BUILDING PERFORMANCE DATABASE

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SYNOPSIS

The Building Performance Database (BPD) is an on line collection of information which allows researchers to consolidate large amounts of data from single or multiple buildings regarding such parameters as building materials, energy use, ventilation, lighting, acoustics, pollutant levels, and reported effects on the health and comfort of occupants. BPD provides architects, engineers, epidemiologists, hygienists, and building scientists with an interactive archival and analytical tool for research into building performance. The Database is intended as a clearing house for information on and research into effects of the multitude of variables that impact on each other in buildings with the aim of improved building design. Widespread use should open the lines of communication between engineers, designers and managers and focus on the most needed building performance research.

Here we describe the structure and content of the Database, and give examples of investigations and analyses users can perform.

INTRODUCTION

The Building Performance Database (BPD) is an open ended Database derived from a large number of studies on the performance of office, commercial, institutional, and residential buildings. Some of these buildings were studied in response to occupant complaints; others, as part of ongoing investigations into occupant health and comfort, the quality of indoor environments and the performance of buildings in general. Investigations were conducted by public agencies such as the National Institute for Occupational Safety and Health, the Center for Disease Control, the Department of Energy, Public Works Canada, as well as by investigator teams from universities and private organizations. Relevant data were extracted from each report and entered into BPD. The Database now contains nearly 300 reports, however, new studies are being added as reports become available.

CONTENT AND ANALYTICAL CAPABILITIES

BPD contains hundreds of items of information related to building performance. Some examples are:

1. Bibliographic information describing the organization(s) conducting or sponsoring the study, names of the investigators involved, and complete references to the reports and published work from which information was obtained.
2. Research report briefs including information on where to find the report, summaries, descriptions of the initial motives for the study, conclusions, and recommendations.
3. Architectural and engineering data giving detailed descriptions of the buildings, their environmental service systems, as well as the equipment and materials in them.
4. Macro and micro geographic data.
5. Environmental measurements, e.g. ventilation, temperature, humidity, lighting, acoustics, types and concentrations of pollutants, as well as information on measurement methodology and equipment used.
6. Occupant health information recorded using International Classification of Disease (ICD) codes.
7. Results of investigating factors relating to occupant comfort.

The Database is maintained on the Simon

Fraser University mainframe computing system and is accessed via the Multiple Attribute Retrieval System (MARS). MARS is a general system to store, organize, describe, manipulate and analyze information. (TDS, 1984)

Information in the Database is stored in files and described in terms of attributes. Data may be retrieved according to some specific criterion or combination of criteria and either listed on a terminal or placed in files or arrays on which a variety of manipulations may be performed and to which various types of multivariate analyses may be applied. Some examples of these capabilities are:

1. Any item or items in the Database may be quickly retrieved and listed at the user's terminal or on a printer.

2. Multidimensional cross tabulations of any attribute variables can be displayed in report form.

3. Multiplicative models may be fit to contingency tables to test for main effects and interactions among variables.

4. The frequency with which any combination of attribute variables occurs may be counted.

5. Data may be extracted from the on line Database, placed into user files, and used as input to data analysis and graphing packages (such as BMPD and TELLAGRAF).

DATABASE STRUCTURE

BPD contains information representing various types of entities. Examples of entities are: a building, a measurement of a pollutant, or a specification of a health complaint. Of course, different types of entities require different descriptions. To cope with this diversity, the Database consists of several logical collections of data called files. A file contains a number of records, each of which corresponds to a specific instance of the entity represented in that file. In turn, each record contains a set of variables whose values collectively describe the entity represented by that record. Figure 1 summarizes the set of files of which BPD is composed and their relationships. The eight files of which BPD is composed are: REPORT, FACILITY, MODULE, AREA, DATA, ENVIRON, HEALTH and COMFORT.

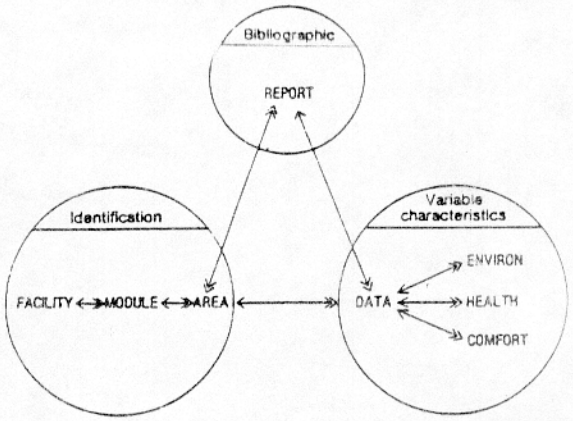

Figure 1. Overview of BPD Structure

The REPORT File

Studies and research usually culminate in a published report. BPD reflects this by making the report the source of all data. Each distinct report from which information was obtained is detailed in a separate REPORT record; thus, the set of all REPORT records is the REPORT file. Each REPORT record consists of a number of variables containing information which describes, for example, what the study is about, the investigators, summary findings, and recommendations.

