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ABSTRACT

The United States changeover to the use of the SI (International Metric) measurement language presents the construction industry with the need to review and adapt many product standards and practices for the use of metric measurement units. These adaptations and changes can bring substantial benefits to the industry in the form of permanently recurring cost savings. A practice of potentially great benefit would be the incorporation of dimensional coordination in the new metric standards for sizes of building products. For such benefits to be realized however, the involved issues must be effectively addressed and the requisite decisions made and implemented. Considerable literature pertinent to the issues and decisions has been published in the United States and in other (primarily English-speaking) countries that have been implementing metriciation and dimensional coordination in the past decade. This report aids construction industry consideration and resolution of metrication decisions by providing a guide to the best available resources relevant to the issues. A list of key issues and relevant questions to those issues is presented and referenced to a list of sources with abstracts. The key issues are: metrication, dimensional coordination, institutional arrangements, international interchange, and general. (MP/Author)

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made the decision to convert to the SI metric system." It "aids trainers in deciding which employees need what type and degree of metric training." The guide contains a sample lesson plan (with a pre/post test and answer sheet), editorial guidelines, and a list of possible resource materials.

4. American National Standards Institute, New York

Request from:
American National Standards Institute, Inc.
1430 Broadway
New York, New York 10018

American National Standard Basis for the Coordination of Dimensions of Building Materials and Equipment, A62.1–1957.

This standard establishes the standard grid based on the module of 4 in to be the basis for dimensional coordination. The grid is to be used to correlate building plans with coordinated dimensions of building materials and equipment.

American National Standard Basis for the Coordination of Masonry, A62.2–1945.

This standard establishes that "coordinated sizes for masonry products shall conform to the American Standard Basis for the Coordination of Dimensions of Building Materials and Equipment, A62.1."

American National Standard Sizes of Clay and Concrete Modular Masonry Units, A62.3–1946.

This standard covers unit sizes (standard, nominal and supplementary) and variations, as well as standard joint thickness, for clay and concrete modular masonry units.

American National Standard Sizes of Clay Flue Linings, A62.4–1947.

This standard covers sizes, dimensions, and permissible size variations for clay flue linings.

American National Standard Basis for the Horizontal Dimensioning of Coordinated Building Components and Systems, A62.5–1968.

This standard establishes a unit equal to sixty basic modules (60M) in length as a systems module (SM) for the planning, dimensioning and coordinating of building systems. It also establishes preferred coordinating dimensions for components.

American National Standard Classification for Properties and Performances of Coordinated Building Components and Systems, A62.6–1969.

This is a listing of the functions of building components and systems to be coordinated.

American National Standard Basis for the Vertical Dimensioning of Coordinated Building Components and Systems, A62.7–1969.

This standard establishes a multimodule (4M if vertical dimension exceeds 20M) as the dimensional basis for coordinating vertical dimensioning. It also establishes preferred vertical dimensions for building components, story heights, ceiling heights and floor-ceiling sandwich thickness.

American National Standard Numerical Designation of Modular Grid Coordinates, A62.8–1971.

This standard establishes a system for the numerical identification of the various planes in the three-dimensional modular grid.

5. American Society for Testing and Materials (ASTM), Institute of Electrical and Electronic Engineers (IEEE), Standard for Metric Practice, ASTM E 380–76 or IEEE 268–1976.

Request from:
ASTM
1916 Race Street
Philadelphia, Pa. 19103
or
IEEE
345 East 47th Street
New York, New York 10017

This is American National Standard Z210.1–1976, a guide to the use of the SI measurement language. It applies to the use of SI measurement units in engineering and other technical practice.

6. Bloomfield, Byron C., AIA, Doors and Frames—Dimensional and Installation Characteristics of Modular Building Products and Materials, 1, Modular Building Standards Association, Washington, D.C., 1963, 37 pp.

Out of print.

This booklet is intended to assist draftsmen and detailers of building projects. It contains graphic illustrations of over thirty typical door and frame installations in common types of wall construction. Included are steel, wood and aluminum doors and frames for exterior and interior doors, and swinging, sliding and folding doors. All details are expressed in conventional modular drafting. It is suggested that, if modular dimensioning is used in details, the latter

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Office of Standard Reference Data — Office of Information Activities — Office of Technical Publications — Library — Office of International Standards — Office of International Relations.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Located at Boulder, Colorado 80302.

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Contents

PREFACE

This report was prepared to assist the building community in the location of definitive information on metrication and dimensional coordination. With the passage of the metric Conversion Act of 1975 (Public Law 94-168), it is expected that activities and the need for information with regard to metrication in the building community will accelerate.

This report is one of a series developed under the Coordination of Metric Dimensions Program of the Office of Building Standards and Codes Services, Center for Building Technology, Institute for Applied Technology, National Bureau of Standards. Other published reports on this subject developed for the use of building community include:

- NBS Technical Note 915, Metrication Problems in the Construction Codes and Standards Sector, June 1976.
- Technical Note 938, Recommended Practice for the Use of Metric (SI) Units in Building Design and Construction, February 1977.

These documents are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 or in microfilm from the National Technical Information Service (NTIS), Springfield, Virginia 22161.

The principal author of this document is Mr. Roy Clark, technical writer in the Architectural Research Section of the Center for Building Technology. The work was conducted under the technical direction of Dr. Robert Wehrli, Chief, Architectural Research Section, and under the programmatic direction of Mr. Robert J. Kapsch, Assistant Chief, Office of Building Standards and Codes Services, Center for Building Technology.

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Metrication and Dimensional Coordination—A Selected Bibliography

Roy E. Clark and Candace L. Roat

The United States changeover to the use of the SI (International metric) measurement language presents our construction industry with the need to review and adapt many product standards and practices for the use of metric measurement units. These adaptations and changes can bring substantial benefits to the industry in the form of permanently recurring cost savings. A practice of potentially great benefit would be the incorporation of dimensional coordination in the new metric standards for sizes of building products. For such benefits to be realized, however, the involved issues must be effectively addressed and the requisite decisions made and implemented. Considerable literature pertinent to the issues and decisions has been published in the United States and in the other (primarily English-speaking) countries that have been implementing metrication and dimensional coordination in the past decade. This report aids construction industry consideration and resolution of metrication decisions by providing a guide to the best available sources relevant to the issues.

Key words: Building codes and standards; construction industry; dimensional coordination; metric system; metrication; modular coordination; SI.

1. Introduction

The United States has finally embarked officially on a course of joining the rest of the world in the use of the metric system of measurement. In July 1968, the then Secretary of Commerce transmitted to the Congress the report of the three-year U.S. Metric Study that had been carried out by the National Bureau of Standards at the behest of the Congress. The Secretary accompanied the report with a recommendation, based on the findings of the study, that "the United States change to the International Metric System deliberately and carefully." In December 1975, after four years of consideration of this issue by the Congress and the body politic, the President signed into law the Metric Conversion Act of 1975 that declares the policy of the United States to be "to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the Metric system."

The challenge now facing the Nation is to accomplish the voluntary but coordinated shift to predominant use of metric measurement units over the next decade or so in the least disruptive and most efficient and beneficial manner. In order to meet this challenge, each sector of our economy and society is going to have to examine its measurement use practices and determine how best to adapt them to the growing use of metric in the Nation, making every effort in this process to secure the potential benefits of the adaptation while avoiding its potential pitfalls.

That a change of measurement language on the part of the construction industry would have widespread impact and ramifications is self evident. It would eventually touch, in some way, everyone from building designers to building users. The disruptions and costs of such a shift could be large for the industry and for the Nation. However, the metric changeover does offer the potential—for the construction industry as for the country as a whole—of permanent, recurring cost savings. This potential can be realized only if full advantage is taken of the use of a simpler, systematic measurement language and of the stimulus and opportunity provided by the measurement change to review and update standards, procedures, product designs and practices (a process normally retarded by difficult to justify costs of change).

Metric changeover presents a once in a lifetime opportunity to minimize, based on contemporary technology and good design principles, the varieties of sizes of various products used in building. Since the product sizes established by standards are influenced by the measurement units used, adoption of metric measurements implies, at the least, modification of existing standards. The preferable course is the writing of new standards, in order to avoid the awkward and fractional numbers that result from converting round numbers or fractions of inches and pounds into millimeters and kilograms. Any rewriting of product standards—even if only their "translation" to reasonable metric equivalents—should be looked on as a one-time chance to "clean house" of excessive variety of product sizes, as well as obsolete practices, that have come into use over the years. Pursuing this goal will reduce costs of both manufacturing and distribution by: (1) permitting longer manufacturing runs of each size and (2) reducing the warehousing and distribution capacity needed to stock all available sizes.

This approach to cost savings through metrication is being followed by the Industrial Fasteners Institute with its new Optimum Metric Fastener System standard, now being processed internationally as the Modified ISO Fastener System standard. This system utilizes less than one-half the number of different sizes (diameters) as any other existing threaded fastener standard to cover the same size range. A similar effort to minimize the diversity of needed product sizes is being made by the automobile manufacturers as they adopt new product standards for components such as fan belts. The construction industry likewise has an opportunity to realize long-term savings by minimizing (through rationalizing) the variety of sizes of manufactured products that it uses. Although complete analysis of the potential benefits of reduction in numbers of sizes has not been performed, it is believed that the long term benefits could be substantial.

This effort could be carried one step further. There has been developed in this country and abroad a methodology and discipline that greatly facilitates the onsite assembly of manufactured and pre-cut components into buildings. It is variously referred to as dimensional or modular coordination or precoordination. The use of this apprach to design and construction requires that the sizes of components—such as door sets, windows, bricks, concrete masonry units, wall panels—be tailored to multiples of a basic dimensional module, so that they will readily fit together without cutting and adjusting. Here again, the development of new product standards in metric dimension offers a unique opportunity to incorporate modular dimensioning into the new standards, thus making coordinated products available for those designers who desire to take advantage of them. Many commentators, as far back as the time of the U.S. Metric Study (1970)—see Reference No. 49 in sec. 4—have suggested that metric changeover for the construction industry could be economically justified only if adoption of dimensional coordination were joined with it. This belief seems to be supported by the experiences of the other English-speaking countries now going metric—particularly the United Kingdom and Australia—in combining the adoption of this methodology with their metric changeover.

The information presented in sections 3 and 4 of this report demonstrates that metrication and dimensional coordination, although quite different in nature, are closely interrelated at the present juncture for the U.S. construction industry. They share many of the same problems of implementation. Attempting to separately evaluate the benefits, costs, and other effects of each is a complex and many faceted task.

2. Purpose and Approach

All participants in the activity of building—land planners, architects and designers, manufacturers, suppliers, builders and contractors, and building managers and owners—face the need in the near future to at least understand the implications and impacts of U.S. metric changeover on this activity. Many of these participants will be making—by intent or by default—crucial decisions concerning the adaptation of the construction industry to the metric measurement environment. In this context, the present publication is intended to serve as an annotated guide to the extant literature pertinent to the situation.

The approach taken was first to identify the key issues and questions that appear to be facing the various elements of building and construction in regard to metrication. Then we searched for the sources that best addressed these questions.

