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EXPERIENCE OF EXPERT ACTIVITY

(ANALYSIS OF COMPLEX PROBLEMS ASSUMING VARIOUS DIAGNOSTIC MEANS)

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Abstract

Difficulties in expert activity are introduced in the first section of the paper. The second section gives examples of expert activity, which integrates the knowledge of several professional fields. As an illustration, the aspects of preparing expert opinions on buildings with damage caused by water and on pavements of small elements in large-surface parking roofs are discussed. The paper concludes with thoughts on the development of expert activity and its arising interdisciplinary features.

Keywords: expert activity, building construction and related fields, damage caused by water, pavement defects in parking roofs.

1. Difficulties in Expert Activity

Experts whose activity involves identifying (diagnosing) construction faults, specifying the proper repair methods and preparing the repair design documentation, encounter special difficulties today. Assuming that great care is taken, which is a requirement in this field, the major obstacles in the way of the correct solution of the problem, in case of buildings of *conventional construction technology* (built three to four decades ago or earlier), are as follows:

- Difficulties occur in obtaining the original plans.
- Data on technical properties of the period materials applied at construction, including the evolution characteristics of these properties (rheology), and on the employed construction technology, may be lacking.
- In case of buildings of multiple reconstruction, no sufficient documentation of applied materials and construction technology is available.
- Faulty structural elements may be covered by several other structures.
- There are no non-destructive diagnostic methods that could be applied in occupied, furnished buildings, and there is no solvent demand for costly instrumental examination, which limits its scope of application.
- Expert activity may cause inconvenience, and people concerned tend to retain information and data because they assume that would insult their interests, and fail to cooperate.

In case of buildings of *advanced construction methods* (built recently), the main difficulties in expert activity are as follows:

- Market economy generated an oversupply of construction materials, and data of technical approval certificates are not regularly updated.
- Construction materials of intensive building physical properties may suffer damage
  - in case of defective construction technology, and
  - in case of the faulty action of construction workers who have insufficient knowledge of material properties and the specified construction technology.

Construction industry is a market player that acts for *the fastest possible capital recovery*, therefore it agrees to tight deadlines in order to get a commission, which may require reducing the time span of certain technological processes. Having no thorough knowledge of the consequences of applying materials of intensive building physical properties in a construction environment of higher moisture content than specified in laboratory circumstances may lead to inappropriate material behaviour.

Experts encounter difficulties due to the often *defective activity of quality control and quality assurance authorities*, which is characteristic of our country.

- The approval certificates of certain materials and products sometimes fail to include a number of building physical parameters, which can be found in standards on building physics and which should always be specified (e.g. data on moisture technique of elements of masonry structures of different geometry but of the same material etc.).
- Approval certificates do not include sorption isothermal curves, i.e. diagrams on the variation in the moisture absorption capacity of materials, which is related to moisture saturation.
- It is hard to obtain diagrams on the variation in the specific thermal conductivity coefficient (λ) and the vapour conductivity resistance (ρ) of certain construction materials, being in a moisture condition that is different from the one assumed under laboratory circumstances, and they are not available in the Hungarian and foreign technical literature either.
- Software conducting building physical checks and designs according to the Hungarian building physics standard, which can handle the combined effect of variation in the specific thermal conductivity coefficient (λ) and the vapour conductivity resistance (ρ) due to the variation in moisture content, is not yet available on the software market. In expert activity, it is not practicable to employ foreign software which can mathematically handle the above-described building physical problems, since they cost extremely lot (app. 5000-6000 Euros) and due to the lacking material properties to be applied in Hungary.

- Softwares which can mathematically model the evolution of thermal and moisture conditions of two- and three-dimensional heat bridges, based on a finite element method, and which can conduct checks and designs, are not easily available either.

In case of buildings built recently, the problem that *no sufficient documentation is available* also occurs, although the reason for that is different. The related problems are as follows:

- The original working drawings do not have sufficient details.
- Derivations from the working drawings are not recorded in sufficient detail.
- In case a building is sold for business purpose, the customer, i.e. the owner of the building under construction, or the entrepreneur, who finances the construction as an investor, organises construction work (within his scope of activities) and finally sells the building, may not hand over written documents and drawings on the technical parameters of the building, or may fail to hand over the entire documentation, to the purchaser. The reason for that may be that any of the mentioned parties are not well-informed about laws related to construction, or, at the extreme, there can be an intention to deceive the other party on purpose.

A regular inspection, initiated by an inspection authority that is independent of market demand and supply, does not involve checking whether material properties of certain materials and products (specified by *approval certificates*) are ensured at production, and the findings of the inspection are not published and made available for professionals. This leads to inefficient quality assurance mainly in production, and the fear of loosing market does not control production either.

State agancies and specialised administrative departments, who communicate social expectations to the profession, so far do not seem to have a well-developed strategy nor an intention to eliminate the above-described shortcomings and irregularities.

