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THE ARCHITECTURAL AESTHETIC ORDER OF FIRE PROTECTION

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Abstract: *Nowadays, the damaging effects on humanity, such as extreme weather caused by climate change, the pandemic-induced isolation, or the drastic increase in the cost of energy carriers, etc., have led to the need to change the design of our buildings. The need to design buildings for safety, prevention and sustainability requires a change in our design thinking.*
The damaging effects of these extremes all have an impact on the fire safety situation of a building. The conclusions of fire investigation procedures suggest that a disorderly state of the built environment typically develops prior to fire starts.
As stated above, the researchers are investigating the degree of orderliness in the research, for which they are using network science methods. Based on the hypothesis, tidiness is also an aesthetic value, whose high level of appearance determines the appropriate fire safety situation.
The high aesthetic value of architectural fire protection correlates with the degree of orderliness, i.e. it is a significant determinant of the long-term sustainable stable fire safety situation of a building.

Keywords: *architecture, fire protection, fire safety, sustainability, fire prevention*

INTRODUCTION: BUILDERART AND SAFETY FUNCTION HARMONY

Throughout human history, architecture has always been more than just the creation of practical buildings. Man's creative inclination has always inspired architects to dream up artistic values behind buildings. Architecture as an applied art therefore has very high aesthetic values. Fire safety and architectural aesthetics may seem to be two seemingly contradictory concepts, but in fact they can be linked and work together to create safe and beautiful architecture.

People spend a large part of their lives in buildings and their surroundings have a significant impact on their mood and well-being, so architects need to consider not only functionality but also aesthetics when making designs. However, architectural aesthetics is not only about the exterior appearance of a building, but also about its interior design, use of space, structural organisation and many other aspects.

Fire safety is a vital aspect of health and safety that should never be overlooked when designing buildings. The risk of fire can be volatile and subject to many conditions, so buildings must be prepared for the possibility of fire. Accordingly, buildings should have an appropriate fire safety structure. [1]

Striking a balance between architectural aesthetics and fire safety is not always easy, but it is important to strive for it. One key factor is the choice of building materials. Combining

aesthetic and fire-resistant materials allows buildings to be not only safe, but also attractive. For example, the use of fire-resistant glass allows natural light to enter buildings while preventing the spread of fire by forming a passive fire-resistant structure with transparent surfaces. When reconciling architectural aesthetics and fire protection, architects and fire protection designers should take into account the layout, structural design, spatial arrangement, etc. of buildings. An important aesthetic consideration in relation to the location of protection systems, such as fire alarm systems, fire extinguishers, escape route signage, is that they should be easily accessible but not interfere with the aesthetics of the building, interior design objectives. [2]

From the point of view of architectural aesthetics and the aesthetics of fire protection, we should also take Leonardo da Vinci's motto: "*Simplicity is the ultimate sophistication"*. The idea is that the highest level of refinement and elegance lies in simplicity, not only in aesthetic terms, but also in all aspects of life. It suggests that the best solutions, designs and creations are usually those that are pure. This positive sense of simplicity is not only aesthetically appealing, but also functionally most effective. Simplicity allows you to focus on the essentials and avoids adding unnecessary or complicated elements that can be distracting. This is also where the above idea relates to the prominence of fire safety. The measure of simplicity in a given context is the degree of orderliness. The harmony between the architectural order and the orderliness of the fire protection equipment is the basis for basic safety.

According to the researcher's hypothesis, simplicity and orderliness is also an aesthetic value, the high level of which determines the appropriate fire safety situation. The high aesthetic value of fire protection by architectural means correlates with the degree of orderliness, i.e. it is a significant determinant of the long-term sustainable stable fire safety situation of a building.

The problem of maintaining the fire safety situation in the long term stems fundamentally from disorder. In extreme cases, disorder can also lead to chaotic conditions that determine the range of dangerous conditions. In the case of traditional uses, but especially in the case of the damaging effects of today's increased extremes, the fire safety situation of a building has reached a critical state. The conclusions of the fire investigation procedures showed that a disorderly condition of the built environment typically develops prior to fire starts. This observation encouraged the researcher not only to address the fire prevention issues of the processes and mechanisms leading to fire initiation, but also to investigate the degree of environmental disorder that influences the course of fires, and in many cases the pathway to initiation.

