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THE HIGH RISE

Trends and developments in smoke control

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Member ASHRAE

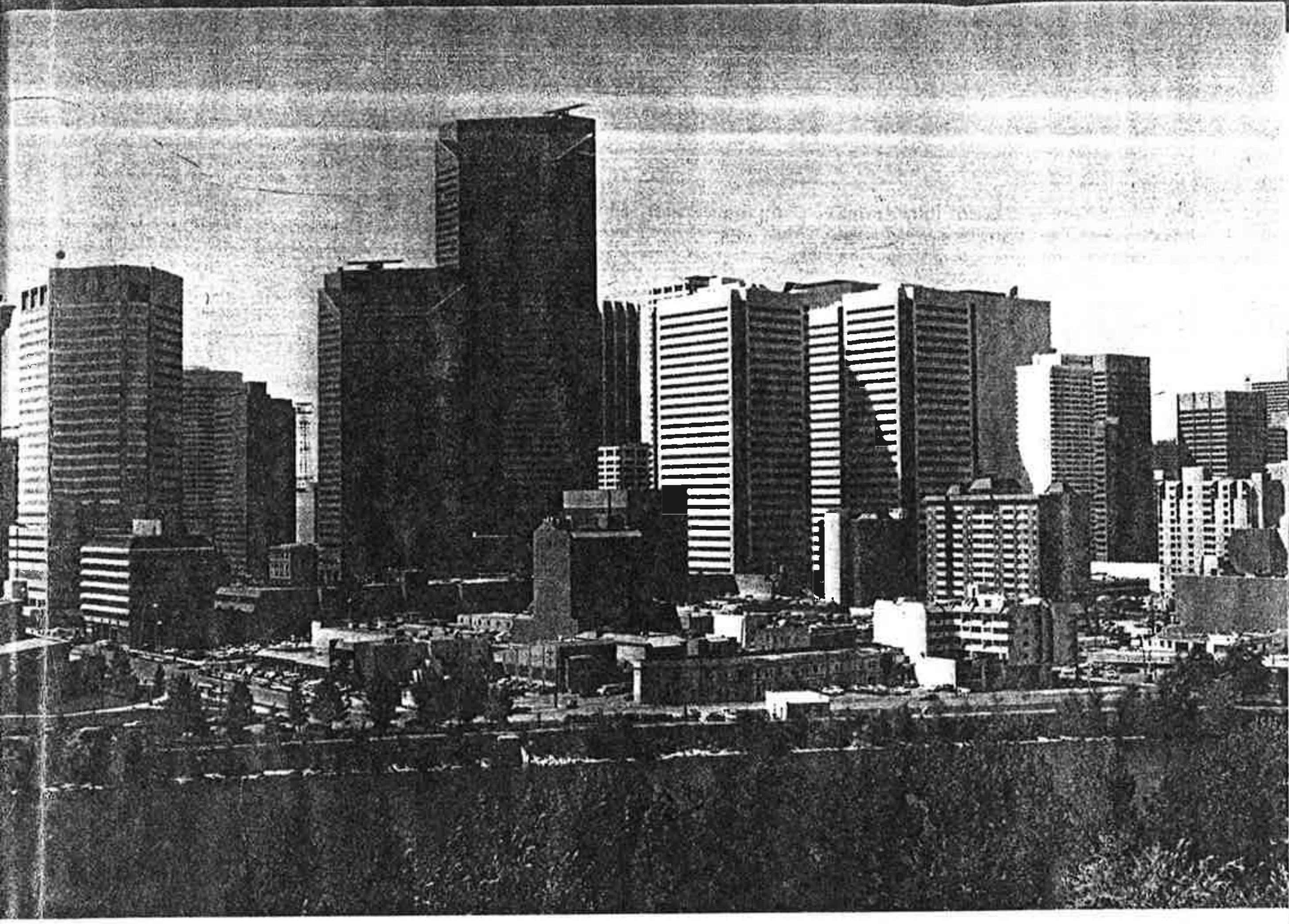
CALGARY WAS ONE of the most dynamic cities in North America during the late 70's. In 1981, the building construction activity peaked to a value of $2,536.8 million, the second largest in the world, surpassed only by that of Houston, Texas. Recently, recessionary trends have affected the construction industry dramatically. The "building boom" saw the emergence of a number of high rise office and residential towers in the City.

