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DURABILITY OF DIMENSION STONE

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Key-words: Dimension stone, Strain, Deformation, Deposit, Quarrying, Stone processing, Dressing, Environment

The paper presents a survey of the possible origins of the strain and deformation of stone. A range of origins which can be influenced is suggested, from those occurring under natural conditions in the deposit to those resulting from technologies applied in quarrying, stone processing and dressing, including environment with natural and technogenic factors. No new information can be given on the behavior of the stone processed and used in building according to the most recent technologies, because the time-span of its exposure to the influence of natural and technogenic factors has been too short.

Ključne riječi: Arhitektonski kamen, Naprezanje, Deformacija, Ležište, Eksploatacija, Prerada, Oblaganje, Okoliš

Izloženi su mogući izvori naprezanja i deformacija u kamenu. Sugeriran je raspon porijekla naprezanja koja utječu na otpornost kamena, od onih koja pripadaju prirodnim uvjetima u ležištu do onih koja su rezultat primijenjenih tehnologija u eksploataciji, preradi i oblaganju uključivši okoliš s prirodnim i tehnogenim činiocima. O pojavama na kamenu obrađenom najnovijim tehnologijama ne mogu se izložiti neka saznanja zbog prekratkog vremena kroz koje je ugrađeni kamen bio izložen utjecaju prirodnih i tehnogenih činilaca.

Introduction

The evaluation of the quality and durability of dimension stone, accompanied by the obligatory determination of physical and mechanical properties, is based both on the analysis of the previous condition of the stone built into the existing buildings.

The behaviour, appearance and durability of stone used for building in a distant or more recent past depends on a number of factors which have to be taken into account (Fig. 1).

In the past and today the stone was actually quarried with the application of various technologies, the stone elements were processed and finished through various processing, and finally, the stone was dressed in various ways. All the different aspects of the technologies mentioned in the three phases (quarrying, processing, dressing) incite and cause various kinds of strain with reversible and irreversible or residual deformations.

However, all the kinds of strain and deformations in stone due to a wide range of syngenetical, diagenetical and postgenetical processes in the deposit must not be neglected or omitted from the discussion.

After the blocks of stone are extracted from the rock mass of the deposit they contain such kinds of strain and they are gradually relieved of them. Strain in the stone extracted also depends on the depth in the deposit from which the stone block was taken. It is not irrelevant whether the blocks are dug out from the part of the deposit nearer the surface or from deeper parts of the rock mass with considerable strain from the hanging beds. Sheating can occur on the surface of the beds effected by relief from strain (Winkler, 1973).

Stone blocks, particularly those from deeper parts of the deposit, adapt to new conditions, different

