Data	Yes
	01CA019_Nasser and Marzouk, 1979/Performance Data	Yes
	01CA020_Bertero and Polivka, 1972/Performance Data	Yes
	01CA021_U. of Birmingham, Mix L1/Performance Data	Yes
	01CA022_U. of Birmingham, Mix C1/Performance Data	Yes
	01CA023_Wylfa Nuclear Power Satation (NPS)/Performance Data	Yes
	01CA024_Heysham I Nuclear Power Satation (NPS)/Performance Data	Yes
	01CA025_Heysham II Nuclear Power Satation (NPS)/Performance Data	Yes
	01CA026_Hartlepool Nuclear Power Satation (NPS)/Performance Data	Yes
	01CA027_Torness Nuclear Power Satation (NPS)/Performance Data	Yes
	01CB-Gravel/Performance Data	Yes
	01CB001_ANL-West Fuel Cycle Facility/Performance Data	Yes
	01CB002_Series B, Janesville, 0.51/Performance Data	Yes
	01CB003_Series B, Janesville, 0.67/Performance Data	Yes
	01CB004_Series B, Janesville, 0.41/Performance Data	Yes
	01CB005_Series B, Janesville, 0.69/Performance Data	Yes
	01CB006_EBR-II, Lift 5, Subbasement/Performance Data	Yes
	01CB007_EBR-II, Biological Shield/Performance Data	Yes
	01CB008_Walz, Series A/Performance Data	Yes
	01CB009_Walz, Series B/Performance Data	Yes
	01CB010_Walz, Series C/Performance Data	Yes
	01CB011_Walz, Series D/Performance Data	Yes
	01CB012_Walz, Series E/Performance Data	Yes
	01CB013_Walz, Series F/Performance Data	Yes
	01CB014_Walz, Series G/Performance Data	Yes
	01CB015_Walz, Series H/Performance Data	Yes
	01CB016_Kondo, Control/Performance Data	Yes
	01CB017_Kondo, 0.1 Fly Ash/Performance Data	Yes
	01CB018_Kondo, 0.2 Fly Ash/Performance Data	Yes
	01CB019_Kondo, 0.3 Fly Ash/Performance Data	Yes
	01CB020_Kondo, 0.0025 Calcium Chloride/Performance Data	Yes
	01CB021_Kondo, 0.01 Calcium Chloride/Performance Data	Yes

	01CB022_Kondo, Calcium Lignosulfonate/Performance Data	Yes
	01CB023_Kondo, 0.0025 and 0.25%/Performance Data	Yes
	01CB024_Kondo, 0.01 and 0.25%/Performance Data	Yes
	01CB025_SABNGS No. 2, 5.4 Bag Plain/Performance Data	Yes
	01CB026_SABNGS No. 2, 6 Bag Plain/Performance Data	Yes
	01CB027_SABNGS No. 2, 7 Bag Plain/Performance Data	Yes
	01CB028_SABNGS NO.2, 5.4 Bag Air/Performance Data	Yes
	01CB029_SABNGS No.2, 6 Bag Air/Performance Data	Yes
	01CB030_SABNGS No.2, 7 Bag Air/Performance Data	Yes
	01CB031_SABNGS No.2, 5.4 Bag Fly Ash/Performance Data	Yes
	01CB032_SABNGS NO.2, 6 Bag Fly Ash/Performance Data	Yes
	01CB033_SABNGS No.2, 7 Bag Fly Ash/Performance Data	Yes
	01CB034_Stewartville G.S., Core/Performance Data	Yes
	01CB035_Stewartville G.S., Face/Performance Data	Yes
	01CB036_PCA - Series 356, Mix AV1/Performance Data	Yes
	01CB037_PCA - Series 356, Mix AV2/Performance Data	Yes
	01CB038_PCA - Series 356, Mix AV3/Performance Data	Yes
	01CB039_PCA - Series 356, Mix DV1/Performance Data	Yes
	01CB040_PCA - Series 356, Mix DV2/Performance Data	Yes
	01CB041_PCA - Series 356, Mix DV3/Performance Data	Yes
	01CB042_PCA - Series 356, Mix EV1/Performance Data	Yes
	01CB043_PCA - Series 356, Mix EV2/Performance Data	Yes
	01CB044_PCA - Series 356, Mix EV3/Performance Data	Yes
	01CB045_PCA - Series 356, Mix XV1/Performance Data	Yes
	01CB046_PCA - Series 356, Mix XV2/Performance Data	Yes
	01CB047_PCA - Series 356, Mix XV3/Performance Data	Yes
	01CB048_PCA - Series 356, Mix XW1/Performance Data	Yes
	01CB049_PCA - Series 356, Mix XW2/Performance Data	Yes
	01CB050_PCA - Series 356, Mix XW3/Performance Data	Yes
	01CB051_PCA - Series 356, Mix AhV1/Performance Data	Yes
	01CB052_PCA - Series 356, Mix AhV2/Performance Data	Yes
	01CB053_PCA - Series 356, Mix AhV3/Performance Data	Yes
	01CB054_PCA - Series 356, Mix DhV1/Performance Data	Yes
	01CB055_PCA - Series 356, Mix DhV2/Performance Data	Yes