Life safety provisions for high buildings have been part of the National Building Code of Canada since 1973. The supplement, "Measures for Fire Safety in High Buildings", to the Canadian Building Code enumerates 14 measures designed to provide safe conditions for the occupants of a high building who may have to remain within the building during a fire. These measures, in general, provide exit routes or refuge areas which are either pressurized or exposed to the outdoors, or a fire suppression system to extinguish the fire locally. The Canadian Code also requires the following additional provisions in high buildings:

- Means of venting the fire floor to the outdoors.
- Controls of the elevators for fire fighters' use.
- Central alarm and control panel.
- Voice communication system.
- Protected emergency power supply for all life safety systems.

A survey of 135 buildings built in Calgary since 1976 shows that there is compliance, in general, with the requirements of the Building Code. Residential buildings more than 36 m (118 ft.) high have either exit stairs and elevator shafts, or the building core containing the exit routes is pressurized to render these areas smoke free. Those less than 36 m (118 ft.) but more than 18 m (59 ft.) high use exterior balconies as refuge areas in case of a fire.

Of the 51 office towers studied, all except two are sprinklered and use a mechanical venting system to remove smoke from the fire floor. Buildings with central air conditioning systems use the return air or the exhaust shaft in a smoke exhaust mode, and those with compartmental systems use fresh air shafts on a reverse mode for the smoke removal. The mechanical venting is provided by either the building ventilation system fans or separate smoke exhaust fans.



In one office tower, the supply fan is used to provide an induced draft to vent the smoke to the outdoors. Although the Code does not require any pressurization for above-grade floors in sprinklered buildings, a number of office towers have provisions for pressurizing above-grade stairs, elevators shafts or floor areas to provide tenable conditions in these areas and aid the venting of smoke from a fire floor.

Smoke control measures presently prescribed in the Building Codes are of a general nature and do not account for all the field conditions and installation problems. A number of field tests done in Calgary have shown that, for an effective and reliable system, a number of significant changes have to be made into the design and installation. This article describes a few of those required modifications.

Mechanical exhaust

The rate of smoke removal from a fire floor using the natural draft in a smoke shaft, which is open at the top and at the fire floor, is at least four to five times slower than that with a mechanical exhaust fan. Buildings with smoke exhaust fans clear the smoke from a fire floor within 10 to 12 minutes, to permit visibility across the floor area in most office towers when tested with smoke bombs. The fan motor and wiring must be designed to withstand the exhaust air temperatures in a fire situation.

Smoke dampers

Selection of proper dampers to be used in the openings from a floor area to the smoke shaft, which will satisfy the building codes and provide a reliable smoke venting measure, is still a problem facing the consultants and Code officials. Two types of make-fit dampers are presently used.

- A multi-blade fire damper with its fusible link and locking catch removed and motorized.
- A multiple damper combination consisting of a fire damper (curtain type or multi-blade) and a multi-blade control damper mounted separately or in a single frame. The control damper is motorized for remote operation and the fire damper maintains the integrity of the fire separation between the shaft and the floor area.

Although the combination arrangement meets the Building Code requirements, the fire damper can close on exposure to a fire and nullify the smoke venting system. High temperature fusible links for these fire dampers are recommended and are used in buildings.

The former arrangement with the fusible link and the latching mechanism removed, while being controllable from a remote location, provides the rating required of a closure in the fire separation when the damper is closed. The removal of the fusible link and latching mechanism, however, can invalidate the certification of these dampers as fire dampers.

NFPA 90A permits the use of control dampers in openings in service shaft walls when these shafts are part of a smoke control system. Some building codes do not allow this. Although these dampers may work satisfactorily under non-fire conditions, they can become inoperative and unable to control the spread of fire to other floors in a fire condition.

Motorized fire dampers may limit the spread of fire to other floors but may not be operable under real fire conditions. In sprinklered buildings, the dampers are exposed to temperatures of about 250°F with the sprinkler system operating. Most buildings using vertical shafts for smoke removal are office towers and are fully sprinklered. Therefore, dampers which can be opened and closed successfully from a remote station up to about 300°F can provide a reliable smoke control system compared to the ones presently used. Improvements have been made recently in this area by the industry.

Air leakage through dampers

Air leakage across the smoke dampers is another concern. Tests have shown that, depending on the height of the building and the stack effect it creates, the leakage through closed dampers which are presently used, can account for about half the air discharged by the fan. Thus, a fan designed to give six air changes from a fire floor may actually provide only three to four air changes. This leakage from other floors through closed dampers should also be accounted for while designing the fan capacity. UL Standard 555S was established in 1983 to regulate the leakage across dampers used in smoke control systems.

