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An American National Standard

Standard Guide for Evaluating Economic Performance of Alternative Designs, Systems, and Materials in Compliance with Performance Standard Guides for Single-Family Attached and Detached Dwellings¹

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INTRODUCTION

This guide on economics is part of a set which together presents a complete performance guide for specifying and evaluating single-family attached and detached dwellings. The complete set in the series, when finished, is to include the following attributes:

- A Structural Safety and Serviceability
- B Fire Safety
- C Accident Safety
- D Health and Hygiene
- E Indoor Air Quality
- F Light
- G Acoustics
- H Durability
- I Accessibility
- J Security
- K Economics
- L Functionality
- M Aesthetics
- N Adaptability
- O Maintainability
- P Sustainability

The series provides a framework for specifying and evaluating qualities of building products and systems to meet user needs without limiting ways and means. The format for this series of standard guides includes performance statements that consist of four components—Objectives, Criteria, Evaluation, and Commentary (O-C-E-C)—which together provide a systematic performance-based approach for the intended purpose.

Each standard guide in the set presents a collection of information and a series of options available to the specifier. The standard guides include examples of performance statements that may be used for the specification and evaluation of residential designs, materials, products, components, subsystems, and systems.

1. Scope

1.1 What This Guide Does—This guide helps designers, builders, home owners, and other stakeholders to identify and evaluate benefits and costs in order to make efficient choices between two or more traditional alternatives and between traditional alternatives and new-technology products, systems, materials, and designs. It directs the users to ASTM

classifications, practices, adjuncts, and computer programs that implement the appropriate economic method to evaluate these benefits and costs in making technology choices. The focus, however, is on a nine-step process for using two ASTM practices—life-cycle costing (LCC), [E917](#), and the analytical hierarchy process (AHP), [E1765](#)—to measure and evaluate the economic and overall performance of investments in single-family attached and detached dwellings. This guide contains three appendixes. The first two are designed to help users identify and evaluate benefits and costs. [Appendix X1](#) contains a classification of benefits and a methodology for estimating these benefits. [Appendix X2](#) contains a classification of costs and a methodology for estimating these costs. [Appendix X3](#) illustrates how to evaluate the economic performance of three

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alternative carpet materials, two traditional products and a new-technology product, when considering the guide for durability.

1.2 Purpose of This Guide—The purpose of this guide is to help users make cost-effective choices between traditional alternatives and new technologies permitted under performance standards. This guide (1) explains how the lack of economic information discourages the introduction of new technologies; (2) helps decision makers to identify and classify the key types of benefits and costs associated with both new technologies and traditional alternatives; (3) shows how to select alternatives that meet the performance standards, but cost less than traditional alternatives; and (4) shows how to incorporate nonfinancial information into the decision-making process, enabling performance to be defined and using costs and other criteria.

1.3 Relationship of This Guide to Other Performance Standards Guides—In this guide, economic analysis is used to evaluate and compare the economic performance of traditional alternatives and new technologies permitted under performance standards for single-family attached and detached dwellings. Use this economic analysis guide in evaluating alternatives permitted under any of the other 15 performance attributes, either singly or in combination. The objective of economic analysis in this guide is to identify cost-effective choices among traditional alternatives and new technologies permitted under performance standards. The other 15 performance attributes define the scope of the economic analysis. That is, cost-effectiveness derives from better economic value while providing comparable or better technical performance for each attribute's O-C-E-C performance statements. Consequently, to evaluate the economic performance of alternative residential designs, materials, products, components, subsystems, or systems permitted under performance standards, the user of this guide must first select one or more attributes, use the O-C-E-C framework to develop and present the corresponding performance statements, and identify the alternatives to be evaluated. **Appendix X3**, for example, evaluates carpeting with respect to the durability attribute and the economics attribute.

