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Performance Based Building Design for Fire Safety
Electronic Arts Atrium

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When Electronic Arts expanded their studios to include a new location in the top four storeys of a high rise office building in downtown Vancouver, they were looking for a dynamic and integrated space that reflects the innovative and creative nature of their business and that would inspire the talents of their team of designers, artists and computer programmers.

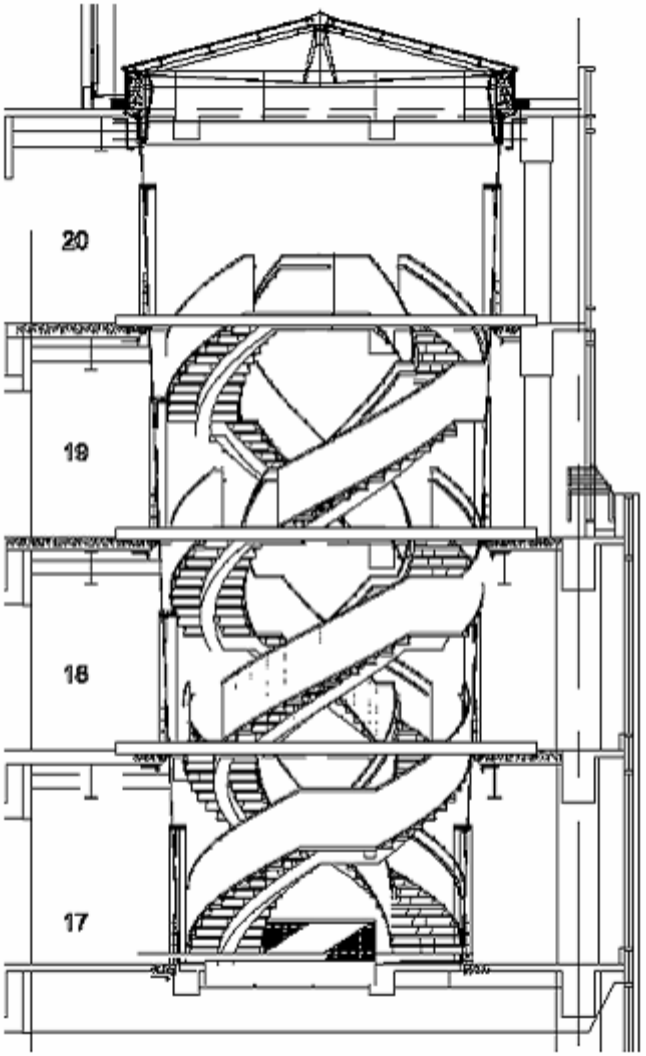
Musson Cattell Mackey Partnership Architects rose to the challenge with a spectacular design incorporating a four storey glass atrium with a stairway spiralling around a 40ft tall bamboo tree. However, this innovative design did not fit neatly into the Building Code's prescriptive requirements for fire safety. GHL Consultants Ltd worked with the project team to demonstrate to the Authority Having Jurisdiction that this innovative design could meet or exceed the objectives of the fire safety requirements of the Building Code.

Photo: Michael Sherman

The Building Code states that the requirements of the Code are not intended to limit the methods of construction or types of design that may be used in the construction of a new building or renovation of an existing building, and that alternate or equivalent approaches to Building Code compliance may be accepted provided that the proponent can prove that the proposed design meets the intent of the Code and provides an acceptable level of fire safety. This statement permits the development of a performance based design or equivalency approach to demonstrate the acceptability of unique building designs not specifically addressed by the Building Code. This approach requires extensive knowledge of the original fire safety design basis and intent of the Code requirements, as well as knowledge of fire behaviour and its associated hazards, performance of buildings in fire conditions and the behaviour of people during a fire incident. This requires careful analysis and the use of simulation tools such as fire modelling.

In the construction of a building, floor assemblies are usually constructed as continuous fire separations that prevent the passage of flame and limit temperature rise on the other side of the floor assembly such that a fire starting on one floor of a building will not be able to spread quickly to other floors.

The construction of openings through the floor assemblies to accommodate the four storey convenience stair and bamboo tree created an interconnected floor space. In a fire incident, an interconnected floor space could enable a fire to spread more quickly through the building and delay evacuation if the occupants of all levels were to begin entering the building exit stairshafts simultaneously.



