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Assessment of the Safe Evacuation of People in the Case of Fire and Other Emergencies in Religious Places-Mosques on the Base of Scientific Calculations

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Abstract: *This article provides information on the number of fires and emergencies in religious places in the world over the past decade, as well as the risk of fires and emergencies that can occur in these places. There are also calculations on the timing of the safe evacuation of people from the mosque building during emergencies.*

Keywords: *religious places - mosques, fire, emergency, fire heat, fire load, necessary time of evacuation.*

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It is consdere that Islam is one of the most comprehensive religions in the world, and today about 24% of the world's population are Muslims who believe in this religion[1]. Muslims, as we all know, pray in mosques, which is one of Islam's five pillars.

The mass gathering of people of various ages (from children to the elderly) and mobility in mosques, as well as the rapid spread of flames and smoke throughout the building in the event of a fire, complicates not only the extinguishing of fires, but also the evacuation and rescue of people within the mosque building.

When the fires and emergency occurrences that happened in mosques across the world during the previous 10 years were examined, the following results were discovered (Table 1).

Table 1. Fires in mosques in the last ten years in the world and emergencies

The time it happened	***The name of the place and the situation***	***The consequence***
15.04.2012	The "Hazret Sultan" mosque, one of the largest in Central Asia, is located in Astana, Republic of Kazakhstan, and has a total area of 17.7 thousand square meters. Extinguishing the fire required the	One person died as a result of the fire.

1 Islam by country [Electronic resource] / Wikipedia, the free encyclopedia: site. – Access mode: https://ru.wikipedia.org/wiki/Islam_po_stranam

	use of 32 different firefighting tactics.	
26.09.2015	A big fire broke out in Baitul-Futuh mosque, one of the biggest mosques in London. About 70 firefighters were involved in extinguishing the fire.	1 smoke-poisoned person was rescued.
14.07.2015	An animal that looks like a mouse caused confusion among people during the evening prayer in the mosque of Casablanca in Morocco.	As a result, about 80 people received various fractures and lacerations as a result of squeezing each other.
10.04.2015	A fire broke out in the central mosque of Kizlyar (Dagestan).	As a result, the fire area covered more than 1000 square meters
26.06.2015	An explosion occurred in one of the mosques in Kuwait. At the time of the explosion, about two thousand people had gathered for Friday prayers.	As a result, 27 people died and more than 200 people were injured.
23.08.2015	A fire broke out in a mosque in the Aravan district of the Osh region, Kyrgyz Republic.	As a result, 2 people died.

As seen above, when there is a fire or other emergency scenario in a mosque, the development of various confusions and disorders among people can produce dangerous conditions for the lives and health of individuals of all ages and movement abilities assembled in this area.

Toxic gases emitted as a result of fire and extremely hot temperature (combustion heat) are the greatest dangers to human life in fire and emergency situations in mosques, which we shall discuss briefly below.

The rate or density of the smoke – The decrease of vision in the smoke region and the amount of toxicity in the atmosphere characterize these fire indicators. The density of the haze determines the deterioration of visibility. It is measured in g/m^3 and is calculated by the thickness of the smoke layer visible to the light of the reference lamp or by the amount of solids present per unit volume.

Information on the density of smoke produced during the combustion of carbon-containing substances is presented in Table 2 below.

Table 2

Type of smoke	smoke density, layer. phase g/m3	The appearance of objects when illuminated by a lamp corresponding to a candle, m
Thick (dense) smoke	More than 1,5	No more than 3
Smoke of medium density (density).	from 0,6 to 1,5	from 3 to 6
Low density (density).	From 0,1 to 0,6	from 6 to 12

Fire heat – Q_y, kJ/s, describes how much heat is released in the combustion area per unit of time. Fire heat input Q'_y kJ/m^2·c indicates the heat released from a unit fire area per unit time:

$$Q_y = \beta \nu'_M F_y Q_q^{ish} \qquad (1)$$

here β - coefficient of chemical incomplete combustion; ν'_M - quoted mass rate of combustion, kg/(m^{2}c); F_y - fire area, m^2; Q_q^{ish} - combustion heat, kJ/kg.

The heat produced by fire is determined by the following formula:

$$Q'_y = \beta \nu'_M Q_q^{ish} \qquad (2)$$

The chemical incomplete combustion coefficient for substances and materials is chosen based on the quantity of air required for full combustion of a unit of combustible mass:

when ν_h^0	β
> 10 нм^3/кг	0,8÷0,9
~ 5 нм^3/кг	0,9÷0,95
< 5 нм^3/кг	0,95÷0,99

The magnitude of the fire is defined by the region that is burning. Heat stress Q_q^{hajm} [кЖ/(м^3·с)] characterizes the energy capacity of the combustion zone. It then indicates how much heat is emitted in a unit of volume in the combustion region over time.

