Errare Humanum Est.

Errors, Mistakes and Failures in Design – Execution – Use

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for Prof. Em. Dr. Arch. Emil-Barbu Popescu

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FOREWORD

First it was an optional course, some 20 years ago, in the last year of study; then it moved to the Master's programme; then back as an undergraduate course; eventually it was eliminated and I reinvented it, as a workshop, in my last year as a professor in the "Ion Mincu" University of Architecture and Urban Planning, in Bucharest, Romania.

In fact, it was a logical development, in three acts, of the Architectural Detailing Courses: the madatory two-semester course was followed by an optional course on Contemporary Products and Systems (which, in fact, illustrated the use of details in subassemblies) and everything was wrapped up in a last part of the trilogy: Mistakes and Failures in Design – Construction – Use, an optional course that was emphasizing the consequences of poor design / execution and maintenance.

Part of this theory is written in the book *Failures of the Building Envelope*, published at Editura Universitară Ion Mincu, in Romanian language – in fact a synthesis of the early courses.

Some failures are reccurent; therefore, it is worth mentioning the causes, so that they can be avoided. There is a world of mistakes and faults that can be made, why repeat the same old ones? We can be creative in this field as well (and, as an expert in building pathologies, I had the chance to see that human imagination has no boundaries in improvizing solutions that lead to... failures).

Almost from the beginning, the idea of the course was to bring together, in the class, professionals from different areas: architects, engineers, geologists, different specialists in building components... to speak about failures in their field of activity. Therefore, it was a lively and interactive course, very much appreciated by students as well as by the guests. And yes, it takes courage and responsibility to speak about your mistakes (and, believe it or not, architecture is also the art of compromise). What I always told my students is that the first sign that you are on the way of becoming an architect is when you... see; when you understand what is happening, when you can tell right from wrong and intention from failure. One thing that I have learned – and it was a motto of the course – is that we can only see what we can understand (sad but true). As previously mentioned, although much appreciated by the students, the course was dissolved a few years ago.

During the first semester of the Academic year 2022-2023 – my last year as professor in the “Ion Mincu” University of Architecture and Urban Planning – I had the surprise of my life when some of the students from the optional course of Contemporary Products and Systems declared that if I organize something... they will come. Really? This group of young and enthusiastic students made me think: what should I organize for them, if they want to continue to listen to me!? And this ”seed” germinated: why not organize a workshop? Somewhere nice, where we would be together and learn and visit and enjoy...

...and the idea was passed on to Anda and Radu Sfinteș, my wonderful team who backed up many of the projects I carried out in the Univesity as Professor, Vice-Rector and later as Director of the Center of Architectural and Urban Studies.

...and Răzvan Dobre, the director of Glamour Floors, stepped in and offered us a lovely location in Satul Banului, in Prahova, with the possibility of visiting architectural monuments like the Potlogi Palace, the Little Trianon Palace in Florești, the Bellu House in Urlați, the fabulous jewels that are the Măgureni and Filipeștii de Pădure churches, painted by Pârvu Mutu, and other restored or abandoned historic sites.

...and why not benefit of the knowledge and experience of professors from abroad – with whom I have collaborated throughout the years and who gracefully accepted to come and take part in the workshop... So the team grew with Prof. Em. Dr. Arch. Fani Vavili from the Aristotles University, Assoc. Prof. Dr. Arch. Paola De Joanna from Federico II University in Naples, Adjunct Prof. Dr. Arch. Artemis Kyrkou from the International Hellenic University...

...and as we deal with building materials, why not have a geologist to speak about the failures in architectural stone choices and products... and we benfitted of the knowledge of Dr. Geol. Valentina Cetean from the Geologic Institute...

...and let’s add some specialists from the building product market – the ones that were my guests in many lectures throughout the years: Dragoș Matei from AGC Glass, Vasile Urzică from Daw-Bența, Marius Olteanu from Siniat...

...and as we are so close to a factory of architectural Aluminum Systems – Alumil – why not see it and have a presentation from their staff...

...and as we are in a rural environment, why not have an architectural competition on the revitalization of a community space...

So the workshop became a multi-facetted studio, where old and new, correct and failed, work and play, sun and rain intertwined in five days, two months of home-work and a jury session for the students' outcome.

As always in the past decade, I am thankfull to Assist. Dr. Arch. Radu Sfineș and Lect. Dr. Arch. Anda Sfinteș who took the lead and managed the teams of students during the workshop and in the phase of the students' competition.

And, last but not least, I am forever grateful to Prof. Em. Dr. Arch. Emil-Barbu Popescu, whose help and support kept things going and led to the success of this endeavour. Unfortunatelly for us all, he will not see the outcome of this complex workshop. This book is dedicated to him.

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WHAT REALLY MAKES A GOOD BUILDING?

Abstract: Is it possible to identify the factors that can make a good building? Thankfully or not, architecture is far more complicated than a simple yes or no answer to this question and, after all, a "good building" is a combination of many things happening simultaneously. The main objective of this paper is to mention, analyse and clarify the numerous factors that play an essential role, in order to understand how a "good building" can be translated in architectural terms. The purpose of this research is to identify the important elements of "good architecture".

Keywords: good architecture, building design, important design elements, design procedure

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Introduction

Is it really possible to identify the factors that can make a good building? Can they really be specified and have architectural formulas, or even checklists, that result only in good buildings? Are the architectural prizes, the amount of “likes” in social media, or various evaluations enough reliable criteria for a “good building” (Cantacuzino, 1994)? Thankfully or not, architecture is far more complicated than a simple yes or no answer to the above questions and after all a “good building” is a combination of many things happening simultaneously. The main objective of this paper is to mention, analyse and clarify the numerous factors that play an essential role, in order to understand how a “good building” can be translated in architectural terms. The purpose of this research is to identify the important elements of “good architecture”.

Indeed, it is rather hard nowadays to formally define the term “good architecture”. Probably one of the oldest (from the 9th century) but best definitions of “good architecture” was given by Vitruvius. According to him, in order to have “good architecture” and therefore a “good building” it is necessary to include three basic qualities: *utilitas*, *firmitas* and *venustas*. In other words, a structure should be useful, solid and beautiful (Rowland, 2001). It is worth mentioning that Vitruvius didn’t set any kind of hierarchy or priority between these three qualities. Each of them is as important and as necessary as the other two.

In our times, there can be many interpretations and different point of views regarding these three qualities. Architectural structures and buildings define the common spaces, facades, aesthetics etc. which we use and experience in our everyday life. According to F. Keré, “architecture is not just about building. It’s a means of improving people’s quality of life” (in Hales, 2005). So, in a way, architecture is everywhere and it affects everything. Modern architects usually work for a client and therefore satisfying the client is usually top priority. Throughout time, Vitruvius’ three qualities were re-evaluated, re-stated, re-approached and they were adjusted according to the values and the priorities of each era, staring from the interpretations of Leon Battista Alberti (in the 15th century) and Andrea Palladio (in the 16th century), until the present values. Nowadays, there is a shift in design priorities and there is a special focus on goals like sustainability, zero waste buildings etc. (UN, 2020).

The surrounding environment of a building

From a first point of view, the surrounding environment of a building is of great importance from the very early stages of the design process (Ding, 2008). It is a factor of thorough research because, after construction, a whole "new reality" and "new system" of communication, circulation and new relationships will be created (Fig. 1). Whether the new building is located in the heart of a city, in an area of great natural beauty, in a rural area, or on the outskirts of an urban area (e.g. industrial zone), the importance of the surrounding environment is still of great importance.

Fig. 1. Life between buildings: on the left, the seafront public space, Thessaloniki, Greece. © Facebook Hello Greece, free use. On the right, the ancient theatre / conservatory in the city of Patras, Greece © Prof. N. Tsinikas

It is very common – especially in urban areas – to observe the construction of new buildings. The relationship of the new building with the surrounding environment and the pre-existing buildings in this case can be intrusive, harmonious, indifferent etc. (Mehta, 2007). There are certain rules and limitations (always depending on the existing building regulations) that apply for these relationships e.g. minimum distances between the buildings, volume, height, shape and material specifications (Fig. 2). In total though, whether the new building fits harmoniously with its surrounding environment is a matter of many variants. Apart from the subjective opinions of the users, it is simultaneously a matter of successful plot utilization, aesthetics, maintenance, cost issues, etc.

Fig. 2. On the left, Pompidou centre in Paris, France and, on the right, Metropol Parasol in Seville, Spain. New buildings and their relationships with the pre-existing buildings in the heart of cities. © Wikipedia public domain, © Unsplash photos free use

Fig. 3. The surrounding area of Parthenon. In front of it, the new Acropolis museum by B. Tsumi, Athens, Greece. © prof. N. Tsinikas

According to Aldo Rossi, in his *L'architettura della Citta* (first published in 1966), where he thoroughly describes his perception on issues regarding environment, a turn towards the release of architecture from historic and traditional conventions is obvious in order to redefine the architectural vocabulary at the times of industrialization (Rossi, 1991). At the same time, Robert Venturi's *Complexity and Contradiction in Architecture* is published and he states that a new building in an existing built environment can't always achieve a harmonious integration and this fact can be either part of a deeper architectural design intention or not (Fig. 3). In conclusion, architects have to deal with this issue as it is a new challenge or a new opportunity. If one could translate Venturi's perception into today's needs, the "energy consumption issues" in buildings could be considered as a challenge.

People using the space

People who use the built environment or the new building are in the centre of attention and importance in architectural design. After all, the design of a new construction aims to provide shelter and comfort (Zanariah et al., 2013). The famous principle of Louis Sullivan "form follows function" is linked with the use of the space and therefore architectural programming depends on the use of the space and its layout. Examples regarding the interior architecture of open plan layouts for open spaces or flexible/adaptable spaces are connected to the multifunctional use of the same space. In these cases, other issues come up e.g. energy consumption or even sanitation issues during the recent experience of the COVID-19 pandemic (2020).


Fig. 4. Villa Savoye by Le Corbusier, one of the most representative modern movement masterpieces, Poissy, France © Wikipedia public domain

These functionalistic and rationalist approaches are explained in detail in Le Corbusier's *Vers une architecture* (1923) and also identified in Alvar Aalto's interior design details. One of the most representative works of the modern movement in architecture, is Villa Savoye. This masterpiece by Le Corbusier is perhaps the best example of his attempts to create a house which would be a machine for living in (*machine a habiter*) (Fig. 4). The house is near Paris and it is considered to be as beautiful and functional as a machine. This Villa was the product of many years of design, and the basis for much of Le Corbusier's later architecture. Although it looks simple in photographs, it is a complex and visually stimulating structure. The design features of the Villa Savoye include:

_modulor design – the result of Le Corbusiers's researches into mathematics, architecture (the golden section), and human proportion;
_*pilotis* – the house is raised on stilts to separate it from the earth, and to maximise the use of the plot. These also suggest a modernized classicism;
_absence of historical ornaments;
_abstract sculptural design;
_pure colour – white on the outside, a colour associated with newness, purity, simplicity, and health (Le Corbusier earlier wrote a book entitled *When the Cathedrals Were White*), and planes of subtle colour in the interior living areas;
_a "very open" interior plan – so open that it makes it difficult to heat;
_dynamic, non-traditional transitions between levels/floors – spiral staircases and ramps;
_built-in furniture;
_ribbon windows (echoing industrial architecture, but also providing openness, unification with the exterior, and natural light);
_roof garden, with both plantings and architectural (sculptural) shapes (primary integration of an architectural element that is used widely today);
_interior garage (based on the turning radius of the 1927 Citroen).

All the above include functionality, durability, beauty and comfort. On the other hand, the interior atmposhpere and the total experience that people get from a building may be the final judge of whether a building is "good" or not. In other words, an architect may have analyzed beforehand all the necessary data, set the design goals, worked with passion and energy, but the result may not be the expected one if people don't spend time in it or don't use it as much as they are supposed to.

According to the philosopher Gernot Böhme, atmosphere is achieved only by the use of people inside a building. Defining the term atmosphere is rather difficult as it is linked to time and personal experience and perception (Stidsen et al., 2010). At this point it is worth mentioning Zumthor (2006) and his detailed explanation on the way he aims to achieve a "perfectly tempered feel" in his built spaces. His intention is to create architecture that immediately communicates a certain atmosphere to those who experience it. According to him, a successful atmosphere is one in which people want to stay longer, where they feel comfortable in their surroundings and at the same time one where they can be surprised and intrigued. He implies that atmosphere is an aesthetic element or a quality a building can achieve and states that good architecture should "move" him. The impression of a building can offer a basic insight into its atmosphere. Speaking of atmosphere, he highlights that "in the fraction of a second – [you] have this feeling about it. We perceive atmosphere through our emotional sensibility – a form of perception that works incredibly quickly" (Zumthor, 2006, p. 13).

Functionality – Durability – Beauty. Analysing the basics

The fundamental quality of functionality refers to the program and the uses of the building in order to maximise the satisfaction of the users. A new building without functionality may be beautiful but not useful at all – than it is like a sculpture.

Durability refers to the construction details of a building. Concrete, metal, wood, mud or no matter what other material is used, the construction must be steady and obey the laws of physics. In order to be part of "architecture", beauty and analogies need to also be a part of it; otherwise, it is closer to engineering than architecture.

Beauty refers to the aesthetics and the appearance of buildings. Vitruvius refers to it as "delight". Visual pleasure in terms of architecture could be noticed on a well-constructed brick wall, a vaulted stone ceiling, a slot for natural light in a dark room. Beauty is the essential part of "good architecture". Without the element of beauty an exceptionally functional building is just utilitarian and it has nothing to add to architecture; it is the difference between a plain suburban house and Frank Lloyd Wright's Fallingwater. Beauty standards have also changed through time. An understandable example on this change is the Kennedy Centre (Washington D.C.) by Edward Durrell. At the time it was constructed (1971) is was considered to be the most stunning building, but now it has received negative comments based on the simplicity of its shape, its analogies and the interior design.

Sometimes, beauty in architecture is linked to a certain architectural style which is “in fashion” or to architectural elements that are excessively used. As time goes by, certain architectural trends come back “in fashion” with new arguments and regrets for their abandonment. It is worth mentioning a relevant characteristic example in Florida (USA). The art deco style hotels built in the 1970s and 1980s were re-appreciated after years of neglect. After a while, they were renovated and now they are a worldwide known tourist attraction and a landmark for Miami. Architectural masterpieces such as the Parthenon, Stonehenge, the Pyramids, the Louvre, etc. impress with their spatial power and their size.

Conclusions

In conclusion, is it possible to say whether a building is “really good”? Maybe if one can answer positively to most of the following subjects:

_Has functionality been expressed in a substantial yet visually interesting way? The visual information along with proportions (height and volume) that respect the human scale play a vital role. For example, an aerodynamic shape of an airport or an abstract shape of a contemporary museum may enhance the final result.

_Does the building have a competitive, or a harmonious relationship with its surrounding environment? The limits of a “good building” are not supposed to be obvious. When designing a single building, the surrounding environment is crucial for the integration of the result. Some of the most valuable architectural buildings are not invasive to their surrounding environment (especially in cases when this environment is the natural landscape), and the choices of the applied materials and their volumes totally respect nature (Fig. 5). On the other hand, in other cases, new buildings use a totally different architectural vocabulary from the one used in their surrounding environment in order to gain visual attention and depending on their use.

_Is the new building well-constructed? As Mies van der Rohe once quoted, “God is in the details”. A well-constructed building with attention to the details (e.g. the color of a wall, the material of a single door, etc.) can always play a vital role for the coherence of the final result.

_Will its architecture last in time? “Good architecture” has a significant character that remains over time even if the use of the building or the space changes/adapts to the needs of the users. The Grand Central Terminal in New York was built in 1913 with large waiting rooms for the passengers. Despite the fact that passengers continue to sit in the same rooms, the interior of the station changed over time. New enhanced uses, coffee areas, shops and – almost – a shopping mall appeared. The sense one gets is still the same – the feelings of glamour and impressiveness become even greater as time passes by.

The element of “surprise” in architecture can be translated into an inspiring quiet corner for recreation or a beautiful enclosed green garden. These are spaces that can evoke feelings in users and therefore they become places. Understanding the complexity of architecture can be terrifying but yet challenging. There might be more “good buildings” and even “good cities” if more people tried to approach and understand the deeper meanings of architecture.

Fig. 5. Thermal Baths, Vals, Switzerland, by P. Zumthor: To be noted the surrounding area and the relationship of the building with the natural environment. © Wikimedia commons free use

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REFLECTION ON THE FAILURES IN MAKING ARCHITECTURE: ENVIRONMENT – BUILDING – OBJECTS

Abstract: The text explores the complexity of errors in architectural projects, starting with a reflection on the concept of "error" for architects and subsequently investigating the different forms in which errors manifest themselves. By defining errors, mistakes and failures as deviations from good practice, they are distinguished as unintentional human actions, deviations from accuracy and lack of success.

The concept of harmony between architecture and environment is explored through different perspectives, highlighting the importance of integrating architecture with the surrounding environment for sustainable regeneration. Error allocation and its consequences are also addressed, with a detailed analysis of where, when and how errors occur. The text emphasizes that the severity of errors is independent of scale but must be measured on the impact on ecosystems.

Finally, the text highlights the importance of a holistic and multidimensional approach that considers ecological harmony, cultural values and the integration of elements to create cohesive, sustainable and culturally significant environments. Reducing the discrepancy between cognitive maps and reality is seen as possible through multidisciplinary research and collaborative problem solving.

Keywords: errors, good practice, harmony, architecture, environment

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The meaning of error, mistake, failure

May I take you to the shores of a mountain lake?

The sky is blue, the water green and everything is deep peace. The mountains and the clouds are reflected in the lake and so are the houses, ... everything breathes beauty and peace…

But what's there?

A false note creeps into this peace. Among the houses of the peasants, which were not built by them but by God, there is a villa. The work of a good or a bad architect?

I do not know. I only know that peace and quiet and beauty are already gone. ....

And I ask then: why do all architects, good or bad, end up disfiguring the lake?

The farmer doesn't do it .... he has marked out the land on which the new house is to be built on the green grass .... the mason lays brick by brick, stone by stone .... the carpenter takes the measurements for the doors and windows .... then the farmer paints the beautiful house white.

But he keeps the brush because at Easter, next year, it will be used again.

Is the house beautiful? Yes, she's really beautiful

And I ask again: why does a good architect or a bad architect disfigure the lake?

The architect, like almost every inhabitant of civilization, has no civilization. He lacks the security of the farmer, who possesses his civilization instead.

Adolf Loos (1898, as cited in Rossi, 1987)

In arguing on the issues of errors in the architectural project, we firstly must reflect on the concept of "error" for an architect, then we will investigate the different forms in which an error can manifest itself. Error/mistake/failure in general is understood as "deviation from good practice"; they can be caused by poor reasoning, carelessness, insufficient knowledge, but there are some differences:

_a mistake is a human action or decision that is not intended or that deviates from the outcome that is expected or good;

_an error is a deviation from accuracy or correctness;

_a failure is a lack of success in doing or achieving something.

