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THE EVOLUTION OF USERS' REQUIREMENTS COMPARED TO THE EVOLUTION OF BUILDINGS

BY

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Abstract. Building requirements are conditions that a building needs to fulfil in order to meet the needs of users and to guarantee its quality. In a usable definition of residential buildings, user requirements refer to the conditions they want to be met in the spaces they use.

Bio-physiological requirements refer to the possibility of using the building spaces for creative activities, rest or entertainment, in conditions of hygiene, comfort and protection against any harmful factors, and to move easily from one place to another.

Psycho-social requirements aim at feeling comfortable with the environment and the ability to communicate or to be separated.

Economic or efficiency requirements refer to investment/acquisition and building costs, minimum consumption of materials and energy under sustainability conditions.

Acknowledging and using building requirements will lead to a judicious conception of the building to be rehabilitated or conceived. For a long time the success of the building was based only on the repetition of what the practice had long proved.

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"Law no. 10/1995 of 18 January 1995 regarding the quality in construction" establishes, in a differentiated way according to the categories of importance of constructions, the system of quality in constructions that requires the construction and maintenance of a number of 7 essential requirements throughout the life of the constructions.

Through the documentary analysis carried out by analyzing the constructions from different periods beginning with the prehistoric period and ending with the buildings of the 21st century, we conclude that the exigencies of the user date back to the prehistoric period, the man being forced to work in order to increase the level of performance. This, the development of requirements led to the evolution of buildings.

The first necessary and user-driven demand was resistance and stability, by satisfying this demand, the user was able to create the central core for developing the other requirements. Over time, the mandatory requirements existent nowadays have been introduced, which, due to the increasing demands of users, are in a continuous development.

Keywords: requirements; bio-physiological; psychosocial; economic; categories.

1. Introduction

Building requirements are conditions that a building needs to fullfil in order to meet the needs of users. (Ciornei, 2000).

The quality of a building results from the degree to which users' requirements are met throughout the life of the building (Ciornei, 2000).

In a usable definition of residential buildings, user requirements refer to the conditions they want to be met in the spaces they use. These are grouped in the following requirements categories (Fig. 1).

Bio-physiological requirements refer to the possibility of using the spaces of the building for creative, resting or entertainment activities, in hygienic, comfort and protection conditions against any harmful factors and the possibility to move easily (not to be too cold or too hot, not to be noisy in order to rest or to work) (Ciornei, 2000).

Psycho-social requirements aim at feeling comfortable with the environment and the ability to communicate or to be separated.

Economic or efficiency requirements refer to investment/acquisition and building costs, minimum consumption of materials and energy under sustainability conditions. (Ciornei, 2000).

Acknowledging and using building requirements will lead to a judicious conception of the building to be rehabilitated or conceived. For a long time the

success of the building was based only on the repetition of what the practice had long proved. (Ciornei, 2000).

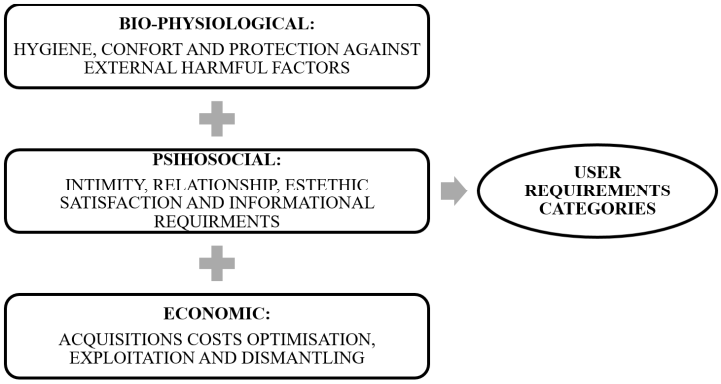

Fig. 1 − User requirements and classification categories.

The requirements of residential buildings are:

- user requirements;
- performance requirements.

"Law no. 10/1995 of 18 January 1995 regarding the quality in construction" establishes, in a differentiated way according to the categories of importance of constructions, the system of quality in constructions that requires the construction and maintenance of a number of 7 essential requirements throughout the life of the constructions (Fig. 2).

