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A Partnership for a National Computer-Integrated Knowledge Systems Network for High-Performance Construction Materials and Systems: Workshop Report

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NIST

United States Department of Commerce
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A PARTNERSHIP FOR A NATIONAL COMPUTER-INTEGRATED KNOWLEDGE SYSTEMS NETWORK FOR HIGH-PERFORMANCE CONSTRUCTION MATERIALS AND SYSTEMS: WORKSHOP REPORT

by
James R. Clifton
S. Shyam Sunder

EXECUTIVE SUMMARY

The nation's construction industry is fragmented, being composed of many small firms; it tends to be a low profit margin industry which is averse to risk taking. Also, in general it is a low technology industry. However, changes appear to be occurring as the industry becomes increasingly aware of the importance of knowledge and information dissemination. Limits on knowledge of materials affects: the capacity to construct; construction productivity; durability of constructed facilities; and, becoming increasingly important, environmental issues. According to the Civil Engineering Research Foundation (CERF), the construction industry materials information technology needs include:

- A universal base of knowledge
- Inexpensive, decentralized, and user-friendly access
- An expanded level of information development and organization
- Reliable information on risk and innovation; information is needed on i) material performance and durability, and ii) materials cost
- Standardized methods for predicting life-cycle cost

In recognition of these needs, the CONMAT Council has supported the development a computer-integrated knowledge systems (CIKS) network for high-performance construction materials and systems (HPCMS). The Council endorsed a national CIKS partnership under the umbrella of the CONMAT program and in cooperation with CERF, ASTM, and the National Institute of Standards and Technology (NIST). Development of the CIKS network could significantly mitigate knowledge transfer barriers posed by the construction industry's fragmentation. As currently envisioned, the functional goals for the CIKS network are to provide:

- universal electronic access to distributed material data, information, and knowledge;
- application systems that use the data, information, and knowledge in (1) material design, and (2) facility design, construction (or installation/application), operation, maintenance, repair, and disposal;
- an open testbed for industry, university, and government partners to build and evaluate prototype systems, including enabling information technologies; and
- commercial-scale systems developed, deployed, and maintained by industry.

As a result, a workshop on A National Partnership on Computer-Integrated Knowledge Systems Network for High-Performance Construction Materials and Systems was organized and held at NIST on June 13 and 14, 1996.

For the purposes of the workshop, CIKS was defined as *a computerized intelligent system of integrated knowledge base systems providing the knowledge needed for solving problems of a range of complexities.* A CIKS can be developed to solve problems which may require the use of databases or a wide spectrum of knowledge ranging from the experience of experts in the form of heuristics, to fundamental knowledge and factual data that is contained in either locally or globally distributed databases. The term "knowledge bases" denotes any entity that contains knowledge including models, databases, expert systems, images, handbooks, guides, and standards and codes. Integration means that knowledge and data flow seamlessly (automatically) across interfaces, i.e., from one knowledge base to another.

The objectives of the workshop were to identify and prioritize current and future needs of the construction industry for:

- Universal electronic access to distributed data, information, and knowledge on HPCMS;
- New applications and/or new ways of using that data, information, and knowledge in (a) material design, processing, selection, and testing; and (b) facility design, construction or installation/application, operation, maintenance, repair, and disposal;
- Potential industry-university-government partnerships and pilot projects for testbed activities.

To achieve these objectives, noted experts in HPCMS and information technology brought to the attention of the participants the importance of a National Partnership for a CIKS Network dealing with HPCMS. After the plenary session, six working groups, based on different materials, and a seventh group of information technology experts were convened:

WG1 - Coatings	WG2 - Roofing
WG3 - Concrete and Masonry	WG4 - Steel, Aluminum, and Stainless Materials
WG5 - Composites, Wood, and Plastics	WG6 - Asphalt
WG7 - Information Technology	

The materials working groups were requested to discuss if the development of CIKS for their specific materials would be beneficial and, if so, identify potential pilot projects. The information technology group was requested to analyze the potential applications for information technology in the pilot projects and the views on CIKS from the materials working groups.

Although the CIKS Network concept is new to the construction industry, the workshop participants appeared to be strongly in favor of the development of pilot projects. The working groups recommended the development of pilot CIKS projects which would educate the developers and demonstrate the benefits of such systems to potential users. They were in favor of relatively straightforward projects which used existing data, information, and knowledge of known reliability, which should be of interest to potential users. For example, a pilot project of high priority suggested by the Coatings Group was the development of a guide covering the searching for information on the Internet and how to develop an Internet site for information on material performance. Several groups proposed the development of a product data and product source system. However, little attention by the materials working groups was given to the evolution of CIKS beyond the pilot projects or to their potential power as major problem solvers in the construction industry. The concept of integration of knowledge systems was not demonstrated in the in the planning of many of the pilot projects. Also, while sufficient knowledge is available for the pilot projects in the future the lack of applicable knowledge may eventually become a barrier to CIKS attaining their potential abilities as problem solvers.

The keynote presentations advised that databases and other knowledge bases, which will be the heart of most CIKS efforts, must be easy to understand and to use, the data must be in consistent formats, and their reliability must be documented. The material working groups considered the development of standard formats to be a necessity for the representation and exchange of data. The Information Technology Working Group considered that the one area which was not adequately discussed was knowledge systems. Differences in fundamental concepts such as data, information, and knowledge did not appear to have been considered by the materials groups and a future workshop should expand on this issue. Information models also were not given adequate attention, only being discussed by one group, and should be one of the subjects of a future workshop. However, the desired characteristics or attributes of a CIKS were discussed by all the groups, with 29 being items identified by the Composites, Wood, and Plastic group. The commercial significance of the establishment of a CIKS network, either nationally or globally, was well recognized. Attention was given to marketing plans, payment for intellectual property, and creation of business ventures dealing with development, implementation, and marketing. Partnerships between government and the construction industry were considered to be very desirable, if not necessary, for the commercial side of CIKS to be fully realized.

It is recommended that a further workshop be held to review the progress made in the pilot projects and also to address the important issues, such as user needs, identified but not adequately covered by the workshop.

ABSTRACT

A workshop on a National Partnership on Computer-Integrated Knowledge Systems (CIKS) Network for High-Performance Construction Materials and Systems (HPCMS) was held in Gaithersburg, MD on June 13 and 14, 1996. The workshop was sponsored by the American Society for Testing and Materials, the Civil Engineering Research Foundation, the CONMAT Council, and the National Institute of Standards and Technology. The objectives of the workshop were to identify and prioritize current and future needs of the construction industry for:

- Universal electronic access to distributed data, information, and knowledge on HPCMS;
- New applications and/or new ways of using that data, information, and knowledge in (a) material design, processing, selection, and testing; and (b) facility design, construction or installation/application, operation, maintenance, repair, and disposal;
- Potential industry-university-government partnerships and pilot projects for testbed activities.

To achieve these objectives, experts in HPCMS and information technology brought to the attention of the participants the importance of a National Partnership for a CIKS Network dealing with HPCMS. After the plenary session, six working groups, based on different HPCMS, and a seventh group of Information Technology experts were convened. The materials working groups overall concluded that the development of CIKS would be beneficial and, in doing so, identified several potential pilot projects. The Information Technology group reported that the workshop clearly revealed that the need for CIKS was timely and critical to the construction industry as a whole. This report summarizes the keynote presentations, and the discussions and recommendations of the working groups.

Keywords: computer-integrated knowledge system; construction industry; high-performance construction materials; information technology; knowledge base systems; pilot projects; workshop.

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1. INTRODUCTION

The workshop on A Partnership for a National Computer-Integrated Knowledge Systems (CIKS) Network for High-Performance Construction Materials and Systems was sponsored by the American Society for Testing and Materials (ASTM), the Civil Engineering Research Foundation (CERF), the CONMAT Council, and the National Institute of Standards and Technology (NIST). The idea for the workshop grew out of a presentation by NIST to the CONMAT Council, whose secretariat is CERF, and whose members are twelve major sectors of the construction materials industry.

1.1 Purpose of the Proposed Partnership for a National CIKS Network

The intent of the proposed partnership is to stimulate the accelerated and widespread dissemination of knowledge on High-Performance Construction Materials and Systems (HPCMS) through the development of a CIKS network. Development of the CIKS network is anticipated to significantly mitigate knowledge transfer barriers posed by the construction industry's highly fragmented information network. As currently envisioned, the functional goals for the CIKS network are to provide:

- universal electronic access to distributed material data, information, and knowledge;
- application systems that use the data, information, and knowledge in: (a) material design, and (b) facility design, construction or installation/application, operation, maintenance, repair, and disposal;
- an open testbed for industry, university, and government partners to build and evaluate prototype systems, including enabling information technologies; and
- commercial-scale systems developed, deployed, and maintained by industry.

