Conservation state of geosites in Japanese geoparks

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There are 8 UNESCO Global Geoparks and 35 domestic Geoparks in Japan. Each geopark has many geosites. Some geosites have not been thoroughly examined how to manage them. In this presentation, we will define the degradation of geoheritage in the natural environment of Japan, and organize the Geopark's geosites that are weathered and destroyed. In order to properly manage geosite in Japan, it is necessary to understand the natural environment of the place correctly.

Keywords: Japanese Geoparks, management of geosites, geoheritage, geodiversity, conservation earth science

Evaluating deterioration of stone-built Cultural Heritage and rock-formed Natural Heritage by means of Non-Destructive Techniques

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Natural and Cultural Heritage conservation is regarded as a priority for humankind, as the UNESCO recognised in the Convention Concerning the Protection of the World Cultural and Natural Heritage in 1972. This convention encouraged to adopt joint policies aiming to give the cultural and natural heritage a function in the life of the community. From the material point of view, both stone-built Cultural Heritage and rock-formed Natural Heritage undergo similar weathering processes and in both cases the use non-destructive techniques to evaluate the effects of weathering is particularly relevant. Non-destructive evaluation techniques do not only allow to respect the integrity of the studied elements, but also allow to make successive repeated measurements in particular points. Repeatability is crucial to understand the evolution of weathering processes and plan preventive conservation strategies. Even more so as changing climate in necessarily affecting the type and extent of weathering processes. This presentation explores a series of existing non-destructive techniques used for the evaluation of weathering/decay, stressing the parallelism between the evaluation of stone decay in built heritage and the assessment of weathering in rock-formed natural heritage. These techniques include morphological evaluation through 3-D digital models, Ultrasound Pulse Velocity determination and Infrared Thermography among others. This presentation will give an overview of how these tools have been used in specific case studies and discuss their advantages and disadvantages for evaluating weathering.

Keywords: Stone decay, Rock weathering , Non-destructive testing

Dynamic Geoconservation and Tourism as a Geoconservation Tool: Comparative Analysis of Europe and Japan

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This paper analyzes the concept of dynamic geoconservation, particularly focusing on two concepts: Despite identification of ‘geosites’ and creating appropriate protection measures in geoparks, many sites continue to be ‘fragmented’ because of insufficient attention to the ‘integrity’ of the natural processes operating at large spatial scales and over long time.
How properly informed tourism could be used as a ‘tool’ for monitoring such environments and promote non-obtrusive geoconservaion.
Through key case studies from Europe (especially the UK) and comparative cases in Japan, the paper analyzes the problems of mismatch between geoconservation objectives and praxis. The paper introduces Gray(2013)’s contention that the abiotic diversity of the planet should be recognized for its ‘intrinsic’ value, and Mathews’ (2014) contention that geodiversity and biodiversity components should be integrated to promote a strong feedback loop for conservation of geosites. The paper argues that geomorphic and ecological processes operating over large spatial units (and over long temporal scale) offer important insights for geoconservation. Based on the case studies, we also put forward the idea of ‘dynamic geoconservation’ whereby the integrity of natural processes rather than scenic or tourism capital values of a specific site or landmark is considered the conservation goal. Lack of monitoring data on geosites and heritage landmarks is a major challenge for dynamic conservation, and the paper argues that properly informed multi-stakeholder tourism can act as a ‘stewardship’ tool for geoparks (or similar heritage management schemes) by providing monitoring bby guides and tourists and elevating the awareness for dynamic conservation at the same time.

Keywords: Dynamic Geoconservation , Natural Processes, UK, Japan

Three dimensional documentation and surface erosion of andesitic building stones in Yokosuka Arsenal Dry Dock No.1, Japan