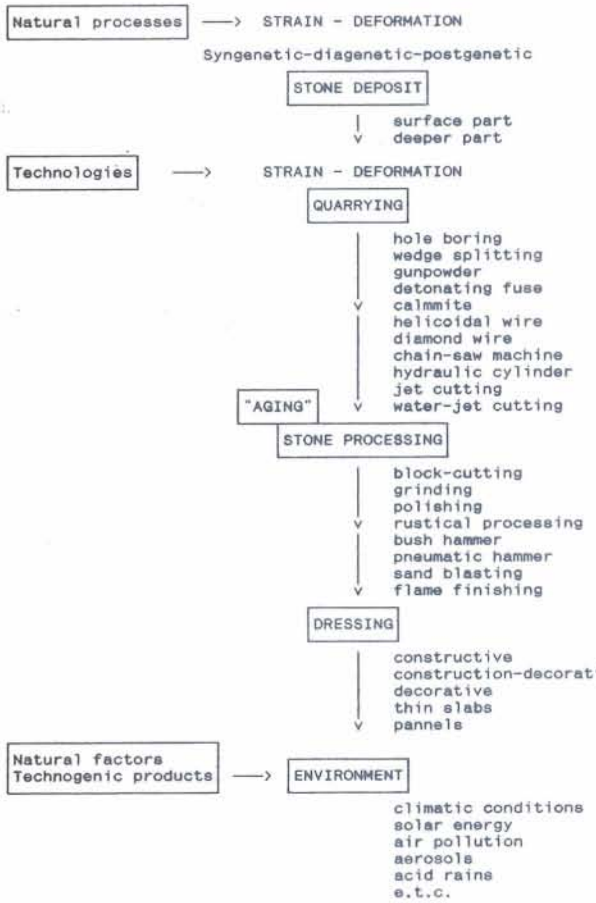

Fig. 1 Origin of strain and deformations caused by natural and technogenic factors

from those they were exposed to in the rock mass. The adaptation period varies, depending on a number of factors. During the adaptation period it is not desirable to dress the stone and expose it to new strain. Karaulov (1966) writes that »the architects of former centuries knew that recently extracted stone, particularly limestone, must not be dressed immediately. They first dried it in order to provide it with durability, keeping it in open air at least over a year. The limestone gradually dries, hardens and becomes resistant to frost.« Winkler (1973), discussing this point makes a note: »Stone blocks should be stored for a few months . . . the process may be summarized as »aging«.«

Strain and deformation in the deposit

There is a wide range of strain and deformations occurring in the course of syngenetic, diagenetic and postgenetic processes, of which only a few will be mentioned.

Polymorphic transformations of high-temperature quartz into a low-temperature type at 573°C is accompanied by changes in volume. In volcanic rocks containing quartz such transformations cause strain and elastic and/or irreversible deformations. The technical properties of stone depend on the distribution and intensity of the strain and deformations.

Great strain and deformations develop in metamorphic and deuteric processes. For example, serpentinization of olivine in olivine gabbro is followed by an increase in the volume of the newly formed products. This in turn causes the occurrence of cracks radiating through components surrounding the serpentinized olivine. This phenomenon has certainly an unfavourable influence on the technical properties of the gabbro.

The marbles of granoblastic textures have never such good technical properties as dense limestones. This is due to the larger sizes of granoblasts, but even more so to the ever present plastic deformations. In marble are these deformations marked by the presence in considerable proportions of mechanical twinings in the calcite.

In quantity and intensity are, however, most important the strain and deformations caused by tectonic processes. The deformations caused by tectonics can be noticed in a number of phenomena that can be determined by macroscopic examination and microcsopic analyses. Among them there are a more or less conspicous undulatory extinction, segmentation and mosaic structure of grain, mechanical twinings, changes in optical properties when opticaly uniaxial minerals become biaxial ones. Next there is a weakening of intergranular links, and even occurrences of cracks and visible fractures, crumbling and decay.

Detailed field research and microscopic analyses of the tectonically impaired and preserved limestone (biosparite) have shown that the sparite calcite in the tectonic zone was deformed. This calcite is segmented, it contains mechanical twinings and it has become optically biaxial. Grains of sparite calcite in the limestone protected from tectonics, further away from the tectonic zone, do not show the deformation listed above.

Some syngenetic, diagenetic and postgenetic processes in carbonate sediments, which are characterized by a smaller or greater degree of porosity, can have a beneficial influence on the properties and durability of stone. This refers to the pore water containing various dissolved salts, among them also calcium hydrocarbonate.