Our search was conducted primarily through the following repositories and indexes:

- Department of Housing and Urban Development library;
- *Industrialization Forum* index;
- catalog of the Graduate School of Design of Harvard University (available in facsimile at the HUD library);
- National Bureau of Standards library;
- *Generic Modules Bibliography* of the Royal Architectural Institute of Canada Committee on Generic Modules; and
- collection of the Metric Information Office of the National Bureau of Standards (which contains most of the official publications and many nongovernmental materials from the countries currently going metric or recently having done so).

With a comprehensive listing of apparently relevant references compiled, we obtained as many of the documents as was possible. Some items, although listed in library catalogs, were unavailable even from the Library of Congress or through other interlibrary loan efforts. Such items have for the most part been omitted on the double ground that (1) they could not be reviewed and evaluated, and (2) in any case they are apparently not usefully available.

The two authors read and annotated the available materials, keeping in mind the issues and noting those addressed by a given item. Obviously references of a more comprehensive nature are likely to touch on several issues.

The selection of references for inclusion in this bibliography was made on an issue by issue basis. The set of references associated with each issue was reviewed in toto, and the one or several items that best address the issue selected. Thus, the bibliography listed in section 4 consists of those references selected for at least one issue, and is by no means exhaustive or even comprehensive.

For readers desiring to explore matters of metrication or dimensional coordination to greater depth, we have listed in section 5 several bibliographies that do cover more comprehensively the world literature on these subjects.

The issues presented in section 3 are followed by numbers identifying the particular references (in the list in section 4) that relate to the issue in question. Perusal of sections 3 and 4 will reveal that two general problems have been identified: (1) There exist gaps—for some identified issues, no useful sources were located. (2) Some worthwhile references are either out of print or only available with difficulty from such repositories as the library of the Department of Housing and Urban Development or the Library of Congress. For these materials we have endeavored to convey in the abstract the key information contained in the document.

3. List of Key Issues and Questions

We have sought to identify both the general and particular issues that will be facing all or parts of the construction industry in the era of metric changeover.

For questions with several references, the reference numbers have been ranked in a rough order of comprehensiveness, overall value or timeliness. However, this ranking will not necessarily serve the purposes of every inquirer, since some may well be interested in a particular approach to a question that is better served by a reference further down in the order.

Numbers enclosed in parentheses ( ) indicate sources that, while not dealing comprehensively with the question, do touch on it partially or tangentially.

In those cases where an issue is not followed by any reference numbers, our search did not turn up any sources usefully addressing the issue. With a view to a future, updated edition of this publication, the authors would appreciate hearing from readers who discover informative references on said issues—or better sources on others of the issues.

3.1 Metrication

(1) The U.S. situation

—Why is the United States changing to the use of the metric system of measurements?
36, 60, 59, 19, 58

—What is the policy of the United States concerning metric changeover—the nature of the national legislation and the role of the various governments: Federal, State and local?
59, 45, 36

—What are the likely attitudes toward metric changeover on the part of various participants in the industry: professionals (e.g. architects, structural engineers, managers), tradesmen (e.g. carpenters, pipefitters, electricians, bricklayers), building material suppliers, or contractors and subcontractors?
58, 49, 52, 11, 29

(2) Metric: what it is

—What is the SI or Système International d'Unités and how is it correctly employed?
45, 5, 38, 44, 46, 60, 39, 35, 41, 50, 62

—What SI units, multiples and submultiples should be used in construction activities?
39, 41, 35, 15, 38, 60, 62

(3) Costs and benefits

—What are the likely economic costs and benefits of adapting to the use of metric measurements: for architects and designers, for manufacturers and suppliers, for contractors and subcontractors, for industrialized builders, for home builders, for members of the various trades, for building managers and users?
(19)

—Are incentives necessary for changeover of some segments of the industry? For example, should tradesmen be reimbursed for the acquisition of necessary metric tools? Should local authorities be subsidized in their adaptation of building codes?
58, 19, 29 (These do not address the general question, only the issue of tools.)

(4) Education and information needs

—How will textbooks, educational programs and courses for the construction industry be appropriately updated to reflect the use of metric measurements?

—How should employees, including tradesmen, be taught the metric system?
3, 39, 60, 38, (14), (20)

—What educational or informational efforts vis-a-vis the general public would be necessitated by the adoption of metric measurement by the construction industry, and who should be responsible for such efforts?
(19)

—What about building managers and users—how will their information needs be affected by metric changeover?

(5) Design, drawing and codes

—What will be the impacts of metrication on the design process?
23, 15, 61, 52, 34, (42)

—What are the implications of hard versus soft conversion* for the design process?
61, 23

—What metric scales and practices are best used on drawings?
39, 14, 15

—How will metrication affect structural design and engineering?
23, 39, 42, 12

—What is the principle of geometrical similarity of design and what can it contribute to the adaptation of structural design to metric measurement?
12

*"Hard" refers to the fabrication of products and components in round-numbered metric sizes. "soft" implies continuing to employ customary sizes, but describing them in metric measures, which usually are awkward numbers of units.

—What are the implications of metrication for building codes and standards?
35, 31

(6) Onsite activities

—How will metrication affect the measurement of land?
39

—What will be the effects of metrication on onsite assembly activities?
(37)

—What are the implications of hard versus soft conversion* for onsite activities?

(7) Suppliers

—What are the implications of metrication for product and engineering standards?
19, 60, 23

—What are potential effects of metric changeover on the various elements of the building materials and supplies industry, including the local hardware or do-it-yourself outlet?

(8) Particular construction types—benefits/problems

—Are there particular problems or benefits for industrialized or factory building in adapting to the metric measurement language?

—Are there particular problems or benefits to conventional stick building from the adoption of metric measurement?

—Are there any particular problems or benefits for commercial, industrial, or public construction from the adoption of metric measurement?

(9) Existing buildings

—What will be the effects of metrication of the construction industry on building maintenance activities?
56

—How will changeover to the use of metric measurements affect repair and remodelling of old buildings?
56, (9)

*Refer to footnote on page 3.

3.2 Dimensional Coordination

(1) What it is

—What is dimensional or modular coordination?
1, 15, 16, 23, 41, 13, 25, 54, 62, 64

(2) Possible benefits

—What are the potential benefits of dimensional coordination?
15, 16, 47, 39, 21, 38, 41, 48, 1

—What are the potential impacts of dimensional coordination on building costs for different types of construction?
21, 57, 54, 47, 41

—Could implementation of dimensional coordination have noticeable effect on materials consumption by the industry?
(38), (22), (26)

—Might the adoption of dimensional coordination affect energy consumption in the construction industry?

(3) How it can be implemented (See also number 7, below.)

—How can dimensions be coordinated across various types of products and what are the prospects for reducing the variety of sizes of prefabricated components (windows, door sets, roof trusses, etc.) along with such coordination?
1, 52, 6, 51

—What should be the sequence, timing, and priorities for implementing dimensional coordination?

—Is acceptance and implementation of modular coordination likely to be affected by regional differences?

(4) Information and education: available or needed

—What educational efforts and approaches within the industry would be necessitated by adoption of the discipline of dimensional coordination?

—What existing U.S. standards apply to dimensional coordination?
14, 54, 48

—What international (ISO) standards relate to dimensional coordination?
30, 21

(5) How it impacts design

—How does dimensional coordination affect the design process?
1, 15, 23, 16, 32, 18, 13, 17, 41, 6, 54, (53), 27, 48

—What are the implications of dimensional coordination for structural design?
15, 1, 48

—How can dimensional coordination relate to the human needs of building users?
61, 23, 33

(6) How it impacts the technical aspects of building

—What are the potential effects of dimensional coordination on the quality of the assembly job?
18, 22, 26, (20)

—What are the effects of using dimensionally coordinated designs and materials on the tools, equipment and labor needed at the job site?
1, 30, 22, 41, 26, 48, (21)

—How does the dimensional coordination methodology affect technical problems and practices of joining materials and components?
1, 28, 10, 7, 63, 64

—How can existing stocks of building materials in old "customary" sizes be utilized along with "coordinated" metric sizes?
43

—How will adoption of dimensionally coordinated sizes for building components affect the repair and remodelling of old buildings?
(9)

(7) Impact on suppliers

—How can the dimensional coordination discipline be effectively infused into the product standards-making process as new, metric dimensional standards for building materials and components are developed?

—Are incentives necessary for some industry participants—are some likely to incur a cost in adopting dimensional coordination that is not compensated by a reasonable benefit?

—What are the potential effects of widespread dimensional coordination of building components on the various elements of the building materials and supplies industry—including the local hardware or do-it-yourself outlet?
(21), (51)

(8) Application to particular types of construction

—Does the use of dimensional coordination offer particular potential benefits to industrialized building? Might it offer possibilities of more individualized design within factory-building constraints?
54, 53, 63

—How does dimensional coordination apply to conventional residential construction?
47, 22, 26, 48

—Are there particular benefits or costs in applying dimensional coordination in the construction of multifamily residential or commercial/industrial buildings?

3.3 Institutional Arrangements

—What institutions and resources are available—or are needed—to facilitate implementation of metric measurement and dimensional coordination by the U.S. construction industry?
35, 59, 2, 36, 54

—What is the American National Metric Council? What is its role in U.S. metrication and what does it have to offer the construction industry?
2, 62

3.4 International Interchange

—How are the other "English-measurement" countries going about the metrication of their construction industries?
39, 24, 8, 40, 20

—What lessons can be learned from the experience of other countries in adopting modular coordination as a correlate with changeover to use of metric measurements?
40, 18, 8, 55, 54

—What has been the experience of other countries in the use of dimensional coordination in building?
21, 18, 54, 22

—What are the opportunities for and potential benefits and costs from U.S. participation in international (metric) standardization and harmonization of building materials, products, and practices?
(2)

—How may export/import of building components be affected by U.S. adoption of metric-based dimensional coordination?

3.5 General

—Are there other priorities for the construction industry with which conversion to metric dimensioning or implementation of dimensional coordination may conflict?

—Are there significant incentives for some industry participants to continue using customary measurements?

—What are the implications of metrication and dimensional coordination for do-it-yourself repair and remodelling activities of the home owner?

4. List of Sources with Abstracts

Sources are listed alphabetically: by author (if identified); otherwise by originating institution, or by title.

1. Adams, Myron W. and Prentice Bradley, A62 Guide for Modular Coordination—A Guide to Assist Architects and Engineers in Applying Modular Coordination to Building Plans and Details, Boston, Massachusetts: Modular Service Association, 1946, 275 pp.

   Out of print.

   This book is a guide to modular coordination for engineers and architects. It begins with a discussion of the goals and benefits of modular coordination and explains the economics of standardization. The "general method and principles of modular coordination" and their "connection with the various stages of the architect's work" are presented. This includes information on (1) drawing procedures and drafting symbols for architecture, (2) the standard 4" grid, (3) dimensioning symbols, (4) sample modular details, and (5) applications of dimensional coordination to working drawings. Much of the book is concerned with the application of modular coordination to various building components and the then existing status of the components as to their standardization and coordination. Components covered include (1) masonry, (2) wood frame, (3) windows, (4) doors, (5) glass block, (6) skeleton frame, and (7) stairs. Examples of dimensionally coordinated working drawings for actual buildings are presented.

   Appendices cover the derivation of the standard basis for modular coordination and three approved American standards for modular coordination.