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There are 6 dry docks in Yokosuka Naval Base, Japan. Three of them are made with building stones. The first one, which was called as “Yokosuka Arsenal Dry Dock No. 1” had been constructed about 150 years ago. Mount Hakusen, which was composed of Pleistocene mud sediments, was excavated during the construction of the dock. The building stones are mainly andesite from the quarry in Manazuru Peninsula, far southwestern corner of Kanagawa Prefecture. The stone is called as “Shin-Komatus-Ishi”. Shin means new and ishi is stone. The dock was suffered from 1923 Great Kanto earthquake, however there was no serious damage in the dock. The dock is still in use today. However the surfaces of building stones have been eroded by weathering. And some of them show honeycomb structure.
For the purpose of future preservation, three-dimensional mapping of the dry dock No. 1 was carried out by means of close-range digital photogrammetry. About 100 photographs had been taken as photo-sequence for the total area of the dock. And these multiple 2-D images had been installed into a computer and analyzed by a commercial photogrammetric software. After the photogrammetric manual analysis, the software can match the same position on multiple 2-D images and generate 3-D points in the computer. Finally, three dimensional surface model could be generated.
In addition to three dimensional documentation of the total site of the dock, photogrammetric measurement could be applied to the surface erosion of andesitic building stones in the dock. Generally, surface erosion had been measured by scale, and only the depth of erosion could be clarified. Application of photogrammetry makes it possible to measure the volume of erosion on the surface of building stones. Thirteen building stones have been selected for measurement. Those stone show various depth erosion on the surface. As the results of mean erosion depth calculated from erosion volume and surface are of the building stones, erosion process by weathering is clarified by comparison of erosion rates and erosion structures.
The quarry site of the building stone “Shin-Komatus-Ishi” had been closed many years ago. At present, we can observe the old quarry site in the coast line of Manazuru Peninsula. There are many plug-and-feather holes and traces of the pickax in the quarry site. And some small honeycomb structures can be recognized on the rock surface of the site. However the depth of erosion is not so much compare to the building stones of the dry dock from the view point of weathering structure. In the case of the dry dock, sea water had been carried in and out every time the ship had been repaired. Therefore, it is considered that surface erosion had been advanced inside the dock with seawater fill and dry.

Keywords: photogrammetry, honeycomb structure, seawater, quarry site

Historic porous limestone quarries in the city of Budapest (Central Europe), their exploitation history and preservation

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Budapest, the capital of Hungary (Central Europe) had a rapid urbanization and transformation at the end of 19th and at the beginning of 20th century. The population of the city grew from 300,000 (in 1880) to nearly 900,000 (in 1920). This process invoked an urgent and continuously growing need of construction material. The closest resource that was available was a porous limestone. The Miocene limestone has appropriate properties for constructional use. It has a high porosity (up to 40%), a low unit weight (light stone) and good workability (easy to cut and carve). Due to the appropriate properties its use already began by the Romans (1st and 2nd century AD) and continued in the medieval period, however major and large-scale exploitation was mostly in the late 18th to early 19th century associated with the population boom. The porous limestone covered smaller elevated hills on both side of river Danube in Buda and in Pest site. The exploitation of the stone first started in open quarries. The first quarries were located outside of the town during the Roman times. The Medieval stone exploitation was also from external quarries, while from the 18th century onward with the city development the suburbs provided stone materials: The stone was used for the construction of public buildings and housing. These monuments, which date back to that period, are now in the city centre (House of Parliament, Opera House, Mathias Church), but at the construction time some of them were in the suburbs (e.g. Central Building of Technical University). The first quarrying operation started where vineyards and orchards were located. Due to the increasing need of stone larger areas were used for quarrying and it caused a conflict with agriculture, and caused the significant loss of fertile areas. Consequently, in the second phase of stone exploitation the quarrying activity were shifted toward subsurface galleries. It reduced the land use and resulted in the excavation of long passages and larger galleries at subsurface. In the late early 20th century the operation of the quarries terminated and galleries became abandoned. These abandoned quarries than were used as wine cellars or occupied by inhabitants and became a dwelling and housing place, an urban habitat. In the 1960’ies the population were pulled out from these unhealthy “cave dwellings” and some of the galleries were used as storage facilities and mushroom cultivation sites. At present these subsurface openings cause high risk of land development (collapse) and limit the land use of the given area. Despite their engineering geological risks the galleries and previous quarries represent historic values and their preservation is crucial. The protection of these galleries and subsurface quarries are now in progress. Coevally with the preservation measures it is necessary to record the condition and preserved values (quarrying activity related tool traces, inscriptions, etc.) of these systems. It is also crucial to make surveys and stability calculations to avoid outbreaks and collapses. This paper points out that urban development, cultural and geological heritage needs to be understood and managed in a sustainable way.

