CONTAM93 A Multizone Airflow and Contaminant Dispersal Model with a Graphic User Interface

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Abstract

A new multizone airflow and contaminant dispersal program CONTAM93 is described. While this program is based on existing theory of network airflow analysis and contaminant dispersal, it employs a unique graphic interface for data input and display. The interface uses a sketchpad to describe the connections between zones and icons to represent zones, openings, ventilation system components, and contaminant sources and sinks. The program, its graphic interface and plans for its further development are described.

Introduction

Airflow rates in buildings are determined by the interaction of the building structure, its HVAC system, and weather conditions. Indoor pollutant concentrations depend on these airflow rates, pollutant source and sink characteristics, and outdoor concentrations. A whole-building, multizone approach, accounting for all of these factors, is required to study many important issues in building airflow and IAQ and has been implemented in many multizone airflow and IAQ models. A survey of multizone models, all of which provide at least some of the required modeling capabilities, is described by Feustel and Dieris (1). This paper describes a new multizone airflow and pollutant transport program CONTAM93 (2), which is the latest in the series of multizone IAQ modeling programs developed at the National Institute of Standards and Technology (NIST). The application of CONTAM93 in a residential IAQ modeling study was discussed at the 15th AIVC Conference (3).

CONTAM93 - General Description

CONTAM93 is an easily used contaminant analysis program combining the best available algorithms for modeling the airflow and contaminant dispersal in multizone buildings. It employs a graphic interface and is usable on commonly available small computers. Over the past several years, NIST has developed a series of public domain computer programs for calculating airflow and contaminant dispersal in multizone buildings. The earliest such program was ASCOS (Analysis of Smoke Control Systems) (4). Another program, TARP (Thermal Analysis Research Program) (5, 6), used multizone airflow calculations to estimate the portion of building thermal load due to infiltration and perform a simple contaminant migration analysis. Programs developed specifically for the study of contaminant dispersal included CONTAM86 (7) and CONTAM87 (8). NBSAVIS/CONTAM88 (9) added multizone airflow analysis capability, based on the program AIRMOV (10), and a menu-driven interface to CONTAM87. Improvements in the airflow calculation algorithm were implemented in the AIRNET program (11). CONTAM93 combines a new graphic interface with the contaminant simulation capabilities of CONTAM88 and the airflow analysis method of AIRNET.

CONTAM93 requires a 286-class (or higher) PC compatible computer with math coprocessor, VGA graphics, and MS-DOS. CONTAM93 consists of two programs: CONTAM and CONTAMX. CONTAMX is a non-interactive program which computes the airflows and/or contaminant concentrations in a building from information on the building, its HVAC system, ambient conditions, contaminant sources, and contaminant removal mechanisms. CONTAMX can perform steady-state, transient (up to 24 hour), and 24-hour cyclic simulations with a user specified time step. CONTAM is an interactive program for processing the required CONTAMX input and for displaying or exporting the CONTAMX output. Both CONTAM and CONTAMX operate under the 640K-byte memory limit of MS-DOS, which is sufficient for simulating buildings with several hundred zones and multiple contaminants.

Graphic Interface

When using CONTAM93, the user does not directly access the data files describing the building. All access to the building description is done through the CONTAM program and its graphic interface. The description of the building is created (or modified) in the SketchPad. The SketchPad consists of an invisible array of about 3600 small cells into which the user places various symbols representing building features relevant to the calculation of airflow and contaminant dispersal. This produces a simple illustration which has been chosen intentionally to represent the simplicity of the underlying mathematical model. The SketchPad is used to establish the geometric relationships of the relevant building features. It is not intended to produce a scale drawing of the building. Instead, it is used to create a simplified model where the walls, zones,

and airflow paths are topologically similar to the actual building. The SketchPad allows the entry and display of the data in an intuitive manner. The SketchPad brings up various data entry screens needed to define the mathematical characteristics of the various building features (e.g. leakage areas and contaminant source strengths). After performing the simulation, the flows and pressure drops at each opening are presented on the SketchPad. Transient contaminant concentrations can also be displayed as separate graphs.

The CONTAM93 SketchPad is designed to simplify the data input and analysis processes for a multi-zone airflow and contaminant dispersal simulation. It is still up to the user to decide how best to idealize the building as a multizone system based on the building layout and the objectives of the simulation. The user must also determine which contaminant dispersal processes are important and appropriate input values for the building being simulated. The required input values can be numerous and include the following: airtightness of exterior envelope and interior partition components, ventilation system airflow rates, wind pressure coefficients, ambient weather and contaminant concentrations, indoor contaminant source strengths and sink characteristics, contaminant reaction rates, and filter efficiencies. Values of these quantities can be determined from the published literature and field measurement.

Once the user has decided how to represent the building as a multizone system and has determined appropriate input values, the building data is entered into the SketchPad. Building data is organized by levels with data entry beginning at the lowest level. A level would typically be a building floor, but a suspended ceiling acting as a return air plenum or a raised floor acting as a supply plenum may also be treated as a level leading to multiple levels per floor. Each level is divided by walls into separate regions of uniform air temperature, pressure, and contaminant concentration called zones. Walls include the building envelope and internal partitions with a significant resistance to air flow, and are drawn as either horizontal or vertical lines. There is a set of implicit walls (generally floors) separating the zones on different levels. A default ambient zone surrounds the building. Other zones can be designated as ambient to represent, for example, a courtyard. An airflow path indicates some building feature by which air can move from one zone to another. Such features include cracks in the building envelope, open doorways, and exhaust fans. Path symbols placed on the walls are used to represent openings between zones or to ambient; any other placement represents an opening in the floor to the zone on the level below. Contaminant source (or sink) symbols may be placed in any zone. These represent any feature (within the list of available models) which produces or removes a contaminant. A simple model of an air handling system is available with supply and return point symbols placed within the appropriate zones. All supply and return airflows follow user defined schedules.