	01CB056_PCA - Series 356, Mix DhV3/Performance Data	Yes
	01CB063_PCA - Series 356, Mix XhW1/Performance Data	Yes
	01CB064_PCA - Series 356, Mix XhW2/Performance Data	Yes
	01CB065_PCA - Series 356, Mix XhW3/Performance Data	Yes
	01CB068_PCA - Series 374, Mix 11T1/Performance Data	Yes
	01CB069_PCA - Series 374, Mix 11T2/Performance Data	Yes
	01CB093_PCA - Series 374, Mix 19B1/Performance Data	Yes
	01CB094_PCA - Series 374, Mix 19B2/Performance Data	Yes
	01CB097_PCA - Series 374, Mix 21A/Performance Data	Yes
	01CB098_PCA - Series 374, Mix 21B/Performance Data	Yes
	01CB099_PCA - Series 374, Mix 21T1/Performance Data	Yes
	01CB100_PCA - Series 374, Mix 21T2/Performance Data	Yes
	01CB110_PCA - Series 374, Mix 31A/Performance Data	Yes
	01CB111_PCA - Series 374, Mix 31B/Performance Data	Yes
	01CB124_PCA - Series 374, Mix 43A3/Performance Data	Yes
	01CB125_PCA - Series 374, Mix 51A/Performance Data	Yes
	01CB126_PCA - Series 374, Mix 51B/Performance Data	Yes
	01CB127_PCA - Series 436, Mix 1/Performance Data	Yes
	01CB128_PCA - Series 436, Mix 2/Performance Data	Yes
	01CB129_PCA - Series 436, Mix 3/Performance Data	Yes
	01CB130_PCA - Series 436, Mix 4/Performance Data	Yes
	01CB131_PCA - Series 436, Mix 5/Performance Data	Yes
	01CB132_PCA - Series 436, Mix 6/Performance Data	Yes
	01CB133_PCA - Series 436, Mix 7/Performance Data	Yes
	01CB134_PCA - Series 436, Mix 8/Performance Data	Yes
	01CB151_GETR, Mix 57-1842/Performance Data	Yes
	01CB152_JPDR, Biological Shielding Walls/Performance Data	Yes
	01CB153_Mears, Mix BF/Performance Data	Yes
	01CB154_Mears, Mix AF/Performance Data	Yes
	01CB155_Seki and Kawasumi, CRIEPI/Performance Data	Yes
	01CB156_Hanford Concrete. Mix 3K/Performance Data	Yes
	01CB157_Hanford Concrete. Mix 4.5K/Performance Data	Yes
	01CB158_BNL, Portland I/Performance Data	Yes
	01CB159_BNL, Portland V/Performance Data	Yes

