

FIRE SAFETY DESIGN, MEANS OF EGRESS AND FIRE MODELLING WITH SPRINKLER ACTUATION IN A HIGH MULTIFUNCTIONAL SPORTS AND EVENTS HALL – CASE STUDY

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ABSTRACT

In early 2022, the European Men's Handball Championship were held in Hungary, and a brand-new sports hall called MVM Dome was built in less than 3 years. The capacity of the seating area is around 20,000 people and will be used for other - non-sporting - events in various layouts.

Our paper outline the fire safety design process and the impact of changing needs on design. Fire simulations and evacuation simulations were also carried out during the design of the building, and their results were examined together.

Due to the layout of the building, the sports area and the surrounding circulation areas required a completely different approach in terms of both evacuation and smoke control.

The circulation areas were relatively narrow in several places due to the shape of the building, which evolved in several rounds of evacuation simulation testing. The number of staircases and their sizing were based on results of the simulations.

Due to the planned multifunctional use of the sports hall, 12 scenarios were drawn up for evacuation at the beginning of the design. 16 variants were checked again at the end of the construction. In contrast, the manager considered that testing 60-70 scenarios would cover all possible uses. All these evacuation variations, possibly considered in conjunction with the results of the 37 fire scenes, posed a significant professional and technical challenge.

Efficiency of the smoke and heat ventilation and the actuation of sprinklers in the large event hall and in the surrounding circulation were the most difficult design tasks mainly due to the high clearance between the floor and the ceiling in the event hall. Question is whether the sprinklers installed on such a high ceiling would operate properly when there is a fire and how it can be modelled. Fire scenarios were developed and evaluated with three-dimensional fire source instead of more conventional localized fire source. Threshold fire sizes were determined for actuation of the ceiling sprinklers modelled with a 3-dimensional growing fire load, special for the sprinkler skipping. Our model was validated with full scale fire tests from publications.

THE BUILDING

In early 2022, the European Men's Handball Championship was held in Hungary, and a brand-new sports hall called MVM Dome was built in less than 3 years. The capacity of the seating area is around 20,000 people and will be used for other - non-sporting - events in various layouts. We have been involved in the design process from conceptual design to the handover of the building by assisting at the construction. Fire safety design was carried out from the very beginning with an engineering approach, using complex simulation capabilities.

Basic fire safety data of the MVM Dome are the following:

- Number of floors: ground floor + 5 floors + rooftop HVAC level; there is no basement.
- The highest floor level is at +23,25 m measured from the adjoining level.
- The capacity of the seating area is around 20.000 people and for events, the maximum number of spectators including the central area can reach around 24,000 guests.
- Total net floor area of the building is 51.750 m² divided to 17 fire compartments. Basic principle of fire compartmentation was to separate the Event Hall from the surrounding circulation area and every staircase taken into consideration for evacuation are forming independent fire compartments.
- There is an automatic fire detection and alarm system and a wet sprinkler system in the building.
- A public address system with technical parameters equivalent to those of an evacuation sound system has been installed.
- Staircases are pressurized, while there is a mechanical smoke and heat ventilation with natural air supply in the Event Hall. At the circulation (concourse) areas, there is a smoke control system provided with reversible mechanical smoke exhaust and air supply points. Actuation of the smoke control system depends on the position of the fire source.

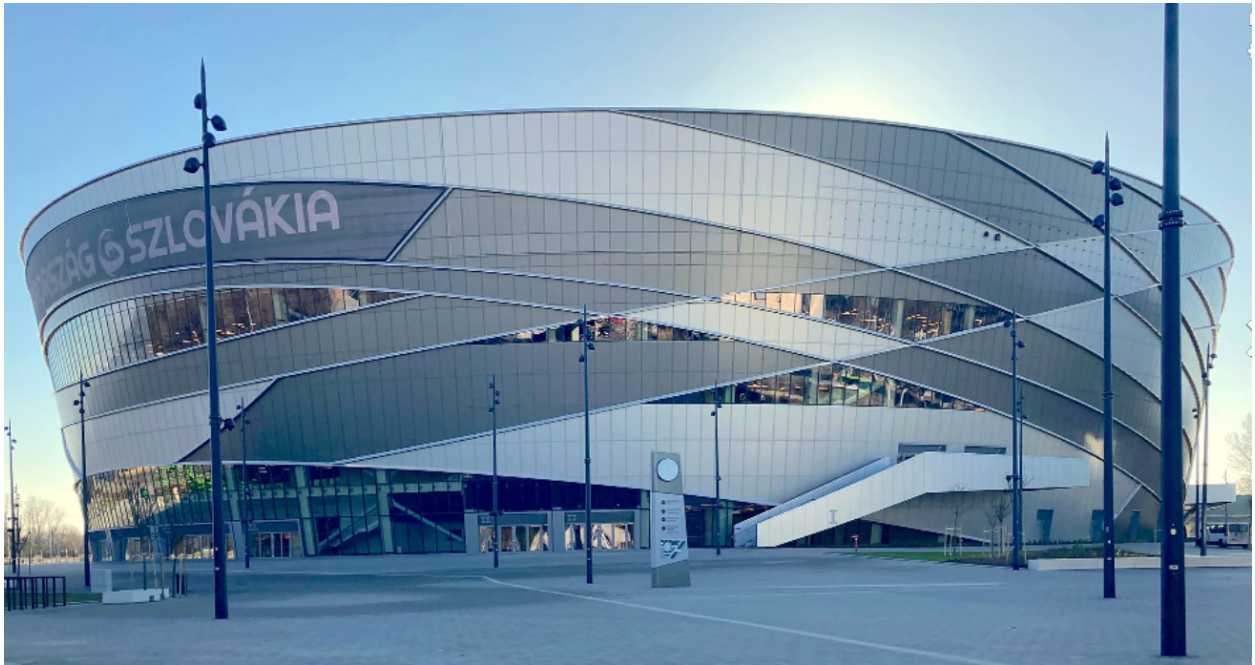


Figure 1. External view of the MVM Dome

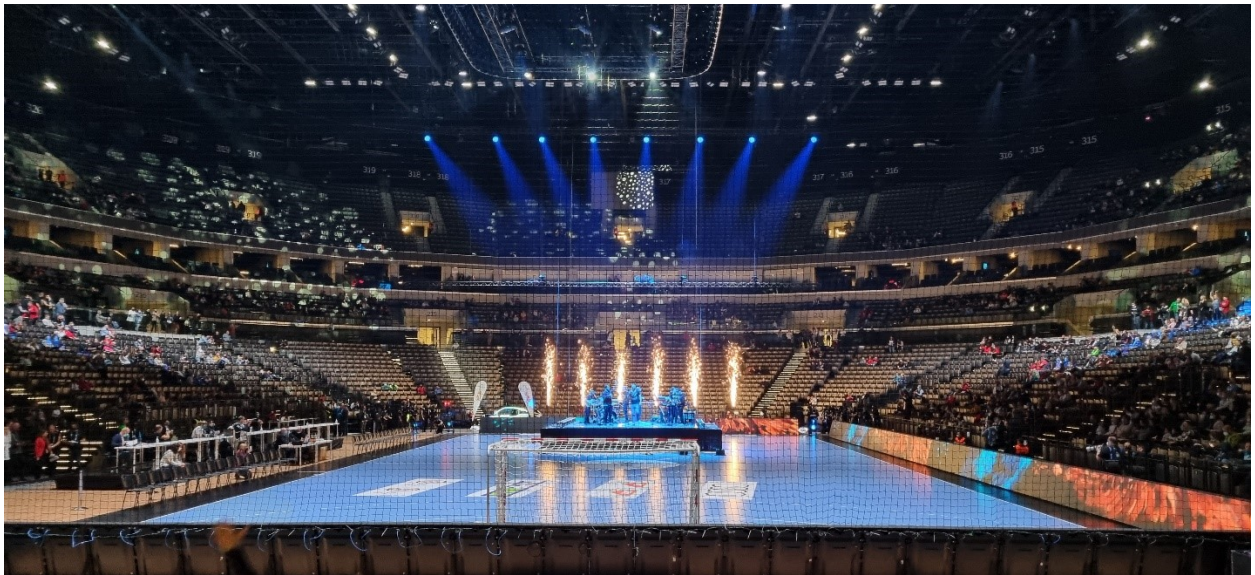


Figure 2. The Event Hall during the opening ceremony

SPRINKLER ACTUATION IN THE EVENT HALL WITH HIGH CLEARANCE

Requirements of sprinkler protection in high ceiling facilities

In MSZ EN 12845:2015+A1 standard about sprinklers [1] there is only one sentence about high ceilings. In point 7.7.2.1, authorities shall be consulted for buildings exceeding 12 m. Further requirements can be found in the Hungarian guideline “Planning, Design and Installation of Fixed Firefighting Systems” [2], as follows:

4.2.2. If the ceiling height exceeds 12 m, in any hazard class (LH, OH, HHS, HHP), a K factor of minimum K115 and quick response ($RTI < 50(m \cdot s)^{1/2}$) sprinklers are recommended.

