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A Conceptual Approach to the Control of Fire Hazards

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This Digest addresses a conceptual approach to the control of fire hazards in buildings and discusses the means by which this approach may be applied in consideration of the minimum level of safety established in codes.

What can be done to control a fire hazard? How can a building designer be sure that he is not creating a death trap for the occupants? These problems can be addressed by three basic methods for controlling fire hazards in buildings: prohibition, isolation and protection.

Prohibition

Prohibition is the removal of a hazard from a building. If a material or activity is likely to cause serious fires, it should not be permitted in a building. The dispensing of gasoline, for example, is considered to be a dangerous operation. In buildings containing large crowds, patients incapacitated by illness, or people sleeping, the potentially large loss of life makes this type of operation unacceptable. For this reason such a hazard is usually prohibited.

In actual fact, prohibition is not commonly used to control fire hazards in modern buildings. Considerations such as the economic impact of prohibiting the use of a certain product and the functional necessity of combining certain activities make prohibition the least practical control method. Other methods are the norm.

Isolation

Of the two remaining methods, hazard isolation is the one more often used. Isolation may take two forms. The first requires cutting off the hazard from the remainder of the building to minimize its effects. This is usually done by surrounding the hazard with fire-rated construction to form a fire compartment, which is typically designed to contain a fire during a complete burnout. Any openings in the construction surrounding the compartment must also be protected with fire-rated devices to maintain the integrity of the compartment.

The second form of isolating a hazard involves spatial separation. This is often used to prevent fire spread from one building to another. Much research work has been undertaken to determine the distances necessary to isolate a building from the effects of thermal radiation due to fire in a neighbouring building. Several approaches are now available to the designer including the prescriptive approach provided in building regulations, and analytical approaches based on theoretical calculations.

Protection

Controlling a fire hazard by isolation assumes that its worst effects will be contained. The third method of controlling the hazard is to minimize these effects; in other words, to counteract the

hazard and thereby protect the building. This is best done by limiting fire growth, which in turn reduces the potential effects of the fire.

Protection usually implies the use of automatic fire-extinguishing systems, although manual systems such as portable extinguishers and hoses often fill this role. Of the automatic systems, sprinklers are the most popular, but many other systems are available which use a variety of extinguishing agents such as high expansion foam, carbon dioxide, halogenated extinguishing agents and dry chemical agents. Each system has special features suitable for different hazards and must be evaluated carefully in order to select the most appropriate one.

Selection of Control Method

Careful selection is also important in choosing the most effective method for controlling a particular hazard. The prohibition, isolation and protection methods, taken individually, may be inadequate; consequently, most designs specify a combination of methods to achieve the desired result.

It is often extremely difficult for a designer to choose the most appropriate method since this requires an awareness of the many situations which could lead to an uncontrolled fire in a building. Frequently, the control of these hazards is the last consideration in the design process and, as a matter of convenience, there is a tendency to rely on the letter-of-the-law requirements set down in various provincial or municipal codes. In the process, designers may neglect to consider the objective of these requirements and thus overlook the alternatives available to them.

Control by Minimum Standards

Codes adopted through legislation offer one system of achieving control of a fire hazard. They are developed on a consensus basis and are accepted by society's elected representatives. Collectively they form the minimum level of safety that building designers must achieve.

Alternative solutions to achieve the fire safety objectives of the codes are permitted in most legislation, and building regulatory authorities are generally receptive to such solutions. To be acceptable. these alternatives must provide a level of safety equivalent to that intended by the code requirements.

Fire Protection Analysis

The conceptual approach leading to an optimum fire safety system is a fire protection analysis. which evaluates fire hazards and their effects on a building and its occupants in relation to the minimum level of safety established by code requirements.

The analysis begins with the identification of the fire hazard in terms of its two main components, fuel load and fire growth.

The fuel load is used to predict the potential fire size and duration. It includes:

- the structure (beams, columns and structural assemblies);
- the finishes (insulation, wall, ceiling and floor finishes); and
- the contents (items that are brought in after the structure is erected).