The researcher's objective is to investigate the degree of orderliness using network science methods. In analysing the degree of orderliness, or disorder, he explores the basic architectural aesthetics that are related to the architectural aesthetics of fire safety. By applying network science methods, it seeks correlations between the level of safety and the degree of orderliness based on the formal, spatial ordering principles of architectural aesthetics. [3]

SAFETY AND DESIGN

Contemporary fire safety brings to architecture and design an awareness and responsibility to integrate fire safety elements and systems with the aesthetics and functionality of buildings. Aesthetics is not only about the external appearance of buildings, but also about their internal

design, use of space, safe operation and comfort. It is in this context that the relationship between contemporary fire safety and aesthetics is explored. This relationship can be examined from five important perspectives:

1	Balance of design and function	aesthetics and functionality (balance between hidden and visible design)
2	Aesthetic fire protection materials	aesthetic fire retardant textures, transparent fire retardant structures
3	Sustainable solutions	simplicity, renewability, minimising energy use
4	Integrating fire safety design into architectural design	cooperation between architects and fire protection designers
5	Fire safety awareness	raising user awareness through education

Table 1. The relationship between contemporary fire safety and aesthetics

In contemporary fire safety design, the main objective is to ensure that fire protection systems and equipment do not interfere with the design and functionality of buildings. Innovative design allows fire extinguishers or fire alarms to be easily integrated into architectural elements, for example in the form of concealed finishes or elegant designs. The primary objective is to provide visibility of the part of the protection system that gives a basic sense of security, but it is unnecessary to have all fire protection system components visible in normal use. The aim is to conceal them and then make them visible in the event of a hazard, in a way that is harmonious with the architectural aesthetic. [4]

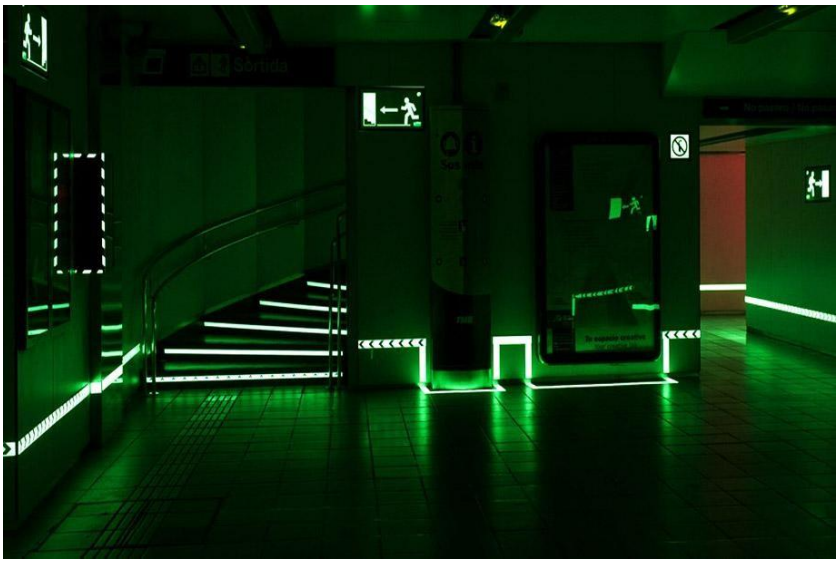

Figure 1. Escape route lighting

Contemporary fire protection requires materials that are not only fire resistant but also aesthetically pleasing. For example, refractory glass or refractory cladding allows natural light to enter and provides an aesthetic appearance while offering safety to users. In passive fire-resistant structures, it is therefore the fire-retardant properties of the materials that determine the aesthetic value of the structure and the location and method of use. A high level of knowledge of materials and developments based on the latest research are the most effective means of achieving this. [5]

