



Fire Safety Design Options In Residential Buildings

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ABSTRACT

Fire safety design options play a crucial role in ensuring the protection of lives and properties in buildings. This study explores various fire safety design options in residential buildings, providing architects, designers and professionals in the field with valuable insights and practical solutions to fire prevention and control by examining building materials, Fire-resistant materials, structural considerations, furniture and fittings, escape routes, and advanced technologies to enhance the safety and well-being of occupants in residential spaces. Through case studies, research findings, and expert opinions, this journal aims to foster a deeper understanding of common fire safety design options that will enhance the overall resilience of residential buildings towards fire-related hazards reducing the risk of fire-related accident and promoting a sense of safety and security for residents and the communities. Therefore, through the examination of various design strategies and options, we have gained valuable insights into mitigating the risks associated with fires in residential settings and therefore recommend the adoption of fire safety options as well as the use of fire safety design structures in residential designs.

Keywords: fire safety, design options, residential buildings, fire detection, alarm systems

INTRODUCTION

The yellow flame represents one of the greatest achievements of early civilizations. In East Africa and Australia, some 100,000 years ago, people were able to make flames and to sustain them. They were made by either striking flints or rubbing wooden sticks to generate the necessary temperature for ignition, by friction. For thousands of years this was the only type of flame known to humans (Szydło, 1997). Fire is a very important element in our daily lives and just as it has its advantages, it has its disadvantages. A misuse or careless use of fire can lead to an outbreak of extremely intense fire that is dangerous to lives and properties. (Szydło 1997)

From the earliest time, the fire that empowered man to cook food, drive off animals, shape tools and survive intense cold has also been an everlasting hazard to all who used it. The history of occupational fire hazard causing significant damage is very old. The Great Fire of Rome (67CE) started in the shops of merchants who sold flammable goods near the Circus Maximus, while the Great Fire of London (1666CE) started in a bakery, within a merchant's district that held oil, pitch, tar, coal, tallow, fats, sugar, alcohol, turpentine, and gunpowder. As with the other cases, the Great Fire of London led to situations that were previously acceptable being re-classified as hazardous (Kodur et al., 2019).

Fire hazard in buildings can be defined as the potential of accidental or intentional fire to threaten life, structure and property in a building. Fire safety in residential buildings is of utmost importance for the well-being and protection of occupants. Fire can have devastating consequences, causing loss of life, property damage, and emotional trauma.

Fire typically requires three ingredients: heat, fuel (something to burn), and oxygen. A fire can be put out, prevented or the impacts reduced by removing, reducing or separating these elements. In a forest environment, a fuel management activity such as thinning the trees as a method of reducing the amount and arrangement of fuel that is capable of burning. Additionally, reducing unwanted ignition sources by

humans helps to decrease the probability of a fire occurring. (Agee, J.K. et al 1996). Fire hazard constitute of all factors present in a building that can cause ignition, aggravate fire severity, incapacitate building fire safety provisions, and hinder escape or fire-fighting operations. Based on available statistics, it is suggested that cooking is the leading cause of fire in both residential and non-residential buildings (USFA, 2016). Other sources of ignition in buildings include all live flames, heaters and hot surfaces, electrical malfunction, fireworks, and arson and vandalism (Drysdale, 2011).