Keywords: limestone, cultural heritage, urban development, subsurface galleries, cellars

Methodology of 3D Measurement - Case Study in the Main Church of Sopocani Monastery, Southern Serbia -

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Aim of study

This paper deals with the methodological challenges of 3D scanning of the main church of Sopocani Monastery (hereafter called Sopocani church)[Fig.1], the world cultural heritage in southern Serbia. Accurate documentation of the heritage is the fundamental basis of scientific analyses as well as its conservation. 3D scanning, with rapid development both in hardware and software during last decades, has been applied in the field of the heritage study with different range of accuracy and scale.
In some cases, however, the requirement of survey and the delicacy of the heritage may cause particular difficulties, even though 3D scanning enables us to reach such part where measurement could not be carried out otherwise. This paper shows challenges of heritage scanning, taking Sopocani church an example of historical structure of stone. The scanning data of this church, threatened of decay, should constitute an effective base for the future conservation project.

Method of study

Two types of 3D measurement were carried out: the laser scanning (Riegl VZ400) and the LED scanning (Artec Spider).

Approach

The laser scanner is effective for architectural space, while the LED scanner is suitable for details of the surface, though the view-field of the latter is limited to 180×140mm. The combination of these two apparatus of different scale is indispensable for measuring the historical structure, the value of which exists both in architecture and in surface. In Sopocani church, 23 laser scans were carried out in measuring inside/outside of the structure, and 477 LED scans were carried out in measuring west wall of naos. The mural painting of Sopocani church is uniquely characterized by the golden background made of numerous gold leaves. As the gold has turned almost invisible because of degradation, the art-historical research of its iconography would be possible only through the accurate detection of the minute thickness change of paint layers by LED scanner.

Outcome

The laser scanning data indicate relatively small variation of the thickness of the wall of the church, 0.957-1.001m, which may prove the quality of the original construction[Fig.2]. Regarding the porch, added later, there is a difference of 0.784m in width. Columns of the porch show outward inclinations, being 7 degree at the most[Fig.3]. If such inclinations, already confirmed by the author in old photographs as well, should be monitored together with the deformation of the arches, the scanning data are of fundamental importance. The data clearly indicate the difference of building quality between the original and later extension.
LED scanning data have shown certain hidden painting technique and characteristic depiction of the west wall of naos (12.811×6.323m), where saints and angels are painted[Fig.4]. Analysis of scan data has revealed that position of the aureoles of saints is different in lower and upper part of the painting. In lower part, centers of aureoles are placed around the temple, while they are placed around the forehead in higher part. The faces are slightly longer in upper part. We may presume that painters adopted this technical device as they were conscious of the figures to be looked up by people standing on the ground floor. LED scanning also clarified unique depiction in Sopocani church: fine grid pattern is obvious on the

golden background of the alter, which is supposed to be mosaic-imitation. The same pattern is also found in the west wall of naos.

Conclusion

3D measurement is an effective method for the documentation of the architectural heritage. In Sopocani church the scanning measurement clarified the quality of the original construction. The LED scanning has shown particular technique and devices of painters. 3D measurement will be useful for the monitoring of the heritage structure as well.

