USER'S GUIDE TO AHP/EXPERT CHOICE® FOR

ASTM BUILDING EVALUATION

Robert E. Chapman
Harold E. Marshall
Editors

Ernest H. Forman
Software Developer

EXPERT™ CHOICE INC.

User's Guide to AHP/Expert Choice® for ASTM Building Evaluation

Software to Support ASTM
E 1765: Standard Practice for
Applying Analytical Hierarchy Process
(AHP) to Multiattribute Decision
Analysis of Investments Related to
Buildings and Building Systems

Robert E. Chapman and Harold E. Marshall, editors

Ernest H. Forman, software developer

Software Package in Support of ASTM E 1765
Software License Agreement

SYSTEM REQUIREMENTS

- IBM or IBM compatible PC (preferable 486-25SX or above)
- Hard disk storage of at least 10 Mbytes
- Windows 3.1 or later; Windows NT 4.51
- Monitor (VGA Color)
- Printer - any line printer
- Mouse (optional)

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Foreword

Manual 29, *User's Guide to AHP/Expert Choice® for ASTM Building Evaluation,* was sponsored by ASTM Committee E06 on Performance of Buildings and by Expert Choice, Inc.

Note: Manual 29 is designed for use in conjunction with ASTM Standard Practice for Applying Analytical Hierarchy Process (AHP) to Multiattribute Decision Analysis of Investments Related to Buildings and Building Systems (E 1765).
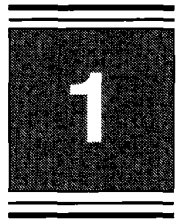
Preface

This software product supports the application of ASTM's AHP (Analytical Hierarchy Process) standard practice (E 1765) for performing multiattribute decision analysis in the evaluation of buildings and building systems. The commercial software product Expert Choice®, on which it is based, has been modified in three ways to customize it for building applications. First, the customized version includes a comprehensive list of building-related attributes (developed in ASTM Subcommittees E06.25 and E06.81) in a glossary from which users can select attributes of interest when evaluating their building decision. The software provides a model-building feature that allows the user to "slice" away those attributes not wanted to create a model of remaining attributes that best represent the user's unique problem. The software is quite flexible in that any attributes important to the user, whether or not they are included in the building-related attribute glossary, can be added to the model structure.

A second unique feature of the ASTM version of Expert Choice® is an application example in the documentation that illustrates how to create a model structure of a building-related problem. It also shows how to use the AHP method to select the best alternative for the user. In the case illustration, a private company uses the software to evaluate alternative commercial properties to find the best property for a new headquarters building. Note that the general documentation of Expert Choice® also has building-related case examples. One is in the tutorial booklet that leads the decision maker through the decision process of selecting the best retail site for a new ice cream outlet. The second is in Chapter 9, "Introduction to Modeling," of the *EC Pro for Windows—Decision Support Software: User Manual,* where the choice between an apartment, old house, and new house is modeled with respect to 13 attributes or criteria.

The third feature that distinguishes the ASTM software product is this user's guide that explains in detail the building-related features of the software. For help in understanding the Expert Choice® software in general, see the general documentation on Expert Choice®.

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AHP in Building-Related Decisions

What is AHP?

The analytical hierarchy process (AHP) is a decision analysis method that considers non-monetary attributes (qualitative and quantitative) in addition to common economic evaluation measures (such as life-cycle costing or profits) when evaluating project alternatives. The hierarchy arranges project alternatives and attributes (also called objectives or criteria) in such a way that the decision maker can logically and consistently evaluate all of the alternatives in a complex decision problem. Furthermore, it presents the user with a single combined score for each alternative. That score can be used to select the best alternative.

How Does It Apply in Building-Related Decisions?

Building-related decisions depend in part on how competing options perform with respect to non-monetary attributes. The choice of building roofing materials, for example, depends on environmental impacts as well as on traditional cost considerations. The material choice is difficult because improving performance in one attribute, say cost, typically reduces performance in another, in this case, environmental impacts. The AHP helps the decision maker integrate the roof's life-cycle cost performance with indexes of environmental performance to choose the optimum material that best balances the decision maker's requirements for economy and environmental protection.

What This Guide Provides

This *User's Guide* does three principal things. First, it provides examples of typical applications of AHP in evaluating building-related choices. It defines four types of building-related decisions and provides AHP models of each.

