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Research on Methods for the Rapid and Effective Elimination of Occurring Fires

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Abstract:

Secondary fires ignited by earthquakes, are common, which can aggravate human and infrastructure casualties and lengthen the period of relief operation. All this, means that efficient extinguishing of such fires requires, not only the technical firefighting capacity, but also proper forecasting of the fire development, as well as coordinated tactical actions in conditions of unstable structural conditions. However, what is missing in practice and research is that a much-neglected a crucial link has to do with sequencing of joint actions of fire and rescue units and the population during strong earthquake and other emergent cases.

This study fills this gap by looking at the effectiveness of preventive and tactical activities directed toward rapid and effective eradication of fires occurring after tectonic shocks, including fire spread regularities, combustion conditions, and operational training systems. We discuss research through analytical review of fire development parameters, review of earthquake related building damage patterns, assessments of training exercises and coordinated response measures from both regulatory and practical perspectives.

The study results indicated that a small number of factors influence the reduction of fire extinguishing time, which can be achieved through the increased fire resistance of buildings or other structures subject to seismic protection, as well as a better organization of withdrawals and enhanced interaction between all governing bodies, civil protection structures and the local population. The results suggest that systematic preventive measures including construction density reduction, water supply accessibility, and low flammability construction materials can greatly aid in combating fire.

Implications for practice include integrating seismic and fire safety planning; emergency coordination with communities; and regular high-quality tactical training that reduces total elimination time for consequences of an earthquake.

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

Introduction

In ensuring the engineering protection of the population and territories, forecasting fire development in advance and assessing the fire situation under specific conditions are of great importance for solving issues related to extinguishing occurring fires [1]. In order to forecast fire development in advance, it is necessary to know and study methods for calculating the speed and directions of fire spread, the duration of fire development, changes over time in temperature and the composition of the gas environment, the intensity of gas exchange, as well as other parameters of the fire.

Each fire includes circumstances that may lead to unexpected consequences, for example, wind speed during a fire, changes in direction, and other factors. Therefore, it is not possible to forecast fire development in all details in advance; however, fires have general regularities, which makes it possible to analytically describe general fire situations and their characteristics [2].

The main phenomena observed as a result of a fire are the combustion process that occurs due to gas and heat exchange. They change over time depending on the location of the fire and are characterized by fire parameters. A fire is considered as an open thermodynamic system in which matter and energy exchange with the environment takes place [3].

When studying the processes occurring in a fire, its parameters and characteristics, it was determined that the combustion process of combustible substances and materials is observed due to a chemical oxidation reaction and the rapid occurrence of physical phenomena (without this process, a fire does not occur), as well as due to the release of heat radiation from heated surfaces of heat and combustion products as a result of laminar or turbulent diffusion flames.

The main conditions of combustion consist of the presence of combustible material, the entry of an oxidizing agent into the zone where chemical reactions occur, continuous heat that ensures combustion, and similar factors; in addition, the impact of fires caused by earthquakes is still being studied [4].

Today, in order to further improve tactical capabilities aimed at eliminating the consequences of primary and secondary fires occurring during earthquakes worldwide, when strong earthquakes and other types of emergencies occur, the knowledge and skills of fire and rescue service personnel can be further improved through drills and training exercises [5]. The Decree of the President of the Republic of Uzbekistan No. PF-5066 dated June 1, 2017, “On Measures to Fundamentally Improve the Effectiveness of the System for Preventing and Eliminating Emergency Situations,” proved the need to further increase the relevance of this task.

Methodology

This research designed a method that is analytical as well as practice oriented aiming to enhance the efficiency by which rapid fire can be displaced through the recommendation of an analytical process that will recommend the design earthquake and even during other emergency situations as well. The methodology was built on a systematic literary review and synthesis of scientific papers, regulatory documents of the Republic of Uzbekistan, and operational guide on seismic safety, emergency response and fire rescue activities [6]. The study investigated the essential fire spreading characteristics necessary for a forecast, including calculated fire propagation rate and heading, fire growth time-scale, time-solved thermodynamic properties, gas environment composition, and gas exchange intensity. Simultaneously, a portion of the study examined normal structural forms of earthquake damage in residential and industrial buildings, focusing on the case of multi storey structures where upper floor collapse and wall separation could affect access for search and rescue and firefighting efforts [7]. Preventive and tactical measures were assessed through circular comparative analysis of existing recommendations determined in terms of urban planning solutions, water supply accessibility, construction material flammability, and the availability of firefighting equipment according to established norms. In addition, for determining the objectives of the research exercise, exercises and drills were the main operational tool for strengthening the connections of the fire rescue units with governing bodies, facility personnel, and the population [8].

Proposed approaches were evaluated based on the efficiency of the combined impact of fire fighting improvements, co-ordination of joint activities, and tactical preparedness in terms of reducing the fire extinguishing time, thereby minimizing the total time spent on earthquake consequence elimination.

Result and Discussion

Various damages and losses caused by fires occurring during earthquakes may mainly be influenced by four factors:

- the number of primary fires;
- potential fires;
- the combustible area available for fire spread;
- the level of combustible load considered as a component of building structures [9].

Tectonic shaking is mainly observed in multi storey residential buildings through the destruction of the upper two floors; in some cases, destruction is also observed on the lower floors.