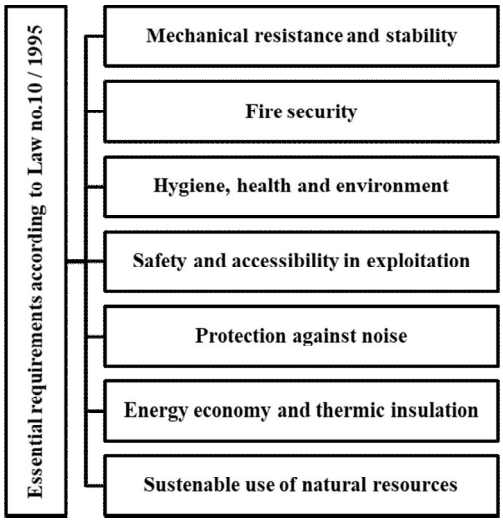

Fig. 2 − Essential requirements according to Law no.10 / 1995.

2. Evolution of User Requirements Compared to Building Evolution

In the period of 500,000 BC – 10,000 BC the first homes used by people were temporary and mobile, reflecting the nomadic lifestyle, the hunter-gatherer type. Easily transportable materials such as animal skins, bones, wood, clay and sludge were the main building materials.

Since the Neolithic period man has felt the need to satisfy the exigencies, the first developed requirement being the creation of durable and stable shelters for gravitational loads (Fig. 3). Building strength was due to the massiveness of the stone blocks. This period is the beginning of the resistance and stability requirement development.

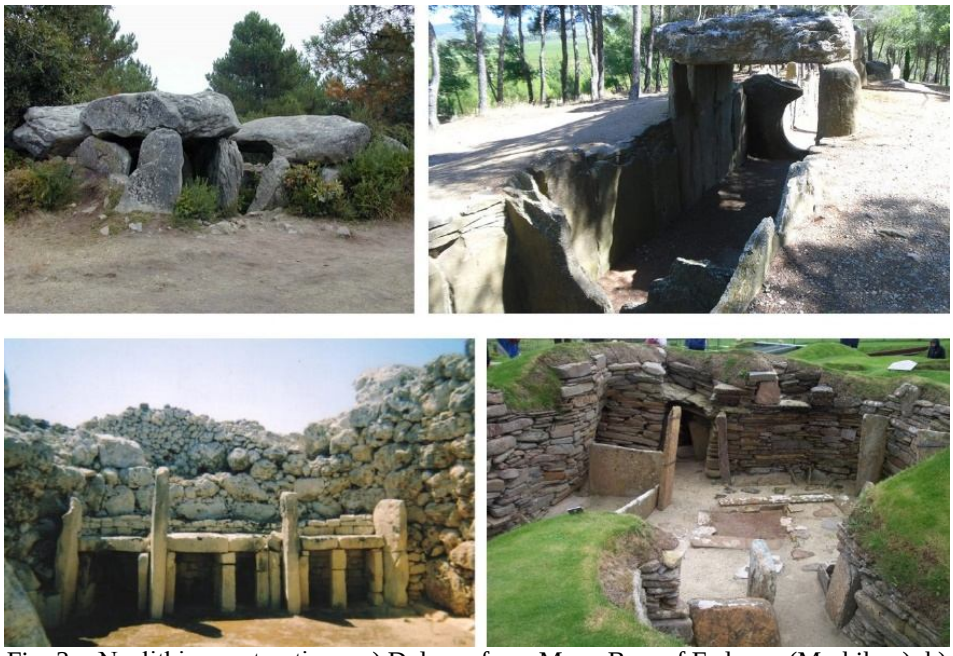

Fig. 3 − Neolithic constructions: a) Dolmen from Mane-Bras of Erdeven (Morbihan); b) The dolmen Dom Lo Morrel dos Dados of Pepieux (Aude, France); c) Gantija Megalithic Temple (Gozo Island); d) Dwellings discovered at Skara Brae (Scotland).