1.2 Workshop Objectives

The objectives of the workshop were to identify and prioritize current and future needs of the construction industry for:

1. Universal electronic access to distributed data, information, and knowledge on HPCMS.

2. New applications and/or new ways of using that data, information, and knowledge in: (a) material design, processing, selection, and testing; and (b) facility design, construction or installation/application, operation, maintenance, repair, and disposal.

3. Industry-university-government partnerships and pilot projects for testbed activities.

1.3 Workshop Organization

Information about the organization of the workshop is given in Appendix I - Workshop Program; Appendix II - Sponsoring Organizations and the Steering and Organizing Committees; Appendix III - List of Participants; and Appendix IV - Working Groups. Invitations to attend the workshop were sent to the sponsoring organizations, including the 12 material group members of the CONMAT Council. Also, invitations were sent to researchers involved with HPCMS and computer specialists with knowledge on computerized knowledge bases and construction materials. Some 72 people attended.

The workshop began with Welcoming and Introductory Comments in which the purpose of the Workshop was presented. Then the importance of realizing the proposed Partnership for a National CIKS Network dealing with HPCMS was brought to the attention of the participants. Eight keynote presentations followed, each of which addressed a specific aspect of information technology. Collectively, they provided a framework for the subsequent Working Group discussions. After the opening plenary session, each of six working groups, organized to represent different types of HPCMS, and a seventh group made of information technology experts convened. The subjects of the seven groups were:

- WG1 - Coating
- WG2 - Roofing
- WG3 - Concrete and Masonry
- WG4 - Steel, Aluminum, and Stainless Materials
- WG5 - Composites, Wood, and Plastics
- WG6 - Asphalt
- WG7 - Information Technology

Two half-day sessions were devoted to the working group discussions. The goal of the first half-day session was to identify and prioritize information needs pertinent to each group's interest and of the CIKS functional goals. The goal of the second session was to identify potential partnerships and pilot projects. A final plenary session was held during which the working groups gave an outline of their discussions and recommendations.

1.4 Organization and Scope of the Report

Following this Introduction, summaries of the keynote presentations are given in Chapter 2; reports from the six material working groups are presented in Chapter 3; the report from the Information Technology Group is given in Chapter 4; and the workshop is summarized in Chapter 5. Several appendices follow which contain supporting information.

2. SUMMARIES OF KEYNOTE PRESENTATIONS.

The eight invited presentations provided a perspective to the participants of the state-of-the-art, applications, and needs for information technology in the construction industry. These presentations had a significant influence on the deliberations of the working groups. Summaries of the presentations follow.

I. Information Technology Needs in the Construction Industry

William Kirksey
Civil Engineering Research Foundation

The construction industry has been characterized as being: (1) fragmented and composed of many small firms; (2) a low profit margin industry and accordingly averse to risk-taking; (3) focused on low first cost which has been largely imposed by owners and competition; and (4) a low technology industry. However, the industry is becoming increasingly aware that information is its key economic resource and information about materials is the key to competitiveness. Limits on knowledge of materials affects: the capacity to construct; construction productivity; durability of constructed facilities; and, increasingly important, environmental issues. Construction industry materials information technology needs include:

- A universal base of knowledge
- Inexpensive, decentralized, and user-friendly access
- An expanded level of information development and organization
- Reliable information on risk and innovation
- Information on i) material performance and durability, and ii) materials cost
- Recognized methods for predicting life-cycle cost

In recognition of these needs, the CONMAT Council has supported the establishment of a CIKS network for HPCMS. The Council endorsed a national partnership under the umbrella of the CONMAT program and in cooperation with CERF, ASTM, and NIST.

A CIKS network could help the construction industry become more economically robust in many ways such as:

- Bridging the industry's fragmentation through a shared knowledge base
- Providing small firms easier access to state-of-the-art knowledge
- Sharing the cost of developing innovation
- Reducing risk by leveraging the experience and knowledge of others
- Promoting the understanding and adoption of life-cycle analysis

If CIKS is going to be a viable technology for disseminating knowledge, the construction industry has to play a significant role by:

- Endorsing and promoting the concept
- Joining in the planning and development process
- Hosting pilot projects

- Developing or adopting applications programs
- Using and promoting the system

Development of the CIKS network would greatly assist the construction industry in meeting the National Construction Goals.

II. Uses and Delivery of Materials Information

Gilbert Kaufman
Aluminum Association

The present state of databases for scientific and engineering applications is inadequate to meet the economic and competitiveness challenges facing the nation's industries. The present state can be characterized as:

- A large number of databases is available
- The available databases are largely unknown to most potential users
- Most of the databases are rather difficult to access
- Insufficient documentation of data
- Impact: searches are often tedious and ineffective, giving rise to unsatisfactory decision making.

The attributes of databases to effectively distribute materials information are:

- Direct access to many sources of machine-readable numeric performance data
- High quality data with careful documentation
- Access/guidance to many sources
- Easy-to-use interfaces, directed to the engineering and materials science community
- Provide assistance with nomenclature/terminology

The data needs for scientific and engineering applications are different from those for other industries: e.g., types of numeric data needed often include individual test results; nominal or typical values; product/supplier data; and statistically based values. The variables which may need to be quantified in scientific and engineering databases can be very large including the constituents of materials, production variables, exposure or service conditions, geometry of test specimens, and test method and conditions. Also, the nature of scientific and engineering numeric data is complex and they can vary in value by orders of magnitude, involve multiple units and unit classes, be multivariant, and require many supporting facts. In addition to the above identified database attributes a critical mass of data is usually required (especially to make sound statistical inferences) and calculation/analysis support is frequently needed.

For effective searches, the search software should possess several key elements:

- Range search capability
- Units conversion capability

- Deal with tolerances
- Display data in table formats
- Calculation packages.

In summary, the challenges that developers of scientific and engineering databases will encounter if the databases are to be of significant value, and thus used, are:

- Critical mass of data
- Accessibility of data
- Ease of access of data
- Value of data

III. Material Information for the Construction Criteria Database

Earle Kennett
National Institute of Building Sciences

The National Institute of Building Science (NIBS) initiated the development of the Construction Criteria Database (CCB) in 1986. It consists of :

- Guide specifications
- Regulations (ADA, EPA, DOE, etc.)
- Design and engineering documents
- Industry standards
- CADD details and drawings
- Cost data and estimating applications
- Maintenance and operations documents

At present it has 4.5 gigabits of data, full text and graphics for 12,000 documents, standards from over 100 private associations, documents from over 12 Federal agencies, documents from five major professional organizations, and over 20,000 users. It is available on CD/ROM and is networkable using DOS or Windows.

The CCB can be found on the World Wide Web with an URL address of www.ccb.org. The complete system is available on the Web site, except for industry standards. Applications can be downloaded by subscribers. Free limited access to non- subscribers, largely to directories, is now available.

NOTE : The following information on NIBS was downloaded from its Web site by the report editors - "NIBS is a non-profit organization authorized by Congress in 1974 to provide a national forum for addressing issues with a direct impact on the $500-billion-per-year American building industry. NIBS works through a unique consensus process, bringing corporations, institutions, federal agencies, universities, and concerned individuals together to develop criteria and guidance on numerous subjects related to buildings including asbestos, radon, moisture protection of wood, lead-based paint, indoor air quality, design for seismic and other hazards, metrication, design for special needs such as health care facilities and courthouses, computers in buildings and in the building process, and other building projects."

IV. Automated Materials Information for the Construction Industry

Eugene Allen
The MacNeal-Schwendler Corporation

A need for better systems for providing materials information for predictive engineering is being driven by three major forces:

- Predictive engineering: Simulation is increasing the demand for accurate, electronic materials information
- New Materials: Availability of new materials makes materials a design variable, not a constraint
- Standards for Data Integration: Demand for enterprise discipline drives companies to standards and systems for data exchange

The goal of "best of class manufacturing," meaning increased performance, faster time-to-market, and lower cost, imposes challenges to the way industry manages materials data. New needs and issues have risen in attempting to meet the goal, e.g.:

- Need for data to support analysis (e.g., performance of plastics from -40 to 200°F (-40 to 93°C))
- How do we share consistent data across multiple engineering disciplines in a common computer program?
- How do we foster corporately approved material data usage?
- Where do we find statistically accurate, traceably validated, analysis-ready property data?

To meet these needs and respond to the issues, we must manage data more efficiently by automating the process, spending less time in:

- Finding old test data
- Tabulating and plotting data to answer design questions
- Reducing and archiving data
- Editing and distributing materials information

while also preventing improper use of materials data. An approach for fulfilling the material information requirements for predictive engineering is by integrating materials information knowledge bases. MacNeal-Schwendler Corp. provides a system for ensuring consistent data for engineers evaluating new designs and reducing cycle time by integrating materials data directly into CAD/CAE. Such systems are becoming the preferred media for exchange of materials information.

