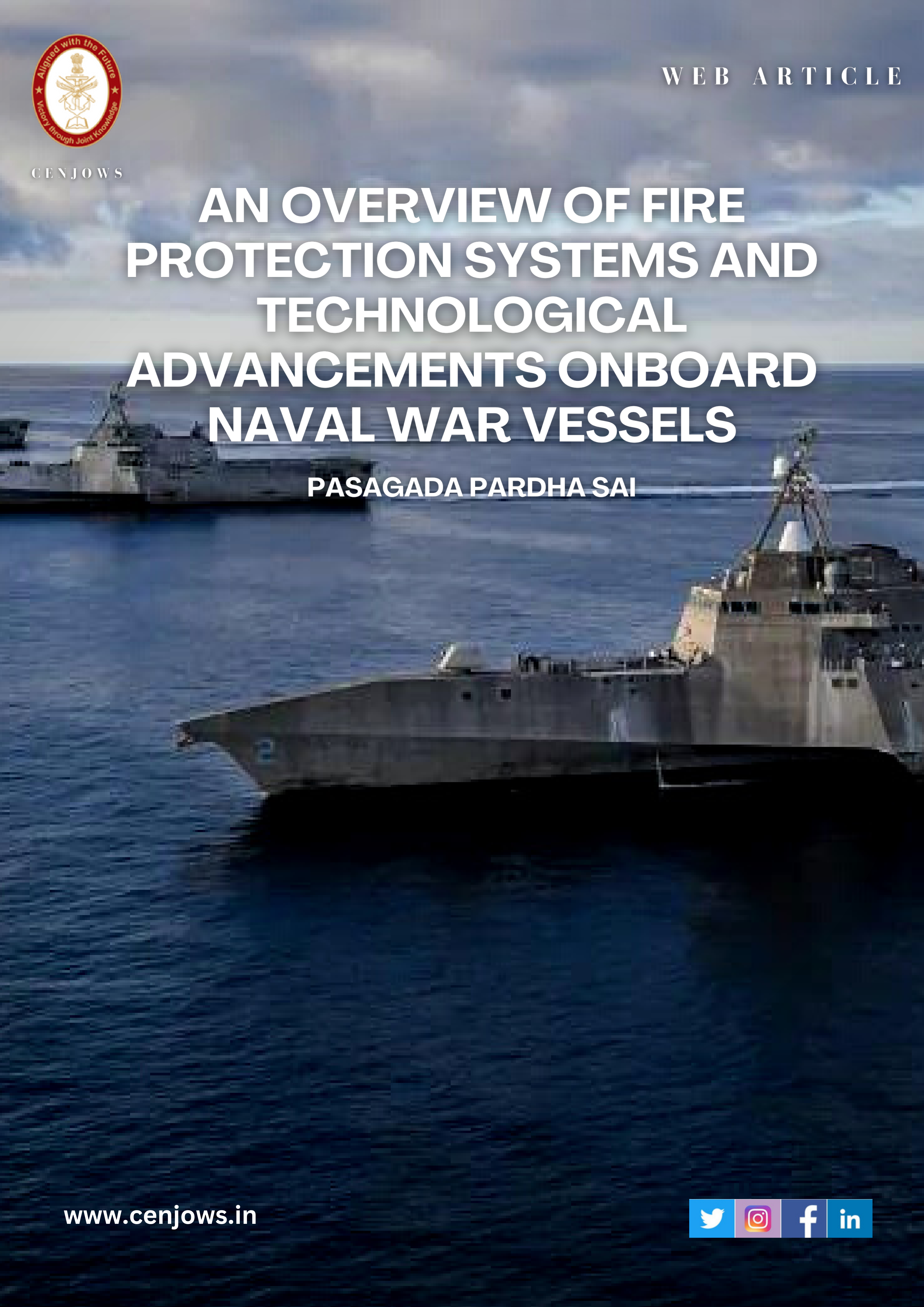

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# AN OVERVIEW OF FIRE PROTECTION SYSTEMS AND TECHNOLOGICAL ADVANCEMENTS ONBOARD NAVAL WAR VESSELS

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# AN OVERVIEW OF FIRE PROTECTION SYSTEMS AND TECHNOLOGICAL ADVANCEMENTS ONBOARD NAVAL WAR VESSELS