Second, it presents a comprehensive glossary of building attributes drawn from ASTM's serviceability standards that describe the features of

commercial buildings that building users find most important. It also explains how to use the model building feature of the program to quickly construct from this comprehensive list of building attributes, and any other attributes identified by the user, a customized model that represents the decision maker's objective function.

Third, the *User's Guide* illustrates step-by-step an AHP application in making a building-related decision using the ASTM AHP/Expert Choice® software product.

The following steps are provided to help you install the software product on your computer.

1. Make sure that you have Windows, version 3.1 or later, already installed on your computer. If Windows is not installed, run the Setup program for Windows before trying to install the software product.
2. Start Windows. If you are running Windows version 3.x, select File then Run from the Program Manager menu. Put the software medium in the appropriate drive. In the Command Line box, type #:setup, where # is the appropriate drive for the software medium. If you are running Windows 95, follow the same procedure except select Start (from the lower left-hand corner of your screen), then Run to begin.

This will begin the installation program for the software product. Follow the instructions on the screen. It will take several minutes to complete the installation, depending on the speed of your computer. You may quit Setup at any time. For more detailed advice on how to install and run the ASTM AHP/Expert Choice® software product, see the *EC Pro for Windows User Manual.*[1]

Note: When entering your name, you cannot begin with a number or character other than a letter. The default directories are C:\ASTM__EC for the program files, and C:\ASTM__EC\SAMPLES for sample models. It is recommended that you create a directory (e.g., C:\ASTM__EC\MODELS) for models that you create or modify. You can use these directories, or specify your own, but we recommend that you keep your models in a separate directory from the program files or sample models.

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[1]Expert Choice, Inc. 1995. *EC Pro for Windows-Decision Support Software: User Manual.* Pittsburgh, PA: Expert Choice, Inc.

Typical Applications of
the Software

There are four common types of AHP building-related choice decisions:

(1) Choosing among buildings,
(2) Choosing among building components or elements,
(3) Choosing among building materials, and
(4) Choosing among locations.

The following examples illustrate for these four decision types how to identify the goal, select attributes and alternatives, and display them in a hierarchy for AHP evaluation.[2]

(1) Choosing Among Buildings

Selecting the Best Residence

A real estate company specializing in residential properties helps clients select the "best" match between their individual housing wants and what is available on the multiple listing. An out-of-town client on a two-day house search comes to the real estate office and asks to be shown houses. The client wants a four-bedroom, three-bath, traditional home with two-car garage in the suburbs that is reasonably accessible to a commuter train station on route to the central business district. The client wants a highly respectable, safe neighborhood, and is willing to pay up to $200,000 for the house. An important consideration to the client is the quality of the public schools. The goal is to find the best house for the client.

An AHP analysis is appropriate here in two stages. First, the real estate salesperson helps the client select that set of houses to visit. The client identifies significant attributes to the building serviceability (number of rooms and baths, capacity of garage); aesthetics (tastefully designed traditional home); location (accessibility to commuter station, desirability of neighborhood, proximity of good public schools); security; and economics (budget constraint). Figure 1 displays the hierarchy of attributes. The house-hunting client visits the houses with the highest AHP scores.

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[2]Throughout this section, alternatives are shown in the figures as dashed lines emanating from the lowest level attribute in the hierarchy.
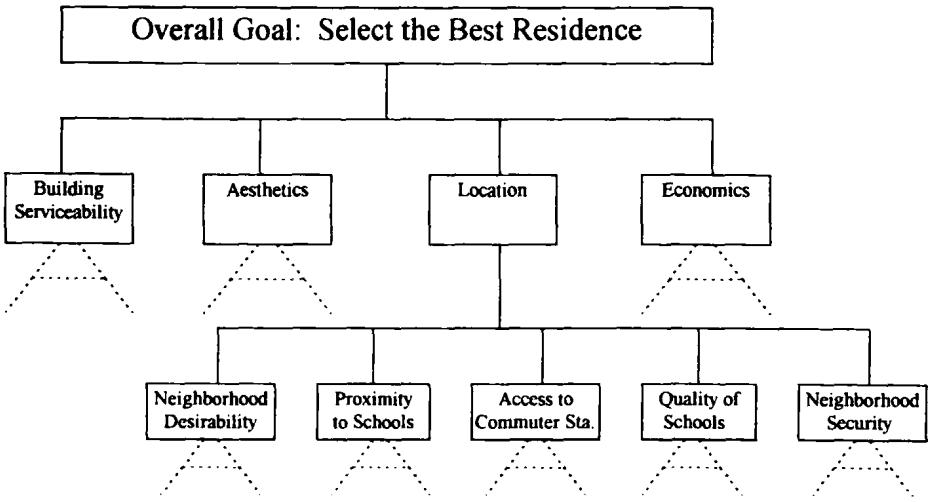
FIG. 1—*An example hierarchy for the problem of selecting a residence.*

The real estate salesperson does the AHP analysis a second time once the client has seen the selected houses and has additional information. An AHP analysis with a graphical presentation of the score of each house helps satisfy home buyers that they are selecting the house that is best for them.

