ADVANCED BUILDING TECHNOLOGY MATRIX SYSTEM

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ABSTRACT: The cost of industrial building construction has risen dramatically in recent years. Excessive construction costs have eroded the competitive position of the US construction industry and are having a similar impact on the manufacturing industry by preventing it from building new plants and modernizing existing ones. An effective solution to these problems is the introduction of new technologies that enhance the quality of the building product, increase construction efficiency, and decrease costs. This paper presents the ABT Matrix system, an information system for describing and documenting advanced building technologies (ABTs) and lists the names of the 151 ABTs that have been documented using this system. The Advanced Building Technologies Matrix is a database system that relates building systems to specific technologies and vice versa. In its present implementation the ABT Matrix can be used as: (1) a direct source of initial information about the documented ABTs, (2) a pilot implementation and an example of the ABT database system, and (3) a basis for developing similar, in-house, ABT documentation systems.

INTRODUCTION

The cost of industrial building construction has risen dramatically in recent years. Excessive construction costs have eroded the competitive position of the US construction industry and are having a similar impact on the manufacturing industry by preventing it from building new plants and modernizing existing ones. A large number of projects have been abandoned because the cost of construction is a large component of a corporation's cash flow. The decline will continue until construction firms lower costs and improve techniques to the point where growth is worth the risk and investment.

An effective solution to the above problems is the introduction of new technologies that enhance the quality of the building product, increase construction efficiency, and decrease costs. In order for new technologies to be incorporated in building construction, however, they must first be identified and evaluated during the project design phase and the construction planning phase.

In most organizations it is typically assumed that architects and engineers will initiate and be responsible for the introduction of new building technologies through research and evaluation. Often, however, these professionals are not given the necessary time nor the incentive to do so. Practicing A/Es have admitted that their typical information base on available and future technologies is limited to one or two magazine articles or advertisements.

The purpose of this study is to assist the construction and manufacturing industries in becoming more efficient and cost effective through the introduction and broad use of new technologies. Approximately 50% of construction costs in light industrial and commercial building construction are related directly to enclosure and structural systems. Since these systems are common among industrial buildings, the identification and adoption of effective and efficient technologies in these areas is a major step towards improving quality, reducing costs, and expediting schedules.

ABT MATRIX---OBJECTIVES AND SCOPE

The broad objective of this research was to provide owners, designers, and contractors with structured information on the state of the art of building technologies that are applicable to industrial and commercial construction. These include available and future technologies, that may or may not be in widespread use, which show a promise towards improving the cost effectiveness and efficiency of construction, and enhancing the functional and operational performance of the constructed product.

The scope of the research included the development of the Advanced Building Technologies (ABT) Matrix system, an information database that relates technologies to building systems and vice versa, and the identification and documentation of the benefits, advantages, and limitations of promising technologies that are applicable to the enclosure and structural systems of commercial and light industrial buildings. The specific focus was on technologies that apply to: (1) Floor, (2) Roof, (3) Structure, and (4) Wall systems for industrial and commercial building construction. A fifth category "Miscellaneous" includes technologies that were identified in the course of the study but were not directly related to the above systems.

The selection of the scope and direction of this study were based on the following criteria and goals:

- The project provides in-depth coverage of the current and future state of the art in a particular technological domain. A wider scope would dilute the effectiveness and utility of the research.
- The scope of the research was of direct interest to the members of the Subcommittee on Advanced Building Technology (ABT), the Technology Task Force, and the members of the Construction Industry Institute. Light industrial and commercial building construction provides excellent possibilities both in terms of interest and in terms of potential for innovation.
- The domain of light industrial and commercial building construction is too diverse in itself for the resources allocated to the research because of the wide range of possible building functions and uses. In order to maximize the benefit of the research in terms of breadth of applicability, it was focused on building systems that are more or less independent of function, including wall, roofing, floor, and structural systems.
- The results of this effort constitute a basis for future CII projects with a broader scope and provide the framework for the development of similar information systems within CII member companies and other construction organizations.