V. The Future of Global Electronic Commerce

David Jefferson
NIST

My colleagues and I at NIST were asked to help the White House National Economic Council plan an International Pilot Project entitled "A Global Marketplace for SMEs" (SMEs denote small and medium enterprises). We believe that this project will drive the future of global electronic commerce.

To demonstrate the potential of the information society to stimulate the development of the Global Market Place for SMEs , the G-7 nations have established 11 international programs which will enable SMEs to access the information needed to integrate themselves into the fabric of world trade. The pilot projects support not only worldwide electronic purchasing and selling of goods and services, but also the formation and operation of multi-national virtual enterprises to exploit opportunities anywhere in the world. It is based on a pragmatic approach to the use of existing, available technology to address the needs of SMEs. There is a very strong emphasis on Internet and World Wide Web (WWW) technologies.

There are three major themes for the project:
(1) "Global Information Network for SMEs" which is being coordinated by Japan. The Japanese Government has developed an English-language "Global Information Network for SMEs Home Page" on the WWW. It provides an initial access point to the home pages of each of the participating countries.
(2) "SMEs Requirements - Legal, Institutional, and Technical" which is being coordinated by the EC. International workshops will address topics such as market access, financial issues, ownership, confidentiality and verification, and interoperability and standards.
(3) Testbeds for EDI/Electronic Commerce" which is coordinated by the U.S. Technical issues will be identified and resolved in testbeds and other cooperative ventures led by the private sector.

As could be expected, several barriers have arisen which may be detrimental to the participation by U.S. SMEs in the Global Marketplace. There is a need for increased participation of the nation's SMEs in the planning of Global Marketplace activities, development and participation in workshops related to the Global Market place, and industry-government collaboration on electronic commerce. Also, there is a lack of technologies and standards for information discovery and retrieval, and information security.

VI. Standards for Computerization of Materials Data

Crystal H. Newton
Material Sciences Corporation

An objective of standards and guidelines for developing databases for materials is to assist database creators in identifying fully, with the same data elements, and the same category/value sets, the:

- test material,
- test method,
- test results,

where all the data are obtained using a single standard test method, with the same test parameters, and from a material identified (or described) by a single standard specification. This is the goal of ASTM Committee E49 - Computerization of Material and Chemical Property Data. The approach of E49 in attempting to achieve its goal, is (1) to identify what information is needed to fully describe a data element of known quality; (2) to provide guidance on the content of a database without excessively constraining the database structure or contractual reporting requirements; and (3) to identify the scope and application for each guide it develops. Also, Committee E49 recognizes the vital need to be able to classify the quality of data elements and databases, e.g., ASTM Committee E1484 is a standard dealing with indicators of the quality of data, and a standard for the evaluation of data and databases is being prepared.

The material identifiers being developed by ASTM Committee E49 are applicable to many HPCMS including concrete, coatings, metals (aluminum alloys, copper and copper alloys, and steel), plastics, ceramics, and fibers. Material property data element relationships include composition of construction materials, mechanical properties of metals, corrosion of metals, properties of plastics, mechanical properties of composite materials, and properties of concrete. In addition to these activities, ASTM Committee E-49 can provide a forum and an opportunity for standardization of expert systems for construction materials.

VII. Commercial Uses of NIST Standard Reference Data

Phoebe Fagan
NIST

The NIST Standard Reference Data (SRD) Program was started in 1968 with the goal of making critically evaluated reference data readily available to scientists, engineers, and the general public. The criteria used in evaluating the data are:

- Are the data from well controlled experiments?
- Do the data agree with the known laws of nature?

- Do the data compare well with other measurements (calculations) of the same phenomena?

The data in the program cover the following fields:

- Analytical and thermodynamic chemistry and chemical kinetics
- Atomic and molecular physics
- Building and fire research
- Industrial fluids
- Materials: electronic and engineering materials
- Biotechnology
- Software recognition

Needs for standard reference data are identified by close contacts with users, workshops, partnerships with industry, program advisory groups, NIST research, and interactions with other governmental and private organizations. Priorities for introducing new data into the program include the significance of the data to current R&D and the importance of reliability, internal consistency and verification of data to anticipated users. The NIST SRD program focuses its resources on technical areas where high quality data are required.

The needs for materials data for product manufacturing is broad, encompassing:

- Preliminary design
- Performance analysis
- Materials design, selection, procurement, and production
- Maintenance
- Failure analysis
- Disposal

The type of data impacts the database structure, interface, and search strategy. The data collection may consist of one test per material giving multiple properties. Another common structure for the data is multiple test results for each material. The differences control the database structure and influence their search techniques.

Information can yield economic value by reducing costs if the information is reliable. However, development and maintenance of good databases requires a substantial commitment and investment. In summary, the major processes involved in database development are:

- Compile/evaluate data
- Understand how engineers use the data
- Formulate interfaces to meet user needs
- Test databases in terms of accuracy (works), consistency (always works), and reliability (always gives the same value).

VIII. Matching Information Technology with the Objectives of Materials Data Users

Charles Sturrock
NIST

The form of information systems needed by an user depends upon the user's objectives and desired deliverables. If the user's objectives are to organize and retrieve numeric data for direct use, then a database is the appropriate deliverable. However, for many material data users, numeric data presents more questions than answers. Often an expert is needed to interpret the data, which may contain linguistic elements, such as case histories and/or logical relationships, in addition to numeric data. Also, the user's objective may be to identify patterns in the data, in order to infer new knowledge of the domain. The following (generic) objectives suggest the applications of the corresponding information technologies (IT):

Objective	Applicable IT
Infer specific conclusions from general principles and a finite set of facts	Expert systems
Adapt previously successful solutions to similar problems	Case-based reasoning
Infer a general principle or relationship from a finite set of observations	Computer learning systems (e.g., statistical connectionist, machine learning methods)

All three of the above information technologies have been applied to problems involving construction materials and systems.

Expert systems are domain specific with the knowledge largely composed of heuristics from experts in the domain. The knowledge is usually represented in the form of "if / then" rules. An inference engine interacts with the user to define the problem and selects the applicable knowledge in attempting to give solutions to the problem. Expert systems have been developed dealing with structural design; layout of temporary constructed facilities; traffic control in work zones; and for diagnosis, material selection, and repair/rehabilitation of concrete pavements.

Case-based reasoning systems provide solutions based on previous experiences (cases). The reasoning is by analogy or association, providing for case adaptation and automated system maintenance. They are useful in reasoning from prior cases, e.g., in medicine and law, and also in design and failure analysis. Such systems have dealt with conceptual design of office buildings and building failure analysis.

Computer learning systems infer a general principle from a set of observations: (i) to develop input/output relationships where no prior model exists; and (ii) to discover hidden relationships in the data. The most prominent and basic learning task is classification, e.g., assigning new observations to one of several prescribed categories. The most popular class of computer learning systems is artificial neural networks (ANNs). ANNs have been used in non-destructive evaluation, e.g., to classify impulse radar waveforms from asphalt-covered bridge decks for the purpose of (i) identifying the presence of waterproofing membranes, and (ii) distinguishing among different types of bridge decks. ANNs have also have been used to predict the risk of chloride-induced corrosion of stainless steels.

In summary, expert systems, case-based reasoning, and computer learning systems are powerful information technologies that have been used successfully to solve diverse problems involving construction materials and systems. The most successful systems are those that meet the needs and objectives of the end users.

3. WORKING GROUP REPORTS

CIKS is a new concept to which many of the workshop participants were introduced during the keynote presentations. As a result, the reports from the working groups varied greatly in scope and form. Rather than attempt to "squeeze" the reports into a specific detailed format, each will be described under two major headings: "Summary of Discussion"; and "CIKS Pilot Projects" The reports from the six working groups on materials are summarized in this chapter. The report from Working Group 7 - Enabling Information Technology, which was given the responsibility of analyzing the implications for Information Technology (IT) and the corresponding views on CIKS from each of the six materials working groups, is presented in Chapter 4.

3.1 Coatings

Chair: Bernard Appleman

3.1.1 Summary of Discussion
Users of coating knowledge include owners, contractors, suppliers, engineering/contracting firms, and researchers. There is a difference between the needs of public and private users. A basic need for coating users is to have sufficient information to decide what coating system and strategy should be selected. Existing activities on coating knowledge were identified.

The role of the Coatings Group was discussed in relationship to the overall construction industry. It was decided that the Group's main goal was to identify the knowledge needs of the coating industry.