Diagenetic changes in carbonate sediments that occurred during the period of sinking, and fall into three groups (Parker and Sellwood, 1983), continued during the postgenetic geological era as well. It is certain that processes which reduce or increase porosity are also postgenetic. The most important cations in all intersticial water of sediment rocks are Na, Ca, Mg, and the most important anions are Cl, HCO_3, SO_4, (Engelhardt, 1973). It is not certain how much connate water there is in these sediments today, i.e. water that was caught in the intersticies of the sedimentary rock at the time of its deposition, water that was been out of contact with the atmosphere, with original ion composition for at least an appreciable part of geologic period. The original ionic composition of the connative water was certainly changed during the geological time. The intensity of change of the original composition depends on the communication of the pore space, and on the constant balancing in the pore water. Garrels and Christ (1965) provided a general balance scheme of carbonates, analyzing five cases. Carbonate sediments in the deposit correspond to the third case: the balanced relations of dissolved carbonate coponents at specific pH, when the balance in the system is controlled by other reactions. However, the extracted blocks from the carbonate sediment beds would correspond to the fourth case, when there is balance in the system at a specific pH accompanied by external factors characterized by a given partial pressure of CO_2. The existing balance is disturbed by airing, when the stone loses the pore water and the various salts are crystallized, immediately below or on the surface of stone. Some of the salts are soluble (cations Na and Mg and anions Cl and SO_4) and are easily washed out. Others are represented by calcium hydrocarbonate crystallized as calcite. This process hardens the stone on the surface, making it more resistant through airing and drying. The more porose the stone of a carbonate composition is the more pore water contains, and therefore probably also more dissolved salts. This makes the phenomenom on its surface more conspicuous.

There are a few published data on the recent composition of soluble salts in the pore space of carbonate sediments, particularly in Yugoslavia. Some of the information is immediately connected with the determination of soluble salts that can have a damaging influence on the stone as a building material.

Lamar and Shrode (1953) determined the quantity of soluble salts in 29 samples of paleozoic limestones and dolomites. Among the anions they analyzed quantities of hydrocarbonates, sulphates and chlorides. The amount of sulphate in these rocks was between 0.001 and 0.184 %, and of chlorides between 0.003 and 0.100 %. By X–ray analysis of leached salts determined were NaCl, $CaSO_4$, KCl,

$MgSO_4$ and $MgCl_2$, as well as $CaCO_3$ leached by water as hydrocarbonate and $Mg(OH)_2.2MgCO_3$.

Examing the decayed stone, a lithotamnian limestone, of the cathedral church in Zagreb, Marić (1938) analyzed also the stone from the deposit in Bizek (near Zagreb), and determined that limestone in the deposit did not contain sulphates, but surface of stone from church contains to 38 % of gypsum.

Data on soluble salts (chlorides, sulphates) from 30 deposits of dimension stone in carbonate sediments of the outer Dinarides, were published by Crnković and Babić (1983). The chlorides in the samples analyzed amount from 0.013 to 0.073 %, and sulphates from 0.000 to 0.0127 %. Soluble salts in limestones were examined for their intergranular and intragranular character. Intergranular soluble salts are contained in the pore space of the limestone. Their composition and participation in the pore space has certainly suffered changes during the geological time. The intragranular soluble salts, possibly »caught« and included into grains of sparite calcite and idioblasts of dolomite, could be close to the syngenetic compositon and represent the original composition of the connate water. These two types of soluble salts were not separated. Preparing the samples for analyses, the authors crushed the stone to micronic dimensions, by doing which they destroyed the grains of sparite calcite and dolomite. As a result they obtained a summary quantity of intergranular and intragranular soluble salts. In order to separate these two types of soluble salts it would have been necessary to adapt the preparation of samples for analysis. The preparation would consists of cruching the samles twice. The first time they would be crushed to the dimension of a grain to obtain the quantity and the composition of intergranular soluble salts. The second time the grains of sparite calcite and dolomite would be fragmented by crushing, to obtain the quantitiy and the composition of intragranular salts.

The most recent data refer to the quantity of sulphate and chloride in the limestone from the Vinkuran deposit in Istria (Crnković and Miko, 1991). The arithmetic mean (10 samples were analyzed) are 0.018 % for the sulphate, and 0.014 % for the chloride. This corresponds to the quantity of primary soluble salts determined in Cretaceous limestones quarried in Croatia as dimension stone.

Quarrying

The ancient technology of quarrying stone blocks will be discussed first.