01CB160_BNL, Portland V/SF/Performance Data	Yes
01CB161_Abrams, Mix I/Performance Data	Yes
01CB162_Abrams, Mix III/Performance Data	Yes
01CB163_U. of Birmingham, Mix M1/Performance Data	Yes
01CB164_Tech. U. Braunschweig, 1981/Performance Data	Yes
01CB165_Takenaka, Mix 1/Performance Data	Yes
01CB166_Takenaka, Mix 2/Performance Data	Yes
01CB167_Sizewell 'B' Nuclear Power Satation (NPS)/Performance Data	Yes
01CC-Manufactured or By-Product/Performance Data	No
01D-Heavyweight/Performance Data	Yes
01DA-Stone/Performance Data	Yes
01DA001_ANL-West Argon Cell Walls/Performance Data	Yes
01DA002_HD Shielding Wall Concrete/Performance Data	Yes
01DA003_GETR, Mix 58-1970/Performance Data	Yes
01DA004_SERCOTER Concrete/Performance Data	Yes
01DB-Gravel/Performance Data	No
01DC-Manufactured or By-Product/Performance Data	No
Chapter 02 - Metallic Reinforcements/Performance Data	Yes
02A-Carbon Steel Bars/Performance Data	Yes
02AA-Uncoated without Deformations/Performance Data	Yes
02AA001_ASTM A 15, Structural/Performance Data	Yes
02AA002_ASTM A 15, Intermediate/Performance Data	Yes
02AA003_ASTM A 15, Hard/Performance Data	Yes
02AA004_ASTM A 615, Gr. 40/Performance Data	Yes
02AA005_ASTM A 615, Gr. 60/Performance Data	Yes
02AA006_ASTM A 615, Gr. 75/Performance Data	Yes
02AB-Coated without Deformations/Performance Data	No
02AC-Uncoated with Deformations/Performance Data	Yes
02AC001_ASTM A 15, Structural/Performance Data	Yes
02AC002_ASTM A 15, Intermediate/Performance Data	Yes
02AC003_ASTM A 15, Hard/Performance Data	Yes
02AC004_ASTM A 615, Gr. 40/Performance Data	Yes

02AC005_ASTM A 615, Gr. 60/Performance Data	Yes
02AC006_ASTM A 615, Gr. 75/Performance Data	Yes
02AD-Coated with Deformations/Performance Data	No
02B-Stainless Steel Bars/Performance Data	No
02BA-Uncoated without Deformations/Performance Data	No
02BB-Gravel/Performance Data	No
02BC-Manufactured or By-product/Performance Data	No
02BD-Coated with Deformations/Performance Data	No
02C-Steel Wires/Performance Data	No
02CA-Uncoated without Deformations/Performance Data	No
02CB-Gravel/Performance Data	No
02CC-Manufactured or By-product/Performance Data	No
02CD-Coated with Deformations/Performance Data	No
02D-Bar Mats/Wire Fabric/Performance Data	No
02DA-Uncoated without Deformations/Performance Data	No
02DB-Gravel/Performance Data	No
02DC-Manufactured or By-product/Performance Data	No
02DD-Coated with Deformations/Performance Data	No
Chapter 03 - Prestressing Tendons/Performance Data	Yes
03A-Carbon Steel Bars/Performance Data	No
03AA-Materials without Deformations/Performance Data	No
03AB-Materials with Deformations/Performance Data	No
03B-Carbon Steel Wires/Performance Data	Yes
03BA-Materials without Deformations/Performance Data	Yes
03BA003_ASTM A 421, Type BA, 7.01 mm/Performance Data	Yes
03BB-Materials with Deformations/Performance Data	No
03C-Strand/Performance Data	No
03CA-Materials without Deformations/Performance Data	No
03CB-Materials with Deformations/Performance Data	No
03D-Nonmetallic Materials/Performance Data	No
03DA-Materials without Deformations/Performance Data	No
03DB-Materials with Deformations/Performance Data	No