(2) Choosing Among Building Components or Elements

Retrofitting an Existing Heating and Cooling System

A trade association representing the heating and cooling equipment industry is choosing among three high-technology systems for retrofitting its office building. It wants to show the state of the art in its choice of equipment components, but at the same time it does not want to appear to its constituency as being uneconomic in its choice of a heating and cooling system. Furthermore, the association does not want the equipment to impair
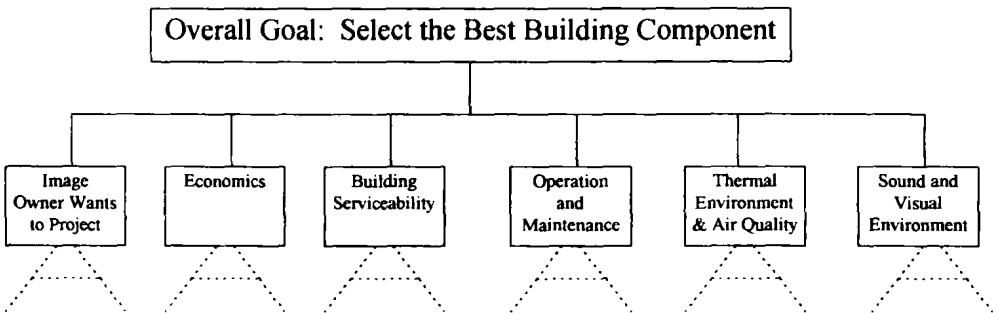

FIG. 2—*An example hierarchy for the problem of selecting a building component.*

the existing successful operation and maintenance of the building. The goal is to identify the best alternative among the candidate systems.

The association selects several attributes in evaluating the systems. In seeking to show the state of the art in equipment, the association acknowledges that image to the owner is important. Economics was also pointed out. Maintaining successful building functions, smooth operation and maintenance, a high level of thermal environment and air quality, and a high standard of sound and visual environment are also important. Figure 2 displays a hierarchy made up of these attributes.

(3) Choosing Among Building Materials
Selecting Environmentally Friendly Building Materials

An architect is working with clients to select materials for a large office building. The clients tell the architect that they want a building made from materials that are friendly to the environment. The clients qualify their specifications, however, to say that they do not want the building's functions to be compromised by the design or choice of materials. They go on to say that, while they are willing to spend more money on materials to achieve a "green building," cost is still a consideration. The architect decides to use AHP to help the clients satisfy their goal of choosing the materials that best satisfy their overall needs. Figure 3 displays a hierarchy made up of the attributes that the clients identified: environmental impacts, economics, building serviceability, and operation and maintenance.

(4) Choosing Among Locations
Selecting the Site for a New Manufacturing Plant

A large corporation is seeking the best location in the U.S. for a new manufacturing plant. The search committee is seeking an area where there will be a continuing, abundant, sufficiently educated labor pool to staff an
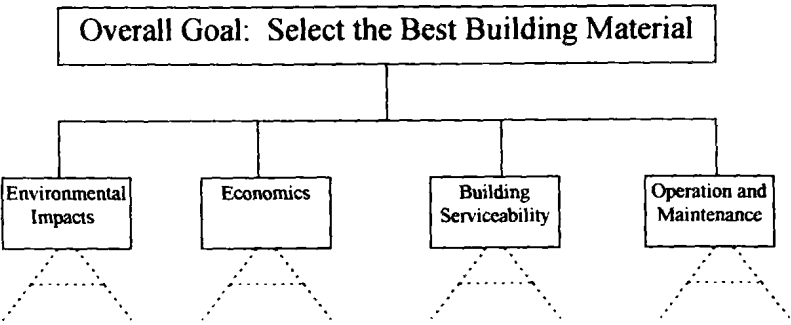