The digging of deep channels, by which part of the rock mass is separated from the whole on a vertical line, was performed mannually using a chisel and a hammer. The splits for woodden spikes were also made by hand. Such handwork and swelling of the woodden spikes, by pouring water over them after their insertion into the rock, produced either no strain, or the strain was so insignificant that it can be completely neglected.

Manual or machine hole boring to separate blocks by wedge-splitting, must needs cause strain in the rock at the base and around the cutter head, as well deformations. The strain and deformations are certainly more violent if a pneumatic block-cutter is used. If a hydraulic cutter is used, the strain and thus also the deformations are diminished. An iron wedge struck by a heavy mallet increases strain to a certain extent. The introduction of block-splitting by gunpowder and detonating fuse can, depending on the properties of the rock, lead to considerable strain and deformations, which often occur along the entire block separated.

The introduction of helicoidal wire with quartz sand as abrasive material, and a diamond wire, has removed the possibility of strain occuring during separation. In distinction to the above mentioned wire-cutting, a chain-saw machine does develop strain along the surface of the cut. This is caused by the strokes of each widia insert of the holder chain, which produce stroke after each discontinuity, and damages to the surface of the rock in the channel. By discontinuity in the rock are understood the fine cracks and joints as well a vuggs, but also the intergranular contacts of minerals of different mechanical properties and the cleavage of minerals in coarse-grained stones.

A new way of block cutting from the rock mass was recently introduced. It is cutting by means of »Calmmite« (or other trade marks) cutter, which operates by means of a powerful expansive pressure generated in the hydratation process, i. e. without explosion. As to its effect, this technology can be compared with the ancient technology of wood swelling by exposure to water, though it is more powerful. A similar effect on the stone has the application of a hydraulic cylinder.

The boring and cutting of silicate rocks are effectively performed by jet-piercing or -cutting (Pfleider, 1972). A high temperature is effected by flux burning in an oxygen current. This technology is particularly advantageous for quartz-containing rocks. Strain in the rocks caused by concentrated jets of thermal energy and models of thermal erosion of rocks were developed by Dmitrijev et al. (1990).

Thermal fluxible strain caused by the use of recent technologies such as electrothermal, electrothermomechanical and laser technologies are similar to thermal jet-cutting.

The least influence on the rock along the cut, causing no strain or deformation, has most probably been achieved by high-pressure water-jet cutting. This technology does not cause damage to the compactness of the rock, because is no vibration occurs during block cutting.

If we rank the technologies of stone-block cutting listed above from the point of view of strain development and accompanying deformations, the first place, with respect to the intensity of strain and influence in depth of stone will be taken by explosion cutting. The least influence on the stone will be exerted by helicoidal and diamond wire cutting.

Stone processing

There is less likelihood for strain occurring during stone processing in plain and profiled stone elements and slabs.

Sawing the blocks on a log frame by abrasives or diamond log frames, and block-cutting by diamond discs, produce a shallow strain, concentrated along the surface of the cut. The abrasive shot and diamond-coated blades produce abrasion along the surface of the cut, striking the stone compounds with varying speed after each macro- and micro-discontinuity. Each stroke causes a corresponding type of strain in the stone.

When stone elements and plates are polished the surface is taken away. It is also possible for a minimal strain to occur under the pressure of various machines during machine polishing.

The final rustical processing of stone elements and slabs is executed:

a) manually, using a stone pick, bush hammer, pick hammer etc.,
b) mechanically by a pneumatic hammer,
c) by flame-finishing, and
d) by sandblasting.

Each of the stroke producing method causes strain. The strain is negligible in manual processing, particularly if the tool is used by a skilled worker who knows how to control the stroke impact. Much stronger and deeper is the effect on stone in machine processing. Sandblasting produces surface strain, depending on the size of the abrasive grains and force of the jet stroke.

