Innovative: International Multi-disciplinary Journal of Applied Technology
(ISSN 2995-486X) VOLUME 04 ISSUE 02, 2026

Improving Methods for Effective Elimination of Natural Disasters

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Abstract:

Earthquake-induced secondary fires are frequent, potentially worsening human and infrastructure losses and prolonging the duration of relief efforts. All this implies that effectively putting out such fires necessitates not only technical firefighting skills but also accurate forecasting of fire progression, alongside coordinated tactical responses in the face of unpredictable structural circumstances. Nonetheless, what is lacking in both practice and research is the often-overlooked essential connection regarding the coordination of joint actions between fire and rescue units and the community during significant earthquakes and other emergencies.

This research addresses this gap by examining the efficiency of preventive and tactical measures aimed at the swift and successful elimination of fires that arise following tectonic shocks, encompassing patterns of fire spread, combustion circumstances, and operational training frameworks. We examine research by analytically reviewing fire development factors, analyzing earthquake-related damage patterns in buildings, evaluating training practices, and assessing coordinated response strategies from both regulatory and practical viewpoints.

The research findings revealed that a limited number of factors impact the decrease in fire extinguishing time, which can be improved through heightened fire resistance of buildings or other structures under seismic protection, along with more effective coordination of evacuations and better collaboration among all governing

authorities, civil protection agencies, and the local community. The findings indicate that organized preventive actions such as reducing construction density, improving water supply access, and using fire-resistant building materials can significantly help in fighting fires.

Practice implications involve combining seismic and fire safety strategies; coordinating emergency efforts with local communities; and ensuring consistent, high-quality tactical training that minimizes overall response time to earthquake impacts.

Keywords: Earthquakes, fires, buildings and structures, injuries, tectonic shocks, population, flammability levels and exercises.

Introduction

To guarantee the engineering safety of the population and regions, it is vital to anticipate fire progression ahead of time and evaluate the fire situation under particular circumstances for addressing problems linked to extinguishing fires that arise [1]. To predict fire progression beforehand, it is essential to understand and examine techniques for determining the rate and paths of fire spread, the length of fire evolution, variations in temperature and gas composition over time, the intensity of gas exchange, along with additional fire parameters.

Every fire encompasses situations that can result in unforeseen outcomes, such as wind velocity during a blaze, shifts in trajectory, and additional elements. Consequently, predicting the exact progression of a fire beforehand is unfeasible; nonetheless, fires exhibit common patterns, allowing for an analytical description of typical fire scenarios and their attributes [2].

The primary phenomena noted due to a fire include the combustion process arising from gas and heat transfer. They evolve with time based on the fire's position and are defined by fire characteristics. A fire is regarded as an open thermodynamic system where there is an exchange of matter and energy with the surroundings [3].

In examining the processes involved in a fire, it was found that the combustion of flammable substances and materials takes place due to a chemical oxidation reaction and the swift occurrence of physical phenomena (without this reaction, a fire cannot ignite), along with the emission of heat radiation from the heated surfaces of combustion products or heat because of laminar or turbulent diffusion flames.

The primary requirements for combustion include the existence of combustible substances, the introduction of an oxidizing agent into the area where chemical reactions take place, a steady supply of heat that sustains combustion, and other related factors; furthermore, the effects of fires triggered by earthquakes remain under investigation [4].

Today, to enhance tactical abilities in addressing the aftermath of primary and secondary fires caused by earthquakes globally, the expertise and proficiency of fire and rescue personnel can be significantly advanced through training drills and exercises during strong earthquakes and other emergencies [5]. The Presidential Decree of the Republic of Uzbekistan No. PF-5066, issued on June 1, 2017, titled "On Measures to

Fundamentally Enhance the Effectiveness of the System for Preventing and Addressing Emergency Situations," demonstrated the necessity to elevate the importance of this objective.

Methodology

This study developed a method that is both analytical and practice-oriented, aimed at improving the efficiency of rapid fire displacement by suggesting an analytical process that will propose the design earthquake and also during other emergency scenarios. The approach was developed based on a systematic literary review and integration of scientific articles, regulatory documents from the Republic of Uzbekistan, and an operational guide on seismic safety, emergency response, and fire rescue operations [6]. The research examined the critical fire spreading traits required for a prediction, encompassing assessed fire movement speed and direction, fire expansion duration, time-resolved thermodynamic characteristics, gas mixture composition, and gas exchange levels. Concurrently, part of the research analyzed typical structural characteristics of earthquake damage in both residential and industrial buildings, emphasizing multi-storey structures where the collapse of upper floors and wall detachment could hinder access for search, rescue, and firefighting operations [7]. Preventive and tactical strategies were evaluated via circular comparative analysis of current recommendations established regarding urban planning solutions, water supply access, flammability of construction materials, and the availability of firefighting equipment as per set norms. Moreover, to establish the goals of the research activity, exercises and drills served as the primary operational means for enhancing the links between the fire rescue units, governing authorities, facility staff, and the community [8]. Evaluated proposed strategies focused on the effectiveness of enhanced firefighting methods, coordination of collaborative efforts, and tactical readiness in reducing fire extinguishing duration, consequently decreasing the overall time dedicated to addressing earthquake aftermath

Result and Discussion

Several harms and losses resulting from fires that happen during earthquakes can primarily be affected by four elements:

- the total count of main fires;
- possible fires;
- the flammable region accessible for the advancement of flames;
- the extent of combustible load regarded as a factor in building structures [9].