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ABT MATRIX SYSTEM

The Advanced Building Technologies (ABT) Matrix is an information system that relates building systems to specific technologies and vice versa. The ABT Matrix associates a given building system with the applicable technologies and associates a particular technology with its domain of applications. This matrix serves as an indexing system for retrieving detailed ABT information, and it is similar in function to a relational database.

The system currently includes 151 advanced building technologies (ABTs), the description and documentation of which constitutes the main part of a research report (Ioannou 1987). This report also includes a set of six indexes for retrieving information by relating technologies to the appropriate building systems and vice versa. The indexes also allow locating particular technologies based on keywords in their names. The names of the technologies documented in the report are listed in Appendix II of this paper.

The documentation of the technologies included in the ABT Matrix is based on a standard format that was developed in cooperation with the CII Technology Task Force. The ABT format and the degree of detail in the database were determined on the basis of experience and the industry's needs. The purpose of this format was to provide information in a form that is sufficient, non-product specific, and readily usable in everyday practice. Our objective in developing the format was to provide the user with enough information to make the initial and crucial decision as to the whether a certain technology is of interest and should be pursued further. It was not our intention to provide all the information that may be available about each technology and each specific product. The user is provided with references and is directed to other information sources for that purpose.

The ABT Matrix system is also available in microcomputer-based database format for rapid retrieval and easy updating and expansion. The computerized form utilizes two commercial microcomputer software packages: an (ASCII) text editor/text formatter (FinalWord II), and a spreadsheet/database system (Lotus 1-2-3). These software packages were used to create the research report and were chosen so that it would be easy to transfer the ABT system to other micro, mini, and mainframe computer systems. The current implementation can be used as (1) a direct source of initial information about the documented ABTs, (2) a pilot implementation and an example of the ABT database system, and (3) a basis for developing similar, in-house, ABT documentation systems. All the microcomputer files for the ABT Matrix system, as well as the research report, are available from us upon request. A more detailed description of the system appears below.

THE ABT DOCUMENTATION FORMAT

Each technology in the ABT Matrix is documented using a standard format which serves the purpose of a database record. The format includes a standard number of fields that appear in the description of every technology. Certain fields have subfields whose names or purpose depend on the nature of the specific technology being described. The need and the headings for the subfields are determined on an individual basis.

The organization of the ABT format and the degree of detail in the database were determined in cooperation with the CII Technology Task Force and reflect the experience gained during the research study. Many of the related decisions were dictated by the need for consistency, brevity, and clarity. The final format provides sufficient information for identifying promising technologies, and it is easy to use in everyday practice. The underlying objective was to provide users (owners, architects, engineers and contractors) with concise and sufficient information for making the preliminary decision on whether they are (or should be) interested in a particular technology. It was not intended to provide a detailed description of each technology to the degree necessary for design, specification, procurement, and construction. The users are directed to other information sources for detailed data.

An example application of the standard format is presented below. An explanation of the various fields is shown in *italic* type.

Name: Single Ply Membrane Roofing System
This is a generic and descriptive name for the technology. The words in the "Name" are used as keywords in the Indexes for locating the technology.

Classification: Roof--CSI 07500 - Membrane Roofing
Each technology is classified in one or more of the following ABT categories: Floor, Roof, Structure, Wall, and Misc. The ABT classification is followed by the CSI MasterFormat Section Number and Title.

Application: Flat and sloped roofs for industrial and commercial buildings.
Short description of the specific applications for the technology within industrial and commercial building construction.

Description: Single ply membrane is made of synthetic rubber or plastic, 0.045 in. to 0.06 in. thick and weighs less than 0.5 psf. Membrane is delivered in sheets up to 50 ft wide and 200 ft long. Membrane is laid over roof deck and can be secured by mechanical fasteners, adhesives, or stone ballast. Sheets are joined by heating seams, solvent welding, or taping.
A short description of the technology that explains what it is, what it does, what it is used for, how it is applied, and the materials involved.

Benefits: Large sheets reduce the number of roof joints. Membrane needs little or no maintenance. Membrane elasticity allows normal building movement without cracking, rupturing, or leaking. Has low installation costs and can be installed in all weather conditions. Membrane is reusable.
The particular benefits of this technology.