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**Abstract**

*The armed forces are a global requirement for every nation, which fulfil their various aspects of operational safety and national security of the nation from imminent threats. These forces operate on varied levels of mobilisation including the personnel mobilisation, armoured and machinery-based mobilisations. These installations and machinery require highest priority-based safety features enabled at varied levels to protect against imminent internal machinery failures and threats, which usually lead to a possible explosive fire reactions and detonations. The Naval vessels operated in the Naval Forces of various countries are integrated with these highest levels of weaponry and armoured missiles. The operational capacities integrated within the naval forces vessels are of highest standard which are integrated with utmost available technologies. When new technologies are integrated with enhanced weaponry systems, it increase the severity and risk of lower understanding for the personnel serving onboard. The Compartment fires and missile fire detonations are one of the most extensively noticed safety failures and fire redundancies seen onboard the destroyer, frigate, and offshore patrol vessels in the naval forces. The Compartment fire often leads to a considerable damage in the ship, which directly affects the integrity and watertight structural capability of the naval vessel. This paper takes through the various situational awareness of fire and connecting failures onboard the naval vessels and the varied levels of mitigation procedures and administrative controls followed for enhanced protection and capabilities compliance of the vessels as part of national security control.* [1]

## Introduction

The Naval Vessels operate on a considerable crew with varied levels of operational duties assigned as part of maintaining the continuity of security requirements in the waters adjoining the respective nation. These naval vessels include the Destroyers, Offshore Patrol vessel, Frigates and Corvettes. These are one of them most tightly compartmented vessels in the global operations, which are retrofitted multi levels missile technologies and other explosive ballistic requirements, which enhance its capabilities. Considering their enhanced ballistic firepower, the risk of possible explosion, detonation and fire accidents increases with the compartmentation being closer to each other, which again increases the possibility of high rated spread. When the focus is shifted to a larger tonnage vessels involved in the operational capacities of the naval forces, the Aircraft Carriers or Supercarriers are part of the much-expected requirement of fire protection systems. The carriers are one of the utmost delicate forces, which have higher rate of fire probability on-board considering high machinery capacities placed on-board the vessel with other possibilities of initiated, and unintentional explosions of aircraft placed onboard the vessel integrated with highest ballistic and explosive content possible for emergency requirements. There has been varied levels of analysis and mitigation techniques followed which mostly integrate the administrative control on several levels of requirements. In order to control the results of a weapon strike with a fire, it should be possible to achieve a balanced mixture of active and passive systems. [2] The activities in the early phases of fire are critical and an efficient way to combat early fire, either through the complete automatic suppression of fires, without operator involvement or manual actions, should be worked out. Because of the fast spread of fire and dense smoke, shipboard fires are typically difficult to combat. An essential issue to emphasise is the necessity for well qualified personnel with the appropriate equipment. Most ship compartment fires will progress to the ventilation-control stage based on the navy vessel management and preparedness. Furthermore, simulations of fire conditions following a missile strike indicate that no more than 10 minutes will be available for firefighting before circumstances get too severe. After around 10-15 minutes, the temperature of the air in the upper compartment will be high enough to spontaneously ignite additional combustible materials. The spread of fire to neighbouring compartments is generally slower. [3] The production and spread of smoke is another major problem for any firefighting efforts on board. Low visibility, difficulty locating the source of the fire, and poisonous consequences are just a few of the issues. There varied level of hazard induced through the fire emissions onboard the naval vessels are of utmost importance, which would be explained in the following sections of the paper.

## Fire Hazard Damage Concepts And Framework

The effects of fires aboard vessels in general have mainly been demonstrated as experiences of fires on board civilian ships such as passenger and cargo ships and because of collisions between ships during peacetime. The effects of fires aboard vessels in general are experienced on board civilian ships such as passenger and cargo ships and because of collisions between ships during peacetime, which is considerably different from armament-studded warships. There has been an enhanced usage of extensive risk analysis methodologies, which employs factors and consideration requirements being in specific to the Ship Fire safety provisions. The most used model of emphasis is the Ship Fire Safety Engineering Methodology or SFEM, which employs rather probabilistic based fire risk analysis on-board naval vessels of armed and national security roles. [4]

As a fire safety system, it is beneficial to undertake a structured and complete examination of the performance of all types of surface ships. The SFSEM is a comprehensive framework for assessing fires aboard ships in relation to specified fire safety goals. It takes into consideration all essential aspects of fire safety, including fire development and spread, the efficacy of passive design measures like barriers, as well as active fire protection features like fixed fire extinguishing and manual suppression devices. In the event of a fire onboard a ship, the steel structure will never burn. However, considering the fact of a naval combat vessel being deployed on a long-toured tenure in the international and territorial waters, a steel made naval ship has plenty of fuel for a fire, thus using steel as a structural material does not remove fire hazards. Steel, although being incombustible, has a characteristic that makes it difficult to extinguish fires: it has a high heat conductivity. An unprotected steel panel transfers heat from a fire-affected side to the opposite side very immediately, allowing the fire to spread through structural panels that are still intact. As a result, if not properly insulated, a steel panel alone is ineffective as a fire barrier. [5]