In 10,000 BC - 500 BC people have begun to develop new methods so that the bricks from dry mud have been invented and the use of wood for building houses has begun. The walls were covered with a layer of fine plaster, on which they were painting ornaments using plant dyes. The floors were empty or made of straw or animal skins, and the furniture was made of mud bricks. To

avoid weathering, the roofs were made of wood covered with branches and leaves, with straw or thick layers of earth caught between herbaceous roots. In warm areas, flat roofs were made to reflect the sun's rays and cool in the building. In temperate regions, the roofs were tilted so the rainwater could drain quickly. On the Indul Valley, the first civilizations date from 3,300–1,700 BC, revealing a remarkable architectural execution, the buildings being fitted with a sewer system designed to separate the water used by the clean one.

The ancient Egyptian cities were built of adobes and bricks, but built in the floodplain valley of the Nile, they degraded and were destroyed.

The palaces of the Mesopotamian peoples were vast and imposing. Because stone and wood were rare in this region, as construction material there were used bricks from dry or sunburned earth. Around 2300 BC, the brick burned in the ovens began to be used, and bitumen as binder. An innovation of that period consists of the introduction of the arches and the vaults that replace the classical trilitic structure (pillar and beam) (Fig. 4).

Fig. 4 − Neolithic constructions: a) Domains from Mane-Bras of Erdeven (Morbihan); b) The domain Dom Lo Morrel dos Dados of Pepieux (Aude, France); c) Gantija Megalithic Temple (Gozo Island); d) Dwellings discovered at Skara Brae (Scotland).

With the passage of time, man has learned to build ever more imposing buildings to satisfy the necessary requirements. The requirement for strength and stability has been developed through the use of burnt bricks as a material to make buildings more durable at water action, the introduction of arches, vaults and wood for the roofing, which has also allowed generating spaces with more generous surfaces. The building's tightness began to develop by building brick walls and ceilings. The innovation of this period consists in the emergence of the first sewer systems, the man needing to meet his hygiene requirement.

Period **500 BC - 500** is characterized by a spectacular architectural and structural evolution (Fig. 6), the Romans first using concrete for constructions (made of lime, debris, water and volcanic ash), which allowed the development of constructions at a scale not seen until then, these being made much faster and with much greater stability. Arches, vaults and columns were mainly used for making buildings, the study of mathematics serving the design of well-proportioned buildings. By the 200th century, there were apartments blocks of 4-5-storeys in the Roman cities, called "insulae," these constituting the germs of today's crowded towns.

The buildings were provided with windows to ensure natural lighting and ventilation, the floors began to be covered with polished marble and the walls were finished with plasters, sculpted or plated with ornamental stones.

This period reinforces the knowledge of strength and stability. By discovering the concrete and combining it with the arc and vault construction systems, it has been possible to build monumental buildings that have lasted for thousands of years.

An important step was the realization of constructions to meet the hygiene requirements, with sewage and water supply systems, communal bathrooms and toilets (Figs. 5 and 7). At the same time, buildings have begun to be fitted with walls and ceilings to provide natural lighting, thus ensuring visual requirements.

Fig. 5 – Constructions from the period of 500 BC – 500:
a) Baths in Bath, England; b) Roman public toilets.

Fig. 6 – Constructions from 500 BC – 500: a) Colosseum in Rome; b) The Great Wall of China; c) d) Rome's pantheon;