Limitations: No long term record on performance, because product is relatively new.
Any limitations and weaknesses of the technology or other pertinent information that should be weighted against the benefits described above.

Construction: By manufacturer approved contractors.
Who can undertake or incorporate the technology in construction.

Sources: Manufacturer.
Sources from which the technology can be procured, procurement time, and availability.

Design: Standard design details available from manufacturers.
Design requirements, ease of design, availability of codes and specifications, who

does the design for systems that include this technology, need and ease of access to sources of (standard) design details.

Specifications: Manufacturer.
Specifications sources for the technology.

Connections:
Brief description of connections to other systems; what it will support and how attachments are made.

Joints:
How joints are made; special methods, procedures, and materials involved.

Compatibility: Compatible with all types of roof decks. Can also be used for re-roofing.
Compatibility with other systems or materials: materials/components with which it does or does not work.

Special Problems: Flying stones (ballast type roofing system) during strong winds may cause damage to surrounding areas. Metal fasteners may corrode and lead to failure of roof. Lap joints can fail due to improper use of adhesive in joining sheets together.
Special problems and conditions under which it misbehaves, fails, or does not fulfill its function, etc.

Experience: Wide use since about 1975 has produced over 50,000 installations.
Summary of past experiences, types of construction where used, and performance therein.

Lifetime information: Common warranty is 20 years.
Lifetime information, life expectancy, factors affecting life, etc.

Weathering: Product is stable against ultraviolet and ozone exposures. Can withstand severe temperature fluctuations.
Weathering information including how well it weathers, causes of weathering, how to prevent weathering, changes in properties and behavior, etc.

Repair: Tears and punctures can be repaired by special sealing tapes or patches available from manufacturers.
Possibility and ease of repair, repair methods, and probability of success.

Costs: Material and installation cost ranges from $1.25/sq ft to $2.50/sq ft (based on inquiry, Oct. 1986). No operation or maintenance costs. Repair costs are low.
Construction, operation, and maintenance costs. Best if given as unit costs, including ranges and sources of information.

Properties: Thermal: Not significant.
Structural: Tear strength = 90 x 90 lb (ASTM D751). Dynamic impact = 250 lb (Method 2031, Fed. Std. 101B). Lap joint strength =>350 lb (ASTM D751).
Waterproofing: Hydrostatic resistance = 500 psi (ASTM D751). Low temperature cracking: No cracks (ASTM D2136).
Colors: White is standard. Other colors available.
Texture: Smooth.
Short description of important properties applicable to the technology: thermal, structural, waterproofing, color, texture, etc. The specific properties listed vary depending on the nature of the technology.

Dimensions: Single sheet as large as 50 ft x 200 ft.
Thickness: 0.045 to 0.060 in.
Dimension classification varies depending on the nature, shape, and application of the technology. May include length, width, depth, thickness, cross section area, sheet area, etc.

Acceptance Testing: Factory Mutual approved Class I roof.
Underwriters Laboratories UL 790 and ULP assembly test, classified Class A roof.
Standard acceptance tests for quality assurance and quality control.

Further Information: Carlisle SynTec Systems
Div. of Carlisle Corp.
P.O. Box 7000
Carlisle, PA 17013
(800) 233-0551
... etc.

The same fields are used for the description of all technologies. Fields that cannot be completed due to lack of sufficient information are shown blank. The listing of all field names, even if the fields are blank, insures uniformity and indicates which information is missing. It also prevents the misinterpretation that if a field name or information is not listed then it must not be applicable.

THE ABT MATRIX DATABASE ORGANIZATION

The ABT Matrix associates each technology with the appropriate building systems and associates each building system with the applicable technologies. In database terminology this is a standard "many to many" relationship. In implementing this relationship the ABT Matrix had to satisfy several conflicting criteria in order to be as useful as possible to a diverse user group: (1) It should have an organization that can be implemented both on paper and in electronic form, (2) it should be simple, easy to understand and use, (3) it should be easy to expand by adding new undocumented technologies or updating existing ones, and (4) it should be transportable from one hardware or software system to another. The implementation described below satisfies these criteria in an efficient and effective manner.