Keywords: 3D measurement, Cultural Heritage, Serbia


Fig.1 Sopocani church

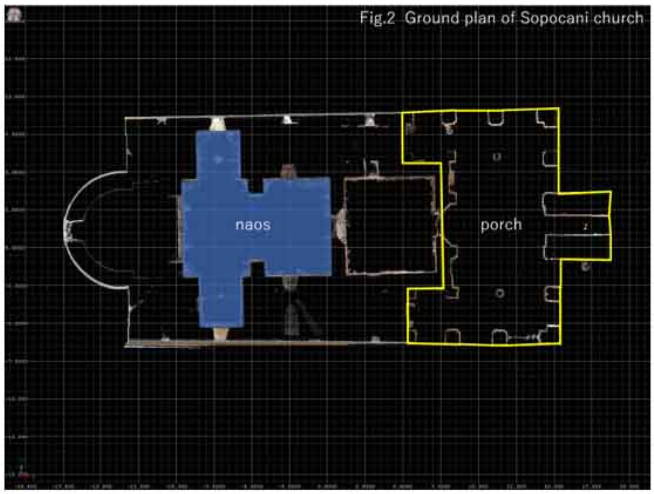

Fig.2 Ground plan of Sopocani church

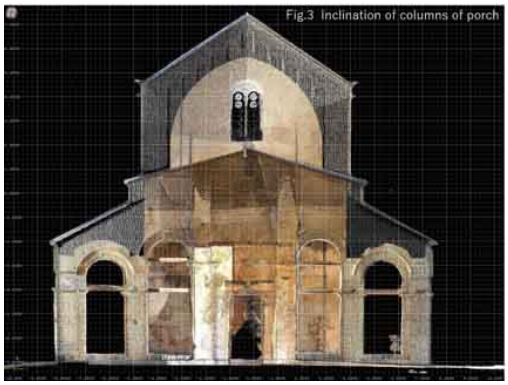
Fig.3 Inclination of columns of porch

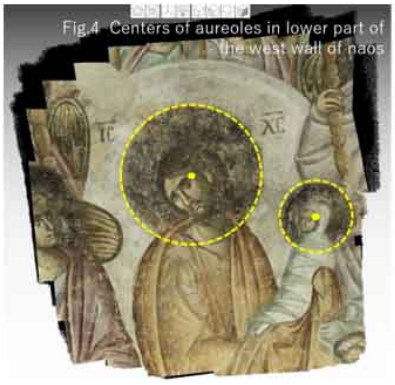
Fig.4 Centers of aureoles in lower part of the west wall of naos

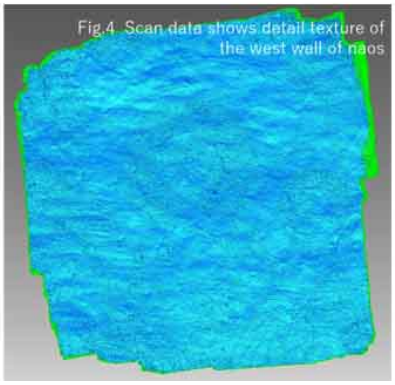
Fig.4 Scan data shows detail texture of the west wall of naos

Chemical and mineralogical properties of backfilling soils of Yokosuka Dry Dock, Kanagawa, Japan

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Three dry docks of Yokosuka Arsenal opened during 1871-1884. The first one was constructed according to the guidance of French engineer, Francois Leonce Verny (1837–1902). These dry dock areas have been occupied by the USA navy after the World War II, and still been in service even today. Surface covering stones of the docks are volcanic rocks or tuff collected from Izu or Manadzuru peninsula (Shizuoka and Kanagawa prefectures). They are cut in the size of around 60×40×30 cm and placed on the surface of cut bedrock, Pleistocene mudstone or silt, reinforced by “Beton” which is improved soil composed by gravel, lime and volcanic ash. In order to investigate the properties of beton, boring core samples were taken from a few points and mineralogical and chemical analyses were carried out using powder XRD and SEM-EDS, respectively. The dominant minerals are quartz and K-feldspar in the bedrock reflecting original sediments, whereas quartz and calcite in the beton. Chemical analysis results shows that the higher contents of SiO2 and K2O indicating the existence of K-feldspar, and that the higher contents of CaO, Al2O3 and FeO+Fe2O3 but low content of SiO2 reflecting beton. To consider these differences, the CaO/SiO2, MgO/SiO_2 , (FeO+Fe_2O_3)/SiO_2 ratios are fairly useful to compare the influences of lime or cement. From these investigation, it is concluded that the beton had similar characteristics as a dawn cement in civilization in Japan, and that some points were affected by seawater leak.

Keywords: Yokosuka Dry Dock, beton, improved soils

Quantitative relationships between salt-weathering of tuff and microclimatic environments, in the Yoshimi Hyaku-Ana historic site, Japan

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This study monitored the temperature and relative humidity near the cave wall of the Yoshimi Hyaku-Ana, a historic site. The purpose of the study was to investigate the relationships between salt-weathering denudation of the cave wall (which is composed of tuff) and the local weathering environment. Five measuring points were established inside the cave, with differing degrees of tuff denudation. Monthly observations and measurements were made over 1 year. Small ‘button-type’ sensors (with data loggers) were attached to the cave wall to record temperature and humidity at hourly intervals. After collecting these data, the relationships between environmental condition (temperature and humidity) and the degree of denudation due to salt weathering were evaluated. The degree of denudation were larger in dry measureing point near the entrance of the cave, compared with the inner areas of the cave. This suggests that humidity is one of the major climatic conditions for salt weathering.