Stating that deviation from good practice can issue in errors or mistake or failure, it is necessary to define what is a correct practice.

According to Adolf Loos' words, "the good practice" is the farmer's law: the measure of necessity and the correspondence with the ecosystem; in these two rules there is peace and harmony.

The harmony between architecture and environment emerges as a multifaceted concept through different perspectives. The context often influences design decisions, underlining the importance of integrating architecture with the surrounding environment for sustainable regeneration (Gaskin, 2020). The close connection between aesthetics and ecology in the landscape determines that aesthetic perception can contribute to ecological awareness, suggesting that architecture, that is harmonious with the environment, can foster greater emotional connection and ecological awareness (Gobster et al., 2007). A harmonious landscape helps to provide cultural ecosystem services in transferring identity, consciousness and sense of belonging to communities (Tengberg et al., 2012, Kaltenborn and Bjerke, 2002).

In this sense, good practices qualify as interventions in harmony with the ecosystem context; cultural values, senses and balance in architectural design must contribute to a single objective of authentic harmony with the surrounding because the integration of these elements can contribute to creating cohesive, sustainable and culturally significant environments.

Error allocation and consequences

> .... because among the human arts there is none that teaches us to sin; indeed, the only master is the misuse of it. But to introduce the knowledge of the errors of badly used architecture, so that someone who is a scholar of this profession can learn to avoid them, and become excellent in it; with this being that by making mistakes one learns, and by learning one acquires with perfection any skill of science and art; since the error, by careful observation, leads to the knowledge of the thing badly done, and this let us know the good and perfect work, the

nature of the opposites being such that one is known for the other. Having therefore known, for the sake of argument, how useful it was to be aware of the errors of architects, I proposed to narrow down a part of them in a short treatise: not with the intention of forming a belt against everyone, but with the desire to teach good and regulated architecture through this knowledge.

Teofilo Gallaccini (1621)

In exploring the meaning of "mistaking" in architecture, a deep analysis on different factors affecting or deriving from an error or mistake or failure must be conduct.

The errors detection can be splitted into three aspects: Where it happens, When and How.

Where - The place of error

"From the Spoon to the City" is the slogan created by Ernesto Nathan Rogers in 1952, wanting to explain the approach to the design of a spoon, a chair and a lamp, and, at the same time, to the project of a skyscraper. The slogan indicates that the method is common in designing both small objects and entire cities.

As the design can be at different scales, errors can also occur at different levels:

_Detail scale;

_Building scale;

_Environmental scale.

In referring to the scale where errors can happen, in the end we cannot assume that scale is really the extent of the error effects because a little mistake on a little component could, in fact, seriously affect a wider context (Fig. 1).

Fig. 1. Different scales of error. Source: Authors' archive

The severity of the error is independent of the scale of the object but must be measured by the extent of the impact on the ecosystem in terms of depletion of tangible and intangible resources.

The extent of the spread of an effect depends on:

_the specific use/common use (for the details);

_the role of the building in the settlement (for the building);

_the perceptibility, if perceivable/not perceptible, visible or hidden place, localized/widespread, one invasive operation or many small operations (for the environment).

Errors in the design of an object, a building or a landscape can have significant consequences that affect the functionality, safety and aesthetics of the work. Design is a complex process that involves the consideration of multiple variables, and even small errors can amplify with significant effects. First, design errors in everyday objects can compromise their functionality and durability; inadequate design can lead to products that do not meet user needs or that deteriorate rapidly over time. This not only affects the user experience but can also lead to wasted resources and negative environmental impacts. In the context of buildings, architectural errors can cause structural problems, reducing the safety of the building. Problems such as poor load planning, errors in materials or incorrect structural calculations can lead to structural failures, putting people's lives at risk and requiring expensive repairs; from an aesthetic point of view, design errors can influence the visual perception of an object or environment. A poorly designed building can negatively impact the urban landscape, influencing the image of a city and the well-being of its inhabitants.

In landscapes, design errors can compromise ecological balance and sustainability. Inadequate choice of plants, excessive use of pesticides or ignorance of the natural characteristics of the soil can lead to negative impacts on the surrounding environment, compromising biodiversity and the ecosystem.

When - The time of error

The extent of the error increases inversely proportional to the development of the phases; if it occurs in the initial phase, it can compromise the entire subsequent process (both actors and products); if it occurs in the final phase, it is easier to correct.

The governance of the process must take place through successive and scheduled checks.

The needs of safety, well-being, usability, appearance, management, integrability, environmental protection represent the list of needs of potential users who, for various reasons, will benefit from the operation; these needs must be satisfied in comparison with environmental, cultural and economic factors.

For the governance of the process (Fig. 2), it is therefore necessary to define a uniquely determined control formula for each specific project, controlling the various phases and verifying the technical and cultural compatibility with the context in which it develops.

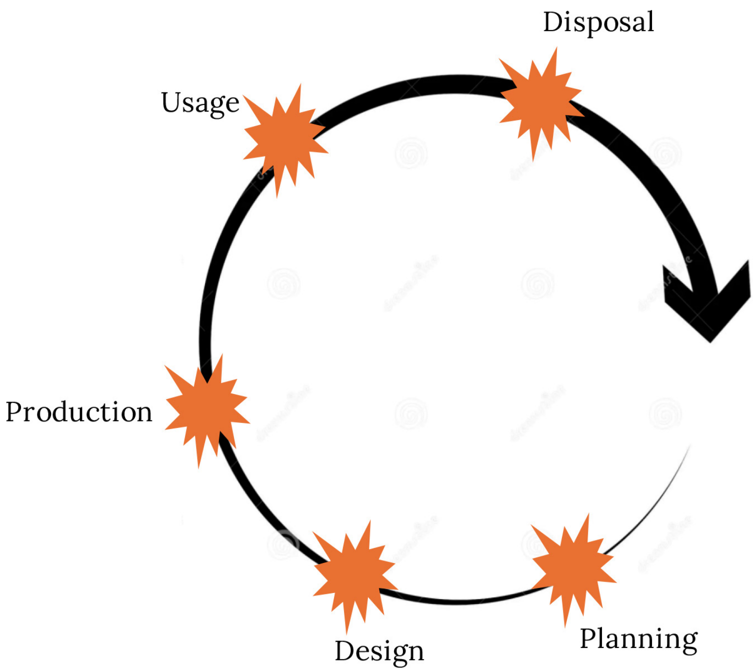

Fig. 2. The constructive process.

The **planning** is the phase necessary to achieve coordination between objectives and goals (Fig. 3).

It is the phase of the process in which the tangible and intangible resources, the implementation tools and the limits of the intervention are recognized (regulatory and physical – location of the intervention, geomorphological, climatic and environmental characteristics of the area).

Key factors at this stage are:

_technical knowledge regarding the technical means of realization;

_operator identifications;

_regulation of the assignment of works;

_quality control systems;

_definition of models of use and management of the intervention.

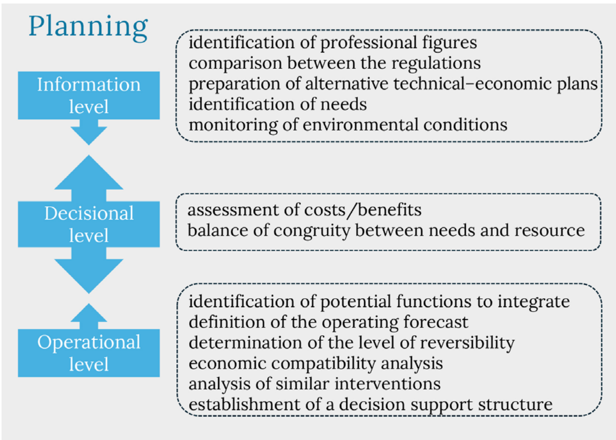

Fig. 3. The Planning phase. Source: authors

The **design** is aimed at achieving a single vision that optimizes all needs (Fig. 4).

Key factors at this stage are:

_analysis of the needs related to the specificity of the place and its socio-cultural context;

_documentary analysis of knowledge and technical solutions in use;

_summary framework of the technical experiences acquired and the specifics of the case;

_optimization of the solution through the information and experiments taken as a reference.

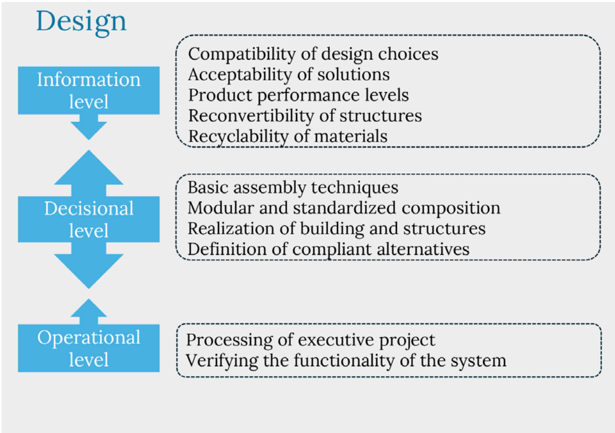

Fig. 4. The Design phase. Source: authors

The **production** phase must, therefore, include the control of the execution of the structures and equipment on the construction site but also the correct realization of the components from the industrial sector (Fig. 5).

Key factors at this stage are:

_the size of the intervention and logistics, given the location;

_the characteristics of the project;

_the specialization of the workers;

_the timing for the implementation of activities.

The **use** of the asset is the phase in which the verification of the hypothesized project performance takes place. It is necessary to foresee, right from the design phase, all those requisites aimed at guaranteeing the full usability of the structures and equipment by the users (Fig. 6).

Key factors at this phase are:

_maintaining quality over time;

_ease of maintenance operations;

_sustainability of maintenance costs in relation to the user.

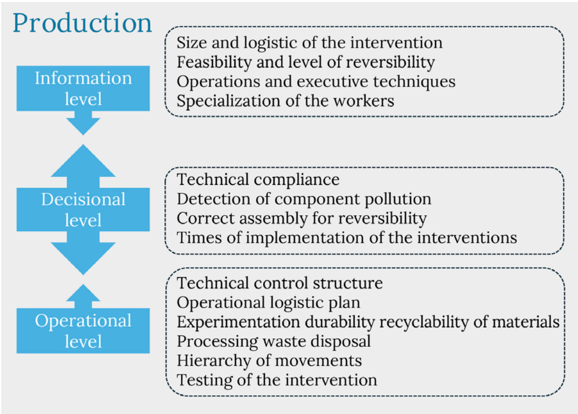

Fig. 5. The Production phase. Source: authors

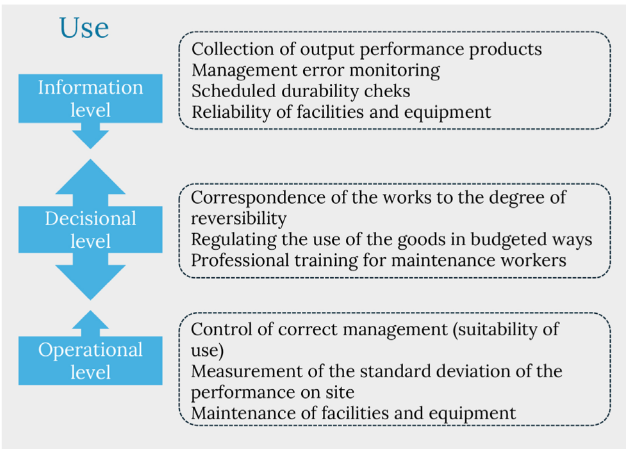

Fig. 6. The Use phase. Source: authors

During the disposal phase, problems may arise for the health of the workers, such as noise pollution and the production of both inorganic and organic dusts. Furthermore, demolition leads to the difficulty of removing the rubble as it is difficult to distinguish and separate the different materials (Fig. 7).

Key factors at this stage are:

_the logistic/dimensional analysis of the intervention area;

_the analysis and survey of the artefacts present on the site;

_the identification of the materials to be recycled;

_different levels of difficulty in disassembly;

_the economic evaluation of the intervention in relation to the revenues from the sale of the recovered materials.

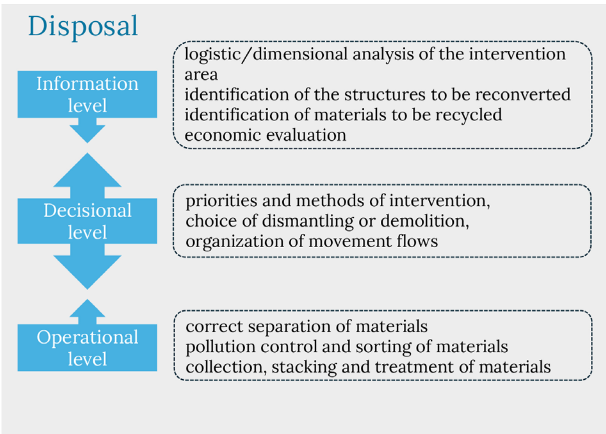

Fig. 7. The Disposal phase. Source: authors

How - The type of error

Conceptual errors in architecture are, first of all, the result of cognitive distortions; deformations in the perception and interpretation of information can derive from preconceptions, stereotypes or cognitive limitations, and can lead to conceptual errors in the creative process. The consequences of such errors can be significant, influencing the aesthetics, functionality and usability of the designed spaces (Fomenko and Danylov, 2017). Reflection on the nature of these conceptual errors contributes to understanding the relationship between the human mind and architecture, highlighting how cognitive distortions can influence the quality of architectural design.

Cognitive distortions can manifest themselves in various ways, such as inadequacy to social needs, misunderstandings of the function of space, incorrect choices of materials, accessibility problems and can be attributed to incorrect analysis of users categories, to incorrect assessment of the region's raw material resources, and of the ecosystem to which they belong.

Mainly we can categorize errors in morphological, structural and functional, considering that each of them can affect different scales of the design, such as detail, building, or environmental scale (Fig. 8).

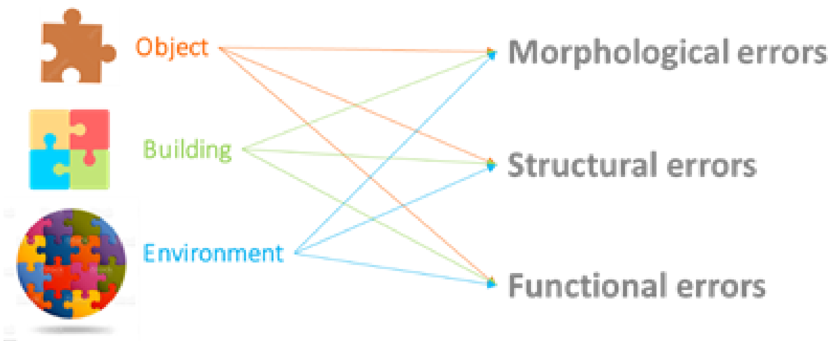

Fig. 8. Cathegories of errors. Source: authors

The seriousness of the error depends on the relationship between the provided services and the expected needs.

The logical question arises: how to minimize the gap between cognitive maps of perception of a problem and the real situation. The answer lies in the plane of the multidisciplinary research. When several cognitive maps of a problem existing in the perception of experts in different fields of knowledge are combined, it is possible to identify the objective and subjective clusters, the analysis of which will help to find the closest approach to the real assessment of the problem.

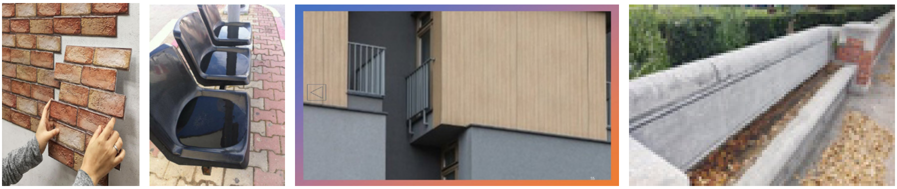

Fig. 9. Details – Morphological errors. Sources, from the left: Creative Commons License; unlocomqx/Reddit; u/Snoo_90160/Reddit; BedrockPanda/Reddit

Fig. 10. Details – Structural errors. Sources, from the left: acvdk/Reddit; Hell_Awaitz/Reddit; xFlinchyu/Reddit; TeresaKitsu/Reddit

Fig. 11. Details – Functional errors. Sources, from the left: Paarnahkrin/Reddit; PrestigiosoZombie531/Reddit; unfederica/Reddit

Fig. 12. Details – Buildings – Morphological errors. Source: Authors' archive.

Fig. 13. Buildings – Structural errors. Source: Authors' archive.

Fig. 14. Buildings – Functional errors. Source: Authors' archive.

Fig. 15. Environment - Morphological errors. Source: Authors' archive.

Fig. 16. Environment - Structural errors. Source: Authors' archive.

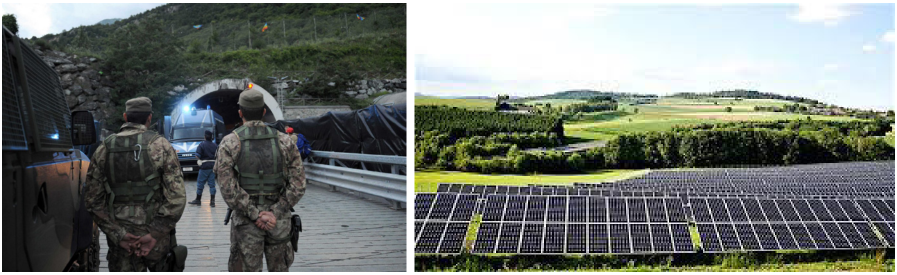

Fig. 17. Environment – Functional errors. Sources, from the left: https://www.fanpage.it/attualita/decreto-sviluppo-la-tav-torino-lione-diviene-un-opera-di-interesse-strategico/; Creative commons License

Conclusions

> a work that does not contain contradictions within itself is not "living", it is not vital because it is not "true": true things, Creation, reality, history contain contrary principles within themselves, which "coexist" in them
>
> …error is the high sign of human intellect, the emblem of its inequality: an error today may not be an error tomorrow
>
> Gio Ponti (1957)

The discussion on errors in architectural projects prompts a reflection on the concept of "error" for an architect, exploring the various forms in which errors can manifest. Errors, mistakes, and failures are deviations from good practice, caused by poor reasoning, carelessness, or insufficient knowledge. The distinction between a mistake, an error, and a failure lies in the nature of the deviation.

According to Adolf Loos, "good practice" in architecture is akin to the farmer's law, emphasizing the measure of necessity and correspondence with the ecosystem, fostering peace and harmony. Harmony between architecture and the environment is multifaceted, involving integration for sustainable regeneration, the aesthetic-ecological link, and the provision of cultural ecosystem services that convey identity and belonging.

The consequences of errors in design can manifest at different scales: detail, building, and environmental. Even a small mistake in a minor component can significantly impact a broader context. Severity is measured by the extent of impact on tangible and intangible resources within the ecosystem.

Errors can lead to compromised functionality, safety, and aesthetics in objects, buildings, or landscapes. Design errors in everyday objects can result in poor functionality and rapid deterioration. In buildings, structural problems may arise, jeopardizing safety. Aesthetically, poorly designed structures can negatively impact the urban landscape. In landscapes, design errors can compromise ecological balance and sustainability.