3.1.2 CIKS Pilot Projects
Six pilot projects were proposed.

3.1.2.1 Develop a User Guides to the Internet

<u>Main Discussion Points</u>:

- Starting point
- The need to select a navigation tool
- Identify the top Web sites for coating information
- Cautions on developing the guide
- The need for a general section for construction materials
- The need for a specific section for coatings

<u>Actions Proposed</u>:

- Retrieve and review general guides currently available
- Prepare a draft outline
- Circulate listing of current sites to the coating industry

Priority: Very high
Level of Effort Required: Low to moderate
Time Frame: 4 months

3.1.2.2 Develop a Uniform Format for Product Data Sheets

Main Discussion Points:

- Great need expressed in coating industry for knowledge dissemination (e.g., recent Journal of Protective Coatings and Linings (JPCL) problem solving forum)
- Use of computerized format would be of benefit to such an effort and give it impetus
- Some guidelines as to content are already available
- Some manufactures may be reluctant to participate because they feel that their products have unique properties
- With a good selling job, manufacturers with excellent products can be convinced that the system will benefit them
- Initially, data sheets would include some mandatory information (e.g., content of Volatile Organic Compounds (VOC); application conditions) and some optional information (e.g., resistance to specific chemicals)
- Development should be coordinated with the work of the Steel Structures Painting Council (SSPC) Committee C.4.10 on Knowledge-Based Systems for Coatings.

Action Proposed:

- Recruit a task group of varied interests
- Use product data sheets (PDS) as the starting point for a task group draft

Priority: High
Level of Effort Required: Moderate
Time Frame: 5 months

3.1.2.3 Establish an Electronic Forum for Questions

Main Discussion Points:

- The need for user chat groups
- Referred responses to questions
- A mechanism for responding to frequently asked questions
- The need for a "coatings hot line"

Actions Proposed:

- Review what is now available from the SSPC, and others sources
- Determine whether NIST can help by providing applicable server resources
- Develop an approach for forum and chat groups

Priority:	High
Level of Effort Required:	Low to Moderate
Time Frame:	3 to 6 months

3.1.2.4 Development of am Expert System for Coatings Selection

Main Discussion Points:

- Development of some experts systems on protective coatings has been started (e.g., NIST, U.S. Navy, ITI/BIRL, Counselware, KTA/Brevort)
- Would require a major effort to develop a comprehensive system

Actions Proposed:

- Prepare a state-of-the-art report on existing coatings related expert systems.

Priority:	Moderate
Level of Effort Required:	Moderate
Time Frame:	6 months

- Develop Model Expert System

Priority:	Low to Moderate
Level of Effort Required:	High
Time Frame:	12 to 18 months

3.1.2.5 Develop Standards Formats and Protocols for Performance Data

Main Discussion Points:

- Possibly use existing SSPC, ASTM, or other data formats
- Need for a second phase involve the development of protocols

Action proposed:

- Develop formats through a SSPC Committee after, or concurrently with, the development of application data formats

Priority:	Moderate
Level of Effort Required:	Moderate to high
Time Frame:	12 months

3.1.2.6 Documentation of Field Performance/Case Histories

Main Discussion Points:

- Use of a "case-based reasoning" approach
- Use of manufacturer's data
- Available information on "how to handle failures"

Approach Proposed:

- Review existing efforts (e.g., SSPC, DOD, NIST)
- Identify potential sponsors

Priority:	Low to Moderate
Level of Effort Required:	Very High
Time Frame:	18 to 24 months

3.2 Roofing Materials

Chair: Mark Graham

3.2.1 Summary of Discussion

Initial discussion within the group revolved around the potential users of a roofing-related CIKS system. Potential users of such a system would probably include:

- Roof designers (architects/engineers/roof consultants)
- Roofing applicators (applicators)
- Material suppliers (manufacturers, distributors)
- Regulatory organizations (codes and standard bodies)
- Researchers
- Building owners (commercial and residential)

The group concluded that building owners would be one of the largest potential users of a roofing-related CIKS system, but they would be a fundamentally different audience compared to the other material groups participating in the CIKS Workshop. In the roofing industry, a large number of purchasing decisions are made directly between roofing contractors and building owners, without the assistance of professional roof designers. The concept of the owners being the "decision maker" in the roofing industry is further complicated by the fact that there are two distinct types of owners purchasing roofing materials and systems: commercial (large building) owners and homeowners. Both types of owners, and the roofing contractors who primarily supply them with information on roofing materials and systems, are demanding more current information. Some of the types of information being requested are:

- Product literature
- Specifications/details
- Application instructions
- Safety-related information (e.g., Material Safety Data Sheets (SDS))
- Codes and standards compliance
- Manuals, sales and promotional information
- Technical information and data
- Performance data
- Maintenance information

- Life-cycle cost information

The first seven items already exist in the industry in printed forms, but not necessarily in an accessible computer data formats. The last three items do not currently exist readily in either a printed form or a computer data format.

3.2.2 Pilot Project

3.2.2.1 Recommendations for Initial Actions

In attempting to immediately satisfy the need for information by the potential users of a roofing-related CIKS, the working group recommended that the following initial steps be considered for implementation:

- Develop a list of existing CIKS-type applications available within the roofing industry.
- Develop a users guide for the identified applications and distribute it to interested parties.
- Conduct a "roofing industry summit" to further evaluate the CIKS concept as it relates to the roofing industry and identify other possible pilot projects.

3.2.2.2 Possible Pilot Project

The working group concluded that a roofing materials database could be considered as a possible pilot project to demonstrate the CIKS concept. The database would contain detailed information, such as product literature, technical information, safety-related information, and application instructions, for various roofing materials and systems. The information would be supplied by roofing materials manufacturers, and would include information on applicable standards and codes. The database would allow users to cross-reference manufacturers data with applicable codes and standards information, and application information. The system should include the ability to link manufacturers' proprietary information, e.g. promotional and technical information, to the centralized database.

The primary advantage of such a system would be that users could go to a centralized location to search for roofing-related information. Also, the system would allow for dissemination of continually updated information - a major advantage over the way that information is currently disseminated in the roofing industry.

3.3 Concrete and Masonry

Chair: Paul Breeze

3.3.1 Summary of Discussion

During the first session, the group struggled with the apparent enormity of the CIKS concept, especially whether such a system could be restricted to High-Performance concrete (HPC) and High-Performance Masonry (HPM). It was decided that any system should not be restricted to high-performance systems as this would eliminate valuable data, especially when the definition of high-performance can vary according to the application. The group was fairly comfortable with the definitions of data and information (as presented in the keynote presentations), but did not reach consensus on the definition of knowledge, which was not considered critical. Specific aspects of the concept of CIKS and the development of pilot CIKS projects were discussed as follows.

3.3.1.1. Market Research

The group recommended that one of the first actions to be undertaken in developing a CIKS would be a comprehensive market research, including identification of critical needs. Following the survey, the proposed system may have to be adapted to meet the needs of potential users or customers. It may be necessary for the project leaders to consider retaining an independent and professional survey organization so the credibility of the survey is not compromised.

3.3.1.2 Information Resources.

Regarding resources for databases, the group thought they were almost unlimited for concrete and masonry. However, international resources would greatly increase the diversity of databases.

3.3.1.3 Standardization of Data.

There was considerable concern that requiring the standardization of numerical data from various organizations would cause some of them to withdraw from the process or that the CIKS project would suffer unnecessary delay. Particular concern was expressed for invoking requirements that databases identify the geographic sources of materials, and the need to include information on related materials, such as admixtures, supplementary cementing materials, and various types of reinforcement. With this concern in mind, the group thought that the first pilot project should emphasize textual information rather than numerical data.

3.3.1.4 Education and Marketing.

Education of users was considered to be an important factor that would have to be formalized before any pilot project was undertaken. In addition, the need for promotion of the project was considered to be critical: too many products fail to gain market acceptance because potential customers are unaware of their availability. Also, the acronym, CIKS, should be changed to a name that will provide a clear description of the system.

3.3.1.5 Technical Considerations.

The group did not consider themselves experts in the design of hardware and software required of a system such as CIKS. Nevertheless, they expressed a strong desire for information to be retrieved rapidly and the system should be able to search for selected information. The system should be capable of comparing data with required performance from codes and standards, in order to minimize cross-referencing and compliance checking.

3.3.1.6 Trends.
In the 21st century a real shift could occur from prescriptive to performance or objective based codes. This should result in more structures being designed for a specific service life and the owner paying more attention to life-cycle cost. A system, such as that envisioned for CIKS, could provide a valuable tool for facilitating these changes.

3.3.1.7 New Material and Systems Development.
As CIKS matures, it could become a valuable tool for the materials and systems researcher. New modeling and simulation software, available through CIKS, would enable the development of ultra high-performance concrete and masonry and hybrid structural systems.