2. Examples of Expert Activities Integrating a Knowledge of Many Fields

2.1. Preparing Expert Opinions on Buildings with Damage Caused by Water

In the past 10–15 years, there was a growing number of cases where the expert task was to identify the cause of the damage of building structures, which are or are not in contact with the soil, where there was seemingly no reason for the defectiveness of waterproofing. Examinations found that some materials of special moisture physical properties are of significance, since they can bind a considerable mass percent of the moisture content of air if they are present in construction materials in a few tenths of volume per cent, as a foreign matter. These materials, which occur in nature and can get into construction materials due to human activity, are the so-called saline residues such as sulphate (SO_4^{2-}), chloride (Cl^-) and nitrate (NO_3^-), which feature special 'hygroscopic' characteristics and can get into masonry structures in a water solution by way of capillarity. As the temperature of the environment changes, the solution flows towards structural boundary surfaces of lower partial moisture pressure and it gradually loses its moisture content. Following crystallisation, saline residues remain in the capillary tubes of external structural layers, and they constantly reduce their evaporation potential. Crystallisation triturate and thus damage construction materials at a speed that depends on the size of saline crystals and the pores of the material, and on the mechanical strength of the material. This process can become dangerous to the concerned building structure due to the fact that these saline residues cannot leave the masonry structure, and that they can again bind humidity from the air and form a solution if climatic conditions change (e.g. the temperature drops or the relative humidity increases). At a shallow observation, it seems to be a soaking or wetting phenomenon on the surface of the structure. What makes this process extremely dangerous is that the successions of drying $\rightarrow$ crystal pressure $\rightarrow$ mechanic break-up and hydration $\rightarrow$ solution formation $\rightarrow$ soaking are self-maintaining, and they take place every year at a fluctuating intensity. For the operation of this self-maintaining process, it is enough that 0.15–0.20 mass percent of hygroscopic saline residues gets into the masonry structure and remains there. It is highly dangerous if saline content increases up to 1.5–2 mass percent of the construction material, since the wall section may become saturated at this concentration and the core of the wall may constantly remain in a state close to saturation. Reasons for the accumulation of saline components, which are a danger to structures, are as follows: a defective waterproofing lets the structure absorb ground moisture, which forms a solution that can carry saline components; the gradually increasing moisture content dissolves chemical compounds (primarily calcium sulphate) from construction materials; and detergent residues (chloride and nitrate) and excrement (nitrate and nitrite) may be released from a defective building engineering system, e.g. the sanitary system. A further risk is the chloride ions of sodium and calcium chloride (which are used for de-icing pavements) which can be absorbed by building structures.

Expert examinations and repair proposals should include not only the identification of the reasons for damage on the internal or external surface of structures and the preparation of a repair proposal, but also the disclosure of all the possible reasons for damage around the building and the concerned structure, and the preparation of a proposal to eliminate them.

It is essential to take great care at diagnostics as the costs of different technological solutions vary widely, and it is also very important to carefully consider all the aspects of the technically required and satisfactory repair method.

The phenomenon described in previous paragraphs occurred in the structures of the *New Synagogue in Szeged*, which suffered damage caused by water. The repair proposals were based on findings of an expert examination in the summer of 1999. Similar expert methods were applied at the moisture diagnostic examination and repair process of the *Nádasdy Manor* in Nádasladány, the *Károlyi Manor* in Fehérvárcsurgó, the *Fáy Manor* in Fáj and the *Becsky Mansion* in Komlódtótfalu.

2.2. Preparation of Expert Opinions on Pavements of Small Elements in Large-surface Parking Roofs

The subject of the examination was the flat roof of a shopping centre (of app. 3376 m^2), with thermally insulated roof layers, paved with SEMMELROCK flagstones, and its two-storey parking garage (of app. 2016 m^2) with no thermal insulation and no roof. The pavement of both areas suffered damage: the concrete flagstones and sink-holes were displaced from their projected, original position and the floor structure of the parking garage leaked. The expert task was to find the reasons for the damage and to select a repair technology of optimal expenditure.

After the review of the original design documentation on waterproofing, the following remarks were made on its technical content, and the following deficiencies were found:

- In the layer system, no separation course (i.e. shifting layer) between the TROCAL rainwater-proof course and the tapered concrete was specified.
- In the layer system mailed later, there was no bedding course sand under flagstones and no filter layer that would prevent pointing sand from getting driven away by water.
- In the eastern section, in the two-storey parking garage with no thermal insulation, two sink-holes were installed instead of the projected one sink-hole, that is twice as many. In case of gravitational rainwater drainage, the cross-sectional area of a sink-hole per 1 m^2 roof surface is 0.8–1.5 cm^2 according to the relevant Hungarian Standard in force. Obviously, this requirement can only be satisfied with two sink-holes. (The roof surface is $17 \times 24 = 408$ m^2, and the sectional area of a sink-hole of 150 mm nominal diameter is 176 cm^2.) Note that the area to be drained should be divided into a maximum of 200 m^2 units according to Hungarian recommendations.
- The surface area to be drained by a supposedly machine-sucked sink-hole of 56 mm nominal diameter, type GEBERIT PLUVIA, is $16 \times 18 = 288$ m^2. This ratio of the sectional area of a sink-hole to roof surface is not satisfactory in case of gravitational rainwater drainage. Because of the defects, it is proposed that the rainwater drainage system should be checked considering mechanical aspects.

