アジア人材養成研究センター創立20周年記念
国際シンポジウム

International Symposium Commemorating the 20th Anniversary of Sophia Asia Center for Research and Human Development

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上智大学アジア人材養成研究センター創立20周年記念　国際シンポジム
「ボロブドゥールからアンコール・ワットへ ―人材養成による文化復興―」

アジア人材養成研究センターが、カンボジア現地に開設されて 20 年になります。センターは、「カンボジア人によるアンコール・ワット修復」ができるよう現地において人材養成の手伝いを続けてきました。そして、カンボジア和平（1993 年）が実現し、同年カンボジア王国政府から要請があり、本学とカンボジア王国政府アンコール地域遺跡整備機構（アプサラ機構）が共同でアンコール・ワット西参道修復工事（第 1 期）にとりかかりました。この修復工事はカンボジア王国の文化復興を先導する契機となり、それが平和構築につながる意義深い修復活動でした。

インドネシアのボロブドゥールは、1973 年から 10 年間をかけて修復が完成しました。アジアで初めての石造伽藍の修復でした。ボロブドゥールではインドネシア人担当者が現場で研修を受けながら修復を行いました。

お国事情とはいいながら、インドネシアの独立は 1945 年 、カンボジアは政治的混乱と内戦が 1993 年まで続きました。遅れてアンコール･ワットの修復が始まりました。こうした遺跡の修復事業は学術を振興し、地域社会の発展や観光産業につながる波及効果もあります。

今回の国際シンポジウムは、ボロブドゥール遺跡の修復に参画されたマウラナ・イブラヒム先生をお招きし、修復後約 35 年を経た現在の遺跡保存とその維持活動についてご高見を伺うも

のです。三輪悟研究員からは、カンボジア王国アプサラ機構との共同工事の修復計画について発表いただきます。パネル・ディスカッションでは建築構造力学の平山善吉先生、アンコール・ワット西参道の考古学調査を実施してこられた丸井雅子先生、そして西参道修復工事の三輪悟研究員、また、かねてから西参道修復に参画してきたカンボジア人 Dr. ニム・ソテイーヴン研究員には、カンボジア人の立場から意見を伺います。

○日　　時：　2016 年 10 月 22 日（土）13 時 30 分～ 16 時 30 分

○会　　場：　上智大学 2 号館 4 階　2-401 室

○プログラム

13：30 ～ 13：35（ 5 分）

挨拶

上智学院理事長、イエズス会高等教育担当理事、上智大学教授　髙祖敏明

13：35 ～ 13：50（15 分）

アジアの現場に出かけて 20 年―上智大学の国際協力―

上智大学アジア人材養成研究センター所長　石澤良昭

13：50 ～ 14：35（45 分）

基調講演①

「ボロブドゥール修復はインドネシア人の手で（1975-1983）」

マウラナ・アブドゥラヒム・イブラヒム（Maulana Abdulrahim Ibrahim）氏

インドネシア教育文化省文化総局　元上級技官（ボロブドゥール保存官）

14：45 ～ 15：30（45 分）

基調講演②

「アンコール・ワット西参道修復工事（第 2 期）の人材養成について」

上智大学アジア人材養成研究センター研究員　三輪　悟

15：30 ～ 16：30（60 分）

パネル・ディスカッション

平山善吉（アンコール・ワット西参道修復技術交流研修委員会委員長、
日本大学名誉教授／建築構造力学）

丸井雅子（上智大学総合グローバル学部教授／アジア考古学）

三輪　悟（上智大学アジア人材養成研究センター研究員／アンコール建築学）

ニム・ソテイーヴン（Nhim Sotheavin、上智大学アジア人材養成研究センター研究員／カンボジア中世史）

司会：石澤良昭

開会挨拶

上智学院理事長
髙祖敏明

上智学院理事長の髙祖敏明でございます。

本日は、上智大学アジア人材養成研究センターの創立 20 周年を記念した、国際シンポジウム「ボロブドゥールからアンコール・ワットへ―人材養成による文化復興」の開催にあたり、一言ご挨拶を申しあげます。

まずは、アジア人材養成研究センターの創立 20 周年おめでとうございます。また、本日、ご来場の皆さまには、石澤良昭先生が推進するアジア人材養成研究センターの活動に対して、日頃よりご理解と暖かなご支援をお寄せくださっていることに対しまして、厚く御礼を申しあげます。

そして、本日、シンポジウムのために昨日インドネシアから来日くださったマウラナ・アブドゥラヒム・イブラヒムさんには心から感謝申しあげます。後ほど、ボロブドゥール遺跡の専門家として基調講演をしてくださいます。

Welcome to Sophia University, Mr. Maulana !