3.3.2 CIKS Pilot Project
The working group did not propose a specific CIKS pilot project but made recommendations relative to the general development of a pilot CIKS. The members were concerned that constraints may be placed on databases which could result in significant delay in developing a CIKS. The working group noted that NIST was carrying out projects on database formats and service life predictions which could form the basis for CIKS development. The group endorsed these developments, but also thought that a pilot project should be based on existing technologies. It was recommended that a pilot project should focus on the development of an information system that would provide problem-solving and decision-making tools to the construction industry.

Regarding databases, the group recommended that databases should be distributed and reside with the owner of the information rather than being placed in a centralized database. In this way, information could be maintained and new data added efficiently. Powerful search engines would be required to search the distributed databases so that abstracts could be browsed, discarded, or retrieved. The user should be able to browse the database at no cost; however, a fee should be charged if specific documents were retrieved. Part of the fee would be paid to the owner of the intellectual property and the remainder used to maintain and upgrade the system.

Beyond the pilot projects, the group suggested that the feasibility of forming a new for-profit company dealing with CIKS development, implementation, and marketing should be determined. The shareholders (or stakeholders) would then be eligible for dividends as the success of CIKS grows. This approach would offer an incentive for stakeholders to provide the knowledge and/or funding for CIKS.

3.4 Steel, Aluminum, and Stainless Materials

Chair: Gilbert Kaufman and Katrina Slaughter

3.4.1 Summary of Discussion

3.4.1.1 Common Need

The working group started its discussion by reviewing the workshop objectives and goals, and their applicability to steel, aluminum, and stainless materials. A common need among the three materials was identified - education. This education included not only that about the materials and their uses, but also of any information the system created. It was also agreed that users would include the university community in addition to engineers and specifiers.

3.4.1.2 Approach to Development of a Pilot CIKS

The group considered the objectives and goals of the workshop and considered them too ambitious. A four-step approach to address the common need of education was recommended as follows. Step 1 would be to provide an electronic directory of computerized sources accessible via an on-line host (Figure 3.1). Step 2 would link sources of information to the host, permitting searches by a common host (Figure 3.2). A more difficult task, Step 3, would be the development of a "one search" capability via the on-line host (Figure 3.3). Step 4 would be aimed at increasing the functionality of the system. This would be done by creating an open architecture. Automated updating of information would also be desirable. This would allow the user, when signing on to the system, to have files previously downloaded automatically updated to have the most current information. A document delivery system would also add to the appeal of the system. One such service could be "FAX on-demand."

The group recommended that comparability and compatibility of the data in a CIKS must be insured throughout the development process. This should be done through the use of standard formats and standard terminology, such as has been developed by ASTM Committee E49.

3.4.1.3 Information Concepts and Applications.

Material information which could be included in, or be the subject of, a CIKS for metals was explored. Ideas brought forward were:

- Life-cycle cost data
- Recycle/reuse/disposal data
- Safety and health data, including OSHA regulations
- Welding and/or joining information
- Damage assessment and failure analysis information, diagnostics, and case histories
- Tutorials should be prepared on the use and operation of CIKS
- On-line seminars developed and monitored either by the administering organization or by an independent company
- Directories of producers and manufacturers of semi-fabricated or fabricated products, or suppliers

3.4.2 CIKS Pilot Project

3.4.2.1 Subject and Contents of a Pilot Project

The first CIKS project that the working group recommended for metals involved the creation of a directory of current sources of metals. The group considered NIST as the best location for this testbed because of the technology and the information technology present at its facilities. In the first phase of development, metal associations would provide data to NIST; the data would include the name of the source, point of contact at the source (including E-mail and fax numbers), a synopsis of the content of the subject database, and keywords to facilitate searches. After the home page was created, the metal associations would promote its availability to their customers and members. An activity record would be analyzed after about three months of operation.

3.4.2.2 Advisory Council

It was noted that the working group was at a disadvantage in its deliberations as no users and/or customers were in attendance. To insure that the system would be what the potential users wanted and would find useful, it was recommended that a User Advisory Council be formed while the pilot project was being carried out. This council would consist of representatives from the following industries:

- Highways and bridges
- Buildings (including AIA and CSI)
- Residential construction (including NAHB)
- Military service, e.g., the U.S. Army Corps of Engineers
- State/council/city engineers
- Shipbuilding
- Dams
- Plants/equipment

The council would have the responsibility of guiding the metal associations on what to include and what was needed to make the system the most useful.

3.4.2.3 Database Formats

While material properties are available for steel, aluminum, and stainless materials, they are likely to be in different formats. The creation of standard formats for material property databases is recommended. Technical committees of the metal associations should work closely with NIST and ASTM E49 to insure compatibility and standardization of formats for property data values. This effort would likely be the longest running effort of the pilot project.

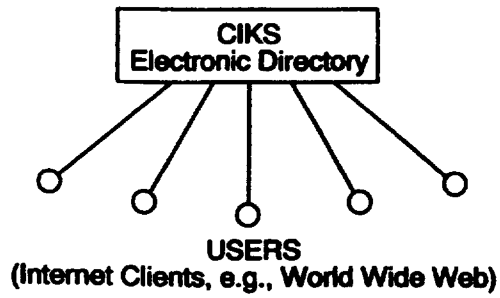

Figure 3.1

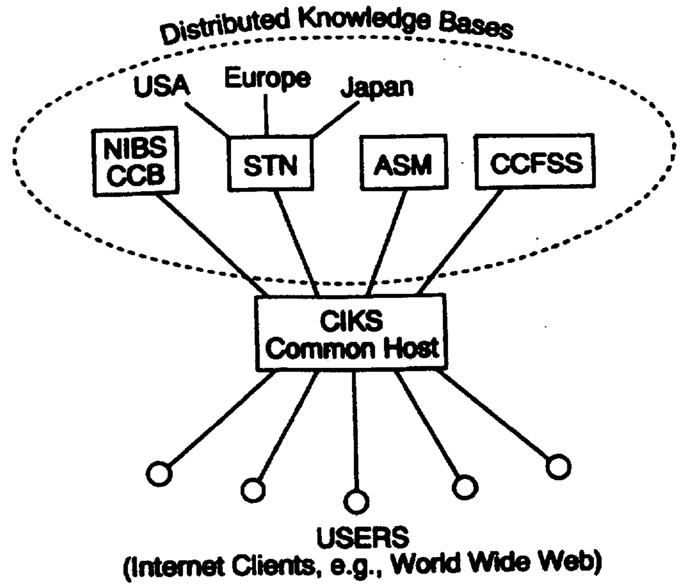

Figure 3.2

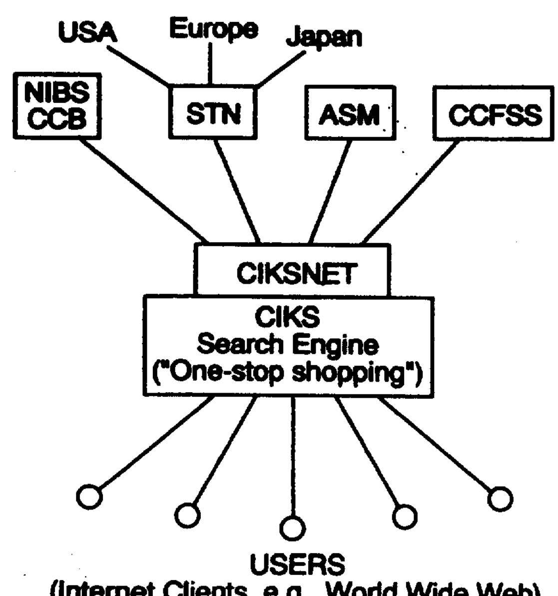

Figure 3.3

Figure 3.1. Electronic directory of sources of information on metal products. Figure 3.2. Linking distributed knowledge bases to CIKS. Figure 3.3. CIKS with "one-stop shopping" search capability.

3.4.2.4 Features of the Pilot CIKS

The CIKS should have an open architecture that would allow users to perform multiple searches concurrently from the Web site. Upon entering the system, data previously downloaded would be updated. Also, document delivery, possibly by fax on-demand, should be offered.

3.4.2.5 Outline of Work Plan

The work plan for the CIKS pilot project was outlined as follows:

- Collect data on current information sources for metals
- Create a home page
- Promotion of the site by metal associations
- Analysis of acceptance of the pilot project
- Development of standard reporting formats
- Creation of a User Advisory Council
- Secure co-funding from all partners

The completion of the above tasks would take about 18 months.

3.4.2.6 Support for the Pilot CIKS Project

The members of the working group agreed that a system such as CIKS is much needed and is currently a missing element of material promotion and marketing and customer resource. Full support for the effort is expected from the governing committees and boards of the metal trade associations.

3.5 Composites, Wood, and Plastics

Chair: Douglas Barno

3.5.1 Summary of Discussion

Working Group 5, represented an extremely wide range of materials and technical interests. The three materials groups: wood, plastics and FRP composites, are in very different phases of their industrial development, they represent mature, new, and emerging technologies, respectively.