Keywords: Denudation, Relative humidity, Salt weathering, Tuff, Yoshimi Hyaku-Ana, Historic site

An experimental study for evaluating weathering susceptibility of cave sediments with relief structure on the wall

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Weathering is a universal phenomenon which is observed not only in natural landscapes but also many historic buildings. Salt weathering is often reported, however, there are very few studies of slaking at these historical sites. The Taya cave in Kanagawa Prefecture is now suffering from exfoliation, which has been attributed to damage by slaking (wetting and drying weathering). To explore these phenomena, simple slaking tests were carried out. Physical properties of the rocks were also measured. The results indicate that that the rocks of the Taya cave system are susceptible to slaking.

Keywords: slaking, wetting and drying experiment, swelling clay

Interdisciplinary investigation of stone heritage sites for conservation purposes; a case study of the Székesfehérvár Ruin Garden in Hungary.

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Székesfehérvár is a historic town in Hungary, Central Europe, located 65 km southwest of Budapest, the current capital. The Ruin Garden of Székesfehérvár is a unique monument, which served as the coronation and burial church for the Kings of the Hungarian Christian Kingdom. The site is considered a "National Monument" due its importance in the Middle Ages, therefore its protection is deemed necessary. Several expansions and/or reconstructions took place between the 11th and 15th centuries. The Basilica and other associated buildings were severely damaged by the Turks (16th to 17th century). Further deterioration was followed; the site was used for storage and many of its building and decorative stones were removed and reused in new constructions in the area. The first archaeological excavations began in the 19th century.

Several lithotypes could be found among the remaining stones on site. The interdisciplinary characterisation of the identified materials was crucial not only for the conservation of the Székesfehérvár Ruin Garden but also for other historic structures in Central Europe. The different lithologies were described and depicted on coloured maps, which were also used for the different construction phases of the monument and the weathering phenomena observed on the materials. Moreover, non- or micro-destructive tests were implemented for the in-situ characterisation of the studied building materials (e.g. Schmidt Hammer, moisture content measurement, micro-drilling). Further testing and analysis took place under laboratory conditions, using analogous stones obtained from active quarries and it included petrographic analysis, X-Ray Diffractometry, determination of real density by means of helium pycnometer and bulk density by means of mercury pycnometer, pore size distribution by mercury intrusion porosimetry and by nitrogen adsorption, water absorption, determination of open porosity, micro-drilling, frost resistance, ultrasonic pulse velocity test, uniaxial compressive strength test and dynamic modulus of elasticity.

The most common lithotypes were limestones (>80%). Porous Miocene limestone prevailed, while cemented Mesozoic limestone and travertine were less common. Rhyolite, siliceous sandstone and white marble were sparse. The stones showed moderate to high grade of weathering. The main identified weathering form was black crust on the porous limestones. White crusts, scaling and flaking were also common. Biological growth was also identified on several parts of the ruin.

The laboratory results showed that strength was not necessarily a clear indicator of the stone durability. Bedding and other lithological heterogeneities could influence the strength and durability of the specimens. In addition, long-term behaviour was influenced by the exposure conditions, the fabric and the pore size distribution of each sample. Porosimetry showed high porosities for the oolitic limestones, with their main pore volumes found in the range of larger pores. On the contrary, cemented Mesozoic limestone showed very low porosities. Wide ranges in water absorption and strength values were recorded suggesting significant physical differences among the lithotypes. The interdisciplinary study confirmed that the monumental stones suffered from deterioration in terms of mineralogy, fabric and physical properties, when compared to the freshly quarried stones. Compatibility between the freshly quarried and historical stones was proven, which would be crucial in case of future interventions demanding new materials of similar properties and composition. The strong correlation observed between the micro-destructive techniques and the laboratory test indicated the possibility of minimizing sampling from

cultural heritage sites. The interdisciplinary investigation of the stone material properties and long-term behavior can contribute to the preservation of the site and allow the selection of appropriate interventions and conservation measures.