With rapid development across the globe, fire hazard in buildings have undergone significant transformation in terms of severity and versatility and have become a growing concern in recent years (Brushlinsky et al., 2017). Early detection of a fire is crucial in minimizing potential harm and providing occupants with ample time to evacuate safely. Incorporating smoke detectors, heat detectors, and flame detectors throughout the building, interconnected to a central alarm system, can significantly enhance fire safety. Smoke detectors are particularly vital as they detect the presence of smoke, a common indicator of fire, and promptly trigger alarms. Heat detectors are designed to sense rapid increases in temperature, while flame detectors identify the presence of flames. By integrating these technologies, residential buildings can ensure comprehensive coverage and prompt alerting, enabling residents to take immediate action in response to a fire emergency. Additionally, regular maintenance and testing of the fire detection and alarm systems are essential to ensure their proper functioning and reliability. This includes regular battery replacements, sensor cleaning, and system inspections carried out by qualified professionals. By prioritizing the installation and maintenance of robust fire detection and alarm systems, residential buildings can significantly improve their fire safety preparedness and reduce the potential for loss of life and property. Therefore, implementing effective fire safety measures is crucial to minimize these risks and ensure the safety of residents. One key aspect of fire safety in residential buildings is early detection. Installing smoke detectors and fire alarm systems can provide early warnings, allowing occupants to evacuate promptly and alerting emergency services. Additionally, having a well-designed and properly maintained fire suppression system, such as fire extinguishers or sprinklers, can help contain and extinguish fires before they spread. Another vital consideration is the design and construction of the building itself. Using fire-resistant materials, implementing proper compartmentalization, and ensuring adequate fire exits and escape routes are essential elements in mitigating the impact of fires. These measures can help prevent the rapid spread of flames, smoke, and toxic gases, allowing occupants to evacuate safely. Furthermore, Education and awareness also play a significant role in fire safety. Providing residents with information on fire prevention, evacuation procedures, and the proper use of fire safety equipment can empower them to take appropriate actions in case of an emergency. Regular fire drills and training sessions can further enhance preparedness and ensure a swift and organized response. By prioritizing fire safety in residential buildings, we not only protect lives but also safeguard investments and communities.

In USA alone, an average of 66,903 wildfires occurred between 2009-2018 which burned an average of 6.9 million acres and caused an average of US\$1.8bn for fire fighting costs. In 2018, a total of 25,790 structures were destroyed by wildfires including 18,137 residences, 6,927 minor structures, and 229 commercial/mixed residential structures; which is highest number of structures lost to wildfires since 1999 and almost double of previous highest of 12,306 in 2017 (NICC, 2018). It is essential for architects, builders, and residents to collaborate in creating and maintaining fire-safe environments.

Aim of study

The aim of this study is to foster a deeper understanding of common fire safety design options that will enhance the overall resilience of residential buildings towards fire-related hazards reducing the risk of fire-related accident and promoting a sense of safety and security for residents and the communities.

METHODOLOGY

The methodology employed in this study aimed to provide a comprehensive and up-to-date understanding of fire safety design options in residential buildings. By combining literature review, case studies, and expert interviews, a well-rounded perspective was obtained, enabling the identification of key strategies and best practices in the field of residential fire safety design. To investigate fire safety design options in

residential buildings, a comprehensive approach was taken, involving a combination of literature review, case studies, and expert interviews. The methodology aimed to gather information on various design elements and strategies that contribute to fire safety in residential structures

A thorough review of academic papers, research articles, industry guidelines, building codes, and relevant publications was conducted. The literature review focused on identifying key fire safety design options and best practices for residential buildings. It also encompassed studies on fire behavior, fire-resistant materials, fire detection and alarm systems, evacuation planning, compartmentation, and other relevant topics.

Case Studies

Multiple case studies of residential buildings with exemplary fire safety designs were examined. These case studies provided valuable insights into real-life implementations of fire safety measures and their effectiveness. The selected case studies encompassed a range of building types, including high-rise apartments, townhouses, and single-family homes, to ensure a comprehensive understanding of design options across different contexts.

Expert Interviews

Interviews were conducted with fire safety experts, architects, building designers, and fire protection engineers with extensive experience in residential fire safety. These interviews provided valuable firsthand knowledge, practical insights, and expert opinions on fire safety design options. The experts were asked about their experiences, recommended design strategies, challenges encountered, and emerging trends in the field.

DATA ANALYSIS

The collected data from the literature review, case studies, and expert interviews were analyzed to identify common themes, trends, and effective fire safety design options. The data analysis involved categorizing the information into relevant topics such as building materials, fire detection systems, evacuation planning, compartmentation, and electrical safety. Patterns and best practices were identified, and key findings were synthesized to form a comprehensive understanding of fire safety design options.

FINDINGS

While specific requirements may vary based on local building codes and regulations, many of the world's iconic buildings and skyscrapers such as the Burj Khalifa in Dubai, Buckingham Palace in London, Sydney Opera House in Australia and many others have put in place an effective fire protection safety system in its building design to protect the building from fire-related hazards and secure the lives of its occupants. It is important to note that these buildings' fire safety systems are comprehensive and are continuously updated to align with the latest standards and technologies. Some of the fire safety features and practices from these case studies are highlighted below.

