# THE BUILDING PERFORMANCE DATABASE: AN ANALYTICAL TOOL FOR INDOOR AIR QUALITY RESEARCH

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## Abstract

The Building Performance Database (BPD) is an on-line collection of information which allows researchers to consolidate and search through large amounts of data from single or multiple buildings regarding such parameters as building materials, energy use, ventilation, lighting, acoustics, indoor air 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 indoor air quality and building performance.

## 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. Other buildings were studied 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 U.S. National Institute for Occupational Safety and Health, the Centers for Disease Control, Public Works Canada, as well as by investigator teams from universities and private organizations. Relevant data were extracted from each report and entered into the BPD.

The BPD currently contains 230 reports, covering 261 separate buildings and 434 specific study areas, including data from 2,179 measurements of 189 different chemical contaminants and 323 measurements of 11 different ventilation parameters. New studies are continually being sought and added as they become available.

## Content of the Database

The 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, for example 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 accessed via the Multiple Attribute Retrieval System (MARS), which is an interactive system designed to store, organize, describe, manipulate and analyze information (1). A users guide and data dictionary are available upon request to the principal author (2,3).

## Analytical Capabilities

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. For example, studies in which carbon monoxide concentrations exceeded 5 ppm may be listed by using a simple, short command.

2. Cross tabulations of variables can be displayed. For example, a table showing the joint distribution of carbon dioxide and formaldehyde levels in office buildings.

3. The frequency with which a single variable or any combination of variables occurs may be counted. For example, the number of office buildings where eye irritation complaints were reported.

4. 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 BMDP and TELLAGRAF.

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

## 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. 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 One 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.

### Bibliographic File: REPORT

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 is the largest physical aggregation of buildings in the Database. It can be a university, a hospital, 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 is the next largest level of aggregation. 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, two department stores 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 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, for example, 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.

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.

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.

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.

The COMFORT file contains data on environmental complaints recorded during the investigation and is constructed similarly to the HEALTH file. The relationships between files are shown in Figure One by the arrows connecting the files names. A single arrowhead is the one and the double arrowhead the many, in the one to many relationship.

## 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 completed. BPD provides a tool to enable technical and scientific design professionals to investigate relationships between indoor air quality, ventilation and other variables that impact building performance.

BPD is implemented on Simon Fraser University mainframe IBM computing facility in Burnaby, British Columbia and may be accessed through any international network, for example, DATAPAC in Canada and TELENET and TYMNET in the United States. Access and charges will be based on university computing center guidelines.

## References


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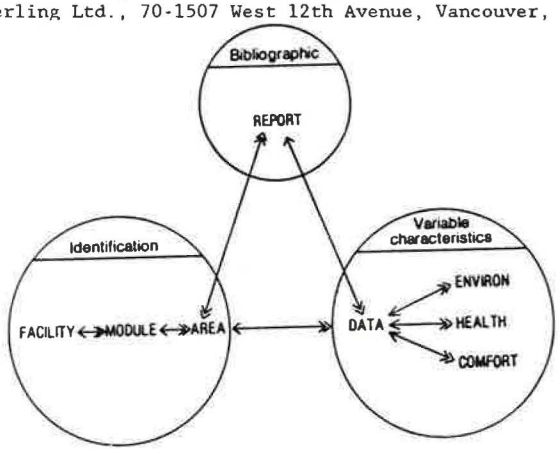


Fig. 1. File Structure of BPD



# THE SICK BUILDING SYNDROME FURTHER PREVALENCE STUDIES AND INVESTIGATION OF POSSIBLE CAUSES


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## Abstract


A total of 2587 white collar workers in 27 buildings participated in a study of building related symptoms - collectively referred to as "the sick building syndrome". Prevalences rates, obtained via a doctor-administered questionnaire, were significantly higher in buildings with sealed windows and differing ventilation systems compared to a naturally ventilated control group. There was, however, a significant variation in symptom prevalences within the control group. The results of air sampling in 2 buildings and analysis of V.D.U. usage in 2 buildings did not correlate with symptom prevalences in the buildings.


## Introduction

Finnegan et al (3) demonstrated a raised prevalence of work-related nasal, eye and throat symptoms, headache, lethargy and dry skin in sealed buildings with differing ventilation systems. This combination of symptoms has been found in similar buildings (4) and called "the sick building syndrome" (S.B.S.). This paper examines further the suggested relationship between method of ventilation and excess symptoms. Two possible causes of work related symptoms - airborne contaminants and visual display units (V.D.U.) - are assessed.

Method: Symptom and V.D.U. data was obtained via a doctor-administered modified M.R.C. questionnaire. Work related symptoms were defined as symptoms improving on a day away from work or over a weekend. For each building a sample of the total workforce was randomly selected, stratifying for place of work.

Particulate air sampling was performed using Air Sentinel and Staplex samplers over a 24 hour period. These instruments give the total weight of particles captured but not the size. Biological sampling was performed using an Andersen sampler. Bacterial plates were cultured at 15°C and 37°C and fungal plates