実は、去る 9 月 29 日、上智大学の構内に、ハラルフード専門の食堂「東京ハラルデリ＆カフェ」がオープンしたところです。本学ではインドネシアからの留学生を中心に約 50 人のイスラム教徒の学生が学んでいます。イスラム教の戒律に沿って調理された料理を安心して、低価格で食べてもらいたいと開設しました。マウラナさんにも早速お試しいただいたと聞いています。どうぞ皆さんもお立ち寄りください。場所はこのキャンパス内でホフマン・ホールという建物の 4 階です。本日 6 時まで営業しています。

さて、本シンポジウムでは、日本大学名誉教授で、アンコール・ワット西参道修復技術交流研修委員会委員長として格別のご尽力をいただいております、平山善吉先生にご出席いただいております。平山先生には大変お忙しいなか、ありがとうございます。

また、カンボジアのシェムリアップのアジア人材養成研究センター本部の研究員、三輪悟さん、上智大学総合グローバル学部教授の丸井雅子先生、そして、石澤先生のもとで博士号を取得した、新進気鋭のカンボジア人研究者、ニム・ソテイーヴン先生にも参加いただきます。

こうした先生方にご出席いただき、創立 20 周年を祝い、そして 4 年～ 5 年をかけてのアンコール・ワット西参道修復工事の完成と創立 25 周年を目指して、この国際シンポジウムはまさに出発点となります。どうぞ、皆さまの温かいご支援とご鞭撻をいただきたく存じます。

Let us begin working together. Working hard is very important,but Working smart, more important.

以上、実り多いシンポジウムとなりますように祈念いたしまして、閉会の挨拶とさせていただきます。ありがとうございました。

THE RESTORATION OF CANDI BOROBUDUR

(1973 – 1983)

Maulana Abdulrahim Ibrahim

I

Candi Borobudur is one of hundreds of monuments that mark the great traditional of building religions edifices in Indonesia. These splendid architectural achievements were erected at a variety of locations, not only in the open plains and valleys but also on the slopes and even at the Summits Mountains.

Candi Borobudur is constructed on a hill that rise some 15 meters from the surrounding plain. The top of the hill was leveled to form a plateau. The main part of this was designated as the site of monument.

The erection of a candi on top of a hill is common feature, but to build it around the top of hill. Using it as core of the structure and wrapping it totally in the construction is a technique thus far only found at Borobudur.

The builders of candi Borobudur apparently realized the need for a drainage system to cope with heavy rains. Spouts were provided at tiled corners of the mounting stages to drain off the rainwater from galleries, all the 100 spouts are beautifully carved in shape of makara or gargoyles.

We do not know exactly when candi Borobudur was built. There are not records to inform us which king had the monument built or which architect is was who created this wonder. Nor are there any documents to reveal what technique were applied to carry out such a grand design. Not the slight test idea can be gained as to how much time and how much labor were needed for the construction of this gigantic work.

Based on some bits of archaeological evidence with fragmentary historical data, it is generally assumed that construction can be dated to a round the year AD 800, at the time when Central Java was ruled by the kings of the Shailendra dynasty.

II

Comparison of the condition of the reliefs in stone and photographs taken about 1910 finally led to the conclusion that the greater part of the damage could not possibly be caused by vandalism. Neither could it be due to erosion by water, the growth of mosses or to vertical load pressure. The main cause proved to be the fact that the stone were being continuously subjected to rapid changes of temperature, the considerable heat during the day being immediately followed by cold during the night, with extreme heat during sunshine and considerable cold during rainy period.

In 1960 the first preparations were undertaken for programme to eliminate both the physic-chemical and the techno-architectural dangers that threatened candi Borobudur. The planners were mindful of the fact that van Erp's restoration – in spite of its technical merits and praiseworthy execution – was guaranteed to list only few decades. In fact, it was more or less a palliative, patchwork restoration that left the fundamental cause of deterioration only half settle by improving the water discharge system.

Such a total restoration would mean that the entire monument had to be altogether dismantled. The obvious consequence would be that candi Borobudur should be closed to visitors for considerable period, at least during the execution of the restoration. It was therefore of the greatest importance to find way to speed up the restoration work in order to save as much time as possible. The application of modern equipment such as electric cranes, and motorized means of transportation was taken into consideration.

III

Preparation before physical restoration, take about two and a half years of work (mid 1963 to the end of 1966) the essential measures for preparatory stage of the restoration programme were taken consisting of the following items.