4.2.3. In case of high hazard (HHP or HHS), when the clearance between the highest intermediate sprinkler levels (f.i. in-rack sprinklers) and the ceiling sprinklers, or without intermediate sprinkler levels the headroom exceeds 15 m, K factor of minimum K160 and quick response ($RTI < 50(m \cdot s)^{1/2}$) sprinklers are recommended as ceiling sprinkler system.

4.2.4. At the hydraulic calculations, requirements of the MSZ EN 12845:2015+A1 standard concerning to the given hazard classification are recommended.

Note:

The above mentioned points are based on full-scale fire tests testing and minimizing the so-called skipping effect at high ceiling areas.

The note refers to full scale fire tests, which are extremely important at validation of the fire modeling results at any jobs.

The European sprinkler standard has no real requirements for sprinklers protecting rooms above 12 m clearance, question is what to do when the clearance is significantly larger than 12 m? At Event Hall, the following clearances were designed:

- clearance between the floor and the bottom of the girders 27,68 m;
- clearance between the floor and the roof is from 34,5 to 40,0 m.

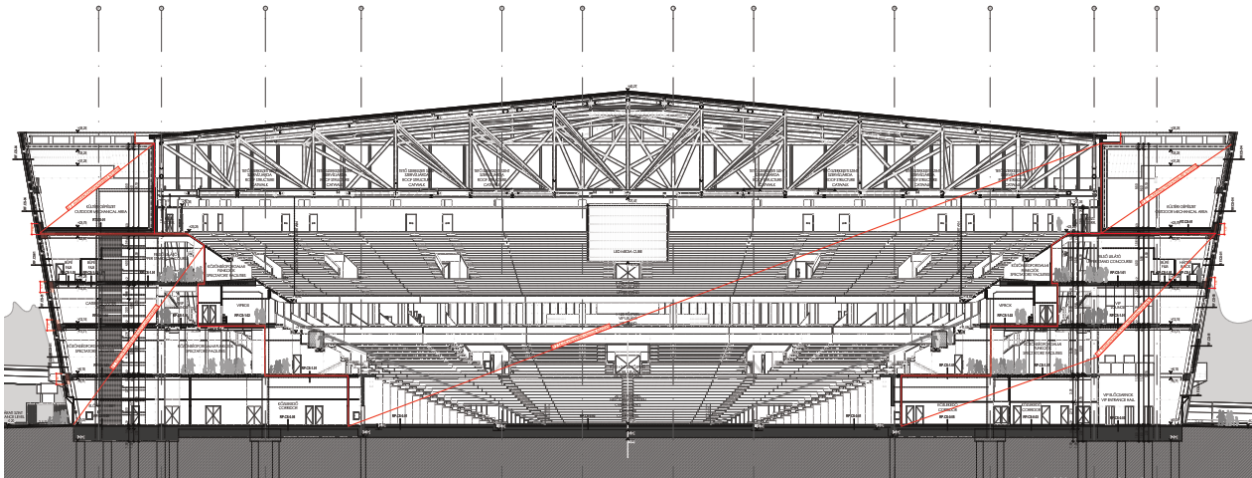


Figure 3. Section of the MVM Dome through the Event Hall showing the fire compartmentation

In addition, intermediate sprinkler levels were not possible due to the function of the building.

Sprinklers at high ceiling clearance facilities

In the Event Hall, sprinkler protection was required by both National Fire Safety Code [3] and by the authorities creating a unique challenge in both sprinkler design and fire modelling. The sprinklers were designed according to considerations from different publications about full-scale fire tests in high clearance areas with sprinklers. Critical issues are whether the sprinklers are activated when there is a fire and what are the parameters they can effectively control the fire after activation. S. Nam states [4] the actuation of the first sprinkler mainly depends on the ceiling clearance from the fire source on the floor, the heat release rate of fire, the temperature rating of the sprinkler, and the response time index (RTI) of the sprinkler. It was also found that the actuation would depend upon whether the fire source is three-dimensional (like growing fires of storages or stage settings) or plane two-dimensional (like pan fires). After 7 full-scale tests carried out with different sprinklers in 18,3 m clearance, Nam pointed out quick-response extra-large-orifice (QRELO) sprinklers were able to control the fires used in tests No. 6. and 7 and unlike in the previous tests No. 1-5, without skipping. Skipping of sprinkler is a phenomenon in a sprinkler operation that sprinkler opening pattern does not coincide with the logical sequence of the opening. When skipping occurs, sprinklers that are farther away from the fire source open before sprinklers that are closer to the fire source do. Sprinkler skipping is typical at high clearances and can hinder sprinklers properly controlling the fire [4] [5] [6].

Based on the above mentioned, in the Event Hall quick-response extra-large-orifice (QRELO) sprinklers were designed with the following parameters: K factor 160, activation temperature 68 °C, RTI value 28. This is also adequate to the 4.2.3. point of the Hungarian guideline “Planning, Design and Installation of Fixed Firefighting Systems”.

Fire modelling considerations

In most fire simulations, pyrolysis is defined by specifying a Heat Release Rate Per Unit Area (HRRPUA) as part of a surface, especially at localized fire scenarios controlled usually by sprinklers. The heat release rate to time curves are based on full scale fire test reports and the surface is usually a simple rectangular object or a cube (see Figures 5 - 6.).

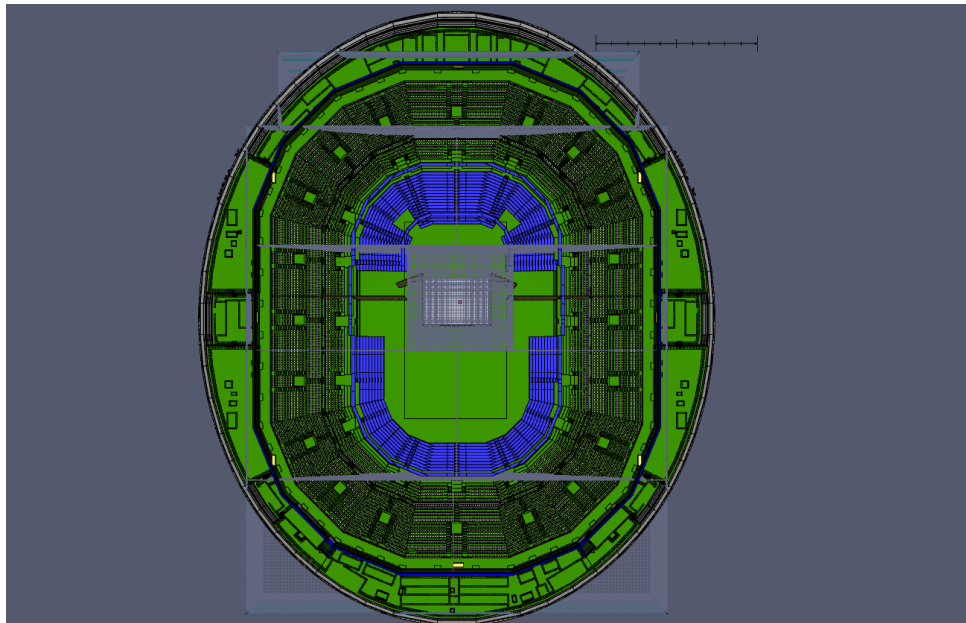
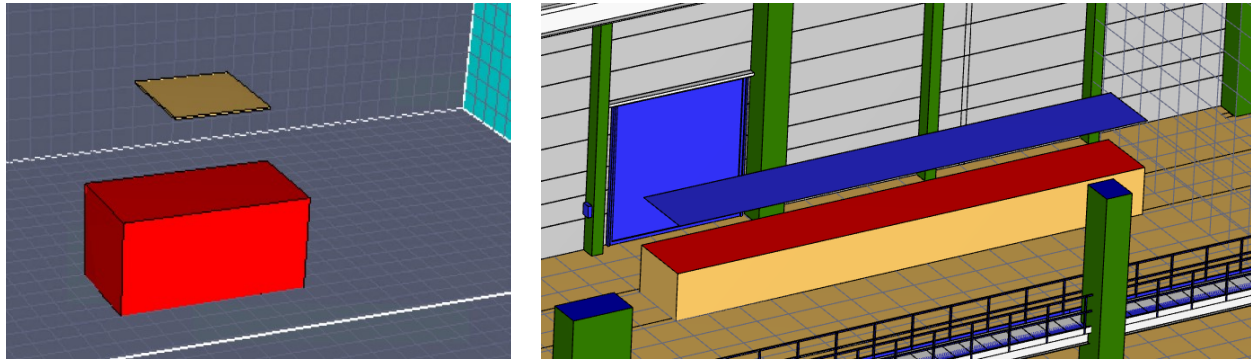


Figure 4. PyroSim/FDS model of the building, with fire scenario on a stage used for multifunctional purposes.

