

Cause and Analysis of Fires Caused As A Result of Earthquake

Ph.D., professor B.T.Ibragimov (Academy of the Ministry of Emergency Situations of the Republic of Uzbekistan)

S.Jabbarov (Navoi Region Mining and Metallurgical Combine Joint-Stock Company and Navoi Uranium State Enterprise)

If you look at the history of earthquakes, up to 60% of fires occur after and as a result of earthquakes in developed cities. At present, the potential assessment of losses expected from earthquakes that may occur for large cities has been calculated, and appropriate measures are being developed to reduce the seismic risk in the US, Japan, China and other developed countries, as well as in the Philippine Islands. The most famous earthquake in the history of the United States of America, which occurred in 1989, caused the burning of most of the city of San Francisco. Up to 90% of buildings were damaged after this earthquake due to fires and crude firefighting techniques used to extinguish the fire (Figure 1). The total amount of damage was not less than 60 billion US dollars. No insurance company can cover the indicated loss (damage). Also, the fires caused by the Loma Prieta earthquake in the San Francisco Bay area have complicated the work of firefighting and emergency rescue operations.

Fire after earthquakes has long been considered a major threat. Until the 20th century, fires after earthquakes were often caused by candles, lights, lamps, stoves and fireplaces (burning hazardous fuels). Today, the most common sources of ignition for such fires are gas lines, electric arcs, wires and equipment ruptured by earthquakes. In addition to creating the possibility of ignition, earthquakes can block access to firefighting equipment and damage firefighting water supplies. This causes many fires in the city. Fighting fires caused by earthquakes is much more difficult than fighting ordinary fires.



Fig. 1. A fire broke out in San Francisco after the earthquake.

One of the most potential and dangerous consequences of earthquakes is the threat of fire. Fires are a common occurrence after earthquakes. In 1995, after the earthquake in Kobe, Japan, the danger of urban fires increased. Hundreds of fires broke out after the earthquake. The Japanese proudly call Kobe the "21st century city". After the 7.3-magnitude earthquake in Kobe, it was determined that material damage (loss) worth 102.5 billion dollars was caused to it. The fires that followed the earthquakes completely destroyed the old part of Kobe. If an earthquake similar to this one is repeated, in Japan, according to the information of the National Agency, the total economic loss will be 180 billion dollar, and its consequences will undoubtedly have a negative impact on the growth rate of the world economy. Extinguishing the fire was difficult because traffic jams and debris blocked many streets. 22 of the 30 reservoirs in Kobe had fire hydrants to stop the fire. All of these were used, but extensive damage to the pipeline systems and traffic congestion made access to these reserves very difficult. In Kobe, 968 tanks with a capacity of approximately 40,000 gallons were called to fight the fire. In a truck with such a large capacity, it took about 10 minutes to extinguish the fire from a tank of water. But within 2-3 hours, the combined underground water system ran out. Tankers were quickly put into operation to transport water from the bay.

The fires covered a total area of 4,500 m² and 5,500 buildings were destroyed by fire (Fig. 2).



Fig. 2. Image of fires after the earthquake in Kobe, Japan.

It should be noted that fire is always a threat to all regions and any category of structures as a consequence of any earthquake. During the earthquake that occurred in the city of Tashkent on April

26, 1966, a large number of fires and sparks were observed, all of which were liquidated in time thanks to the careful organization of the city's fire service.

Earthquakes cause damaging fires because they cause ground cracks and landslides. This damages buildings and gas pipelines and causes fire. Fires are the second most common casualty or hazard after earthquakes. Earthquakes can cause landslides and tsunamis that can cause infrastructure-destroying explosions and extreme fires. **Earthquakes can cause life-threatening fires when gas pipelines are destroyed or broken - as a result of strong shaking.** When strong earthquakes occur, flammable gas, for example, hydrogen, which flows out of cracks formed by ground shaking, serves as a source of fires. This is what happened in Lisbon on November 1, 1755. German scientist A. Humboldt wrote in his work "Universes" (1858) about the formation of fire in Lisbon: "On November 1, 1755, during the earthquake that destroyed Lisbon, a column of fire and smoke could be seen emanating from the new cracks in the rock of Alvidras and spread around the city."

Furnace breakdowns, kerosene fires, primus and kerosene spills, electrical short circuits, especially in oil and gas warehouses and cotton mills, are very dangerous, as are characteristic of any earthquake with high potential energy. High-density construction of the city, failure or non-existence of fire extinguishing systems are the initial conditions that cause the burning of building structures, confusion and agitation among the population, unfavorable weather conditions and heat effects, which cause fires. In addition, ground shaking causes explosions from ruptured gas pipelines, which is the second most damaging effect of earthquakes. After a dangerous earthquake, buildings are destroyed, roads and bridges are damaged. Chemicals are spilled, cars are thrown off the road and buildings collapse, petroleum products cause explosions due to combustion (Figure 3).

