

³ In order to prevent mistaken understanding by numerous representatives of the expert public, here I specially emphasise that comprehensive protection of settlement and building heritage in planning or development, doesn't imply the archaic interpretation of particular development or architectural design. Neither does it imply the protection of built structures co-creating identity in an unchangeable archaic form. The latter of course doesn't imply especially valuable urban and architectural heritage, that have after expert evaluation been granted the special status of cultural heritage, and are maintained and restored under specific conditions (Law on the protection of cultural heritage, Official bulletin, No. 7, dated 5. 2. 1999).

Pictures

Picture 1: According to directives concerning protection, areas of »dispersed settlement« have no qualities. They occupy too much open spaces, traffic and communal infrastructure is irrational and expensive and often poorly executed, thus directly destroying natural resources. Because of their poorly thought out setting, layout or unprofessional use of material and poor construction, particular homes offering a high living standard are spatially irrational and wasteful (two photos).

Picture 2: »the logic of traditional construction, stemming from specific local conditions is in its primeval form a consequence of thorough reflection and is thus rational even today. On the contrary, almost all of new development is unimaginative and irrational in all its aspects, i.e. spatial disposition, plot organisation, organisation of modern homesteads and selection of material. We can easily establish that numerous new development isn't technologically advanced« (Koželj, J., Round table discussion: Why is authentic architecture in the Kras region disappearing, Kras magazine, April-May 1999, No. 32–33) (two photos).

Picture 3: At present more than half the Slovenian population (50,5 %) live in urban areas. Urban areas are the most polluted regional ecosystems and the pollution of air and water is worst. Other manifestations of urban pollution are also the pollution of soil, noise etc. (Pirc Velkavrh Anita, The environment in Slovenia in 1996, Ljubljana 1999, pp. 30).

Picture 4: »Professional and public estimates point out changes and growth of urban settlements are achieved at the cost of traditional urban and landscape identities« (from Pogačnik, A., Urban image is also important; Cities and urbanisation, No. 3/1999; Ljubljana 1999). From the description of conditions we can establish, that the present structure and image of settlements are created by processes following sub-urbanisation, increase of services and use of motor vehicles, as well as spontaneous market mechanisms,

Picture 5: According to analyses of architectural composition and applied research on particular typical architecture in Slovenian regions, we can conclude that all of them are harmonious (based on simultaneous symmetrical relations – relations of rhythm, size and proportions) and sensible (layouts adapted to work and space and their translation to the façade). All buildings whatever the material used (stone, timber or brick), disposition (on a plain or slope), size (three-, four- or multi-cellular; single- or multi-storeyed), richness of style etc., are all built according to general measures of architectural design. They are a consequence

of anthropometric ratios of the human body similar to the system of harmonious relations, developed by Le Corbusier, and relate to the basic dimensions of the human body.

Picture 6: Because of all its advantages, prefabricated construction should be developed into the part of the construction industry, that would be promoted as the qualitative example for development of new urban areas and other smaller settlements.

This is a task for architects, employed by developers (bad architecture, that results in poorly organised and unplanned new urban areas is in most cases a result of »self-help«, usually ignoring the provisions in a building permit). Planners (designers) of prefabricated homes put on the market, should be the first in respecting and fulfilling new guidelines of the sustainable development philosophy, even in the education of users. Their sales methods do have immense influence! Unfortunately many experts have discovered that prefabricated construction in the prevailing architectural image is and remains the development that only aggravates the chaotic image of our settlements!

Picture 7: Proof and stimuli that the noted guidelines can be implemented, are seen on the prefabricated building designed by architect Marjan Suša, according to principles and directives of »sustainable« development, built by the Slovenian producer of prefabricated homes Kager from Ptuj.

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Tomaž NOVLJAN

Underground spaces/ cybernetic spaces

Cybernetic space: mutual hallucination, experienced daily by billions of computer operators of all nations, children learning new mathematical expressions ... Graphic presentation of abstract data bases from each and every computer of humanity. Unbelievable complexity. Light streams, spreading through the non-space of intellect, swarms and managed clusters of data. The distant lights of a metropolis ...

William Gibson, Neuromancer, 1984

1. Introduction

In known history of human settlement and even nowadays, the term underground contains the attributes mystery, sanctity, darkness, social unacceptability, generally it is an environment unsuitable for life. Compared to the World above it can be understood with the basic duality. It resembles the relationship from Plato's understanding of rational versus irrational or the ancient Chinese philosophy of I Ching – Yin and Yang, where the earth embodies the feminine principle Yin, compared to the celestial male principle Yang (Walter, 1994).