The timing of errors is crucial, with early-phase errors potentially compromising the entire process. Governance, through successive and scheduled checks, is essential. Planning involves recognizing tangible and intangible resources, tools, and intervention limits. Design aims at a single vision optimizing all needs, while production must include on-site and industrial component control. The use phase involves verifying hypothesized project performance, ensuring usability, quality maintenance, and ease of maintenance. Disposal presents challenges related to health, noise pollution, and material separation difficulties.

The type of error is often conceptual, stemming from cognitive distortions such as preconceptions or stereotypes. These distortions affect aesthetics, functionality, and usability. Categorizing errors as morphological, structural, or functional helps assess their impact on different design scales. Minimizing the gap between cognitive maps and the real situation requires multidisciplinary research, combining expert perspectives to approach a more accurate problem assessment. In essence, understanding, identifying, and mitigating errors in architectural projects necessitate a holistic and multidimensional approach.

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ARCHITECTURAL DESIGN: POSITIVE INTENTIONS WITH QUESTIONABLE RESULTS

Abstract: The atmosphere of a space is connected to the experience. Experiencing architecture is after all a rather subjective and personal matter. According to P. Zumthor, experiencing a place and trying to decide on its "success or failure" depends on a huge variety of factors. The purpose of this paper is twofold. First, to analyse and understand the concept and the design intentions of famous architects on some of their well-known projects, and second, to specify and highlight important design factors and study the gap between theory and practice based on the subjective parameter of experiencing a space. The applied methodology is a comparison study between relevant literature review and observations made during on-site visits to contemporary architectural masterpieces as case studies.

Keywords: atmosphere, experiencing architecture, architectural experience, success and failure in architecture

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Introduction

According to Albert Einstein, "failure is success in progress"; and additionally to that previous quote: "[...] anyone who has never made a mistake has never tried anything new". When these words apply to architectural design it is obvious that progress shall come only through innovative ideas and trials. The purpose of this paper is twofold: first, to analyse and understand the concept and the design intentions of famous architects on some of their well-known projects, and second, to specify and highlight important design factors and study the gap between theory and practice based on the subjective parameter of experiencing the space. The applied methodology is a comparison study between relevant literature review and observations made during on-site visits to contemporary architectural masterpieces.

The significant importance of experiencing a space

Architecture is the art of space and it is the art of time as well – between order and freedom, between following a path and discovering a path of our own, wandering, strolling being seduced (Zumthor, 2010). People experience the built environment in different ways depending on "their social, cultural and economic background but also on their psychology and disposition" (Vavili, 2009a, p. 17). An architectural experience cannot be perceived only through the visual sense. On the contrary, it has been emphasized by many theorists and architects (e.g. Juhani Pallasmaa, Peter Zumthor, Kengo Kuma, Yi-Fu Tuan) that it is understood through the eyes and experienced through the entire range of bodily senses and the physical movements of the body, "as one moves through it [space] and actively interacts with it" (Basyazici-Kulac and Ito-Alpturer, 2013, p. 168).

According to Peter Zumthor, the emotional connection between the space and the body is like an impulse or like a natural reaction. He implies that atmosphere is an aesthetic element or a quality a building can achieve. He states that good architecture should "move" him and the impression of a building can offer a basic insight into its atmosphere. In his words: "in the fraction of a second – have this feeling about it. We perceive atmosphere through our emotional sensibility – a form of perception that works incredibly quickly" (Zumthor, 2006, p. 13). It is also worth mentioning that, in his book *Atmospheres*, he stresses how people are capable of an immediate emotional response of appreciation or spontaneous rejection based on their understanding and experience of atmospheres.

The exact meaning of the term "atmosphere" is rather hard to be defined both verbally and in the design process. This happens because atmosphere is linked to time, it has a temporary effect and a subjective unique meaning for each and every one. In order to clarify its meaning in terms of architectural design, some of the elements that are related in the creation of atmosphere are the following (Stidsen et. al, 2010):

_Spatial relationships (size, distances, proportions, positions of objects);

_Functional relationships;

_Aesthetics;

_Sensory aspects (subjective – personal experiences).

Based on relevant literature, it is also stressed that an atmosphere of a place is connected to the parameter of "light", both natural and artificial (Stidsen et. al, 2010). Therefore, experiencing a place and trying to decide on its "success or failure" depends on a huge variety of factors. Zumthor's comment on the justification of the success of a building or a project is in its use. Architecture, after all, is made for use. The idea of things coming into their own and becoming coherent is what makes a successful atmosphere and therefore a successful experience.

Vitruvius had long ago (in the 9th century) defined the three necessary attributes of a successful architectural project. Useful, durable and beautiful (*utilitas*, *firmitas* and *venustas*), all of them co-existing simultaneously. Can actually these qualities be measured and evaluated under real circumstances on existing architectural projects and will the results mean the same for all users? Nowadays, there are numerous researches, evaluation toolkits, handbooks, design guidelines etc. that aim to ensure a better quality in architecture. Architecture, though, is a much more complex and interdisciplinary field and this is what makes it more challenging, demanding and beautiful at the same time.

Human scale and relationship with the environment

The perception of space (visually) is mainly based on our relationship with scale. The sense of scale is enhanced by bodily sense, primarily through haptic feedback. According to the theories of Alois Riegl (1858–1905) and his Aesthetic Model, there are three main scales at which space is experienced: near, middle and far range (Allais and Pop, 2020). Experiencing an architectural project under the scope of its human scale suggests a secure and friendly environment. According to Gatermann (2009), "architects today, try to make the building look less severe, to construct low buildings with few floors and to ensure a human scale. The idea is an appealing structure of masses as well as an attractive façade" (pp. 38-40). The front view of a building or complex should create a unique visual impact to the viewer.

The scale of an architectural project is closely linked with its relationship with the environment, especially, if it is located in a natural setting and it is about its relationship with the natural environment. An efficient architectural project should offer the harmonic balance between built and natural environment. In terms of modern architecture, nature can be read through fractal geometry; it can be identified and visualized by dynamic hybrid forms (Gregory, 2003). These hybrid forms are very close to nature's forms. The traditional meaning of ground (as fixed, horizontal, homogeneous, etc. meant as a platform) can be also used nowadays to describe the topo-morphic manifestos of an artificial/man-made topography of architecture.

In some cases, the architectural result is close to the natural meaning of ground. The material and physical act of shaping the earth through technology and innovation has opened up a realm of ideals (caves and caverns) burrowing into the land to discover new spatial experiences, unfolding the land through buildings that transform the earth into a tectonic landscape merged with architecture, the natural with the human; "new nature" landscapes can inform buildings to become architecture that wears its nature on the outside (Betsky, 2002). A representative example of a l*andscape building* (Jauslin, 2019) is the "City of Culture of Galicia" by P. Eisenman (1999-2011).

The famous architectural project is located it Santiago de Compostela in Spain. It is a cultural centre that consists of six buildings (organized in pairs of two based on their functional programs). Eisenman's unique concept is expressed through his pioneering architectural design process for this project. It is based on the unification of historical and cultural elements as part of memory of the context in combination with elements of the existing site. The final design of the project derives from the superposition of three sets of information (the street plan of the medieval centre of Santiago, a Cartesian grid laid over these medieval routes and the topography of the site) through computer 3D modelling software as a generated topological surface that repositions old and new data in a matrix, so that local culture and history would play an essential role as basic design parameters and therefore become a vital part of the ending result (Curtis, 2010). His focus was on the design process and he aimed to create a national symbol of Galicia history and culture (Gomez-Moriana, 2010). His design intention was to create an amorphous structure that would blend in with the landscape by rising like a wave and disappear.


Fig. 1. (left) The relationship of the City of Culture of Galicia with the natural surrounding environment. (right) The absence of human scale in the circulation paths of the project. © A. Gkoutzouri (2018).

_On-site visit comments: The relationship of the project with the surrounding natural environment could be characterized as invasive. Although it has curvy slopes that imitate earth-like hilltops, its massive volume and the applied stone cladding on it give an intrusive and hostile - to the surrounding environment - first impression, rather than homogeneously blending in with it (Fig. 1). At a closer look, the complex of the buildings as a whole is striking; this is mainly because of its vast analogies and enormous size; but the human scale of the project was absent. The high rise of the buildings (e.g. the Performing Arts building is 42.5 meters high) in combination with the narrow width of the paths (in between voids) give a feeling of intimidation when walking through them.

Adjusting to local climate and orientation

Since the beginning of time and the primitive man-made constructions, climate conditions have been a significant factor for adapting architecture to it. Local climate, orientation and wind direction are determinant parameters for the architectural synthesis (Vavili & Dova, 2009). Especially now, attention to local climate condition is more relevant and needed than ever before because the consequences of climate change are starting to be more obvious.

The recent term “climate responsive architecture” describes an architectural approach that focuses on designing energy-efficient buildings uniquely suited to the climate in which they are constructed (Biro, 2023). Climate responsive designs are based on local weather conditions by taking into account seasonality, natural shading, humidity, and annual rainfall. This approach recognizes that the local climatic and geographic characteristics of a region must be considered when designing efficient and resilient structures (Biro, 2023). Climate responsive architectural projects work with the local climate to provide comfort to users with the least possible amount of energy expenses. This design approach is also crucial in urban planning because of the increasing frequency of severe weather events linked to climate change.

Given the long lifetime and high cost of the built environment, it is imperative to plan for and create communities and public spaces that are robust in the face of climate change. New developments must be designed to cope with future rather than historical climates (Shaw et al., 2007). Also, small scale interventions in existing public spaces (e.g. urban squares) that are strategically located within the urban fabric can drive change on the large scale by transforming the urban context and strengthening the city’s resilience to climate change impacts (Sitzoglou, 2022). In total, urban public spaces are of great importance to the city and can play an essential role in challenging demands for climate change adaption.

A relatively recent project of great meaning and deep symbolism is the re-design of “Eleftheria square” in Nicosia (Cyprus) by Zaha Hadid (2005-2021). The project’s main objective was the transformation of an unused public area in the centre of Nicosia city, which had been negatively marked by the painful and cruel history of the island (the city is still split in half since the Turkish invasion of 1974). Hadid’s architectural concept in this project centres on the meaning of “unification” on multiple levels both metaphorically and literally. The main objectives of the redesign were to weave together Nicosia’s rich history with an unwavering optimism for the future, transform the urban square into an important gateway to the old city, to bridge the Venetian Wall and the dried moat of the area, and to enable city streets for further pedestrianization in order to enhance the urban realm of this historic district (Fig. 2). New public gardens and plazas were introduced to be enjoyed by residents and visitors, connecting the upper level of the city and the lower level of the moat, etc.

 

Fig. 2. Elefhteria Square in Nicosia: the local climate conditions (humidity, sun and 42°C, at 12:30 p.m. in July 2023), in combination with the choices of the materials and the total absence of shade made it impossible and unbearable to walk through the urban plaza. The absence of human presence in the photos is a confirmation of the questionable results of the project. © A. Kyrkou (2023).

_On-site visit comments: The fluidity of the design and the aesthetics of Zaha's characteristic design vocabulary have created an urban public space of exceptional beauty. Unfortunately, though the local climate conditions (humidity, sun, high temperature and lack of wind) in combination with the material choices that absorbed and emitted all the heat, made the visit of the square and walking through it almost impossible. The absence of human presence (Fig. 2) until the sunset, especially during summer time, stresses the need for small scale interventions in order to adapt to the local climate.

The Holistic approaches of "health" and the design of healing environment

"Health" is defined by WHO as the state of complete physical, mental and social well-being, not merely the absence of disease or infirmity. Under this more positive and broader definition of health, in the last decades, a more holistic approach of health and well-being gained ground. As it is obvious, even from its definition, the emphasis is on the presence of well-being rather than the absence of illness (Steemers, 2021). The relationship between architecture and health has historically received little attention, beyond the design requirements of healthy buildings. Recent work changed this and established a more holistic awareness of the role of architecture in health (Steemers, 2021). From the same perspective, the term "hospital" gained a more positive connotation in recent decades; according to relevant literature, “a hospital it is not a place for sickness and sick people but rather a place for health and recreation” (Vavili, 2019, p. 27). Architecture and the built environment are now closely linked to these perspectives and ideas. Terms such as: healthy buildings, healthy cities, healthy public spaces, etc. are design goals for a healthier and more sustainable future.

It was in the 1980s when the environmental psychologist R. Ulrich developed the theory of psychologically supportive design and studied the link between the built environment and the psychology of the users (especially in hospital settings). The term “healing environment” was defined by Ulrich (1984) at one of his comparative studies in which he highlighted the importance of the natural views from a patient’s bed and the value of the hospital environment with the presence of natural elements (in particular it was about window with a view of a tree). Specifically, for children, the inclusion of natural elements is very crucial as they positively affect their psychology during the hospitalization and offer a feeling of security (Ulrich, 1984). This serves as a bond to the external world for a child’s psychology, reminding them of life before their hospital admission.

It is not only the inclusion of natural elements in the design of healthcare facilities that can introduce a healing environment; their design is actually more complicated compared to adult hospitals, due to the children’s unique needs and their fragile psychological balance. Ideally, a children’s hospital should “[...] give a sense of discovery and detail, it should stimulate the senses, it should encourage movement, it should have the elements of whimsy, humor and variety” (Cleper-Borkovi, 2009, p. 54). In architectural terms, modern healthcare facilities for children use the basic elements of design (such as exterior design, façades, natural environment, scale, colors, materials, light and shadows, movement and orientation) in an innovative and creative way along with the newest technological findings (Vavili, 2009b). Regarding the healthcare environment architecture, design, art, technology and ecology combined all together can create the exceptional circumstances for a child’s healing process and promote his well-being (Paraskeva, 2009).

Briefly, some basic characteristics of the healing environment are described by a design that:

_Offers contact/unification with the exterior environment (large openings for views or gardens, small parks, healing gardens, etc.);

_Inspires security and tranquility;

_Stimulates children’s interests;

_Includes elements that are used as positive distractions (e.g. nature, technology, art, etc.);

_Offers pleasant/interesting views (e.g. especially views of nature).

Many modern examples of healthcare facilities follow successfully some of these design guidelines. According to relevant literature, the front view of a building or complex should create a unique visual impact to the viewer; after all it is the first impression. The exterior (façade and volume) of a children's healthcare facility is of great importance as what children experience at the front door of a hospital will color the impression of their entire stay (Mead, 2005). An example that is worth mentioning at this point is the Basel University Children's hospital in Switzerland, by Stump and Schibli ArhciteKten (2013). The innovative façade of the children's hospital aims to function as a positive distraction for children who approach or pass by the hospital building. Due to the multiple layers of a special film, the façade of the children's hospital changes colours depending on the natural light angle and the point of view (Fig. 3). This subjective interaction creates a unique experience and it is considered to be a positive distraction for children.

Fig. 3. The changing colour façade at University Children's Hospital in Basel works as a positive distraction for children, turning the hospital building into a familiar city landmark building, but at the same time it works as a negative distraction for the drivers. © A. Kyrkou (2014).

_On-site visit comments: Indeed this unique facade works as an interactive element for anyone who approaches the hospital building. Depending on the amount, the angle of the natural light and the point of

> view the changing colors turn the building into an interactive landmark for the city. Unfortunately, this interaction is also valid for the drivers who pass by. From the on-site visit and interviews it was noted that this interactive façade works as a distraction for the drivers in a negative way as their attention is also captured by the façade.

There are many examples of healthcare facilities that use art in all of its forms (fine arts, music, theatre, etc.), in order to encourage the psychology of patients and positively affect the healing process. Many studies and opinion surveys have proved that visual and performing arts contribute to changes of mood and easing of stress levels (Vavili, 2009a). The choice of the artworks, their adequacy and their installation should be a part of the designing process. The appropriate configuration of spaces with artworks would give a better result. Another exceptional example of modern children hospital where there is much attention given in the creation of healing environment is the Great Ormond Street Hospital (GOSH), in London. In this case study, the inclusion of arts within the hospital environment plays a vital role. All the artwork is very carefully chosen, as there is an arts program in the hospital (since 2006), in order to create a welcoming environment and offer opportunities to commit for communities in and around the hospital.

A very special artwork at GOSH is an interactive wall art installation by Jeff Bruges' studio entitled "Nature Trail" (2013). According to the artist, the main aim of this artwork is

> [...] to improve the quality of the experience for patients on their way to the operating theatre, by creating a calming yet engaging route on the way to the anaesthetic room. Along the journey to theatre we have installed a nature trail with forest-like wallpaper, which houses a range of woodland creatures. Motion sensors and digital panels located behind the wallpaper will reveal creatures including deer, hedgehogs and birds who accompany them on their journey along the theatres corridor and into the anaesthetic room. This installation provides a calming distraction along the route to theatre. (Nature Trail, n.d.)

The concept of the work was based on viewing the hospital walls as a natural canvas for a digital forest, with scenes depicting various "forest creatures" (Fig. 4). It has essentially two main elements: integrated LED panels and graphic wallpaper. The LED panels (72000 LEDs) are embedded into the wall surface at various heights in order to be accessible to the eye levels and positions of patients moving along the corridors.

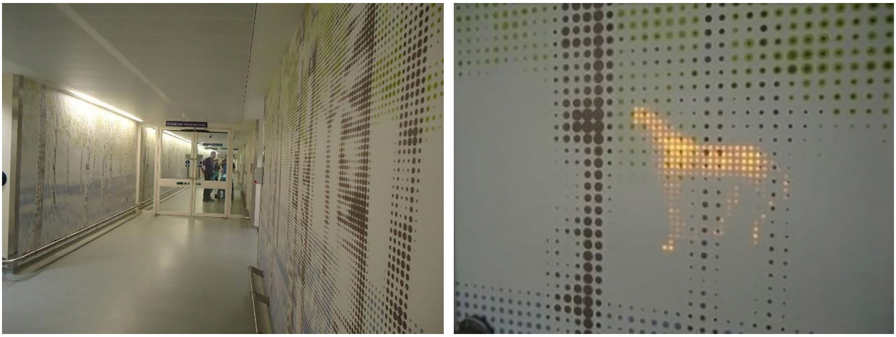

Fig. 4. Interactive Wall, Art installation at Great Ormond Street Hospital, by Jason Bruges studio (2013). Choice of the wrong location for the art installation cancels all the positive intentions of the artist. © A. Kyrkou (2015).

_On-site visit comments: It was noted that the relatively narrow width of corridor is not enough for the viewer to follow the movement of the light shaped animals. Doctors and nurses through their interviews highlighted that there is no actual interaction between the young patients and the walls as they were always on carriers or in wheelchairs and at most times all the patients were almost sedated. Apart from that, the maintenance of the installation is too expensive and needed too often mainly because of its lack of durability facing the use of the space (patient carriers often hit the walls). Although the artist's intention is excellent in many ways, the choice of the location for the installation is definitely wrong.