2. American National Metric Council, Metrication: Myths and Realities—Facing the Issues, Washington, D.C., April 1976.

   Request from:
   American National Metric Council
   1625 Massachusetts Avenue, N.W.
   Washington, D.C. 20036

   This is the second annual report of the American National Metric Council (ANMC), a private-sector organization, formed in 1973 under the sponsorship of the American National Standards Institute, to help manage voluntary metric implementation in the United States. The Council is governed by a Board of Directors representing most activities in the nation that are affected by growing use of metric. This report focuses on the many myths as well as realities of metric changeover that have emerged during the past year of growing metrication effort in the U.S. Myths and realities are considered: (1) for the metric situation of the nation as a whole, (2) for the national legislation enacted in December, 1975 (see Reference 59), and (3) for standards activity during metric changeover. One section discusses the developing uniformity in the Nation regarding metric practice—i.e., how we will use the SI as we go metric.

   A second theme of the report is "facing the issues," under which the sector committees of the ANMC describe the status and prospects of metric activities in their respective sectors of economic or other activity. The council has organized, to date, thirty sector committees which are actively addressing such specific tasks and issues as: identification of standards needs, relevant laws and regulations, soft versus hard conversion, time requirements for transition, and measurement unit selection. The sector committees are organized into five broad groupings, with the chairmen of these committees forming five coordinating committees: Materials, Engineering Industries, Consumer Products, Education and Industrial Training, and Construction Industries.

   The report also describes the current status of metrication activity in Canada and the latest experience of Great Britain, South Africa, Australia and New Zealand.

3. American National Metric Council, In-service Training Sector Committee, Metric Education Guide for Employee Training.

   Request from:
   ANMC
   Education Guide
   1625 Massachusetts Avenue, N.W.
   Washington, D.C. 20036

   This publication "provides general training guidelines for companies that have voluntarily made the decision to convert to the SI metric system." It "aids trainers in deciding which employees need what type and degree of metric training." The guide contains a sample lesson plan (with a pre/post test and answer sheet), editorial guidelines, and a list of possible resource materials.

4. American National Standards Institute, New York

Request from:
American National Standards Institute, Inc.
1430 Broadway
New York, New York 10018

American National Standard Basis for the Coordination of Dimensions of Building Materials and Equipment, A62.1–1957.

This standard establishes the standard grid based on the module of 4 in to be the basis for dimensional coordination. The grid is to be used to correlate building plans with coordinated dimensions of building materials and equipment.

American National Standard Basis for the Coordination of Masonry, A62.2–1945.

This standard establishes that "coordinated sizes for masonry products shall conform to the American Standard Basis for the Coordination of Dimensions of Building Materials and Equipment, A62.1."

American National Standard Sizes of Clay and Concrete Modular Masonry Units, A62.3–1946.

This standard covers unit sizes (standard, nominal and supplementary) and variations, as well as standard joint thickness, for clay and concrete modular masonry units.

American National Standard Sizes of Clay Flue Linings, A62.4–1947.

This standard covers sizes, dimensions, and permissible size variations for clay flue linings.

American National Standard Basis for the Horizontal Dimensioning of Coordinated Building Components and Systems, A62.5–1968.

This standard establishes a unit equal to sixty basic modules (60M) in length as a systems module (SM) for the planning, dimensioning and coordinating of building systems. It also establishes preferred coordinating dimensions for components.

American National Standard Classification for Properties and Performances of Coordinated Building Components and Systems, A62.6–1969.

This is a listing of the functions of building components and systems to be coordinated.

American National Standard Basis for the Vertical Dimensioning of Coordinated Building Components and Systems, A62.7–1969.

This standard establishes a multimodule (4M if vertical dimension exceeds 20M) as the dimensional basis for coordinating vertical dimensioning. It also establishes preferred vertical dimensions for building components, story heights, ceiling heights and floor-ceiling sandwich thickness.

American National Standard Numerical Designation of Modular Grid Coordinates, A62.8–1971.

This standard establishes a system for the numerical identification of the various planes in the three-dimensional modular grid.

5. American Society for Testing and Materials (ASTM), Institute of Electrical and Electronic Engineers (IEEE), Standard for Metric Practice, ASTM E 380–76 or IEEE 268–1976.

Request from:
ASTM
1916 Race Street
Philadelphia, Pa. 19103
or
IEEE
345 East 47th Street
New York, New York 10017

This is American National Standard Z210.1–1976, a guide to the use of the SI measurement language. It applies to the use of SI measurement units in engineering and other technical practice.

6. Bloomfield, Byron C., AIA, Doors and Frames—Dimensional and Installation Characteristics of Modular Building Products and Materials, 1, Modular Building Standards Association, Washington, D.C., 1963, 37 pp.

Out of print.

This booklet is intended to assist draftsmen and detailers of building projects. It contains graphic illustrations of over thirty typical door and frame installations in common types of wall construction. Included are steel, wood and aluminum doors and frames for exterior and interior doors, and swinging, sliding and folding doors. All details are expressed in conventional modular drafting. It is suggested that, if modular dimensioning is used in details, the latter can be transferred directly onto the working drawings of building projects and can be further related to the working drawing plans and sections, re[illegible]lting in efficiencies in drafting and dimension[illegible].

7. Bonshor, R. B. an[illegible] W. Harrison. The Relationship between Component Size and Joint Dimension, Building Research Establishment Current Paper—CP 5/71, February 1971.

Reprinted from: Building, Vol. **219**, No. 6652, 13 Nov 1970, pp. 141–150

Request from:
Publications Officer, Information Division
Building Research Station
Garston, Watford. WD2 7JR, Great Britain

In the context of building with components, this paper sets out procedures that may be used to determine the relationship between component size and joint dimension. It is becoming recognized that the utilization of a (modular) dimensional framework for planning purposes and for rationalizing the ranges of "nominal" sizes of components—while necessary—is only the first step toward the securing of fit in real terms. Beyond this stage, is required examination in turn of each proposed situation of use of a component. Then, for each situation, sizing of the component must take realistic account of the dimensional deviations operating in that situation and the dimensional limits within which a joint suitable for the situation can function adequately. Finally, the various solutions must be reconciled. It is implicit that "fit" is a term with functional as well as dimensional implications and thus that, if buildings are to function satisfactorily, fit must take precedence over interchangeability. Joints do not, in general, function so well that reduced performance is acceptable.

8. Bowen, Gordon, Metrication Experience in the United Kingdom, Building Research, Vol. **10**, No. 1, Jan/Mar 1974, pp. 31–36. (See Reference 11.)

This paper, by the Director of the British Metrication Board, discusses the experience of metrication and the adoption of dimensional coordination in the construction industry in the United Kingdom. Both shifts were begun simultaneously, but the implementation of dimensional coordination has lagged behind metrication. Metric conversion was mainly carried out by existing professional organizations through the leadership of the British Standards Institution. Other organizations that were involved in the construction industry's conversion are described and their roles explained in this article.

The author emphasizes the importance of education and information flow in a conversion effort.

9. Brick Manufacturers' Association of New South Wales (Australia), Brick Development Division. Metric Brickwork, Technical Note No. 8, Jan 1974, 10 pp.

Request from:
Brick Development Division
The Brick Manufacturers' Association of NSW
412 Railway Pde.
Burwood 2134, NSW, Australia

This publication discusses the following aspects of metric brickwork: (1) dimensional coordination, including preferred modules, format size vs. manufacturing size, and preferred metric sizes of brick, (2) brick cavity walls, (3) brick veneer walls, (4) brick dimensional tolerances, (5) type and spacing of wall ties in cavity walls, (6) measurement of brickwork (the number of bricks per m^2 is given for traditional and metric modular sizes of bricks), and (7) metric linear measurement for brickwork (e.g., the centimeter will not be used). The document states that comparisons of (Australian) traditional and modular metric bricks show their differences in measurement to be sufficiently negligible that existing buildings can easily be altered or extended by using the new metric brick.

10. Building Industrialization Research and Development Group, Washington University, St. Louis. Component Building and the Organization of the Building Process: A Study of Joints and Jointing, 1973, 3 vols., 220, 208 and 167 pp.

Request from:
National Technical Information Service
U.S. Department of Commerce
Springfield, Virginia 22161
Order Nos: Vol. **1** (PB–223 255), Vol. **2** (PB–223 356), Vol. **3** (PB–223 256)

This is the report of an applied research project that investigates the organizational aspects of industrialized building. It examines and compares "open" and "closed" component building systems, giving examples and showing how the creation of the appropriate administrative conditions can lead to innovations in building technology, particularly in the case of joints and jointing. Volumes 1 and 2 contain the project Information System (abstracts, summaries of interviews and case studies). Volume 3 contains Factual Information (discussion of key terms, recommendations on joint design, glossary) and Debate (an analysis and synthesis of the results of the case studies).

11. Building Research Institute, U.S. National Academy of Sciences, Metrication in Building. Building Research, Vol. 10, No. 1 (entire issue), Jan Mar 1974. (See References 8, 24, 40, 52, 61.)

This issue consists of 10 papers originally presented at the Conference "Metrication in Building Design, Production, and Construction," held in Washington, D.C., 27 November 1973. The first seven articles present reactions of various elements of the United States construction industry to metric conversion. The change is seen as inevitable and most of the authors call for a planned, coordinated effort in converting. Advantages, as well as expected disadvantages and problems are described. Hard vs. soft conversion is discussed. Metrication is seen by some as an opportunity to implement dimensional coordination. The role of volunteer standards committees is discussed and the importance of education is stressed. The last three articles discuss the experience of three other countries (Canada, the United Kingdom and Australia) with metrication and dimensional coordination.

12. Burgess, H. J., Head, Engineering Section, (U.K.) Timber Research and Development Association, Timber in Construction, paper presented at a conference held by the U.K. Metrication Board on 14 July 1971.

Request from:
Metrication Board
22 Kingsway
London WC2B 6LE
England

This paper considers the prospective impact (in the United Kingdom) of metric changeover on wood product sizes, particularly in the context of structural design in timber. It discusses the concept of geometrical similarity (said to be detailed in a Timber Research and Development Association leaflet), and illustrates its usefulness for adapting existing designs to metric dimensioning. Geometrical similarity establishes that, if the depth of a beam is increased (or decreased) by a certain percentage, then its span may be lengthened (must be shortened only) by the same percentage. For example, an existing design using inch size timber can be used in metric by converting the wood sizes at 25 mm to the inch and the spans by a corresponding 300 mm to the foot. Acceptance of this slight shrinking of the design sizes makes unnecessary calculations to "justify" the metric version.

The paper makes a misguided reference to using the kilogram as the unit of force for normal structural design purposes. In the SI the kilogram is the unit for measuring mass. It cannot be used to express force, which must be measured in newtons.

13. Callender, John H. (Editor-in-Chief), Time-Saver Standards for Architectural Design Data (Fifth Edition), New York: McGraw Hill, 1974, 1042 pp.

This is a comprehensive handbook of standards and information useful for all who design, construct or maintain buildings. One section (authored by B. C. Bloomfield, AIA, Executive Director of the Modular Building Standards Association) discusses modular coordination. The theory is briefly presented. Then the principle of joint-centerline to joint-centerline dimensioning is described. It is used here with multiples of the standard four inch module. Modular drafting and its three conventions—the grid, the arrowhead, and the dot—are discussed. Assembly of modular masonry units is used as an example of the use of modular dimensioning. The author suggests that modular coordination will not adversely affect freedom of design. Five steps to planning on a modular system are elaborated: (1) preliminary drawings, (2) selection of overall dimensions, (3) identification of significant details, (4) development of modular details, and (5) correlation of details on working drawings.