Tectonic shaking is primarily seen in multi-story residential structures with damage to the top two floors; in certain instances, damage is also noted on the lower levels.

In accordance with the Resolution of the President of the Republic of Uzbekistan No. PQ-3190 dated August 9, 2017, “On Measures to Further Develop Scientific Research in the Field of Seismic Safety of the Territory and Population of the Republic of Uzbekistan, Earthquake Resistant Construction, and Seismology,” outlines ongoing research in our republic that adheres to current standards in areas such as seismic and fire safety, scientific investigation in construction and seismology, enhancing the

emergency prevention and response system, safeguarding the population and areas from seismic threats, and securing fire safety.

In Uzbekistan, earthquakes with a strength of up to 7.5 on the Richter scale can happen. In Uzbekistan's seismically risky regions, over 330 settlements and 120 cities exist. In these circumstances, pressing matters like enhancing the earthquake resilience of multi-story residential and industrial structures in our republic persist.

Prior to evaluating the potential for greater damage on the upper floors from possible earthquakes, it's necessary to assess the structural integrity by performing inspections via calculations on the lower levels [10]. In this instance, it is deemed adequate to perform restoration activities on the upper levels, whereas in other situations, enhancing the safety of the structures across all levels will be required.

Along with the affected zones, fissures can also be seen in one-fourth of the structure at the junctions of external longitudinal and lateral walls positioned at right angles, as well as at the meeting points of internal walls, resulting in their detachment from one another. These occurrences are primarily seen in single-story structures built without considering seismic resistance and in certain heavily deteriorated multi-story buildings. During the examination of construction objects by individuals involved in emergency rescue efforts in homes impacted by tectonic events, it was noted that the width of cracks causing separation had not increased substantially, no significant tilting of the separated wall was detected, and there was no movement of floor slabs at the area where the walls were joined or supported [11]. In these instances, it is deemed that the load bearing capacity has diminished and the overall structural integrity of the building has suffered damage.

One can notice the detachment of an exterior wall from the adjacent walls and, in certain situations, its obvious tilting away from the vertical alignment, alongside the fall of the disconnected walls. In this scenario, the structure is regarded as entirely ruined and is typically viewed as needing total demolition.

This scenario is typical of a one-story structure built from adobe. The demolition of multi-story structures is seen as an anomaly and results solely in harm to individual rooms on the upper level.

Only in infrequent situations may specific rooms or minor areas of a building reach an авария condition. Certainly, in these instances, the walls of separate rooms are partially taken down and reconstructed by linking them to the current walls [12]. Structures that have experienced first category damage are typically repaired using conventional techniques. In every instance, basic details are employed to avoid quick deterioration of architectural finishes in room interiors and to guarantee earthquake-resistant building.

Consequently, measures aimed at preventing secondary fires during earthquakes include preventative actions taken earlier and those that support the tactical efforts of fire rescue teams [13].

Drawing from the information provided, the subsequent measures can be highlighted as essential for guaranteeing safety in urban planning development:

• decreasing building density;

• expanding spaces between communities (blocks);
• providing extensive green spaces and pathways;
• building drainage water pathways (canals);
• building open-type artificial water reservoirs in every neighborhood (block) that enhance the community's living standards and ensure a constant water supply for fire trucks;
• применение трудно воспламеняющихся или полностью невоспламеняющихся строительных материалов при возведении зданий и сооружений;
• emphasizing the supply of fire extinguishing equipment in line with current standards and regulations.

Following the examination of the preventive and tactical actions taken by units to effectively tackle the consequences of secondary fires following earthquakes, it is essential to acknowledge that well-organized efforts conducted in collaboration with the public during significant earthquakes and other emergencies are crucial [14].

Properly notifying relevant organizations about fire risks, coordinating victim protection and rescue, administering first aid, and establishing fire containment, while ensuring the seamless execution of actions by governing bodies, Civil Protection agencies, and facility staff, is regarded as a primary responsibility, necessitating that specialists effectively carry out training sessions.

From the analysis of training sessions informed by the research conducted, it becomes feasible to specify the following:

• minimizing the duration of fire suppression by implementing seismic protection structures that possess a high degree of fire resistance;
• by decreasing the duration of fire suppression, resulting in a shorter overall time for addressing the aftermath of earthquakes [15].

The examination of the preventive and tactical measures undertaken by units for effectively addressing the aftermath of secondary fires resulting from natural and technogenic incidents revealed that, during severe earthquakes and various emergencies, efficiently coordinating their efforts alongside the public is extremely important. Exercising and rehearsing the procedural actions of governing body structures and facility staff, aligned with potential scenarios, regarding reporting fire risks, arranging victim protection and rescue, delivering initial medical assistance, and executing fire containment, represents the primary form (approach) of training.

Conclusion

Considering the above, to enhance the operational tactical actions of fire rescue units in effectively extinguishing various fires resulting from natural and technological incidents, it is crucial to protect the health and lives of individuals trapped under building debris from potential future earthquakes, while ensuring prompt fire suppression through regular and high-quality drills and training sessions based on regulatory documents. To achieve this, it is essential today to enhance the efficiency and localization of different kinds of fire suppression equipment.

Enhancing the seismic resilience of tall buildings and structures is essential, alongside creating innovative passive and active seismic protection systems to avert earthquakes and fires, and enhancing the coordination and organization of emergency rescue operations. In this context, creating a комплекс strategy for organizing fire suppression and enhancing this system further is also a significant matter.

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