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BASIC PROBLEMS OF MAINTENANCE OF SELECTED BUILDING STRUCTURES

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Abstract
Many building elements are exposed to the influence of external environment, often very aggressive. Due to that such building elements should be protected in a special way. The outline of problems related with maintenance of building structures has been presented, taking into account the principles of sustainable building. Extra attention has been paid to the characteristics of local environment conditions. Requirements regarding structural-material solutions for structures, bases for diagnostic tests and the essence of repair and strengthening of buildings structures have been discussed as well.

Streszczenie
Wiele elementów budowlanych narażonych jest na wpływy środowiska zewnętrznego, często bardzo agresywnego. W związku z tym elementy takie powinny być chronione w sposób szczególny. W artykule zaprezentowano zarys problemów związanych z utrzymaniem konstrukcji budowlanych, biorąc pod uwagę zasady zrównoważonego budownictwa. Szczególną uwagę zwrócono na charakterystykę lokalnych warunków środowiskowych. Przedstawiono również: wymagania odnośnie rozwiązań strukturalno-materiałowych konstrukcji budowlanych, podstawy ich diagnostyki oraz istotę ich napraw i wzmocnień.

Keywords: **Durability; Maintenance of building structures; Repair and rehabilitations methods; Strengthening of structures; Sustainable building; Thermal insulation protecting.**

1. INTRODUCTION

Many building elements, due to their destination, are exposed to the influence of external environment, often very aggressive. Due to that such building elements should be protected in a special way. The monograph [10] is devoted to the issues of repairing and protecting concrete structures. The issues of repairing concrete structures in accordance with European standards were, among others, the subject of discussions during the conference „Jadwisin 2006" [11]. Because in excellent majority of cases we deal with structures made of concrete, the above mentioned publication may be useful for designing all sorts of repairs and reinforcements of the mentioned structures. Taking this all into account, this paper has been prepared in order to discuss more widely some issues, very important in my opinion. The outline of problems related with maintenance of building structures has been presented, taking into account the principles of sustainable housing [8], [22]. Extra attention has been paid to the characteristics of local environment conditions and to their influence on the response of selected building elements [6], [17], [19], [21], [26], [27], [30], [31]. Requirements regarding structural-material solutions for structures, bases for diagnostic tests and the essence of repair and strengthening of buildings structures were discussed as well.

2. PRINCIPLES OF SUSTAINABLE HOUSING

Satisfying the needs of society is possible thanks to such shaping of buildings that makes them friendly for the users. At the same time, they must not interfere with the surrounding natural environment in a considerable way and they must be acceptable from the point of view

of incurred expenditures [8]. Such a point of view is compliant with the principles

of sustainable development, in particular with the principles of sustainable housing. Moreover, such principles should not only be valid during the process of erecting new building facilities, but also during the process of maintenance of existing structures [8]. It is with contentment that one may observe the fact that this sort of approach is favoured by the entries of chapter 6, entitled: "Maintenance of structures" of the act of 7.07.1994 – Building Engineering Law [34].

The influence of building process on the environment begins the moment building works start, and it ceases the moment of dismantling of the facility and utilization of what is left of it. Such a process is commonly called technical life cycle of the structure and the assessment of the impact of this period of time on natural environment – Life Cycle Assessment [22]. In most cases the technical life-time run of the structure construction corresponds with durability and utilization period, justified technically and economically [22].