However, in some cases when simple geometrical forms do not represent properly the localized fire or the burning item. This is especially important at vehicles (cars, buses, trains, forklifts etc.) where there are metal hoods, bonnets, roofs between the burning parts and the sprinklers. Since fire sources should be fitted to the grid, the form of the burning vehicle must be simplified (see Figures 5,6). Horizontal non-combustible parts over the fire source can have effect – among others - on the sprinkler activation time.

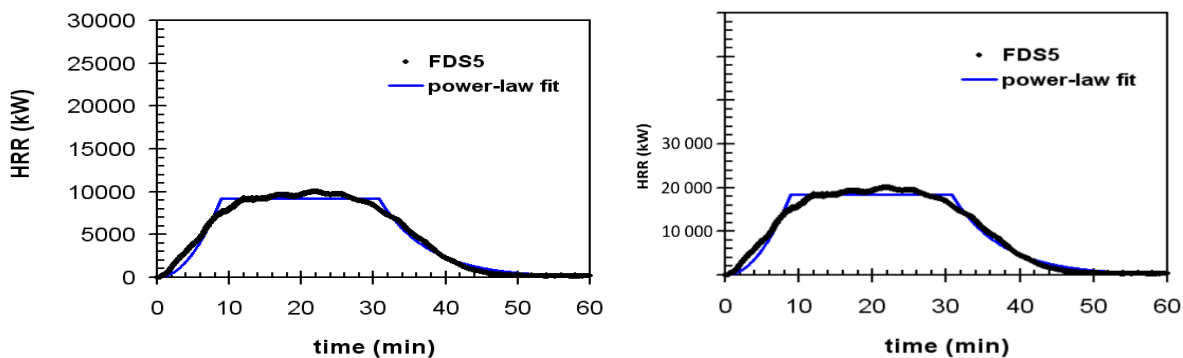


Figures 5 – 6. Fire source examples: forklift fire (left) and a Diesel engine fire (right) with solid slabs above representing the roof of the vehicles

Fire modelling in the event hall

In the Event Hall, there are two totally different kind of fire scenarios.

- In the spectator’s area, the only combustible material is the plastics chairs so we had used heat release rate to time curve from SFPE Handbook [7], Chapter 3-1., Figure 3-1.15. with 1,8 MW peak heat release rate.
- In the Event Hall, due to the multifunctional role of the building, theater arrangements are common with stage settings. Due to the large amount of combustible materials like timber, paper and different plastics used at stage settings, fires with 10 and 20 MW peak heat release rate were used for fire modelling from VTT “Design Fires for Fire Safety Engineering” [8].



Figures 7 –8. Fire scenarios used for stage fire with 10 MW HRR (left) and 20 MW HRR (right)

Our first results were the following:

- 1,8 MW fire scenarios were able to activate sprinkler nozzles only at the highest position of the spectator’s area but no sprinklers were activated at fire scenarios at lower rows;
- in case of a stage fire, both 10 MW and 20 MW stage fires were able to activate sprinkler nozzles.

Based on our first results, further fire scenarios were carried out with simple (see Figure 8.) and more complicated obstructions set as fire sources representing a stage setting (see Figure 9.).

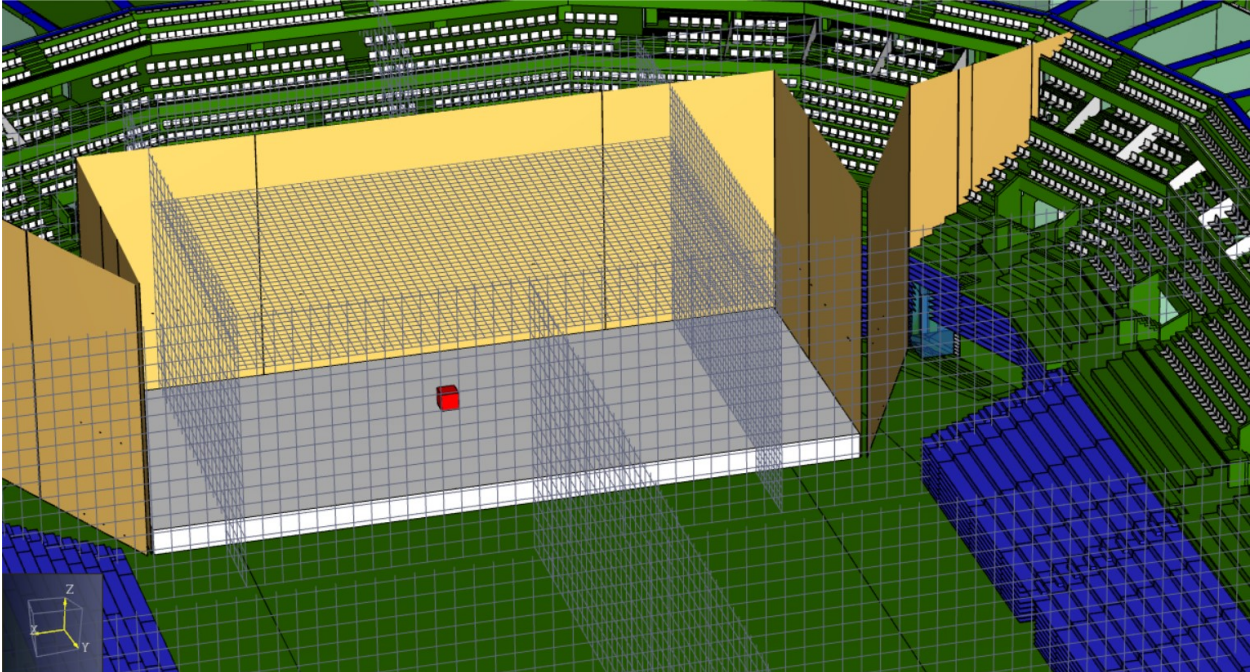


Figure 9. 20 MW stage fire scenario with simple obstruction

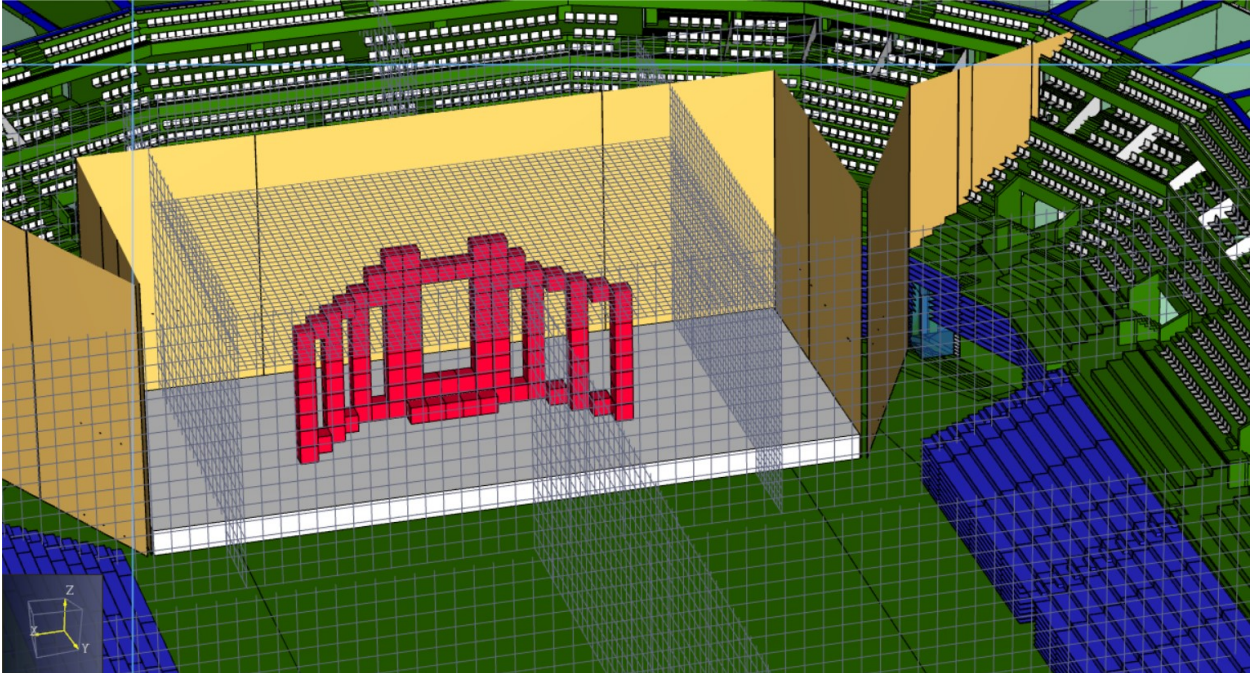


Figure 10. Stage fire scenario with complicated obstruction representing stage setting

At fire scenarios with simple cubes, sprinkler activation times and sequences were the following:

Fire scenario	Peak heat release rate	Activated sprinklers	Sprinkler activation time	Fire scenario	Peak heat release rate	Activated sprinklers	Sprinkler activation time
19/A (end stage)	10 MW	3	422,7-438,2 s	23/B (end stage)	20 MW	6	422,5-485,6 s
21/A (side stage)	10 MW	1	432,0 s	23/B (side stage)	20 MW	10	402,2-706,0 s
23/A (center stage)	10 MW	1	426,8 s	23/B (center stage)	20 MW	6	400-973,3 s
25/A (2/3 stage)	10 MW	1	811,2 s	25/B (2/3 stage)	20 MW	6	449,5-509,7 s

Table 1: Sprinkler activation sequences with simple fire source

At fire scenarios represented with complicated obstruction, sprinkler activation times and sequences were the following:

Fire scenario	Peak heat release rate	Activated sprinklers	Sprinkler activation time
19/A (end stage)	20 MW	-	
19/A (end stage)	25 MW	4	862-1009
19/A (end stage)	30 MW	18	535,3-856,6

Table 2: Sprinkler activation sequences with complex fire source

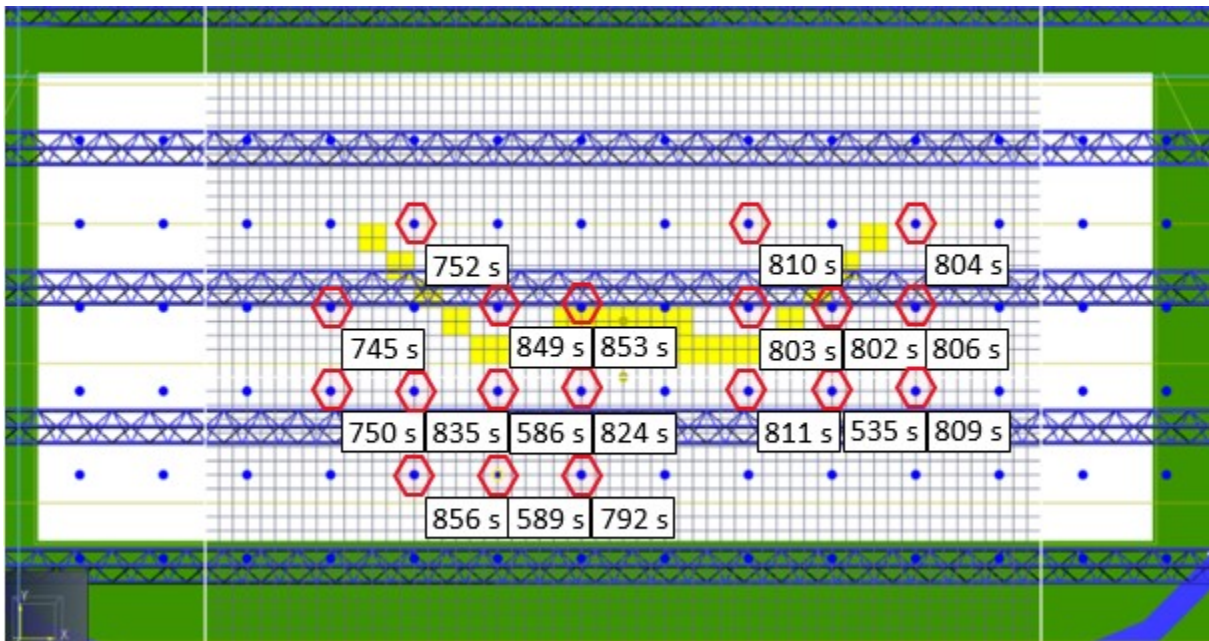


Figure 11. Sprinkler activation pattern at 30 MW stage fire scenario

Consequences:

- in case of multifunctional use, several kinds of fire scenarios are possible so a wide range of design fire scenarios must be tested, both in terms of heat release rate curve and form of the fire scenario (simple forms, complex forms representing a stage setting)
- sprinkler activation time strongly depends on the heat release rate curve: at higher peak HRR, more sprinkler heads are activated; when the peak HRR is less than 10 MW, in the Event Hall no sprinkler activation happened due to the high clearance; however, even in such situations, firefighting intervention possibilities must be provided so the fire brigades can extinguish small and middle size fires while large fires are controlled by sprinklers providing conditions to the fire brigades to extinguish the fire;
- to avoid extensive sprinkler skipping, sprinkler activation times and patterns must be checked at every fire scenario and if there are skipping problems, sprinkler design or even the smoke and heat ventilation must be modified.

All the above mentioned detailed design goals can be tested only with fire modelling; prescriptive standards, guidelines cannot provide methods for the proper design.

SMOKE AND HEAT VENTILATION

Basic requirements in Hungary

Basic principles of fire safety design – included the efficiency of smoke and heat ventilation – can be found in the National Fire Safety Code [3], while the detailed requirements are included in “Fire-, smoke spread and evacuation modelling”, Fire Protection Technical Guideline, TvMI 8.5: 13-06-2022 [9].

According to the technical Guideline, during the evacuation time, the visibility cannot fall below 15 meters. In every fire scenario fire detection and alarm system’s activation time shall be added separately to the evacuation time limit.

We shall assign the simulation time limit based on the running of the fire. Fire Department’s distance from the building, its emergency response time:

- Leaving the fire department: 2,0 mins
- Travel time with average speed of 30 km/hrs (0,5 km/mins) ≈ 5,0 mins
- fire reconnaissance, setting time: 3,0 mins
- building that is above 5000 m² ground area extra 1,0 min
- more discovery time is needed in case of a different level of the building level:
 - first floor (lower concourse area): extra 1,0 min
 - second floor (VIP level): extra 3,0 mins
 - third floor (upper concourse): extra 4,0 mins
 - fourth floor (HVAC level): extra 5,0 mins

Total response time calculations:

- ground floor fire scenarios: 12,0 mins (720 s)
- first floor fire scenarios: 13,0 mins (780 s)
- second floor fire scenarios: 14,0 mins (840 s)
- third floor fire scenarios: 15,0 mins (900 s)
- fourth floor fire scenarios: 16,0 mins (960 s)

The result of the simulation shall be acceptable when according to the “Fire-, smoke spread and evacuation modelling”, Fire Protection Technical Guideline, TvMI 8.5: 13-06-2022. 5.1.3.4. points the visibility and the referenced conditions are adequate [9].

Under the total response time of the Fire Brigades the “Fire-, smoke spread and evacuation modelling”, Fire Protection Technical Guideline, TvMI 8.5: 13-06-2022. the detailed requirements are the followings:

Within the evacuation time limit:

- within the time limit of the evacuation the visibility shall not decrease under 15 m (in case of a visibility of not less than 15 meters the examination of toxic gases is omissible).
- During evacuation higher temperature than 60 C° shall not reach people.
- During evacuation radiation heat flux density more than 2,5 kW/m² shall not reach people. Because the Guideline do not declare data about the length limit of the radiation heat flux density within 2,5 kW/m² measured from fire location, we placed the radiation sensors to a distance of 5-10 meters from the fire source, it is 2 meters higher than the evacuation route’s walking surface.
- To the evacuation time limit in case of every fire location at the height of Z = 2 m a visibility slice and a temperature examination slice must be provided. The evacuation time limit in this case shall be thickened with the visibility of 15 m.



Figure 12. On the scale blue shows better and red shows poorer visibility between 0 – 30 meters.

Within the total firefighting response time:

- Further distance than 25 meters measured from the fire source the visibility shall not be lower than 5 meters at that exact moment when the firefighter intervention begins. This criteria needs to be fulfilled so that the appropriate number of Firefighters with the right equipment shall reach the fire source.
- To ensure the conditions of the intervention visibility slice should be set in case of every fire location at Z = 2 m height.

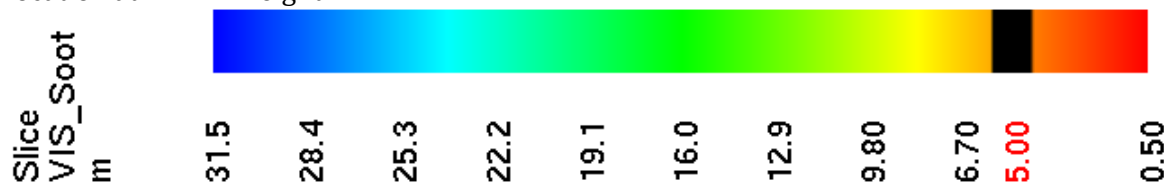


Figure 13. On the scale blue shows better and red shows poorer visibility between 0 – 30 meters.

Smoke and heat ventilation of the event hall and the circulation areas

The circulation area is divided into 7 or 8 control zones on every floor except the ground floor where there is only one zone due to the significantly smaller area. Control zones are not real but only virtual smoke compartments because there are no fix or active smoke curtains. There are reversible mechanical smoke and heat exhaust and air supply points in every control zones; depending on their position, there are vent points with 27.000 m³/h, 54.000 m³/h and 60.000 m³/h exhaust or supply capacity. Operation of the smoke and heat ventilation is the following:

- mechanical smoke and heat ventilation starts in the closest virtual smoke compartments to the fire source;
- mechanical air supply ventilation is activated in two virtual smoke compartments next to the smoke compartments where the smoke exhaust had been started,
- emergency exits on the ground floor serving as natural auxiliary air supply openings are always activated.