- Measuring and drawing of galleries
- Measuring and drawing of the deviating part of structure
- Photographing of walls and their reliefs
- Investigation of foundation of the monument
- etc

The appeal to UNESCO was supported by the twenty-seventh international congress of Orientalists, which was held in United State in August 1967, and which inter alia adopted a resolution urging UNESCO to help save Borobudur. Until January 1973 that the contracting agreement between the Republic of Indonesia and UNESCO was signed, indicating the real beginning of the restoration of candi Borobudur with international aid.

A candi is usually constructed on a flat surface, and the foundations are also laid out flat. Even when the location is sloping, part of the site is dug out in order to obtain the required flat court yard.

In contrast to the normal pattern, candi Borobudur was built on and around the top of a hill. Moreover, it was not erected directly on the natural soil of the hill but on layers of earthen fill. This additional soil was apparently needed to enlarge the site, horizontally as well as vertically, to make it suitable for the monument that was designed to rise step – wise while diminishing in size with height.

When in 1968 UNESCO decide to take part activity in Borobudur Restoration project, the studies of the engineering designs were resumed in close cooperation with the experts of UNESCO missions. In meantime, the Netherlands government provided UNESCO with funds for the engineering consultants NEDECO (Netherland Engineering Consultant) to prepare an overall restoration plan, comprising an engineering design, a detailed work plan and financial analysis.

NEDECO plan, made slabs concrete under the four stages. The slabs to be constructed in such a way the outer end supported the balustrade and the inner end reached the surface of the hill inside the monument. The thickness of the first and second slabs (counting from the bottom upward) was 0.66 meters, and the third and fourth 0.44 meters.

The concrete slabs, to be laid in unbroken layer under the four gallery walls, we designed:

- to strengthen the foundation while distributing the load on the subsoil evenly
- to collect and disperse run off water on the floors of the upper structure and galleries
- to prevent the penetration of shallow percolation water
- to distribute lateral seismic forces uniformly throughout the structure.

IV

The restoration project was be divided into three major parts:

- The archaeological work was concerned with the handling of the temple stones, starting with the very first action of dismantling and ending with the return of the cleaned and chemically treated stones to their original places in the monuments.
- The civil engineering work entailed the installation of the reinforced concrete slabs under the gallery floors, including the establishment of the different kinds of filter and watertight layers
- The ancillary works had to provide the project with all means and facilities so that the gigantic under taking could be executed in the best way possible, e.q the preparation of the working areas, the construction of inner reads, the provision of equipment for transporting the stones and building material. Once these three kinds of activities had started, they proceeded simultaneously.

The dismantling work was to be carried out on two sides of the monument at the sometime, starting from the axes side way and from top downwards. The most crucial part, the northern side, would be dealt with first, followed a few weeks later by southern side. This work was scheduled to be completed within not more than three years, but the rebuilding would not that long.

The stone be detached were provided with identification marks and registered on cards. One by one they were hoisted manually, and collected in wooden pallets, which each had nine compartments. A single pallet could carry nine stones, and the tower crane would bring it down to the upper working area. The gantry crane then took over to transport the pallet down to lower working area, where a forklift truck was waiting to transport it to the buffer storage.

From the buffer storage the stones still had a long way to go. After manual cleaning, they passed to another department for chemical treatment. Broken or damaged stones were brought to special shed for repairing, before being treated chemically. The next step was the drying chamber, where the stones were dried artificially. Only then were the stones put in final storage waiting for moment when they could be returned to the monument. The first stone detached from the monument would be the last to reoccupy its original place, after three years.

Water the main source of destructive processes close observations and intensive studies made it clear that candi Borobudur was endangered by a twofold destructive process. Techno structural

deformations of the building components and the physicochemical deterioration building material.

The primary source of both kind of danger turned out to be water. It was water that had disturbed the bearing capacity of the subsoil and hence caused the subsidence and leaning of walls and tilting of the floors, it was water that made possible the growth of mosses, lichens, algae and other micro-organisms.

The deep procolation water saturated the subsoil, causing an inner case in its volume and a decrease in its bearing capacity. Simultaneously, fine particle, of soil were translocate. The particles, saturated with soil salt and minerals, seeped through the seams and pores of the stones and were finally deposited on the surface of carved outer stones when the carrying water evaporated.

A great number of borings into the core of candi Borobudur were carried out to provide the necessary information concerning the soil supports the monument. The samples were taken at different places and different depths, not only throughout the structure but also in the immediate surroundings of the monument.

