ZABORAVLJENE TEHNOLOGIJE GRAĐENJA

FORGOTTEN CONSTRUCTION TECHNOLOGIES

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STRUČNI RAD
UDK: 693.21 = 861

1 UVOD

Najljepši objekti koji su izgrađeni na području Sredozemnog mora su palate i drugi reprezentativni objekti kod kojih je kao osnovni materijal korišćen kamen. Takvi objekti su drevne kamene palate u starom gradu Kotoru, Dubrovniku, Budvi, Ulcinju, a posebno predivna kamena zdanja u kapetanskom gradu Perastu. Fascinirajuće kamene fasade peraških palata su gradili uzorni pomorci i kapetani koji su živjeli u ovom gradu u različitim epohama. Njihovo stalno kretanje širom svijeta, bogastvo i slava su im omogućavali da grade najkvalitenije i naprestižnije objekte u periodu u kojem su živjeli. Takvi objekti su: zgrada muzeja u Perastu, Palata Vickovića, Palata Smekja, Palata Mazarovic i druge.

Osnovni cilj ovog rada je da prezentira javnosti ovu veoma interesantnu, a gotovo zaboravljenu tehenologiju građenja kod koje se kao osnovni materijal koriste kameni blokovi od krečnjačkih stijena, da bismo je, ne samo zaštitili od zaborava, nego i pokušali da proučimo mogućnost njene primjene u savremenim uslovima privređivanja, tj. kod izgradnje objekata visokogradnje.

Nakon analize osnovnih karakteristika ove tehnologije i mogućnosti njene primjene u današnjim uslovima građenja, daćemo predlog orginalne tehnologije građenja koja će sadržati savremene tehnološke procese, a zadržati primjenu tradicionalnih alata i zanata , da bi se dobili oblici i forme drevnih kamenih fasada i unutrašnje dekoracije, a ujedno omogućila brža i ekonomičnija izgradnja ovakve vrste objekata.

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1 INTRODUCTION

The most beautiful buildings constructed in the Mediterranean are the palaces and other representative buildings which used stone as a basic material. These buildings are ancient stone palaces in the old town of Kotor, Dubrovnik, Budva, Ulcinj, and particularly beautiful stone buildings in the captain's town of Perast. The fascinating stone frontages of the palaces of Perast were constructed by sailors and captains who lived in this town in different eras. Their continuous movement around the world, as well as their wealth and glory, enabled them to construct the most quality and the most prestigious buildings during their lifetime. These buildings are: the museum building in Perast, Vicković Palace, Smekja Palace, Mazarović Palace and others.

The basic aim of this paper is to present to the public this very interesting, almost forgotten construction technology which used stone blocks from limestone rocks as a basic material, not only to protect them from oblivion, but also to study the possibility of its usage in contemporary industrial conditions, i.e. in building construction.

After the analysis of basic characteristics of this technology and the possibilities of its usage in present construction conditions, we will propose the original construction technology which will contain modern technological processes, and retain the usage of traditional tools and trades to obtain shapes and forms of ancient stone frontages and interior decorations, and at the same time enable faster and more economic construction of these types of buildings.

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2 PRIKAZ I ANALIZA OVE DREVNE TEHNOLOGIJE GRAĐENJA

Kada se posmatraju stare kamene fasade stiče se utisak da one imaju dušu koju su im uklesali oni koji su utkali svoj znoj da bi objekat dobio željene i projektovane forme. Obrađivanje kamena zasnivalo se na ručnoj eksploataciji u majdanima i ručnoj obradi uz korištenje tradicionalnih alata koji se nijesu mijenjali hiljadama godina.

Za izgradnju pomenutih reprezentativnih objekata na ovim prostorima korišćene su karbonantne stijene od kojih su klesani kameni blokovi projektovanih dimenzija. Karakteristika ove tehnologije je da su se blokovi obrađivali u neposrednoj blizini majdana gdje je vršena eksploatacija materijala.

Sama tehnika eksploatacije kamena u majdanima je stara gotovo koliko i ljudska civilizacija i nije se znatno mijenjala do pojave eksploziva. Eksploatacija kamena se zasnivala na cijepanju prirodnih stijena putem metalnih klinova ili klinova od drveta koji su ubadani u rupe i natapani vodom, što je izazivalo povećanje zapremine drvenog klina a zatim cijepanja kamenih stijena u blokove željenih dimenzija.

Kamen je eksploatisan i obrađivan na tradicionalan način na ostrvima Brač, Korčula i td. i brodom transportovan do Perasta, Kotora i drugih mjesta na Primorju u kojima su se gradili objekti od ovog materijala. Ova tehnologija je bila veoma interesantna za stanovnike tih mjesta jer su svi oni, uglavnom, bili uzorni pomorci, pa im je transport brodom bio najprikladnije rješenje.

Na slici 1. je prikazan alat koji se koristio za ekploataciju kamena iz majdana i ručnu obradu.