RELATING TECHNOLOGIES TO BUILDING SYSTEMS

Each technology must be related to all the building systems to which it applies. This association is accomplished through the field "Classification" in the ABT standard format described above. This field relates each technology to one or more of the building systems included in the scope of the project: Floor, Roof, Structure, Wall, and Miscellaneous. For example, the single ply membrane roofing system is shown to apply to the system "Roof".

In order to make the system more compatible with an industry-standard system, the "Classification" field has been expanded to include the corresponding CSI MasterFormat Broadscope Section Number and Title for each technology (CSI 1987). This format is published by the Construction Specification Institute (CSI) and has been widely adopted by many trade technical, professional,

and public groups involved with design and construction. This is especially true for building construction where most building materials are now identified by the CSI classification numbers for filing purposes. The CSI numbering system is also the classification basis for the Spec-Data system described below.

The five digit CSI number in the "Classification" field serves as the primary index for the ABT database system. Each technology is documented in a separate text file whose filename is in the form "ABTccccc.xxx", or "APPccccc.xx". Filenames with the prefix "ABT" indicate technologies that have been adequately documented (these are described in the main part of the report). The prefix "APP" indicates that the corresponding technology has not been adequately documented due to lack of sufficient information (included in Appendix A of the report). The same explanation applies to the character "" in the filename suffix. The ABT Matrix currently includes 126 "ABT" and 25 "APP" technologies.

The numbers included in each filename are based on the corresponding CSI section number. For example, the single-ply membrane system described above is documented in the file "ABT07500.001". The five digit number "07500" is the CSI number for "Membrane Roofing". The suffix "001" indicates that this technology was the first one that we documented within the CSI number "07500". As other technologies with the same CSI number were identified, they were assigned consecutive suffix numbers. The CSI number and the suffix number determine the sequence in which the technologies are documented in paper form as shown in Appendix II of this paper. They are also the means by which the user can locate a particular technology using the indexes.

RELATING BUILDING SYSTEMS TO TECHNOLOGIES

The association of building systems with the applicable technologies is accomplished through six indexes. The first is a general index that lists all the technologies irrespective of the building system to which they apply. Each of the remaining five includes technologies that are applicable to a particular building system: Floor, Roof, Structure, Wall, and Miscellaneous. (Miscellaneous refers to ABTs that are applicable to building systems other than the previous four.) Technologies applicable to more than one building system are listed in each one of the appropriate indexes.

The indexes direct the user to the appropriate printed documentation or computer file by listing the computer filename for each technology next to its name. They also allow the identification of a particular technology for a given building application without requiring that the exact name of the technology be known. This is accomplished by using separate indexes for each building system, and multiple entries for each technology within each index. The multiple entries were created by dividing the name of each technology into a set of up to five descriptive keywords. The keywords for all the technologies in a particular index were sorted alphabetically, and a complete entry for each technology was made under each of its keywords. For example, the name "Single Ply Membrane Roofing System" has been divided into the two keywords "Single Ply", and "Membrane Roofing System". This technology is listed both under "Single Ply" and under "Membrane Roofing System". Both entries can be found in the General Index and the Roof Index.

The applications of each technology are listed next to its name by using the first letter of each of the appropriate building systems: "F"=Floor, "R"=Roof, "S"= Structure, "W"=Wall, and "M"=Miscellaneous, as shown in Appendix II. The actual ABT indexes are not reproduced in this paper due to space limitations.

SOURCES OF INFORMATION

The identification and documentation of ABTs involved thorough searches of professional and trade magazines, product catalogs and manufacturers' literature, request letters and phone calls to product manufacturers and suppliers, and communications with the Technology Task Force member organizations. A complete list of information sources appears in Appendix B of the research report and includes product manufacturers, suppliers, professional associations, professional societies, professional and trade magazines, technical reports, individuals within design and construction companies, and CII member organizations.

The specific sources of information for each technology are listed at the end of each ABT file. These include product manufacturers and/or other sources, and their complete addresses and telephone numbers.

Similar documentation efforts have been undertaken by the Construction Engineering Research Laboratory (Napier 1987) and GM Argonaut AEC (Argonaut 1987). A very important source of information is the CSI Spec-Data system described below. It deserves particular attention, not only because it is useful, but also because many potential users are not aware of its existence and purpose.