A section on modular clay masonry units discusses (1) sizes, (2) relations to the grid, (3) estimating quantities, and (4) vertical coursing. Another short section presents sizes of modular concrete masonry units.

14. Construction Industry Training Board, Programmed Learning Section, Scales on Metric Drawings, CITB Learning Text, London, 1968, 27 pp.

Request from:
Construction Industry Training Board
Metric Training Aids, Radnor House
London Road, Norbury
London, S.W. 16

This is a programmed workbook on scales for metric drawings. Instruction and practice questions are given on (1) reading scales on drawings, (2) the meaning of the scales, (3) scales recommended for use by the British Standards Institution, (4) finding a missing dimension on a drawing, (5) drawing to scale, (6) finding a missing scale. A practice test is given at the end of the book along with rules for writing the decimal and the thousands marker. (United States practice as to recommended scales for metric drawings and recommended unit usage has not yet been firmly established. However, this publication offers an excellent model for adaptation to U.S. needs.

15. Crocker, Alan E., Module and Metric: The Theory and Practice of Dimensional Coordination in Metric, New York: Praeger Publishers, Inc., 1971, 135 pp.

This book describes metrication and dimensional coordination in simple terms. It explains how the two can be combined, the benefits to be derived from the combination, and the use of dimensional coordination in translating designers' ideas into buildings. The book explains the purpose of dimensional coordination and discusses the general principles, including the role of the basic module. The metric system is also discussed. Rules are presented for the use of both basic (length, area, volume) and derived units important to the building industry.

The author suggests that a change to dimensional coordination accompany the change to metric so that the advantages of both can be obtained simultaneously. The book includes detailed discussion of the application of the theory of dimensional coordination to building design, and speculation as to how metrication and dimensional coordination could affect the building process and the manufacture of buildings components.

16. Darlington. R. P., AIA, M. W. Isenberg, PE, and D. A. Pierce, AIA (eds.), Modular Practice: The Schoolhouse and the Building Industry, New York: John Wiley and Sons, 1962, 194 pp.

This handbook, prepared by the Modular Building Standards Association, begins with a description of the concept of modular coordination and the different grid types used as reference systems in the design and construction of buildings. The three basic tools of modular dimensioning on drawings are then presented: the 4 in grid, the dimensioning arrow and the dimensioning dot. The different dimensioning techniques are discussed. Explanations accompanied by many example drawings cover the following topics as they relate to modular coordination: (1) designing with the modular grid, (2) the development of working drawings (a smaller scale can usually be used with modular dimensioning), (3) application of modular dimensioning in plans to building dimensions, columns, doors and windows, and partitions, (4) elevations and sections, (5) details, and (6) engineering drawings. Benefits derived from modular coordination by the contractor as well as some problems for manufacturers of building components are discussed. The handbook states that research (on materials, components and construction methods), standards and education are needed if modular coordination is to be used increasingly in the future.

Appendices include (1) definitions of terms, (2) a brief history of modular coordination, (3) a Canadian article on the meaning of modular coordination and how it can be applied in manufacturing, in building design and on the construction job, (4) a description of a system for modular coordination, (5) a method of relating various building components to each other such that flexibility to small increments is achieved by combinations of large sizes, (6) a report of modular practice in the Minneapolis-St. Paul area, where the majoity of construction industry personnel feel it has benefited the industry, and (7) a survey of systems of proportion of the Greeks and Romans, of the Renaissance period, and modern systems including that of Le Corbusier.

17. Demarest, William, Jr., The Five Fundamentals of Modular Drafting, American Institute of Architects, Washington, D.C., undated.

Out of print.

This pamphlet describes the basic principles of preparing drawings in modular measure, namely: (1) Be sure that any design modules used are in multiples of 4 in. (2) Begin all details—even hasty sketches—with the gridlines. (3) Give nominal or "grid" dimensions on small-scale layout drawings. (4) Use arrows and dots to indicate, respectively, dimensioning to a gridline and dimensioning to a point not on the grid. (5) Vertical dimensions are coordinated from a gridline coinciding with nominal finished floor level (top of subfloor or of slab-on-ground with wood-frame construction, otherwise, 1/8" above actual finished floor).

18. Department of the Environment (U.K.), Property Services Agency, Going Metric in the Construction Industry: Bulletin No. 4, Six Case Studies, London, 1972, 64 pp.

Request from:
Building Information Room
Lunar House
Wellesley Road
Croydon CR9 3EL, England

This bulletin describes several of the first metric, dimensionally coordinated construction projects in the United Kingdom. It was intended to provide early feedback to the industry on the experience obtained from these "pilot" efforts. The first section is a general summary, and lists tasks made easier, as well as those made more difficult, by the use of the metric system and dimensional coordination, for architects, quantity surveyors, structural engineers, services engineers, estimators and site staff. Starting to use the metric system seemed to generate fewer problems than adopting dimensional coordination. The case study projects generally achieved a degree of accuracy in excess of expectation. This is probably attributable to greater than normal attention and supervision having been given—however, no one reported that the better accuracy had increased costs. Recommendations on paper sizes, scales, and grids to use on contract drawings grew out of the reappraisal of working methods that accompanied the conversion to metric and dimensional coordination.

Most of the book is taken up with the case studies of the six buildings. A general description of each building is given, followed by a discussion of the ways in which dimensional coordination was applied in its design and construction. Working drawings of various components are shown, and problems and decisions concerning them in relation to the dimensional coordination discipline are discussed.

19. De Simone, Daniel V., A Metric America: A decision whose time has come. National Bureau of Standards Special Publication, SP 345, July 1971, 170 pp.

Request from:
Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402
SD Catalog No. C13.10:345

This is the final, overall report of the U.S. Metric Study, a 3-year investigation conducted by the National Bureau of Standards pursuant to the mandate of the Metric Study Act of 1968 to assess the impact on the United States of increasing worldwide use of the metric system. The report describes the history and background of metric use in this country, what a metric changeover would and would not mean for the Nation, and the world context for a decision. Appendices describe how the U.S. Metric Study was planned and carried out and present a biblography of Metric Study and important related reports. (Twelve supplemental reports were published by the U.S. Metric Study as the detailed record of the investigations.)

The findings and conclusions contained in this report constituted the basis for the recommendation to the Congress by the then Secretary of Commerce that the United States "change to the International Metric System deliberately and carefully . . . through a coordinated national program . . . with a central coordinating body responsive to all sectors of our society"—a recommendation finally taken up in the Metric Conversion Act of 1975, enacted in December of that year.

20. Dunstone, Philip, Change to Metric, Construction Specifier, Jan. 1974, pp. 26–33.

This article is a subjective account of change to the metric system by the construction industry in the United Kingdom. The government chose the British Standards Institution (BSI) to be the focal point for the change. The Construction Industry Division of BSI formed a Metric Panel, which developed the changeover program, making use of an opinion questionnaire submitted to all those in the industry. A high-level (government-BSI) decision was made to link dimensional coordination with metrication. The author states the potential benefits of this approach to the product manager, the building designer, the contractor and the developer. He makes two specific suggestions for the United States, based on the U.K. experience: (1) a National Metric Board should be formed early on, and (2) a pool of speakers lecturing all over the country is needed to awaken everyone to the changeover.

Today (1973) most drawings and contract documents are metric, except those for small addition or remodeling work and those which flow from a few last ditchers. The problem of joints and tolerances remains, mainly because of the change to dimensional coordination. The theory has been done, but what will take some time is the feedback. The author suggests that employees be taught at the outset only what they must know for their jobs, and that all their old measuring instruments be taken away. The Construction Industry Training Board helped a great deal in the training of construction industry employees (see Reference 14 for one example).

21. Economic Commission for Europe (ECE), Dimensional Coordination in Building: Current Trends and Policies in ECE Countries, New York, United Nations, 1974.

Request from:
United Nations
Sales Section
New York, N.Y.
Sales No. E.74.II.E.3

This report is based on the response of 20 ECE countries to a questionnaire issued by a Working Party of the Building Industry reviewing progress made in the field of standardization and dimensional coordination in building.

The report first describes the purpose of dimensional coordination: to make possible the mass production of building components that will also fit together without onsite modification. A brief history of international cooperation concerning dimensional coordination and a description of the role and documentation of such organizations as the European Productivity Agency, the International Organization for Standardization

(ISO) and the Permanent Commission on Buildings of the Council of Mutual Economic Aid are presented.

The principles of dimensional coordination in buildings—including the basic module of 100 mm, multi-modules, and intra-modular sizes —are then discussed. A country-by-country description of preferred sizes, work sizes and tolerances, and standard dimensions of sheet materials and joints is included.

The report describes the methods of application of dimensional coordination and the problems related to it in each country. The following information is presented for each country: (1) the national building policy involving standardization and dimensional coordination, (2) the extent of promotion of dimensional coordination (which ranged from laws in half of the countries to education and dissemination of information in all countries), and (3) a list of the authorities and institutions concerned with dimensional coordination in building.

A subject-by-subject account of the results achieved and experience gained by each country makes up Part V. The following areas are covered: (1) use of modular grids, (2) application of standardized controlling dimensions, (3) stage of development of type design, especially with regard to the application of dimensional coordination, (4) economics obtained through the application of modular design, standard controlling dimensions and type design, (5) advantages and disadvantages experienced in the application of dimensional coordination, (6) use of standardized modular components, (7) experience gained by enterprises producing building materials, components and equipment, (8) experience gained by building enterprises, (9) difficulties experienced in obtaining modular components and (10) use of modular components in system building.

The questionnaire on dimensional coordination in building that was used to collect the information is presented in Annex I. ECE and ISO recommendations and ISO international standards are listed in Annexes II and III.

22. Edmondson, P. D., Dimensional Coordination Methods in Rationalised Traditional Housing, CPTB Technical Note, September 1968, 19 pp.

Request from:
Clay Products Technical Bureau
Drayton House
Gordon Street
London W.C. 1, England

This paper describes two experiences of building traditional row- or townhouses to dimensionally-coordinated (4" module) designs. The houses were built for Local Authorities, using traditional materials—e.g., brick and block walls. The primary concern was to reconcile the use of standard brickwork with other components in buildings that are designed or planned to facilitate methodical construction, i.e., with a minimum of waste, either of labor or of materials, and with a desirably increasing use of prefabrication and of "dry" construction. Results reported include measured dimensions of the buildings as erected.

23. Fairweather, Leslie, ARIBA, and Jan A. Sliwa, DipIng, DipArch, ARIBA, The VNR Metric Handbook, New York: Van Nostrand Reinhold Co., 1969, 206 pp.

This handbook, first published in England, is a comprehensive reference of basic metric design data. First, it discusses some of the implications and difficulties of changing to the metric system in the construction industry. The (U.K.) program of metric changeover is presented, along with some positive and negative consequences of the change. Rounded and rationalized dimensions (soft and hard conversion) are discussed. The authors suggest that, with the conversion, the manufacturer-oriented standards for all aspects of the building be replaced by user requirements. A check list of such requirements is presented as a guide to the types of questions that should be addressed.