2. Referenced Documents

2.1 ASTM Standards:²

- E631 Terminology of Building Constructions**
- E833 Terminology of Building Economics**
- E917 Practice for Measuring Life-Cycle Costs of Buildings and Building Systems**
- E1369 Guide for Selecting Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Buildings and Building Systems**
- E1557 Classification for Building Elements and Related Sitework—UNIFORMAT II**
- E1765 Practice for Applying Analytical Hierarchy Process**

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

(AHP) to Multiattribute Decision Analysis of Investments Related to Buildings and Building Systems

E2151 Terminology of Guides for Specifying and Evaluating Performance of Single Family Attached and Detached Dwellings

2.2 ASTM Adjuncts:

Discount Factor Tables, Adjunct to Practice E917

Computer Program and User's Guide to Building Maintenance, Repair, and Replacement Database for Life-Cycle Cost Analysis, Adjunct to Practices E917, E964, E1057, E1074, and E1121

Computer Program and User's Guide to AHP/Expert Choice for ASTM Building Evaluation, Adjunct to Classifications E1557, E1660 through E1671, E1693, E1694, E1700, and E1701, and Practices E917, E964, E1057, E1074, and E1765

3. Terminology

3.1 Definitions—For definitions of terms used in this guide, refer to Terminologies **E631**, **E833**, and Terminology **E2151**.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 building economics, n—the application of economic analysis to the design, financing, engineering, construction, management, operation, maintenance, repair, ownership, or disposition of buildings.

3.2.2 commentary, n—an informative narrative explaining aspects of the performance statement.

3.2.2.1 Discussion—The commentary explains how the objective relates to user needs in fields such as physiology, psychology, and tradition; how the criteria are established, including guides for setting different levels of performance to meet various user needs; and the reliability of the evaluation method. The commentary also includes example solutions that are deemed to comply with the performance statement.

3.2.3 criteria, n—quantitative statements defining the level or range of performance necessary to meet an objective or, where such a level or range cannot be established, the units of measurement of the performance.

3.2.4 evaluation, n—the method of assessing conformance of the element being addressed to the criteria.

3.2.4.1 Discussion—The evaluation states the standards, inspection methods, analysis, review procedures, historical documentation, test methods, in-use performance, engineering analyses, models, or other means to be used in assessing whether or not a criterion has been satisfied.

3.2.5 specifier, n—the individual or organization using the standard guides to specify and accept designs, materials, products, components, subsystems, or buildings to be provided by providers.

3.2.6 user need, n—a statement of the activities and behavior to be carried out in relation to the dwelling by its residents, or other users, defined in terms of motor, kinetic, physiological, psychological, emotional, and other parameters of human behavior.



Documents

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4. Significance and Use

4.1 Why This Guide Is Needed—The lack of information on economic consequences discourages the introduction of new technologies permitted under performance standards. The economic information needs are further complicated because decisions to adopt or accept a new technology are made by different types of stakeholders (for example, building materials manufacturers, home builders, and home owners). Thus, the type of economic information treated in this guide and the associated standard classifications, practices, adjuncts, and computer programs covers the information needs of the entire group of key stakeholders.

4.2 Use of This Guide by Specifiers and Providers—To make efficient choices, decision makers require factual information on both how a particular alternative addresses the relevant performance statements and how much it costs. The O-C-E-C framework enables the specifier to develop the performance statements that satisfy one or more user needs and incorporate them into a request for proposals. Providers respond to the request for proposals by offering designs, materials, products, components, subsystems, or systems for acceptance. Because cost is one aspect of each provider's response, the specifier has an opportunity to request information from the provider that may be used in evaluating economic performance. This guide is intended as a resource from which the specifier compiles lists of information to be collected as part of each provider's response to the request for proposals. It is also intended for use by providers in preparing their response to the specifier. The generic types of information that the specifier may request from the provider in their response to the request for proposals are described in [Appendix X1](#) for benefits and [Appendix X2](#) for costs. A detailed example based on the durability attribute is given in [Appendix X3](#).

4.3 Use of Economic Tools for Evaluating New Technologies—Having a package of economic tools (methods and software) that helps decision makers identify and evaluate benefits and costs when choosing between traditional alternatives and new-technology products, systems, materials, and designs will accelerate the introduction and acceptance of new technologies which are cost effective.

4.4 Use of ASTM Standards on Building Economics—Standard practices for using life-cycle costing (LCC), [E917](#), and the analytical hierarchy process (AHP), [E1765](#), to measure the economic and overall performance of investments in buildings and building systems have been published by ASTM. Two computer programs^{3,4} that produce economic measures consistent with these practices are available. The Building Maintenance, Repair, and Replacement Database Program and the Discount Factor Tables have been published (Adjuncts to [E917](#)) by ASTM to facilitate computing measures of performance for the LCC practice. The economic tools described in

this guide apply to the evaluation of all the building elements as described in the series of performance standard guides as well as in the UNIFORMAT II elemental Classification [E1557](#).