Damage occurring in flame-flashing was described by Pitts (1989), supported by electronic microphotography. The model and cynetics of thermal destruction and lamellation in quartzite was studied by Dmitrijev et al. (1990).

Come back to ancient technology in stone processing, too. The ancient technology of manual block-cutting with abrasive saws was not so much hard work as it was tedious. The saw with the abrasive cut into the rock slowly. The abrasive affected the surface of the cut without striking, so that any strain was diminished or practically absent.

Dressing

Various complex types of strain are possible during dressing the stone for various purposes.

The role of the stone element in a building has to be considered to see whether the element is to be used in the construction like a constructive, or both a constructive and decorative, or decorative.

Stone elements used for construction and construction-decoration in a more distant or recent past of a building, come in appropriate sizes. These elements represent an appropriate volume or stone mass as units. This means that the bulding contains the same natural material in depth, which is exposed to all outside influences as a whole regardless of its origin, intensity and duration. This is an explanation of the fact that the stone of old buildings is relatively well preserved, even after centuries or milennia.

Today the stone of house fronts serves in the first place as a decorative and protective element. The facades are covered with relatively thin (30 to 40 mm) stone slabs. The slabs are fastened to the building structure by anchoring and mortar-casting, or by ventilating facing, when the stone slabs are fastened by anchoring and do not touch the structure of the building.

In some cases the thickness of the stone slabs is insufficient for the stone to successfully weather various types of strain under external influences. Such strain can be detrimental for the stone, particularly when the slabs are not dressed in an appropriate way, i.e. when the facing design is not adapted to the properties and reaction of the thin stone slabs.

Facades of buildings have recently been faced with very thin stone slabs fastened to large pannels. An example of this technique is the »Promastone System«, a sandwich with a beehive-like aluminium grate on both sides with glass-fibre and phenol-pitch plates, and very thin stone slabs. The entire thickness of such a sendwich is only 25 mm, and the mass only 20 kg/m^2. The maximum size of the pannel surface is 2400x1200 mm. Such a facing technology is justified for a number of practical and economic reasons, but it is possible only if a stone with a silicate composition is used, that is to say, granite. In no case can such a technology be recommended and accepted for stone with a carbonate composition, such as limestones and marbles have. The reason is in the first place the great difference in the properties of these two stone groups, and their durability regardless of climatic and environmental conditions. The technology is new, so there are no data of the behaviour of such pannels on facades exposed to exogenic factors of the environment, however, it is a fact that the sandwich pannel contains a variety of different material with defferent physical and mechanical properties, particularly in their reaction to changes of temperature.

Environment

The tendency in the world today is to face house facades with silicate stones, i.e. all types of granite, including sienite, diorite, gabbro, gneiss etc. Such a tendency is logical for a number reasons, one of which is the silicate composition of stone:

- in an urban environmet it is resistant to a wide range of climatic conditions and technogenic products in the anthropogenic sphere,
- because of its properties it is adequate for industrial production of thine slabes for the production of large pannels,
- it is characterized by particularly favourable physical and mechanical properties,
- it is characterizes by durability of its surface appearance.

Such of tendency will certainly render the carbonate stone less used for facing, regardless of the differences in the cost of quarrying and stone processing.

In discussing the behaviour of stone in urban and even in rural environments, we must pose the question to what extent we can tolerate further air polution, and through it the polution of rain, surface and underground water, as well as the entire biosphere. Alarming data on polution have been published in a number of works, which are commented and summarized by Winkler (1973) and Amaroso and Fassina (1983), and they are made public every year in various professional conference. The reduction of larger quantities particularly of CO_2 and SO_2 in the air, will normally result in the reduction of »acid rain« quantities, which turn will have a favourable effect on the durability of the facing stone of carbonate composition. The durability can be prolonged by hydrophoboizing the surface of the house facades made of carbonate stone, which can be regarded as prevention but only for stone, not for the rest of the human environment.