Next, the book presents a basic description of the metric system and of SI units. It discusses notation and drawing office practice, and the progress of public sector and other official bodies involved (in the U.K.) in metrication and dimensional coordination. The basic features of dimensional coordination are described. Some 40 pages are devoted to basic design data, in metric units, for the following areas: anthropomorphic, internal and external circulation and car parking, heating, thermal insulation and condensation, lighting, sound, and structural design. Another 80 pages contain recommended basic measurements and data needed for the design of buildings of fifteen different usage types. A selective bibliography and conversion factors and tables are included.

24. Gossage, S. M., Canadian Experience in Metric Conversion, Building Research, Vol. 10, No. 1, Jan/Mar 1974, pp. 27–30 (see Reference 11).

This paper, by the Chairman of the Canadian Metric Commission, gives a brief history and description of the organization for conversion to the metric system in that country. The national Metric Commission was established in June 1971, to investigate the implications of Metrication and develop a plan for change. The seventeen members of the Commission are widely representative of the economy.

Ten steering committees, with members from different segments of the economy as well as from the federal government, are organized under the Metric Commission. Steering committee No. 5 represents and serves the Construction Industry. Under the steering committees are sector committees which represent an individual interest or group of interests. Their duties are (1) to determine the metric units to be used in their industry, (2) to set priorities for the writing of metric standards, (3) to set priorities for the revision of legislation and regulations from imperial to metric units, and (4) to devise a specific conversion plan for their industry. Also under the steering committees are task forces or working groups that study particular problems of interest.

The Canadians foresaw a three phase conversion process: (1) investigation, (2) planning and scheduling, and (3) implementation. The author stresses the importance for the changeover of metric education as well as of its acceptance by the public

25. Housing and Home Finance Agency, Washington, D.C., Basic Principles of Modular Coordination, 1953, 29 pp.

Out of print.

This pamphlet is a brief illustrated description of the criteria and standards for 4" modular coordination presented in the A62 Guide for Modular Coordination. It treats: the basic module, modular dimensions, modular masonry, modular coordination with varying joint thicknesses, modular coordination of dissimilar materials (i.e., footings, foundation walls, wood frame or masonry (walls, and floors), modular framing, and modular products (such as interior wall facings or blanket insulation).

26. Housing and Home Finance Agency, Washington, D.C., Building Better from Modular Drawings—The Modular Method in Building Construction, Jan 1954, 22 pp.

Out of print.

This pamphlet shows how construction drawings are much more clear and readable—and the implied construction more easily visualizable and realizable—when they are based on a modular design grid. It demonstrates how cutting and fitting of materials at the job site are minimized.

27. Housing and Home Finance Agency, Washington, D.C., The Modular Method in Dwelling Design, May 1951, 54 pp.

Out of print.

This booklet is a detailed explanation of the application of the principles and criteria contained in the A62 Guide to Modular Coordination to design and drafting practice—particularly to the preparation of working drawings. It shows how the modular methodology simplifies and reduces the latter task by enabling the use modular (i.e., repetitive) details.

28. Interdepartmental Sub-committee for Component Coordination (U.K.), Dimensional Coordination for Building—Designing with components: an appreciation of the problems of fit that arise and techniques that may be used in solving them, D.C. 21, 1972, 46 pp.

Request from:
Component Co-ordination Group
Room 108, Cleland House, Page Street
London SW1P 4LL, Great Britain

This publication results from work carried out within the British Standards Institution that will form the revision to BS 3626: Recommendations for a System of Tolerances and Fits for Building. It provides guidance for those involved in system designing on the use of the principles set out in the revision to BS 3626 and on the selection of component work sizes and dimensionally suitable jointing techniques. It also gives the designer an appreciation of the problems inherent in the use of components so that he can choose the appropriate means of overcoming them and conveying the necessary information to the builder.

29. International Brotherhood of Electrical Workers, International Association of Machinists and Aerospace Workers, and United Brotherhood of Carpenters and Joiners, Metric Conversion: Unanswered Questions and a Practical Solution—Metric Monitoring and Assistance Board, Washington, D.C., undated, 15 pp.

Out of print.

This pamphlet argues against metrication. It discusses the past recommendations of the AFL-CIO concerning metrication. Fault is found with the metric study conducted by the National Bureau of Standards. The pamphlet argues that too many questions are still unanswered to make metrication a national policy. The claim is made that metrication would only add to this country's problems with the economy and with energy, and that it would also tend to accelerate a trend towards economic concentration. Conversion is seen as not helping our world trade, but creating employment problems at home. The pamphlet goes on to state that letting the "costs lie where they fall" is unfair. It asserts that the worker will also feel other negative impacts, only some of which collective bargaining can help protect against. It is suggested that an independent Metric Monitoring and Assistance Board be formed to conduct further research into metrication and to provide full reimbursement to workers for newly acquired metric tools as well as special unemployment and job placement assistance, relocation allowances, technical assistance, and education and retraining opportunities including financial assistance for apprentice training porgrams.

30. International Organization for Standardization (ISO)

Request from:
American National Standards Institute
1430 Broadway
New York, New York 10018

Modular Coordination—Basic Module, International Standard ISO 1006 (1973).

This standard establishes 100 mm as the international standardized value of the basic module (4 in for countries using the foot-inch system of measurement). The module is to be represented by the letter M.

Modular Coordination—Multimodule for Horizontal Coordinating Dimensions, International Standard ISO 1040 (1973).

This standard fixes the values of several multimodules for horizontal coordinating dimensions used in modular coordination.

Modular Coordination—Storey Heights and Room Heights for Residential Buildings, International Standard ISO 1789 (1973).

This standard fixes the sizes for modular heights of storeys as: 26M, 27M, 28M and 30M (1M = 100 mm). It fixes the sizes for modular heights of rooms as: 20M, 21M, 22M, 23M, 24M, 25M, 26M, 27M and 28M.

Modular Coordination—Reference Lines of Horizontal Controlling Coordinating Dimensions, ISO Recommendation R 1790 (1970).

This recommendation fixes the position of the reference lines of horizontal controlling coordinating dimensions.

Modular Coordination—Vocabulary, International Standard ISO 1791 (1973).

This standard gives definitions of terms used in modular coordination.

Tolerances for Building—Vocabulary, International Standard ISO 1803 (1973).

This standard gives definitions of the terms used for the study and application of tolerances in building.

Joints in Building—Vocabulary, International Standard ISO 2444 (1974).

This standard defines terms used to describe building joints, their constituent parts and their design in building construction.

Joints in Building—Fundamental Principles for Design, International Standard ISO 2445 (1972).

This standard "outlines some basic principles for the design of joints in buildings." Three properties of joints are discussed: (1) geometrical, (2) structural, and (3) environmental.

Modular Coordination—Coordinating Sizes for Doorsets—External and Internal, International Standard ISO 2776 (1974).

This standard gives the coordinated sizes (width and height) for external and internal doorsets.

Modular Coordination—Coordinating Sizes for Rigid Flat Sheet Boards Used in Building, International Standard ISO 2777 (1974).

This Standard specifies coordinating sizes for rigid flat sheet boards used in building. Lengths are 18M, 21M, 24M, 27M, 30M and widths are 6M, 9M, 12M, (1 M = 100 mm).

Modular Coordination—Principles and Rules, International Standard ISO 2848 (1974).

This standard specifies the aims of modular coordination and states the general principles and rules to be applied in determining the sizes of building components and equipment and of assemblies and buildings themselves.

Kitchen Equipment Coordinating Sizes, International Standard ISO 3055 (1974).

This standard defines sizes (heights, widths and lengths) for components of kitchen equipment in dwellings.

Joints in Building—General Check-List of Joint Functions, International Standard ISO 3447 (1975).

This standard gives a general check list of functions of joints in building for use in their design. Design aspects covered are (1) environmental factors, (2) capacity to withstand stress, (3) safety, (4) accommodation of dimensional deviations, (5) fixing of components, (6) appearance, (7) economics, (8) durability, (9) maintenance, and (10) ambient conditions.

31. Kapsch, Robert J. Office of Building Standards and Codes Services, Center for Building Technology, National Bureau of Standards, Metrication: Building Codes and Standards, paper prepared for the Engineering Society of Baltimore Metrication Seminar, 30 Oct 1975.

To be published in The Baltimore Engineer.

This paper discusses the current metric situation in the United States, the experience of and the rationale for linkage of dimensional coordination with metrication, and the implications of both for building codes and standards. It uses several hypothetical examples to illustrate the problems inherent in reasonably adapting building standards to metric units.

32. Kent, S. R., Modular Drafting Manual: A Guide to the Application of Modular Coordination in Design, Technical Paper No. 123, Division of Building Research, National Research Council, Ottawa, Canada, Aug 1961, 40 pp.

Request from:
Publications Division
National Research Council of Canada
Ottawa, Canada K1A OR6

This manual is well characterized by its title. A brief description of modular (or dimensional) coordination and some historical background information are first given. Topics treated include (1) the module and its use, (2) tolerances and joints, (3) preferred sizes of components, (4) use of grids (including modular space planning, structural, and modular grids), (5) dot and arrowhead conventions, and (6) neutral zone and displacement principle. The manual then presents four examples of the selection of planning grids and shows the relationship of components to the grid. These examples illustrate the application of modular design to four common types of construction: (1) metal frame and prefabricated panel walls, (2) metal frame and masonry, (3) wood frame and (4) wood frame and masonry. Typical drawings are shown and discussed. An appendix contains illustrated definitions of terms related to dimensional coordination.

33. Le Corbusier, translated by Peter De Francia and Ama Bostock, The Modulor: A Harmonious Measure to the Human Scale Universally Applicable to Architecture and Mechanics, Cambridge, Massachusetts: MIT Press, 1954, 243 pp.

This book discusses the author's invention of a proportioning grid rule, which he calls the Modulor. It is a measure based on mathematics and the human scale and is intended to be used in designing in architecture and mechanics. The book presents a history of how the Modulor was derived and developed and an explanation of it. The author feels that the Modulor, being harmonious, "lends itself to an infinity of combinations" as well as "ensures unity with diversity." The aims of using the Modulor are explained as (1) to harmonize, (2) to standardize, and (3) to reconcile the obstacles brought about by the differences between the metric and the foot-and-inch systems of measurement. The book includes "panel exercises" using the Modulor; illustrated examples of how the author applied the Modulor; and examples of pleasing designs that, upon measurement, were found to agree with the measure of the Modulor.

34. Lindsay, Arthur, FRIBA, Changing to Metric, The Building Economist, Aug 1970, pp. 48, 49, 68.

This article is a lighthearted (and reassuring) talk given by a British architect practicing in Belgium to British architects practicing in Great Britain about his experiences in working in the metric system. The author describes himself as completely bilingual as regards imperial and metric. Mr. Lindsay suggests that his audience will remember quickly the units and dimensions that they will need to know. He offers some measurement comparisons, useful in getting a "feel" for the new units. He advises against the use of aids, such as rulers with both metric and imperial units marked off, as they tend to be confusing and inhibit learning of the new system. The change is described as really nothing but the substitution of one set of arbitrarily established units for another. The new units just happen to be much simpler to use than those to which we are accustomed from our childhood, but which most of us still have the greatest difficulty remembering.

35. Mahaffey, Charles T., Metrication Problems in the Building Codes and Standards Sector, National Bureau of Standards, NBS Technical Note 915, June 1976, 21 pp.