In general everything that represents depth, darkness, enclosure, also carries the tone of mystery, eternity and potential danger, at least while based on mere results of visual perception and ignoring knowledge about a subject as a conglomerate of mutually and logically connected, understandable and presented information. On the other hand (Chinese philosophy), the celestial dome (during daylight) represents all knowledge. Of course, only until we penetrate the blue sky and encounter the black mysterious depth of space, whose phenomenon were visually noted and used as the basis for measuring time, and in certain cases even in ancient times, to design and orient buildings. In short, the mentioned »rational« part appears only as a paragraph between the »irrational« subterranean (submerged) underneath and still cosmic above. Technology, complemented by all industrial revolutions since the 18th century and continuous evolution, had at first enabled humanity to transgress deeper, beyond the limits of knowledge, i.e. underground and underwater. Lately the quest continues even beyond the upper limits, to the end of space, followed by recognition, that the field of ignorance extends even further, despite all measurements based on known mathematical and physical principles.

1.1 What space can be understood as subterranean?

The context of underground spaces doesn't imply its understanding only as a space where the surface layer of soil coincides with its roof construction (body). They are also underground spaces, just below the surface, with direct access to the surface, as can be proved by historical and present examples (China, 2000 BC till today).

Subterranean space can be generally defined as space that complies with one of the mentioned conditions:

- it has no visual contact with the surface;
- it has no direct functional connection with the surface,
- its dimensions enable basic life supporting functions,
- life-supporting conditions are ensured by/even primitive) technology.

Historically the genesis of underground places includes spiritual, military and other possibilities (necropolis, catacombs, fortresses etc.). They have predominantly static functional layouts, communication needs and emphasised linear spatial components (emergency exits), warehousing, water retention (reservoirs), supply or drainage (potable water and sewers) with connected maintenance spaces, needs for exploiting natural resources (mines) and protection in calamities (war etc.). In modern times, especially in the vacated above mentioned places, they appear with new functions, such as museums, sports facilities, cultural objects, warehouses for dangerous waste matter, while transportation spaces are tied to other service activities.

2. The physical/cybernetic character of subterranean city places

In (contemporary) urban ensembles unhindered functioning on the »surface« is increasingly dependent on unhindered functioning in their underground space. Most infrastructures have been removed directly or deeper below the street level, thus avoiding the use of precious (and expensive) surfaces. The influence of atmospheric conditions on their unhindered operation is thus diminished significantly.

Underground urban spaces can be divided into two groups:

1. **Physical spaces**, completely three-dimensional and measurable, where the user is present most of the time and uses them directly. They are:
 - places directly or indirectly connected to the public transportation system of underground railroads: passenger platforms, passages, crossroads etc., tied to (possible) other programmes and service activities;
 - parking garages, where efficient use of space and security measures are most important;
 - tunnels, where the goal is efficient and unhindered passage of vehicles with security measures in calamities;
 - culture, sports and spiritual facilities, often used to revitalise spaces whose former function was different (warehouses, shelters...).
2. **Cyberspaces**¹, where physical and non-physical transport (communication) occurs are:
 - supply of life-supporting goods (water, energy) and transfer of data in digital form (telephone, data networks – internet, television);
 - spaces, needed for the maintenance of all the above mentioned uses, but are not in permanent use.

3. Underground space/ the technical security aspect

Underground spaces can be understood as spaces in a potentially aggressive environment, thus technical standards in planning, construction and use are much more rigid or strict. The most important difference between usual spaces and spaces in an aggressive environment is, that functioning of the latter is conditioned by high technology and products that facilitate adequate ventilation, lighting, heating, cooling, transport and preventive measures. They ensure the safety of users and equipment against potential dangers and their direct or indirect consequences:

- **Fire** is the most dangerous possible accident in underground spaces, because of the numerous factors that can cause it (faulty electrical wiring, poor maintenance of equipment, careless users, traffic accidents etc.), rapid spreading (higher air circulation because of ventilation), indirect effects of poor visibility (disorientation and panic of those affected) and toxic contents of smoke (possible cause of poisoning or suffocation).²
- **Flooding** as an acute possible calamity is predictable and has to be dealt with in the planning phase, as well as during construction itself. During the use of such underground spaces, preventive actions and constant drainage can alleviate or eliminate possible dangers.
- **Appearance and explosion of methane** is dangerous mainly during construction and simultaneously poor ventilation.
- **Traffic accidents** as a consequence of collision or derailment (mainly in tunnels) are relatively rare, possible dangerous zones or areas (crossroads, junctions etc.) are diminished to the highest possible level, road traffic signalisation is emphasised while management and control of rail traffic is almost completely automated.

