SURVEYING IN ÓBUDA EXCAVATIONS

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Branches of industry and science where geodesy and related knowledge find an application include archaeology and monuments preservation. There is, however, a scarcity of publications on geodesy in archaeology. The more interesting seems to be an account of geodesy aspects of archaeological excavations in *Óbuda*, now a district of *Budapest*.

The first professional archaeological excavation in Hungary was made exactly in Óbuda, near the actual Flórián tér, where in 1778 *István Schönvisner* excavated ruins of a Roman bath known actually to have belonged to the Roman castrum in *Aquincum*. Half a century later, excavations were undertaken in the area of the civil town Aquincum near the actual Aquincum museum, and another half a century later, track construction of the Szentendre district railways detected a Roman aqueduct connecting these two spots, highlighting archaeological excavations. By the turn of the century, the search for *Fehéregyháza*, mediaeval predecessor of Óbuda, and for the tomb of conquering *Árpád*, and in general, investigation of mediaeval settlement structures came to the foreground; planned, wide-range archeological research in Óbuda dates from the World War I years. Since then, archaeological work was multifaceted, purposeful, but concentrated at given spots. Most sensational excavations of this period are the amphitheatrum in Nagyszombat-utca, the palace of Roman proconsuls in the Shipyard Island, the mosaic-decorated Villa Herculea in Meggyfa utca, and the Aquincum ruin field itself, illustrative of grandeur and life of the Roman civilian town of quondam. By the early 'seventies, the impact of the construction of a new residential estate in Óbuda involved forced excavations, so-called rescue excavations by the dozens, and later by the hundreds, parallel to earthworks of the construction, as a constant, regular work of archaeologists of the *Budapest Historical Museum* [1] (Fig. 1).

Except for the latest ones, drawings, location plans, maps on excavation results are rather heterogeneous both in purport and in form.

No written documents, technical descriptions are available on the technology of surveying the archeological objects, but even these works seem to be no geodesic surveyings, with a few exceptions. The more demanding of them were made in a local co-ordinate system consisting of setting out a 5 to 50 m mesh net over the excavation area, to the corner points of which the form points of the terrain objects to be surveyed were fixed by distance-distance intersection, a method current in archaeology surveying. In other cases, even this control point net was missing, and the archaeologist or his tracer fixed the excavated object by simply assessing geometrical conditions, making use of direct linear measurements.

Fig. 1. Detail of the wall of the ambulatory of the Clarissan nunnery from the 14th century (Excavated by Dr. Hertha Bertalan) (By courtesy Budapest Historical Museum)

Several location plans were left from the excavations scattered over the Óbuda territory in the first half of this century, fixing the excavation and its findings to a one-time building, well or tree in a yard. These drawings are useless or require reservations in actual archaeological topographical research. The situation is somewhat better for drawings indicating the one-time topographical lot number or containing a figure likely to connect them with actual maps through cadastral maps of the age — at a lesser or greater accuracy.

No radical change in the technology of survey and mapping intervened in the 'thirties either, when uniform urban survey of Budapest was launched; little drawing matter clearly exhibiting numerical bases, belonging to the urban survey system, is found. With the newly arising requirement of plotting the multiplying find spots in a uniform system, urban survey maps begin to be applied so that the location plans are traced on map magnifications. Since, however, the applied basic material is mostly not defined, its origin is a guess-work, and so is the scale.

The drawings are difficult to interpret because of the lack of unity in style and workmanship. The missing legend, the varying niveau and manner of drawings, and the wanton scale are often deceiving the future user for whom it would be the simplest to get informed of the importance and size of an archaeological work from drawings of documentation. One may wonder if the drawings reflect the tracer's personality rather than the archaeological importance of excavation. This is a rather extended opinion [2]. Scale may either be not indicated or replaced by a linear scale. Drawing matter points to the interest of archaeology more in so-called vertical sections — drawings made of vertical earthen walls, "witnessing walls" — than in ground plan of the excavation area complete with elevation data, let alone in the unambiguous and complete indication of section sites in location plans.