Request from:
Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402
SD Catalog No. C13.46:915

This report discusses the problems the building codes and standards sector is likely to encounter with metrication. A brief description of

SI units and the coherence of the metric system is followed by an explanation of which units will most likely be used in the construction industry. Examples are presented of conventions for usage of SI units employed in other countries.

Dimensional or modular coordination is described and a brief history of its use in the United Kingdom is given. The British Standards Institution, together with the planners of U.K. metrication, decided that since sizes of products and components had to be changed for metrication, they might as well be coordinated at the same time. In order to obtain the flexibility needed by designers and the practical size range limitations needed by product manufacturers, preferred dimensions were selected. The author feels that, if dimensional coordination is to accompany metrication in this country, there must be early national agreement on the bases for applying the principles of dimensional coordination. The author stresses that a coordinated effort on the part of the fragmented building industry is needed for a change to metric and dimensional coordination.

Codes and standards promulgators need to plan and set up now an organizational structure to deal with their share of the metric conversion problems. Two of the problems are (1) coordinating the introduction of SI units and dimensional coordination model documents used in the building regulatory system and (2) timing and coordinating the introduction of the model documents into state and local laws. These codes and standards groups must first, though, develop a position on selecting SI units to be used in the building industry, and develop standards explicating the principles and methods of dimensional coordination.

The author urges education on the metric system and dimensional coordination for members of metric committees, members of model code organizations, officials in state and big city building departments and federal building regulatory agencies, as well as for building code inspectors.

36. —, America Joins a Metric World, reprint from Dimensions, Vol. **60,** No. 2, Feb. 1976, pp 69.

Request from:
Office of Technical Publications
National Bureau of Standards
Washington, D.C. 20234

This article discusses the national policy in support of metric measurement and of coordinating the increasing use of metric in the U.S. on a voluntary basis that was established by the Metric Conversion Act of 1975. The act provides for the establishment of a U.S. Metric Board, which is responsible for a broad program of planning, coordination and public education to facilitate coordinated and efficient increase in the use of the metric system. The author discusses the background and reasons for this momentous national decision. He observes that among the sectors of American life already participating in the changeover are industry, many retailers, education and some state governments. The metrication activities underway in several Federal agencies are reported. Finally, the article describes the expected minimal impact of the gradual changeover on the average citizen in his everyday living activities.

37. Metric Conversion Board (Australia), Builders' and General Hardware, Oct 1974.

Request from:
Metric Conversion Board
18-24 Chandos Street
St. Leonards NSW 2065
Australia

This pamphlet lists converted metric sizes for many items associated with the building and engineering industries. Items included are tools (specified by linear dimensions or by mass (weight)), bolts, nails, screws, chain, fencing wire, paints and brushes, rope, kitchen utensils, and building materials, generally. Metric (SI) units used in building and engineering are listed and hard and soft conversion are defined.

38. Metric Conversion Board (Australia), Metric Information for Building Tradesmen, 58 pp.

Request from:
Metric Conversion Board
18-24 Chandos Street
St. Leonards 2065, N.S.W.
Australia

This Australian pocket book is designed to help tradesmen understand and be able to work in metric units. It gives specific, practical information on units of length, area, volume, mass, temperature and time. It goes on to "indicate the units to be used in specific trades and describe some of the more important changes in the material sizes and supply," including dimensionally coordinated sizes. Building components in Australia will increasingly be in preferred sizes designed around the preferred metric module of 300 mm. This dimensional coordination should mean less waste of material and time on the building site. Additional information is presented on the prefixes used with metric units and the units used for force, energy, pressure, power and electricity supply, and lighting.

39. Milton, H. J., FRAIA, Metric Conversion in Building and Construction, Metric Handbook: SAA MH-1972, Metric Conversion Board (Australia), 1972, 96 pp.

Request from:
Standards Association of Australia
Standards House, 80-86 Arthur Street
North Sydney, NSW, Australia 2060

This is a comprehensive handbook for the application of the SI measurement language to all aspects of building. In the absence of a similar U.S.-oriented publication, it is probably the best available reference for such information. Of the handbooks available from other countries, it is the least encumbered with information extraneous to U.S. users, although it does of necessity include data on standard metric sizes of materials and products that are at least premature, if not inapplicable, in the U.S.

The book presents and discusses the SI units for the measurement of all quantities involved in the industry, from land surveying to lighting and acoustics. It describes mental images and recognition points for getting a "feel" for the new units. It treats conversion and how to correctly present numerical values in SI units, metric drawing practice, and metric measuring instruments and equipment. The principles of dimensional coordination are described, along with the advantages expected from it. Included are a good-practice check list for metric projects, a guide to managing metric change in an organization, and a guide for the training of staff and operatives.

The first section of the book describes the background and planning for the change in Australia, and presents and discusses the agreed-on timetable for changeover by the Australian industry. The metrication experience of Australia, in general, and of their construction industry is regarded by many U.S. observers as constituting the most efficient and successful model yet demonstrated for changeover from the use of English to the use of metric measurements.

40. Milton, Hans J., FRAIA, Metric Conversion—The Australian Approach, Building Research, Vol. **10**, No. 1, Jan/Mar 1974, pp. 37–44 (see Reference 11).

This paper, by the Director of Metric Conversion for the Australian Department of Works, discusses Australia's experience with metric conversion. The author sees conversion as an opportunity for "rationalization through metrication." He also offers Australia as a model for conversion in the United States.

The background of the change in Australia is presented and the approach characterized as planned and coordinated. The main implementing body is the Metric Conversion Board, which has eleven advisory committees. The Building and Construction Advisory Committee has four sector committees: (1) Building sector, (2) Building Supply sector, (3) Civil Engineering and Architectural sector, and (4) Government Construction sector. These sector committees are responsible for developing basic programs and methods for conversion in their respective sectors.

The author lists a number of objectives of the metric changeover process in the building and construction industry. Only the first has to do with "change to the most up to date version of the metric system in the most efficient and economical manner." The rest are concerned with modernizing manufacturing processes, procedures, practices, standards, codes, documentation and communication in the industry; reducing unnecessary variety of products and procedures; and making possible the use of dimensionally coordinated products and systems by all who wish to avail themselves of this discipline. The author states that these objectives are fairly demanding, that most of them could be achieved without metrication, but that the changeover provides the necessary stimulus of an enforced change as an opportunity for review of the existing situation.

The process by which the timetable for construction industry conversion was developed is described, and the timetable, itself, is shown. Three general phases are involved in the changeover process: (1) planning and preparation, (2) implementation, and (3) finishing-off. The importance of all parts of the industry adhering to the guideline timetable is stressed. The government construction sector has adopted a leading role on metric conversion matters, in order to impart the initial momentum to the change. The article concludes with a list of Do's and Don'ts based on the Australians' experience.

41. Ministry of Public Building and Works (U.K.), Metrication in the Construction Industry, No. 1: Metric in Practice, HMSO, London, 1970, 52 pp.

Request from:
HMSO
49 High Holborn
London, W.C.1
England

The first section of this British publication discusses the reasons for metric conversion in the U.K., why the International System of Units (SI) was chosen, and the scope of retraining needed by those working in the construction industry. Guidelines for learning and appreciating metric units are presented, along with rules for uniformity of measurement expressions, especially on drawings. The second section describes the coherent SI system and its units, including base or primary units, supplementary units, derived units with and without special names, decimal multiples and submultiples, and permitted non-SI units. The third section is an introduction to dimensional coordination. A definition of the concept is given, along with the recommended basic multiples of size. Discussed are: controlling dimensions and practical applications of them, zones and their contents, and basic space and work size. A list of benefits of dimensional coordination includes saving of design time and effort, reduced cost of components resulting from the efficiency of standardization, increased site productivity bringing reduced site labor cost, and, overall, quicker building at less cost.

42. Ministry of Public Building and Works (U.K.), Metrication in the Construction Industry—Bulletin No. 2. Calculations in SI Units: Structural, Civil, Heating, Ventilating, London, 1970, 148 pp.

Request from:
HMSO
49 High Holborn
London, W.C.1, England

This publication was designed to assist British civil, mechanical, and electrical engineers in the transition from imperial to the use of metric measurements. It illustrates typical calculations in SI units for the engineer, with particular emphasis on the ubiquitous unit of force, the newton in SI. The base and supplementary units and prefixes for multiples and submultiples are listed, followed by the derivations of the derived units used in engineering. The important relationships between force, mass and weight in the SI measurement language are discussed and basic equations for hydraulic pressure and energy are illustrated. Most of the publication is taken up with example problems showing application of the base and derived units to fundamental problems of applied mechanics and to civil, mechanical and electrical engineering calculations.

43. National Building Agency (U.K.), Metric Housing—The Transitional Period: A guide to using existing imperial components within the metric dimensional framework, London, Feb. 1969, 24 pp.

Request from:
The National Building Agency
NBA House
Arundel Street
London WC2, England

This bulletin describes ways in which housing, designed using the recommended metric framework, can be built using existing "imperial" (or "customary") dimensional components with only minor adjustments in positioning. This information is seen as necessary during the transition period, when metric components will not always be available and existing imperial components, described in metric dimensions by manufacturers, will have to be used. Information is given on (1) external walls, (2) separating walls, (3) brickwork, (4) windows, (5) windows in brickwork, (6) private internal staircases, (7) timber upper floors, (8) door sets, (9) partitions, (10) baths, heater units, kitchen fittings, (11) site applied finishes and (12) internal plan layout.

44. National Bureau of Standards, Brief History of Measurement Systems with a Chart of the Modernized Metric System, Special Publication 304A, Revised Aug. 1975.

Request from:
Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402
SD Catalog No. C13.10:304A
or
Office of Technical Publications
National Bureau of Standards
Washington, D.C. 20234

This pamphlet gives a brief history of the development of measurement systems, particularly the English and metric systems of weights and measures. The English system, commonly used in the U.S. today, developed through customary use in many cultures. Royal (English) edict also helped to shape it through standardization for commercial needs. The Metric System was created in France in 1790 to meet the growing need for a single, world-wide coordinated measurement system. Because the metric system was a "base-10" or "decimal" system, it spread rapidly throughout the world. The pamphlet observes that, in 1875, the U.S. and sixteen other countries signed the Treaty of the Meter making the metric system an international standard. In 1960 this system was revised and modernized and is now referred to as Le Système International d'Unités—The International System of Units or SI. A center chart gives basic information about this modernized metric system. It includes the current definitions of the seven base units, the two supplementary units for angular measure and the commonly used derived units, the prefixes used to form multiples and submultiples of SI units, and some common conversion factors between customary and SI units. (This chart, without the history of measurement systems, is also available in wall chart size from the Superintendent of Documents as NBS Special Publication 304.)

45. National Bureau of Standards, Metric System of Weights and Measures, Guidelines for Use, Federal Register, Vol. 40, No. 119, 19 Jun 1975, p. 25837.