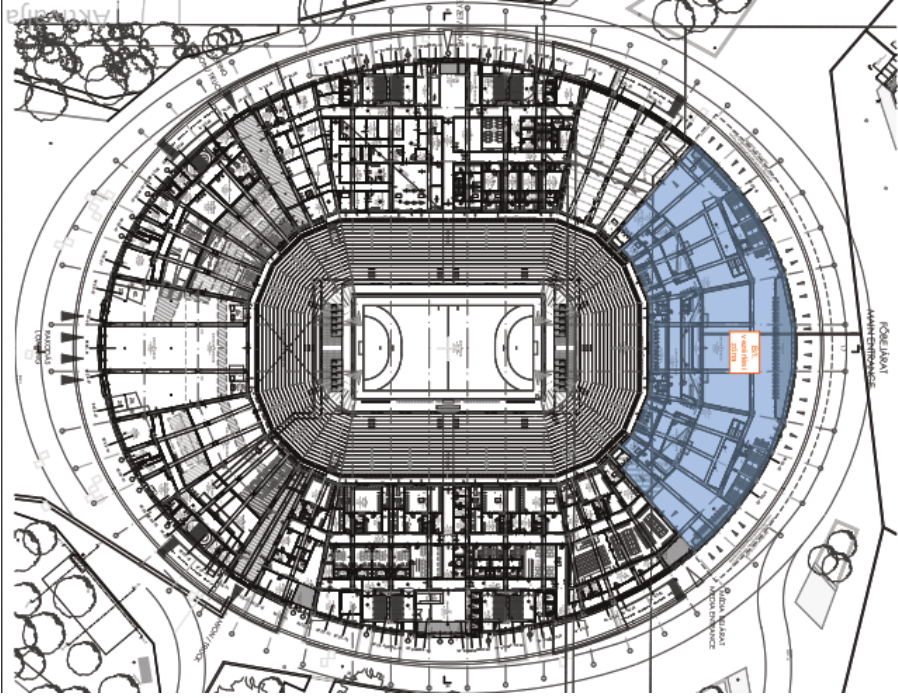


Figure 14: Ground floor layout showing the concourse area with green; there is only one control zone

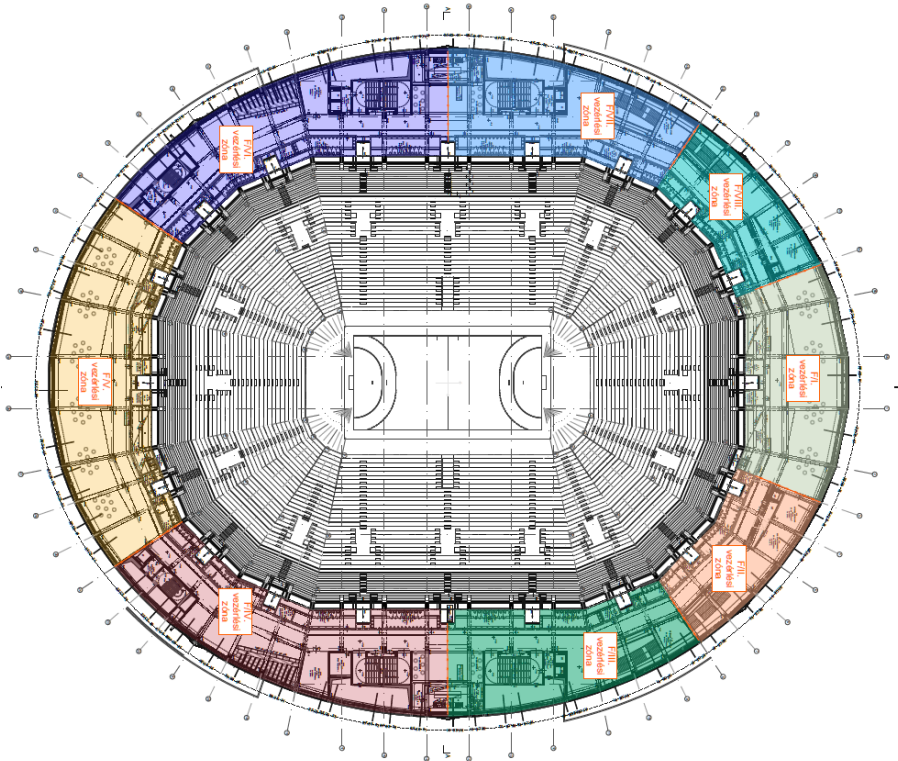


Figure 15: Control zones on the upper concourse area (4th floor). There are 8 control zones

According to our simulation results, this system can control fires under 1 MW so the buffets connected to the circulation area - where larger fires expected - were separated from the concourse area with active fire curtains. The aim of the design was to ensure that the spectator areas could be evacuated safely even if a fire occurs in the circulation areas.

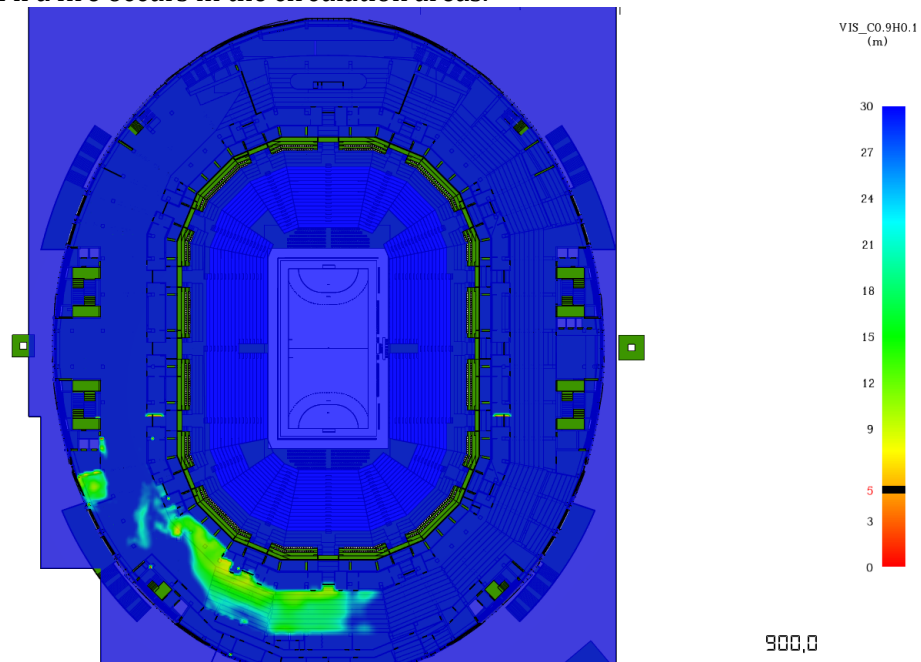


Figure 16 Simulation result example showing the visibility slice 2 m over the floor area on the lower concourse area (Level +6,00 m)

While the circulation area around the Event Hall have a complicated but effective smoke control system, the smoke and heat ventilation of the Event Hall is rather simple: there are only 4 mechanical exhaust point at the level of the girders, and there are 2 natural air supply gates. There are neither virtual nor real smoke compartments.

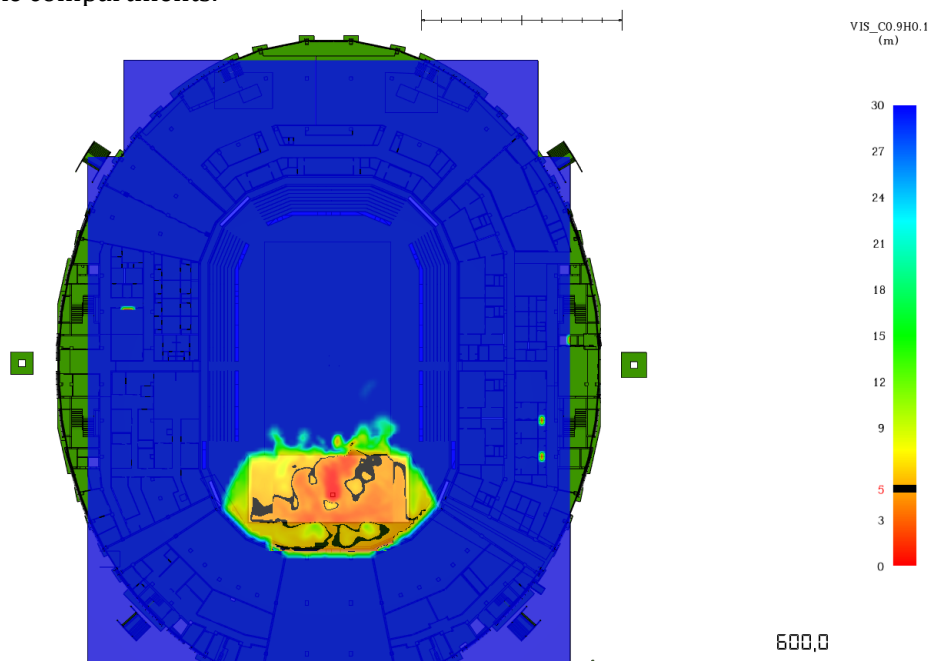


Figure 17: Simulation result example showing the visibility slice 2 m over the floor area (Level ±0,00) The 20 MW fire is on a stage (end-stage multifunctional arrangement)

MEANS OF EGRESS

Hungarian regulation

According to Hungarian legislation [3], the adequacy of the evacuation of buildings can be demonstrated in 3 ways: by observing geometric parameters (width, distance) or by calculation or by evacuation simulation.