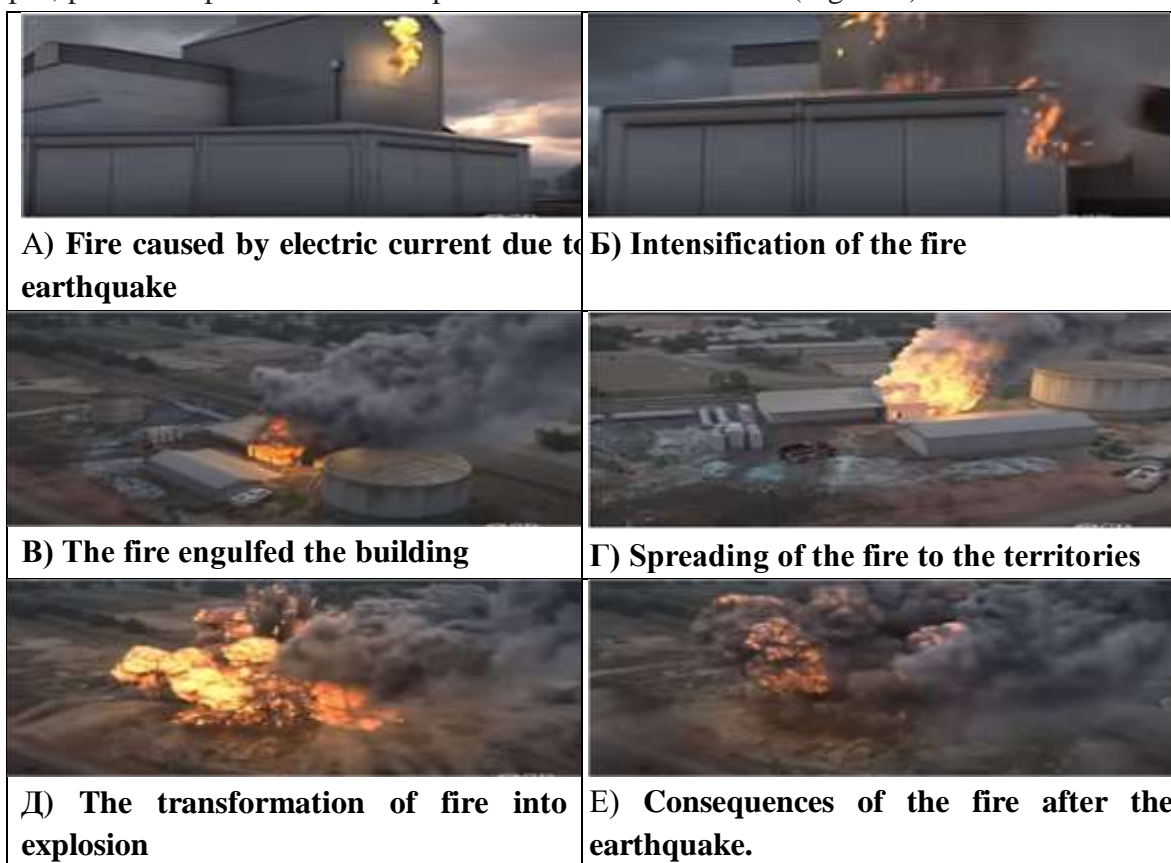


Fig. 3. Fire and explosion damage after the earthquake.

Anywhere there is a flammable liquid or gas is a source of flame. Collapse of buildings, disconnection of electricity and gas pipelines is the biggest loss after an earthquake, causing fire, destroying lives, and causing material damage (Fig. 4). Earthquakes cause billions of dollars in economic losses to countries every year, and in some regions this amount is even higher. Loss of life is the main loss after an earthquake, followed by loss of property.



Fig. 4. Power outage due to earthquake.

3 factors affect the scale of losses from fires caused by earthquakes: the number of primary fires; potential power of fires; availability of free space for the spread of fire.

In the event of a fire, the presence of human resources, equipment and water is certainly necessary for the effective operation of the fire safety service. The availability of water plays a key role in extinguishing fires, preventing the spread of infectious diseases and the like. One of the important characteristics of strong earthquakes is explained by the difficulty of supplying water to the population due to the complete destruction and failure of many pipelines. Such difficulty also has a significant negative impact on firefighting operations. This was the case in Tian Shan (China in 1976), where almost all residential buildings (96%) and industrial buildings (90%), bridges were destroyed, railway cars overturned, the entire engineering communications of the city completely failed, pipes and water the dams burst. Due to the destruction of the city's water facilities, mass infectious diseases began to spread: one million of the city's population of three million died.

Earthquakes cause disturbances, and if that disturbance is near a fire hazard, such as a burning candle or a broken gas line, a fire will start. Before gas lines, when candles were used to light buildings instead of electricity, they caused fires after earthquakes (Figure 5). Currently, these same elements are used in our life.