2 PRESENTATION AND ANALYSIS OF THIS ANCIENT CONSTRUCTION TECHNOLOGY

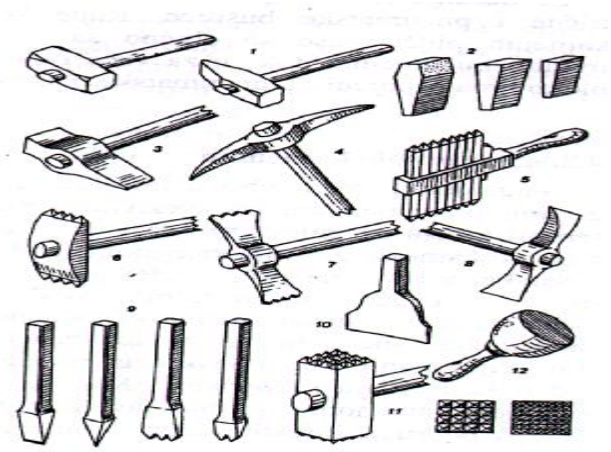
When you observe the old stone frontages, you get the impression that they have souls of the persons who sweated to give to the buildings the desired and projected forms. Stone dressing was based on manual exploitation of quarries and manual dressing using traditional tools which haven't been changed for thousands of years.

For the construction of mentioned representative buildings in these areas carbonate rocks were used of which stone blocks with projected dimensions were carved. The characteristic of this technology is dressing of the blocks nearby the quarry where the exploitation of material was done.

The technique of exploitation of quarries is almost as old as human civilization and it hasn't changed significantly until the discovery of explosive. Stone exploitation is based on splitting of natural stones using metal wedges or wooden wedges stuck into the holes and soaked with water, which caused the increase of the size of wooden wedge, and then splitting of the stone into blocks with desired dimensions.

The stone was exploited and dressed in traditional way on the islands of Brač, Korčula etc. and transported by ships to Perast, Kotor and other places at the seaside where the buildings were constructed using this material. This technology was very interesting for the inhabitants of those places, because they were mostly model sailors, and, as a result, the transport by ship was the most appropriate solution.

In Figure 1 tools used for stone exploitation of the quarry and manual dressing are shown.



Slika 1.
Figure 1.

Alat se sastojao od: ćuskija, klinova, malja, macole, odbijača, škvadra, glijeta, matelina, cokade, raznih vrsta bruseva i drugog. Ćuskije, maljevi i klinovi su korišćeni za eksploataciju kamena u majdanima, a za transport su se koristile oble cijevi, poluge, i konjska zaprega. Gruba obrada kamena je vršena raznim vrstama grubljih glijeta, odbijačima, martelinima sa više vrsta različitih zubaca i ugaonim škvadarima, a finija obrada cokadama sa više vrsta različitih zubaca i glijeta. Kod elemenata kod kojih je zatijevana preciznija obrada vršeno je fino ručno

The tools consisted of: bars, wedges, ram, beetle, bumper, square, chisel, stone hammer, "cokada", different types of grinders and others. Bars, rams and wedges were used for stone exploitation of the quarries, while round pipes, levers and horse-car were used for transport. Dressing of rough stone was done using different types of rough chisels, bumpers, stone hammers with several types of teeth and angle squares, while finer dressing was done using "cokada" with several types of teeth and chisels. The elements which

brušenje i poliranje. Na slici 2 je prikazan tehnološki proces proizvodnje elemenata od kamena i izgradnje objekata u ovoj drevnoj tehnologiji.

Ova tehnologija je, u stvari, bila preteča savremenih industrijskih metoda građenja. Da bi se izgradio jedan ovakav objekat, prije obrade kamena se morala obraditi kompletna fasada i unutrašnji eneterijer, a projekti su bili tako detaljni da je svaki kameni blok koji se obrađivao imao precizno definisane dimenzije, formu i kamenu plastiku. Prije utovara u brod svaki kameni element je bio završno obrađen, jed se na licu mjesta vršila samo montaža i zidanje. Ova tehnologija je omogućavala projektantima da ostvare željena arhitektonska rješenja, koristaći klesarske vještine poznatih bračkih i drugih majstora ovog zanata.