Among the other potential dangers that endanger underground spaces in public use are: effects of earthquakes, flooding by surface water through the entrances/exits, terrorist activity, collapse caused by mistakes in the planning, construction phase etc.

Building of new underground spaces and rehabilitation of existing ones follows two main reasons:

- **New development** occurs as an answer to demands for faster/cheaper infrastructure connections within and between urban areas and simultaneous demands for diminishing ecological impacts on the environment. These are tunnels of all kinds, with linear, dynamic flow patterns. The other kind are spatially static built structures intended for warehousing goods and/or waste matter or temporary sheltering of people during calamities.
- **Rehabilitation** of underground spaces is emerging as a consequence of local and/or global events on the »surface«. Derelict shelters are changing into spaces for commercial and public civil use. In Europe Scandinavian countries are in the forefront, because of beneficial geological condition. Numerous underground cultural and sports facilities are being built, as well as all significant kinds of spatial surface alleviation, above all for parking in city centres. Spaces which were until recently used for water supply and sewage (Paris) or mining for coal or metal ore (Idrija, Velenje), are changing into museums of their history or profession.

3.1 Perception of underground space

Human perception of underground places is tied to perception of limited space – outer internal space (directly beyond the outer wall), reaching into the visually closed hard lithosphere, from which the virtual infinity and ephemeral biosphere don't extend. In the context of designing underground spaces, this fact should be observed. The scope and intensity of manipulating perception are technologically almost unlimited. Similarly the »projected« time spent by individuals in such a place is limited to the inevitable time of passage/voyage from point A to point B, maybe with a short time shift to satisfy ones physiological »input/output« or consumer needs. The basic question is, how to diminish subconsciously conditioned feelings of enclosure in a physically limited underground space, without the use of banal visual elements (directly transferred images of the outside) and establish an indirect link with attributes from the surface.

3.2 Structure, texture and colour

Structure, texture and colour are among the basic perceptual properties of any physical space. Structure of elements (construction or inner system, organisation) can be externally directly or indirectly perceived or hidden under a protective mantle of its coat. The latter is, artistically speaking, similar or different from the structure. Often the structure and texture differ at first glance. If however, in perception of a naturally or artificially created object, due respect is given to the dynamic factor, closeness or distance, then one could state, that texture and structure mutually exchange. For example a city seen from a height of a hundred kilometres is perceived only as a surface pattern, a texture different

from its surroundings. Gradual approach reveals the structure, based on a more or less orthogonal network of »strongest« linear elements or transport corridors, dividing the city into surfaces with different textures. Further approach reveals structures of more delicate communication and separate groups of volumes in the surface. Then, particular elements of roofing, whose surface at first appears as a texture and later, with increased magnification, as a crystalline structure, whereby each crystal has a typical texture ... all the way to the molecular or atomic structure.

Similarly as for structures, thus also for textures, under conditions of natural or artificial lighting, the presence of a coloured impression is a co-creator of any space. Under conditions of natural lighting colour depends on the properties of the viewed object reflecting a certain interval of the visual part of electromagnetic radiation – spectre³. If there is no natural light, as is the case in underground spaces, co-operation between artificial light and colour pigments can manipulate perception of a spatial quality with additive or subtractive processes, and if necessary correct those perceived by the human brain as negative. There arises a need to establish a pleasant colour environment by applying the properties of so called functional colours (Trstenjak, 1978) and combining static and dynamic colour impressions.

4. The fractal principle

The principle is known from mathematical literature and in the 70s named fractal by scientists. Objects that enable constant perception of new information, theoretically to infinity, whatever the distance they are viewed from. F. K. Musgrove explained the concept of fractal (as): »... geometrically complex objects, whose complexity through repetition of similar forms and different levels constantly increases« (Musgrove, 1994). Mathematicians discovered basic fractal geometrical forms in the 19th and early 20th century, but because of the complexity of mathematical operations, that only modern computer can cope with, they couldn't attempt the depths of unlimited iteration. Nevertheless, H. Von Koch, G. Julia, W. Sierpinski and others, established the mathematical foundation for contemporary understanding of natural and created artificial systems, either as clear artistic impressions or to analyse changes on the stock exchange and simulate natural phenomena in virtual spaces.

Fractals are an efficient mode of expression to describe forms and phenomena in nature. Of course they are not the absolute tool for describing all matter existing in nature, neither are they the only tool for creating artificial realistic images of nature. Simultaneously they are more and less, than what people want them to be. Fractal geometry is above all mathematics that doesn't demand knowledge about complicated equations, but only »infinite« iteration of simple equations.