Conclusion

The best indicator of the behaviours and durability of stone is the analysis of its condition when used as building stone in the recent or the more distant past. The condition of building stone, however, depends on a number of factors, which have to be taken into account when evaluating the analysis.

Firstly, it is necessary to know the genesis, all syngenetic, diagenetic and postgenetic processes in the stone deposit. Consequences of all these processes or only of some of them, remained in the stone as clearly conspicuous or less conspicuous deformations. Some of them can be, or definitely are, of essential and »fatal« importance for the behaviour and durability of the stone in the building. On the genesis and development of such strains and deformations can not be influenced.

Secondly, depending on the technology of quarrying it is possible that various aspects of strain will develop in stone, including deformations. If these deformations have not been noticed in the stone processing they will certainly influence the age of the building stone and will manifest themselves as unsiderable phenomena in the stone of house facades. This, however, suggests a more favourable and more acceptable choice of quarrying technology, such as, block-cutting by a diamond or helicoidal wire.

Thirdly, in stone processing, cutting and polishing, or other processing of stone surface, with some exception, practically no deformation develop. Exceptions are methods applying strokes or fire in the processing of the stone surface.

Fourthly, the requirement that the stone elements and slabs should be built into the facade in an appropriate way has to be met. This is to say, that the facing design has to be adapted to the properties and suitability of the stone.

And finaly.

According to Konta (1987) the intensity of weathering of any rock (or stone) can be generally expressed by the following relation:

$$I_w = f(R, E_s, A + H, E_m, t)$$

where:

I_w ... the intensity of weathering,
R ... physical properties and material composition of rock,
E_s ... amount of the accepted solar energy and climatic conditions,
A ... chemical and physical actions of atmosphere,
H ... the average annual rainfall, chemical composition, state of aggregation of water, its physical action,
E_m ... the energy of effective tectonic and further movements, and
t ... the duration of all counted factors

This Konta's relation we are obliged enlarged with:

$$(D_r, D_q, D_p, D_c)$$

where:

D_r ... the sume of syngenetic, diagenetic and postgenetic remnants with negative influences,
D_q ... strain rest caused by quarrying,
D_p ... strain rest caused by stone processing, and
D_c ... strain caused by dressing and influence of construction

The short description of the influences on stone, from quarrying, stone processing, dressing and exposing to natural and technological factors of the environment, and a number of questions and factors still unknown, make further research necessary in order to gain knowledge of the numerous processes in stone, caused by natural and technogenic factors, which, no doubt, influence the durability and age of the inbuilt stone.

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LITERATURA:

Amoroso, G. G. and Fassina, V. (1983): Stone decay and conservation, atmospheric pollution, cleaning, consolidation and protection. Elsevier, 453, Amsterdam.

Crnković, B. and Babić, V. (1983): Soluble salts in carbonate rocks. *Geol. vjesnik*, 36, 117–129, Zagreb.

Crnković, B. and Miko, S. (1991): The influence of the urban environment on the stone of the Arena in Pula. *Rudarsko-geološko-naftni zbornik*, 3, 1–6, Zagreb.

Dmitrijev, A. P., Goncharov, S. A. and Germanovich, L. N. (1990): Termičeskoje razrushenije gornih parod. Nedra, 254, Moskva.

Engelhardt, W. F. (1973): Bildung von Sedimenten und Sedimentgesteine. E. Schweizerbart'sche Verlagsbuchhandling, 378, Stuttgart.

Garrels, R. M. and Christ, Ch. L. (1965): Solutions, Minerals and Equilibria. Harper and Rov, 364, New York.

Karaulov, E. V. (1966): Kamenie konstrukciji – ih razvitije i sahranjenije. Izd. lit. po stroiteljstvu, 235, Moskva.

Konta, J. (1987): Decay of building stones in historical monuments: First quantitative approach. The sixth Meeting of the European clay groups, Round table on: The decay of building stone, 7–9, Cádiz.