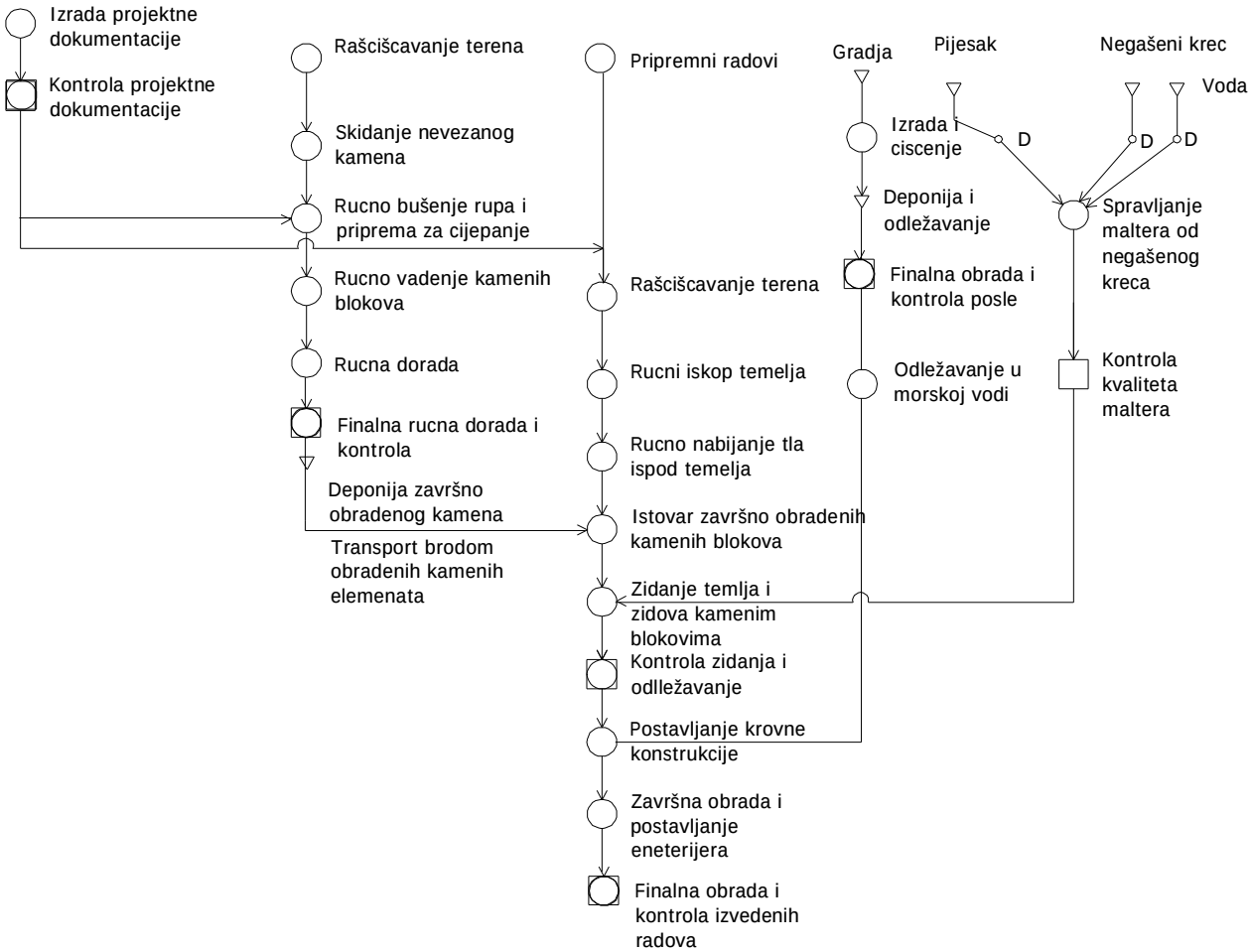
Osnovna karakteristika ove tehnologije građenja i njena originalnost je u tome što su se kameni blokovi od krečnjačke stijene međusobno povezivali negašenim krečom i na taj način su zidani svi zidovi na objektu. Tako ozidani kameni zidovi su ostavljani godinu dana da kisnu jer su se tako kameni blokovi isklesani od stijena kalcijumkarbonata međusobno spajali u jednu cjelinu.

need more precise dressing were exposed to fine manual grinding and polishing. In Figure 2 it is shown the technological production process of stone elements and construction of buildings using this ancient technology.

This technology, in fact, was the antecedent of contemporary industrial construction methods. In order to construct such building, before stone dressing the frontage and the interior should have been dressed and the projects were so detailed that each stone block for dressing had precisely defined dimensions, form and marble dimensions. Each stone element was finally dressed before the shipment, because only the assemblage and masonry works were done on the spot. This technology enabled the planners to realize the desired architecture solutions, using stonemason abilities of famous craftsmen from Brac and other places.

The basic characteristic of this construction technology and its originality is the fact that the blocks of limestone rock were bound with quicklime and all the walls of the building were built in that way. These stone

KARTA PROCESA ZA STARI TEHNOLOŠKI PROCES



Slika 2. Prikaz starog tehnološkog procesa izvođenja objekata od kamena
Figure 2 Demonstration of the old technological process for the construction of stone buildings

Za isto to vrijeme se prirodno osušena drvena građa za krovnu konstrukciju objekta ostavljala da odleži potopljena u more. Na ovaj način su se uništavali svi insekti u drvetu i trajno štitila drvena konstrukcija od njihovog dejstva. Nakon toga drvena konstrukcija se morala dobro osušiti u adekvatnim uslovima, a zatim su se izvodili krovopokrivački radovi.

Nakon završenih grubih izvođeni su zanatski radovi na tradicionalan način: malterisanje, postavljanje stolarije, izrada podova, ograda i drugi zanatski radovi.

3 PREZENTACIJA OBJEKATA KOJI SU GRAĐENI U OVOJ TEHNOLOGIJI

Tako su nastale kamene palate u Persatu i drugim primorskim mjestima koje i danas izazivaju divljenje kod svakog posjetioca ovih naših dragulja uz obalu Jadranskog mora. Na slikama 1,2,3 su prikazani objekti koji su građeni od kamena, uz primjenu opisane tehnologije u Perastu.

walls were exposed to rain for a year, because the stone blocks carved from the calcium-carbonate rocks were bonded to form the whole.

Meanwhile naturally dried wood for the roof construction of the building was left soaked into the sea. In this way all the insects in the wood were destroyed and the wooden construction was permanently protected from their effect. Afterwards the wooden construction had to be dried well in appropriate conditions, and then the covering of the roof could start.

After rough works the artisan works were performed in traditional way: rendering, cabinet making, floor making, fence making and other artisan works.