Beauty in architecture

P. Zumthor (2010), in his book *Thinking Architecture*, states that beauty is at its most intense when it is born out of absence. After experiencing beauty in architecture, it is then possible to long for it and miss it. There are many examples in the built environment that can trigger these feelings when experienced. Regardless of their main purpose and the architect's original design intention, beauty within a space is the proof that architecture can become pure poetry (Fig. 5). Martin Walser stresses about beauty that the more we miss something, the more beautiful that which we have to mobilize in order to endure absence may become (as cited in Zumthor, 2010). Sometimes, a single ray of natural light in to a dark space, a clear shape or a harmonious form in all of its simplicity can become the centre of attention.

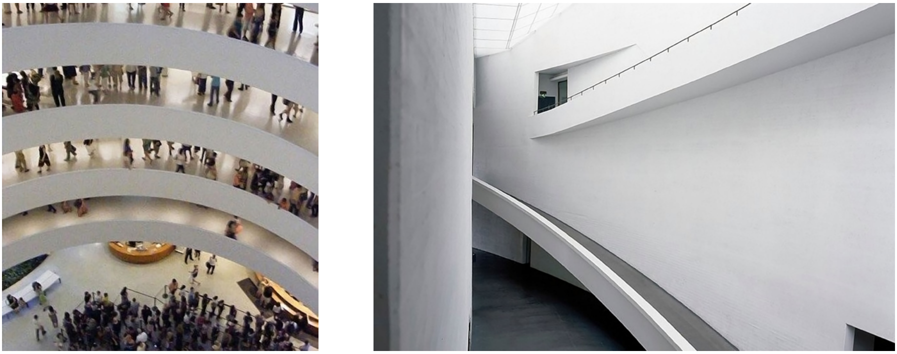

Fig. 5. Is there such a thing as “too much” beauty within a space? The Guggenheim (left) and the Kiasma museum (right). © A. Kyrkou (2008, 2019).

_On-site visit comments: Both Solomon R. Guggenheim museum by Frank Lloyd Wright in New York and Kiasma museum by Steven Holl in Helsinki are two incomparable examples in which the beauty of a space - and therefore the beauty of architecture - becomes superior to their original purpose. Experiencing the harmonious forms, the coherence of the space, the continuity of the layout, and the walkthrough visit procedure - in a way - diminished the importance of the exhibits, in total, though it is the uniqueness and the value of this exact experience.

Conclusions

As theory differs from practice, original design intentions to ending results sometimes have gaps between them. Architecture is a combination of numerous factors and its beauty and success are justified through time. A single idea, an innovative concept or a design gesture can define and change so much in the built environment and therefore in people’s behaviour. Architecture has proven that it shapes the future and that is, after all, its greatest power.

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WORKING WITH CONSTRAINTS

Abstract: Constraints are usually understood as restrictions (imposed by laws, regulations, or even by the site itself – by its conformation, by its surroundings). Sometimes they are the limits imposed or demanded by stakeholders (from a minimum height, to a maximum budget, etc.). In any case, giving constraints a positive connotation and treating them as assets can lead to designing an innovative, representative and remarkable architecture, with a high impact at various scales.

Keywords: constraints, assets, laws and regulations, innovation

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Introduction

Any discipline works within its own constraints. Architecture, through its implications in practice, deals with an array of constraints ranging from normative, to economic, technological as well as, in certain situations, socio-cultural. Some are imposed – like those required by law and regulations; others are a result of certain conditions – like those dictated by where and how the site is located, by context or by the technological limitations; and others are requested by beneficiaries, investors, or stakeholders given their economic capabilities, demands and needs that led to commissioning the design of the building.

This chapter is an investigation of these constraints and of ways to avoid errors in design determined by a rigid way of thinking that see constrains not as limitations that can be creatively interpreted, but as unchallengeable impositions, with deeply negative connotations. In an actual situation, various types of constraints combine and that challenges the architect to navigate through them and to respond to all of them while still delivering a good design. Anyway, while some cannot be avoided, others, even some of those imposed, can be negotiated with authorities, stakeholders or other deciding parties. Such a negotiation requires arguments and demonstrations that the proposed situation will have a high positive impact upon the area or even the city, upon the community, or for the investment. However, determining the relation between the changes advocated for and the implications of convening certain deciding parties is very important, as often costs and time delays must be seriously taken into consideration.

The majority of constrains should be known from the beginning and already solved in the conceptual phase of a project. Otherwise, major issues could make the design impossible to authorize and/or build. The project should be developed knowing the actual possibilities of development and implementation, but no matter how strict the constraints are they must not be regarded as an impossibility to be creative. Plowright (2014) even considers constraints as assets when they are treated as beneficial forces that inform the design. The most creative designs transform constraints into features, using them to underline particularities of the site: they overturn them into elements that confer the building its special character, by not only overcoming the difficulties, but by also correctly solving issues in a creative and innovative manner.

In the following sections we shall go through the three main types of constraints we identified: (1) imposed by laws and regulations, (2) dictated by site and program, and (3) constraints framed by the requirements of the commissioning parties. We shall discuss their particularities, but also their degrees of freedom and possibility of being negotiated. In parallel, we will analyse examples of creative and innovative solutions, advocating for the architect's responsibility of designing buildings that, despite the various constraints that must be regarded, "do" more than their primary function – buildings that become icons for the community they are part of, buildings that have a positive impact and even change the quality of life for its users, buildings that are healthy, sustainable, inclusive, etc. (Sfintes, 2022).

Constraints imposed by laws and regulations

Laws and regulations are the most restrictive constraints. They keep their mandatory character due to their role. Laws ensure justice for all the members of a country or community through rules that follow sets of values recognized at a local, national, supranational (as in the case of laws imposed by EU) or international level. Regulations, in the case of architecture, impose minimal standards to be respected in order to assure the conformation to the accepted parameters of building and of building behaviour, in the end protecting both the direct and indirect users in various circumstances influenced by design, construction and design in use. They are not negotiable, but on the other hand they are, or should be, constantly updated to keep up with the changing society, state of development, technological advancements, etc. Changing situations open regulations up for debate and amendments, but the changes made to laws and regulations should be valid at the full scale of their extent. We give two opposite examples regarding the update of regulations. In Romania, regulations are not updated regularly. The oldest norm in place is from 1982 and it is a regulation regarding the provision of elevators in residential, socio-cultural, tourism and administrative buildings (P92-1982 *Normativ privind dotarea cu ascensoare a clădirilor de locuit, social-culturale, de turism și administrative*, 1983). Even when norms are updated, many stipulations can be contested, all the more so as there are around 90 active regulations in architecture. What is worse is that they are not correlated, this leading to confusing situations of not knowing what to respect or when – as, for example, in the case of the regulation regarding the design, construction and operation of constructions for kindergartens (*NP 011-2022 Normativ privind proiectarea, realizarea și exploatarea construcțiilor pentru grădinițe de copii*, 2022) and regulation concerning the specific performance criteria of ramps and stairs for pedestrian circulation in buildings (NP 063-2002 *normativ privind criteriile de performanță specifice* *rampelor și scărilor pentru circulația pietonală în construcții*, 2002). NP063-2002 stipulates minimum heights of interior stairs handrails of 0,90m for levels at more than 4m above ground (Art. 2.2.1.6.a). NP 011-2022 requires a handrail of minimum 1,25m in case of free standing stairs (Art. 4.2.1.2(35)). In USA, there is a much smaller number of regulatory documents: for example, there is an International Building Code, an International Existing Building Code, an International Fire Code (International Code Council, n.d.) and each is updated every 3 years. Thus, it is easier for the designers to access the latest norms in place and to make sure that they refer to all the norms that apply in a certain situation.

In any case, even if in the case of Romania it can be more difficult, laws and regulations do change and their update requires research as well as a deep understanding of current situations, problems, and possibilities. Their change requires adaptation to current realities, but also preventive and anticipative thinking. In this case, the architects should engage in the research and development of the new stipulations, to be active and participate to debates, feeling responsible to represent the interests of the profession, but also of the potential users of their architecture.

Constraints dictated by site and program

Site and program are the main elements the architects operate with. Designs are most of the time site-specific and that entails a deep reading and understanding of the context. Architects can relate differently to various specificities considered relevant or important in the particular context of the commissioning, but also as a specific way of approaching architecture. Architects' biases influence the approach, underlining creativity as an individual trait. They have the freedom and tools to interpret and negotiate these specificities through design – relating architecture and its components for example to topography, climate, cardinal directions, etc. However, other specificities impose limitations and here we speak of regulations that apply particularly to the site – the urbanistic regulations, or dictated by the program – design norms.

The former can sometimes be contested and changed (in Romania maybe easier than in other parts of the world), usually with extra costs indeed, for example: the edification limits, the building height, the building coverage ratio and floor area ratio. On the other hand, such constraints can lead to most interesting, creative and innovative designs just by transforming constraints into traits. They pave the way towards a building that has architectural identity, proving as an excuse the assertion that rules and regulations are too restrictive.

Plowright (2014) gives as a good example in this case Mineral House by Yasuhiro Yamashita and Yoichi Tanaka/Atelier Tekuto where the architects interpreted the slant plane restrictions into particular relationships with the surroundings (Fig. 1). They overturned a restrictive situation through architecture understood in its poetics dictated by natural light: "Thinking about light as an asset allows the designer to consider it in more sensitive ways, instead of simply allowing the physical nature of sunlight regulations or shadow considerations to shape exterior massing." (Plowright, 2014, p. 192). Plowright mentions architecture studios like OMA, Foreign Office Architects, MVRDV, BIG, etc. as studios deeply involved into research and analysis of constraints and of ways they can be transformed into assets: "The content generated is then explored and resolved in order to produce radical but rational innovation in their design work" (Plowright, 2014, p. 43).

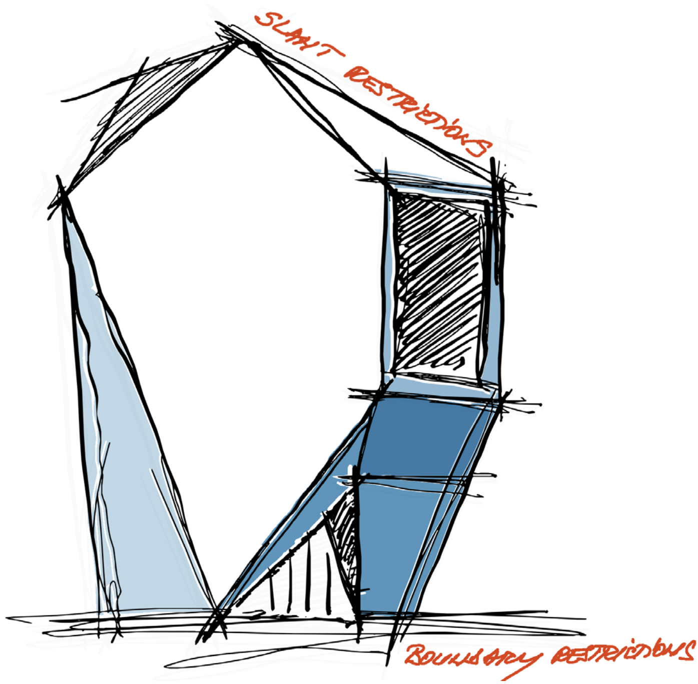

Fig. 1. The Mineral House by Yasuhiro Yamashita and Yoichi Tanaka/Atelier Tekuto.
Sketch by Anda Sfinteș

Another challenging example is Vancouver House, a tower developed by BIG in Vancouver, Canada (Fig. 2). The project could have been abandoned almost from the beginning, following the site regulations that demanded a 30m setback from the bridge and other stipulations that left, on the ground, "a small triangular site nearly too small to build on" (*Vancouver House*, n.d.). The sculptural shape of the tower proposed in the end is, in fact, the result of ingeniously understanding these regulations – that the 30m setback from the bridge apply just until the building reaches 30m up in the air. So, "the surreal gesture is in fact a highly responsive architecture – shaped by its environment" (*Vancouver House*, n.d.).

Fig. 2. Vancouver House by BIG. Sketch by Anda Sfinteș

We would like to end this topic by highlighting the fact that, although regulations aim to protect the interests of the city and its inhabitants, sometimes they stop developments that would bring great value to both. We give as an example a project that asked students in the 2nd year of study at the Faculty of Architecture, "Ion Mincu" University of Architecture and Urban Planning in Bucharest, Romania to propose a row house on a 6,5m wide and 30m long site, considered unbuildable in Romanian legislation due to its narrowness. The exercise led to highly different and creative solutions that, at the city level, filled in a void while, for the potential inhabitants, offered less common scenarios of use (for example by interpreted ways of access to rooms that no longer could be put in usual relationships to each other, or by transforming the courtyard into a "room"). Yes, such houses are not suitable for anyone, as they imply assuming a certain way of living. Still, when they are particularly designed for certain persons, considering their needs, dreams, and characters, they can become part of their common identity. In such cases, the entire concept builds upon the constraint itself and even gains meaning.

Requested constraints

The requests made by commissioning parties can be considered constraints when they are hard to implement, especially if they are against laws, regulations, or norms. Of course, the architects must inform parties about such conflicts and discuss the real possibilities of building. As stated above, some issues can be interpreted, negotiated, and surpassed through creative and innovative thinking, or even by amending the regulations and norms. The entire design team (including collaborators) is, however, responsible of appreciating what such modifications could imply, as well as of being capable of demonstrating that the changes have a positive impact. This can sometimes be a huge challenge, as the team might find itself to be torn between the responsibilities towards the commissioning parties and the responsibilities of the profession, on top of ethical considerations.

Anyway, the most common requested constraints are rather those related to costs and time. They might not be so problematic, but rather undesired by architects that would like to have a free hand in proposing great designs, as they see them. Such constraints become problematic the bigger the unbalance between needs, effort, design challenges and needed money and time, not to mention the possibility of situational issues occurring, leading to liability claims (Burgoyne, 2019).

However, we would like to direct the discussion towards a crucial problem when it comes to working with constraints. We consider that the biggest challenges are those of helping people who do not have the possibilities of meeting their basic needs of shelter. Sometimes the state has in place policies of building for scarcity and accommodating the needs of vulnerable persons. Sometimes such needs are addressed by NGOs, or even by physical persons. In such cases, costs and rapidity of construction are the main constraints. Thus, it is hard to propose buildings that possess qualities assumed by good architecture (both functional and, even more so, aesthetic). However, numerous contests dedicated to this subject, as well as numerous interventions prove the concern of addressing and solving these issues. In the same time, well recognized examples like buildings developed by Alejandro Aravena (Elemental) or Francis Kéré (Kéré Architecture) are proofs that good designs can come alive even from scarcity. We must, however, highlight that in these case the design is also related to the need felt by the architects to lead, through architecture, to social and cultural change. The extreme challenges in this context remain the designs that approach conflict areas and crisis situation, speaking of the responsibility "to engage the socio-political and economic domains that have remained peripheral to the specialisations of art and architecture, questioning our profession's powerlessness in the context of the world's most pressing current crises", as Teddy Cruz (2016, p. 205) states.

Following this thought, but in more common situations, we consider that when it comes to constraints imposed by stakeholders, the challenge for the architects rather resides not only in respecting those limitations, but in working within them and trying to give more back. We speak of the architects' responsibility towards society at large, no matter the project, of the need to attain sustainability and the need of being socially responsible (Sfintes, 2023). More than that, James Soane (2019) says (in what can be seen also as a critique addressed towards architects that dream of doing starchitecture) that "The new story of our profession needs to be one that builds a better habitat for everyone, enhancing community engagement over the singularity of the architect's vision and bringing with it economic, political and environmental evolution." (p. 219).

Conclusions

In fact, almost anything can become a constraint if it is regarded as such – as an unavoidable condition that imposes restrictions which cannot be ignored.

In this paper we advocated for treating constraints rather as challenges for finding creative and innovative solutions. When regarded as particularities (with a positive connotation), the solutions found to constraints become statements of identity. Such solutions are proof that approaching constraints with courage and determination can not only solve a problem, but become a way of giving back something more – to the city, to the community or at least to the users of the building. Such projects are inspiring and transformative, triggering various developments as the solutions can sometimes require progress and advancement in various sectors, not only in design, but also in construction: new techniques or technologies can be developed. Constraints are also a matter of capability. For example, due to limited competencies of architecture firms that try to design details beyond their capabilities, collaboration with other firms is required like in the case of Soumaya Museum in Mexico City designed by FR-EE Fernando Romero Enterprise; the complicated façade was supposed to be designed by Gehry Technologies, but it proved to be more challenging than anticipated and ended up being solved by Geometrica (Zwicker, n.d.). Anyway, in the context of discussing constrains, we should also note that companies like Gehry Technologies were set up in the first place with the purpose of overcoming technological issues and being able to carry out innovative designs. This is just an example, trying to prove the point.

The chapter itself wishes to be an encouragement addressed to many that feel threatened and stuck when facing apparently adamant restrictions or demands. Some see site, regulation and budgetary constraints as limits and they don't even try to challenge them ...and yes, it's not always the case. Yet, other times, challenging them can make a big difference.

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NATURAL STONE FOR ARCHITECTS AND BUILDERS. ROMANIAN ORNAMENTAL AND HERITAGE STONES

Abstract: The purpose of this paper is to offer the minimal information necessary for future architects, builders and people working in monuments restoration, regarding the types of rocks that can be used for buildings and monuments, their main characteristics and some details about the influence of the weathering processes on the stone elements put in the work. Also, for the same target group, information was provided about the ornamental stones from Romania that are known and/or are available for sale, as well a selection and presentation of Romanian stones with national and global heritage value.

Keywords: stone, ornamental, durability, architecture, heritage stone

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Introduction

The purpose of this paper is to offer the minimal information necessary for future architects, builders and people working in monuments restoration, regarding the types of rocks that can be used for buildings and monuments, their main characteristics and some details about the influence of the weathering processes on the stone elements put in the work. Also, for the same target group, information was provided about the ornamental stones from Romania that are known and/or are available for sale, as well a selection and presentation of Romanian stones with national and global heritage value.

Besides the general geological data about various type of stones, the main properties that provide the durability of the stone used architecturally were listed: mineralogical composition, porosity, resistance to compression, flexion or abrasion. The links between these properties and the way in which natural stone undergoes physical degradation and/or chemical alteration were also presented, as well as recommendations of indoor or outdoor application of different types of stones, for façade, roofing or paving.

The limitations in this paper are given only by the amount of information presented, which took into account the usual curriculum of the students or the basic knowledge of the people who work with stone. The information was selected from the long experience in this area and from previous projects of the authors, most of the examples and images being presented here with novelty character. Among these are: the location of the 67 Romanian ornamental stone deposits, of which 29 in operation, data regarding their colour, the owner of the exploitation, and recommendations of application for some Romanian ornamental stones, depending on the type of stone elements and place of application.

Natural stone for architects and builders - classifications and properties

Rocks represent solid fragments from the crust of the earth, with composition and properties depending on their origin and specifically transforming stages during geological time. When used for building purposes, the rocks are commonly referred to as *natural stones* (to distinguish them from the artificial ones). The large majority of natural stones used in construction are non-homogeneous materials, presenting slight to strong variations in terms of their mineralogical and chemical composition. They also present specific physical and mechanical properties, including color, fabric, natural porosity and water absorption, density, compressive and flexural strength, hardness, etc.