Lamar, J. E. and Shrode, R. S. (1953): Water soluble salts in limestones and dolomites. *Econ. geol.*, 48(2), 97–112.

Marić, L. (1938): Litotamnijski vapnenjak (krečnjak) u prirodi i građevini (Lithothamnion limestone in nature and building). Tisak jug. štampe d.d., 22, Zagreb.

Parker, A. and Sellwood, B. W. (1983): Sediment diagenesis. D. Riedel Publ. Comp., 427, Dordrecht.

Pfleider, E. P. (1972): Surface mining. The American Institute of Mining, Metallurgical and Petroleum Engineers Inc. 1061, New York.

Pitts, J. (1989): Selecting and testing stone for cladding. *Stone Industries*, 24/7, 24–28, Ealing Publ. Maidenhead.

Winkler, E. M. (1973): Stone: Properties, Durability in Man's Environment. Springer-Verlag, I–XIII, 230, New York.

Trajnost arhitektonskog kamena

B. Crnković

Arhitektonski kamen vrednuje se na osnovi fizičko-mehaničkih svojstava određenih u laboratoriju, ali i stanja kamena ugrađenog u objekte.

Stanje kamena ugrađenog u objekte, sa stanovišta njegove otpornosti i trajnosti, ovisi o nizu činilaca. U prošlosti i danas kamen je eksploatiran i prerađivan različitim tehnologijama i ugrađivan na različite načine. U tim razmatranjima ne smijemo zanemariti naprezanja i deformacije u kamenu koje su rezultat singenetskih, dijagenetskih i postgenetskih procesa (sl. 1).

Naprezanja i deformacije u ležištu

Postoji širok raspon razvoja mogućih naprezanja i deformacija što je uzrokovano singenetskim, dijagenetskim i postgenetskim procesima.

To su, primjerice, polimorfne transformacije visokotemperaturskog kvarca u niskotemperaturski što prati promjena volumena, zatim deuterički procesi kao u serpentinizacije olivina s promjenom volumena, postanak mehaničkih sraslaca u kalcitu pri metamorfozi vapnenca u granoblastični mramor, utjecaj tektonskih procesa i sl.

Eksploatacija

U vađenju blokova kamena iz stijenske mase postoje velike razlike u tehnologijama, od antike do danas. Kod antičke tehnologije ručnim radom, dlijetom i čekićem, kao i bubrenjem drva uz potiskivanje kamenih blokova, naprezanja i deformacije u bloku kamena se mogu zanemariti.

Uvođenjem pneumatskog bušenja na dnu bušotine radom bušaćeg čekića sigurno se razvijaju naprezanja i deformacije. Naprezanja i zaostale deformacije u bloku kamena još su znatnija kad se pri odvajanju blokova koriste eksplozivi, crni barut i detonirajući štapin.

Mogući nastanak naprezanja i deformacija je isključen uvođenjem helikodalne žice s kvarcnim pijeskom kao abrazivom i dijamantne žice. Za razliku od netom izloženih tehnologija, kod rezanja kamena lančastom zasjekačicom duž površine reza nastaju naprezanja i deformacije.

Nova metoda upotrebe »Calmmita« po svom djelovanju usporediva je s antičkim metodama bubrenja suhog drva pri kvašenju. Sličan efekt imaju i hidrauličke naprave.

Bušenje i rezanje plamenom, kao i tehnologije u fazi ispitivanja kao što su elektrotermalna, elektrotermalnomehanička i laserska, također u kamenu razvijaju naprezanja i deformacije.

Rangiramo li široki raspon tehnologija vađenja ili branja blokova kamena sa stanovišta nastanka naprezanja i deformacija i njihovih intenziteta, na prvom mjestu nalazi se eksploatacija korištenjem eksploziva. Najmanji, zanemariv ili nikakav utjecaj imaju upotreba helikoidalne i dijamantne žice i rezanje vodom pod pritiskom.