3.5.1.1 Audience for Information

The group identified five general audiences for information/data:

1. Owners and operators of constructed facilities
2. Designers and engineers (A&E)
3. Constructors (builders, contractors, trades, etc.)
4. Researchers
5. Other, which includes the regulatory community, the finance and underwriting community, and trade/technical/professional organizations (TTPO's)

3.5.1.2 Information Model

The information model which the working group envisions is based on the traditional working arrangement of the U. S. construction industry and is shown in Figure 5.1. Generally speaking, the importance of TTPO's in focusing and promoting new technology is directly proportional to the size, diversity and fragmentation of the industry served. As the nation's largest industry, as well as its most fragmented and diverse, the construction markets rely heavily on their TTPO's to screen and validate information concerning new technology.

The group further discussed the fact that a CIKS-type technology will almost certainly proceed like the steps of a dance. In the beginning, the materials sources and information technology communities must lead, to get the system up and running. Once in place, and assuming the system has been built to meet the real needs of the end-users and practitioners, they will come and use it over time (but only if the system has been built right!)

Proceeding on the basis that "form follows function", the group identified forty-two separate information "families" which the CIKS system must provide. These may be consolidated as follows:

1. Materials data
2. Products and services
3. Specifications and standards
4. Application and case histories
5. R&D activities (types of research and where being conducted)
6. Resources (industry and technology experts)
7. Means and methods
8. User-to-user experience
9. Educational modules

3.5.1.3 Characteristics of a CIKS

The group defined the characteristics of a user-friendly, high-quality information technology system which includes characteristics ranging from ease of use, to technical requirements, to commercial viability, as follows:

1. Easy to use
2. Easy to understand
3. Flexible
4. Intuitive
5. Easily updated
6. Pleasing, attractive and enticing
7. Fast and reliable
8. Self demonstrable
9. Message-leaving capability
10. Affordable (inexpensive to support and use)

11. Useful (delivers appropriate information and data)
12. Avoid data/information overkill
13. Links similar and related data
14. Different levels or tiers (quick tour and in-depth search)
15. Multi-media (graphics, pictorial, text, sound, video)
16. Transparent between reference operating systems
17. Comprehensive
18. Provides security (supplier and user)
19. Capable of simultaneous multiple searches
20. Multi-tasking
21. Option to access via gateways or WorldWide Web
22. Minimum system requirements (RAM, disk space, etc.)
23. Tractability (inquiries, bulletin board, etc.)
24. U. S. customary and SI units
25. TTPO sponsored and endorsed
26. Commercially viable (self-sufficient in 2-3 years)
27. Permits sale of information, data, and handbooks
28. Copyright protection for providers of data and information

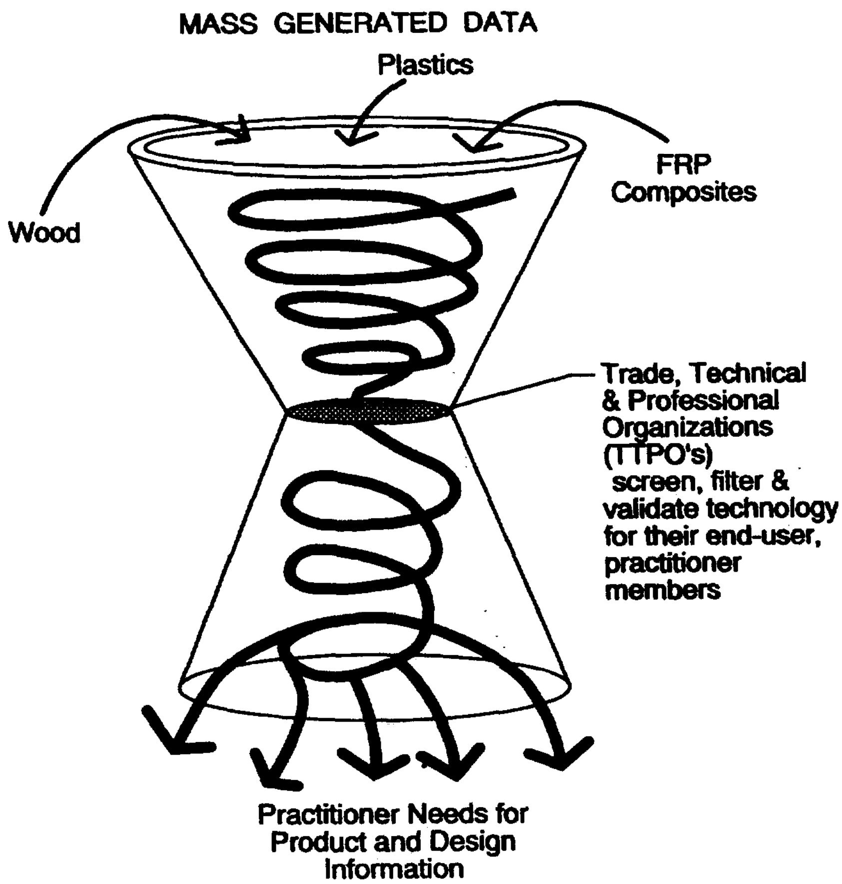

Figure 5.1

Figure 5.1 Information model envisioned by the Composites, Wood, and Plastics working group.

All construction materials companies involved in Work Group 5 agreed that, if a CIKS system with the above characteristics could be developed, their respective organizations would support and provide information and data to such a system.

3.6 Asphalt

Chair: Michael Zupanick

3.6.1 Summary of Discussion

The group discussed potential issues facing the asphalt industry information needs, types of information users, and how to disseminate the information to users. They recognized that progress in the asphalt industry requires information exchange. Three levels of information users were identified:

- Technical level: concerned about details
- Management level: concerned about success and failure; case histories; and trade-offs - risk reduction
- Policy level: concerned about funding; resource allocation and optimization; and public perception

A major need by information users is data on economics, with the specific information depending on the level of the user:

- Technical level: raw cost
- Management level: budget control
- Policy level: cost effectiveness

The group considered that information access was most important for technical users who should be the initial focus for any CIKS pilot project.

The group concluded that a substantial amount of information is available, with sources including the TRIS Research Abstract Database, FHWA Bibliography, AASHTO Materials Reference Laboratory data, and the Strategic Highway Research Program. Also, a considerable amount of information is on-line. Information needs not currently being met included:

- General background information on-line
- Centralized pointers to on-line data sources and to printed data sources
- Distributed databases: mix designs; material test results
- Mix design software to enable data capture.

3.6.2 CIKS Pilot Projects

Four potential pilot projects were proposed with the first one listed below being of the highest priority.

1) Data on Validation and Performance of Superpavements

- Gather mix design/materials information
- Coordinate data from various research projects
- Make data accessible online with user-friendly front end.

2) Long Term Pavement Performance Database
    - Requests for data online
    - Data access/sharing
    - Access to the National Info Management System (NIMS).

3) Materials Reference Library (MRL) Database
    - Identification of material samples
    - Data on samples.

4) Dissemination of European Technology
    - Successful performance
    - Innovative technology and contracting
    - Collection of input from international researchers
    - Information from PIRAC and RILEM.

4. ENABLING INFORMATION TECHNOLOGY

Chair: Jayanta Sircar

Working Group VII, Information Technology, was charged with the task of analyzing the application of Information Technology (IT) and CIKS in the construction industry taking into account the views on CIKS from the six working groups on construction materials.

The group's report is presented in three sections. In the first section, an overview is presented on the proceedings of the workshop as relevant to IT; in the second section, some important issues that pertain to the IT aspects of CIKS are summarized; and in the third section, the group's views of the overall management and operation of a CIKS initiative are summarized.

4.1 Overview of the Workshop

All working groups recognized the urgency for the integration on emerging information technologies with the traditional enterprise of the construction industry. The need for a CIKS was well established, although there was some question whether the system would ultimately require a separate name. For the purpose of this report, we adhere to the term CIKS and alternatively refer to it as "the system".

The discussion of the IT aspects of CIKS, as highlighted through the deliberations of the six working groups on materials, is most easily done by separating the discussion into its four basic semantic components—

i) Computer (or Technology)

ii) Integrated (or users/needs)

iii) Knowledge (Data/Information/Knowledge)

iv) System

4.1.1 Technology

From the IT perspective it was clear that existing information technologies, ranging from data communication to knowledge based or expert systems, would provide an adequate framework for the initial development phases of CIKS. The discussion on needs analysis in each of the working groups tended to focused on the need for training within the overall community of the construction materials industry. Such training needs ranged from basic use of PC desktop tools and Internet access, to raising the awareness, within academia and the engineering curriculum, on key aspects of the materials industry.