Natural stones can be described either by their geological origin (including post-depositional processes) or by their mineralogical content. The main groups from each category are presented in Table 1 and detailed further.

Igneous (magmatic and volcanic) stones

Granite, granodiorite, rhyolite, dacite, diabase, porphyry, andesite, basalt are the main types of stones from this category. They are, in general, very resistant to chemical and physical weathering, thus being appropriate for use in every type of climate. They present good mechanical resistance (compression, flexion), and most of the varieties can also be used not only for ornamental flooring, paving and cladding, but also as load bearing elements in building structures. However, there are some igneous rocks with lower resistances, usually containing a lot of mica or feldspar, that are weathered in clayey minerals or iron hydroxides.

Sedimentary stones

This stone group includes very different types, with different properties and behavior. The most important ones for architectural purposes are briefly described below.

Compact limestones can be used for any kind of building application (except roofing), but depending very much on the climate. They are normally not recommended in Romania for applications in contact with or close to the ground, as load bearing elements or exposed to intense rainfalls or to insolation effect.

Table 1. Classification of natural stone depending of different criteria

Classification criteria	**Categories**	**Type of stones general used for architecture purposes**	**Details**
according to the geological origin	**Sedimentary rocks**	sandstone, limestone, travertine, shale, conglomerate, breccia	Rocks formed by deposition, aerial or submarine, after disintegration of pre-existing rocks under weathering processes or different geological events.
	Igneous rocks	granite, granodiorite, rhyolite, dacite, diabase, porphyry, andesite, basalt	Rocks consolidated from magma, under crust of earth (plutonic rocks) or at the surface of earth (volcanic rocks).
	Metamorphic rocks	marble, gneiss, slate	Rocks resulted by the alteration of pre-existing rocks, in response to changing environmental conditions, such as variations in temperature, pressure, and mechanical stress.
according to the mineralogical content	**Silicate stones**	**Hard silicate stones** granite, gneiss, diabase, syenite, quartzite, schist; silicate-sandstone	Consists of silicate minerals containing a SiO_2 part. Stone types consisting of hard silicate minerals as quartz, feldspar, pyroxene and mica.
		Soft silicate stones	Stone types containing soft clay minerals.
	Carbonaceous stones	marble, limestone, travertine, aragonite	The main components are minerals containing CO_3 which is sensitive to reaction with acid substances. Common minerals are calcite, dolomite and in certain cases Serpentine.

Porous limestones (and sandy limestone) have a low abrasion resistance and, in general, are not recommended for use in outdoor or indoor floor applications. Although they show no high values for flexural and compressive strength tests, they can be used as massive building elements. However, in a humid environment, most of the limestones weather strongly and have to be replaced soon.

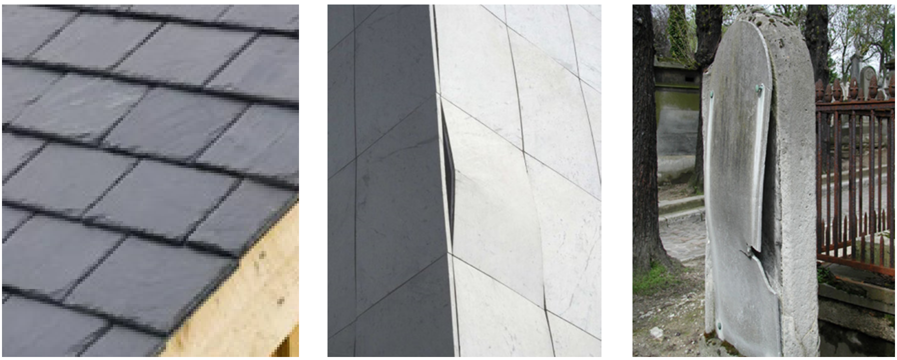
Sandstone with silica bound is better indicated to be used for outdoor application (except roofing), instead of sandstone with carbonate bound. When the sandstone is quite porous, it is best to use it for indoor applications only, if the climate is humid or many thermal cycles are counted.

Chert is a very hard and compact stone. It will give no problems in any kind of climate, but the workability is problematical for this type of sedimentary rock. It is not often used as cladding or floor tiles because it is too hard and energy consuming for an easy polishing.

Metamorphic stones

Many metamorphic stones have a low porosity and good bonding between the crystals and, thus, are suitable for external use in every type of climate. *Slate* and *schist* as building materials are especially known for their roofing application (Fig. 1a). However, some types of *marble* can show bowing (Fig. 1b, c) and severe strength loss when used in a humid climate.

Some details regarding the types of stones and their important properties and behavior are given below.



a) b) c)

Fig. 1. Examples of applications of metamorphic rocks used as stone elements: a) slate roof; b), c) bowing process of large marble panels in humid climate or having unfit anchorage system. Source: (TEAM, 2005)

Granite (and granitic type rocks) present small, medium or high crystallinity and has a big variation of visual appearance, referring to the color, size of minerals, and compactness. They contain feldspar, quartz and ferromagnesian minerals. With or without being polished on the surface, the stones from this category are very resistant and could present a good behavior under climatic variations (especially the granites with small granulation) and for flooring in public area with intense traffic (Fig. 2a).

Marble and limestone are carbonate stones with metamorphic (marble) or sedimentary origin. Marble is a recrystallized limestone; it usually lacks layers (bedding plane), while limestone has more or less developed layers (sometimes containing other minerals with a higher porosity than the rest of the stone), which often make up a weakness zone. In international natural stone contexts, often no difference is made between limestone and marble. Well polishable limestone is sometimes called marble, for commercial purposes, but the difference lies in their crystal structure and composition. From a constructive point of view, with a polished surface finish they are not hard enough to keep the shine when subjected to wear in public environments (Fig. 2b, 2c). As a walking passage (e.g stairs, commercial traffic area), a dull surface can easily form after a while. A polished surface in a public environment often needs regular finish with polish or crystallization if it is to remain shiny. On the other hand, some types of marbles used like finishing outdoor elements in the regions with many freeze-thaw cycles could suffer modification of intracrystalline strength (reflected in the rapid decrease of the dynamic modulus of elasticity, demonstrated by many laboratory tests, even if the visual appearance doesn't suffer significant changes). The limestone presents an irregular variation during climatic ageing, fdepending on its genesis: different porosity, large palette of color (what induce a different absorption degree of daylight or sunlight), massive until breccious structure, sometimes with recrystallizations, with or without fossils, etc.

a) b) c) d)

Fig. 2. Examples of application for different stone types: a) stairs from Măcin polished granite; b), c) improper exterior old application of Rușchița marble at Ministry of Eonomy building from Bucharest; d) Borsec travertine, Rușchița marble and Măcin granite used for stairs and vertical cladding at Gara de Nord underground station in Bucharest.

Travertine has a good behavior under different climatic variations, but the petrographic types of stone with a large number of vacuoles looses quickly their resistance due to the periodical infiltration of water and the effect of an intense traffic (Fig. 2d).

Sandstone is a sedimentary rock normally containing quartz and feldspars held together either by siliceous or carbonaceous natural cement (Hallsworth, 1999). The sandstone gets dirty quickly and is difficult to clean, but due to its large availability it can be seen being used in various circumstances, from wall elements to facade material, in particular in areas and countries with a long tradition of use and where it is the only locally available material (as Romanian Eastern Carpathian area). Sandstone usually presents high water absorption, in comparison with other stone groups, and, for this reason, its use is limited in building and construction works. Due to the normally high contents of quartz as grains, sandstone is often hard. However, the hardness of the stone is very much dependent on the binding agent: silicate, carbonate, clay or iron. The last two are present in old buildings but they are not very important as building and construction materials today. Sandstone cannot be polished, except for quartzite, which is metamorphosed sandstone and behaves like granite.

Durability of stones in moderate climatic area. Weathering and erosion

The rocks are the hardest natural materials on earth and it may take thousands of years to disintegrate them. By definition, weathering is the general deterioration process by which rocks, soils and minerals are broken down (through contact with water, atmospheric gases, sunlight, and biological organisms) at Earth's surface and are displaced gravitationally to isostatic position. This process takes place in two ways:

_Chemical weathering – when the minerals in a rock are chemically altered or dissolved. The blurring or disappearance of lettering on old gravestones and monuments is attributable mainly to chemical weathering;

_Physical weathering – when solid rock becomes fragmented by physical processes that do not change its chemical composition.

Physical and chemical weathering interact and reinforce each other. There are numerous examples that demonstrate the faster decay manifests, the more susceptible the stone pieces are to breakage. The smaller the pieces, the greater the surface area available for chemical attack and the faster the decay. On the other hand, through erosion, the weathered material is moved, carried away and deposited somewhere else. Thus, new, fresh, unaltered surface rocks are exposed to other cycles of weathering.

The weathering is influenced by the mineralogical composition and internal structure of natural stones, due to the fact that different minerals weather at different rates. For example, constructions made with igneous rocks (as granite, andesite, dacite etc.) may remain unbroken and uncracked for centuries (Fig. 3a, b), though they may show evidence of superficial chemical weathering. The granitic, andesitic or dacitic massive elements may have no planes of weakness that contribute to cracking or fragmentation. In contrast, limestone with high porosity (Fig. 3c, d) or shale, a sedimentary rock that splits easily across thin bedding planes, could break into small pieces quickly only a few years after placing; the stone will turn into sand and gravel.

a) b) c) d)

Fig. 3. The durability of stones used for outdoor application has a decisive role in the architecture of the built space: a), b) Bologa Church, Hunedoara county, made with Bologa dacite and Bologa-Hent andesite; c) improper use of the Podeni limestone for external balusters at Palace of Parliament, Bucharest; d) Vratza limestone showing cracking processes after thermal shock laboratory tests.

High temperatures and heavy rainfall speed up the chemical weathering, while cold and dryness impede this process – in arid regions water is relatively unavailable, and in cold climates water may be chemically inert because it is frozen; in both cases, chemical weathering proceeds slowly. Freezing water may act as a wedge, widening cracks and pushing the stone pieces apart (Fig. 3c). The durability of stone elements can also be influenced by the stress along natural zones of weakness (Fig. 3d) and by biological and chemical activity (Fig. 4a).

Most stones have natural zones/planes of weakness along which they tend to crack. In sedimentary rocks such as sandstone and shale, these zones are the stratification planes formed by the successive layers of solidified sediments. Metamorphic rocks such as slate form parallel planes of fractures that enable them to be split easily to form roofing tiles. Granites and other rocks are massive – that is, large masses that show no changes in rock type or structure. Massive rocks tend to crack along regular fractures at intervals of one to several meters called joints. These and more irregular fractures form while rocks are still deeply buried in Earth's crust.

Beside the climate parameters, both chemical and physical weathering are influenced by the activity of organisms – from bacteria, algae (Fig. 4a) to tree roots – all working in ways that destroy the rock, by widening the cracks formed by weathering.

Porosity depends on the size and shape of the grains and on how the grains are packed together. Rock itself may have a specific porosity, fractures (cracks and joints) or natural lineation (cleavage, schistosity). Sometimes, dissolution features may create a second (higher) porosity, especially in the carbonate rocks. The interaction of these porosities is very complex.

Stone elements can be also weakened or even break as a result of daily alternation between hot days and cold nights, rainfalls or freeze-thaw cycles. These processes may be weakening for the stone because of its expansion in the heat and contraction during the cold. So, it becomes very important to correctly select the type of stone on facades exposed for a long time to humidity, sunlight or strong winds (Fig. 4b). Sometimes, very important negative visual changes occur due to the humidity resulting from the method of fixing the plates (wet installation) (Fig. 4c), or physical degradation due to the chemical processes resulting from the anchorage system (Fig. 4d).

a) b) c) d)

Fig. 4. Examples of degradation of stone elements: a) algae, urban polution and weathering processes drasticly change the visual appareance of a limestone hotel façade in Bucharest; b) cracks in a Podeni architectural limestone element at the Palace of Parliament in Bucharest, due to the weathering and load bearing, c) improper interior wet instalation of Baschioi limestony sandstone in a residential house; d) degradated limestone tiles due to the anchorage metallic system.

Depending of the stone type, some recommendations for outdoor application of the stone elements with architectural purposes are presented in Table 2.

Table 2. Recommendations for applications of stone elements, depending of their genetic type (***I-STONE project, 2005)

APPLICATIONS \ STONE TYPES			IGNEOUS ROCKS		SEDIMENTARY ROCKS					METAMORPHIC ROCKS		
			granite	basalt	chert	sandstone	porous limestone	compact limestone	shale	slate - phyllite - schist	marble	quarzite
OUTDOOR	façade	massive elements	xx	xx	xx	xx	-	xx	-	-	xx	xx
OUTDOOR	façade	thin slabs	xx	xx	-	xx	x	xx	xx	xx	xx	xx
OUTDOOR	façade	elements in contact with floor	xx	xx	xx	xx	-	xx	-	xx	xx	xx
OUTDOOR	roofing		-	-	-	-	-	-	-	xx	-	-
OUTDOOR	paving	slabs	xx	xx	-	xx	-	xx	xx	xx	xx	xx
OUTDOOR	paving	setts	xx	xx	xx	xx	-	xx	-	-	xx	xx
OUTDOOR	paving	kerbs	xx	xx	xx	xx	-	xx	-	-	xx	xx

xx: suitable x : can be used but not recommended -: not suitable

Ornamental stone from Romania – types, availability for use, recommendations for architects and builders

Ornamental and Dimensioned (cut-to-size) Stone is “the collective description of natural stone which has been extracted from the earth in an orderly manner, further worked by cutting and processing, then used in various building activities either structurally or for decorative purposes” (***I-STONE project, 2005).

An increasing market induced a big demand for high quality stone construction and decorative materials, for interior or exterior application, due to their durability and aesthetical unique properties, while also having a positive role in the improvement of the quality of building environment. The final commercial stone products include tiles, panels, ashlars, solid masonry units for walling or different other purposes, or for architectural elements (Cetean, 2009).

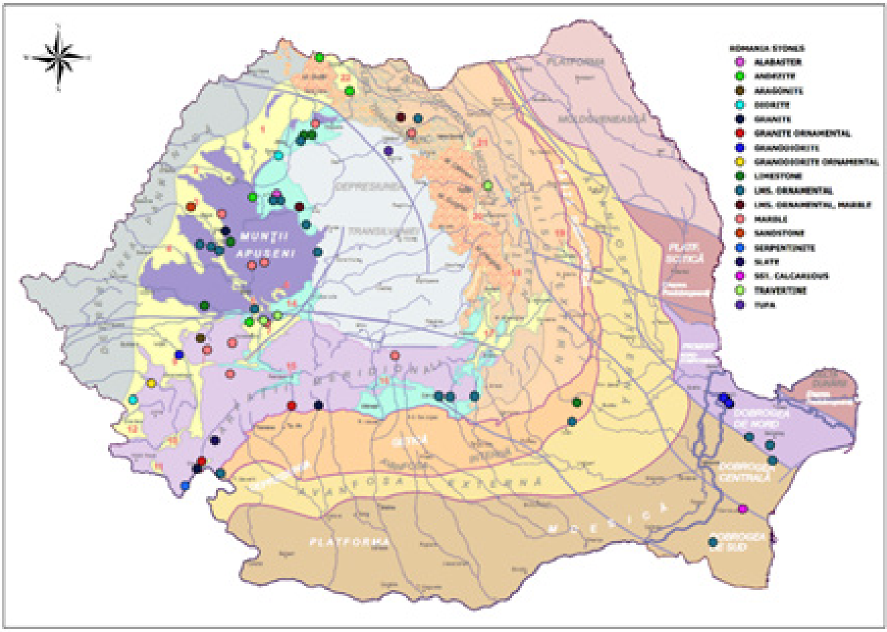


Fig. 5. The location of the ornamental stone deposits included in the national annex (no. A.2.18) of the EN 12440:2017 – Natural stone – Denomination criteria, represented in relation to the structural geology information of Romania.

From a total of over 130 ornamental stones from Romania inventoried by PROCEMA GEOLOGI Ltd in in the period 1999-2002, respectively Geological Institute of Romania between 2019-2022 in the frame of RoQ-Stone project, almost 80 perimeters (corresponding to 67 deposits – Fig. 5) are included in the National Annex (no. A.2.18) of the European Standard EN 12440:2017 – Natural stone – Denomination criteria (this European regulation establishes the criteria for the designation of natural stone from raw material to finished products).

As of 2023, only 29 of these are registered in the official records as being in operation, or at least with valid operating licenses (Table 3).

Table 3. Active Romanian ornamental stone quarries

	Name of deposit / perimeter	County	Type of stone	Colour	Quarry owner
1	Albești - Muscel	AG	Limestone	yellow-beige	ROCAS S.A. Albeștii de Muscel
2	Innieş – Valea Secii	BN	Limestone	white-grayish	VALSECMAR S.R.L. Anieș
3	Başchioi – N. Bălcescu	TL	Sandstone	yellow-beige	MACIMO SRL
4	Bologa-Henţ	CJ	Andesite	dark grey	GRANDEMAR S.A. Cluj Napoca
5	Bratcu Meri	GJ	Granite	white-grayish	CARIERA MERI S.R.L. Bumbești Jiu
6	Buteasa (II), V. Ursului – Buteasa	MM	Marble	white-grayish	C.M.C. S.R.L. Cărbunari
7	Cărpiniş – Banpotoc 1	HD	Travertine	yellow-beige	MARMOSIM S.A. Simeria
8	Ciolanu Mare - Gornenți	MH	Slate	grey-greenish	MERIDIAN CC S.R.L. Orșova
9	Codru Babadag	TL	Limestone	yellow-beige	TIB 90 COM S.R.L. Tulcea
10	Cresuia - Beiuş	BH	Marble	light grey	MARMOCALC S.A. Vașcău
11	Dealul Blidarului (Zărnești)	BV	Granodiorit	red	MORANI IMPEX SRL Zărnești
12	Forotic	CS	Diorite	grey-whitish	GABROU CARIERE S.R.L. Timișoara
13	Geoagiu (Băi)	HD	Travertine	beige-yellowish	MARMOSIM S.A. Simeria
14	Gura Văii – Vărănic (Dl. Pârlipatului)	MH	Limestone	beige-yellowish	MARMURA SA București
15	Iardaștița Mică	CS	Tuff	whitish	GRANIT STAR S.A. Orșova
16	Luncani (Pârâul Popii)	TM	Aragonite	yellow	BEGA MINIERALE INDUSTRIALE S.A. Timișoara

17	Măcin - Izvoarele, Greci - Măcin	TL	Granite	reddish-grey	HIDROMINERAL S.A. Greci MINERAL EXTRACT S.R.L. Călărași
18	Mateiaș - Valea Mare	AG	Limestone	yellow-beige	MINERAL ROM SRL(FOSTA)
19	Moigrad	SJ	Diorite	grey-whitish	CARIERA MOIGRAD S.R.L. Mârșid
20	Năieni - Nifon	BZ	Limestone	yellow-beige	FINCOM CONSTRUCT S.R.L. Năieni
21	Novaci, Novaci - La Brazi	GJ	Granite	grey-reddish	NOVAGRAN S.R.L. București
22	Orko - Sf. Gheorghe	CV	Sandstone	beige-reddish	TERRACOTTA STAR S.A. Sfântu Gheorghe
23	Pietroasa - Deva	AB	Andesite	grey	MARMOSIM S.A. Simeria
24	Podeni	CJ	Limestone	grey-whitish	MARMOSIM S.A. Simeria
25	Porumbacu	SB	Marble	whitish	MARM WORK SRL București
26	Ruşchiţa - Cariera Veche, Dealul lui Ionel, Dealul Maria, Pârâul Porcului, Dealul Plumbului	CS	Marble	pink, white-grayish, white-yellowish grey	MARMOSIM S.A. Simeria DORECO 2001 S.R.L. Rusca Montană OMYA CALCITA S.R.L. București
27	Sohodol, Sohodol - Valea Verde, Sohodol - Vădăoiești	AB	Marble	white	MARMURA SA București
28	Stana (Petrindu)	SJ	Alabaster	grey-whitish	COMINEX NEMETALIFERE S.A. Cluj
29	Vaşcău Câmp Moţi Sat (Lara - Câmp Moți)	BH	Limestone	reddish	B.A.A.S. S.R.L. Timișoara

In Table 4, recommendations of application for some Romanian ornamental stones, depending of the type of stone elements and place of application, are presented.