Prerada

Kod rezanja blokova kamena bilo na gaterima ili pomoću dijamantnih diskova, naprezanja i deformacije su koncentrirane duž površine reza.

Kod finalne rustične obrade površine kamenih ploča i elemenata, po intenzitetu nastajanja i naprezanja na prvom mjestu se nalaze mehaničke obrade pneumatikom i plamenom. Ostale tehnologije, obrada ručnim alatkama i pjeskarenje, neznatno utječu na nastanak naprezanja i deformacija.

Ugrađivanje

Kamen se u građevinu može ugrađivati kao konstruktivni, konstruktivno-dekorativni i dekorativni element.

Kamen kao konstruktivni i konstruktivno-dekorativni element ima svoju dimenziju, volumen ili kamenu masu u cjelini, dakle fizički isti materijal u površinskom dijelu i u dubini. Ta cjelina je izložena vanjskim utjecajima i svim njihovim promjenama.

Danas je kamen na pročeljima objekata dekorativni element u obliku tankih kamenih ploča. U takvim kamenim pločama pod djelovanjem vanjskih činilaca moguć je širok raspon nastanka naprezanja i deformacija, posebice kada projekt oblaganja objekta nije prilagođen svojstvima kamena.

Recentne tehnologije oblaganja pročelja objekata velikim panelima prihvatljive su jedino za oblaganje granitima, odnosno kamenom silikatnog sastava, a ni u kom slučaju s mramorom i vapnencem, kamenom karbonatnog sastava.

Takvoj tehnologiji, na primjer, pripada »Promastone System«, sendvič debljine 25 mm, koji se sastoji od aluminijskog lima saćaste građe, staklastih vlakana i fenolne smole, te kamenih ploča. Radi se dakle o panelu koji sadrži u svojoj konstrukciji materijale različitih fizikalnih parametara i ponašanja prema utjecaju okoliša, prvenstveno promjene temperature.

Okoliš

Današnja je tendencija da se za oblaganje pročelja objekata upotrebljava prvenstveno kamen silikatnog sastava, dakle graniti u širem smislu. To je opravdano iz niza razloga, kao što su utjecaj klime i tehnogenih proizvoda, preferirano oblaganje panelima, bolja fizičko-mehanička svojstva, te otpornost i trajnost. To potiskuje upotrebu mramora i vapnenca, bez obzira na razlike u troškovima eksploatacije i prerade kamena karbonatnog sastava u odnosu na kamen silikatnog sastava. U raspravama o različitostima u ponašanju kamena karbonatnog i silikatnog sastava, čak i u ruralnom okolišu, obavezno se mora uzeti u obzir, po kamen karbonatnog sastava, štetan i poguban utjecaj i djelovanje »kisele kiše«.

Zaključak

U razmatranjima o trajnosti kamena i njegovog vrednovanja u obzir treba uzeti nekoliko faktora.

Prvo, potrebno je poznavanje geneze, svih genetskih, dijagenetskih i postgenetskih procesa ležišta kamena. Na nastanak naprezanja i deformacija u kamenu vezanim za genezu ne možemo utjecati.

Drugo, u toku eksploatacije u blokovima kamena mogu nastati naprezanja i deformacije, ako je tehnologija neprikladna.

Treće, u toku prerade blokova kamena, osim nekih izuzetaka, praktički nema mogućnosti nastanka značajnijih naprezanja i deformacija.

Četvrto, tehnologiju primjene kamena, oblaganja, treba prilagoditi svojstvima kamena.

I konačno, relaciju intenziteta trošenja K o n t e (1987) treba dopuniti s novim članovima koji sadrže sumu singenetskih, dijagenetskih i postgenetskih procesa s negativnim utjecajima, naprezanja uzrokovana eksploatacijom, naprezanja uzrokovana preradom i naprezanja uzrokovana oblaganjem i utjecajem konstrukcije.