Although no uniquely new technological roadblock was visible, a key issue in the area of technology is the challenge of providing uniform access to the end-users given the diverse level of technology penetration reported within each of the different materials groups. Technically, access to a system such as CIKS would require a range of interfaces appropriate to the level of technology available at the user end. All of the groups noted the potential of the World Wide Web to serve as a framework for exchange of information among key participants.

In addition, it was noted that the asymmetric range of bandwidth requirements for CIKS might in the near term suffer from some limitations due to network bandwidth constraints over wide areas. Yet, with planned improvements in networking speeds on the national scene, this factor was not seen as limiting in the future.

4.1.2 Integration

The extent of IT integration within CIKS or its applications to each of the materials groups was observed to be highly user-dependent. Clearly, there were several areas where IT was determined to be immediately integratable over the entire range of applications—from data to information, to knowledge, and to the use of expert systems. Yet in some areas, the need for IT remained at a basic level of data directories, navigational aids and browsers.

A major concern among some working groups was the role of CIKS to address separately the technological needs for Intranets (networks within individual organizations) in contrast to Internet access. Many organizations regarded data and information as key business assets in their individual enterprises and would not make these freely available to the public. Nevertheless, there was a significant level of publicly available information that all organizations would prefer to be sharable. Acceptance of CIKS would therefore require the development of an appropriate architecture for organization to address these concerns.

4.1.3 Knowledge

If there was a single area that was not adequately discussed during the entire workshop, it was the area of knowledge systems. Most of the IT experts present expressed the view that the community of the materials industry as a whole should examine the fundamental differences between key concepts such as data, information, and knowledge. If CIKS is to successfully launch a development phase, it is strongly recommended that future discussions further expand on this issue. Protocols, data schemas, and entire "expert system" algorithms depend on a clear definition and understanding of these issues. Later in this report, we present our views at some length on this concern.

The workshop participants generally agreed that the information content of the system should be spatially distributed, with some parts being public and some private and accessible, if at all, only under specified terms and conditions. However, a major focus of the workshop was on the need for an early 'PRE-CIKS" release as a precursor to CIKS itself, that would provide a rapid electronic navigational system into a directory of guides and other basic information that is currently available only manually.

4.1.4. System

The CIKS System was viewed as evolving, in contrast to a single, one-event project. The system was seen to be modular and based on concurrent developments, drawing on the strengths of available developments and with gradual technological penetration within the target user areas for each of the materials considered. In the same vein, a concurrent or just-in-time development strategy was seen as more efficient because it would enable the integration of future developments in IT without loss in efficiency or cost.

Left to future discussions were the issues of identifying partners, locations, and security aspects of the designed system.

4.2 Information Aspects of CIKS

4.2.1 Terminology

A particularly important issue was developing an understanding of the distinctions among data, information, and knowledge, and ensuring that the terms are used appropriately within the context of CIKS. In his introductory speech, Dr. R. N. Wright, the Director of the Building and Fire Research Laboratory at NIST, presented the following definitions:

1. "DATA: basic building blocks in the form of numbers, words, sounds, and images"
2. "INFORMATION: data that has been arranged into meaningful patterns (e.g., database, plans, specifications)"
3. "KNOWLEDGE: application and productive use of information (e.g., models, expert systems)"

There was little discussion of these definitions; instead, there seemed to be implicit agreement that they were appropriate, and that CIKS should be a mechanism for facilitating evolution from the present data-oriented environment, through an information-oriented environment, and finally into a knowledge-oriented environment.

4.2.2 Working Group Approaches

The Working Groups' summaries indicated that they generally started from an analysis of where they were in a data-oriented environment, and then moved into the issues of capturing existing data and making it more easily available as information (e.g., adding value by providing better tools for finding, searching, and accessing existing data collections). System requirements that were mentioned included ease-of-use (particularly important to accommodate different levels of users), flexibility, and copyright protection. Electronic forums could be used to solicit suggestions and encourage discussions among users.

A particularly broad but useful goal that seemed to be implicit in many of the discussions is to have seamless, secure integration of private and public databases. The user would appear to have a huge, up-to-date collection of publicly available data with private value-added extensions, summaries, analyses, and comparisons of different data sources. The user would select what details were visible at any particular time. Achievement of such a goal is possible but requires addressing issues of data and system structure, and data exchange, analysis, and filtering.

4.2.3 Data and System Structure

There are current or foreseeable requirements for accommodating a wide and extensible range of data types, including text, numeric tables with associated data such as precision and footnotes, and multimedia.

An object-oriented approach would seem appropriate, since that could provide a uniform interface to a wide variety of existing or future data sources. Such an approach would hide the structural details, allowing them to vary from one database to another while still presenting the appearance of one common structure.

4.2.4 Data Exchange, Analysis, and Filtering

Participants seemed to understand the current environment and to recognize its limitations, but were wary of trying to move too fast and perhaps going in the wrong direction. This would seem to dictate an approach which would begin with existing data assets and build new and very flexible information- or knowledge-oriented interfaces. Rigid formats, protocols, and user interfaces would appear to be quite inappropriate at this time.

Current widely available examples of useful interfaces include directories, the relational database standard SQL, and the Remote Database Access standard, which together reduce the burden of knowing where the data is and the physical details of how it is structured; high-speed searches and filtering can be performed fairly easily and safely.

4.3 The Management and Operation of a CIKS

4.3.1 Revenue Generation

The generation of revenue from the CIKS activity will occur if the attempts to establish an infrastructure consisting of distributed construction materials knowledge bases and supporting information technologies are successful. The CIKS test bed will be a major contributor to this effort. The needs of construction industry organizations will likely drive the creation and development of CIKS. Needs such as sharing knowledge and marketing products such as guides, standards, and materials will be addressed.

Current barriers that exist in electronic commerce need to be removed to facilitate the development of a framework allowing increased marketability of knowledge of construction materials, thereby permitting it to develop into a commercial entity. This will create a favorable environment for the commercial distribution of construction materials knowledge.

4.3.2 Test Bed Creation and Partnerships

To address the knowledge needs of construction materials users, a test bed must be created and maintained. Along, with the activities of the test bed, information models, heterogeneous computing platforms, and network capabilities must be implemented and tested using sample data sets from industry and government. Material properties, product data, and standards and guides of accepted practice are examples of types of knowledge that should be considered. Promising information technologies (e.g., intelligent agents for seeking and interpreting knowledge) and information standards (e.g., ANSI, ISO) must be evaluated and tested. These should be used to represent, communicate, and interpret knowledge.

Criteria must be established for validating and screening knowledge to be included in the test bed. This will be developed in concert by the public sector and construction industry organizations. Database formats for representing and exchanging material properties will need to be created and tested. Cooperative Research and Development Agreements (CRADAs) can be developed to maintain a focus and commitment to achieving practical solutions for the use of knowledge. Virtually every type of organization involved in construction materials manufacturing and use could be active participants in the CIKS development. The needs of other disciplines such as building designers should also be addressed. Academia should play a role both in the development of knowledge bases and systems, and also be a disseminator of knowledge through their curricula.

4.3.3 Pilot CIKS Projects

Recognizing the individual needs of organizations and users CIKS pilot projects must be developed using a framework that addresses the need for distributed knowledge and heterogeneous computing platforms. Diverse users that span the spectrum from novice to expert, and researchers to construction contractors, should be involved. A test bed can serve as a framework for performing evaluations and developing products that address these diverse needs. Working under the guidance of CERF and CONMAT, and in unison with the materials working groups, pilot CIKS projects could be carried out to address specific needs and topics. Providing guidance and education for users and assessing user knowledge needs will be an initial focus of the CIKS activity.

The development of methods and prototypes for the representation and dissemination of database information using the Internet, should be pursued as an important part of a pilot CIKS program. Also, methods must be developed to provide the knowledge users with the ability to seek, find, and interpret knowledge that is relevant to their specific interests.

Data quality must be an important characteristic of the CIKS knowledge bases. The ability to use multiple forms of knowledge from distributed locations, using diverse computing platforms, in the decision-making process must also be an important aspect of CIKS activities and products.

The overall approach for the CIKS activity should be to seek out organizations and interests and not attempt to solve all problems at once. For example, materials engineers within the highway industry (e.g., bridge and pavement engineers) could serve as model users for the CIKS test bed. Typically, this group is involved with multiple materials such as concrete, coatings, steel and materials which are used to construct, maintain, and rehabilitate highway structures.

4.4 Conclusion

The workshop clearly revealed that the need for CIKS is timely and critical to the construction materials industry as a whole. The success of CIKS depends on using innovative and creative ways to engage the attention and interest of the end-user. While the technological needs for CIKS are well-established in terms of the major IT tools available today, the need for the early release of a pilot CIKS, with efficient navigational interfaces to directories and to other readily available off-the-shelf information, was well articulated by all of the working groups. Coupled to a pilot CIKS release (possibly using the Internet Web technology), the needs for training, education, and user-friendly interfaces were recognized and judged not to pose significant problems.