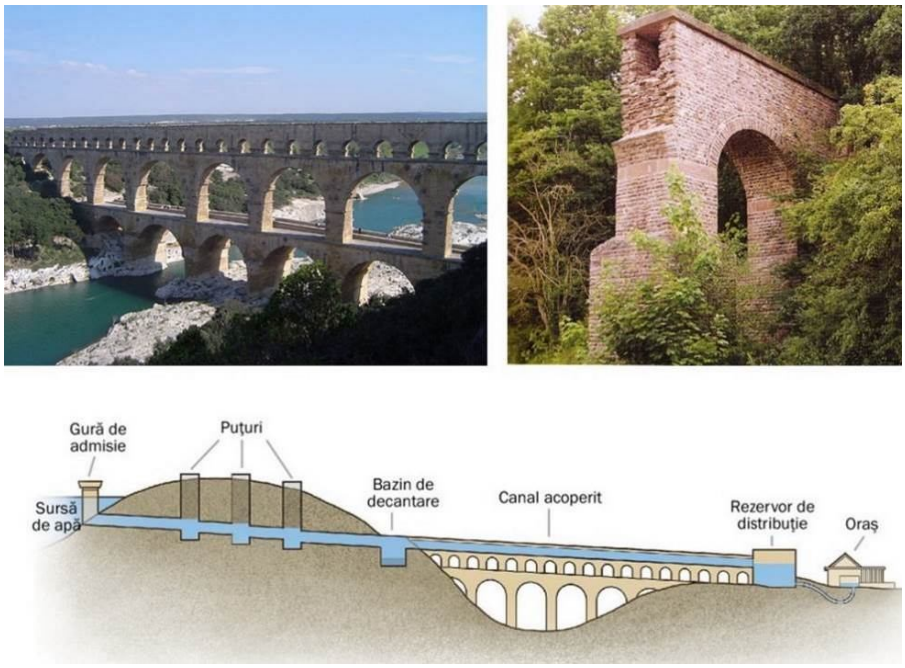

Fig. 7 – Buildings from 500 BC – 500: Pont du Gard, France; b) Eifel aqueduct, Germany; c) Water transport system of the Roman period.

Another major innovation has been the use of sanitary and sewage systems to meet hygiene requirements. The water was sent to power the cities through channels and elevated aqueducts (Fig. 5).

The period between **500 and 1500** is characterized by the appearance of the fortified buildings for defence and the beginning of building churches and cathedrals. The innovation of this period in terms of resistance and stability was developed in the Gothic style, which was based on the architect's preoccupation with the distribution of the forces acting inside the structure of the building, which they had directed along the columns, beams and outer buttresses 8).

Roman architects occasionally decorated the edges of the cross vaults with ribbings. The Gothic architects turned the ribs into the main structural elements of the roof, which gave them a slightly semi-circular arched shape, then filling the spaces between strips with gothic broken vaults. Thus, stronger and lighter construction resulted. At the meeting point with a column or wall, the broken arches and vaults have the advantage of transferring the force down, producing less lateral pressure than an arch or a semi-circular vault.

Gothic architects have proposed a series of strategies to facilitate pressure-relief. One of these innovations consisted in supplementing the columns with thin and small columns that would climb up to the beams, supporting the pressure of the vault. The outer fortification of the walls by means of the pillars, to which were added the curving arches curved over the pillars, and the big distances between the pillars, were elements designed to take up the lateral pressure. All of these features diminished the pressure of the structural mass inside, allowing the light to penetrate the holes.

The political instability in the Middle Ages Europe has led to the construction of a large number of castles and fortifications that served as residences for nobles, seniors and kings, as well as fortresses for invasions, resulting in massive and high buildings which would give resistance to attacks.

The stained-glass technique originally used in jewellery and mosaics began to be used around the 1000s to produce windows, which allowed for a better tightness of buildings.

This period was comprehensive in the development of knowledge on building strength and stability, and architects began to understand how the forces were distributed in the building strength structure, which allowed the transition from empirical building based on previous experience to building on the basis of well-understood constructive systems.

During this period, a new demand emerged, namely the need for defence, thus building many fortified buildings.

The appearance of stained glass and the use of the tile made it possible to increase the comfort given by increasing the performance of the buildings in order to satisfy the tightness, hydrothermal, acoustic and visual requirements.

Fig. 8 – Constructions from the period 500 – 1500: a) Bodiam Castle, England; b) Basilica San Marco, Venice; c) Notre-Dame Cathedral, Paris; d) Burgos Cathedral, Spain.

The period between **1500 and 1835** strengthens the previous requirements, and the buildings are more architecturally developed, multi-level buildings, with very large openings being built, and due to the glass industry's development, it was possible to produce much larger windows allowing the natural lighting of the buildings (Fig. 9).

The great innovation of the period consists in the use of cast iron in the resistance structures (Fig. 10). In 1779 the cast iron was first used to build a bridge over the Severn River at Coalbrookdale, England. The tendency to use new materials would have flourished in the Victorian era, from the19th century.

The period was prolific for the consolidation of the previously discovered requirements, by making correct structures from the conformation point of view, generous from the point of view of the spaces and accesses, presenting safety in operation and having way tighter closing elements (doors, windows and covers) that have improved acoustic and visual comfort.