The warships make extensive usage of such analysis to create a phase of understanding through computerised models which in turn given an understanding on the best design for fire safety and alternatives for fire protection. These include usage across multiple phases, which are as follows:

- **Preliminary Phase**: Competing preliminary designs can be compared to one another and ranked according to how safe they are from fire. Alternately, each design could be evaluated using a pass-fail criterion and compared to fire safety goals stated by relevant authorities.
- **Fire Doctrine Analysis**: Warships are the only ones with this fire doctrine. This doctrine outlines the strategies, outlook, and practises related to the use and management of ship fire prevention systems during the suppression of fires. For fighting fires in the main machinery compartments, the Navy and Coast Guard have a formal requirement for a documented fire policy.
- **Damage Control Organization**: A ship's damage control organisation is set up to successfully manage damage, stability, list, trim, fire, and flooding in order to assure the ship's survivability. This organisation has many different facets, such as training, supplies, firefighting theory, casualty control, communication, along inspections, etc.

## Naval Fire Scenario Operation And Euclid Rtp3.21 Project

In addition to the work being done and the physical conditions on board the ship while maintenance is being carried out, navy ships are at a high risk of fire. Recent fire accidents have jeopardised individuals and significantly damaged property and finances. The Navies across the globe conduct two key sorts of investigations after large fires and other noteworthy events. A safety investigation board is appointed by commands that are in charge of providing control for subordinate units and enforcing safety reporting to look into fire accidents that meet specific requirements. Such fire incidents include those that result in property damage, fatalities, or financial thresholds. [6]

According to Navy regulations, ship crewmembers are expected to finish their training programmes during the maintenance time. The ship's commanding officer is in charge of ensuring that there are enough trained individuals on board to respond to crises that arise while the ship is in port. Each ship is required to maintain an in-port emergency squad, which serves as a quick response team in the case of an on-board fire, according to the Navy's surface ship firefighting guidance. According to Navy officials, during all of the ship's regularly scheduled repairs, instruction, and deployments periods, each duty division must retain an in-port contingency crew.

As part of increasing the safety structure of the warships, there has been a continual improvement approach adopted as a research requirement by NATO towards survivability and performance aspects. The RTP3.21 project is a significant European cooperative initiative with 24 partners from six different European nations. The main goal of this project is to improve the technological foundation for the extensive use of fibre-reinforced composite elements in naval components including vessels. The subject matter of this case is the superstructure of a frigate-sized naval ship with a conventional steel hull, and the main dangers to such structures are taken into account. These include fires caused by weapons as well as internal and external blast. [7]

A hybrid superstructure's design offers several key benefits, including lighter construction, lower signatures, and increased payload. Some obstacles need to be addressed in order to take benefit of these opportunities. Collectively, these operations will reveal suitable passive fire prevention systems and divulge knowledge on phenomena that are especially pertinent to navy ships. The final objective is to create a design that is no more susceptible to blast, components, and possibly long-lasting flames than a conventional steel structure. This design will be tested in the RTP3.21 project.

**Latest Integrated Fire Protection Technologies For Naval Warships**

On the international level, naval vessels are integrating a number of cutting-edge technologies for fire and damage detection, abatement, and suppression, with the Indian Navy most recently demonstrating its autonomous firefighting vehicle capacity. These technologies include aerosol fire extinguishers, smoke control (ejection) systems, water mist and gaseous agent fire suppression systems, point and volumetric fire and damages detectors, among technologies. Selecting polymer materials with built-in fire resistance, using flame-retardant ingredients like nanoparticles, incorporating flame-retardant compounds into the polymer's backbone, and using intumescent coatings are a few methods for improving the fire as well as flammability characteristics of non-metallic (polymeric) components employed on naval vessels. There are multiple classes of technologies focused towards fire suppression and safety across naval war vessels, which includes:

- **Nanoparticles**

  Nanoparticles can be introduced to polymers at much lower concentrations than traditional flame and fire retardants, and this has been seen to have an impact on the flammability characteristics of the resulting nanocomposites. Their distribution within the polymer directly affects how effective they are. The enhanced flammability performance of polymers incorporating nanoparticles is explained by two different ways. According to the initially proposed system, when the polymer is heated, the nanoparticles create a multilayer carbonaceous silicate structure. As an insulating layer, the finished product shields the underlying substrate from further deterioration. However, it has been found that nanoparticles decrease the maximum temperature release rate for nanocomposites, additional properties like the limiting oxygen indices as well as time to ignite may suffer. [8]