Drawing: Musson Cattell Mackey Partnership Architects

The intent of the interconnected floor space fire safety requirements is to recognize that the connection of stories by floor openings may result in occupants on all floor levels being exposed to a fire very quickly. Therefore, additional measures are required for interconnected floor spaces to limit smoke migration from floor areas and to limit fire spread between levels.

However, some of the prescribed design requirements for inter- connected floor spaces predate much of the current understanding of fire dynamics, and specifically the use of fast response sprinkler technology. The prescriptive requirements of the Building Code can also be generic and designed to address a worst case scenario. For example, the requirements for interconnected floor spaces were developed to address all atrium situations (for instance, for as high as 25 levels and assuming large floor plates) and as such may not be appropriate for smaller scale atriums. In this case, the prescriptive Building Code requirements would not have permitted the use of glass around the atrium or the installation of the bamboo tree and would have required an awkward system of vestibules between the atrium and the office spaces.

To demonstrate that an acceptable level of fire safety was provided by the innovative design, GHL Consultants Ltd used a combination of active protection measures to provide an adequate level of safety and fire modelling to demonstrate the expected impact of a fire in or near the space. Fire modelling tools are widely used by engineers and fire scientists to provide a better understanding of fire spread in buildings. These tools make use of the available algebraic correlations that relate to fire phenomena, and provide engineers and fire scientists with a better feel of the fire safety concern relating to a problem.

The first stage in the performance-based analysis is to determine a design fire. The type of fire modelled must reflect the occupancy type of the building and the reasonably expected worst case degree of hazard derived from experience with fires in similar buildings. Design fire characteristics can be taken from literature or derived by analyzing the contents and use of a room. Once the design fire is determined, its effects, such as maximum temperature developed, are determined.

For the bamboo and atrium, the design was based on maintenance of the required floor-to-floor fire separation by sprinkler protected tempered glass enclosing the atrium, with glass doors providing access to each of the four floor levels. The sprinkler protection of the glazing included water curtain sprinklers at 6ft intervals around the stair enclosure so that in a fire event the sprinkler water will act to saturate fire gases and maintain the temperature of the glass at a point below its expected failure temperature. The failure temperature chosen took into consideration the fact that the application of cold sprinkler water to the glass could cause thermal shock, producing premature failure of the glazing.

Fire modelling was used to demonstrate that the maximum temperature of the fire gases in the design fire scenarios was not sufficient to cause failure of the glass. The design fire sizes were increased in a sensitivity analysis to determine the point at which flashover (development of temperatures substantial to cause ignition of all materials in a room) was achieved and the effects analyzed. Where temperatures developed were sufficient to cause failure of the glass, the time to failure was compared to the time required for building evacuation. With the addition of a safety factor to the evacuation time and provided that occupants have more than adequate time to evacuate before the glazing could be compromised by fire, an acceptable level of fire safety was deemed to be provided.

Sprinkler systems are very reliable, as statistical records of fires in sprinklered buildings indicate that the possibility of any appreciable size fire occurring is remote when adequate sprinkler protection is provided. However, consideration must also be given to scenarios where sprinklers do not operate, such as in the case of a fire occurring shortly after a seismic event that may compromise the water supply to the building. For this building, a backup water supply system was available and the water curtain sprinklers protecting the atrium glazing are supplied by an independent system from the floor area sprinklers. The fire modelling was repeated assuming no sprinkler activation and the results compared to a new failure temperature. With no application of cold water to the glass, it was no longer necessary to account for the effects of thermal shock.

The results of the fire modelling and analysis demonstrated that the sprinkler protected glass enclosure of the atrium would maintain the level of fire safety intended by the Building Code on a performance basis.

The type of challenge represented by the unique design in this project reflects the level of skill and creativity in the field of Building Code Consulting and Fire Protection Engineering and the receptiveness of the Building Officials in considering innovative designs, as long as adequate technical evidence can be provided that the level of fire safety intended by the Building Code will be maintained.

Building on fire sciences knowledge and Building Code equivalency expertise encourages innovation and creativity where prescriptive requirements of the Building Code would otherwise limit design options.

Andrew Harmsworth, M Eng, P Eng, CP, is a member of GHL Consultants Ltd of Vancouver, BC. The company provides Fire Protection Engineering and Building Code consulting services to a wide range of clients within British Columbia and internationally.

Project Team: Prime Consultant - Musson Cattell Mackey Partnership Architects. Mechanical - Keen Engineering. Electrical - Reid Crowther and Partners. Structural - Read Jones Christoffersen Ltd. Fire Protection and Building Code - GHL Consultants Ltd.