These remarks are valid for the geodesic aspects of the available survey plans pertaining to the archaeological excavations in Óbuda.

Autumn 1973, rate of the reconstruction of the Óbuda residential estate imposed rescue excavations parallel with earthworks far beyond the capacity of experts at the *Budapest Historical Museum* responsible for the excavation. Now, participation in survey and mapping by the *Department of Surveying, Technical University, Budapest*, became imperative.

Preliminary investigations made clear that in Óbuda — at least by that time — archaeologists did not work according to an excavation plan but place and schedule of their work exclusively depended on the progress of earthworks of the housing project. Surveyors found the immediate request to be self-intended that archaeological objects turning up separated in time and in place in rescue excavations and in subsequent normal excavations should be surveyed and mapped so that sketches permit later to reconstruct smaller or greater entities, and serve as bases for planning and setting out excavations for a given purpose.

It seemed self-intended to do the survey in one or other of geodetic co-ordinate systems applied in Hungary. Among them, the most universal in Budapest is the Budapest system of stereographic projection, applied, in addition to urban survey maps of Budapest, for development plans of the Óbuda residential estate, and also for the registration of public services, hence in all fields likely to be affected by archaeologists. Thus, it has been decided to apply the Budapest stereographic co-ordinate system and the pertaining maps for surveys and mapping in this scope.

The elevation data involved more incertainty. No doubt, a uniform reference had to be chosen for the extended excavation area, but this could be either a local reference, or the universally applied, so-called Baltic altitude referred to the mean Baltic sea level, or the Adriatic altitude previously applied in Hungary. Considering that most of the earlier archaeological surveys referred to Adriatic (Nadap) altitudes absolutely to be referred to now, elevation data were decided to refer to Adriatic altitudes, calling for extreme care in working connections with designers and constructors applying already Baltic altitudes.

Much difficulty was due to the immensurable destruction of control points of the selected systems, hence, of the Budapest urban survey in the construction areas, hence in the excavation site. In this area of several square kms, loss of control points was as high as 85 to 90 per cent, leaving plots of twenty hectares or so without any control point. Thus, survey of archaeological objects required to make new — temporary — control points. Both horizontal control point densification and horizontal detail measurement were always made with the locally most appropriate procedure; control points were mostly determined by triangulation, traversing, and polar method. Marks that could be hoped to be spared by the construction and help survey for a time were difficult to select. The most appropriate were found to be the marked centres of manhole covers, the marked lifting hooks of cable manholes, corner edges of new blocks of flats projected to the terrain level, and steel screws contacting kerbstones. Besides of the proper accuracy in keeping the control points, these marks are quite economical by involving little material expense and slight labour demand.

Methods of horizontal detail measurement included bearing intersections preferred for details inaccessible to linear measurement, especially in the case of extended, wide, long and deep trenches hiding the finds. More use was made of rectangular co-ordinate measurement where locating points of finds in long, narrow trenches were appointed on the straight line connecting two control points set out in the depth, near the trench ends. In most cases, polar measurement has been applied. This method proved to meet requirements of archaeology and urban survey, and to be adequate from rapidity and economy aspects. — Of course, in any case, measurements were completed by direct linear measurements on the imaged object.

Elevation measurements were made by levelling.

There are different views on the technology of geodetic measurements in archaeology [2], [3], [4]. It seems us to be improper to pledge oneself for one or the other measurement method but it has to be decided in each case in the knowledge of local features.

Before starting with the detail measurement, a sketch has been made of the area, indicating not only the true to shape drawing of the site but also the elevation points to be determined, and this always as convened with the competent archaeologist.

Confrontation of earlier archaeological surveys with the Óbuda circumstances suggested to be the best to begin with scale 1 : 50 for drawings based on measurement results; minor units are best mapped to scale 1 : 200, and greater areas to scale 1 : 1000. This latter was made by photographing sheets 1 : 50, by precise photogrammetric reduction, joining positive films reduced to 1 : 1000 and fitted by means of cross marks of co-ordinate lines to each other and to the co-ordinate mesh of the 1 : 1000 sheet to be copied of them. Reduction distorsion was found not to exceed 0.15 mm for the 1 : 1000 scale reduction along the sides of areas 25 by 25 m, normally mapped on the 1 : 50 scale sheets, equivalent to 7 to 8 cm in the terrain, taking fitting adjustment possibility into consideration and reconverting for natural dimensions. This is in perfect correspondence with the accuracy of finding and measuring the points.