3 PRESENTATION OF THE BUILDINGS CONSTRUCTED USING THIS TECHNOLOGY

The stone palaces in Perast and other seaside places, which even today arouse admiration in visitors of the Adriatic Sea coast, were built in this way. The buildings made of stone using the described technology in Perast were shown in Figures 1, 2 and 3.

Slika3. Prikaz objekata i palata koji su izgrađeni uz korištenje starog tehnološkog procesa
Figure 3 Presentation of the buildings and palaces built using old technological process

4 PREDLOG ORGINALNE TEHNOLOGIJE GRAĐENJA

4.1 Opis predložene tehnologije građenja

Opisana drevna tehnologija građenja se teško može realizovati u današnjim uslovima zbog velikog učešća fizičkog rada i neekonomičnosti procesa eksploatacije, obrade i građenja. U periodu u kojem se veoma brzo razvija oprema, mehanizacija i tehnologija, evidentan je nedostatak zanatskih majstora za ručnu obradu kamena, tako da bi bilo neracionalno eksploatisati, ručno obrađivati kamen i graditi objekte kao u drevna vremena. Zato predlažemo tehnologiju građenja koja će sadržati stare alate za završnu obradu, a za eksploataciju, montažu i pripremu blokova koristiti savremene alate, mehanizaciju i opremu. Osnovna karakteristika predložene tehnologije građenja je ubrzan proces izgradnje, uz zadržavanje kvaliteta izvedenih radova i ljepote kamenih fasada i enterijera. Ovim tehnološkim procesom treba postići da obrađeni kamen posle završenog ciklusa obrade izgleda kao da je to rađeno u drevna vremena i da izvedeni objekti imaju patinu starih fasada i enterijera u kojima je osnovni materijal kamen.

4.2 Analiza tehnološkog procesa savremenih tehnologija građenja

Na slici 4. je prikazan tehnološki proces realizacije predložene tehnologije građenja. Za eksploataciju kamena u majdanima je predložena tehnologija bez miniranja, to jest vađenje željenih blokova kamena procesom cijepanja. Ovaj proces eksploatacije je u suštini isti kao i u davna vremena, osim što se vađenje rupa ne odvija ručno ćuskijama, već specijalnim opremom i alatima za izvođenje bušotina, a cijepanje blokova se ne vrši klinovima i maljevima, već specijalnim hidrauličkim klinovima, ili uz korišćenje druge opreme za ovu namjenu, pošto će izbor opreme zavisiti od karakteristika samog nalazišta kamena.

Transport do mjesta obrade se odvija kranom ili drugom mehanizacijom koja je najprikladnija za date uslove, a gruba obrada u kamene blokove vrši se gaterima i frezama za reazanje kamena, te drugim savremenim alatima koji služe za grubo skidanje i obradu površina kamena .

Fina obrada kamenih blokova se obavlja istim alatima (materelini, cokade, škvadar, razne vrste glijeta) I na isti način kao u to drevno vrijeme, jer finalno obrađeni kamen mora tako da izgleda kao da je ručno obrađen, sa patinom starih fasada, bez vidnog učešća mehanizovanog rada. Zbog nedostatka majstora za klesarske radove, predloženo je da se u sklopu tehnološkog procesa organizuje škola za edukaciju mladih zanatlija, koja bi omogućila postizanje kvalitetne finalne ručne obrade i montažu i zidanje sa elementima od kamena, odnosno to bi predstavljalo ključnu aktivnost u tehnološkom procesu.

Transport blokova i elemenata od kamena nije precizno određen jer zavisi od lokacije na kojoj se izvodi objekat i mjesta majdana u kojem se vrši eksploatacija i obrada kamena, odnosno od ekonomske analize opravdanosti određene vrste transporta.

4 PROPOSITION OF THE ORIGINAL CONSTRUCTION TECHNOLOGY WITH THE POSSIBILITY OF ITS USAGE IN PRACTICE

4.1. Description of the proposed construction technology

The described ancient construction technology can hardly be carried out in today's conditions because of great physical work and uneconomic exploitation process, dressing and construction. In the era when the equipment is rapidly developed, as well as the mechanization and technology, it is evident the lack of craftsmen for manual stone dressing, so it would be irrational to exploit, manually dress and construct buildings as it was in ancient times. Therefore we propose the construction technology which will use old tools for final dressing and modern tools, mechanization and equipment for exploitation, assemblage and preparation of the blocks. The basic characteristic of the proposed construction technology is the accelerated construction process, keeping the quality of works and beauty of stone frontages and interior. Using this technological process, the dressed stone, after dressing, should look like it was made in ancient times and the constructed buildings should have the patina of the old frontages and interiors, when stone was used as a basic material.