Keywords: building, stone, interdisciplinary, characterization, conservation, Székesfehérvár

Changes in weathering environment due to clearance of trees in the Angkor temples, Cambodia

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Angkor temples severely damaged were covered by dense vegetation when those were discovered in the mid-19th century. Then trees on building materials have been cleared with the progress of conservation and protection projects for the temples. Tree cutting, however, is possible to generate new weathering environment related to temperature and moisture of the building materials. In order to find such environment, this study carried out the analysis of thermal condition at some sandstone-built temples such as Angkor Wat, Ta Prohm and Banteay Kdei that have different vegetation cover. The sandstone blocks of temples are mainly subjected to weathering processes of wet-dry repetition and salt efflorescence. Air temperatures were measured using about forty data loggers on March and September 2014 under the cooperation of APSARA National authority and with field research workers. In addition, surface temperatures of sandstone block was frequently measured by a thermography during each observation period. As the results, it is found that there is high temperature condition at Angkor Wat temple in which trees were cut at surrounding sanctuary. The surface temperatures of sandstone block reached 55˚C in the morning and a temperature difference between the sandstone block and air temperature was more than 20˚C in the temple. In the night time, air temperature of the sanctuary showed 5˚C higher than air temperature of vegetated area. Such continuous high temperature condition is able to induce desiccation of the sandstone blocks. Namely weathering impacts originating from moisture changes in the sandstone blocks may increase in new environment. Although the tree cutting has progressed since the 19th century to conserve and protect the temples, it may be reduced the function of thermal buffer owing to trees, and accelerate to sandstone weathering.
I appreciate the approval of temperature observation in the temples by the Authority for the Protection and Management of Angkor and the Region of Siem Reap (APSARA National Authority), Cambodia and cooperation of Sophia Asia Center for Research and Human Development. I also appreciate the installation and collection of loggers by Dr. T. Takemura, Dr. W. Song, Dr. A. Hada, Dr. T. Kajiyama, Y. Hiki, T. Maeda, M. Hayashi, N. Kambe, and M. Sato as field research workers.

Keywords: Angkor monuments, thermal environment, wet-dry weathering, sandstone

The use of multiscale 3D digital models for non-destructive morphological measurements on sculpted bedforms: implications for erosion and weathering models in bedrock rivers in protected areas

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Rock surfaces are the most sensitive portion to weathering an erosion processes, and therefore, a detailed analysis of surface morphologies is of paramount importance. This importance increases when dealing with heritage sites, such as geosites, cultural heritage sites or any other relevant rock outcrop in protected areas, as sometimes a relatively small surface change may lead to a significant loss of aesthetic or scientific values. There are number of non-destructive techniques to characterise surface morphology to various scales. This communication describes surface morphologies at different scales on the river bed of the Manzanares, a bedrock reach located in “La Pedriza”; within the National Park of Sierra de Guadarrama (Central Spain). “La Pedriza” constitutes the largest granitic outcrop in Europe and a place of historic importance for the development of the geology both in Spain and globally. The studied portion is a place of particular geological interest where the erosion generated by the river reveals a series of microdioritic dikes intruding a coarse-grained Variscan leucogranite. This lithological combination generates dissimilar patterns in terms of weathering and erosion. Surface morphology analysis was made by means of 3D digital models obtained at different scales, from metric scale acquired with photogrammetry from a drone to micrometric scale obtained with a Innowep-TRACEiT surface roughness tester. Combining the results of these techniques relationships between roughness at different scales and erosion-weathering balance were determined as well as the main processes involved in surface weathering and erosion. The resulting features at various scales were identified and its relation to flow patterns and the response of different substrate lithologies to river flow.

Research funded by Madrid’s Regional Government project Geomateriales 2 S2013/MIT-2914

Keywords: Non-destructive testing, bedrock rivers, rock weathering, Protected areas