5. CONCLUDING REMARKS

The necessity for developing improved means, such as CIKS, for disseminating data, information and knowledge on construction materials was clearly stated in the keynote presentations. Although the CIKS Network concept is new to the construction industry, the workshop participants appeared to be essentially unanimous in their support for the development of pilot projects. The working groups recommended the development of pilot CIKS projects which would serve to educate the developers and demonstrate the benefits of such systems to potential users. They were in favor of beginning with relatively straightforward projects which used existing data, information, and knowledge of known reliability, which should be of interest to potential users. For example, a pilot project of high priority from the Coatings Group was the development of a guide for searching information on the Internet and on how to develop an Internet site for information on material performance. Several groups proposed the development of a product data and product source system. However, little attention by the materials working groups was given to the evolution of CIKS beyond the pilot projects or to their potential power as major problem solvers in the construction industry, e.g., the concept of integration of knowledge systems was not apparent in the planning of the pilot projects. Also, while sufficient knowledge is available for the pilot projects, in the future, lack of applicable knowledge may eventually become a barrier to CIKS attaining their potential abilities as problem solvers.

The keynote presentations advised that databases and other knowledge bases, which will be the start point for most CIKS efforts, must be easy to understand and use, the data must be in consistent formats, and their reliability must be documented. The material working groups considered the development of standard formats to be a necessity for the representation and exchange of data. The Information Technology Working Group considered that the one area which was not adequately discussed was knowledge base systems. Differences in fundamental concepts such as data, information, and knowledge did not appear to have been considered by the materials groups and a future workshop should expand on this issue. Information models also were not given adequate attention, only being discussed by the Composites, Wood, and Plastics group, and should also be one of the subjects of a future workshop. However, the desired characteristics or attributes of a CIKS were well-discussed by the groups, with 29 items being identified by the Composites, Wood, and Plastics group.

The commercial aspects of the establishment of a CIKS network, either nationally or globally, were well-recognized. Attention was given to marketing plans, payment for intellectual property, and creation of business ventures dealing with development, implementation, and marketing. Partnerships between government and the construction industry were considered to be very desirable, if not necessary, for the commercial-side of CIKS to be fully realized.

In closing, we feel that the workshop more than met its objectives. Reflecting that the establishment of a CIKS network is a new and technically challenging concept to the construction materials community, the degree of willingness by the workshop participants to test the concept and to engage in future planning for development and implementation more than fulfilled the expectations of the workshop's organizers and sponsors. It is recommended that a further workshop be held to review the progress made in the pilot projects and to address the important issues identified but not adequately covered by this workshop such as the fundamental differences between key concepts such as data, information, and knowledge; standards for knowledge base systems and CIKS; and how to assimilate new knowledge into a CIKS to avoid obsolescence.

6. ACKNOWLEDGEMENTS

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The American Society for Testing and Materials (ASTM)
The Civil Engineering Research Foundation (CERF)
The CONMAT Council
The National Institute of Standards and Technology (NIST)

They also wish to express their appreciation to the workshop participants whose contributions were vital to the success of the workshop. Special thanks are extended to the keynote presenters and to the working group chairmen. The group recorders are commended for their conscientious efforts in documenting the group discussions.

The authors thank all the individuals who reviewed the report and submitted constructive suggestions. We thank Mrs. Nancy Evans for her diligence in planning for the workshop and for processing this report.

APPENDICES

WORKSHOP
A Partnership for a National Computer - Integrated Knowledge Systems Network for High-Performance Construction Materials and Systems

National Institute of Standards and Technology
Gaithersburg, MD
June 13 and 14, 1996.

APPENDIX I WORKSHOP PROGRAM

THURSDAY, JUNE 13, 1996

8:30am - 1:00pm	Welcome and Introduction Opening Presentation	S. Shyam Sunder Workshop Chair, NIST
	A Partnership for a National Computer-Integrated Knowledge Systems Network for High-Performance Construction Materials & Systems	R. N. Wright NIST, Director Building and Fire Research Laboratory

Keynote Presentations - I

	Information Technology Needs for the Construction Industry	W. Kirksey Vice President, CERF
	Uses and Delivery of Materials Information	G. Kaufman Vice President, Aluminum Association
	Materials Information for the Construction Criteria Data Base	E. Kennett, NIBS
	Materials Information for Design and Analysis	G. Allen/D. Marinaro MacNeal-Schwendler
	BREAK	

Keynote Presentations - II

	The Future of Global Electronic Commerce	D. Jefferson, Consultant, NIST
	Standards for Computerization of Materials Data	C. H. Newton Materials Research Corp.
	Commercial Uses of Standard Reference Data	P. Fagan Standard Reference Data Program, NIST
	Matching Information Technologies with the Objectives of Material Data Users	C. P. Sturrock NIST

Panel Session

	Panel of Keynote Speakers Topics: Delivery Mechanisms- Electronic Commerce Enabling Information Technologies	Moderator: S. Shyam Sunder NIST
Charge to Working Groups		C. H. Newton Materials Science Corporation

Working Group Session - I

2:00pm - 5:00pm	Goal: Identify and Prioritize Information Needs in Support of CIKS Functional Goals	
5:15pm - 5:45pm	Summary of Working Group Meeting of Working Group Chairs Meeting of IT Expert Group (ITG7)	Session I Chair: G. Kaufman Chair: J. Sircar

FRIDAY, JUNE 14, 1996

Plenary Session

8:00am - 9:10am	Preliminary Reports from Working Groups	Chair: J. R. Clifton

Working Group Session - II

9:20am - 12:15pm Goal: Identify Potential Partnerships and Pilot Projects

Working Group Session - III

1:00pm - 1:50pm Goal: Write Working Group Reports

Plenary Session

2:00pm - 3:15pm	Presentation of Working Group Reports	Chair: S. J. Dapkunas
3:15pm - 3:30pm	Summary\Wrap-Up and Next Steps	S. Shyam Sunder

APPENDIX II. SPONSORING ORGANIZATIONS, AND STEERING AND ORGANIZING COMMITTEES

Sponsoring Organizations

- Civil Engineering Research Foundation (CERF)
- American Society for Testing and Materials (ASTM)
- National Institute of Standards and Technology (NIST)
- CONMAT Council - Members:
    - American Iron and Steel Institute
    - Aluminum Association
    - Composites Institute
    - Steel Structures Painting Council
    - American Forest and Paper Association
    - American Concrete Institute
    - National Roofing Contractors Association
    - Smart Materials: EMF Industries
    - National Concrete Masonry Association
    - National Asphalt Pavement Association
    - Specialty Steel Industry of North America
    - Society of the Plastics Industry

Steering Committee

B. Appleman	Executive Director, Steel Structures Painting Council
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P. Breeze	Managing Director of Engineering, American Concrete Institute
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G. Kaufman (Chair)	Vice President, Aluminum Association
W. Kirksey	Vice President, Civil Engineering Research Foundation
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WG4 - Steel, Aluminum and Stainless Materials

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P. Grayson	Strain Monitor Systems, Inc.
G. Kaufman, Chair	The Aluminum Assoc.
B. Leslie	SSINA
K. Slaughter	American Iron and Steel Institute
C. Sturrock	NIST/BFRL

WG 5 - Composites, Wood and Plastics

P. Arumugasaamy	Owens Corning S&T Center
G. Barefoot	Morrison Molded Fiber Glass
D. Barno, Chair	SPI Composites Institute
J. Carpenter	NIST
P. Fagan	NIST
T. Goldburg	GHL, Inc.
M. Goldstein	NIST/MEP
R. Griffin	Amoco Polymers
N. Jason	NIST/BFRL
P. Kissinger	CERF
S. Khan	Dupont
P. Line	AF and PA
C. Newton	Materials Sciences Corp.
R. Pauer	Reichhold Chemical, Inc.
R. Rehm	NIST
H. Toner	Society of Plastics Industry
M. Young	PPI

WG6 - Asphalt

L. Hummel	MTAC
S. Killingsworth	BRE, Inc.
W. Kirsey	CERF
P. Spellerberg	AASHTO Materials Reference Lab./NIST
H. Tahir	AASHTO Materials Reference Lab./NIST
M. Zupanick, Chair	Sun Company

WG7 - Information Technology Experts

C. Allen	MacNeal & Schwendler Corp.
J. Carpenter	NIST/MSEL
S. Dapkunas	NIST/MSEL
M. Goldstein	NIST/MEP
N. Jason	NIST/BFRL
D. Jefferson	NIST
C. Newton	Materials Science Corp.
R. Rehm	NIST
J. Sircar, Chair	University of Maryland
A. Wiezel	Arizona State University