Remark that while elements and inscriptions keep their original visibility and beauty on scale 1 : 200 sheets reduced to one fourth of the original, because of the applied notation system, a 1 : 1000 reduction requires certain simplifications and transformations before further application.

As concerns the drawing technique, it is based on a legend tending to present the objects by keys little abstracting the natural aspect of forms,

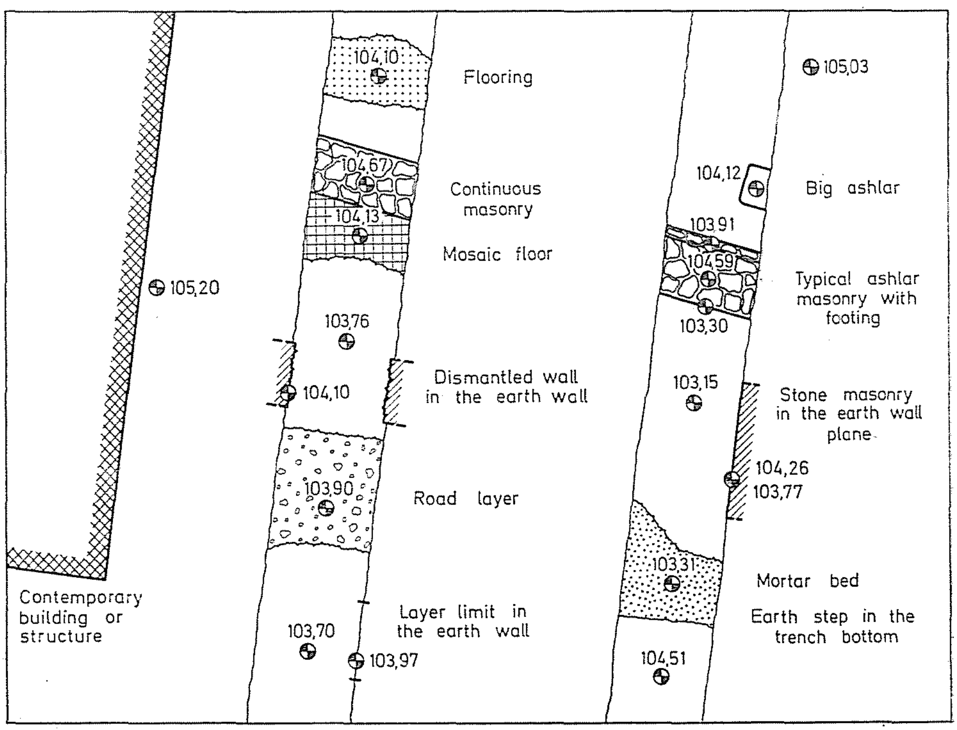

Fig. 2. Part of the legend applied in location plans scale 1 : 50 of excavations in Óbuda

surfaces and structures, so that the symbol reminds even an inexperienced map reader of the presented object (Fig. 2).

Also because of the different surveying methods applied, but mainly because mapping to scale 1 : 50 of detail points measured on distances mostly over 10 m and by polar method could not be made by the normal polar plotters available, it was decided to map by rectangular co-ordinates. To this aim, co-ordinates were computed by pocket calculators — in particular, types Hewlett—Packard 25 and 45.

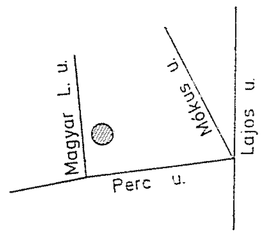

Fig. 3. Site sketch in map sheets 1 : 50

It was attempted to automate the entire process. A program has been made for the computer ODRA 1204 to output co-ordinates of details points measured by any method, and to print or punch them as desired. Another program for a plotter Cartimat III interpreted the output tape of ODRA 1204, plotted the detail points from it, and if desired, connected the points according to the sketch and thereby plotted the surveyed terrain objects. This experiment was by no means a failure, but other difficulties induced us to desist from automatic mapping.