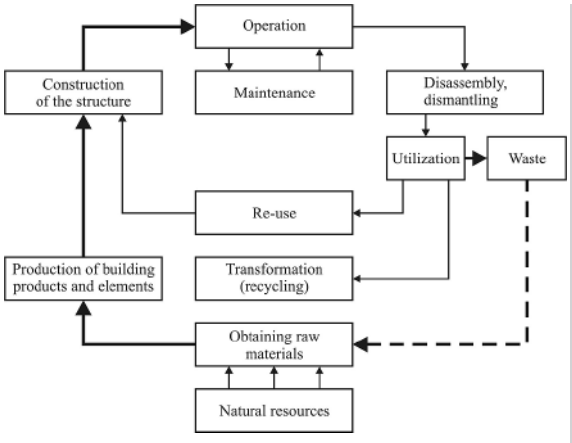

Figure 1.
Technical life cycle of building facility and product [22]

Each of the stages of technical life cycle of the structure is accompanied by the use of raw materials such as water or energy mediums. This is why the method of operation and maintenance of structures is not neutral to the environment. Taking all that into consideration, the statement of the author of the paper [22] seems to be correct – the assessment of technical life cycle of building product or facility may be a criterion of its impact on natural environment [22]. Fig. 1 presents the technical life cycle of building facility and product [22].

3. GENERAL CHARACTERISTICS OF ENVIRONMENT CONDITIONS-SELECTED PARAMETERS OF LOCAL CLIMATE

The term "climate" describes the average weather conditions resulting from observations carried out throughout tens of years, characteristic for the given area. By "weather" we understand a certain state of external atmosphere in a given moment, which determines the influence of meteorological factors occurring in a given place. The following are meteorological factors: solar radiation, air temperature, air pressure, air humidity, velocity and direction of wind as well as precipitations. The following are the factors describing climate: latitude, distribution of land and seas, height above the sea level, sea currents and land shape. Furthermore, depending on the land shape, air pollution, amount of reaching solar radiation intensity, specific movements of air, we may distinguish local climate from the climate of the surrounding area [4]-[6], [14]. Therefore, local climate is an effect of greater or smaller influence of local factors [7], [19].

Solar temperature of air is defined as hypothetic temperature of air outside the building, at which penetration of heat through non-insolated partition would be the same as resulting from insulation with actual temperature of external air. Solar temperature of external air may be determined from the pattern [15], [18], [20].

4. REQUIREMENTS REGARDING STRUCTURAL-MATERIAL SOLUTIONS FOR STRUCTURES

According to the European Union Directive [32] building materials should be characterized by such features that will assure that the facilities, in which

they will be installed, will meet the requirements referring to service features. The ability of a given material to meet the required functions during a determined period of time, in conditions of acting of determined factors, is called the durability.

The requirement of appropriate durability of structure is met if the construction fulfils its functions in terms of usability, load capacity and stability, during the whole planned period of using, without considerable decrease of its usability and with no excessive, unpredicted costs of maintenance [1], [9], [12], [23], [24], [28]. Usability features do not refer directly to materials. However, the materials should meet certain functions within the framework of the building facility.

The general requirements mentioned before are currently of key, pro-ecological importance. It may seem that these are experiences from recent years. Yet this is not the case. Vitruvius (note 1) already reached those conclusions in the 1st century B.C. His opinions in that domain are well illustrated by the scheme presenting the essence of designing, in the context of currently understood functions of engineer, architect and contractor, securing obtaining desired effects (*firmitas, venustas, utilitas* – fig. 2).

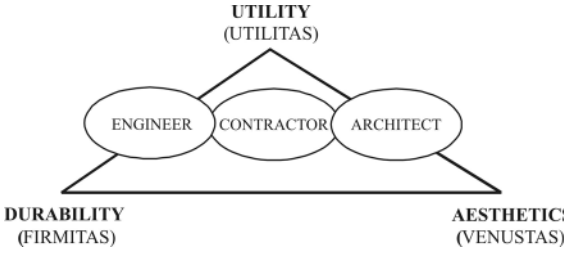

Figure 2.
The essence of designing building facilities according to Vitruvius (the drawing elaborated based on [13])

Taking the requirement of appropriate durability as the starting point, it seems that the essence of designing, presented in the scheme (fig. 2) may be used for application during the process of shaping the structure of analyzed building facilities.