In the case of calculation, the time limit for leaving the event hall is 90 s (reaching the fire compartment without protected route), which is not feasible for a grandstand of this size due to the standard design and the number of spectators.

According to the Hungarian fire protection guideline's specification of Evacuation [10], the walking speed of people is 0.67 m/s in general, no differentiation is made and the pre-movement time is 0 s. The regulation also allows the level of safety to be verified by engineering methods: i.e. ASET can be verified by FDS simulation and RSET can be verified by Pathfinder evacuation simulation. We have chosen this solution throughout the design process.

Evacuation strategy and evacuation routes

Due to the nature of the building and the large number of people, we decided to plan a simultaneous, complete evacuation and the circulation areas were designed accordingly. During the evacuation of the building, several areas have independent routes, which only slightly interact with each other.

From the central arena on the ground floor (sports or concert area), escape is possible in 6 directions, level. This is also the route from the lower 8 rows of the lower grandstand.

From the other areas of the lower grandstand, escape is possible via the loading level, from where guests arrive in normal operation. The main escape routes from the loading level are via the 4 external staircases and the main stairs at main entrance lobby (the escalators are not included in the escape route, as they are shut down on fire alarm).

Exit the upper grandstand towards the loading level and the escape corridor upwards. From here, escape is possible via 6 enclosed staircases, 4 of which are of a devil's stair design, so double the capacity. Escape is planned via 4 staircases easily accessible from the VIP level, but the number of people is proportionally much smaller, so it is not a decisive factor in the evacuation process.

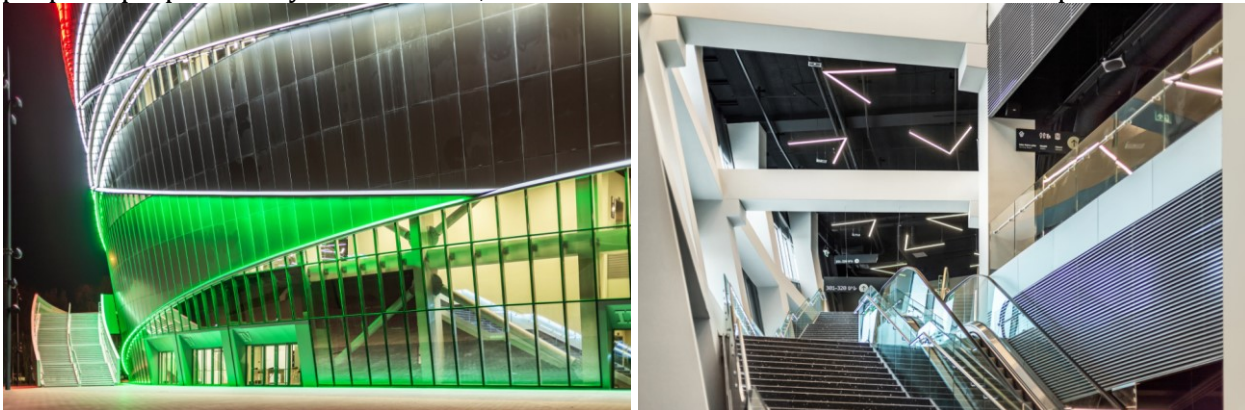


Figure 18-19: External escape stairs and main stairs in the lobby with escalators (source: epiteszforum.hu)



Figure 20-21: Staircases (source: epiteszforum.hu and the authors)

Evacuation scenarios

The investor's aim was to build a multifunctional indoor hall, which could be used for 30% sports events and 70% other events. The architectural design therefore required specific solutions for the arena and the seating area.

The grandstand is divided into several areas: upper grandstand, VIP level and lower grandstand. Part of the lower grandstand is a built structure, while other parts are a mobile structure. The arena area can thus be varied in several ways: full mobile grandstand, the lower 3 rows pushed in, the lower 8 rows pushed in or the full mobile grandstand (11 rows) pushed in. A wide walkway has been created on the loading level of the lower stand, but also with a mobile stand structure, where an additional 8 rows can be inserted if necessary.

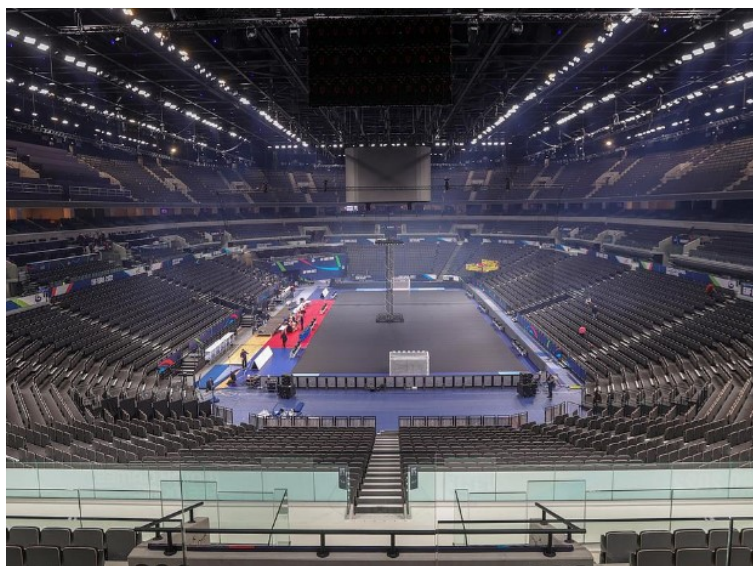


Figure 22: Full grandstand for handball usage



Figure 23: Middle grandstand for handball



Figure 24: Lower grandstand for handball

Based on international recommendations, the evacuation scenario is defined by the following parameters [11]:

- the usage layout
- initial agent number and their distribution
- geometry
- characteristics of the agents
- duration before evacuation
- characteristics and effects of the fire

According to Hungarian legislation [3], it is sufficient to check the worst-case scenario in a building. In contrast, we believe that with an engineering approach this may not be enough without testing.

From the very beginning of the building's design, an important goal was to make it multifunctional. For the conceptual plan, the architects presented 12 different layouts of use.

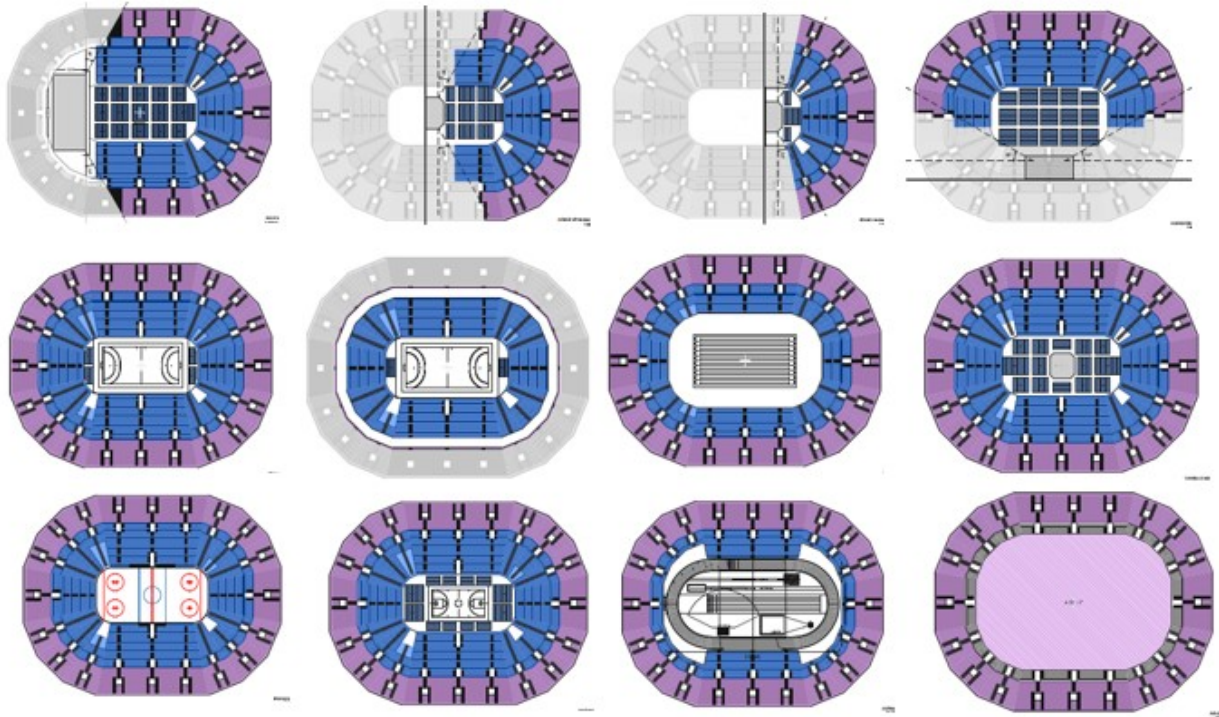


Figure 25: Usage layouts for the conceptual plan

With many issues still to be decided by the client in the licensing plan, we had to choose a main layout for which the building would be suitable: this was the handball layout.