Request from:
Office of Technical Publications
National Bureau of Standards
Washington, D.C. 20234

The Metric Conversion Act of 1975, Public Law 94–168 (Reference 59) states that "'metric system of measurement' means the International system of Units as established by the General Conference of Weights and Measures in 1960 and as interpreted or modified for the United States by the Secretary of Commerce." This Federal Register Notice has been published pursuant to a similar provision in P.L. 93–380, Elementary and Secondary Education Amendments of 1974. In implementation of the Secretary's responsibilities under that act, this notice sets forth guidelines for the use of the SI, as interpreted and modified for the United States by the National Bureau of Standards on behalf of the Secretary of Commerce. Two tables list (1) the seven base units for independent quantities plus two supplementary units for plane angle and solid angle, and (2) the seventeen SI derived units with special names (derived from the nine units).

All other SI derived units are based on these 26 units. Additional tables list (3) examples of SI derived units expressed in terms of base units, and (4) examples of SI derived units expressed by means of special name units. A fifth table lists the sixteen prefixes used to form multiples and submultiples of the SI units. The notice also lists (6) certain non-SI, but widely-used units that are accepted for continued use in the U.S., (7) other non-SI units whose continued use (internationally, as well as in the U.S.) is subject to future review, and (8) metric units, listed in the act of 1866 that legalized the metric system of weights and measures in the United States, but which are not part of the International System of Units and are therefore no longer accepted for use in the U.S.

46. National Bureau of Standards, NBS Guidelines for Use of the Metric System, LC1056, Revised Aug 1975.

Request from:
Office of Technical Publications
National Bureau of Standards
Washington, D.C. 20234

This publication provides a complete set of guidelines for the use of the SI measurement units in technical and nontechnical practice. It contains several tables (extracted from Reference 50) that list: (1) SI base units, (2) SI dervied units with special names, (3) examples of SI derived units expressed in terms of base or special name units, (4) SI prefixes, (5) units acceptable for use with the SI and (6) conversion factors (from customary units) for some common physical quantities. It also contains a style guide on the writing of SI units and symbols. A brief discussion is included on the shift in the treatment of "weight" (mass) and force that is involved in the use of the SI measurement language.

47. National Forest Products Association, A Brief Description of the UNICOM* Method of House Construction (*UNICOM is the Trademark and Service Mark of the National Forest Products Association), 1964, 24 pp.

Request from:
National Forest Products Association
1619 Massachusetts Avenue, N.W.
Washington, D.C. 20036

This pamphlet describes the principles and practice of a system of modular design standards for the wood framing and construction of houses. Based on multiples of 4 in, the standards define components for home building, primarily: modular floor systems, modular exterior wall components, modular roof systems and interior partition units. Use of such components is said to give rise to typical dimensional coordination benefits of: simpler drawings, labor savings and faster erection, and reduced builder and supplier inventory costs.

48. National Lumber Manufacturers Association, Washington, D.C., The UNICOM Method of House Construction—Design Principles: Manual No. 1, Apr 1962, 122 pp.

Out of print.

The UNICOM Method of House Construction—Fabrication of Components: Manual No. 2, Dec. 1963, 248 pp.

Out of print.

These two manuals present a method of house construction (UNICOM) established by the National Lumber Manufacturers Association for use by the residential builder. The approach is based on coordinated modular dimensioning. (See Reference 47 for a brief, in print, description of the method.)

Manual No. 1 describes the design principles of UNICOM (the concept of modular coordination being basic) and discusses the advantages of using it. The book then presents modular standards for design of floor systems, exterior wall components, and roof systems. (These are, of course, established on a 4 inch basic module. They presumably could be readily adapted to the 100 millimeter module.)

Manual No. 2 comprises standards for the fabrication of floor construction, interior partitions, trussed rafters, gable end framing, and conventional roof framing.

49. Odom, Jeffrey V. (ed.), U.S. Metric Study Interim Report: Testimony of Nationally Representative Groups, National Bureau of Standards Special Publication SP 345-12, July 1971.

Request from:
Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402
SD Catalog No. C 13.10:345-12

This is one of the twelve supplemental reports of the U.S. Metric Study (see Reference 19). It contains summaries of the inputs obtained at a series of seven Metric Study Conferences that amounted to open public hearings to gather information for the study. Organizations and associations of various kinds—professional, technical, labor, trade, education, consumer—were invited to make presentations to these conferences, each of which was devoted to an activity or a common area of interest. One of the conferences was concerned with the construction industry, and inputs were received from 26 construction-related groups. Another was addressed to the concerns of labor, and obtained the viewpoints of 45 unions, including several in construction fields.

Although the positions represented in this report were generally based—in view of their date—on meager information as to the true implications and effects of a U.S. metric changeover, and some of them have been invalidated or modified by subsequent developments, they provide at least a starting point for assessing the attitudes of the various elements of the construction industry toward metrication in the industry. (More recent views of some of these elements may be found in Reference 58.)

50. Page, Chester and Paul Vigoureux (editors), The International System of Units (SI), U.S. National Bureau of Standards, Special Publication 330, July 1974.

Request from:
Superintendent of Documents
U.S. Government Printing Office
Washington. D.C. 20402
SD Catalog No. C13.10:330/3

This is an approved translation of Le Système International d'Unités, a publication of the International Bureau of Weights and Measures, Sevres, France, describing the International System of Units (SI). This edition was issued in order to promote knowledge and understanding of the SI throughout the English-speaking world. The three classes of SI units are introduced (i.e., base, supplementary, and derived). Definitions and symbols are given for the base and supplementary units. Expressions of derived units are presented. A chart lists the prefixes which are used to obtain decimal multiples and submultiples of the SI units. Also listed are units outside the International System that are (1) used with SI units, (2) accepted temporarily, or (3) to be avoided. Appendices contain (1) decisions of the General Conference on Weights and Measures and the International Committee for Weights and Measures concerning units of measurement and the International Systems of Units, (2) practical realizations of the definitions of some important units and (3) a description of the organs of the Metre Convention: The International Bureau of Weights and Measures, the International Committee for Weights and Measures and the General Conference on Weights and Measures.

51. Parenteau, Henri-Paul, The Management of Modular Design, Industrialization Forum, Vol. 3, No. 1, Oct 1971, pp. 35–44.

The author feels that modular design bridges that gap between the need for diversity of products and the efficiencies that could be gained by mass production in the construction industry. It allows for both flexibility in design and industrialization. However, with this flexibility comes complexity, and electronic processing is often needed to optimize management decisions. Prefabricated modular partition units are used as an example in illustrating a method of optimizing component combinations. The purpose of the procedure is to minimize the overall cost of putting up panels, taking into account different costs of production and of site assembly, by establishing an optimal list of panel sizes for production.

The procedure is basically an iterative recursion with a conditional step. A formula and the algorithm of the procedure for a computer program is given. The article also suggests some practical constraints which add to the complexities of the problem.

52. Simmons, H. Leslie, AIA, Metrication in Architectural Practice, Building Research, Vol. 10, No. 1, Jan/Mar 1974, pp 24–26 (see Reference 11).

This article assesses the position of the architectural profession vis-a-vis the metric changeover that is taking place in the U.S. The author notes that the AIA has been supporting metric conversion since 1944. In recent years the Institute has testified to the Congress concerning, on the one hand, the potential chaos in the construction industry in particular that could be produced by continuation of unsupervised evolutionary conversion, and on the other, the excellent opportunity for unification and simplification in the industry that could be provided by a well coordinated changeover effort. It is the author's opinion that the building industry is plagued with mismatched and uncoordinated products and procedures due to a lackadaisical attitude toward unification of the industry. Metrication, he feels, will not by itself help this situation but, since we must start over with standards anyway, the changeover provides a probably one-time opportunity to greatly improve the situation. It clearly should not be lost. Furthermore, in view of our rapid move into an era of systems building, incorporation of modular dimensional coordination is also an essential element in this changeover.

53. Sinopli, Nicola, Modular Design for System Building, Industrialization Forum, 1973. Item No. 2582.

This article, which describes a research project sponsored by the National Research Council (Italy), shows how dimensional criteria can be integrated into the early phases of system design, instead of being considered near the end as in conventional modular coordination.

The systems approach, with its interdisciplinary and methodological basis, is generating an increasing concern for processes—particularly for the early, critical phases of system design. Hitherto, dimensions have been selected at a late stage of the design process: it seems desirable that they should be an integral part of the design considerations from the start. System design starts by an analysis of activities, leading to a definition—in qualitative and then in quantitative terms—of required performance. Activities suggest forms and dimensions: operational models of the activities allow the activities to be described, so that they can be combined into environmental units. Predominant activities can be described in modular terms, called "activity-modules." Activity-modules suggest "geometric coordinating shapes," determining in turn form-modules and form-networks (ultimately, catalogs of typical form-modules and form-networks can be formed).

Performance specifications involve explicit and implicit dimensional criteria for the boundaries between, and main features of, environmental units. In practical terms, it is possible to proceed step by step from an analysis of activities and their dimensional requirements, through to preparing the performance specification. At that stage, the tools of modular coordination may become applicable, provided that the flexibility of the new approach is not lost. (IF abstract)

54. Smith, Russell W., Jr. (ed.), Precoordination—Basis for Industrialized Building: Proceedings of a Conference Held at Gaithersburg, Maryland, 24–26 Sep 1969, National Bureau of Standards, Building Science Series (BSS) 32, Jan 1971, 136 pp.

Request from:
National Technical Information Service
U.S. Department of Commerce
Springfield, Virginia 22161
Order No. COM 71–50078

These are the proceedings of a conference held at the National Bureau of Standards under the auspices of American National Standards Institute Committee A62. The papers discuss precoordination, both dimensionally and functionally, of building components and systems.

The first group of papers discusses the experience with dimensional precoordination of Great Britain, Denmark, Canada, the United States and the USSR. Functional precoordination is the subject of the next group of papers. Two papers address a general appraisal of precoordination. The point is made that much of the technology we then had was underutilized because of lack of awareness on the part of those in the industry. One possible approach of an architect to design with precoordination is presented—a method of component assembly construction that allows unlimited design variety within the "system."

A group of papers by ANSI Standards Committee A62 reviews the status of precoordination in the U.S. The final set of papers addresses the communications needed for coordination. The national standards needed for the application of existing technology are explicated. Precoordination is also related to the following activities: (1) automated architectural drawing, (2) automated cost estimating, and (3) computerized specifications.

55. Stone, Leslie J. F., FRICS, In Britain they've—'thought metric', The Building Official and Code Administrator, May 1972, pp. 10–17; reprinted in NBS (National Bureau of Standards) IR 73–421, An Overview of the Factors Impacting Metrication of the U.S. Housing Industry.

Request NBSIR 73–421 from:
National Technical Information Service
U.S. Department of Commerce
Springfield, Virginia 22161

Order No. COM 74-11224, price $4.

This article discusses the early experience of the United Kingdom in metric conversion of the construction industry. General information on actions of the national government is given first. At least three changes are involved in countries with legal systems based on imperial (or other) units: (1) legislation to define metic units, (2) amendment of existing legislation that contains references to measurements in customary units, and (3 metrication of national standards. The author suggests that integrated planning must accompany the change and all sectors must be involved simultaneously.

Metrication in the construction industry in the U.K. is summarized as (1) the adoption of SI units, (2) the adoption of the technique of dimensional coordination, and (3) rationalization of the sizes of components that are not significant to dimensional coordination. Progress in the following areas is then described: (1) standards to be metricated, (2) projects designed in metric, (3) training in metric, and (4) metrication of building materials and components.