Of course, prior to plot detail points, cross marks of co-ordinate lines were plotted, of them at least those about to frame the map content have been transferred to the caulking paper copy made of the sheet, and serving as basis of the multiplication, indicating co-ordinates. Thereby archaeologists, little experienced in map reading and using, could assemble neighbouring, contacting or overlapping map sheets, hence to compose the entire surveyed area mosaic-like, irrespective of simultaneity or time shift between excavation and survey of neighbouring areas. Complementing the pure numerical information by indicated co-ordinates, allocation of the map content was illustrated by a no-scale sketch on each sheet permitting to read the approximate location of the object (Fig. 3).

To comply with the actual pace of excavations in Óbuda, about one hundred map sheets are made yearly. Practical value of such a volume of maps depends on the registration permitting to utilize the contained data. Our registration was based on the Budapest urban survey map sheet numbers. Archaeological map sheets to scale 1 : 50 obtained serial numbers of two parts, the first indicating the urban survey map section including the archaeological survey site, the other being a serial number starting with 1. Numerals of archaeological map sheets neighbouring that of the depicted area, and in general, position of sheets are seen on comprehensive sketches to scale 1 : 1000.

In connection with technical aspects of archaeology, some finds of interest from civil engineering aspects must not be left unmentioned, such as Roman roads, aqueduct, sewerage, and house heating systems.

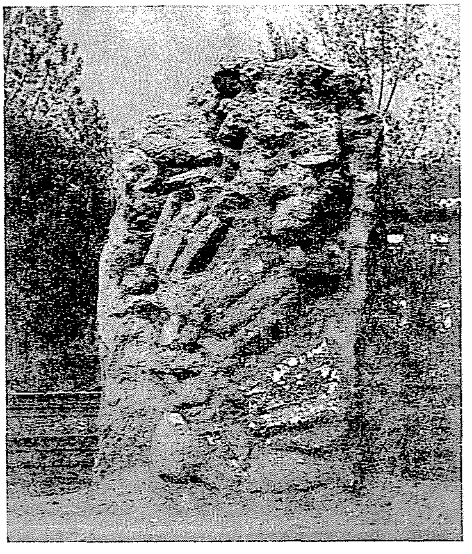

Fig. 4. A pillar of the aqueduct structure in 1975 (Excavated by Dr. Melinda Kaba) (Photo by the Author)

In many instances, rests of the road network of ancient Aquincum have been found 1.5 to 3.5 m below the actual terrain level. Partly by finding ruined road edges, and partly based on the direction of wheel tracks worn out in traffic of that time, finds generally permitted to reliably reconstruct road axis directions. It was interesting to find a deviation as little as 30′ from 90° between axis directions of two road rests spaced at 80 m. This deviation is unlike to be due to the setting out error of careful Roman surveyors but to the incertain determination of the axis direction of the detected road rests. Thus, detection and mapping of the strictly regular road system details is of special importance for determining the settlement structure.

Another proof of the communal supply, perfect in that time, is the Roman aqueduct system. Its main duct would be the aqueduct from the actual "Roman Bath" to at least Flórián tér, with rests subsisting in several spots. This duct of about 3 km supplied with water the civil town in the site actually called Aquincum, and the military town about Flórián tér [5]. The aqueduct