THE SPEC-DATA, MANU-SPEC SYSTEM

The Spec-Data sheets are short descriptions of proprietary products. They are prepared by manufacturers according to a format established by the Construction Specification Institute (CSI). The standard format of a Spec-Data sheet assembles product data into ten groups (headings) of related information. The same headings appear in all Spec-Data sheets as follows:

1. Product Name
2. Manufacturer
3. Product Description
4. Technical Data
5. Installation
6. Availability and Cost
7. Warranty
8. Maintenance
9. Technical Services
10. Filing Systems

The product manufacturer selects and prints the data that apply to the product under each of these headings. While CSI reviews and authorizes the publication of a unit, the technical accuracy of any Spec-Data sheet is solely the responsibility of the manufacturer who produces the sheet. New and/or revised Spec-Data sheets are mailed to CSI subscribers periodically. They are intended to be inserted in 3-ring binders and used as a reference in evaluating and selecting proprietary products.

The Manu-Spec sheets are product specifications that complement the Spec-Data sheets. They provide an easy way for specifying proprietary products using a "closed specification" format. The Manu-Spec format has three parts:

1 - General	Includes a description of general requirements such as Related Work, Quality Assurance, References, Unit Price, Warranty, Delivery, Storage, and Handling.
2 - Products	Includes required information on the materials and their preparation prior to installation.
3 - Execution	Includes "execution" provisions pertinent to the products specified in Part 2. These include

inspection, preparation, installation-application-erection, field quality control, adjusting and cleaning, protection, extra stock/spare parts, and schedules.

The technical accuracy of a Manu-Spec sheet is the responsibility of the manufacturer who produces the sheet. These sheets are kept in binders similar to the Spec-Data sheets. They are ready to use and can be easily inserted into a set of building specifications.

COMBINING THE ABT MATRIX WITH THE SPEC-DATA SYSTEM

The integration of the ABT Matrix with the Spec-Data system produces a very useful and powerful information base. Even though the two systems appear similar, they actually complement each other because they serve different purposes and objectives, they are based on different classifications, they include different technologies, and they list different kinds of information.

The Spec-Data system is product-specific, is prepared and paid for by the manufacturer, and resembles a form of controlled or constrained advertising. The ABT system is intended to be impartial, does not focus on proprietary technologies (if possible), and should be maintained by the user and not by product manufacturers. The ABT system resembles a product review in that it permits the aggregation of similar products under the same ABT heading. It also permits the documentation of technologies that are not associated with specific proprietary building products, including equipment and methods.

Some of the ABT files have counterparts in the Spec-Data sheets, but many do not. This is especially true for newer technologies and technologies produced by small or new companies. Some of the most promising ABTs that have been identified do not have Spec-Data sheets. However, when Spec-Data for a particular product exist, they constitute a valuable source of product-specific information that can be very useful to the user. The same applies to the Manu-Spec sheets, if the user wishes to indicate a particular proprietary product using a "closed specification" format.

ABT MATRIX SYSTEM IMPLEMENTATION

The ABT Matrix documentation system has been implemented on an IBM PC (or compatible) microcomputer. Individual organizations can apply the results of this research project as a basis for implementing and maintaining their own ABT information databases using a variety of hardware and software configurations.

The ABT documentation system is based on two commercial programs, the FinalWord II, a word-processor, and Lotus 1-2-3, a spreadsheet-database. The publishers of these programs are given in Appendix III.

The primary objective in selecting these programs was to maximize the portability of the research files. The FinalWord is a combination of two programs: a text editor that creates pure ASCII manuscript files and a formatter that interprets English-like directives included as part of the manuscript. This permits all text files to be read by any other word-processing system without a need for extensive translations. If necessary, the FinalWord formatting commands can be removed or substituted with delimiters (for importing the descriptions into database programs) by using "global search and replace" or "print to file" options. The FinalWord formatting commands are almost identical to the ones used by the SCRIBE and LaTeX text formatting systems that are widely available on minicomputers and mainframes. Even though Lotus 1-2-3 does not produce ASCII files directly, it is the most widely used software product, and thus it is possible to translate its worksheets into the format of any other program.