Characterization of lime-based mortars from historic aqueducts in Cyprus

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The use of composite materials, such as mortars, in construction dates back to prehistoric times. The systematic study of these materials can reveal the technological knowledge of past civilizations. Therefore, mortar studies can be of great importance for material scientists, engineers, historians and archaeologists. With regards to heritage conservation, the interdisciplinary research of mortars is mandatory for the design, production and application of compatible conservation materials.
This work presents results from the study of fifteen indicative mortar samples collected from nine different sites in Cyprus. All samples were collected from the remains of various aqueducts that date back to different historic periods. A thorough documentation of the specimens preceded the systematic analytical approach that was adopted for the investigation of the mortars. Macroscopic and stereoscopic observations, as well as other experimental analyses were carried out, aiming to characterize the samples in terms of their composition, properties and state of conservation. X-ray diffractometry (XRD) was used for the qualitative and quantitative identification of the main mineral crystalline phases of the specimens. X-ray fluorescence (XRF) was performed on pressed pelletized powder samples for the determination of their chemical composition. Differential thermal analysis (DTA) and thermogravimetry (TG) was also undertaken; based on the results of the structurally bound water, the mortar samples were classified according to the extent of their hydraulicity. Mercury intrusion porosimetry (MIP) took place for the determination of their pore structure and volume (i.e. open porosity, average pore size, bulk density). Last but not least, a portable drilling resistance measurement system (DRMS) was used for the micro-destructive assessment of their mechanical state.
The macroscopic and stereoscopic observations of the specimens showed differences in texture, hardness and microstructure, which could be associated with their use in practise (e.g. plaster, joint mortar). The presence of crushed ceramic fragments was also observed; this was more evident in plaster samples. Furthermore, in some plasters, different layers could be observed, indicating changes in the microstructure of the areas close to the exposed surface. The experimental analyses confirmed calcite as the main mineral in all samples. The presence of quartz was also found. Plagioclase feldspars and dolomite were among the minerals commonly found in the mortar samples, as well. Gehlenite was present in all analyzed materials; this mineral is characteristic of the presence of ceramic fragments in the composites. The latter was probably used in the absence of natural pozzolanas on the island in order to enhance the performance of the mortars, increase their mechanical strength, adhesion and hydraulicity and prolong their longevity. The purposeful use of finely crushed ceramic for the production of hydraulic mortars in Cyprus dates back to the Late Bronze Age; this has already been scientifically proven by the authors as the earliest use of artificial pozzolanic material in the history of mortars technology. The presence of clay minerals in all specimens could be related to the composition of the raw materials and/or the presence of subsequent deposits. The gypsum content in some specimens could be associated with secondary salt formation due to atmospheric pollution. The thermal analyses indicated that the mortars under study might be classified as weakly to strongly hydraulic. DRMS and MIP results showed heterogeneity in the microstructure of the mortars, which can be attributed to the different construction methods that were followed at different time periods, as well as to the occurrence of weathering phenomena.

Keywords: lime, mortars, aqueducts, characterization, conservation, Cyprus

Repair mortar –porous limestone compatibility: an overview of physical properties

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The compatibility of stone and repair mortar is a key issue in the longevity of restoration works. The mortar and stone used in heritage structures can differ in many aspects, in appearance (surface roughness, colour, texture, etc.) in physical properties (density, porosity, strength, etc.) or in composition (mineralogy, chemistry) and any of these differences can contribute to the loss of stone or historic mortar. The current research focuses on the physical properties and tries to outline and compare the properties of porous limestone with different types of repair mortars. A Miocene porous limestone and four different types of restoration mortars were tested. The Miocene limestone is an important “heritage stone” since it is found in historic buildings of Budapest and other cities throughout Hungary and in the surrounding countries of Central Europe such as Austria, Slovakia, Romania and the Czech Republic. The tested stone belongs to the one that occurs near Budapest at Sóskút quarry. It was used for the construction of bridges, fortresses and public buildings, as well as terraced houses. The tested repair mortars are commonly used in the restoration practice for repairing this porous stone. The compatibility tests focused on bulk density, porosity, ultrasonic pulse velocity and compressive strength. Cubic specimens of 3 cm in size were casted and tested 3-360 days after casting. Mortar with added limestone sand filler (50wt%) and pure repair mortars were tested. The results of the tests were compared to the ones of the porous limestone. These experiments have verified that most of the studied commercially available repair mortars have higher strength (10-20 MPa after 28 days) than that of the porous limestone (5-7 MPa). Adding 50wt% of porous limestone sand filler reduced the strength of the mortar but the required loss in strength was still not obtained for the higher strength mortars. The ultrasonic pulse velocity readings show the same trend, higher values were recorded on mortars. In terms of porosity and pore-size distribution most of the studied mortars had lower porosity (26-36%) than the porous limestone (34-38%) and the pore-size distribution was also different. 50wt% of limestone filler mostly increased the porosity of the repair mortars, but with this increase required rate of changes in pore-size distribution were not achieved. Our experiments have proved that the tested commercial repair mortars are not compatible with the highly porous carbonates and the assessment of the physical compatibility and durability require long-term monitoring of physical changes. The research was financed by Hungarian National Research, Development and Innovation Fund (K 116532).

Keywords: mortar, uniaxial compressive strenght, porous limestone, compatibility, historic monument