Fire growth describes how rapidly a fire will grow after ignition of the fuel load. The flame propagation and combustion characteristics of the building components and its contents are estimated and the potential for smoke development and spread is evaluated.

Having assessed the fuel load and fire growth characteristics of the fire hazard, it then is necessary to develop one or more control methods (prohibition, isolation or protection) to attain the desired level of safety. Both the fire hazard and the selected control measures must be carefully evaluated with regard to their impact on the building structure, the occupants and the contents.

In considering the impact of the fire hazard and the control methods on the structure, two factors must be addressed. The first is the ability of the structure to withstand fire and to continue to carry the imposed loads; that is, the degree of fire protection necessary for structural members to retain their stability under fire conditions. In its simplest form, this protection (or fire resistance) is typically determined on the basis of a free-burning fire in a compartment. If other controls such as fire suppression or limits on the fuel load are provided, the effects of the fire will be reduced and the required fire resistance can be modified accordingly.

The second factor to be addressed in relation to the structure is the ability of the building elements to act as barriers to fire and smoke by isolating or compartmenting the effects of the fire. These barriers include floor, corridor, shaft and room separations. Compartments should be designed to limit the fire hazard to a size consistent with the accepted fire safety goal. The fire may be limited to the room of origin, to a single floor level or to multiple floor levels, depending on the particular design.

In considering the impact of fire on the occupants of a building, two possibilities must be examined. The first is that the occupants and the fire may be in the same compartment; the second, that the occupants and the fire may be in different compartments. The following questions must also be considered:

- are the occupants asleep or sedated?
- are the occupants restrained (as in a prison or psychiatric hospital)?
- can the occupants move or be moved (do they require assistance to move; is it possible to move them without endangering their lives)?

Having examined the fire hazard and the control measures with regard to the occupants of the building, one then provides either a fire-safe, smoke-free area of refuge in which the occupants can wait out the fire, or an evacuation system whereby the occupants are notified and then evacuated via a fire-safe, smoke-free path.

Unlike life safety considerations, the control of the fire hazard in relation to the contents of a building should largely be based on the economics involved. If the contents constitute a serious fire hazard in themselves, additional measures may be required, but control measures are generally provided only in proportion to the expected financial loss. Since the contents, in most cases, cannot be readily isolated from a fire hazard, fire suppression measures, if economically feasible, are often used to protect them. Situations in which computers control critical operations in the building or where historical artifacts are involved are usually difficult to assess in terms of financial loss; additional control measures are often provided in such cases.

A fire protection analysis was used as part of the design process for the Royal Bank Centre in Ottawa, shown in Figure 1. The analysis of this building, which has six storeys connected by an atrium, evaluated the potential hazards and assessed the impact of the fire protection measures used. The recommended fire protection system for the atrium space utilized limitations on fuel load in the open space, compartmentation by separating certain floors from the open space with smoke barriers, and fire suppression in the form of automatic sprinklers. In conjunction with these, other fire protection measures included fire detection by smoke detectors and a socially designed egress system to provide life safety equivalent to that intended by the building regulations.

Figure 1. Royal Bank Centre, Ottawa.

Summary

There are three basic methods for controlling fire hazards in buildings: prohibition, isolation and protection.

To determine which method or combination of methods should be used, a minimum level of safety must first be established; this level has traditionally been specified in code documents. These codes which incorporate the three basic methods, provide solutions to the control of fire hazards. A conceptual design approach such as a fire protection analysis can also provide a solution to the control of fire hazards; however, for code compliance purposes, this type of analysis must provide a level of safety equivalent to that established by existing building regulations.

A fire protection analysis is a process which evaluates a fire hazard and its potential impact and selects the appropriate control measures. Although it is perhaps the best design approach for the control of fire hazards in buildings, it requires a type of expertise not commonly found in design offices. This expertise, normally known as fire protection engineering, is in a period of rapid development and acceptance. It is expected that it will make the control of fire hazards a key factor in the building design process.

The Fire protection Handbook, published by the National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts, USA, 02269, contains a detailed description of a fire protection analysis, as well as specific information needed at the conceptual stage of the building design process.