Concluding assessment of the results of building constructional, geotechnical and statical examinations:

Based on the handing-over design documentation provided by the Client, and the layer systems faxed us by the Designer, it was found that the layer system projected by the Designer was partly different from the one generally applied in such cases. The main differences are as follows:

- Concrete flagstones were not laid in a 2–3-cm-thick bedding course of angular-grained, stream sand, which is generally applied in such cases.
- There was no geotextile filter layer designed between the bedding courses of crushed stone and sand.

These findings are recorded in the examination reports on exploration.

- For the above-mentioned reasons (mainly because of the lacking geotextile filter layer), around sink-holes and in lower areas of intense rainwater stream, the pointing sand was driven out of flagstone joints by water, and it got in between grains of the crushed stone bedding course. As pointing sand was partially or completely driven out of flagstone joints, it exerted a reduced or no lateral supporting force on flagstones. Thus, vehicle traffic (brake and acceleration forces) could produce a 0–75 mm horizontal displacement in flagstones. Since the friction coefficient between the concrete flagstones and the bedding course (considering a bedding with or without sand contamination), between the protecting and separating geotextile layer and the bedding course, and between the geotextile layer and the rainwater-proof course, is app. $\tan 39°$ to $\tan 35°$, it is obvious that the waterproofing course, laid as a sheet, will have a considerable displacement upon the protective and separating layer below it, when the lateral supporting force decreased to zero. Around sink-holes, where the rainwater-proof course was fixed at spots, the waterproofing course reached its ultimate strain (even if it was as high as 200–300% both longitudinally and transversely in case of the applied material) and it failed. (The waterproofing course would not have suffered such damage if it had been glued on its entire surface.)

Without removing the rainwater-proof course, it was not possible to inspect the layers underneath.

Concerning the layer system, it was observed that the layers found in the exploration, until reaching the top surface of the rainwater-proof course, basically correspond to the layers specified by the plan. Note that instead of the projected crushed gravel (SiO_2) bedding, magnesium carbonate (crushed dolomite) was applied, which is of common use, and the application of which is approved, as it does not affect the load distributing role of the bedding. In a thorough examination of construction materials, it was observed that the applied materials, excluding the bedding material, and their physical properties correspond to the type of materials specified by the plan and to values to be found in application handbooks, respectively.

The main reason for the damage of the pavement was that the pointing sand was driven away by water, and thus it did not provide flagstones with lateral support anymore. This was proved by physical calculations, based on material properties obtained from geotechnical examinations.

Calculations analysed the effect of the acceleration and deceleration of a larger (20 kN) and a smaller (10 kN) passenger car on the paving elements without lateral support. Dynamic effects at rolling and skidding braking was taken into account in the analysis.

In both cases and in case of both cars, the total weight of the car and the total brake/acceleration force were assumed to be uniformly distributed among the four wheels. Moreover, it was assumed that the adhering surfaces of the wheels were supported by four flagstones, assumed to be perfectly rigid, which transfer a vertical mass force and a brake/acceleration force to the crushed stone bedding. The calculations have proved that the bedding, under the flagstones with no lateral support, suffers base failure in case of the deceleration/acceleration of both cars, and both in case of rolling braking (producing smaller horizontal decelerating/accelerating force) and skidding braking (producing larger horizontal force). This implies that, in both cases, the design stress on the surface of the bedding is app. ten times more than its failure stress.

However, flagstones do not skid on the bedding surface in case of rolling braking, while they can have a horizontal displacement in case of skidding braking. The type of damage proved this concept.

Repair proposals for the pavement of the two roofs were prepared on the basis of the expert opinion, and repair work has already been completed.

3. Development of Expert Activity and its Arising Interdisciplinary Features

In expert activity, it is an essential requirement to know all the possible construction materials and construction technologies, and to regularly check whether new materials appear on the construction market. Due to an increasing level of convenience and high standards in architecture, and the application of materials of intensive building physical properties, it is necessary to have a knowledge of specialised fields related to building diagnostics and to have an overall view of interdisciplinary fields (e.g. building construction, construction materials, geology, construction chemistry, building physics, construction mechanics, building engineering etc.).

In case of the expert task introduced in Section 2.1, the establishment of a new specialised field was fostered by the fact that a knowledge of some specialised fields was required, which may establish further new fields in the future. (The overall knowledge of building construction, finishing works and construction chemistry facilitated the establishment of the field called ‘moisture diagnostics’.)

In the second expert activity case discussed in Section 2.2, the task of identifying the reasons for a damage, which seemed to be simple, required the cooperation of experts of four specialised fields (construction materials, geotechnics, finishing works and traffic technics) and it was also essential that they have an overall knowledge of each other’s field.