4.5 Features and Limitations of Economic Tools—For a description of how to calculate the economic measures, how to interpret them, and their limitations, see Practice [E917](#) for the LCC method and Practice [E1765](#) for the AHP method.

5. Performance Statements

5.1 Objective—Select the alternative (design, material, product, component, subsystem, or system) that results in the best economic value while satisfying the technical performance criteria of one or more performance attributes.

5.2 Criteria:

5.2.1 Life-Cycle Costing—Select the alternative that minimizes life-cycle cost while satisfying the technical performance criteria of one or more performance attributes.

5.2.2 Analytical Hierarchy Process—Select the alternative that maximizes the final overall desirability score while satisfying the technical performance criteria of one or more performance attributes.

5.3 Evaluation:

5.3.1 Life-Cycle Costing—Use Practice [E917](#).

5.3.2 Analytical Hierarchy Process—Use Practice [E1765](#).

5.4 Commentary—Use the nine-step process outlined in [6.1-6.9](#) to evaluate the economic performance of each alternative and select the best economic choice.

6. How to Use This Guide

6.1 Select the Performance Attribute(s)—Select one or more of the other fifteen ASTM performance attributes. Use the O-C-E-C framework to develop and present the corresponding performance statements for the performance attribute(s) of interest. Use information received from providers in response to the specifier's request for proposals, or by other means, as a source of data to support the economic analysis.

6.2 Select the Building Alternatives to be Evaluated—Select at least two building alternatives for evaluation. Designate one alternative as the base case. It is generally easiest to use a traditional alternative (that is, design, system, or material) as the base case. Select one or more new-technology or conventional alternatives to be evaluated *vis-à-vis* the base case. Select only alternatives which are acceptable substitutes in performance for the base-case alternative.

6.3 Select the Economic Method:

6.3.1 Life-Cycle Costing (Practice [E917](#))

6.3.1.1 The life-cycle cost (LCC) method provides a framework for comparing life-cycle costs of alternative building designs, systems, or materials that satisfy the same performance statements.

6.3.1.2 The LCC method measures, in present-value or annual-value terms, the sum of all relevant costs associated with owning, operating, and disposing of a building, building system, or associated building materials, or a combination thereof, over a specified time period, referred to as the study period.

³ Petersen, S.R., *BLCC-The NIST "Building Life-Cycle Cost" Program, Version 4.3, User's Guide and Reference Manual*, NISTIR 5185-3, Gaithersburg, MD: National Institute of Standards and Technology, 1995.

⁴ Chapman, R.E., Marshall, H.E., and Forman, E.H., *User's Guide to AHP/Expert Choice for ASTM Building Evaluation*, MNL 29, West Conshohocken, PA: American Society for Testing and Materials, 1998.

6.3.1.3 The basic premise of the LCC method is that, to an investor or decision maker, all costs arising from an investment decision are potentially important to that decision, including future as well as present costs. Applied to buildings or building systems, the LCC encompasses all relevant costs over a designated study period, including the costs of designing, purchasing/leasing, constructing/installing, operating, maintaining, repairing, replacing, and disposing of a particular building design, system, or material.

6.3.1.4 A comprehensive example of the LCC method applied to a building economics problem is provided in [Appendix X3](#). The example illustrates the LCC method by focusing on issues that relate to the durability attribute. The economic performance of three alternative carpet materials are evaluated—two traditional products and a new-technology product.

6.3.2 Analytical Hierarchy Process (Practice E1765)

6.3.2.1 The analytical hierarchy process (AHP) is appropriate when multiple criteria, not all of which can be framed as costs, are to be considered in making an investment decision. The AHP is a procedure for breaking down a complex problem into its component parts (that is, evaluation criteria and alternatives), arranging these parts into a hierarchical form, deriving numerical values (that is, scores) based on subjective judgments and facts about the relative importance of criteria and the relative preference for alternatives, and synthesizing the information to arrive at a decision.

6.3.2.2 In addition to monetary benefits and costs, the AHP allows for the consideration of characteristics which decision makers regard as important, but which are not readily expressed in monetary terms.