Contemporary fire protection is increasingly based on sustainable and environmentally friendly solutions. For example, fire protection systems should minimise energy loss and use materials that are environmentally friendly in use and during the course of a fire. The use of large amounts of plastics in our buildings has a negative characteristic during building fires because they emit large amounts of harmful combustion products. At the other extreme, the excessive use of non-combustible materials is a cure for the above problem, but has a very large ecological footprint. The solution lies in the increased use of natural, naturally renewable materials, which, although typically combustible, present a problem that can be minimised in their installation and use. [6]

Contemporary fire safety does not treat fire protection as a separate system, but integrates it into the architectural design process. As a result, the architect and fire protection experts and designers work closely together to ensure both safety and aesthetics. The key issue in this cooperation is the correct and harmonious design of the architectural and fire protection concept, which aims at a balanced fire protection situation, taking into account functional needs and architectural requirements.

The architectural aesthetics of fire safety and the creation of a sustainable fire safety situation also involve the fire safety awareness of the users. People need to be aware of fire hazards, how to extinguish initial fires, evacuation plans, etc. Education is the basis of fire safety awareness. It is necessary to know the potential fire hazards, the fire risks in the building, the prevention practices and the rules of behaviour. Functionality is thus fed by user-friendliness, which we humans determine. It is the starting point and, with a continuous circulation over time, it is also the end goal, which is periodically repeated. Fire safety education is therefore a necessary part of sustainable fire safety, which is based on orderliness. [7]

The most aesthetic fire protection systems are design solutions that harmonise fire protection functions with the aesthetics of architecture and the built and natural environment. These devices allow fire protection not to disturb the overall appearance of the building or its surroundings, but even to contribute to its aesthetics. The following are some examples of the most aesthetic fire protection solutions:

1. Concealed fire alarms: modern fire alarms can be extremely small and can be easily hidden in walls or suspended ceilings. These devices allow fire detection without being obvious or disturbing the interior design of the building. Concealed fire detectors, such as aspiration systems or line detectors, provide fire protection, early warning and detection, but do not directly participate in the interior design of the building. For visible smoke detectors, e.g. point smoke detectors, architectural and interior design solutions are needed to integrate smoke detectors into the interior design.

2. Concealment of fire extinguishers: hand-held extinguishers play a very important and useful role in controlling initial fires, and their presence is therefore essential in modern fire protection. These devices can be installed in buildings in a concealed manner using practical solutions. They can also be installed in furniture and concealed built-in architectural spaces in

such a way that their daily presence is completely hidden from the building occupants. Their markings should be integrated into the building signage and marking system, which is a standardised solution that can be implemented by means of illuminated or backlit devices, minimising the extent of marking required.

3. Escape route signage system: an escape route signage system with LED technology or phosphorescent backlighting capability during daytime, normally a safety system discreetly embedded in the building interior design. The translucent, luminous, directional stripes and arrow system, blending into the colour of the wall surfaces, is barely noticeable in the unobtrusive everyday environment, yet becomes a coherent illuminated escape route signage system in seconds in response to a fire alarm. In darkness, at night, in the absence of lighting, it provides safe and precise directions to temporary sheltered spaces or safe open spaces. Its lights, which are essentially for safety, are capable of creating an architectural light show design on their own.

4. Fire-resistant glass, mobile fire curtains to seal openings during a fire: covering glass surfaces with fire-resistant glass allows natural light to enter the building while preventing the spread of fire up to the appropriate fire resistance limit. Such glass is transparent and aesthetically pleasing, so it does not detract from the external or internal appearance of the building. Due to the need for permeability and the design of large open spaces, it may be necessary to close openings and openings in certain surfaces and facades during a fire. Normally invisible fire curtains concealed in suspended ceilings are activated by a fire alarm and close off spaces from each other in a way that protects against the spread of fire. This solution provides a transparent, permeable spatial structure for daily use, with separation of spaces that is only activated in the event of fire.

5. Customised enclosures: fire protection systems can be provided with enclosures that are aesthetically pleasing and in keeping with the environment. For example, fire-resistant cladding can be easily painted or decorated to match the style of the building. The aim is to develop materials, coatings, claddings, etc. that go beyond aesthetics to provide fire resistance performance and thus play a role in fire protection. These structural elements can be well integrated into architectural design requirements. [8]

It is important to note that the most aesthetic fire protection systems can be tailored to the individual needs and design of the building or environment. Aligning fire protection with aesthetics helps buildings and the environment to work as a unit, so they remain safe and attractive.