Table 4. Romanian ornamental stone – recommendation of end-use

Application		Rușchița, Porumbacu, Sohodol marble	Podeni, Năieni limestone	Pietroasa – Deva Andesite, Moigrad dacite	Geoagiu, Cărpiniș Travertine, Mateias limestone	BASCHIOI sandstone	Macin Novaci granite
interior	flooring	*		*	*	*	*
	walling	*	*	*	*	*	*
	solid masonry units	*	*	*	*	*	*
	tablet, kitchen tops	*		*			*
	other: stairs, architectural elements	*		*	*	*	*
exterior	paving and flooring			*			*
	elements in contact with the floor			*	*		*
	non-vertical part or elements sticking out of the facade			*	*	*	*
	solid masonry units	*		*	*		*
	wall cladding units	*		*	*	*	*
	other: columns, basements for monuments, architectural elements	*		*	*		*

Romanian stone with heritage value

Under the name of HERITAGE STONE are included those natural stones that have special significance in the human culture, as the stones that have been used for centuries to build the architectonic heritage of world sites, some of them recognized by UNESCO for their importance in humanity culture. Some of these stones are no longer extracted or even the extraction was stopped for millennia. Other stones continue to be commercially important, but their heritage uses have not been well documented in widely available sources for the interested parties.

Historical use of natural stone can be a major contributor to understand past civilizations and how different civilizations evolved over the millennia, from antiquity to the present. The geological attributes of the stones, which have survived for millennia, enrich our cultural heritage, and they should be documented and studied for the present and future generations. With few exceptions, making the connection between these stone monuments and the historical quarries from which the stones were extracted require important resources.

Up to now, the International Union of Geological Sciences (IUGS) Executive Committee, through its Sub-Subcommission on Stone Heritage (part of the International Commission on Geoheritage - ICG), has adopted 32 Heritage Stones distributed in 17 countries. These stones with global heritage value are: Lede Stone (Belgium), Petit Granit (Belgium), Échaillon Stone (France), Rochlitz Porphyry tuff (Germany), Connemara Marble (Ireland), Carrara Marble (Italy), Rosa Beta Granite (Italy), Pietra Serena Sandstone (Italy), Globigerina Limestone (Malta), Larvikite (Norway), Estremoz Marble (Portugal), Lioz limestone (Portugal), Brecha da Arrabida (Portugal), Podpêc Limestone (Slovenia), Alpedrete Granite (Spain), Villamayor Stone (Spain), Macael Marble (Spain), Bernardos Phyllite (Spain), Kolmården Serpentine Marble (Sweden), Hallandia Gneiss (Sweden), Bath Limestone (UK), Portland Limestone (UK), Welsh Slate (UK), Piedra Mar del Plata (Argentina), Tyndall Stone (Canada), Teozantla Tuff (Mexic), Jacobsville Sandstone (USA), Tennessee Marble (USA), Makrana Marble (India), Deccan Basalt (India), Jaisalmer Limestone (Indi) and Alwar Quartzite (India).

On the other hand, from this list of over 130 ornamental stones used/usable as shaped (dimensioned) stones, 28 of them (from which 19 in operation) were selected by the authors as fulfilling the conditions of a stone with heritage value of national and global significance. The main criteria applied include: their significance in the human culture (for the architectural heritage of world sites or in significant works), wide-ranging geographic application, ornamental properties, and ongoing availability.

Table 5. The “short list” of Romanian ornamental stones which fulfil the heritage value criteria (Cetean et al., 2023)

	Name of natural stone	Petrological family/ group	Typical colour	Status	Coordinates	
					X	Y
1	Rușchița	marble	pink, white-greyish, white-yellowish, grey	in exploitation	45.6462480	22.4057590
2	Moneasa	breccia marble limestone	Reddish, red to brownish, black, grey	in exploitation	46.4737580	22.2793560
3	Alun	marble	white-yellowish-grey	ceased	45.7054670	22.6816530
4	Vaşcău	limestone	polychrom; grey to dark grey, reddish or black	in exploitation	46.4690140	22.4253930
5	Podeni	sandstony limestone	grey-whitish	in exploitation	46.4371030	23.6282500
6	Albești	fossiliferous limestone	yellow-beige	in exploitation	45.3081569	25.0074577
7	Geoagiu & Cărpiniș	travertine	beige-yellowish to yellow-beige	in conservation; in exploitation	45.9315790	23.1854460
8	Viștea	limestone	yellow-beige	in exploitation	46.7988280	23.4650950
9	Măcin	granite	reddish-grey	in exploitation	45.2357038	28.2179546
10	Pietroasa-Deva	trachyte	grey	in exploitation Pre-Roman quarry	45.8700958	22.8706598
11	Codru Babadag	sandstony limestone	yellow-beige	in exploitation	44.8607970	28.6791229
12	Borsec	travertine	beige-yellowish	ceased	46.9651360	25.5699590
13	Măgura Călanului	oolithic and clastic limestone	cream, whitish, cream -yellowish	ceased, Pre-Roman quarry	45.7635790	23.0501571

The biggest challenge was the lack of accessible information regarding the stones used in public and/or heritage buildings (Cetean et al., 2023). Usually, there was information about the construction itself, especially in the case of heritage buildings, and at most the petrographic type of rock used was mentioned (e.g., limestone, marble, granite, basalt, etc.); very rarely the name of the stone (source-area) was mentioned. Another obstacle was the fact that the vast majority of the old quarries changed their owner repeatedly, and their archives no longer exist. Thus, in order to constitute the files supporting the heritage value of these rocks, important human, material and time resources must be allocated.

A "short list" of 12 stones (Cetean et al., 2023) was prepared in order to focus the efforts and laborious work of documenting the monuments and other historical buildings where the stones were used. To these it was added the most important quarry from a historical-cultural point of view, that contributed to the building of the Dacian fortresses in the Orăștiei Mountains, but which was abandoned since the 2nd century AD (Table 5).

Seven types of these stones were used the Palace of the Parliament (Fig. 6), the third largest administrative building for civil use in the world (with a floor area of 330,000 m^2). The construction of this impressive building required a huge amount of stone: Podeni and Viștea limestone tiles and panels for the exterior (approx. 750,000 m^3), and Rușchița and Alun marbles as the preferred materials for the interiors (over 1,000,000 m^3) or Moneasa limestone, but also, even in small quantity, Borsec, Cărpiniș, and Geoagiu travertine – already stones with national heritage value at the time of use.

Fig. 6. The Parliament Palace, the iconic building where a huge volume of Romanian ornamental stones was used for flooring, cladding and different architectural elements.

Conclusions

The exploitation of raw materials has always been one of the most important activities in the human evolution, due to the fact that all productive activities have a mineral material at the base of their development. Natural stones will remain the most resistant construction material, but their use must always take into account efficiency in operation. The fundamental recommendation is that the architects and builders should always find the balance between the desired ornamental characteristics, the maintenance cost and long-term environmental sustainability.

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GLASS AND MISTAKES

Abstract: Glass is a complex material and in the last decades it has been extensively used in constructions. It is important to understand its particularities and to design taking into consideration not only material properties, but also application, the way it will be transported and installed, the way it will be used by people and what will happen in case of breakage, and eventually how it will be recycled at the end of its life span.

This chapter will check most common mistakes when designing with glass; without considering it as a complete guide, the examples are useful, and most of them are coming from personal experience of people working in construction industry.

Keywords: glass, mistakes, legislation, energy efficiency, dimensioning

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Dragos MATEI is a civil engineer by training and a person who is curious by nature. He joined AGC, an important glass producer, some 18 years ago and he never stopped learning about glass since that moment. With a Master in Marketing and Comunication, he is trying to present technical information in a captivating way, making it interesting and easy to be understood.

Introduction

Glass is a complex material and in the last decades it has been extensively used in constructions. It is important to understand its particularities and to design taking into consideration not only material properties, but also application, the way it will be transported and installed, the way it will be used by people and what will happen in case of breakage, and eventually how it will be recycled at the end of its life span.

This chapter will check most common mistakes when designing with glass; without considering it as a complete guide, the examples are useful, and most of them are coming from personal experience of people working in construction industry.

We will group these types of mistakes – that have sometimes led to spectacular breakages – in specific categories:

_Mistakes regarding dimensioning;

_Mistakes regarding comfort and energy efficiency:

_ Mistakes in relation with legislation.

Mistakes regarding dimensioning

In order to avoid difficulties later on during construction phase it's important to know from the design stage how to dimension the glass elements. There are several characteristics which should be taken into consideration.

Architects should be aware that glass dimensions are limited by production capacity, and by processing and transport possibilities. The maximum dimensions for production of raw glass is 3210x6000mm; this is what the contemporary glass plants can provide. The available thickness depends on the speed of movement induced in the line of production: if the tin basin has a slow motion, more melted glass falls into the tank/time unit; if it moves faster, the melted composition will be distributed on a larger surface in the same time unit, hence the thickness will decrease. Regarding thickness range, production of raw glass is 3, 4, 5, 6, 8, 10, 12, 15, 19 and 25mm, but the most common types that are used are 4, 6, 8, 10mm. We cannot use the glass as raw product: we will transform it by cutting, shaping it with beveled edges, tempering, and possibly laminating it. The size of the transformed pieces is limited by the capabilities of the machinery: tempering and laminating can be done usually in size 2400x5100mm, up to 3200x6000mm. On special orders, some larger dimensions can be delivered, up to exceptional 18m long, but the costs might be significant, especially those related to transportation. A glass supplier should be consulted for more details.

Sometimes the weight of glass can be a significant limitation, especially if larger and/or thicker panels are used. Glass density is ρ=2500kg/m^3. Here are some examples:

_a 1 m^2, 4mm thick panel weights 10kg;

_a 1 m^2, 10mm thick panel weights 25kg;

_a double insulated glazing, 4000x2000mm, composition 10-16-88.2 weights 520kg;

_a fish tank 2000x1000x1000mm, composition 10.10.2 (just glass) weights 400kg and, if filled with water (without additional metal structure!) weights 2400kg.

So, designers, architects and engineers should take into consideration the weight of the glass since the design phase, when dimensioning the other structural elements. I remember one situation, when a specialised company created a fish tank on special order of 5000x2000x1000mm wide. Everybody was very much concerned about dimensioning the glass and the joints only to realise, in the moment of filling it with water, that weight exceeded 10tonnes and the building structure was not design to accommodate this extraordinary load. In the end the owner paid for the fish thank and ordered, paid and installed a second one, much smaller in size (and weight!).

Sometimes it's the size of the glass panel itself that causes troubles, especially during transport to the site and installation. Trucks, cranes etc. are usually needed and the possibility of access to construction site must be also checked.

Specialized design company must be used in order to calculate class composition according to EN 16612 standard. Most often, additional to dimensions, they are taking into considerations:

_permanent loads (e.g.: the own weight of the glass element, the weight of other constructive elements permanently fixed to the glass, as well as permanent payloads);

_variable or temporary loads (i.e.: wind load with pressure or suction, the snow load, the hydrostatic pressure in case of aquariums/ swimming pools, etc.);

_accidental actions (i.e: impact with heavy solid bodies, stones, hail, etc.).

Optical deformations may occur in case the glass is not perfectly flat. When light rays strike a curved glass surface, they reflect in different directions. However, they will still obey the law that the angle of incidence equals the angle of reflection. Therefore, the image of an object will be distorted. The curvature of the glass surface causes it to act as a lens. This can be enhanced by a higher reflection (e.g. reflective coating on the glass) and also by objects in front of the glass, acting as guidance lines. Main causes of not so flat glass units can be:

_Lack of flatness because of tempered glass characteristics. Tempering is done by heating up the glass close to softening point (770°C) and cooling it quickly. This creates specific tension in glass, but also lack of flatness. Standards EN1863-1 and EN12150-1 are explaining the limits allowed. As a conclusion, it is always recommended to use the best technology available in terms of glass tempering, in order to limit as much as possible frame effect, bow effect and also anisotropy.

_Lack of flatness because of barometric and/or temperature and/ or altitude: high atmospheric pressure is forcing glazing units to shrink inwards and this will result in exterior pane being concave and interior pane being convex. Similarly, low atmospheric pressure makes it to swell outwards and this will result in exterior pane being convex and interior pane being concave. It is difficult to avoid this completely but it is possible to limit it, if outside glass is thicker than inside glass. In this case, the outside glass will remain more or less flat and inside glass will take all the bows, but that will be much less visible from outside the building.

Fig. 1. In the reflections on the ground floor one can notice a lack of flatness from the objects reflected acting as guiding lines. At the first floor, due to lack of guidance lines (only sky is reflected), glass seems much more flat. Note: both ground floor and first floor have exactly the same glass structure but apparently they look very different.

Mistakes regarding comfort and energy efficiency

Energy efficiency has been for many years now a major topic in building industry. Because glass is a significant part of the windows or the façade, considerable efforts have been made to improve the glass parameters, mainly thermal transmittance during winter time and solar control during summertime. Ug (known as Thermal transmittance) is the rate of transfer of heat through matter (glass). We call it heat loss coefficient. It is expressed in Watts per squared meter and Kelvin - W/(m^2xK). This means that the higher the U-value the worse the thermal performance of the building envelope. A low U-value usually indicates high levels of insulation. Sometimes, R value is used (known as thermal resistance). The thermal resistance of a structure is the reciprocal of its thermal transmittance: U=1/R.

In case of a window/façade, because of energy efficiency requirements, an insulated glass unit (IGU) should be installed. That's because the glass itself is not an insulating material. If a glass panel, 4-millimeter-thick, is installed in a frame, its Ug value is 5.8 W/m^2K. In order to obtain a reasonable Ug Value, like 1.1 W/m^2K, a total glass thickness of no less than 700mm is needed! Obviously this is totally unpractical, so the solution is to use an insulated glass unit: an assembly of glass, air (gas) and glass, all hermetically sealed on the perimeter, instead of a massive, solid block of glass.

The glass thickness is determined as explained above, but special attention should be paid also to limit heat losses of insulated glass unit, which can happen by conduction, by convection or by radiation. Practically, in order to limit the conduction, the aluminum spacer which is separating the glass panes should be replaced with a plastic/composite material, a "warm-edge spacer" type. To improve convection, it is recommended to use Argon or Krypton (rare gases) between the glass panes, and to keep the gap between 15 and 18mm. If the spacer will be wider (like 24 or 30mm or even more) the extra space will generate extra turbulence (convection) in the gas, which will increase the heat transfer (energy loss). In this case, less is more: if gas will be replaced by vacuum it will be even better (no convection, spacer will be close to zero). During recent years we saw several developments of vacuum glazing, and the results are encouraging. Most probably in the near future (10 years or so) we will have a vacuum glazing that will have better parameters than traditional triple glazing. Cutting heat loss by radiation is obtained by using a low emission (lowE) glass, which will reflect heat back into the building. Also, using a triple glazing (a lowE – clear glass – lowE type) will improve the thermal insulation of a glazing by a factor of 2. If the spacer (gas chamber) will be narrower (6-8-12mm), the gap will not provide enough insulation and the result will be a not so efficient insulation. All these parameters should be taken into account when dimensioning the composition of an IGU, in order to get the best result possible within specific limitations of cost and frame design.

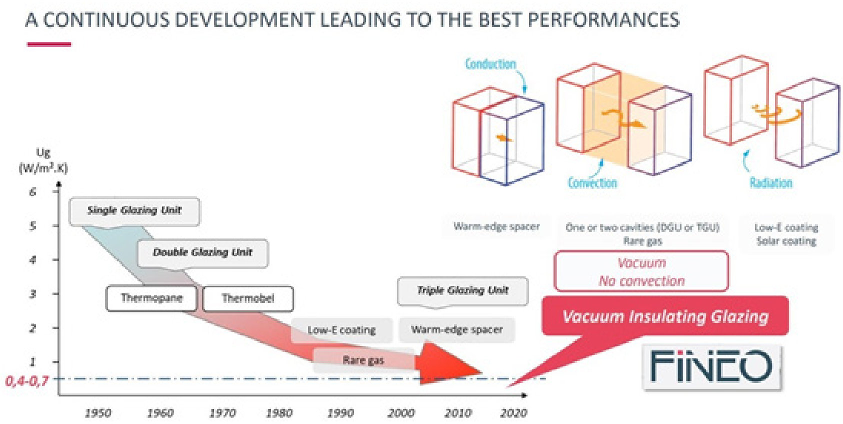

Fig. 2. Improvement of Ug value over the years through specific innovations. © FINEO by AGC

A double insulating unit, comprising of external pane made in clear glass, a 16mm spacer filled with Argon (90% purity, because of technological limitations) and a lowE glass is generating an efficient Ug value of 1,1 or even 1,0 W/m²K. In order to have a better insulating glass, a triple glazing should be used. An ideal composition would comprise low-E outside glass, clear middle glass and low-E inside glass, while spacers should be 16mm wide and Argon filled. The result would be an Ug value of 0,5W/m²K, which is the best value we can obtain in standard, practical solutions.

On top of significant energy savings, using insulating glazing units with low-E glass brings also personal well-being of the people living inside the building: the lower the Ug-value, the higher is the temperature of the glass. That translates in comfort, due to lack of cold wall effect: convection is limited and people can actually use the space near the window, without having chills.

It's not the subject of this paper to cover frames and other materials, but, for sure, a dedicated frame for triple glazing, wide enough and dimensioned considering the correct loads, should be used and later installed accordingly, otherwise all the efforts of having the best glass solution are futile.