Chapter 04 - Structural Steels/Performance Data	No
04A-Carbon Steels/Performance Data	Yes
04AA-Hot- or Cold-Rolled Steels/Performance Data	Yes
04AA001_ASTM A 7/Performance Data	Yes
04AA002_ASTM A 36/Performance Data	Yes
04AB-Bolting Materials/Performance Data	No
04AC-Special Materials/Performance Data	No
04B-Stainless Steels/Performance Data	No
04BA-Hot- or Cold-Rolled Steels/Performance Data	No
04BB-Bolting Materials/Performance Data	No
04BC-Special Materials/Performance Data	No
Chapter 05 - Rubbers/Performance Data	Yes
05A-ASTM D 1418, Class M/Performance Data	Yes
05AA-Polymethylene Type Saturated Chain/Performance Data	Yes
05AB-Polymer Chain with N without O or P/Performance Data	No
05AC-Polymer Chain with O/Performance Data	No
05AD-Unsaturated Carbon Chain/Performance Data	No
05AE-Polymer Chain with Substitute COOH Groups/Performance Data	No
05AF-Polymer Chain with Si and O/Performance Data	No
05B- ASTM D 1418, Class N/Performance Data	No
05BA-Polymethylene Type Saturated Chain/Performance Data	Yes
05AA001_SIS, EPDM, 75 IRHD/Performance Data	Yes
05BB-Polymer Chain with N without O or P/Performance Data	No
05BC-Polymer Chain with O/Performance Data	No
05BD-Unsaturated Carbon Chain/Performance Data	No
05BE-Polymer Chain with Substitute COOH Groups/Performance Data	No
05BF-Polymer Chain with Si and O/Performance Data	No
05C- ASTM D 1418, Class O/Performance Data	No
05CA-Polymethylene Type Saturated Chain/Performance Data	No
05CB-Polymer Chain with N without O or P/Performance Data	No
05CC-Polymer Chain with O/Performance Data	No

	05CD-Unsaturated Carbon Chain/Performance Data	No
	05CE-Polymer Chain with Substitute COOH Groups/Performance Data	No
	05CF-Polymer Chain with Si and O/Performance Data	No
	05D- ASTM D 1418, Class R/Performance Data	No
	05DA-Polymethylene Type Saturated Chain/Performance Data	No
	05DB-Polymer Chain with N without O or P/Performance Data	No
	05DC-Polymer Chain with O/Performance Data	No
	05DD-Unsaturated Carbon Chain/Performance Data	No
	05DE-Polymer Chain with Substitute COOH Groups/Performance Data	No
	05DF-Polymer Chain with Si and O/Performance Data	No
	05E- ASTM D 1418, Class Q/Performance Data	No
	05EA-Polymethylene Type Saturated Chain/Performance Data	No
	05EB-Polymer Chain with N without O or P/Performance Data	No
	05EC-Polymer Chain with O/Performance Data	No
	05ED-Unsaturated Carbon Chain/Performance Data	No
	05EE-Polymer Chain with Substitute COOH Groups/Performance Data	No
	05EF-Polymer Chain with Si and O/Performance Data	No
	05F- ASTM D 1418, Class T/Performance Data	No
	05FA-Polymethylene Type Saturated Chain/Performance Data	No
	05FB-Polymer Chain with N without O or P/Performance Data	No
	05FC-Polymer Chain with O/Performance Data	No
	05FD-Unsaturated Carbon Chain/Performance Data	No
	05FE-Polymer Chain with Substitute COOH Groups/Performance Data	No
	05FF-Polymer Chain with Si and O/Performance Data	No
	05G- ASTM D 1418, Class U/Performance Data	No
	05GA-Polymethylene Type Saturated Chain/Performance Data	No
	05GB-Polymer Chain with N without O or P/Performance Data	No
	05GC-Polymer Chain with O/Performance Data	No
	05GD-Unsaturated Carbon Chain/Performance Data	No
	05GE-Polymer Chain with Substitute COOH Groups/Performance Data	No
	05GF-Polymer Chain with Si and O/Performance Data	No

	05H- ASTM D 1418, Class Z/Performance Data	No
	05HA-Polymethylene Type Saturated Chain/Performance Data	No
	05HB-Polymer Chain with N without O or P/Performance Data	No
	05HC-Polymer Chain with O/Performance Data	No
	05HD-Unsaturated Carbon Chain/Performance Data	No
	05HE-Polymer Chain with Substitute COOH Groups/Performance Data	No
	05HF-Polymer Chain with Si and O/Performance Data	No
	05I- Other Types of Rubbers/Performance Data	No
	05IA-Polymethylene Type Saturated Chain/Performance Data	No
	05IB-Polymer Chain with N without O or P/Performance Data	No
	05IC-Polymer Chain with O/Performance Data	No
	05ID-Unsaturated Carbon Chain/Performance Data	No
	05IE-Polymer Chain with Substitute COOH Groups/Performance Data	No
	05IF-Polymer Chain with Si and O/Performance Data	No

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