With the use of metal to build resistance structures, buildings have become more and more imposing, taller and more supple. The following period was the basis for the today technological advancement and engineering knowledge.

Fig. 9 – Buildings from 1500 to 1835: Basilica di San Pietro, Italy; b) Dome of Santa Maria del Fiore, Italy; c) Versailles Palace, France.

Fig. 10 – Buildings from 1,500 to 1,835: Ironbridge Gorge, England.

The period between **1835 and 1913** had as a characteristic the imitation of the grandiose buildings of the past, but towards the end of the ninth century a new type of architecture was developed based on the use of steel skeleton structures (Fig. 11). Thus, with the invention of the elevator by Elisha Otis in 1884, William Le Bron Jenney built the first skyscraper in the world in the city of Chicago with a GF + 10F height regime.

Fig. 11 – Buildings from 1835 to 1913: The Home Insurance Building, USA; b) Eiffel Tower, France; c) The Statue of Liberty, USA; d) The Crystal Palace, England; e) The Crystal Palace – fire, England.

Small and large towns were becoming more and more densely populate and it was vital that services such as drinking water supply and sewerage systems developed at the same pace. In the underground of the cities were built new water pipes, cast iron pipes and finally, they led to the sewerage.

Technological progress and the advance of engineering knowledge have made it possible to build bridges with ever-increasing openings. Using steel structures, skyscrapers, structures such as the Eiffel Tower (300 m), built for the 1889 Great Exhibition and the New York City Statue of liberty, a gift and a symbol of freedom and friendship on the part of the French people to the American people on the occasion of the US centenary.

The use of metal for building constructions can be considered a first leap in technological and engineering development. The metal being a homogeneous material allowed the engineer Alexandre Gustave Eiffel to dimension the Eiffel Tower on the basis of simple relationships.

Metal structures have highlighted a requirement that has not been prioritized, namely fire safety, the Crystal Palace building being made entirely of metal and with many glazed spaces being totally destroyed by a fire, which was not the case at stone and brick structures.

This period therefore highlights the behaviour of metallic structures at high temperatures and requires the development of technologies to meet the user's exigency to fire action.

The period between **1913 and 1950** came with the architects' tendency to design the buildings in a functional style, considering that the shape should follow the function, the buildings being made of modern materials (glass, steel and reinforced concrete) (Fig. 12).

Fig. 12 – Constructions from 1913 to 1950: Empire State Building, USA; b) Radio City Music Hall, USA; c) Interior - Radio City Music Hall, USA; d) Golden Gate Bridge, USA.

The historical appearance of the skyscrapers at the end of the nineteenth century on American and then Canadian land was one of the triggers of a new

revolution in architecture. As the buildings were taller architects and designers faced the struggle with growing challenges, with regard to the exigencies of users in terms of building strength and stability, fire safety, exploitation safety, hygrothermal performance, sustainability and economy.

The essential requirement of strength and stability began to be well understood, but automatic computing programs were missing. In 1940, the first computer appeared in America, designed by American researcher George Robert Stibitz and completed in Bell Telephone Laboratories, and in 1975 apperead America's first computing program produced by Computers and Structures Inc. (CIS), which has led to a new leap in building development.

By developing vertical buildings, new needs have emerged, with new technologies and systems being needed for improving the atmospheric environment and the tactile requirements (thermal, electrical and mechanical comfort).

The period between **1950 and 1990** came with the tendency of architects to design modern buildings with bronze and glass facades. Structural systems no longer posed the major problem, and the emergence of computational programs has streamlined the design process, architects and designers being able to solve most engineering problems, but at the beginning of this period, the demand for fire safety was treated superficially, the structures not having the appropriate protection against fires (Fig. 13).

If the construction costs were not taken into account in the period up to the year 1950, being tracked only the construction of as imposing as possible buildings, starting with the period after the 1950s, an economic construction took place. During this period, emphasis has been put on the detailed research on user requirements, the industrialization of the execution processes, the development of calculation methods and algorithms for the realization of low consumption materials and low energy consumption.