4.2 Analysis of the technological process of the new construction technology

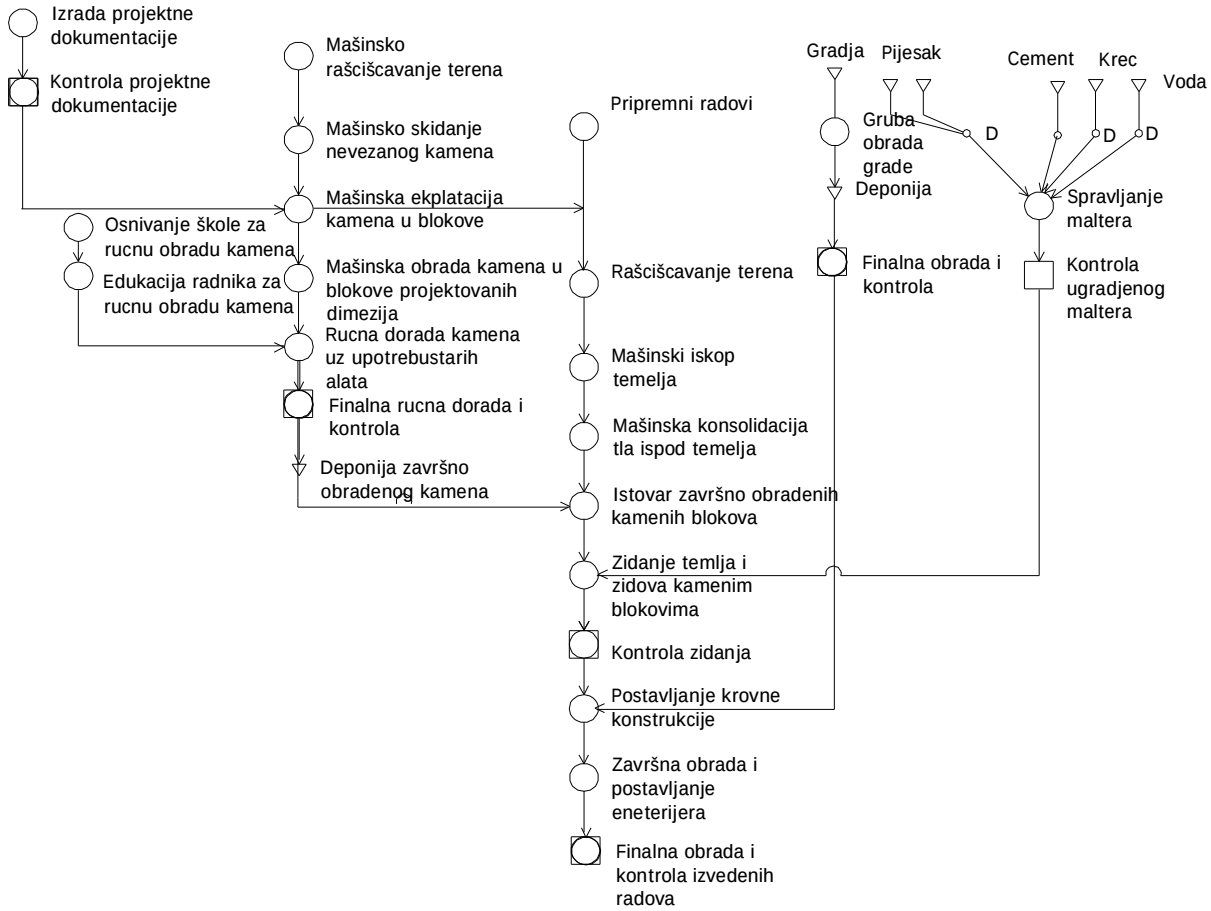
In Figure 4 the technological process of the realization of the proposed construction technology is shown. For stone exploitation of the quarries it was proposed the non-mining technology, i.e. extraction of desired stone blocks by splitting. This exploitation process is basically the same as it was in ancient times, apart from the fact that the hole excavation is not done manually with bars, but with special equipment and tools for bore holes, and block splitting is not performed with wedges and beetles, but with special hydraulic wedges, or using other equipment for this purpose, since the equipment choice depends on the characteristics of the quarry itself.

The transport to the dressing site is performed by building crane or other mechanization which is the most appropriate for actual conditions, while rough dressing of stone blocks is performed using mills and power saws for cutting of the stone, and then using other modern tools for rough removal and dressing of the stone surface.

Fine dressing of stone blocks is done using the same tools (stone hammers, "cokada", square, different types of chisels), the same way as in ancient times, because the dressed stone has to look like manually dressed, with the patina of the old frontages, without obvious mechanized work. Because of the lack of masons, it is suggested the organization of the school for education of young artisans, which would enable to obtain quality manual dressing, as well as the assemblage and masonry with stone elements i.e. it would represent the key activity in technological process.

The transport of the blocks and stone elements is not precisely specified, because it depends on the construction site of the building and quarry, where the exploitation and stone dressing are done, i.e. it depends on the economic analysis of the justification of particular transport mode.

KARTA PROCESA ZA NOVI TEHNOLOŠKI PROCES



Slika 4. Prikaz tehnološkog procesa kod predložene nove tehnologije izgradnje
Figure 4 Presentation of the technological process of the new proposed construction technology

Kod izgradnje objekata zidanje i montaža kamenih elemenata se planira uz korišćenje savremene mehanizacije i tradicionalnih materijala i alata, a sve u funkciji ostvarivanja željenog izgleda izvedenih radova. Predviđena je montaža sa točkova ili sa broda i skladištanje materijala na deponiju, što će zavisiti od uslova na gradilištu. Izbor tipa montaže će se definisati posebnim projektom plana montaže, koji će zavisiti od uslova na gradilištu, dinamike izvođenja radova i karakteristika samog gradilišta na kojem se izvodi predmetni objekat. Prije montaže elemenata neophodno je na licu mjesta iskontrolisati da li je svaki kameni detalj i elemenat urađen prema projektnoj dokumentaciji i da li je došlo do oštećenja prilikom transporta. Posle izvršene kontrole obrađenih elemenata od kamena, vrši se njihova montaža prema urađenom projektu montaže i dinamičkom planu izgradnje objekta. Neophodne dorade i obrade kamena na licu mjesta se izvode na klasičan način i uz korištenje pomenutih starih alata. Spojevi montažnih elemenata se izvode sa savremenim materijalima, ali uz završnu ručnu obradu i korišćenje starih materijala.