The practical implementation of the system in user organizations is relatively straightforward. The first step is to select the appropriate software system that is compatible with the organization's computing facilities. Example systems for companies using IBM microcomputers are: (1) spreadsheet/database programs such as Lotus 1-2-3 or Excel in combination with a word-processing system such as FinalWord, Word, or WordPerfect, (2) spreadsheet/database programs augmented with text-processing capabilities (Excel, or 1-2-3 with a database add-in such as @Base or Silverado, or with a text-processor add-in such as 4-Word), (3) database systems that can accommodate large text fields, such as dBase III Plus, RBASE System V, or Paradox, and (4) integrated systems such as Framework, or Symphony. For Apple Macintosh systems it is possible to use similar systems, for example, a database such as Fourth Dimension, or a hypertext system such as HyperCard.

Once the software system is selected, it is convenient to create a data entry system for the various fields of the ABT standard format (a system-specific task). The actual data entry and the cross-classification of technologies can be performed by either line personnel or trained staff. The actual database could reside on a local area network for direct access or it could be distributed on disks. Searching for appropriate technologies can be accomplished by publishing the indexes on paper, or by using an on-line database index. A very effective search system can also be implemented by using a hypertext system (such as HyperCard on the Macintosh) that allows cross-referencing any word or phrase in the documentation of one technology to the documentation of any other technology.

The effort required to maintain the system depends on the adopted configuration and the robustness of the software. As an estimate, a single experienced person should be able to install and configure the ABT Matrix system in less than a week. Once the system is in place, data entry becomes the most time consuming task and should be assigned to support staff personnel. The source of the information should be the system users (line personnel) who should also check the input for accuracy.

CONCLUSION AND RECOMMENDATIONS

This study has developed an information system for advanced building technologies and has used this system to document 151 promising ABTs for the enclosure systems of light industrial and commercial buildings. The results of this study can be used as: (1) a direct source of initial information about the documented ABTs, (2) a pilot implementation and an example of the ABT database system, and (3) a basis for developing similar, in-house, ABT documentation systems.

We believe that this effort should be continued, either by CII sponsored research, or by individual organizations involved in construction. This recommendation is based on the single observation that once an ABT system is in place, it is very easy to expand, update, and maintain, and its potential benefits towards cost effectiveness, and the improvement of construction quality far outweigh the associated cost. The magnitude of construction costs is so large that even marginal reductions in cost or improvements in quality can easily justify the effort and cost of developing and maintaining the ABT Matrix system.

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APPENDIX I.--REFERENCES

Ioannou, Photios G. and Robert I. Carr (1987). "Advanced Building Technology (ABT) Matrix", Technical Report No. 5, Center of Construction Engineering and Management, Department of Civil Engineering, University of Michigan, October 1987, 310 pages.

CSI (1987). "SPEC-DATA INDEX - 1987", The construction Specifications Institute, 601 Madison Street, Alexandria Virginia 22314, June 1987, 75 pages.

Napier, T.R., et. al. (1987). "Building Technology and Evaluation", in progress report, Construction Engineering Research Laboratory, Department of the Army, Champaign, Illinois 61820-1305, 80 pages.

Argonaut (1987). "Advanced Building Technology Matrix", in-house report, GM Argonaut AEC, Troy, Michigan, 48084.

APPENDIX II.--LIST OF ADVANCED BUILDING TECHNOLOGIES

(ABT Systems: F=Floor, R=Roof, S=Structure, W=Wall, M=Miscellaneous.)