Location Files: FACILITY, MODULE, and AREA

BPD represents the actual locations studied using a three level hierarchy of files: FACILITY, MODULE, and AREA.

FACILITY. The facility is the largest physical aggregation of buildings in the Database. It can be a university, a hospital, a corner store, a shopping centre, an office tower complex, or any other group of one or more related structures. The FACILITY file contains one record for each different facility reported upon. The variables within each FACILITY record contain geographic, climatic, and other environmental setting information which has been drawn from the corresponding report(s).

MODULE. The next largest level of aggregation is the module. A module is a subunit of a facility, for example, a single building within a university, a wing of a hospital, or a store in a shopping centre. The relationship between facilities and modules is one to

many, i.e., a facility may consist of many modules, but a module is within only one facility. For example, J.C. Penny and the Bon Marche could be separate modules in a shopping centre facility. The shopping centre may contain many stores, but each specific store can be in only one shopping centre. The variables in each MODULE record contain architectural and structural data, as well as information specifying how the module is linked to its facility.

AREA. An area is a specific region within a module in which an investigation was conducted. Each AREA record contains detailed information on the physical environment. Typical examples of areas are an individual ward within a hospital and an office within an office building. An area may be as large as an entire building or as small as a single room. The relationship between modules and areas is one to many, e.g., a hospital contains many wards, but a ward can only be in one hospital.

Investigation Files: DATA, ENVIRON, HEALTH, and COMFORT

The actual measurements recorded by a study are contained in four files: DATA, ENVIRON, HEALTH, and COMFORT.

DATA. Each record in the DATA file can be considered as representing the results of an experiment. An experiment is an investigation conducted within an area which generated measurements and/or observations. For example, an experiment could include measurements of several pollutants, measurements of various ventilation parameters, and some health and comfort surveys. One DATA record exists for each experiment.

ENVIRON. The ENVIRON file contains measurements of all types of environmental attributes including temperature, humidity, noise, illumination, ventilation levels, and types and concentrations of pollutants. Information about the equipment used to gather observations and other background information regarding the experimental setting are also included.

HEALTH. The HEALTH file contains the results of health surveys, questionnaires, or reports of health complaints made by the occupants of the area. A DATA record may refer to many HEALTH records. For example, if a study investigates complaints of eye irritation, sore throat, and dizziness, surveys of all three conditions might be undertaken. The results of each survey will be recorded in separate HEALTH records and these records will all be linked to the same DATA record.

COMFORT. The COMFORT file contains data on environmental complaints recorded during the investigation and is constructed similarly to the HEALTH file.

Summary of File Linkages

1. Each FACILITY record refers to one or more MODULE records, while each MODULE record refers to exactly one FACILITY record.

2. Each MODULE record refers to one or more AREA records, while each AREA record refers to exactly one MODULE record.

3. Each AREA record refers to one or more REPORT records, while each REPORT record refers to one or more AREA records. This is called a many to many relationship.

4. Each REPORT record file refers to one or more DATA records, but each DATA record refers to exactly one REPORT record.

5. Each DATA record refers to only one AREA record, but an AREA record may refer to more than one DATA record.

6. Each DATA record refers to zero or more records in each of the ENVIRON, HEALTH or COMFORT files, however, each ENVIRON, HEALTH, or COMFORT record refers to exactly one DATA record.

These relationships are shown in figure 1 by the arrows connecting the file names. A single arrowhead is the one and the double arrowhead the many in a one to many relationship.

SAMPLE APPLICATIONS

In the following examples the actual command language has been omitted.*

*While here is not the place for discussions of occupational problems and their solutions, we do draw attention to the fact that the command structure for manipulating the database is not user friendly, in the conventional sense this idea is understood. The complexity of the database of BPD, coupled with the need for a large number of different manipulations coupled with the need to keep instruction length short and manageable, coupled with other practical requirements, requires in the end a language structure that uses many acronyms and a relatively complex syntax for statements. In short, the language with which BPD is manipulated has to be learned and, in fact, requires some experience in computing. Individuals or

Sample 1: From General to Particular

A user interested in the performance of hospital facilities may first wish to know which hospitals have been studied and reported upon in BPD?

Given the proper commands, the system would respond:

MODULE RECORD 7:

MNAME = Beth Israel Hospital

MODULE RECORD 47:

MNAME = Beth Israel Hospital

MODULE RECORD 51:

MNAME = Ellis Hospital

etc.