Preporuka je da se krovna konstrukcija, koja nije vidna, izvede uz korišćenje savremenih tehnoloških procesa (izbor kvalitetne građe, sušenje u sušarama, kvali-

In the construction of a building, for masonry and assemblage of stone elements it is planned to use modern mechanization and traditional materials and tools, in order to obtain the desired result of the work. It is planned the assemblage from the wheels or ships and storage of the material at the waste disposal site, which will depend on the conditions at the construction site. The right choice of the assemblage type will be defined by special assemblage project, which will depend on the conditions at the construction site, dynamics of the works and characteristics of the construction site itself where the building is constructed. Before the assemblage of the elements it is necessary to control on the spot if each stone detail and element is done according to the project documentation and whether there were damages during transportation. After the control of dressed stone elements, their assemblage is done according to the assemblage project and dynamics plan of the building construction. The necessary refinement and stone dressing on the spot are done in classical way using mentioned old tools. The assemblage elements are joined using modern materials, but with final manual dressing and using old

tetno impregniranje i završna obrada i montaža). Materijal za pokrivanje krova je crijep, zatim ćeramida, bakar i drugo, slično kao nekada.

4.3 Osnovni elementi informacionog sistema za proizvodnju kamena, nadgledanje i građenje

Kompletan proizvodni proces je podržan adekvatnim informacionim sistemom koji prati sve faze radova, od projektovanja, eksploatacije kamena, do izgradnje objekta (urađeni projekat u predloženoj tehnologiji predviđa da svaki kameni elemenat ili kamena plastika imaju precizne dimenzije, na osnovu kojih se vrši eksploatacija i obrada, i dalje transport i montaža). Kompletan proces se planira, realizuje i kontroliše na osnovu urađenog informacionog sistema, kao logističke podrške boljoj implementaciji predložene tehnologije u praksi. Ovaj informacioni sistem treba da omogući da se u svakom trenutku zna koji se kameni elementi obrađuju, u kojoj su fazi izvođački radovi, kada će se kompletirati određena faza radova i ko je odgovoran za njihovu realizaciju, odnosno kada će se završiti kompletni radovi. Prednost takvog informacionog sistema je i mogućnost sveobuhvatnog planiranja, realizacije, kontrole po parametrima vremena izvođenja akativnosti, definisanja odgovornosti, kvaliteta izvedenih radova i utroška finansijskih sredstava. Ukoliko se desi da neki od obrađenih elemenata nije kvalitetno urađen, preko informacionog sistama se automatski dostavlja zahtjev za njegovu doradu, uz definisanje parametara koji su neophodni da bi elemenat imao potreban oblik, formiui traženi kvalitet. Informacioni sistem treba da omogući konstantnu komunikaciju između projektanta i obrađivača kamenih elemenata koji se proizvode na licu mjesta, zbog eventualnih izmjena u projektnom rješenju, ili zbog nemogućnosti obrade određenih projektovanih detalja. On takođe treba da omogući usklađenost transporta elemenata i montaže na samom gradilištu, pogotovo kada se planira montaža sa transportnog sredstva. Ovdje je jako interesantna primjena softvera koji omogućavaju praćenje realizacije u četiri dimenzije, gdje se vizuelno, uz korištenje kamera, prati realizacija obrade kamena na licu mjesta i izvođenje radova na gradilištu, dok se sa druge strane takođe prati realizacija izgradnje objekta prema utvrđenoj dinamici. Ovi softverski paketi još omogućavaju da se na osnovu planirane dinamike i unosa izvršenih pozicija radova na računaru dobije vizuelni prikaz urađenih pozicija, što je jako značajno za koordinaciju, informisanost i donošenje adekvatnih upravljačkih odluka.

4.4 Analiza mogućnosti korišćenja ovih tehnologija

Da bi se predložena tehnologija građenja mogla uspješno primijeniti u praksi i da bi se objekti kvalitetno, brzo i ekonomično izvodili neophodno je obezbijediti radnu snagu za ručnu obradu i doradu kamenih elematerials as well.

It is recommended that the roof construction, which is not visible, should be done using modern technological processes (quality material, drying in ash-dryers, quality impregnation and final dressing and assemblage). The material for roof covering is tile, then hollow tile, copper and others, similar to what it was used before.