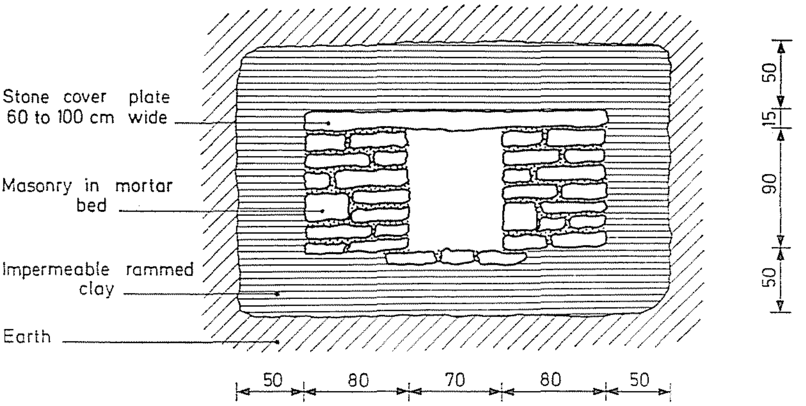

Fig. 5. Cross section of a Roman collector main

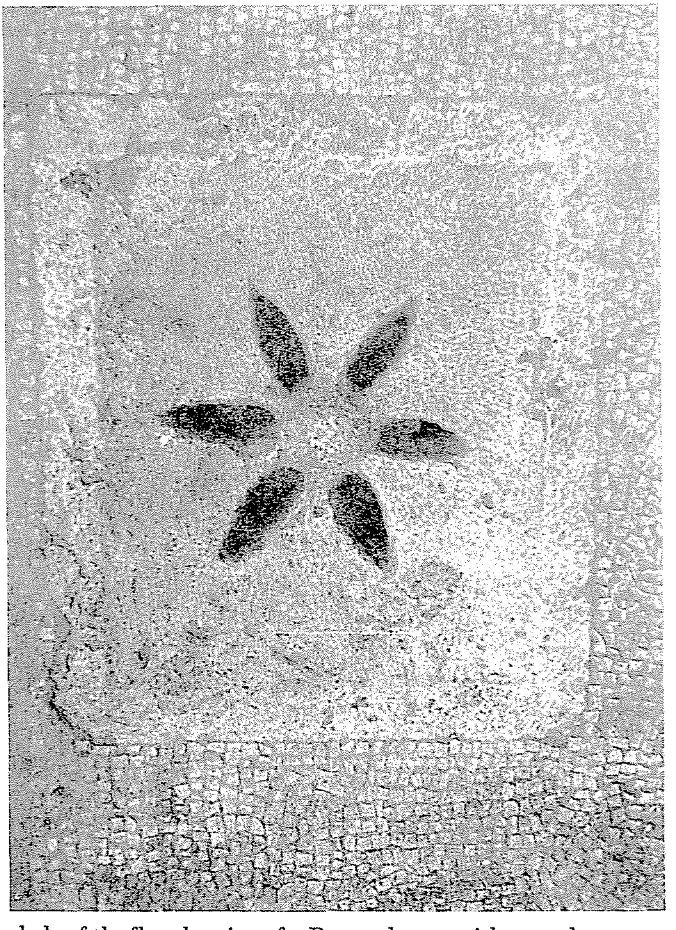

Fig. 6. Blow-in hole of the floor heating of a Roman house, with carved cover stone (Excavated by Dr. István Wellner) (Photo by the Author)

was supported on a circular arch vaulted structure on pillars generally 1.0 by 1.7 m in ground plan, with 3.0 m spans. Pillar heights from the once terrain level to the springing were 1.5 to 2.0 m. Stones of the structure decaying after the decline of Roman Empire were used as building material for centuries, leaving but a few pillar ruins (Fig. 4). Aqueduct tracing had to be set out from rests over the terrain level in 1975 when a length of about 400 m was fully excavated, while another 300 m underwent partial excavation. Eight of the rests exhibited vault springings at more or less probability. Heights determined