In addition to the signs stated above, there are others: fire perimeter, combustion propagation front, flame height, flame radiation speed, and so forth[2].

It is critical to note that all fire indications are interconnected and fluctuate over time. The length of a fire, for example, is determined not only by the amount of the fire load, but also by the pace at which it burns, and the temperature is determined by the rate of gas exchange and heat release. The kind and amount of the fire load are the most important factors in influencing fire performance. The facility's fire load is defined as the mass of all combustible and non-combustible items per 1 m^2 of the room's floor area or the area occupied by the materials in an open space:

$$P_{y.yu} = \frac{P}{F}, \qquad (3)$$

here $P_{y.yu}$ - fire load; P – mass of combustible and hard combustible materials, kg; F – the area of the room floor or open space, m^2.

The fire load of rooms, buildings and structures includes not only raw materials, products, furniture, equipment, etc., but also structural elements of the building made of combustible or hard-to-burn materials, i.e., walls, floors, ceilings, window bars, doors, shelves, roofs, curtains, etc. also includes The fire load in the room is divided into permanent (combustible and difficult to burn materials of building structures, etc.) and temporary (furniture, etc.) types. The fire load of a room is defined as the sum of the permanent or temporary load [6].

The risks to people's lives and health when a fire breaks out in a mosque where a large crowd has assembled are evident from the above.

In order to identify fires in time and conduct the safe evacuation of people from the mosque building, it is crucial to establish adequate volume-planning solutions and standardize evacuation routes and exits based on the calculation approach.

The notion of turn can be applied in this situation to achieve it. In this instance, the parameters of human mobility and the required evacuation time are measured in order to determine how long it will really take for individuals to leave both specific rooms and the entire building.

Based on [2] and [4], it is determined how long the evacuation will take.

2 У.А.Ёқубов “Ёнғинлар ривожланиши ва уларни ўчиришнинг физик-кимёвий асослари” фанидан маъруза матнлари тўплами 2017 йил.

The time required for one or more streams of people to go from the furthest location where people are positioned to the evacuation exits is used to predict how long it will take for people to leave rooms and buildings.

The movement path of the crowd is calculated as l_i portions of width and δ_i sections of length (passage, corridor, doorway, stair march, drum). The beginnings of the road are spaces between furniture, tools, chairs, etc.

The breadth and length of each segment of the evacuation route are taken into consideration when calculating the expected time. The march's length determines how far the walkway extends through stair marches and ramps. At the door's position, the path's length is zero. The thickness is 0.7 m. a hole in the wall (door position) and a drum that exceeds, the final length of the horizontal path is calculated as an independent section equal to l_i [3].

On the basis of the "Sheikh Zainiddin" mosque, which is situated in the Shaikhontohur neighborhood of Tashkent City, we calculate the amount of time required to evacuate people from the mosque's basement in the table below.

The following formula should be used to calculate the expected time of evacuation of people (t_p) and the total duration of movement of the flow of people across various portions of the route t_i.

$t_{умум} = t_1$(масжид ертўласи) + t_2(ертўла йўлаги)

t_1 – the time in the first part of the basement, that is, the time from the basement of the mosque to the basement road;

t_2 – the time of the flow of people on the basement road

1- the movement time of the flow of people in the basement is determined by the following formula.

$$t_1 = \frac{L_1}{\upsilon_1}$$

L_1 = length of the basement = 24.2 m;

υ_1 — according to [3] according to the speed of the flow of people in the first part of the basement (speed of the flow of people m/min).

The density of the flow of people is calculated by the following formula:

$$D_1 = \frac{N_1 f}{\ell_1 \delta_1}$$

here: **N** – the number of people in the first part of the basement - 2455 people;

f – horizontal average area projection of people, m^2;

elders in winter clothes - 0.125 m^2;

δ_1 – the width of the basement **28,4** m, means ℓ_1 - the width of the evacuation route is -2 m

We determine the density of the flow of people in the first section:

[3] ГОСТ 12.1.004-91 Пожарная безопасность. Общие требования.

$$D_1 = \frac{2455 \times 0,125}{4 \times 28,4} = \frac{307}{113,6} = 2,7 м^2 / м^2$$

[2] by (people flow rate m/min). **U_1 =** 8,5 m/min

$$t_1 = \frac{L_1}{\upsilon_1} = \frac{24,2}{8,5} = 2,85 \, дак$$

The following examples [2] from the first section are used to determine the rate of the flow of persons on the longitudinal exits.