Damper controls

Controls for dampers presently used vary from mechanical devices to open the dampers from a location close to the fire floor to fully computerized automatic operation. The most common method is manual control from a remote station through electric or pneumatic switching. While manual control has the advantage of overseeing what is being activated, it is susceptible to human error and time delay.

Automatic control on a reliable "fire indicating device" with a manual override ensures prompt activation of a smoke control system. In sprinklered buildings, the sprinkler flow switch for each floor can be used to activate the smoke control system automatically. A fully computerized automatic operation provides a reliable and fast responding system in buildings such as hospitals where a number of building systems or zones are used for pressurization of the various patient compartments while smoke is vented from the fire compartment.

Protection of control circuits

Protection of the electric or pneumatic control circuit from the remote control panel to the dampers is imperative for their continuous and repetitious operation in case of a fire. All control circuits must be monitored as well.

Location of pressurization fans

A proper location of the pressurization unit is important to ensure smoke-free air into pressurized areas. Ideally, the units should be located at-grade; but this may not always be practical because of appearance, space requirements and the need for expensive ductwork to carry the air to the top of a stair or elevator shaft.

In very high buildings, air is distributed at different levels for balancing the pressure across exit doors and in such cases ground level location may be economical. Location on the roof is more common and practical; however, these locations must be chosen carefully to avoid re- circulation of smoke from a fire in the same or adjoining building. Some Building Codes require smoke detectors on the discharge side of a pressurization unit to shut it down as a precaution automatically in case of a smoke condition.

Smoke shaft discharge location

Unless the exhaust fan has sufficient power to overcome the additional static pressure caused by outdoor wind conditions, an exhaust louvre located on the windward side of a building can create adverse effects to the system. Fan discharges should either be on rooftops or on the leeward side of a building when the prevailing wind direction is known.

Below-grade floors

Removal of smoke from below-grade floors is not given much importance in many buildings. B[...] grade floors are normally use[...] parking and storage and have a lo[...] cupant load. Consequently, no [...] sions are usually made for s[...] removal from these floors. It [...] become necessary, however, to [...] the spread of smoke in case [...] automobile or storage room fi[...] venting these floors to the exterio[...] haust fans, used for general ex[...] from below grade parking floors [...] be used to achieve this.

Maintenance

One of the serious con[...] presently associated with the s[...] control systems is their long [...] reliability, because of a lack of p[...] and regular maintenance. Most [...] equipment is dedicated for emer[...] use and is called upon to funct[...] case of an emergency only. The[...] normally tested prior to the occu[...] of a building and remain idle afte[...] Regular maintenance and test[...] important to ensure reliability o[...] systems. The National Fire Co[...] Canada 1980, which is adopte[...] most Provinces, requires the tes[...] smoke control systems at interv[...] not more than three months. Lon[...] tervals may be permitted by [...] authority having jurisdiction, pro[...] that such long intervals do not r[...] the reliability of the system or [...] ment.

The basic assumption i[...] smoke control measures pre[...] used is that total evacuation [...] highrise building is impractical [...] not required. The occupants of [...] floor are evacuated to another [...] area within the building [...] However, the human tendency [...] leave a building, whether high r[...] low rise, in a fire emergency. A f[...] of safety is achieved only when p[...] are outside a building on fire. [...] evacuation using stairs is time[...] suming and delays the fire fig[...] operations. Furthermore people [...] dicapped either permanently o[...] porarily, may not be able to use [...] Mass evacuation of a high rise bu[...] using elevators is a concept [...] should be considered as an add[...] smoke control measure in sprin[...] buildings. The elevator shafts ar[...] by on each floor can be protecte[...] pressurized during a fire emerg[...] Entry to the lobby from the floo[...] shall be through air locks. Peop[...] moved starting from the fire flo[...] up using the elevators.

About the author

Raju V. Paul is head of the Building Services and Mechanical Engineering Section of the Planning and Building Department, City of Calgary, Alberta, Canada. He received his M.Sc. from the University of Calgary and his M.Tech. (H.V.A.C.) from the Indian Institute of Technology in Bombay, India. Prior to joning the City in 1976, he was active in the building industry for a number of years as a consulting engineer in Calgary. He is a member of the Association of Professional Engineers of Alberta.

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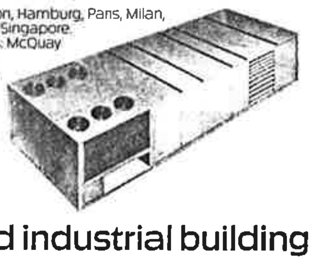

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