During summertime, special attention should be dedicated to solar control solutions. For sure, the best option would be an external shading device, but it's not always possible to have it installed on the building. If this is not possible, then the solar control should be achieved with the help of the glass.

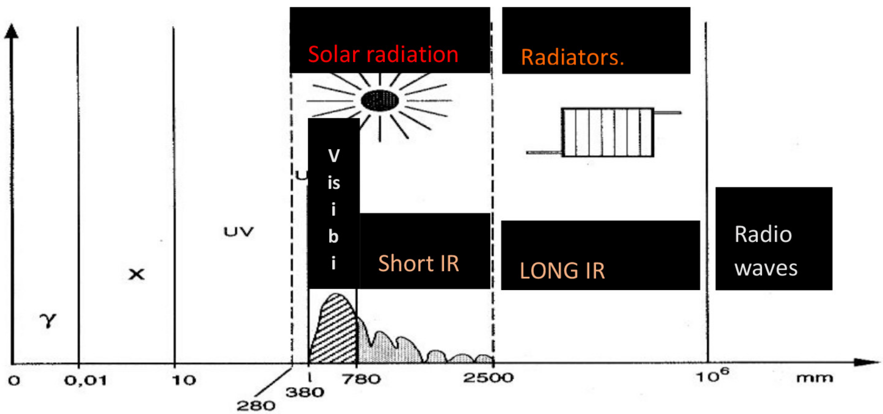

Fig. 3. Energy according to wavelength. Sun radiates energy from 280 to 2500nm (from 280 to 380 it's UV; from 780 to 2500nm is short infrared). Energy produced by burning fuels and energy absorbed by bodies and reradiated has a wavelength above 2700nm (long IR).

The main parameters that characterize the glass unit are:

_Light Transmission (%) is the quantity of light entering a building from the total quantity of light coming from the Sun (wavelength 380 to 780nm). LT of a clear glass is around 85%. A really dark glass has LT around 10%.

_Light Reflection (%) is the quantity of light reflected by the glass from the total quantity of light coming from the Sun. LR of a clear glass is around 10%, while a reflective glass has LR around 50%.

_Solar Factor (%) is the quantity of energy entering a building from the total quantity of energy coming from the Sun. SF of a clear glass is around 80%. A really dark glass or a very reflective one has SF around 5%.

Because solar intensity exceeds 1500 W/m^2 in Romania, choosing a solar control glass is very important, especially in the case of large glass envelopes with orientation towards Sun (south, but also east and west, and also in case of glass roofs). In terms of costs, cooling of a building during summertime with a clear and low-E glass façade exposed to the Sun radiation can be more expensive than heating it during cold winter days, because of the greenhouse effect. This phenomenon was observed since ancient time: clear (or low-E) glass tends to allow visible light and short infrared radiation to pass through its matter almost uninterrupted. However, once the energy has been transmitted through the glass, it is turned into longer infrared radiation waves after it is absorbed by objects; these new waves are blocked by glass and unable to escape back through the windows due to their longer wavelength. Therefore, the heat is trapped inside the room causing the solar gain (overheating). This effect is useful in agriculture and also in cold climates, however, in temperate or warm climates it is causing overheating of the building. In order to keep temperature and cost of cooling under control, a solar control glass must be used. Choosing the right solar control glass is a complex decision: the aspect (color and reflection), the function of the building, the orientation, the ratio between glass surface and opaque surface in a façade, the cost and many other elements must be taken into consideration.

As a very general estimation, the cost of low-E glass is paid back after 1 winter season through energy savings; solar control glass is paid back in 3-5 years through energy savings. If we add the reduced cost of HVAC installation, then we can say that solar control glass is paid back rapidly. Nevertheless, the well-being of dwellers is another benefit of solar control in warm climates:

comfort and general mood are optimised when inside temperatures are not exceeding 25°C.

It is important to remember that finding the best solar factor is something like looking for the Holly Grail: if during summertime we are usually looking for a lower value of SF, during wintertime we prefer a higher SF to get free energy from the Sun. Additionally, by lowering SF, we are lowering LT as well, so a right balance should be chosen. A dynamic solar factor is an ideal situation, but this is possible only in case of external blinds and in case of glass having variable transparency. This is a solution developed in the last years, mainly using electrochromic glass: liquid crystals are able to control both transparency (LT) and energy (SF). There are still several limitations, mainly concerning sizes, low capacity of production and also cost, but in the coming years electrochromic glass will be probably used in most buildings looking for zero consumption (NZEB).

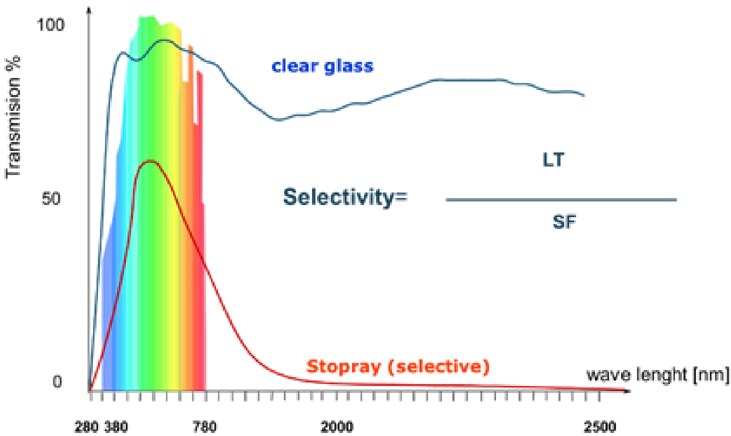

Fig. 4. Clear glass vs selective glass: there is transmission of UV, light and short IR.

In order to understand if a glass is more performant than another, sometimes selectivity is used – a ratio between light transmission and solar factor. The higher the selectivity, the better it is in terms of solar control performance, but architects must choose wisely how much light and how much heat should pass through the glass.

Sound insulation (noise attenuation) is also an important parameter of glass, especially in cities or areas where noise is significant. Excessive noise can affect the well-being of building occupants and cause them to be moodier, with a result in lack of attention and productivity. According to standard EN

ISO 10140-3, sound attenuation is measured in an official notified laboratory (accuracy ± 1dB) always with the same size of the glass (1230x1480mm). The Weighted Sound Reduction Index (Rw) is a number used to rate the effectiveness of a soundproofing system or material. Increasing the Rw by one unit translates into a reduction of approximately 1dB in noise level. Therefore, the higher the Rw number the better a sound insulator will be. C and Ctr are some adjustment factors which are used to account for high, respectively low frequency noise (typically the biggest problem with sound insulation). Ctr is always a negative number, so the Rw+Ctr will always be less than the Rw value. In short, there are few solutions in order to improve sound attenuation of a glazing: more mass (increased glass thickness), asymmetrical glazing in case of insulated units, and especially usage of laminated glass. Most effective is acoustic laminated glass, where the plastic interlayer is specially designed to block sound vibrations. A very effective insulated glass unit can achieve Rw (C; Ctr) of 51 (-1; -4)dB. If we know source of sound and its frequency, we can choose the best glass composition to block the sound propagation as much as possible.

In terms of maintenance, special attention should be dedicated to the possibility of cleaning the glass. Quite often, glass is positioned near solid surfaces (e.g balustrade, ceiling cover, etc.) having very limited space (sometimes centimetres) between inner surface of the glass panel and the other materials. In this case, it is nearly impossible to clean the backside of the glass, and in case the glass remains clear (transparent) the dust, cleaning agent etc. deposit will be very visible. From the design stage, if the glass is not perfectly sealed, for sure it will get dirty over time and it is needed to take into consideration the possibility of cleaning also the back side.

Glass canopies usually installed on top of entrances are also subject of dust deposits, especially if the water stagnates (horizontal installation). In some cases, it is possible for the glass to be permanently damaged because of corrosion of aggressive agents of pollution. The best solution is to install the glass in inclined position, in order to evacuate water and dust, and to have it cleaned regularly.

Sometimes, water condensation may appear on glass surface. There are several possible situations and the solutions should be adapted to each cause.

If condensation appears on the inside surface of the glass it is caused usually by a poorly heated, insufficiently ventilated or very humid interior space. The dew point of a given body of air is the temperature to which it must be cooled to become saturated with water vapor. If the condensation appears on the glass, it is happening because its temperature is bellow the dew point. Condensation on the glass surface facing the room is not a defect; it will improve (decrease) if we will heat the glass, ventilate the room and reduce the air humidity.

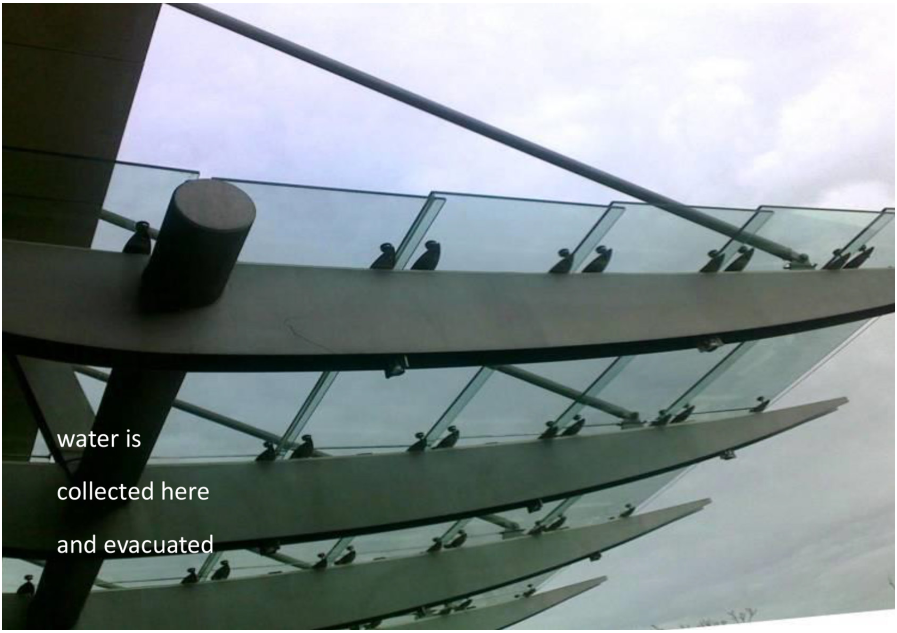

Fig. 5. Glass canopy; water is collected and evacuated.

Superficial condensation on the outside surface of the glazing is a phenomenon that may happen during night and in the early hours of the morning, when the sky is clear, and in the absence of wind. Thermal losses during clear sky are the main cause of this phenomenon; usually after Sun is rising the condensation is disappearing leaving no visible marks. The phenomenon of condensation on exterior glass surface is a proof of very good thermal insulation and it is not a defect.

In case condensation appears between the glass panes (in the enclosed cavity), it is considered a defect. The gas inside is not dry and probably the sealing is no longer working, causing poor thermal insulation. In this case, the insulated glass unit must be replaced.

Mistakes in relation with legislation

Although this topic is complicated and we cannot cover it fully, there are several important aspects to be mentioned. Glass is a particular material and most concerns are related to safety and security. Because of this, it is important to explain different types of glass and their performance:

_Annealed glass is a simple glass; it has a low resistance on stress and when it breaks, the fragments are a potential risk for persons. Annealed glass is not considered a safety glass, and its usage is limited for application with low risk of impact, failure, etc.

_Laminated glass is a type of safety glass consisting of two or more layers of glass with one or more thin polymer interlayers between them which prevent the glass from breaking into large sharp pieces. Breaking produces a characteristic „spider web" cracking pattern (radial and concentric cracks). The most common uses of laminated glass are in automobile windshields, skylight glazing and balustrades. Because the plastic interlayer is keeping glass fragments together, it is considered safety both against injuries with sharp fragments and against falling through, making it mandatory both for large glass panels in areas with traffic, and for panels which should keep the bodies against falling from height (balustrades, glass from floor to floor, etc.). The plastic interlayer can have a decorative function (colored, transparent or opaque film), or can have advanced properties in blocking the sound (acoustic film).

_The wired glass is obtained during the production process of float glass, by inserting a metal mesh in the melted glass mass. Although wired glass has a specific property (integrity in case of fire), it is not considered a safety glass.

_Heat-Strengthened glass has been heat treated (up to 750°C) in order to improve mechanical properties, and, when broken, a few lines of breakage are visible. Because of that, Heat-Strengthened glass is not a safety glass and is usually used in laminated version.

_Toughened or tempered glass has been heat treated (up to 770°C) and then cooled quickly in a controlled way, in order to significantly improve its mechanical properties up to five times compared with annealed glass. When broken, fragments are small and they are not causing injuries even in case of falling on people. Because of that, tempered glass is a safety glass and can be used in applications with a high risk of breakage and no risk of falling trough. In case there is a risk of falling through, then a laminated glass should be used, maybe with tempered glass in composition.

In Romania, a new regulation was recently adopted, *Indicativ* C 47 – 2022 *Instrucțiuni tehnice pentru configurarea, folosirea și montarea vitrajelor și a altor produse din sticlă în construcții*, which must be used when designing a glass element for a new building. This document can be downloaded from https://www.mdlpa.ro/uploads/articole/attachments/62ce6784b2a66269825548.pdf.

Conclusions

Glass is an old material which has ben constantly reinvented; it has been a fascinating material to humankind since it was first made, almost three thousand years ago. Architects love it because of its unique properties: it is transparent or translucent, it is strong (and brittle), it is available in various beautiful colours and textures, it can be easily cleaned and lately can be produced in absolutly impressive sizes. With the advances in technology, it is possible to make glass that is very light and thin, or stronger than steel. Glass is now being used in the building industry as insulation material, structural component, external glazing material, or a cladding material; it helps us harvest solar energy, it can be used as a projection screen or even as a switchable wall (transparent and opaque at a click); it help us comunicate when used as mediascreen.

If we understand the material and its properties, and by learning from mistakes, we can create amazing objects and buildings. This is why we can say glass is the material for the future.

The chapters of this volume have been developed following the *Errare Humanum Est. Errors, Mistakes and Failures in Design – Execution – Use* workshop which took place in Satul Banului, Prahova County, Romania, between 12-16 July 2023.

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REACTIVATION OF A SPACE DEDICATED TO THE COMMUNITY. STUDENT PROJECTS

Abstract: The projects that follow were developed by the participants (4th to 5th year students at “Ion Mincu” University of Architecture and Urban Planning in Bucharest, Romania), as a practical exercise during the *Errare Humanum Est. Errors, Mistakes and Failures in Design – Execution – Use* workshop. The theme was that of reactivating a space in Satul Banului, a space with a high value for the community - as a point of water (there is a spring that provided water for the community and the cattle passing through the village), a place of worship (there is a roadside cross) and a place of gathering.

A NARRATIVE OF FEELINGS

Our intervention aims to integrate the two valuable elements for the Satul Banului – the well and the cross – into a journey that narrates *the story of the cyclical nature of life*, as this very place and these objects bear witness to the long work of a family.

Speaking of the narrative, we have structured the stages of the route based on *the moments of the plot*, each aiming to evoke a series of emotions and sensations - controlled through the interplay of textures, lights, objects, the presence or absence of water, *the primordial symbol of genesis and cyclicality*. The initium and terminus points of this journey become the sources of water themselves - the spring, and later, the well.

Ala BUZILAN

Casian CIUREZU

Andreea PETRE

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Irina TATOMIR

Exposition

The first part of the route - birth, childhood - we wanted it to talk about curiosity, innocence, sensitivity through a compositional simplicity, a mineral fragment to travel, where winding water flows and creates its own bed, leading to the discovery of the route. I hear the muffled sound of the water, and I notice the small meanders that create an organic path among the stones.

Intrigue

Adolescence, youth - marked by revolt, tumult, discovery, identity, I realized it through a gradual change of textures, from the smooth material of the exhibition, to the rocky, difficult texture pierced by steps to make it possible to continue the route. During this period, the water sounds muddy, hitting the stones, the light becomes abundant, and the lack of stopping places marks the need to continue this way.

Story Evolution

For us, symbolizing maturity - compromise, rationality, order - the route takes place for a long time through a fragmented, but clearly visible mineral path, which pierces a vegetal area, with light and shadow variations, creating a sinusoidal experience, in which water becomes a secondary character, the rustle them in the background marking the presence of a ditch.

Climax

Old age - achievement, wisdom, peace, rest - is marked by the horizontal portion of the route, where I have the opportunity to stop, to look back, to remember. Information about the history of the place is also written in this place. The vegetation is abundant, I can no longer see the water, but I can still hear it.

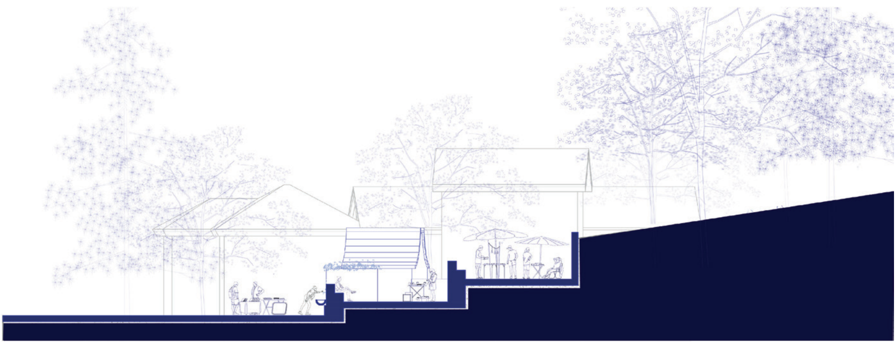
The ending

Death, the end - it marks the end of the cycle, loneliness, vulnerability, oppression, it is the part of the route, marked by silence, the water completely disappears from the landscape and the portion itself tries to be devoid of sensory stimuli.

This tension is suddenly stopped by the meeting with the spring, marking the resumption of the new cycle. The spring, like the cismela, is located in a similar square, marking the 2 points of the route. The spring is accompanied by a water mirror that reminds of the partner element of this journey.

THE STORY OF THE WATER SOMMELIER

"Eternity was born in the village". We concentrated the essence of life in a village in a system of squares, of places for the community and for those outside of it, which connect on a macro level, but at the same time stay a creed of simplicity. The fountain, the roadside cross, the gathering place and the people are the elements that support and carry out our project. The light comes out of the roadside cross and the pavement – a symbol of peace, of a place where life goes on quietly.