5. BASES FOR DIAGNOSTIC TESTS

Building materials, which the building facilities are made of, operate in complex conditions of various destructive impacts. Among them the key ones are mechanical, chemical, electrical, biological impacts as well as radiation [29]. Fig. 3 [29] presents the scheme of destructive impacts. Destruction of materials may also occur as a result of the occurrence of numerous factors at the same time, which often causes the synergistic effect [6]. Single influences would not be enough to cause corrosion, and in total they cause quick destruction of the material, especially in moist environment [9], [12], [29].

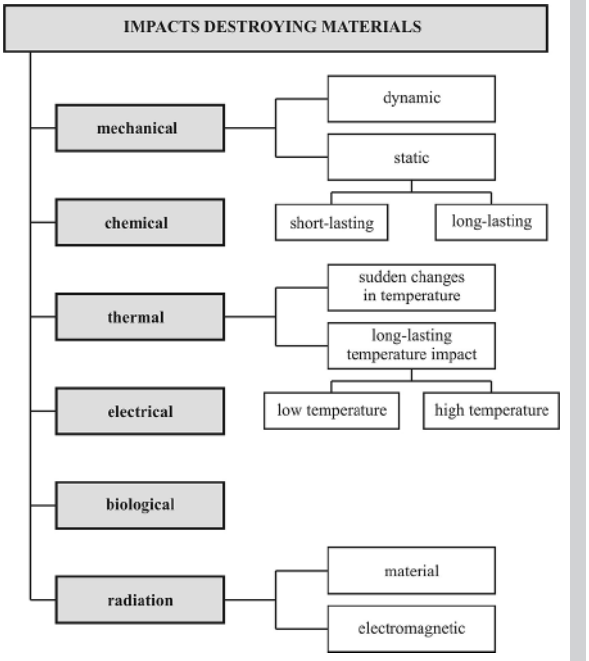

Figure 3.
Scheme of deterioration actions [29]

General principles of acting in assessing the condition of the existing structures are presented in the standard [33]. The scheme of assessing the condition of existing constructions, elaborated based on that standard, is presented in fig. 4 [33]. Detailed analysis of procedures included in this scheme allows for the conclusion that the general conditions of diagnosing building facilities, presented in the documents of WPPK Ustroń 1999 [25], are not inconsistent compared with those. Therefore, those principles [5] may be useful as auxiliary material for expert – diagnostic specialist.

Recently, a lot of attention is focused on to the issues of durability of building structures. The analyses concerning the principles of service life design has recently been presented by the author of the paper [2]. Service life design is the assumed period during which the construction or its part is to be used in the planned way, with assumed scope of maintenance,

but with no necessary repairs. The designed service life is determined by [2]:

- defining appropriate limit condition,
- number of service years,
- level of reliability in relation to non-exceeding of the assumed limit condition in the assumed time period.

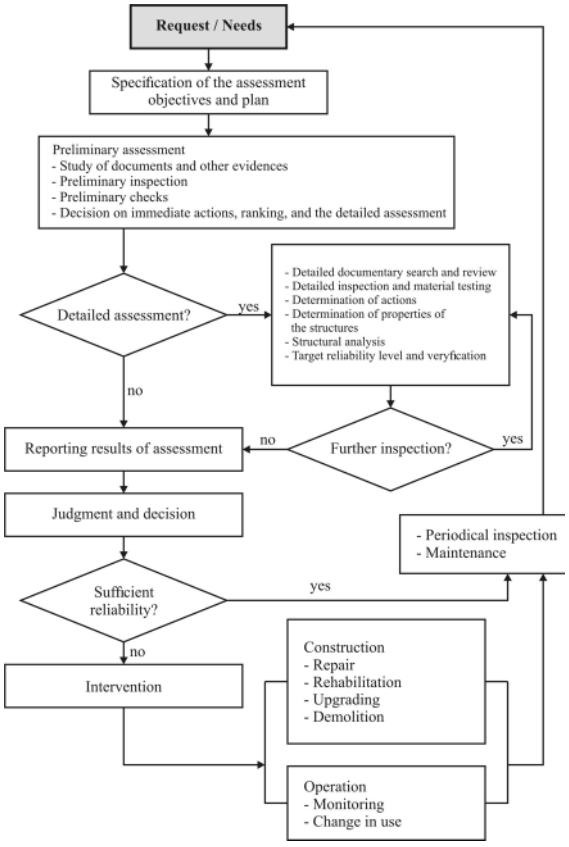

Figure 4.
Scheme of assessing the condition of existing structures. Elaborated basing on ISO/CD 13822 standards [33]