4.3 Proposition of basic elements of the information system for stone production monitoring and construction

The complete production process is supported by adequate information system which follows all the phases of works, from projecting and stone exploitation to building construction (the project in proposed technology predicts precise dimensions of each stone element or marble, on the basis of which the exploitation and dressing are done, as well as the transport and assemblage). The whole process is planned, realized and controlled by the information system as a logistic support to better implementation of the proposed technology in practice. This information system should provide in each moment the information about the stone elements which are dressed, the work phases, the completion time of certain work phase and information about the person responsible for its realization, i.e. to inform when the whole work is going to be finished. The advantage of such information system is the possibility of entire planning, realization, control according to time parameters of the activity, responsibility definition, quality of works and financial expenses. If one of the dressed elements is not of good quality, the demand for its further dressing is presented automatically through the information system, with the definition of parameters necessary to give to the element necessary shape, form and demanded quality. The information system should enable constant communication between planner and processor of stone elements produced on the spot, because of possible changes in the project, or because of the impossibility of dressing of certain projected details. It should also enable the coordination between the transport of the elements and assemblage at the construction site, especially when the assemblage from the means of transport is planned. It is very interesting the software application which enables to follow the realization in four dimensions. The realization of stone dressing on the spot and works at the construction site can be followed visually, with cameras, while on the other side it can also be followed the realization of the construction of the building according to determined dynamics. These software packages also enable visual presentation of the positions on the basis of planned dynamics and entry of performed work positions to the computer, which is very important for coordination, information and adequate management decisions.

4.4 Analysis of the possibility of usage of this original technology in practice

In order to apply successfully in practice the proposed construction technology and to construct quality buildings, rapidly and economically, it is necessary to provide the labour for manual dressing and

menata, prema već urađenom projektnom rješenju. Kako zanati, kao što su ručna obrada kamena, polako izumiru i kako je sve manje majstora koji mogu kvalitetno da izvode ovu vrstu radova, ili iako ih ima, obično nemaju kompletan alat koji je naeophodan za obradu, veoma je teško organizovati kvalitetno izvođenje ovakve vrste radova. Stoga je predloženo osnivanje škole za edukaciju majstora za ručnu obradu kamena, koja bi bila sastavni dio tehnološkog procesa, što bi omogućilo bolju i kvaliteniju obradu. Povoljna okolnost je što je ovaj tip zanatlija deficitaran pa je za organizaciju ovakvih škola moguće naći finansijska sredstva i pomoć. Stvaranjem dobrih majstora za obradu kamenih elemenata imali bismo dobru osnovu za implementaciju predložene tehnologije građenja u praksi i izgranju objekata sa velelepnim kamenim fasadama.

5 ZAKLJUČAK

Prelijepe kamene fasade, detalji kamene plastike i uklopljenost u pejzaž objekata od kamena u Perastu i drugim mjestima uz crnogorsku obalu proizvode utisak kao da su iznikle iz kamena i Bokokotorskog zaliva. Stoga smo ovim radom željeli da izanaliziramo mogućnost izgranje ovakvih i sličnih objekata i danas, ali na savremeniji način, uz korišćenja savremenih tehnologija, mašina, alata i informacionih sistema [1], [2], [3], [5].

Analizirani tehnološki proces nam omugućava da obrađeni kamen u završnoj fazi izgleda kao da je sve ručno rađeno, kao nekad, zbog čega je i predloženo korišćenje istih alata za finalnu obradu. Da bi se ova faza radova realizovala, predloženo je da se u sklopu tog tehnološkog procesa organizuje manja škola za edukaciju zanatskih majstora, pogotovo mlađe populacije [4], [6], [7].

Mišljenja smo da je organizacija jednog ovakvog tehnološkog procesa u praksi veoma interesantna, jer raste zainteresovanost investitora za gradnju ovakve vrste objekata, pogotovo u priobalnom području.

Dosadašnja praksa kod nas je pokazala da iako ima investitora koji žele da izgrade objekte od kamena kao osnovnog materijala, oni teško mogu naći organizovanu kompaniju koja može kvalitetno izvesti ove radove i sve se, uglavnom, završava na improvizacijama, i pored dugog perioda izgradnje i velike cijene koštanja radova. Često se, pak, pristupa oblaganju već postojećih elemenata konstrukcije, što je u suštini samo imitacija. Utoliko predložena tehnologija dobija na značaju, jer rješava ove probleme iz prakse i veoma je interesantna za materijalizaciju, jer investitorima koji žele gradnju objekata uz korištenje kamena kao osnovnog materijala, omogućava bržu i ekonomičniju gradnju. Predložena tehnologija je posebno interesantna za područje Jadrana i šire gdje se povećao obim građenja, a u okruženju postoji veliki broj potencijalnih majdana za eksploataciju kamena.

Ova tehnologija takođe podržava gradnju objeklata uz korišćenje prirodnih materjala i uz minimalni negativni uticaj na životnu sredinu, o čemu će se u budućnosti morati voditi računa.

refinement of stone elements, according to already presented project solution. Since trades, such as manual stone dressing, slowly vanish, and since there are less craftsmen which can do this type of work well, or even if they exist, they usually do not have the necessary tools for dressing, it is very difficult to organize quality works. The activity of manual stone dressing using ancient tools in suggested technological process represents the key activity. The quality of the construction of buildings in proposed new construction technology mostly depends on the quality of work. Therefore the foundation of the school for education of craftsmen for manual stone dressing was suggested, which would enable better and more quality dressing. The favourable circumstance is that there are not much of these artisans, so it is possible to find the financial means and help for the organization of these schools. The education of good craftsmen for stone dressing would be a good basis for the implementation of this original building technology in practice and construction of the buildings with monumental stone frontages.