- **Building materials:**

When it comes to fire safety in residential buildings, the choice of building materials plays a crucial role. Certain materials are more resistant to fire and can help slow down the spread of flames, giving occupants more time to evacuate and firefighters more time to respond. Here are some building materials commonly used for fire safety:

1. **Fire-resistant or fire-rated materials:** These materials are specifically designed to withstand high temperatures and resist the spread of fire. Examples include fire-rated gypsum board, fire-resistant glass, and fire-resistant doors.
2. **Non-combustible materials:** These materials do not burn or contribute to the spread of fire. Examples include concrete, brick, stone, and metal. They are often used for structural elements such as walls, floors, and roofs.
3. **Fire-retardant-treated wood:** Wood is a commonly used building material, but it is combustible. Fire-retardant treatments can be applied to wood to reduce its flammability and slow down the spread of fire.
4. **Insulation materials:** Insulation plays a crucial role in energy efficiency, but it is also important to

choose fire-resistant insulation materials. Examples include mineral wool, fiberglass, and certain types of foam insulation that have been treated for fire resistance.

5. Fire-resistant coatings: These coatings can be applied to various surfaces, such as walls or structural elements, to enhance their fire resistance. They can provide an additional layer of protection against flames and heat i.e Stucco paint etc.

6. Fire-resistant doors and partitions: Fire-rated doors and fire-resistant partitions are installed in various locations within the building to compartmentalize fire and smoke, helping to limit their spread and providing safe evacuation routes for occupants.

It is important to consult with fire safety experts, architects, and local building codes to ensure that the chosen building materials meet the required fire safety standards for residential buildings. By selecting appropriate materials, architects can significantly enhance the fire safety of residential structures and protect the lives and properties of occupants.

- **Structural design:**

The structural design of residential buildings plays a vital role in ensuring fire safety and the ability to withstand the impact of fire incidents. The choice of building materials, construction techniques, and overall structural integrity directly influence the spread of fire, the structural stability during a fire, and the availability of safe escape routes for occupants. Building codes and regulations often dictate the minimum requirements for fire resistance and structural performance in the event of a fire. Incorporating fire-resistant materials, such as concrete, steel, or fire-rated gypsum boards, can significantly enhance the overall fire safety of a residential building. Additionally, the proper design and installation of fire-rated partitions, walls, floors, Pressurized stairwells, Emergency evacuation procedures can help compartmentalize the building, limiting the spread of flames, smoke, and heat. By considering building structure as a fundamental design option for fire safety, architects and engineers can create robust and resilient residential buildings that prioritize the protection and well-being of their occupants.

- **Fittings and furniture:**

When it comes to fire safety in residential buildings, the selection and placement of fittings and furniture are essential design considerations. Fittings, such as electrical fixtures, plumbing systems, and heating appliances should be chosen with fire safety in mind. Opting for fire-resistant materials and ensuring proper installation and maintenance can significantly reduce the risk of fire initiation or propagation. Additionally, the layout and placement of furniture play a crucial role in creating safe and accessible escape routes during a fire emergency. Clear pathways, free from clutter and obstructions, allow for quick and unobstructed evacuation. Moreover, selecting furniture made from fire-resistant materials and avoiding the use of highly flammable substances can help prevent the rapid spread of fire and the release of toxic smoke. By considering fittings and furniture as integral design options for fire safety, residential buildings can be equipped with measures that minimize fire hazards, enhance occupant safety, and facilitate efficient evacuation in case of emergencies

CONCLUSION

In conclusion, this journal has explored the critical topic of fire safety design options in residential buildings, highlighting the importance of prioritizing the safety and well-being of occupants. Through the examination of various design strategies and options, we have gained valuable insights into mitigating the risks associated with fires in residential settings. From building materials and structural considerations to escape routes and advanced technologies, the presented research, case studies, and expert opinions have provided a comprehensive understanding of the latest advancements and best practices in fire safety design. By unlocking the power of intelligent design, we can create residential spaces that not only inspire but also protect lives and properties. As architects, designers, and professionals in the field, it is our responsibility to continue implementing these fire safety measures to ensure the creation of resilient and secure homes. Together, let us strive for a future where fire safety is an integral part of every residential building, fostering a sense of security and peace of mind for all occupants.

RECOMMENDATIONS

Fire safety design is needed in residential buildings. The facility will provide for both passive and active fire prevention system. The use of Fire-fighters response should be considered, therefore, facilities such as fire hydrant should be put in place at strategic points to assist fire-fighting activities.

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