DEGREE OF ORDER AND AESTHETICS OF SIMPLICITY

The author hypothesises that the high aesthetic value of architectural fire protection correlates with the degree of orderliness. The most optimal scheme for this can be expressed in the aesthetics of simplicity. Architectural simplicity, functional simplicity, provides a clear and precise framework that can be well defined by network science methods. The fire protection system of a building can be constructed and modelled according to network research principles and implemented in a way that is integrated with the architectural devices. This approach provides the opportunity to analyse and evaluate fire protection from a new perspective. Network research has drawn from graph theory to provide a toolbox for handling graphs, and from statistical physics to describe the general ordering principles of random processes. Random processes in fire protection systems can therefore be well described by this

method, and the combination of data rigour and empirical methods is also a method well suited to this field. [9]

If you want to describe a network in a complete way, you need to know the relationships in the network. From a mathematical point of view, networks are often described by a so-called adjacency matrix: a directed network of N points has N rows and N columns. In the adjacency matrix of an undirected network, each edge is represented twice and represents the same undirected connection. In a real network, the number of nodes and connections can be very large. Most real networks are proven to be sparse. The weight of nodes in a network is not necessarily equal. From a fire safety point of view, an emergency exit door considered for mass containment does not carry the same weight as a door built into an evacuation route, so the quality of the connections must be weighted. In a weighted network, the elements of the adjacency matrix give the weight of the connections. The weight of edges, i.e. links, is not always well measured. The connectivity of a network can be an important issue. A network is connected if there is a path of edges between any two points in the network. In contrast, a network is not connected if there are at least two points between which there is no path. In addition to connectivity, the clustering property of a network, i.e. the coefficient of clustering, shows how densely the neighbours of all points in the network are connected. Thus, the clustering coefficient measures the local connectivity density of a network. In turn, the clustering of the whole network can be measured by the average clustering coefficient. It gives, for example, the density of connections of fire detectors, manual call points, which influences the quality of early detection and alarm. [10]

One of the problems with fire protection systems is that they have to provide adequate protection at a very high security level. The level of protection is typically set in proportion to the level of risk given or assumed. Identifying the various risks is an exact task: we can know how much and what quality of combustible material we have, how much smoke is likely to be generated in a room, how many people are in a building, how many exits are available for escape, etc. Of course, these parameters are more nuanced in real systems: we may not know where and how combustible material is located at a given moment, where smoke is flowing under given flow conditions, whether people are all following the evacuation protocol, whether an emergency exit is closed for some reason, or whether the emergency exits are being used by the escapees. So, for better certainty, we need to look at the risks in a complex way, at the rational options for solving the problems that we create within an architectural framework. [11]

In order to find optimal and aesthetic solutions, the first step is to map the orderliness of the fire protection system. We need to identify the problems, the sources of danger and their possible outcomes. Fault tree analysis and various risk assessments are good ways to do this. However, in this way, we can only analyse the course of a single series of events, but not necessarily the behaviour of the whole system. In order to holistically examine the behaviour of the whole system, the task is to identify the spatial and temporal elements of the system, within which the degree of orderliness of the system, i.e. the entropy of the system, can be measured. The higher the degree of orderliness, i.e. the lower the entropy of the system, the more stable the fire protection situation. [12]