FIG. 3—*An example hierarchy for the problem of selecting a building material.*
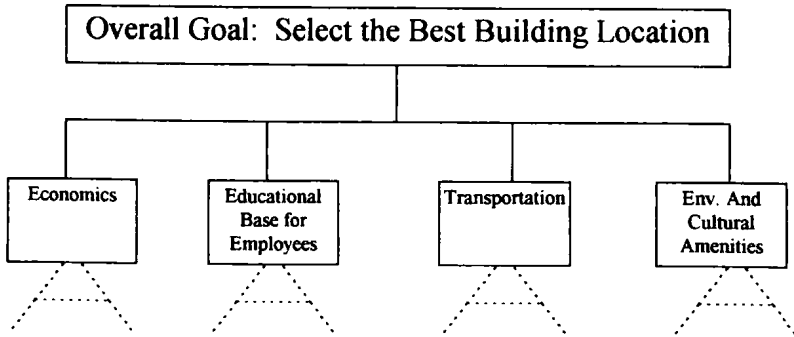
Overall Goal: Select the Best Building Location

Economics	Educational Base for Employees	Transportation	Env. And Cultural Amenities

FIG. 4—*An example hierarchy for the problem of selecting a building location.*

assembly line employing state-of-the-art technology. The company is look-ing for an area where the demand for labor is low, the community will offer incentives to a new company, new hires are expected to be loyal to the company, and where management can likely operate a non-union plant. Convenient and centrally located transportation nodes are also important. The major objective is to hold down costs and remain competitive with foreign manufacturers. Environmental and cultural amenities are also im-portant, however, to attract a high quality management team.

The search committee uses AHP to find the best location. It identifies four attributes: economics (hold down costs to remain competitive); educa-tional base for employees (ability to work in state-of-the-art factory); trans-portation (efficiently moving raw materials in and finished product out); and environmental and cultural amenities. The committee structures their location choice problem as shown in Figure 4.

Unique Features of the Building-Related AHP Software Package

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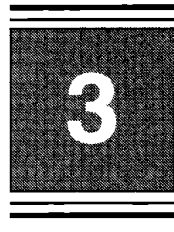
The ASTM AHP/Expert Choice® software product and documentation differ from their general commercial counterparts in three ways:

Supports ASTM's AHP Standard Practice

First, the package directly supports the ASTM (American Society for Testing and Materials) "Standard Practice for Applying Analytical Hierarchy Process (AHP) to Multiattribute Decision Analysis of Investments Related to Buildings and Building Systems," ASTM Standard E 1765.[3] That is, the AHP approach followed in the software is completely consistent with the approach described in the standard practice. In fact, this software package was adapted from the commercial version of Expert Choice®[4] for the specific purpose of supporting implementation of the ASTM AHP standard practice.

Focuses on Building-Related Decisions

Second, the package provides examples of AHP applications encountered in building decision making. An extensive case illustration of a building problem evaluated with AHP is given in the software and documentation. The "Typical Applications Section" provided earlier explains a variety of building contexts in which the AHP is helpful. And the "Ice Cream Store" example in the "Decision Support Software: Tutorial"[5] is a good example of how to apply the AHP to the frequently-made building decision of where to locate.

[3]American Society for Testing and Materials (ASTM). 1995. Standard Practice for Applying Analytical Hierarchy Process (AHP) to Multiattribute Decision Analysis of Investments Related to Buildings and Building Systems. E 1765. West Conshohocken, PA: American Society for Testing and Materials.
[4]Expert Choice, Inc. 1995. *EC Pro for Windows-Decision Support Software: User Manual* Decision Pittsburgh, PA: Expert Choice, Inc.
[5]Expert Choice, Inc. 1995. *EC Pro for Windows-Decision Support Software: Tutorial.* Pittsburgh, PA: Expert Choice, Inc.

Comprehensive Glossary of Building Attributes

Third, a model-building feature of the software is coupled with a comprehensive glossary of office building attributes, the ASTM model template, to facilitate the structuring of AHP models for evaluating building alternatives. These attributes, which are listed in the next section, come from the set of ASTM classification standards for the serviceability of an office facility. The special model-building feature of this software allows the user to ''slice'' away those attributes not wanted to create a model of remaining attributes that best represent decision makers' interests. Note, however, that the model building feature is not restricted to the set of attributes provided in the ASTM model template. The user can customize the model structure by simply typing in any attributes of concern. The ASTM model template is provided only as an aid to fast model building where the attributes are relevant.