The following formula for the flow rate determines people:

$$q_i = \frac{q_{i-1} \cdot \delta_{i-1}}{\delta_i}$$

here δ_i, δ_{i-1} – the width of the considered i th section of the road and the previous section;

q_i, q_{i-1} – indicator of the speed of the flow of people through the i th section of the road under consideration and the previous section, m/min; The indicator of the speed of the flow of people on the first section of the road, which is obtained from [2] based on the indicator of the determined D_1 ($q = q_{i-1}$).

We determine the time of movement of the flow of people along the basement road.

$$D_2 = \frac{50 \times 0,125}{2 \times 2} = \frac{6,25}{4} = 1,56 м^2 / м^2$$

N – the number of people on the basement road - 50 people;

f – projection of horizontal average area of people, m^2;

elders in winter clothes - 0.125 m2;

δ_1 – the width of the basement road is 2 m,

ℓ_1 - the width of the evacuation route is -2 m

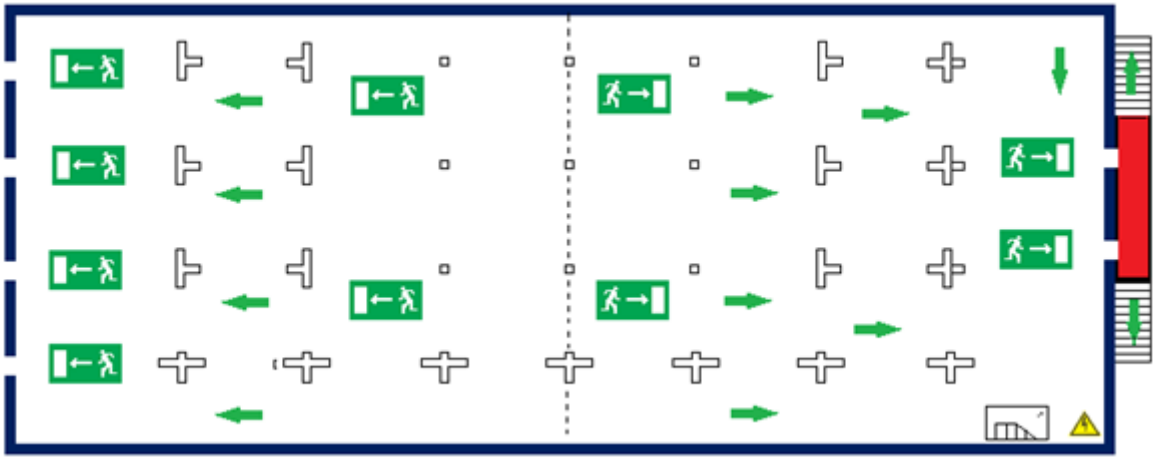
$$t_2 = \frac{L_2}{\upsilon_2} = \frac{2}{11} = 0,18 \, дак$$

[2] by (people flow rate m/min). **U_2 =** 11 m/min

$t_{умум} = t_{1(масжид ертўласи)} + t_{2(ертўла йўлаги)}$= 2,85+0,18=3,03 дақ

[2] time to evacuate the building according to the requirements specified in

It is set to be 2 minutes.



Scheme of evacuation of people from the basement of the mosque

The study's findings led to the deduction that it takes 3.03 minutes to get everyone out of the basement. This indication is based on those who are capable of moving independently, are dressed and equipped for an evacuation.

However, those who visit the mosque to worship are of all ages, and some may be physically unable to walk independently or may move slowly for other medical reasons. Additionally, they take off their shoes at the mosque's front door, and they must put them back on again after prayer. In comparison to other sites, getting people out of the building takes between two and three times as long, or 6 to 9 minutes (where people gather a lot).

The harmful consequences of fire on human life and health can rise with a longer evacuation period, increasing the likelihood that many people would suffer minor to severe injuries or perhaps lose their lives.

Based on this, it is suggested to develop automation and new methods for the secure evacuation of people from the mosque building using modern technologies, which is also the subject of scientific research and is chosen as an important object. This research was conducted for the first time in our country on the evacuation of people from religious places, specifically mosques. In order to ensure the security of sacred sites, it is crucial.

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