Technology Name	System	Filename
Soil Stabilization Fabrics	S	ABT02200.001
Retained Earth System	S	ABT02200.002
Revetment Fabric	S	ABT02200.003
Insulated Drainage Boards and Panels	S	ABT02700.001
Prefabricated Drainage Structure	M	ABT02700.002
Precast Polymer Concrete Trench Drain System	M	ABT02700.003
Expanded Shale Concrete	S	ABT03000.001
Air-Supported Formwork	S	ABT03100.001
Waffle Form for Concrete	S	ABT03100.002
Encapsulated Concrete Forming Panels	S	ABT03100.003
Slip Forms for Concrete	S	ABT03100.004
Polystyrene Forms	W	ABT03100.005
Architectural Form Liners	W	ABT03100.006
Insulated Concrete Forms	M	ABT03100.007
Fiber Forms	M	ABT03100.008
Ductile Steel Fiber Reinforcement	FSW	ABT03200.001
Hollow-Core Rock and Concrete Anchor Bolt	S	ABT03200.002
Cathodic Reinforcement Protection	S	ABT03200.003
Threaded Rebar	S	ABT03200.004
High Strength Stainless Steel Reinforcing Bars	S	ABT03200.005
Epoxy Coated Rebars	S	ABT03200.006
Tilt-Up Concrete	SW	ABT03200.007
Concrete Secondary Reinf. Synthetic Fibers	F	ABT03250.001
Concrete Strength Additive	FSW	ABT03250.002
Chemical Anchor	S	ABT03250.003
Expansion Anchor Bolt	S	ABT03250.004
Concrete Acceleration Admixture	S	ABT03250.005
Plastic Chair for Supporting Welded wire mesh	S	ABT03250.006
Anchor Bolt Sleeves	S	ABT03250.007
Plastic Chair for Supporting, Tying Rebars	S	ABT03250.008
Resin Mortar Cartridge	M	ABT03250.009
Concrete Floor Underlayment	F	ABT03300.001
Lift- Slab Concrete Construction	FRS	ABT03300.002
Stamped Concrete	F	ABT03400.001
Lightweight Concrete Panel	FRW	ABT03400.002
Steel Edge Concrete Plank	R	ABT03400.003
Precast Concrete Trusses	S	ABT03400.004
Polymer Concrete Precast Insulated	W	ABT03400.005
Lightweight Sandwich Concrete Panel	W	ABT03400.006
Acrylic Latex Concrete Repair	S	ABT03700.001
Sound Absorbing Masonry Unit	W	ABT04150.001
Masonry Insulation	W	ABT04150.002
Insulation Fastener for Cavity Wall	W	ABT04150.003

Concrete Masonry Foundation System	S	ABT04200.001
Reinforced Panelized Thin Brick	W	ABT04200.002
Reinforced Panelized Masonry	W	ABT04200.003
Prefaced Concrete Masonry Unit	W	ABT04200.004
Glass Block	W	ABT04200.005
Biaxial Block	W	ABT04200.006
Pre-Insulated Concrete Masonry	W	ABT04200.007
Tension Bolts	S	ABT05050.001
Crimp Curving Panels	W	ABT05050.002
Vibration Resistant Bolts	SM	ABT05050.003
Space Frames	S	ABT05100.001
Prefabricated Fireproof Steel Columns	S	ABT05100.002
Tailor-made Beams	S	ABT05100.003
Bernold System	S	ABT05100.004
Cavity Shaft Wall	S	ABT05100.005
Aluminum Decorative Entrance Framing	W	ABT05100.006
Composite Floor System	F	ABT05500.001
Prefabricated Foam Insulated Metal Wall Panel	W	ABT05580.001
Interlocking Grating	F	ABT05600.001
Laminated Wood Joist	S	ABT06170.001
Wood Foundation System	S	ABT06170.002
Fire Rated Hardboard	W	ABT06200.001
Fire Retardant Wood Treatment	W	ABT06300.001
Prefabricated Plastic Composite Structure	S	ABT06500.001
Fiberglass Reinforced Plastic Panels	WM	ABT06500.002
Solid Surfacing Material	WM	ABT06600.001
Extension Wall System	W	ABT07000.001
Mud Slab Waterproofing	FRW	ABT07100.001
Inverted Roof Membrane System	R	ABT07100.002
Self-Adhering Composite Bentonite System	R	ABT07100.003
Capillary Waterproofing	S	ABT07100.004
Water Repellent Coating	W	ABT07100.005
Water Resistant Tile Base	W	ABT07100.006
Concrete Protective Coating	M	ABT07100.007
Concrete Waterproofing Liquid Membrane	M	ABT07100.008
Water-repellent Block	M	ABT07150.001
Silicone/Urethane Foam	R	ABT07200.001
Perlite Insulating Aggregate Roof System	R	ABT07200.002
Insulating Concrete	R	ABT07200.003
Paver Insulation System	R	ABT07200.004
Reflective Insulation	R	ABT07200.005
Thermal/ Acoustical Spray-on Insulation	S	ABT07200.006
Block Energy Storage	W	ABT07200.007
Sealbags Fire Protection System	M	ABT07250.001
Composite Steel Roof Deck System	F	ABT07400.001
Light Transmitting Insulated Panel	R	ABT07400.002
Prefabricated Membrane Roofing Panel	R	ABT07400.003
Tapered Fiberglass Roof Insulation System	R	ABT07400.004
Structural Cement Fiber Roof Planks	R	ABT07400.005
Composite Roof Panel	W	ABT07400.006
Lightweight Fire Wall	W	ABT07400.007
Single Ply Membrane Roofing System	R	ABT07500.001
Extruded Polystyrene Foam Insulation	R	ABT07500.002
Sprayed in Place Roofing Membrane	R	ABT07500.003
Foamglass Roof Insulation	R	ABT07500.004
EPDM Ethylene Propylene Diene Monomer	R	ABT07500.005
Lightweight Adhered Roofing System	R	ABT07500.006
Paver Pedestal	FR	ABT07700.001
Automatic Fire Vent	R	ABT07700.002
Skylight Type Automatic Melt-out Fire Vents	R	ABT07700.003
Single-ply Roof Fastener	R	ABT07700.004
Prefabricated Toplight Panels	FR	ABT07800.001
Acrylic Liquid applied roof	R	ABT07900.001
Neoprene Gasket	RW	ABT07900.002