6.3.3 Determine which economic method, LCC or AHP, is to be used. The LCC is appropriate for all fifteen attributes. The AHP is appropriate for all fifteen attributes as well. However, when choosing among building alternatives, all AHP applications are constrained to include LCC as a criteria element. A key distinction between AHP and LCC is that AHP applications evaluate the importance of exceeding the performance statements for one or more criteria elements for the selected performance attribute(s). This distinction is particularly useful in cases where several alternatives have values of life-cycle cost close to the minimum.

NOTE 1—Because some performance attributes may be of greater importance in meeting user needs, a decision maker may use the AHP to select a subset of the performance attributes from which to develop performance statements.

NOTE 2—If, for a given performance attribute, an element within the hierarchy of building elements contains more than one objective, then the AHP provides a means for selecting which objective is of greater importance in meeting user needs. If, for a given performance attribute, an objective contains more than one criteria element, then the AHP provides a means for selecting which criteria element is of greater importance in meeting user needs.

NOTE 3—If an alternative for a given performance attribute has no measurable future costs, then its life-cycle cost over the study period may be approximated by its first cost. If a competing alternative has measurable future costs over the study period, then include these costs when calculating its life-cycle costs. In calculating and evaluating economic performance (see [6.8](#) and [6.9](#)), all alternatives must satisfy the same set of performance statements over the same study period.

6.4 *Identify Stakeholder Group(s)*—Because individual stakeholders are affected in different ways by choices between traditional alternatives and new technologies permitted under performance standards, it is useful to first identify classes of individual stakeholders and then classify them into stakeholder groups. By developing a classification hierarchy of stakeholders, we are better able to understand and identify both potential opportunities (that is, real or perceived benefits and cost savings accruing to that stakeholder) and potential barriers (that is, real or perceived additional costs and benefit reductions borne by that stakeholder) to choices between traditional alternatives and new technologies permitted under performance standards. Refer to [Tables 1 and 2](#) to identify the appropriate type(s) of individual stakeholder(s) and corresponding stakeholder group(s) for the application under analysis. [Table 1](#) is a hierarchy of stakeholders; it lists stakeholder groups with their corresponding types of individual stakeholders. [Table 2](#) is arranged as a checklist; it assigns each individual stakeholder type to its corresponding stakeholder group(s).

TABLE 1 Hierarchy of Stakeholders: Stakeholder Groups and Individual Stakeholder

Product Development and Testing:
Product innovators
Product designers
Building materials manufacturers
Building products manufacturers
Research organizations
Government agencies
Testing laboratories/services
Codes, Standards, and Support Services:
Code organizations
Code officials
Standards organizations
Research organizations
Government agencies
Evaluation services/product certification
Building permitting and inspection
Manufacturing Interest Group:
Building materials manufacturers
Building products manufacturers
Commodity suppliers (raw materials)
Trade associations
Construction and Associated Support Services:
Home builders
Specialty trade contractors
Wholesale/retail trade/supply
Construction specifiers
Procurement officials
Owners/Managers/Developers/Users:
Developers
Home owners/renters
Housing managers
Government agencies
Professional Services:
Designers/architects
Engineering consultants
Lawyers
Municipal planners
Facility planners
Real estate companies/brokers
Financial Services:
Financial institutions
Insurance companies
Warranty companies
Other:
Utilities
Environmental interest groups
Housing disposition
Third parties

TABLE 2 Assignment of Individual Stakeholders to Stakeholder Groups

Individual Stakeholders	Stakeholder Groups							
	Product Development and Testing	Codes, Standards, and Support Services	Manufacturing Interest Group	Construction and Associated Support Services	Owners/Managers/Developers/Users	Professional Services	Financial Services	Other
Building materials manufacturers	✓		✓					
Building permitting and inspection		✓						
Building products manufacturers	✓		✓					
Code officials		✓						
Code organizations		✓						
Commodity suppliers (raw materials)			✓					
Construction specifiers				✓				
Designers/architects						✓		
Developers					✓			
Engineering consultants						✓		
Environmental interest groups								✓
Evaluation services/product certification		✓						
Facility planners						✓		
Financial institutions							✓	
Government agencies	✓	✓			✓			
Home builders				✓				
Home owners/renters					✓			
Housing disposition								✓
Housing managers					✓			
Insurance companies							✓	
Lawyers						✓		
Municipal planners						✓		
Procurement officials				✓				
Product designers	✓							
Product innovators	✓							
Real estate companies/ brokers						✓		
Research organizations	✓	✓						
Specialty trade contractors				✓				
Standards organizations		✓						
Testing laboratories/services	✓							
Third parties								✓
Trade associations			✓					
Utilities								✓
Warranty companies							✓	
Wholesale/retail trade/supply				✓				