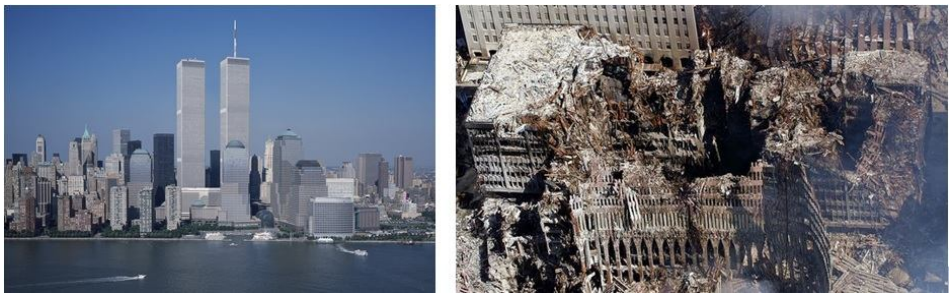

Fig. 13 – Buildings from 1950 to 1990: a) World Trade Center, USA; b) World Trade Center building collapsed after fire.

The period between **1990** and nowadays has imposed the limitations to be exceeded in what was thought to be maximum at a moment, the constructions becoming ever higher (Fig. 14) and energy-independent. At the moment, architects and engineers are constantly working to make safer and more energy-efficient (near zero (nZEB)) buildings.

Fig. 14 – Constructions from 1990 to nowadays: a) Shanghai World Financial Center and Jin Mao Tower, China; b) The Petronas Towers, Malaysia; (c) Burj Khalifa, United Arab Emirates.

At the beginning of the 21st century, the world, and especially the developed countries, reached a very high level of performance, but the rapid development effect led to global warming, which required the development of buildings towards sustainable use of nature resources and the construction of buildings with an energy consumption close to zero (nZEB) (Fig. 15).

The building stock highly contributes to greenhouse gas emissions in Europe. Changes in this sector can result in significant reductions in emissions. Given that more than a quarter of the 2050 building stock is to be built, much of these emissions are not taken into account. In order to achieve the EU's ambitious reduction targets, the energy consumption of these buildings must be approaching zero, which requires the establishment of s definition or of some instructions for putting into practice "nearly zero-energy buildings" (nzEB), wich could simultaneously contribute to 80% reduction in greenhouse gas emissions by 2050 compared to 1990 levels and to increasing energy security by consistently reducing domestic consumption.

Fig. 15 – Constructions from 1990 to nowadays: a) Shanghai World Financial Center and Jin Mao Tower, China; b) The Petronas Towers, Malaysia; (c) Burj Khalifa, United Arab Emirates.

3. Conclusions

Through the documentary analysis we concluded that the exigencies of the user date back to the prehistoric period, the man being forced to make efforts to increase the level of performance. In Fig. 16 we present the evolution of the requirements compared to the evolution of the representative buildings from different periods, which shows that the evolution of the exigencies led to the evolution of buildings and their performances.

The first necessary and user-driven demand was resistance and stability, by satisfying this demand, the user was able to create the central core for developing the other requirements. Over time, the mandatory requirements existent nowadays have been introduced, which, due to the increasing demands of users, are in a continuous development.