Rain water affects the stones of the Borobudur monument in two ways. First, run off water causes erosion of stone surface. Trickling water increases the action of various organisms, and general leaches away the coating together with the detached fragments of rock. Second, the water easily penetrates the porous rock. Transforming the hill underneath into a kind of water reservoir.

The very porous and quite permeable stones of the monument can easily be penetrated by air and water. Moreover, the building's location on top of a hill enhances the downward seepage of water in to the pores of its material. The loose joints between the stone assist this moisture penetration to a considerable extent. The obvious assumption therefore, is that a capillarization process has been taking place continually and that this activity is to be blamed as the principal weathering process.

Another natural force, however, should not be overlooked, earthquakes. Though thus far no damage can be ascribed explicitly to this source. The danger is there and cannot possibly be neglected if the restoration is meant to last into the most remote future. The success of this gigantic under taking should be secured not only from the destructive effect of water but also

from possible deformations or even ruin by an earthquake, not only during the present restoration project but also for the perpetuation of the restored monument. Consequently seismic studies have been carried out to support the planned work.

The first step in dismantling was marking of stones. In principle no outer stone was to be removed before its pallet and area number had indicated on top surface. The exceptions to this rule were of cause stones whose top surface would be visible and so could not be marked; in these cases the only option was for the markings to be placed on the underside.

The outer stones were then carefully loosened from their position and placed in the pallet. Removable scaffolding was used to assist in the work and where the stone was too heavy for two men to lift, a scaffold crane was available at each work point.

The dismantling began from the middle on all galleries and the plateau at both the north and south sides.

The dismantling of the north and south side took approximately two years and was followed by work on the east and west side.

The dismantled stone were brought to the workshops for cleaning and further treatment, which depended on type of stone and its function on monument. Outer stones, inner stones and element stones were stored separately.

Each relief stone was thoroughly cleaned, manually or chemically, through dry or wet cleaning. The replacement of the stone required the most accurate calculations since they had to be put back in the right position, it should be understood that these were not the original places that they had occupied before dismantling.

The rebuilding process itself changed the condition, and the position of stones had to be adjusted to the new circumstances. The formerly leaning and sagging walls had been reconstructed in an upright position and lifted up, previously tilting gallery floors had been leveled.

The rebuilding activity consisted of:

- Laying out of the lead sheets on base of the wall

- Reassembling the outer stones
- Reassembling the second stones (immediately behind the outer stone
- The reconstruction of layer B
- Strengthening the inner stones between layer A and B

The rebuilding at the north side started in February 1976 and was finish in November 1978. In total no less than 35.164 outer stones and 85.680 inner stones had been put back in the reconstructed monument. At the south side the rebuilding started in February 1976 and was completed in August 1978, replacing a total of 35.901 outer stones and 94.504 inner stones.

The rebuilding of the west side was started in February 1979 and was completed in March 1983, involving 51019 outer stones, and 111.130 inner stones. The rebuilding of the east side was begun in March 1979 and was terminated in March 1982, involving 49.442 outer stones and 114.772 inner stones.

February 23, 1983 all the restoration work was completed, by the President Republic of Indonesia declared.

Candi Borobudur restoration project

1973 – 1983

Invention of Candi Borobudur

By "Thomas S. Raffles" 1814

Candi Borobudur condition before 1907

Candi Borobudur condition after cleaning (1854)

stupa condition before restoration
Theodore Van Erp
1907-1911

Stupa condition after cleaning

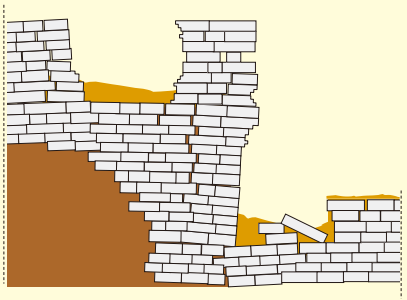
Stupa and terrace of Candi Borobudur before 1854

The origin of main center stupa (1854)