Figure 1 shows the floor plan of a ranch style house and Figure 2 shows the CONTAM93 SketchPad representation of this house. In this case the representation closely mimics the floor plan. Airflow paths are represented by the diamond-shaped symbols on the walls. The zone symbols are squares with x's inside; the contaminant sources are boxes with c's inside. The air handling system, system supply points, and system return points are represented by a bold S, squares with +'s inside, and squares with -'s inside, respectively.

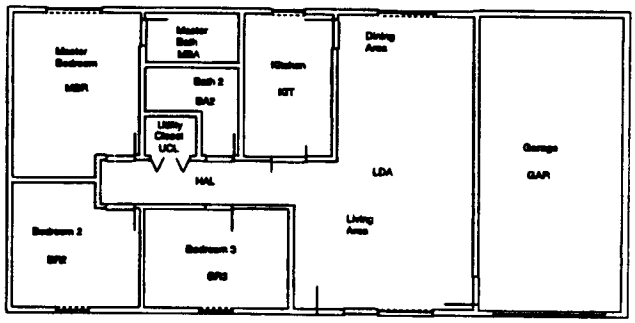

Figure 1 - Miami ranch house floorplan

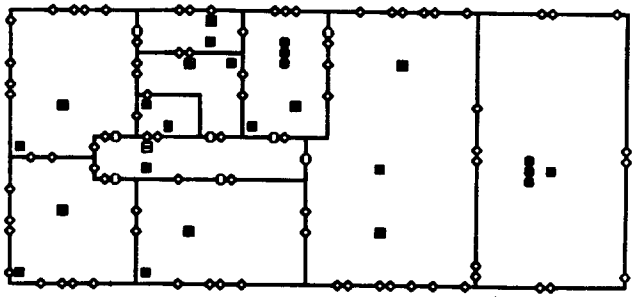

Figure 2 - Miami ranch house in CONTAM93 SketchPad

Future Development Plans

Work is presently in progress to improve the user interface and to extend the simulation capabilities. The logic of the interface is being made more similar to common graphic interface standards, although the next version of the program will still run under DOS. The program is being modified to include libraries of airflow paths and contaminant source/sink models. Extensions in the simulation capabilities will include detailed ductwork models, exposure analysis, non-linear contaminant chemistry, and aerosol transport.

An interim version of the program, called CONTAM94, with an improved interface and employing a DOS extender has been completed. CONTAM94 is a beta-test program with a revised graphical user interface that is serving to test the next generation of the program - CONTAM95. A DOS extender has been used to allow merging of the I/O processor and the simulation programs into a single program. Because of the extender, CONTAM94 requires a 386 class (or higher) PC

compatible computer with math coprocessor (preferably 486DX), VGA graphics, and MS-DOS. The higher CPU is also used by the 32-bit code generated by the compiler, making CONTAM94 slightly faster than CONTAM93.

CONTAM94 includes the following positive (+) and not-so-positive (-) features:

+ The interface has been revised to more closely follow GUI conventions. This makes it much easier and faster to switch between the various screens. Some icons have been modified for better visibility or compatibility with common practice.

- Simulation capabilities are essentially unchanged from CONTAM93.

- Documentation has not yet been revised, but the on-screen help has been updated. Pressing F1 gives information about what the program is requesting from the user, e.g., the physical description of a flow element and its input parameters. F2 gives information about how to perform the current operation, e.g., how to enter an element name or copy an icon.

+ It combines the I/O interface and the simulator into a single program. This gives a very fast response for steady-state problems.

+ This DOS extender allows creation of projects up to the size of available memory. This allows simulations of up to 8000 (zones x contaminants), effectively removing limits on the complexity of the problem.

- Unfortunately, it also appears to conflict with Windows -- stay in DOS at boot-up.

+ It allows the creation of a scrollable SketchPad which is larger than the screen (up to about 32,600 cells). This is very useful for large, low-rise buildings.

+ Multiple projects may be run without exiting the program. The name of the current project is always displayed.

+ An entire level may be deleted; a new level may be added above or below any existing level.

- Note that CONTAM94 cannot use CONTAM93 project files directly.

+ They must be converted to a revised format using the C93TOC94 utility: C93TOC94 .prj .prj

Comments on CONTAM94, as well as CONTAM93, would be greatly appreciated.

Availability

CONTAM93 and 94 are most quickly available via FTP on the Internet accessing NIST's VAX external network host. Use the following procedure:

ftp enh.nist.gov	FTP - Internet address
user name: anon	signon
password:	enter your Internet address
cd contam	change to CONTAM directory
bin	set binary transfer mode
get <file>	get file
...	get other files
bye	signoff

Get the CONTAM93.TXT and CONTAM94.TXT files first. These short files describe the other files that are available for CONTAM93 and/or CONTAM94. Intermediate fixes to the programs will be posted here as they are developed. These fixes will be reported in the .TXT files. Please e-mail a note to gwalton@enh.nist.gov when you use FTP to get a CONTAM upgrade so your name can be added to the CONTAM mailing list.

If you do not have access to FTP and the Internet, call or write for a disk. Contact: George Walton, BR/A313 NIST, Gaithersburg MD 20899, U.S.A.; phone: (301) 975-6421; fax: 990-4192.

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