Next the user would want to find out in which hospitals were the anaesthetic gases nitrous oxide and halothane measured?

Given the proper commands, the system would respond:

MODULE RECORD 63:

MNAME = Boulder Memorial Hospital

MODULE RECORD 64:

MNAME = Porter Memorial Hospital

etc.

What complaints led to these investigations being conducted?

Given the proper commands, the system would respond:

HEALTH RECORD 362:

HCOMP = 784 -- Headache

HEALTH RECORD 363:

HCOMP = 780.4 -- Dizziness and giddiness

etc.

What other pollutants besides anaesthetic gases were measured in these hospitals?

Response:

ENVIRON RECORD 480:

QTY: ENF -- Enflurane

ENVIRON RECORD 487:

QTY: ETR -- Ethane

etc.

How many N_2O measurements were taken in these hospitals and what was the mean and standard deviation?

Response:

6 mean = 35.7 std = 26.7136

Which hospitals had measurements of N_2O exceeding one standard deviation from the mean?

Response:

MODULE RECORD 63:

MNAME - Boulder Memorial Hospital

What were the report's comments regarding this module?

Response:

REPORT RECORD 57:

SREQ = Request by hospital administration

CAUSECOMP = No complaints - Study found inadequate exhaust of gases, consequently worker exposure was greater than necessary.

RECOMMEND = (1) Install non-recirculating air conditioning system, (2) Educate staff on potential hazards, (3) Set up air monitoring program, (4) Improve workpractices

GCOMM = Study instigated through concern over danger of exposure to anaesthetic gases.

Sample 2: Preparing a Tabulation

A table comparing levels of CO_2 and cfm/person (total air supply) can be constructed (to determine perhaps, the effect of ventilation on indoor levels of CO_2). However, before proceeding some additional information is needed to construct the table properly.

What is the range, mean and standard deviation for total air supply in cfm?

Given the proper commands, the system would respond:

23 cfm summary: min = 12.2 mean = 118.261 std = 108.071 max = 389

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organizations wishing to use BPD will have to be able to manage BPD's command language or obtain, or assign, qualified help to do so.

What is the range, mean, and standard deviation for CO_2 in ppm?

Response:

58 CO_2 summary: min = -2 mean = 544.366
std = 375.34 max = 1437.5

Now the user may decide to construct a table to show the relationship between different levels of CO_2 and total air supply. Here the commands could state the ranges of values of CO_2 and total air supplies that are to be grouped for constructing a two dimensional table, cross tabulating CO_2 concentrations in ranges of 0-399, 400-799, and 800 or greater (ppm) along the vertical axis with total air supply in ranges of 0-149, 150-299 and 300 or greater (cfm) along the horizontal axis..

CO_2 concentration (ppm) vs total air supply per person (cfm)

CFM / CO_2	0-149	150-299	300+
0-399	4	1	0
ROW %	80.00	20.00	0.00
COL %	30.77	12.50	0.00
400-799	6	6	1
ROW %	46.15	46.15	7.69
COL %	46.15	75.00	100.00
800+	3	1	0
ROW %	75.00	25.00	0.00
COL %	23.08	12.50	0.00

Note that in addition to the frequency the display shows row and column percentages.

DISCUSSION

By learning a small set of commands and the basic structure of the Database users may search for significant relationships, locate reports which deal with building performance problems similar to those they regularly face, and determine what other studies of interest have been done. In short, BPD provides a tool to enable technical and scientific design professionals to investigate relationships between such variables as indoor air quality and ventilation that impact building performance. Documentation necessary to use BPD consists of the Annotated Dictionary, User's Guide and Mars Manual (see bibliography). To obtain documentation and further information write to BPD/Theodor D. Sterling Ltd., #70 - 1507 W. 12th Avenue, Vancouver, B.C., Canada V6J 2E2 or telephone (604) 733-2701.

BIBLIOGRAPHY

1. Salisbury, Richard A., general editor; MTS The Michigan Terminal System, Volume 1: The Michigan Terminal System; Simon Fraser University Computing Centre, Burnaby, B.C., January 1983.

2. TDS (Theodor D. Sterling Ltd.), The Building Performance Database: User's Guide; Theodor D. Sterling Ltd., #70 - 1507 W. 12th Avenue Vancouver, B.C., 1984.

3. TDS (Theodor D. Sterling Ltd.), The Building Performance Database: Annotated Dictionary; Theodor D. Sterling Ltd., #70 - 1507 W. 12th Avenue, Vancouver, B.C., 1984.

4. TDS (Theodor D. Sterling Ltd.), MARS: A Multiple Attribute Retrieval System: Reference Manual; Weinkam Consultants, Inc. and Theodor D. Sterling Ltd., 1984.