Note that an individual stakeholder may be associated with more than one stakeholder group. For example, government agencies are associated with three stakeholder groups. If information on all types of stakeholders is desired, then proceed directly to 6.5. Otherwise, review the types of individual stakeholders to determine which one (or ones) is (are) appropriate. Either Table 1 or Table 2 may be used to select which type(s) of individual stakeholder(s) is (are) appropriate. Use whichever table is most convenient for the application under analysis to select the individual stakeholder(s). Table 1 is presented as a hierarchy to show how the stakeholder groups are formed. Table 2 lists the types of individual stakeholders in alphabetical order to facilitate cross-referencing of individual stakeholders and stakeholder groups. Based on the selected individual stakeholder(s), use Table 2 to produce a list of the corresponding stakeholder group(s).

6.5 Identify Key Types of Benefits and Costs—Refer to Tables 3-5 to identify the key types of benefits and costs. Follow the procedure described in 6.5.1-6.5.3 to compile a composite list of benefits and a composite list of costs. Each composite list results in those benefits or costs which are relevant for the selected performance attribute(s) and the identified stakeholder group(s). Any benefits or costs which do not appear on a composite list may be excluded from the economic evaluation.

6.5.1 Match Benefits and Costs to the Selected Performance Attribute(s)—Table 3 is arranged by performance attribute; it lists key types of benefits by performance attribute. Because each type of cost applies to all performance attributes, a separate table listing key types of costs by performance attribute is not necessary. For the selected attribute(s), extract from Table 3 a list of the key types of benefits. Note that Table 3 combines information—key types of benefits—on all stakeholder groups. If information on all stakeholders is desired, it is sufficient to use only Table 3 to identify the key types of benefits. Otherwise, it is necessary to use all three tables to identify the key types of benefits and costs.

6.5.2 Match Benefits and Costs to the Identified Stakeholder Group(s)—Tables 4 and 5 are arranged by stakeholder group. Table 4 lists key types of benefits by stakeholder group; Table 5 lists key types of costs by stakeholder group. If information on only a single stakeholder group is desired, then select the appropriate column in each table, go down the column, and extract from it a list of the relevant types of benefits (Table 4) and the relevant types of costs (Table 5) for the stakeholder group. If information on more than one stakeholder group is desired, then follow the procedure just described for each stakeholder group. Combine each stakeholder group list into two lists: one for key types of benefits and one for key types of costs.

TABLE 3 Types of Benefits and Cost Savings Classified by Performance Attribute

Type of Benefit or Cost Saving	Performance Attribute														
	Structural Safety and Serviceability	Fire Safety	Accident Safety	Health and Hygiene	Indoor Air Quality	Light	Acoustics	Durability	Accessibility	Security	Functionality	Aesthetics	Adaptability	Maintainability	Sustainability
Exceeds minimum acceptable performance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Improvements in health, safety, and security	✓	✓	✓	✓	✓		✓	✓		✓					
Increased occupant comfort					✓	✓	✓	✓							
Increased sales for building materials/products manufacturers	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Increased sales for systems design/integration/optimization services	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lower conversion costs											✓		✓		
Lower energy costs					✓	✓	✓	✓			✓			✓	
Lower first costs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lower operations and maintenance costs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Promotes innovation in the construction industry	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reductions in warranty costs								✓			✓			✓	
Reductions in waste and pollution								✓			✓			✓	✓

TABLE 4 Types of Benefits and Cost Savings Classified by Stakeholder Group

Type of Benefit or Cost Saving	Stakeholder Group							
	Product Development and Testing	Codes, Standards, and Support Services	Manufacturing Interest Group	Construction and Associated Support Services	Owners/Managers/Developers/Users	Professional Services	Financial Services	Other
Exceeds minimum acceptable performance				✓	✓	✓	✓	✓
Improvements in health, safety, and security				✓	✓	✓	✓	✓
Increased occupant comfort					✓			✓
Increased sales for building materials/products manufacturers	✓	✓	✓	✓	✓	✓		✓
Increased sales for systems design/integration/optimization services	✓		✓		✓	✓		
Lower conversion costs				✓	✓	✓	✓	
Lower energy costs			✓		✓	✓	✓	✓
Lower first costs				✓	✓	✓	✓	
Lower operations and maintenance costs					✓		✓	
Promotes innovation in the construction industry	✓	✓	✓	✓	✓	✓	✓	✓
Reductions in warranty costs			✓	✓	✓		✓	
Reductions in waste and pollution			✓	✓	✓			✓

6.5.3 *Compile Composite List of Benefits and Costs*—Compare the list of the key types of benefits extracted from Table 3 with the list of benefits extracted from Table 4. Keep only those benefits which appear on both lists. Finally, produce two composite lists: one list for key types of benefits and one list for key types of costs.