- **RAN 30 System**

  A Class N-30 fire division known as the RAN-30 System was created especially for the defence sector. This special structural fire division was created to withstand shock and hydrocarbon fire. The RAN- 30 System, in contrast to other passive fire prevention items, consists of panels located below the deck head, providing simple access to the vessel structure. Cargo compartments, hangars, and main machinery spaces are further possible application locations. [9]

- **MTMFFAS (Magazine Temperature Monitoring and Firefighting Actuation System)**

  Designed and developed by the Indian Navy, the system focuses on placing systems in place towards better fire management and control systems wherein, when temperatures go beyond or below certain high and low limits, the systems sound alarms. All magazine chambers and barbettes are intended for use with the system. All magazine compartments and barbettes must have temperature and humidity sensors installed so that they may be controlled and monitored remotely from a "Alarm unit" (ideally a dozer post or another convenient location). The system runs fire wires around the outside of the chamber. They are positioned such that they will not miss any temperature changes brought on by a fire or explosion anywhere in the compartment. The fire wire will be put in a zigzag pattern at the wall of the magazine sections, about 60 cm above the ground. The heart of the entire Magazine Fire Fighting System will belong to the Master Control Unit. In Hand Shake mode, the device collects information from several sensors using an interface box. [10]

- **Special Firefighting Autonomous operated Bots**

  INS Vikramaditya and INS Vikrant under the aegis of Indian Navy have focused on inducing autonomous bots for firefighting capabilities through the Make in India initiative. Swadeshi Empresa Private Limited has been the forerunner towards the order, with the bots being used to analyse and locate fires, carry out search and rescue operations, keep an eye on potentially dangerous factors, and principally regulate and conceal fires. The robot autonomously locates the fire's origin and puts it out with water, foam, or jets while keeping people safe. [11]

Alongside this, multiple technology-based elements are being developed by navies across the world, with high expansion foam being part of the latest inductions. The application of high expansion foam to safeguard large-volume, mission-critical regions aboard future ships, including magazines, well decks, vehicle stowage facilities, and hangar bays. High levels of impediment make it difficult for standard water or limited expansion foam spray systems to reach fires that accumulate behind objects or beneath machinery. High expansion foam can quickly fill a compartment and send water to fire risks in quantities adequate to put the fires out, but significantly less than what deluge sprinkler watering systems generally deliver.

Alongside this, the US Navy has been currently developing the SSC based methodology into place. The current Landing Craft Air Cushion (LCAC) will be replaced by SSC. The SSC's fire defence must be "Halon-free," which necessitates finding adequate firefighting materials to take the place of the Halon 1301 and Halon 1211 systems that currently shield the LCAC's cargo deck, supplementary power units, turbine engine enclosures, and fuel bays from fire. Additionally, firefighting agents and systems that offer low weight and low life cycle cost efficiencies are crucial because the SSC would be lightly manned and weight will be a key consideration. The substitute firefighting chemicals must also accommodate the working temperature range of the SSC, 10° to 200° F. [12]

## Conclusion

Specific rules and regulations, at their most effective, can produce high-quality fire safety designs. In the worst cases, prescriptive regulations can lead to costly and inadequate methods for addressing fire dangers on military warships. When it is technically and fiscally viable, designers, researchers, and regulatory authorities must question the prescriptive rules and attempt to develop better, safer solutions. Because there are effective ways to prevent fires, contain fires, and battle fires, there is less vulnerability to fire. It is advised that creative concepts for such methods be found and developed, paying close attention to the properties of composite constructions. Forced entry of firefighting equipment into a burning area while safeguarding the firefighters and interim repair would be of great importance. Such similar instances could be noticed across initiatives taken by Indian Navy towards personnel protection by inducting the autonomous bots, which can safeguard the machinery, and equipment across the vessel at all times.

There is a critical need to close the remaining discrepancies so that the cost-benefit assessment technique can be used in the future. This method is essential for developing cost-effective strategies to combine active and passive measures to effectively reduce susceptibility to fire. This would create a solid foundation for comparing a composite structure's fire vulnerability to that of a conventional steel construction. To do this, simulation tools that enable measuring the efficacy of various combinations of firefighting tactics in pertinent scenarios must be developed and verified.

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