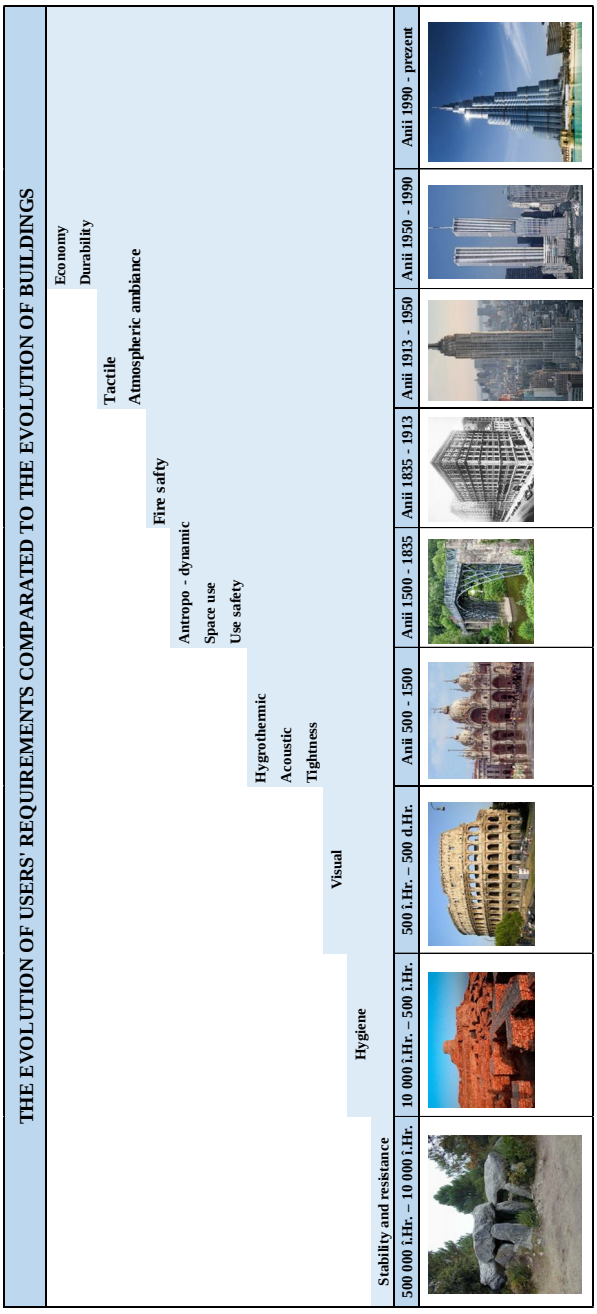

Fig. 16 – The evolution of users' requirements compared to the evolution of buildings.

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EVOLUȚIA EXIGENȚELOR UTILIZATORILOR COMPARATIV CU EVOLUȚIA CLĂDIRILOR

(Rezumat)

Exigențele în construcții sunt condiții pe care o clădire trebuie să le îndeplinească pentru a satisface nevoile utilizatorilor si pentru a garanta calitatea acesteia. Într-un mod de definiție uzabil pentru clădirile rezidențiale, cerințele utilizatorilor se referă la condițiile pe care aceştia le doresc satisfacute în spațiile pe care le folosesc.

Cerințele bio-fiziologice se referă la posibilitatea de a utiliza spațiile din clădire pentru activități creatoare, odihnă sau divertisment, în condiții de igienă, confort şi protecție față de orice factori nocivi, de a se deplasa cu uşurință.

Cerințele psiho-sociale vizează senzația de confort cu mediul înconjurator şi posibilitatea de a comunica sau de a fi separate.

Cerințele economice sau de eficiență se referă la cheltuielile de investiție/ achiziție şi explotare a clădirii, consumuri minime de materiale şi energie în condiții de durabilitate.

Cunoaşterea şi utilizarea exigențelor în construcții va conduce la o concepție judicioasă a clădirii ce trebuie reabilitată sau concepută. Multa vreme reuşita concepției clădirii se baza numai pe repetarea a ceea ce practica verificase îndelungat.

"Legea nr. 10/1995 din 18 ianuarie 1995 privind calitatea în construcții" instituie, în mod diferențiat în funcție de categoriile de importanță ale construcțiilor,

sistemul calitatii în construcţii care impune realizarea şi menţinerea pe întreaga durată de existenţă a construcţiilor a unui numar de 7 exigente esentiale.

Prin analiza documentară realizată analizand constructiile din diferite perioade incepand cu perioada preistorica si finalizand cun cladirile din secolul XXI concluzionam că exigenţele utilizatorului datează încă din perioada preistorică, omul fiind obligat să depună eforturi în vederea creşterii nivelului de performanţă, astfel prin evolutia exigentelor s-a condus la evoluţia clădirilor.

Prima exigenţă necesară şi dezvoltată de utilizator a fost rezistenţa şi stabilitatea, prin satisfacerea acestei exigenţe utilizatorul a reuşit să îşi creeze nucleul central pentru dezvoltarea celorlalte exigenţe. Cu timpul au fost introduse rând pe rând exigenţele obligatorii de astăzi, care datorită cerinţelor tot mai mari ale utilizatorilor sunt într-o continuă dezvoltare.