Based on 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," research works are being carried out in our republic that meet modern requirements in the areas of ensuring seismic and fire safety, conducting scientific research in construction and seismology, increasing the activity of the system for preventing and eliminating emergency situations, protecting the population and territories from seismic hazards, and ensuring fire safety.

As we know, in the territory of Uzbekistan, earthquakes with a magnitude of up to 7.5 on the Richter scale may occur. In seismically hazardous areas of Uzbekistan, more than 330 settlements and 120 cities are located. Under such conditions, urgent issues such as increasing the earthquake resistance of multi storey residential buildings and industrial buildings in our republic still remain.

Before assessing that the upper floors may be more severely damaged as a result of possible earthquakes, it is required to determine the strength of the structures by conducting inspections through calculations on the lower floors [10]. In this case, it is considered sufficient to carry out restoration works on the upper floors, while in other cases it will be necessary to increase the safety of the structures of all floors.

In addition to the damaged areas, cracks may also be observed in one quarter of the building at the separation points of external longitudinal and side walls in mutually perpendicular directions, as well as at the intersections of internal walls, which lead to their separation from each other. Such phenomena are mainly observed in single storey buildings constructed without taking seismic resistance into account and in some significantly worn multi storey buildings. When construction objects were inspected by persons who participated in emergency rescue works in houses affected by tectonic impacts, it was observed that the width of the cracks that led to separation had not increased significantly, and no noticeable tilting of the separated wall was observed, as well as no displacement of floor slabs at the side where the walls were connected or supported [11]. In such cases, the loss of load bearing capacity and damage to the overall structural system of the building are considered to have occurred.

It is possible to observe the separation of an external wall from other walls and, in some cases, its noticeable tilting from the vertical position, as well as the collapse of the separated walls. In such a situation, the building is considered to be completely destroyed and, as a rule, is deemed to require complete demolition.

This situation is characteristic of a single storey building constructed of adobe. The destruction of multi storey buildings is observed as an exception and leads only to damage in separate rooms of the upper floor.

Only in rare cases may individual rooms or small sections of a building enter an авария condition. Of course, in such cases, the walls of individual rooms are partially dismantled and restored by connecting them to the existing walls [12]. Buildings in which first category damage has occurred are usually restored using standard methods. In all cases, simplified details are used in order to prevent

rapid destruction of architectural finishing in the interior parts of rooms and to ensure earthquake resistant construction.

Thus, challenging measures aimed at eliminating secondary fires that may occur during earthquakes include earlier provided preventive measures as well as measures that facilitate the tactical actions of fire rescue units [13].

Based on the above, as examples of necessary measures for ensuring safety through the development of urban planning, the following can be cited:

- reducing construction density;
- increasing distances between neighborhoods (blocks);
- ensuring wide green areas and passageways;
- constructing drainage water channels (canals);
- constructing open type artificial water reservoirs in each neighborhood (block) that serve to improve the population's living activity and provide fire trucks with continuous water supply;
- using трудно combustible or completely non-combustible construction products in the construction of buildings and structures;
- paying special attention to providing fire extinguishing equipment in accordance with existing norms and rules.

As a result of analyzing the preventive and tactical activities of units aimed at effectively eliminating the consequences of secondary fires occurring after earthquakes, it is required to recognize that properly organizing activities carried out in cooperation with the population during strong earthquakes and other types of emergency situations is of great importance [14].

Ensuring correct notification of relevant organizations regarding fire hazards, organizing the protection and rescue of victims, providing first medical aid, and completing fire localization, as well as ensuring the coordinated implementation of actions of governing bodies, Civil Protection structures, and facility workers and employees, is considered one of the main tasks, and it requires that specialists conduct training sessions correctly.

Based on the analyses of training sessions conducted on the basis of carried out research, it becomes possible to clarify the following:

- achieving a reduction in the time spent extinguishing fires through the application of seismic protection structures with a high level of fire resistance;
- with the reduction of fire extinguishing time, achieving a reduction in the total time spent eliminating the consequences of earthquakes [15].

The analysis of the preventive and tactical activities of units aimed at effectively eliminating the consequences of secondary fires occurring after natural and technogenic events showed that, during strong earthquakes and other types of emergencies, properly organizing their activities carried out together with the population is of high relevance. Working out and practicing the sequence of actions of governing body structures and facility personnel, corresponding to possible situations, in terms of reporting fire hazards, organizing the protection and rescue of victims, providing first medical aid, and completing fire localization, constitutes the main form (method) of training.

Conclusion

Taking the above into account, in order to further improve the operational tactical actions of fire rescue units in effectively extinguishing various fires that occur as a result of natural and technogenic events, it is of great importance to ensure the protection of the health and lives of people trapped under building debris as a result of possible future earthquakes, as well as to ensure timely fire extinguishing, by guaranteeing that drills and training sessions planned on the basis of regulatory documents are conducted regularly and with high quality. For this purpose, it is also required today to increase the effectiveness and localization of various types of fire extinguishing technical means.

It is necessary to improve the seismic resistance of high rise buildings and structures, develop new types of passive and active seismic protection systems for preventing earthquakes and fires, and coordinate and improve the organization of emergency rescue operations. In this regard, developing

комплекс measures for organizing fire extinguishing and further improving this system is also one of the important issues.

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