4.1 Applying fractals

Quality of living environments, even underground urban places, manifests itself either as simple access (for functionally disabled people), sheltering in calamities, unhindered flow, high quality surfaces and pleasant climatic conditions. Besides the physical quality, the psychological com-

ponent of comfort – establishing a pleasant environment⁴ is also important. For this reason certain measures are proposed, i.e. to transfer particular elements saved in the human subconscious, such as structures, textures and colours, taken from the natural (or built-up) environment of the space above ground. These should be transformed by principles of fractal theory and transformed into stimulating patterns in the artificially created space, devoid of natural lighting⁵. For example, colour as a psychological corrective factor of an otherwise unpleasant place; texture as a perceptive instrument of surface correction and structure as a generator of artistic elements transformed from natural shapes, rhythms and composition. Coincidental rhythms of a vertically emphasised forest structure/texture, coincidental complexities of rock formation or the arcs formed by distant tree crowns, can be transformed by mathematical analysis into fractal numbers. These can then be implemented as keystones for artistic correction of artificially created underground places. The mentioned procedure could be termed as the algorithm of geometrical transformation of natural forms and their adaptation into the built environment, generating artistic expression in a relatively direct fashion.

In this case the tool is a fractal number, obtained by logarithms and by proceeding Van der Laans' modular scale (Bovill, 1996), representing the users interface for translation. Besides the mentioned method, a method of creating artistic expression exists that is based on principles of fractal objects, whatever the distance of the viewer from the building, thus enabling any level of magnification and providing a new, comprehensive artistic impression, information and legibility of details at different scales.

Thus the basic relations for perceiving the quality of form or composition are:

- long distance: perception of details in the large scale
- medium distance: perception of details in the medium scale
- short distance: details of the small scale become legible

Here respect has been given to the visual perception of structure, texture and colour/coloured light – quantities with a physical »static« prefix⁶, but also dynamic (actually moving) composition elements and sound recordings.

5. Conclusion

Physical underground places of the modern city are/will be hi-tech environments satisfying all technological and safety standards. Environments intended for physical and non-physical communication: transport of people and transfer of information in different modes. Places containing real and virtual elements will not be mere static spatial features, but will be capable of interactive mutual communication and communication with users – as a group or individuals. Spaces of underground connections and events are/will be given the character of cyberspaces, defined as virtual spaces, synergy of computer memory and computer networks, tele-communication networks and digital media. The earliest cybernetic space can be dated to 1830 when the telegraph was invented, enabling transport of data in the form of Morse code. The telegraph network soon became an international and in 1870 an intercontinental proto-cyber space. It was followed by the discovery of radio waves and the television signal, leading to the computer and

computer links, at first relying on the telephone network and later becoming an high technology autonomous system for exchanging and processing data. One could state, that the cybernetic space has become an appendage of the human nervous system, similarly as underground spaces have become an appendage of the surface (not only communication) system.

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Notes

- 1 The expression »cyberspace« is a neologism by cyberpunk writer William Gibson, described as a mutually connected mass of data bases, tele-communication ties and computer networks, that on the perceptual level establish a new space for human interaction and activity.
- 2 The expert report on the reasons and consequences of the fire in the Mont Blanc road tunnel from March 1999 states, that most human casualties were caused directly by suffocation and indirectly by panic. The report is taken from the conference proceedings from the 5th international conference on building tunnels and underground spaces, Ljubljana, 20.–22. September 2000.
- 3 With natural lighting one has to consider deflections caused by atmospheric conditions and the effect of possible neighbouring surfaces that don't reflect the same spectral interval.
- 4 Milié – a higher level of place, the real and spiritual World with particular characteristics surrounding humans.
- 5 Here one could establish a line up of environments according to the level of impact they »affect« on the user: 1. natural environment, 2. built-up environment on the surface, 3. underground built-up environment.
- 6 The property of mutual effects of two equal, not entirely complementary clean colour tones is known from the teachings of colour theory, whereby they simultaneously try to »push« each other to their complementary colours and often while doing so, change their actual colour value. The colour tones transform from a stabile relationship into an unstable dynamic vibration.

Pictures

Picture 1: Settlement of underground homes near Tungkwang, Honnan province, China.

Picture 2: Three-dimensional computer simulation of underground excavation, supported with hydro-geological data enables the use of real circumstances for planning and construction.

Picture 3: Model of an underground warehouse for low-and medium radioactive waste from the Loviisa nuclear power plant in Finland, built in 1996.

Picture 4: Vacated shelter near Helsinki, rehabilitated into a sports-recreation space.

Picture 5: Virtual landscape created with fractal distribution of points on a plain.

Picture 6: Transformation of natural rhythm with fractal numbers.

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