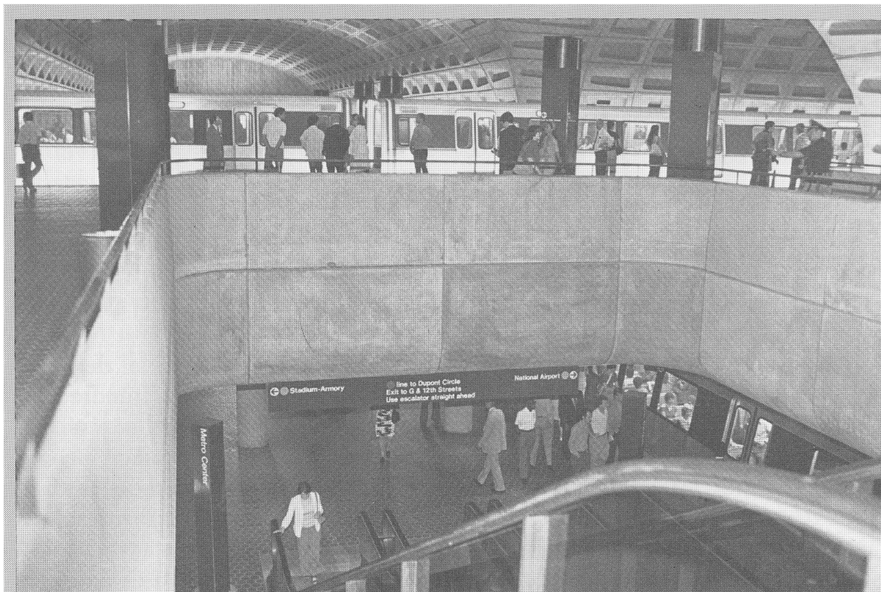
U.S. Department of Transportation

Urban Mass Transportation Administration

Ventilation and Environmental Control in Subways

Urban public transportation, after years of neglect, became the focus of attention in the mid 1960s. As a result, many large metropolitan areas began to plan new or expanded rail transit subway systems. At the same time, engineers, responding to higher public expectations and environmental considerations, began to take a closer look at the adequacy of the 40-year-old design methods, because no major subway construction had been undertaken in the United States since the 1930s.



Metro Center Station, Washington, D.C., Metro.

Problem

During initial planning for new subway systems, it soon became apparent that one of the most critical and vital considerations in transit tunnel design was the need for a well-founded environmental control system. This system would include temperature and humidity control, circulation of fresh air (to meet both normal and emergency requirements), and safety features in case of fire. Because design and construction techniques for ventilation and environmental control systems were based on systems several decades old, engineers were concerned not only with their effectiveness, but also with the need to ensure that they would be cost effective.

Solution

In 1969, under the auspices of the Institute for Rapid Transit (later merged with the American Transit Association to form the American Public Transit Association), the transit industry, through a joint committee, produced a document entitled "Guidelines for Design of Rapid Transit," focusing on this issue. It became increasingly apparent that a comprehensive plan was needed, aimed specifically at design for subway environmental control.

The result was the development of the Subway Environmental Simulation (SES) design package, funded by a $3,500,000 grant from the Urban Mass

Transportation Administration (UMTA).[1] The participating transit systems donated professional and support staff through an advisory board to review and comment during the life of the project.

The research findings resulted in a package of design principles and an accompanying computer simulation program that was confirmed by modeling and full-scale testing. The approach was aided by proven technology in related design fields that also used modeling techniques, full-scale testing, and advanced computer programming applications.

Application

After four-and-a-half years of study and development, the results were released for industry use and application. The package consisted of two parts: *Subway Environmental Design Handbook* (Vol. 1), and *Computer Programmers and Users Manual* (Vol. 2). The SES computer program is also available on tape.

Since the completion of the research work in 1975, there has been a steady flow of requests for the computer tapes and the *Computer Programmers and Users Manual*, plus instructional sessions at the U.S. DOT's Transportation Systems Center, which acts as the custodian of the documentation. Transit systems around the world have used the simulation and analytical tools in the design of their tunnel ventilation systems. As recently as 1985, there have been instructional sessions and requests for the SES program and its 1981 revisions, which added capability for simulating smoke flow and control.

Benefits

At the time of completion of the users package, there was evidence that application during the project development had produced savings approaching $5.5 million in design, engineering, and construction costs of subway systems. These savings were realized by systems under construction in Atlanta, Washington, D.C., and Baltimore.

Since then, savings in new subway and tunnel design and construction in Buffalo, Pittsburgh, Los Angeles, Seattle, Dallas, Hong Kong, Singapore, and Caracas have exceeded the original cost of research more than tenfold, according to conservative estimates.

Previously, the common practice was to construct vent shafts between stations. Using the added design capability for simulating tunnel ventilation, these may no longer be needed. For example, the original design of a currently planned rail transit system with 16 underground stations called for shafts on tunnel segments over 2 miles in length. At a typical shaft cost of $500,000 to $2 million the elimination of about 12 shafts would save up to $12 million.

An additional important benefit of the improved ventilation design has been the increased margin of safety and improved environmental comfort that is provided. Though this benefit is difficult to quantify in terms of dollars, it may be the most tangible direct gain by the riding public.

[1]The spectrum of talent required to develop this comprehensive design package consisted of a joint venture of Parsons Brinckerhoff Quade and Douglas, Inc.; DeLeuw, Cather and Company; and Kaiser Engineers. Supportive basic research and testing was performed by California Institute of Technology's Jet Propulsion Laboratory and Developmental Sciences, Inc. Certain hardware testing support was provided by the General Electric Company. Full-scale testing took place on the Toronto, Chicago, and Washington, D.C., transit systems.