During the preparation of the construction plan, a wide variety of layouts came up: sports (handball, basketball, futsal, volleyball, tennis, badminton, athletics, gymnastics, boxing, wrestling, dodgeball, fencing, weightlifting, archery, roller-skating, rsg, dance, swimming, ice hockey, curling, etc.), stage layouts (end, half, third stage, side stage + standing and/or seated auditorium) and anything else (exhibition, fair, monster truck show, etc.). These were grouped to have common evacuation conditions and were treated together for the rest of the project. This resulted in a total of 14 variants. At the end of construction, these 14 versions were checked back against all the changes made to determine the number of guests for each case.

At that time, the operations expert came to the project and said that the number of people would be determined mainly by the condition of the lower stand and the possibilities it offered. On this basis, the combinations of options listed in Table 3 represent essentially all the options. Thus, $4 \times 5 \times 3 = 60$ variants of the layouts are possible in a staged design (only), and about 8-10 layouts for sport events.

lower grandstand	stage position	visitors
full	end stage	seats only
3 rows pushed in	half stage	seating and standing areas
8 rows pushed in	third stage	seating and standing areas, with priority standing area
11 rows pushed in	side stage	
	center stage	

Table 3: Agent parameters used in the evacuation simulations

Evacuation simulation parameters

Fire protection guideline [9]

In Hungary, the relevant technical directive on fire safety must be complied with when simulations are carried out. It contains detailed recommendations and requirements for the preparation and evaluation of both FDS and evacuation simulations.

Accordingly, a minimum visibility of 15 m must be ensured in an escape environment, at a height of 2 m above the floor surface, which essentially ensures the absence of other accompanying phenomena in general. Therefore, only this parameter was matched in the result evaluation.

The agent parameters

Experimental data was not available as there is no hall of similar size and use in Budapest. Therefore, the agent parameters were designed in coordination with the authority.

agent type	size (cm)	speed (m/s)	note
spectator, attendant, player, staff	45,58	1,19	<i>default</i>
independent wheelchair users	70/120	0,79	Size and form by ISO 7193, speed based on domestic measurement [12].
assisted wheelchair user	70/120	1,19	The internationally published speed for wheelchair users exceeds the commonly used default setting and is therefore not used.
person with reduces mobility	66,00	0,59	Speed based on domestic measurement [12].
visually impaired person	45,58	1,19	The internationally published speed for wheelchair users exceeds the commonly used default setting and is therefore not used.

Table 4: Agent parameters used in the evacuation simulations

In determining the number, we have assumed the worst case scenario for each layout. Tests were carried out to check that the evacuation behavior of the building is very similar if 100% of the spectators are in their allocated seats and if 80% of them are in the circulation area "at the break". During the tests, wheelchair users were in their designated place and in the maximum number, while visually impaired people were scattered in their social proportion (0.83%) according to Fire Protection Guideline for Evacuation [10].

In agreement with the authorities, a uniform pre-movement time of 30 s was used for spectators, and between 30 and 60 s for athletes and staff. This took into account the presence of a large number of support staff on site during an event and the availability of technically adequate sound systems throughout the building in the event of an evacuation. We know that in reality the pre-movement time will not be uniform, but using the default values with fixed locations meant that we did not need as many re-runs.

Evaluation of the simulation results

Safe evacuation was examined by combining FDS and Pathfinder simulations. For the evaluation, the results of the two simulations were matched by "offsetting" them in Pathfinder Result by the time of the fire alarm (from FDS). In addition, each layout itself was checked from an evacuation point of

view to see whether the evacuation process was acceptable and what the size and extent of the congestion was. Table 5 gives some examples of the numbers in the whole building determined by the simulations.

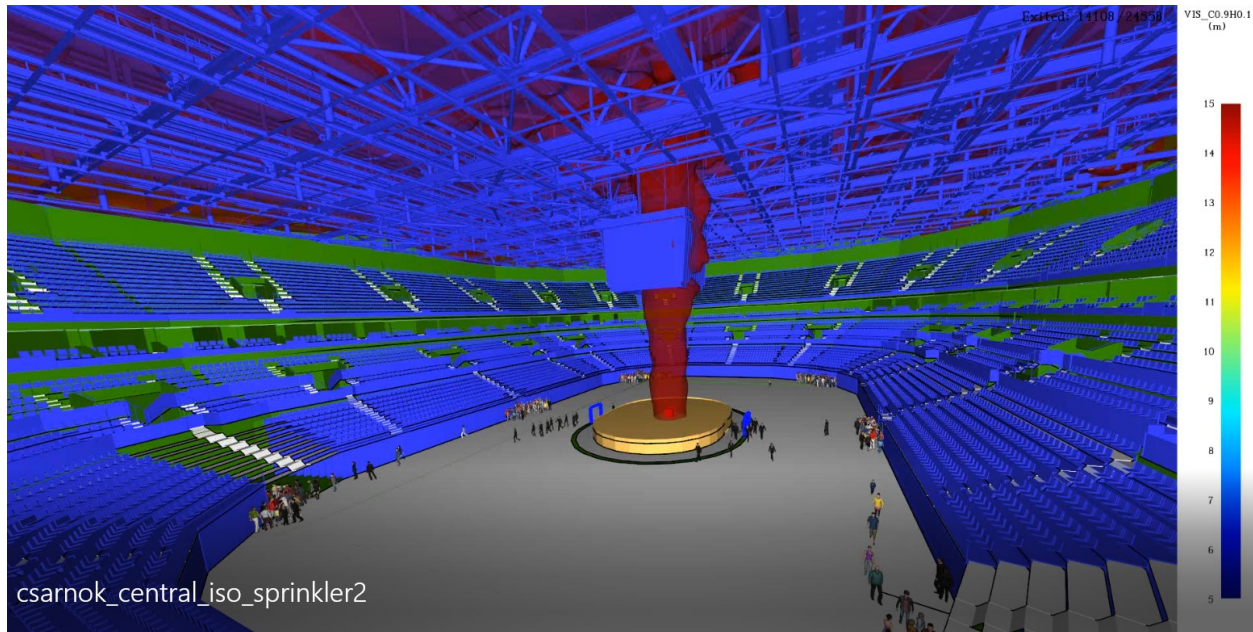
layout	visitors	staff	total number
basic layout (handball)	20.460	1.540	22.000
end stage	16.500-17.600	1.300	17.800-18.900
side stage (standing)	12.500	1.350	13.850
central stage (standing)	24.100	1.350	25.450
ice hokey	19.400	1.540	20.940

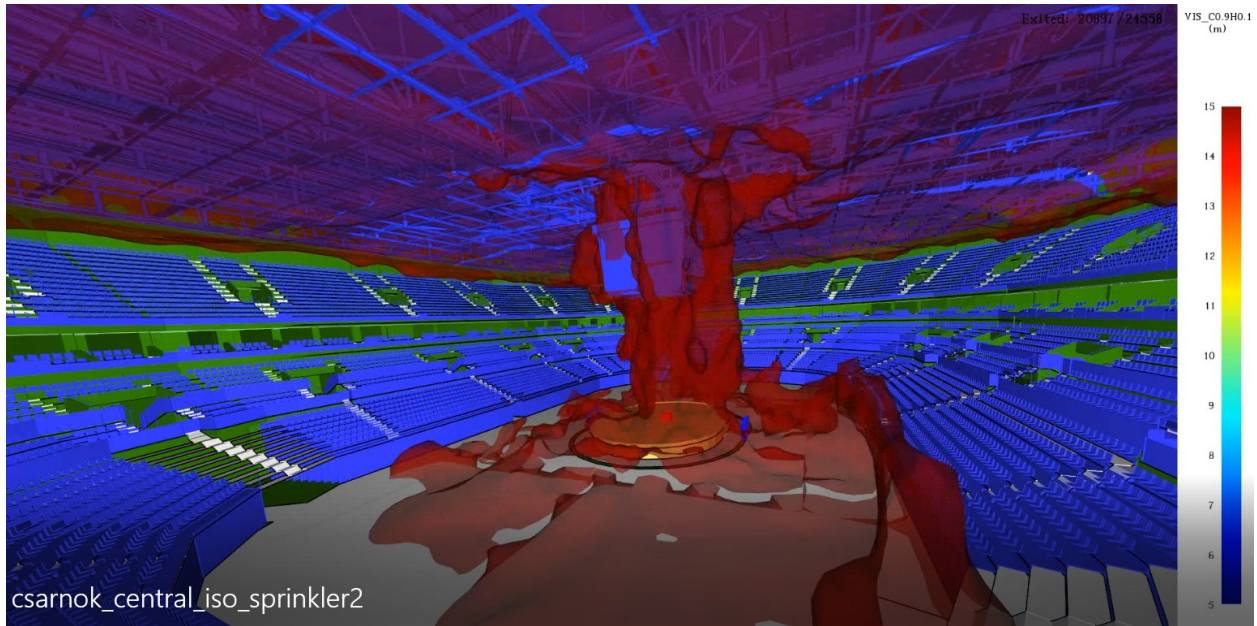
Table 5: Numbers of people in the whole building