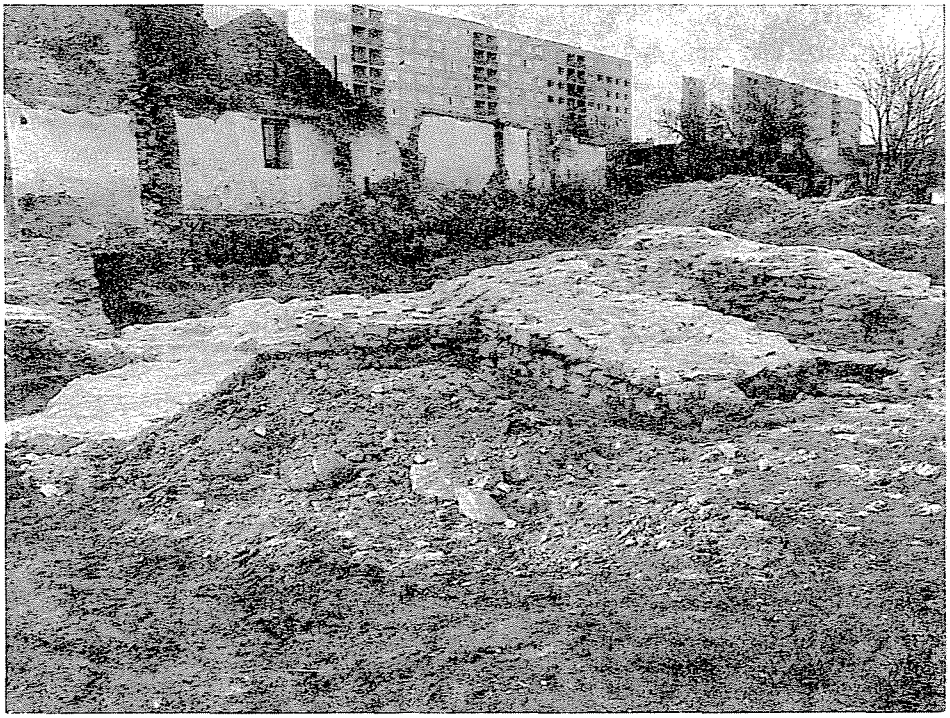

Fig. 7. Basement walls of the apsis of a church from the 14th century (Excavated by Dr. Hertha Bertalan) (By courtesy Budapest Historical Museum)

by levelling permitted to conclude on a slope of 2/3‰, in agreement with Roman prescriptions for aqueducts [6]. Otherwise, over the excavated length, and according to rests in still unexcavated sites, the aqueduct is likely to have been rectilinear throughout its length.

In course of excavations, archaeologists have found rests of canalization in several sites. Among them, the most important ones are those of west to east direction, hence conducting the sewage to the Danube. In one spot — about 60 m from the actual Danube bank — a 40 m length of almost integer collecting main, built to actually up-to-date technology, has been found (Fig. 5).

Deduction of the main bed slope from measurements on its excavated section showed the slight value of 0.5%.

Wealthiness of the Roman Empire, sophisticated way of life of patricians and officers in the provinces, and the fine apartments of the date appear from interiors: pavements, mosaic floors, murals, floor heating systems found in Roman buildings. In several places, archaeologists excavated complete systems: heating furnaces, hot air tracts under the floor supported on small columns, and the opening in the living room, sometimes representing a fine-arts object, a carving of the period (Fig. 6).

Hungary — with her belligerent history — is rather poor in mediaeval monuments. This fact lends a special importance to having found two mediaeval churches known to now only by being mentioned in documents, the basement walls of which have been excavated recently. From architectural aspects, the church belonging to the once Clarissan nunnery seems to be the more interesting, by its very dimensions — 70 by 30 m — likely to raise serious structural and load bearing problems even actually (Fig. 7).

It is hoped to have yielded some insight into the archaeological and related geodetic work in Óbuda. This presentation may be of interest by demonstrating the widening possibilities of collaboration between surveying, other civil engineering knowledge, and other disciplines in this age of scientific integration.

Summary

In the territory of *Óbuda*, now a district of Budapest, lesser or greater excavations look back to a past of about two centuries. Up to recently, surveying and mapping of these excavations were done by various methods and at different reliabilities. A certain unification came about in 1973, when the staff of the *Department of Surveying, Technical University, Budapest,* joined the work of the archaeologists of the *Budapest Historical Museum.* A description is given of the technology of the geodetic work, as well as of some engineering peculiarities of structures — mainly civil engineering objects — found in the excavations.

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* In Hungarian.