Maria Alexandra GHICA

Monica DRĂGHICI

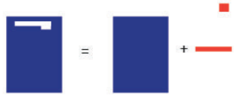
Andreea Elena ISTRATE

Silviu-Daniel ARNĂUTU

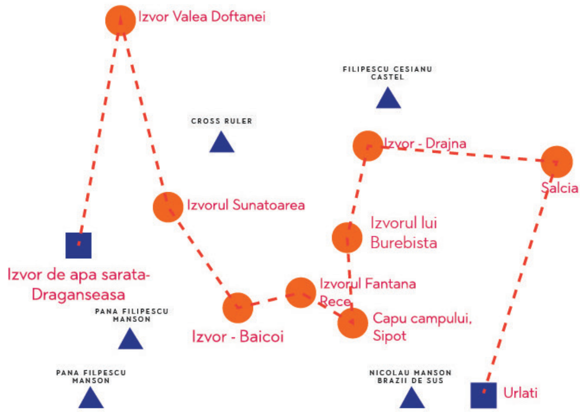
Irina SARĂU

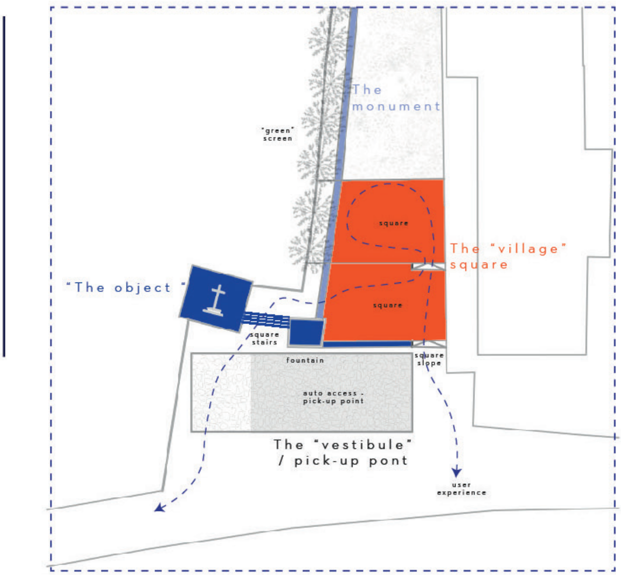
LINKING
WATER SPRINGS

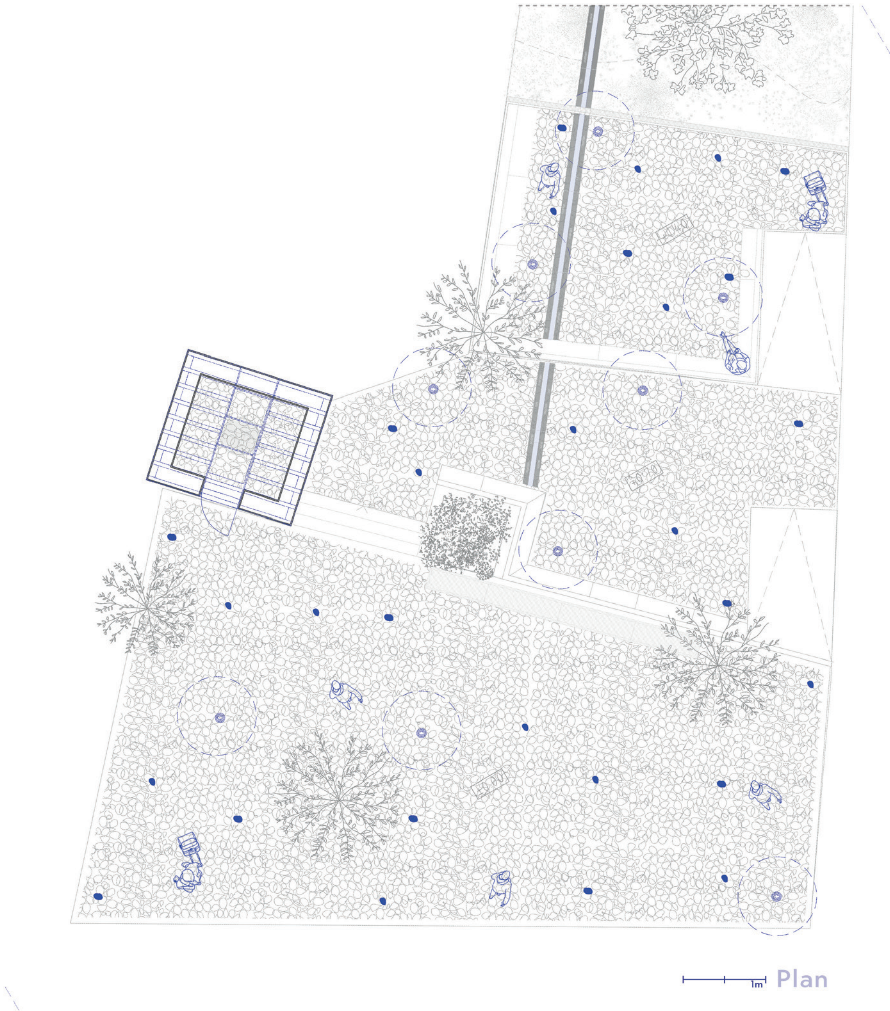
TRADITION -
the village square & fountain



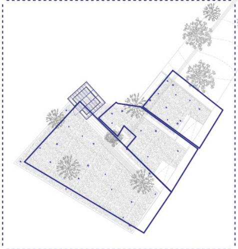
THE STORY OF THE
WATER SOMMELIER



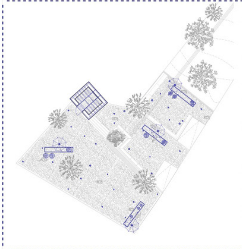




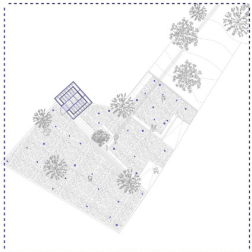
Plan



3-square system



flea market



gathering place

FOLLOWING THE WATER

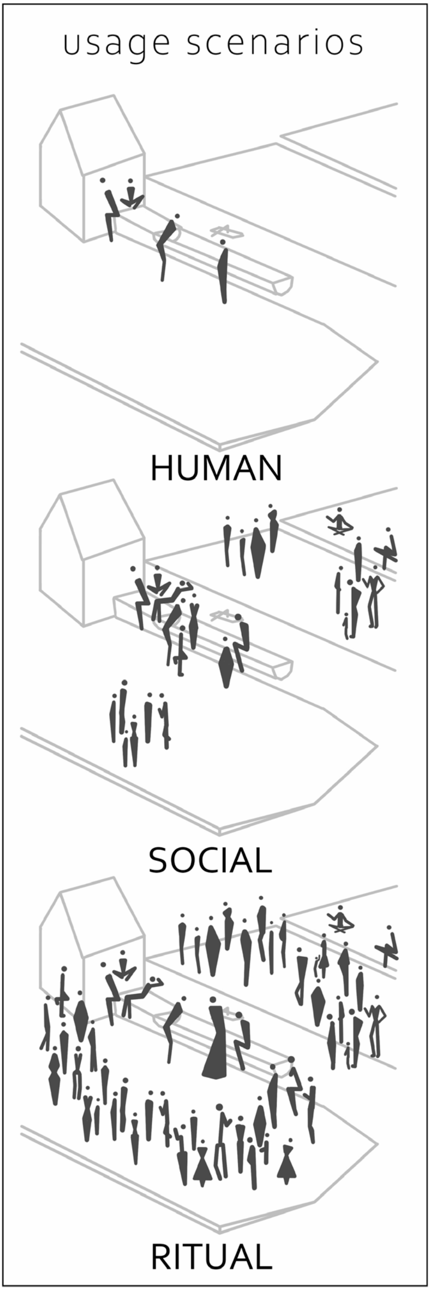
The project wishes to activate an important and historical area in Măgureni, the water fountain. A social attractor in this context needs special attention, a natural treatment with finishes made out of local materials, but not in such a way that it produces discomfort or lack of security. The design is split in three areas, the water fountain, the alleyway and the memorial. The water fountain is a social zone, that comes alive during religious ceremonies, but it also serves as a meeting point. The alley follows the natural slope of the terrain, allowing access to people of all ages. Lastly, the memorial serves as a finish point, the whole concept illustrating the duality of water. At the foot of the slope, the water is social and bubbly and focuses on groups, while, at the end of the journey, the murmur of water encourajes introspection and meditation.

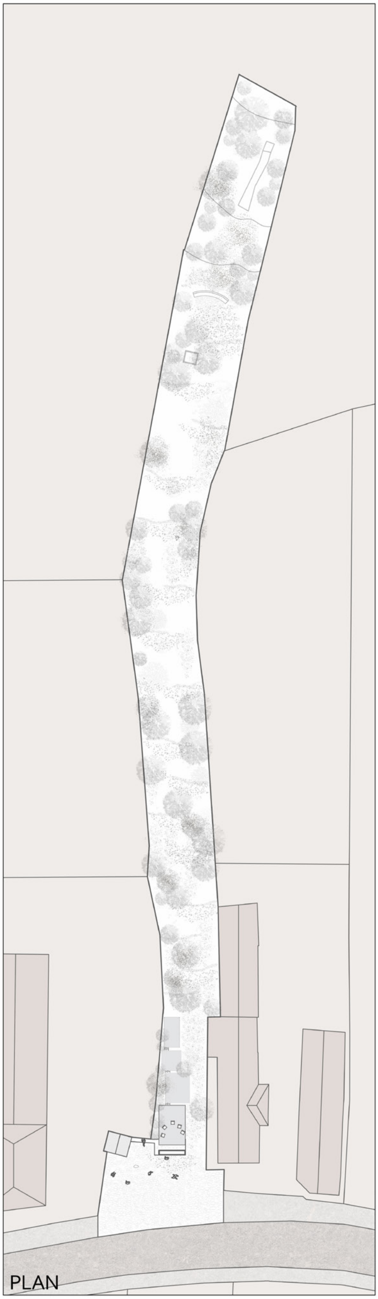
Ana-Maria AVRAMESCU

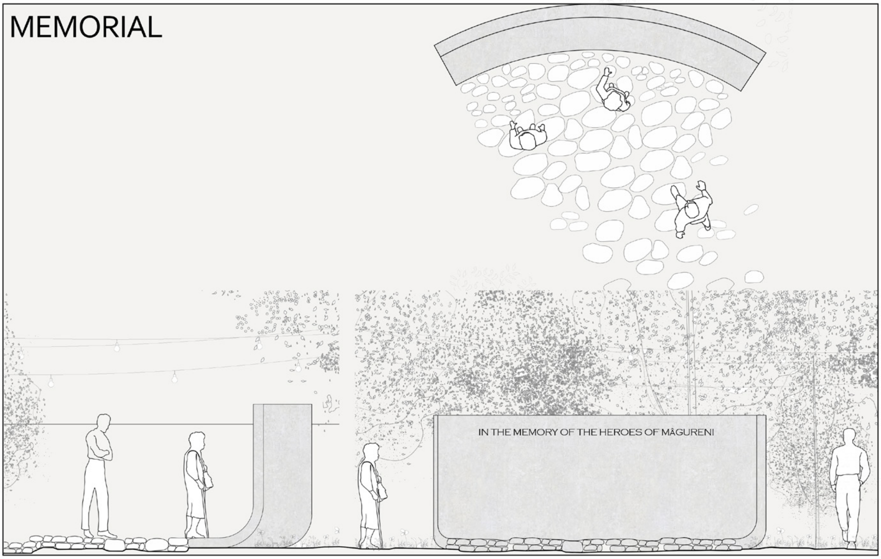
Adelina BURULEA-DRAGOȘ

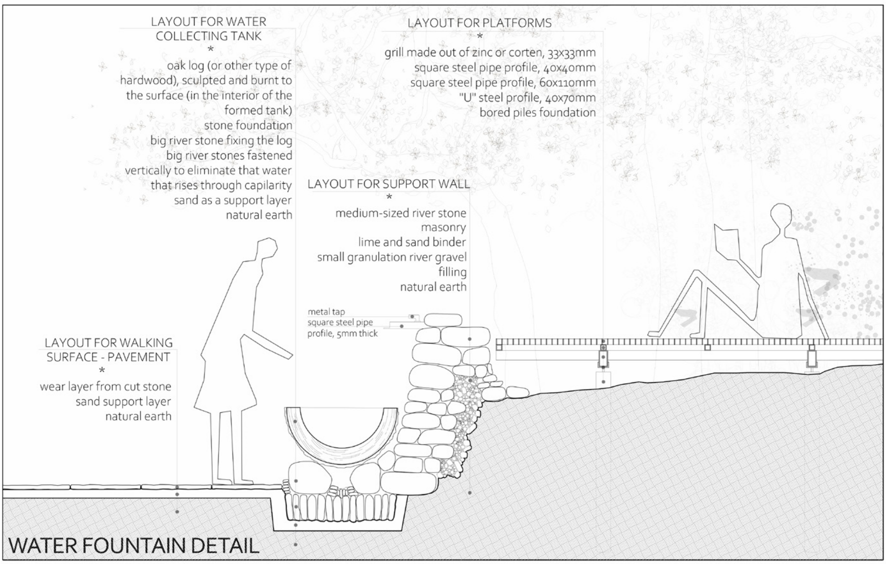
Elena GUGUILĂ

Eliza VOICULESCU


usage scenarios
HUMAN
SOCIAL
RITUAL


PLAN


MEMORIAL
IN THE MEMORY OF THE HEROES OF MĂGURENI

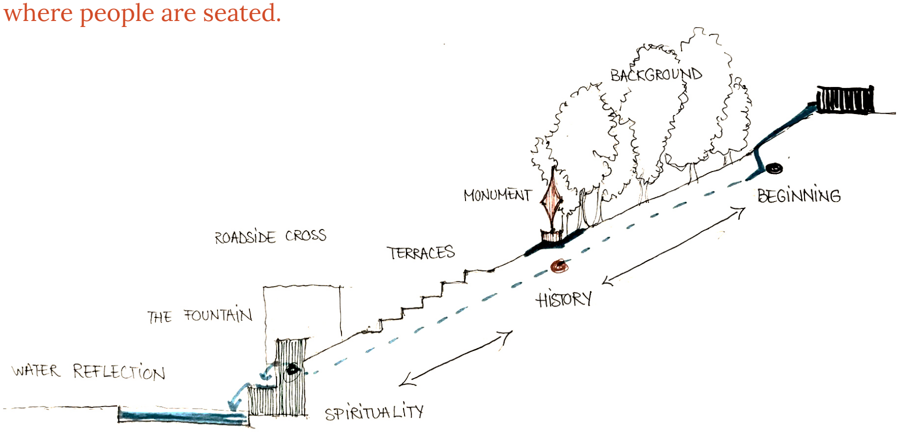

LAYOUT FOR WATER COLLECTING TANK
*
oak log (or other type of hardwood), sculpted and burnt to the surface (in the interior of the formed tank)
stone foundation
big river stone fixing the log
big river stones fastened vertically to eliminate that water that rises through capilarity
sand as a support layer
natural earth
LAYOUT FOR PLATFORMS
*
grill made out of zinc or corten, 33x33mm
square steel pipe profile, 40x40mm
square steel pipe profile, 60x110mm
"U" steel profile, 40x70mm
bored piles foundation
LAYOUT FOR SUPPORT WALL
*
medium-sized river stone masonry
lime and sand binder
small granulation river gravel filling
natural earth
metal tap
square steel pipe profile, 5mm thick
LAYOUT FOR WALKING SURFACE - PAVEMENT
*
wear layer from cut stone
sand support layer
natural earth
WATER FOUNTAIN DETAIL

THE PATH OF WATER

The path of the water, from the moment it springs to where the villagers manage to reach it, has a symbolic route. The link between people and water is very strong, it is an important meeting place, a gathering place, around which societies have been created – a popular symbol of purification.

We associated the course of the water with the cycle of life and we divided the route into three main areas: the first area represents the beginning, from where the water springs; the second area is represented by the course of the water, winding, with historical links; and the third area, a spiritual one, represented by the roadside cross and the fountain, is the symbolic outcome of this route.

In order to materialize these ideas, we designed a connection between the upper and lower parts of the site: namely between the fountain and the roadside cross, and the place where the water springs; the heart of the site, the central point, is marked by a landmark, a monumental axis. The idea of the roadside cross marking the intersection was taken further and we took this symbol to bring a new intersection point, referring to the Roman city. The steps connect the religious side of the fountain – an area of the sacred, with the profane side – where people are seated.



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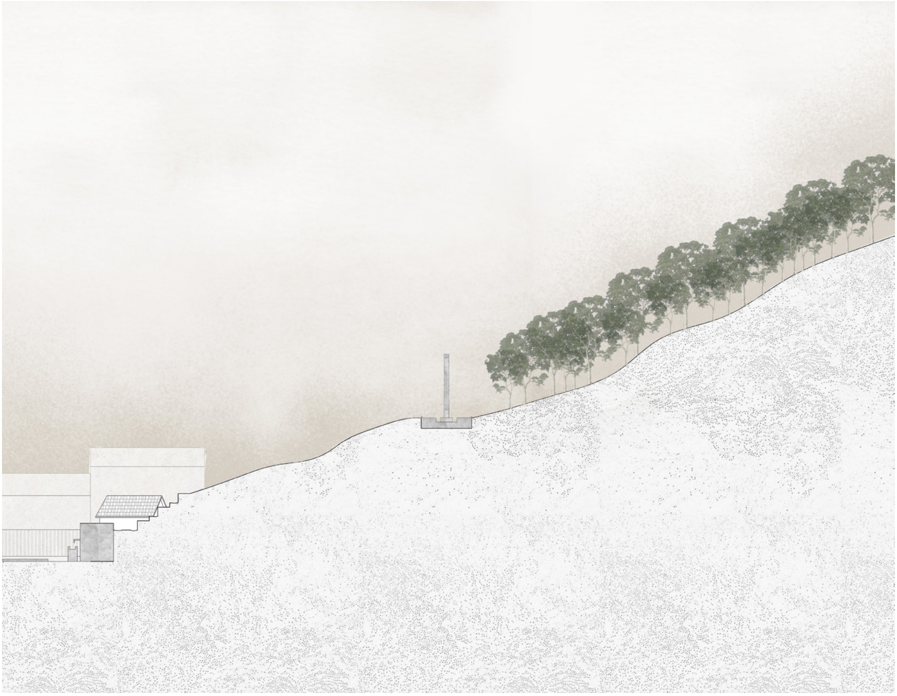
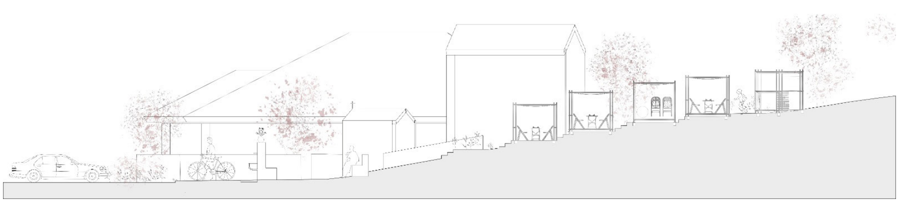


BEYOND THE WELL

The well and roadside cross from Satul Banului are located in an important point and fulfill a vital role in the community, that's why we come with a reinterpretation of the ensemble that works propitiously.

Located on the hill that shelters them, this project proposes a reinvention that pays homage to ancestral traditions. In the village, in the past, in front of the old inn, people sold their products at fairs. In our vision, this place turns into a lively market, crowned by a children's playground.

Above the well, we created a circular meeting space where the priest can hold services on holy days. This architectural revival not only pays homage to traditions, but also becomes a vibrant community center where past and present meet in harmony.



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