Acoustical Windows	W	ABT08500.001
Laminated Glass	W	ABT08800.001
Heat Reflective Glass	W	ABT08800.002
Low Emissivity Glass	W	ABT08800.003
Energy Saving Window Film	W	ABT08800.004
Fire Protection Glass	W	ABT08800.005
Liquid Crystal Light Shutter	W	ABT08900.001
Noise Reduce Matting	F	ABT09500.001
Static-Conductive Floor	F	ABT09700.001
Textured Rubber Floor	F	ABT09700.002
Shrinkage Compensating Component	F	ABT09780.001
Overhead One-coat Painting	W	ABT09800.001
Epoxy Building Coating	W	ABT09800.002
Fire-Warning Wall Paper	W	ABT09950.001
Fiberglass Wallcovering	W	ABT09950.002
Access Flooring	F	ABT10270.001
Tension Fabric Structure	R	ABT13020.001
Geodesic Dome Structure	S	ABT13020.002
Building Unit	S	ABT13020.003
In Floor Wire Duct	F	ABT16050.001
Non-Exploding Breaking Agent	S	APP02050.01
Slurry Trench	S	APP02200.01
Concrete Gratings	F	APP03000.01
Self-Climbing Wall Form System	SW	APP03100.01
Dowel Bar Splicer	S	APP03250.01
Reinforcement Anchor	W	APP03250.02
Concrete Anchorage Grout	M	APP03250.03
Leveling Adjustments	M	APP03250.04
Splice Sleeve	M	APP03250.05
Reinforced Grout	M	APP03600.01
Structural Reinforcing Masonry Walls	SW	APP04000.01
Interlocking Blocks	W	APP04000.02
Colored, Textured Stainless Steel	W	APP05000.01
Steel Tubing	S	APP05010.01
Lightweight Steel Framing System	W	APP05100.01
Aluminum Honeycomb Panels	W	APP05500.01
Fiberglass Grating	F	APP05600.01
Fiberglass & Gypsum Fireproof Sheathing	RW	APP07250.01
Polycarbonate Glazing	W	APP08800.01
Granular Glass Surfacing Material	W	APP09000.01
Automated Finishing Machine	F	APP09780.01
Concrete Floor Grating	F	APP09780.02
Zinc- Aluminum Coated Steel	W	APP09800.01
Relocatable Building	S	APP13120.01

APPENDIX III.--SOFTWARE PUBLISHERS

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