For the evaluation, a basic layout (handball) was selected and tested together with the results of all the fire scenarios. Once we were able to draw general characteristics from this, we matched the other evacuation layouts only with the results of the fire scenarios that was different or critical for them (e.g. stage fires).

Our experience has shown that building areas operate completely differently in the event of fire.

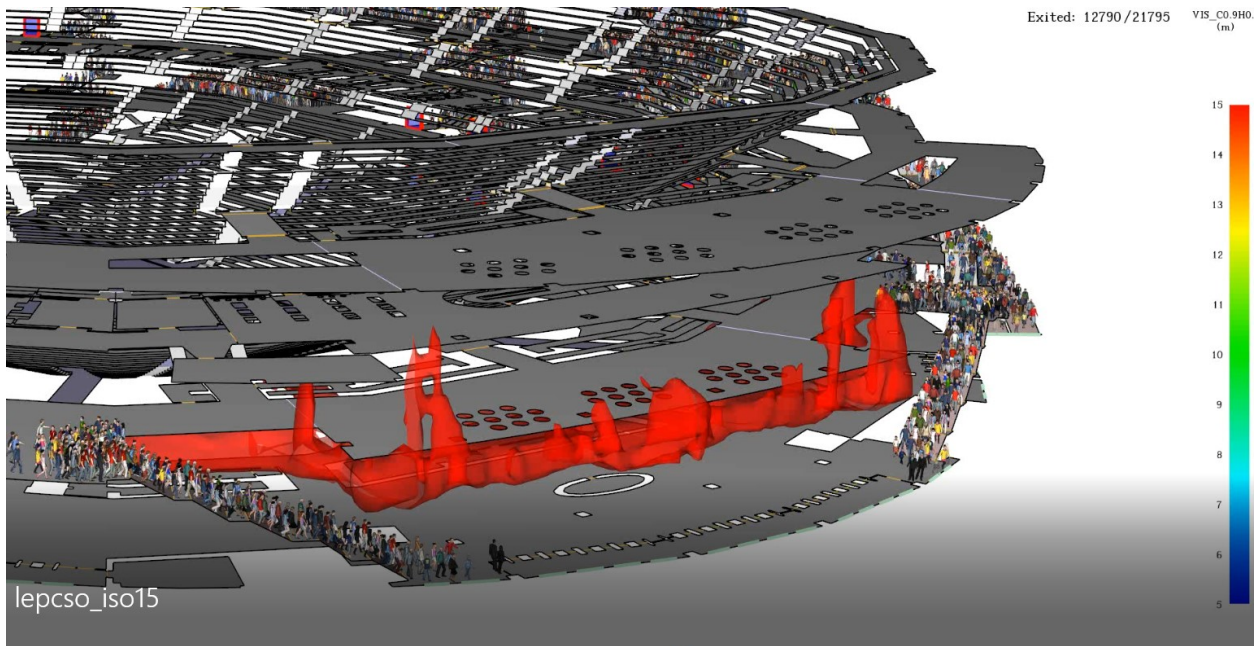
In the case of a fire in the event hall, due to its high clearance, evacuation is essentially unaffected by smoke development. Only when a sprinkler is activated, smoke will appear on the escape routes. This was shown in the previous chapters to occur only for certain sizes of fire, typically for stage installations. Therefore, we no longer checked for chair fires in the stage layouts, as the sprinklers were not activated.





Figures 26-27: Central stage layout, merged results at 360 s (above), and after the sprinkler activation at 500 s (below) with 15 m visibility iso surface

The contiguous, compartmentalized airspace of the circulation areas and the relatively low ceiling heights caused many more problems with smoke dispersion for evacuation. By zoning and "sealing off" the more serious fire loads (like buffets) with active fire curtains, as detailed above, we were able to provide the necessary conditions for escape.



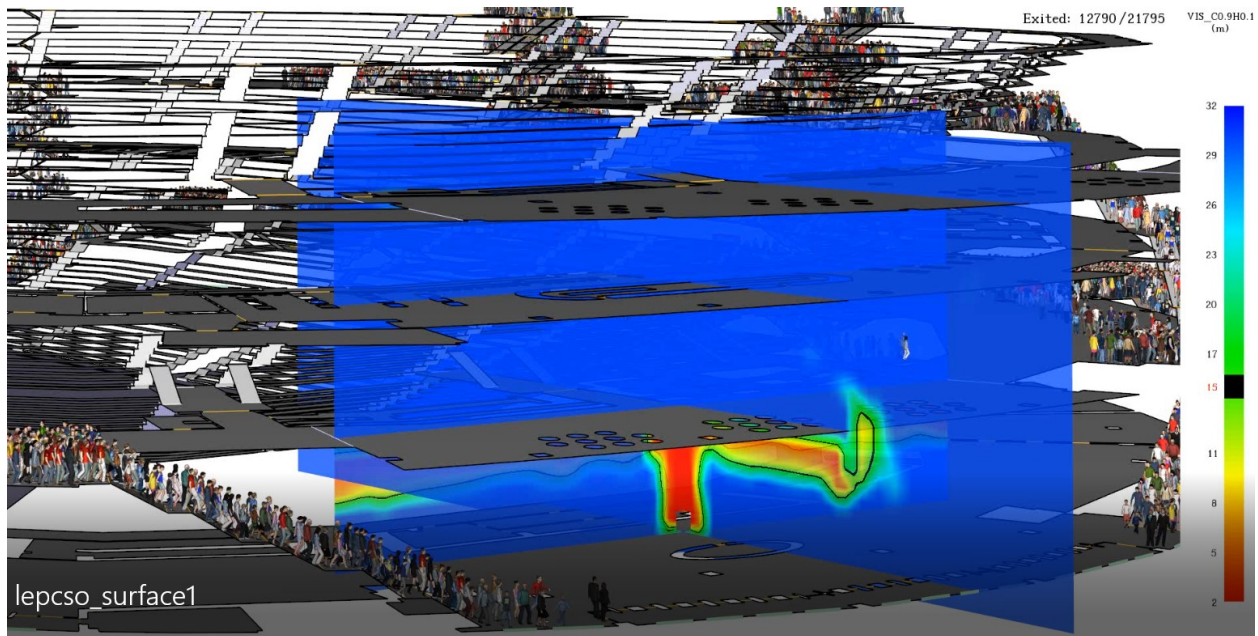


Figure 28-29: Lobby fire layout, merged results at 360 s, 15 m visibility iso surface (above) and with 15 m slices (below)

SUMMARY

In addition to the general fire safety engineering approach, we also used fire and evacuation simulations to develop the required level of safety. For precise evaluation, results of the fire and evacuation simulations were merged in Pathfinder.

We think it is very important that we have followed the design and construction process throughout with the simulations, so that the experience gained during the inspections has been incorporated back into the plans and the completed building. The detailed design of the building was constantly changing during the planning and even during construction. Therefore, the simulations had to be repeatedly modified and the results re-checked. These used to decide whether a particular modification was acceptable from a fire safety point of view or whether some other compromise solution had to be found. During the 2.5-3 years there were examples of both.

It would be important that these are done in a similar way throughout the life cycle of the building, as everything is always changing. However, there is currently no willingness on the part of the management to do this because of the considerable amount of work and, of course, the financial outlay.

We believe that for a large, complicated buildings with large capacity, such an approach to fire safety design would be appropriate in all cases. However, we find that in many cases this is not feasible due to time and cost factors, in addition to the obvious benefits.

And our conclusion was that there are always many more usages than the designer thinks of at the beginning ...

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Sprinkler:	Balázs Szakos/Ventor Kft.
Fire detection system:	József Bangó /Dunamenti Tűzór Kft.

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