The problem with fires and earthquakes is that the ground or area affected by the earthquake shakes and moves. If a fire starts as a result of earth movement, the fire can spread very easily and quickly. If there is wind in the earthquake area, the fire will move faster. Along with other property issues, safety and loss of life issues, earthquake fire prevention is a very difficult problem. Any movement of the earth during an earthquake leads to the possibility of fire. If candles are burning or a special fireplace is working before the earthquake, turning them off will help prevent a fire. Having a fire plan is one way to prevent fires during and after an earthquake. It is important to have a proper evacuation plan in case of an earthquake or fire. The action plan minimizes the impact of the fire by leaving no source of fire and having people turn off the electricity and gas networks at the time of the earthquake. After the gas main is shut off, it is necessary to evacuate as soon as possible.

There is also a risk of liquefaction, which occurs when the earth's soil is damaged due to an earthquake, when the soil loses its stability and strength. Liquefaction is the soil's response to a strong shock such as an earthquake. In this case, the soil acts as a liquid instead of a solid layer, and when combined with damaged gas lines or electrical wires, the result is catastrophic. At the same time, the

water pipes may fail. During and after an earthquake, firefighting supplies, even small fire sources, can be difficult to find. Additionally, when buildings are damaged, there is an increased risk that any combustible materials inside will combine with the flames and become combustible materials that could cause a serious fire. Even exposure to flammable materials can pose a hazard during and after an earthquake. When buildings shake during an earthquake, it allows any debris or combustible material to move into voids and spark to ignite during a disaster. A power outage during an earthquake can delay or stop the fire. However, when electricity is restored, the risk of fire increases significantly. Earthquakes and fires always go hand in hand (Fig. 5).



Fig. 5. Image of burning residential buildings after an earthquake.

Disruption of production processes as a result of fires due to damaged equipment of industrial buildings, especially in production areas with a high risk of fire, the disruption of technological processes leads to further intensification of the fire. This category of fires can include fires in warehouses where combustible materials are stored and in places of their production. In Niigata, Japan, on June 16, 1964, large 400,000-ton fuel tanks burst into flames for two days, turning into a blazing torch. All 8 power stations have failed. The loss is 35 billion. yen or 800 million US dollars.

In such a case, in the cities where the earthquake occurred, fire department employees perform the main task in measures to eliminate the consequences. In this case, preliminary preparatory work will be tested and a system of necessary measures will be developed. However, in many countries, in non-seismically active areas, preparations for earthquakes and firefighting are not planned in advance. The reason for this is that, firstly, earthquakes occur rarely, and secondly, they do not predict the possibility of a fire after an earthquake.

In recent years, the assessment of the consequences of earthquakes in major cities of the world has shown that the number of people killed and the amount of material damage have decreased significantly. If the risk is assessed in advance in densely populated regions, then new constructions and technologies for strengthening existing buildings and structures and restoring earthquake-resistant buildings and structures are envisaged to eliminate the large number of losses and injuries seen from earthquakes.

Fires that occur during earthquakes can be divided into two categories:

- primary fires occur due to breakage of parts of buildings, equipment, everyday objects, gas networks and electric wires, disruption of technological processes in production with a risk of fire, etc.;

- secondary fires occur as a result of the spread of flames from the burning neighboring building. Such fires are caused by the high density of the city, broken fire extinguishing equipment or even their absence, the presence of a sufficient proportion of combustible materials in the building structures, and the influence of bad weather (Fig. 6).



Fig. 6. Consequences of post-earthquake fire in multi-story and raw brick buildings

Thus, the complex of measures aimed at preventing secondary fires occurring before and during an earthquake should include preventive measures provided for in the plan and measures that significantly facilitate the tactical actions of firefighting units. It is possible to enumerate the main types of measures envisaged in the development of urban development: reducing the density of buildings under construction; increase long distances between regions; creation of wide passages and strips of green vegetation; construction of water canal networks; to provide each area with artificial open water bodies suitable for the normal life activity of the population living in them, for supplying water to fire engines in extreme and crisis situations; use of hard-to-burn or non-flammable materials in the construction of buildings and structures; provision of fire extinguishers in accordance with applicable norms and regulations.

We can cite the following as an example of the dangerous factors for human life caused by a fire in residential areas, including the thermal decomposition of combustible materials, the effect of high temperature released from an open flame, the loss of their characteristics and the collapse of building structures. The temperature in the combustion zone reaches very high indicators, i.e. more than 1000 °C, causes dangerous conditions for human life and health. Factors that endanger people's lives as a result of fires include open flames, smoke, difficulty breathing, toxic gases, heated surfaces of combustible products, and damage to structures. In some cases, as a result of the explosions, shock waves, release of toxic gases, various objects and fragments are thrown into the air, high temperature, fire, collapse of buildings and structures, chemical and biological poisoning, and fatal floods occur for human life and health.

In this regard, the tasks of people during fire extinguishing are defined, and during the development of the fire, the actions of organizations and citizens should be focused primarily on ensuring people's safety and, as far as possible, move through the floors and spread the message about the danger that has occurred. Foreign countries (USA, Japan, Switzerland, Great Britain, South Korea) teach children from the age of 5-6 in order to ensure how people act in emergency situations. This, in turn, serves to identify the place where the fire occurred within 24 hours and ensure its timely elimination.

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