A number of difficulties were encountered—some resulting from the decision of the government not to make conversion mandatory—and these are discussed. The article concludes with a list of the benefits expected to be obtained in the construction industry through conversion to the metric system and the use of dimensional coordination.

56. Stone, Lesile J. F., Metrication Officer, (U.K.) Ministry of Public Building and Works, Metrication and Maintenance, unpublished paper, 1970.

Request from:
Building Information Room
Lunar House
Wellesley Road
Croydon CR9 3EL
England

This is a preliminary survey of the effects of metrication-induced changes in building product sizes on building maintenance and repair activities. The paper lists the different types of products and materials that may become involved in such activities, categorizes them by expected degree of measurement change impact, and enumerates the many types of buildings that have to be maintained. The author points out that buildings in his country may be: in addition to "modern" or "late Georgian," "Edwardian," "Victorian" or "pre-Victorian"—i.e., as much as 300 years old. (Compatibility of contemporary products and materials with existing buildings would appear to be more of a problem in the United Kingdom than in the United States—or perhaps it is just a problem with which the English have had more experience than we.) The paper proceeds to discuss, on the basis of the then-known plans for metric product standards, the anticipated impact of metric changeover on the use of products in each of the categories. The author concludes, ". . . in my experience there is almost no limit to the ingenuity of the maintenance supervisor, engineer, operative or fitter and I have no doubt at all that he will take almost all of the comparatively few difficulties in his stride and that there will be little extra cost. The essential point is to examine each situation cooly without prejudice or illconceived notions of the effect of the change and proceed in the normal rational manner."

57. Sweett, Cyril, FRICS, Modular Coordination and Building Costs, Modular Quarterly, London, Spring 1959, pp. 21, 22.

This article is an early, but nevertheless valuable consideration of the potential effects of modular coordination on the cost of finished buildings. The author observes that, since modular coordination was then just developing from the pure research stage into the initial development stages, statements about its possible cost implications must be highly conjectural. However, he offers several penetrating insights into the subject.

With respect to the cost actions of material suppliers, the claim that standardization of many products should lead to economies in production is questioned. While coordination standardizes dimensions, it does not influence such cost factors as the quality, or the minutiae of design. Furthermore, economies of production do not result directly from standardization of products, but only from standardization of the production system—which product standardization permits but does not make inevitable. With some products, modularization of sizes may even cause an otherwise unnecessary size increase and a consequent cost penalty.

It is in the operations of building that modular coordination may offer its greatest economic advantage. For dry construction (i.e., prefabrication), coordinated components will provide the solution to several erection difficulties, thereby reducing construction costs as well as enhancing the efficacy and usability of prefabrication, itself. Costs arise from the whole process of building development. Modular coordination and prefabrication envisage an entirely different set of circumstances on site, which would doubtless give rise to an entirely new set of costing circumstances. What overall impact such changes might have on building costs is an open question.

58. U.S. Congress, Conversion to the Metric System of Weights and Measures, Hearings before the Subcommittee on Science, Research and Technology of the Committee on Science and Technology, U.S. House of Representatives, Ninety-fourth Congress, First Session, April 29, 30; May 1, 6, 7, 8, 1975, No. 12.

Request from:
Committee on Science and Technology,
U. S. House of Representatives,
Suite 2321,
Rayburn House Office Building,
Washington, D. C. 20515

This is the record of the most comprehensive set of hearings on metric legislation and the metric issue held by the Congress in recent years. It includes testimony on behalf of: the AFL-CIO, the International Brotherhood of Electrical Workers, the United Brotherhood of Carpenters and Joiners of America, the M. W. Kellogg Co. (engineering construction), the American Iron and Steel Institute, the American Institute of Architects, the American National Standards Institute, the National Society of Professional Engineers, the Engineers Joint Council, and the International Association of Bridge, Structural and Ornamental Iron Workers.

59. U. S. Congress, Public Law 94–168, 23 December 1975, Metric Conversion Act of 1975.

Request from:
A Congressman or Senator,
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Office of Technical Publications
National Bureau of Standards
Washington, D.C. 20234

This act declares the policy of the United States 1) to coordinate and plan the increasing use of the Metric System (International System of Units) in the U. S. and 2) to establish a U. S. Metric Board to coordinate the voluntary conversion to the Metric System. The Board is to consist of 17 members, chosen to represent various sectors of our national life and economic activity. One board member is to be from the construction industry. The list of duties of the Metric Board characterizes the way in which it is to go about planning and coordinating metric changeover in the United States.

60. Wandmacher, Cornelius, Metrication—SI in America, Engineering Issues, ASCE, Vol. **101**, No. EI1, January 1975, pp. 25–35.

This article surveys the measurement situation of the U. S. and its implications for engineering and for engineering-related activities including construction. The author points out that three systems of measurement units need to be considered: (1) English or "customary" units, (2) metric units, and (3) the International System of Units, or SI. After describing why the U. S. is moving and must move in the direction of changing over to predominant use of the SI (not only the other English-speaking countries but the 120 or so "metric" countries are now doing so), the article proceeds to a clear explanation of what the SI is—and of what is not SI, even though it may be metric. It treats "soft" verses "hard" conversion of dimensions, opportunities for optimization, the interrelatedness of measurements and standards (and of change therein), proper SI usage in engineering design and specification, proper employment of significant figures in converting dimensions, and how to best learn the new measurement language.

61. Wehrli, Robert, AIA, Metrication and the Construction Industry: Potential Problems and Promising Opportunities, AIA Journal, May 1974, pp. 50–53 and 64. (Also in Reference 11)

This article discusses the advantages and disadvantages of soft and hard conversion to the metric system of measurement. Soft conversion, the mere expression of the measurement of a traditional product in metric units, is seen as inadequate for the construction industry. Hard conversion, the physical alteration of a product for simplification of measurement in metric, is seen as necessary. The author discusses three types of hard conversion of standards to be considered: (1) Engineering standards should be changed to metric. (2) To avoid mismatch between the size of building components and to reduce on-site labor, cutting and waste, modular standards should be set. The module of 10 centimeters is used in nearly all European countries. (3) Human standards also should be considered in setting both engineering and modular standards. New product standards should be based on individual and social needs and scale.

Addendum:

62. Lally, Andrew, Metrication in the Construction Trades, ASTM Standardization News, Feb 1976, pp. 8–17.

This article discusses the problems and opportunities of metric changeover for the construction industry from the vantage point of membership on the Construction Industries Coordinating Committee of the American National Metric Council. It includes a list of recommended SI units for use in construction activities.

63. Blachere, G., Account of the Principles of Modular Coordination: Industrialization in Building, NBS Technical Note 710-1, Building Research Translation, March 1972, 15 pp.

Request from:
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Washington, D.C. 20402
SD Catalog No. C13.46:710-1

This paper discusses the conventions fundamental to modular coordination, particularly within the context of its use in industrialized building.

64. Modular Co-ordination in Building, Terminology and Rules for the Positioning and Dimensioning of Modular Elements, Netherlands Draft Standard NEN 2880, Jul 1975.

Request from:
Netherlands Normalisation Institute
Polakweg 5, Rijswijk, Netherlands

This Draft Standard describes the principles of the "tartan" grid for modular coordination. It was written to provide rules for the rationalization of buildings or parts thereof on the basis of modular coordination. The Draft Standard assumes that: (1) principle decisions come before detailed decisions, and (2) principle decisions do not imply specific materials. Thereby it becomes possible to separate decisions during the decision-making process in in such a way that, in each decision phase, not less and above all not more will be laid down than is necessary at that point. With that the Draft Standard offers a basis, not just for coordination, but at the same time for better communication in the building process.

The Draft Standard deals with modular coordination (and metrology) in a four-level structure: 1—main rules modular coordination (main rules tolerances and fits); 2—positioning; 3—dimensioning (joints); and 4—manufacturing sizes of elements and components (tolerances).

Other Bibliographies

1. Hochschule für angewandte Kunst, Vienna, Modular Co-ordination, Tolerances, Joints and Jointing, 1936–1972, 1973, Prepared for the Forschungauftrag des Bundesministeriums für Raumordnung, Bauwesen, und Städtebau, Bonn-Bad Godesberg, B.R.D. (1300 entries, covering the world literature).

2. Government of the U.K., Department of the Environment library, Metric Bibliography—A selection of the most important material of interest to the Construction Industry, 6th revised edition, Jan 1972. (Covers essentially U.K. material—includes dimensional coordination).

3. Fairweather, Leslie and J. A. Sliwa, The VNR Metric Handbook (item 23 in this report) contains an extensive bibliography on metrication and dimensional coordination.

4. Royal Architectural Institute of Canada, Ottawa, Committee on Generic Modules, Generic Modules Bibliography, 1971.

5. American National Standards Institute, New York, A Bibliography of Metric Standards, Jun 1975 (includes American National Standards, ISO (International Organization for Standardization) Standards and Recommendations, IEC (International Electrotechnical Commission) Recommendations and CEE (International Committee on Rules for the Approval of Electrical Equipment) Specifications).

6. Australian Metric Conversion Board (18–24 Chandos Street, St. Leonards, N.S.W. 2065. Australia) from time to time publishes lists of its publications of interest to the construction industry.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The United States changeover to the use of the SI (International metric) measurement language presents our construction industry with the need to review and adapt many product standards and practices for the use of metric measurement units. These adaptations and changes can bring substantial benefits to the industry in the form of permanently recurring cost savings. A practice of potentially great benefit would be the incorporation of dimensional coordination in the new metric standards for sizes of building products. For such benefits to be realized, however, the involved issues must be effectively addressed and the requisite decisions made and implemented. Considerable literature pertinent to the issues and decisions has been published in the United States and in the other (primarily English-speaking) countries that have been implementing metrication and dimensional coordination in the past decade. This report aids construction industry consideration and resolution of metrication decisions by providing a guide to the best available sources relevant to the issues.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Building codes and standards; Construction industry; Dimensional coordination; Metric system; Metrication; Modular coordination; SI

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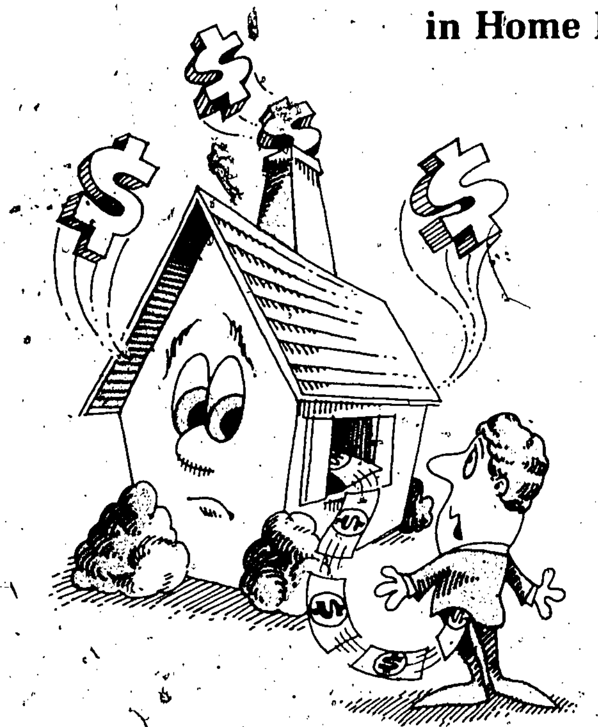

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