6.6 *Identify and Collect Economic Data*—Refer to Appendix X1 for benefits and Appendix X2 for costs to identify the

economic data associated with the key types of benefits and costs for the selected attribute(s) and the identified stakeholder group(s). Produce two lists of economic data: one list for the key types of benefits identified and one list for the key types of costs identified. Finally, collect the data and compile them in a form suitable for analysis.

6.7 *Review the Standard Practice Associated with the Economic Method*—Examine Practices B9.1 and B9.2 in the

TABLE 5 Types of Cost Increases and Benefit Reductions Classified by Stakeholder Group

Type of Cost Increase or Benefit Reduction	Stakeholder Group							
	Product Development and Testing	Codes, Standards, and Support Services	Manufacturing Interest Group	Construction and Associated Support Services	Owners/Managers/Developers/Users	Professional Services	Financial Services	Other
Increased costs of adapting new construction technologies, products, equipment, and practices to industry use	✓	✓	✓	✓	✓	✓		
Increased costs for new standards development	✓	✓	✓			✓		✓
Increased investments/ expenditures by building materials/ products manufacturers	✓		✓					✓
Increased risk exposure and uncertainty due to construction with new technologies, products, equipment, or practices	✓		✓	✓	✓	✓	✓	
Reduced sales of traditional “prescriptive-oriented” building materials/products lines and associated services			✓	✓	✓	✓		✓

which corresponds to the chosen economic method. In the selected practice, read the sections on significance and use, applications, and limitations. If the practice still seems appropriate, follow its procedures. If not, repeat the process until an acceptable practice has been found or it has been determined that neither of the practices is suitable for the decision at hand.

6.8 Calculate the Economic Performance Values for Each Alternative—For assistance in calculating the measure of economic performance provided by the selected method, use the three adjuncts. The adjunct on Discount Factor Tables supports manual calculations for the LCC method. The ASTM Database Program also supports the LCC method; it helps you estimate maintenance, repair, and replacement data. In addition, the Building Life-Cycle Cost Computer Program and User’s Guide⁵ supports the LCC method. For AHP calculations, use the AHP/Expert Choice for ASTM Building Evaluation software product⁶ or similar commercially avail-

able software. Set up the decision problem so that the alternatives may be ranked in descending order according to their final overall desirability score.

6.9 Evaluate the Economic Performance of Each Alternative—If the LCC method is being used, select the alternative which satisfies the performance statements of the attribute(s) in question and minimizes life-cycle cost over the proposed study period. If the AHP method is being used, select the alternative which maximizes the “final overall desirability” score while satisfying the performance statements of the selected attribute(s).

7. Keywords

7.1 analytical hierarchy process; building design; building economics; building materials; building systems; cost analysis; discounting; durability; economic analysis; economic evaluation methods; engineering economics; housing; investment analysis; life-cycle costing; multiattribute decision analysis; operations research methods; performance criteria; present-value analysis; residential dwellings

⁵ Petersen, S.R., 1995.

⁶ Chapman, R.E., Marshall, H.E., and Forman, E.H., 1998.

APPENDIXES

(Nonmandatory Information)

X1. CLASSIFICATION OF COST SAVINGS AND OTHER BENEFITS FOR SINGLE-FAMILY ATTACHED AND DETACHED DWELLINGS

X1.1 Background

X1.1.1 Use this classification to identify the economic data associated with the key types of cost savings and other benefits. This classification is presented as a hierarchy with three levels. The hierarchy incorporates an alphanumeric designation for the

classification: a single letter for Level 1, a three character alphanumeric code for Level 2, and a five character alphanumeric for Level 3. Each Level 1 element corresponds to a specific entry in **Tables 3 and 4**. These entries appear under the column heading Type of Benefit or Cost Saving. To facilitate