The design problems presented in the paper [2] for the period of service refer both to newly designed structures and to the assessment of existing structures – taking into particular consideration the remaining time of their service. This is a big challenge for Polish designers, as the author [2] remarks. The analysis concerning the probability of destroying the structure in the context of their designed service time will be required. Thus, it will be necessary to develop the concept of analyses of reliability and structure safety. These issues were presented for example in the paper [16] – almost 40 years ago.

6. THE ESSENCE OF REPAIR AND REINFORCEMENT OF BUILDING STRUCTURES

The goal of the building repair is complete or partial recovery of its service state, disturbed due to inappropriate execution or damage during operation. The following is distinguished according to EN 1504-3 standards [11]:

- non-construction repairs, not interfering with static operation of the building,
- construction repairs, comprising load-carrying elements of the structure related with interfering with its static operation.

The following works connected with restoring the appropriate condition of the structure are distinguished in the paper [10]:

- repair,
- reinforcement,
- stabilization.

The repair, according to the author of the paper [3] means restoring original load capacity of the structure. The reinforcement means increasing the load capacity of the facility above the designed state. The stabilization is understood as a set of actions aiming at stopping the development of undesired situation [10].

In the figures 5÷9 example methods of repair and temporary protection of "old" Basilica Sanctuary of God's Mother from Guadalupe in Mexico City are presented [35].

Figure 5.
General view of „old" Basilica in Mexico City

Figure 6.
Trace of repair of facade masonry of „old" Basilica [35]

Figure 7.
Temporary protection of arch [35]

Figure 8.
Temporary protection of arch [35]

Figure 9.
Steel ties-temporary protections of pillars [35]

Reinforcement may be passive or active. Passive reinforcement takes place when used material fills the planned space, though it is not involved actively in the cooperation. This also increases the load capacity or stiffness of reinforced element. The reinforced construction "waits" for the occurrence of forces from added loads [3]. Reinforcing using active method consists in modifying static schema or introducing compressing forces to the structure. Active reinforcement "participates" in transmitting the loads "from the beginning" [3].

The rule of compatibility, introduced during International Colloquium – Material Engineering and Restoration should be rigorously respected during repairs. This rule is described in detail in the paper [10]. One should repair similar – similar both in material terms and in terms of technical features. "New" and "old" material should meet the requirements of compatibility in terms of [10]: elasticity, creep, thermal dilatation and shrinkage during hardening process.

7. CONCLUSIONS

Issues of maintaining structures have recently been exposed quite often, especially in media. This probably results, although I hope this is not the only reason, from the traumatic tragedy resulting from building catastrophe in January this year. Appropriate maintenance of structure not only is the obligation of the owner; it must also be the process that may contribute in the future to achieving concrete results, even financial ones.

The paper presents the outline of problems related to maintaining building structures, taking into consideration the principles of sustainable building engineering. I have paid extra attention to characteristics of local environment conditions and their impact on building facilities.

Extra attention has been paid to thermal influences, often neglected and not taken into account in static-strength analysis of building. Requirements regarding structural-material solutions for structures, bases for diagnostic tests and the essence of repair and strengthening of buildings structures were discussed as well.

NOTE 1

Vitruvius, 1st century B.C. – Roman architect and military engineer. In Octavian Augustus' service; the author of "Of Architecture" – the only preserved ancient treatise that had tremendous influence on the art of renaissance and on development of modern architecture theory (Popular Encyclopaedia PWN 1991).

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