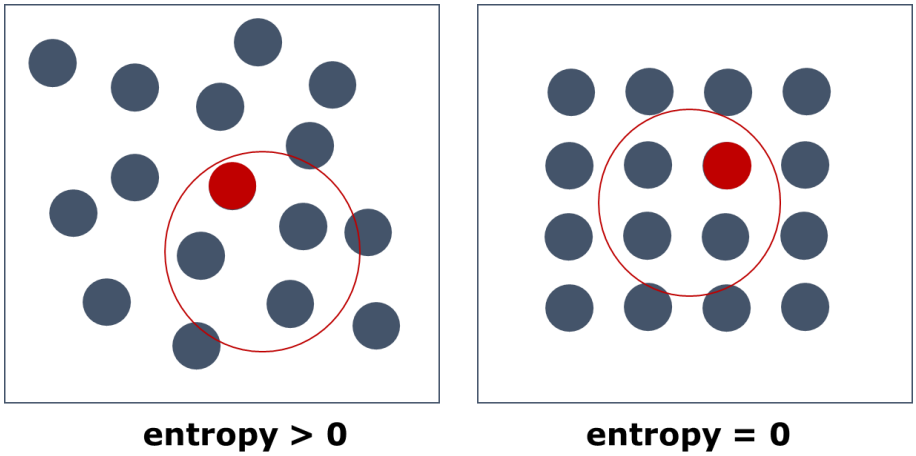

Figure 2. Degree of fixation

To model this and test the models, we apply network research methods to construct a fire network in which the weight of centres can be identified, degree number correlation, degree number distribution can be calculated, clustering coefficient can be determined, correlation of nodes can be measured, etc., by which the expected processes and the optimal responses to them can be predicted in the system. The protection solutions can be dedicated to specific nodes, but also the interactions between the edges connecting the nodes can be identified by analysing the edges, so that the central protection elements that can have a predominantly negative impact on the whole network can be identified, and thus, by providing these centres with a predominantly positive protection structure, a stable fire protection equilibrium can be optimally established that is sustainable in the long term. [13]

The above technical solutions take the form of architectural solutions that integrate fire safety features. In other words, an architectural aesthetic shapes the content of the underlying network. In architectural terms, the appearance of the network takes the form of a building, which determines the properties of the network and also keeps the behaviour of the users within an exact framework. [14]

Fire safety networks are finite networks, all their points and the connections between them can be mapped. However, the degree of nodes does not indicate the quality of the connection between neighbours. We can map out the connections between fire detectors and manual call points, etc., we can determine the degree number of the fire alarm control panel, i.e. its quantitative indicators, but to study their qualitative connectivity we need to know the clustering coefficient. Network science has proven that real networks are not random. [15] Nor are fire safety networks built, expanded or reduced as random networks, but behave in a planned way. Fire safety networks are also subject to the so-called small-world phenomenon, which means that short distances can be identified between two nodes in a network that are randomly selected, i.e. they interact, if not directly, with each other. A fire door and a point smoke detector, although not directly connected at the system level, are connected through specific nodes and a process can be triggered by a signal from the detector, at the end of which, or as an intermediate step, the fire door closes, thus fulfilling its role in fire spread control. So we can create small worlds in the fire safety net in a conscious, planned way. When nodes with a high number of degrees relative to the average degree distribution are formed in a network, midpoints are formed in that network. These midpoints have a decisive influence on the

properties of the network. In a fire protection network, such nodes are crucial in determining the quality of the protection level, and therefore the design of these nodes in proportion to the risk is necessary when identifying and assessing risks. A well-weighted, well-designed node, i.e. a node with a high number of degrees and an appropriate clustering coefficient, can decisively determine the degree of fire safety, the establishment of a stable fire protection situation. [16]

SUMMARY CONCLUSIONS, CONCLUSIONS

In summary, it can be concluded that the fire safety situation of a building can be identified using a network science method, which can be described by its spatial quantitative and qualitative parameters depending on the fire safety characteristics. The network model can be represented as a finite network using architectural tools. The building as a network model is composed of nodes and their interconnections, which are built up of architectural spaces, facades, built-in devices and systems.

Architectural simplicity and functional orderliness facilitate the identification of fire safety parameters. The research has shown that simplicity and orderliness is also an aesthetic value, the high level of which determines the appropriate fire safety situation. The author has demonstrated that the high aesthetic value of architectural fire protection correlates with the degree of orderliness, i.e. it is a significant determinant of the long-term sustainable stable fire safety situation of a building.

In conclusion, the architectural aesthetics of fire protection depends to a large extent on the degree of orderliness. And the degree of tidiness is the key to identifying possible defects and preventing the process that leads to fire. To address this, a wide range of fire protection tools and equipment are available, and there are methods that can be applied to create aesthetic, architecturally pleasing displays.

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