5 CONCLUSION

Beautiful stone frontages, marble details and insertion into the landscape of the stone buildings in Perast and other places on the Montenegrin coast give the impression that they came out of the stone of the Bay of Boka Kotorska. Therefore in this paper it was presented the analysis of the possibility for construction of these and similar buildings even today, but in more modern way, using modern technologies, machines, tools and information systems [1], [2], [3], [5].

The analyzed technological process enables dressed stone to look as it was done manually, as in past times, and as a result the same tools for final dressing are proposed for usage. In order to realize this phase of work, in the context of this technological process it was suggested the organization of a small school for education of craftsmen, especially younger population [4], [6], [7].

We think that the organization of such technological process in practice is very interesting, because the investors are more and more interested in the construction of the buildings of this type, especially in the littoral area.

Previous practice in our country demonstrated that, although there are investors who want to construct buildings of stone as basic material, they can hardly find organized company which can do quality works of this type, almost every attempt is improvisation, regardless the long period of construction and high prices of works. However, it is often done the covering of already existent construction elements, which is basically only imitation. The proposed technology is particularly interesting for the area of the Adriatic Sea and widely, where the construction has grown, and in the surroundings there is great number of potential quarries for stone exploitation.

This technology also supports the construction of buildings using natural materials with minimum negative influence on the environment, which should be taken care of in the future.

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REZIME

ZABORAVLJENE TEHNOLOGIJE GRAĐENJA

Ratko MITROVIĆ

Na početku ovog rada prezentiraćemo tehnologije građenja koje su se koristile u periodu prije dvadesetog vijeka za gradnju luksuznih vila i palata, a u međuvremenu su u potpunosti izumrle. Ova tehnologija je kao osnovni materijal koristila sedimentne krečnjačke stijene, koji su obrađivani u kamene blokove željenog oblika i forme. Vađenje kamena iz stijenskog masiva je bilo ručno i uz primjenu drevnih metoda za eksploataciju kamena. Obrada kamena je takođe bila ručna, uz korišćenje veoma starih alata i metoda za obradu kamena i izradu umjetničkih detalja. Transport obrađenih kamenih elemenata je vršen brodovima, a na mjestu gradnje je rađena samo montaža već završno obrađenih blokova. Da bi se ova tehnologija realizovala neophodno je bilo uraditi projektnu dokumentaciju, gdje su se za vaki kameni blok morale dati precizne dimenzije i forma, jer se obrada obavljala u majdanu na stotine kilometara udaljenom od mjesta montaže. Ova drevna tehnologija izgradnje predivnih palata i drugih reprezentativnih objekata na prostorima Sredozemlja, koja se više ne koristi, je preteča najsavremenijih industrijskih tehnologija građenja, gdje se gotovi elemeti proizvode u fabrikama, a na gradilištu se vrši samo montaža. Ovaj rad ima za cilj da podsjeti na te zaboravljene tehnologije, uz savremeniji pristup eksploataciji i montaži obrađenih kamenih blokova, a zadržavanju korišćenja starih alata i ručne završne obrade. Na osnovu analize starih i najsavremenijih tehnologija predložićemo novu orginalnu tehnologiju građenja objekata sa kamenim fasadama, kod kojih se elementi od kamena koriste kao osnovni materijal. Ta tehnologija će zadržati ljepotu starih kamenih fasada uz tradicionalnu finalnu obradu kamenih blokova, ali će, sa druge strane, omogućiti efikasnije i ekonomičnije građenje, pa tako biti konkurentna na tržištu.

Ključne riječi: stare tehnologije, kamen, tehnološki proces, informacioni sistem

SUMMARY

FORGOTTEN CONSTRUCTION TECHNOLOGIES

Ratko MITROVIĆ

At the beginning of this paper there will be presented the technologies used during the 20th century for the construction of luxury villas and palaces, which have completely disappeared. These technologies used limestone sedimentary rocks, split into stone blocks of desired form and shape, as a basic material. Stone extraction from the rock massif was done manually using ancient methods for stone exploitation. Stone dressing was manual as well, performed using very old tools and methods for stone dressing and artistic details production. Dressed stone elements were transported by ships and at the construction site only the assemblage of dressed blocks was done. In order to realize this technology it was necessary to prepare the project documentation, where for each stone block should have been presented the precise dimensions and form, because dressing was done in the quarry hundred kilometers far from the place of assemblage. This ancient construction technology of beautiful palaces and other representative buildings in the Mediterranean, which is not used any more, is the antecedent of the most modern industrial construction technologies, where the finished elements are produced in factories and only assemblage is performed at the location site. The aim of this paper is to remind of the forgotten technologies, with more modern approach to the exploitation and assemblage of dressed stone blocks and with the usage of old tools and manual final dressing. On the basis of the analysis of old and the most modern technologies we will suggest the new, original construction technology for buildings with stone frontage, where the stone elements are used as a basic material. This technology will keep the beauty of the old stone frontages with traditional final dressing of the stone blocks, but, on the other hand, it will enable more efficient and economic construction, therefore it will be competitive at the market.

Ključne riječi**:** old technologies, stone, technological process, information system