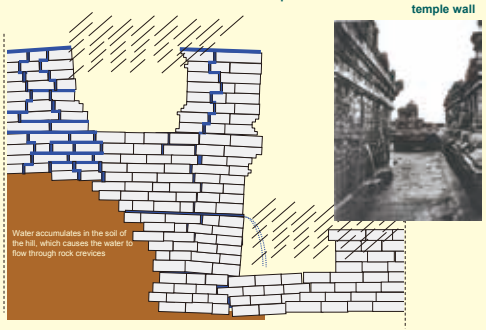
Restoration of Candi Borobudur

"*Theodore Van Erp*" tahun 1907 - 1911

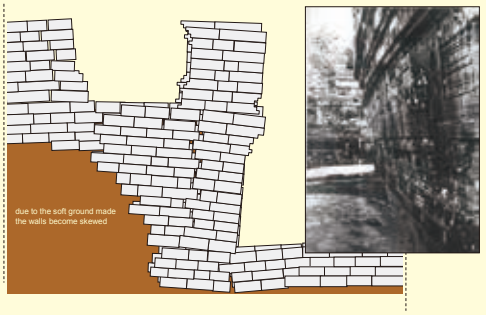
Cleaning the soil buried temples and reassemble the stones in its original place



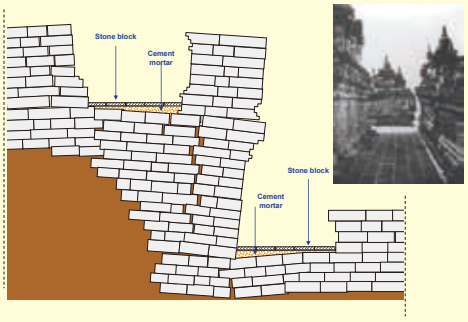
Rainwater to seep into the soil of the hill behind the temple wall



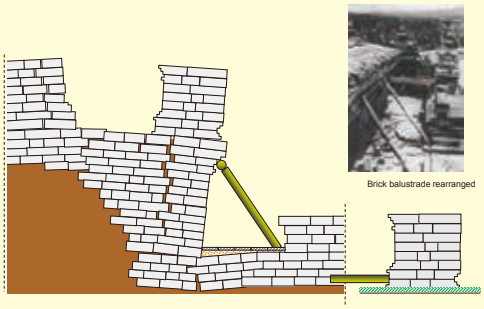
Floor position skewed & sank



Redistributing the sloping floor surfaces using cement mortar and stone blocks



Rescue walls from collapsing by propping up the sloping walls using wood and unload stones balustrade on it



Stupa condition before restoration

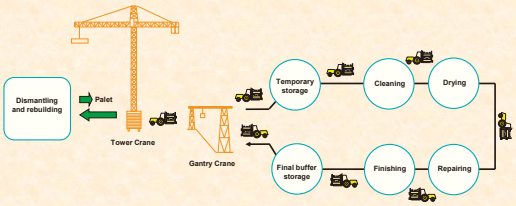
Stupa condition after restored

Before restoration

After restored

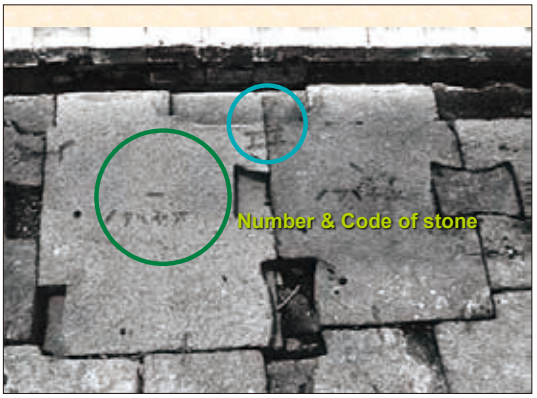
Candi Borobudur
After restoration project
Theodore Van Erp tahun 1911

Flow treatment of restoration and conservation stones



Flow treatment of restoration and conservation stones

Numbering and coding on stone block before dismantling



The code used in the numbering of stone

Number	:	1	2	3	4	5	6	7	8	9	0
Symbol / Code	:	|	\	–	/	V	=	⅂	×	⅄	+

Dismantling of gallery floors are cemented with mortar

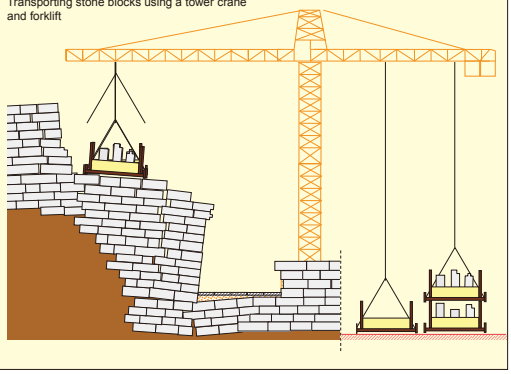
Dismantling of stone blocks

Blocks of stone that had been dismantled put into pallets

Dismantling Activity

Pallets containing stone blocks were taken using a tower crane

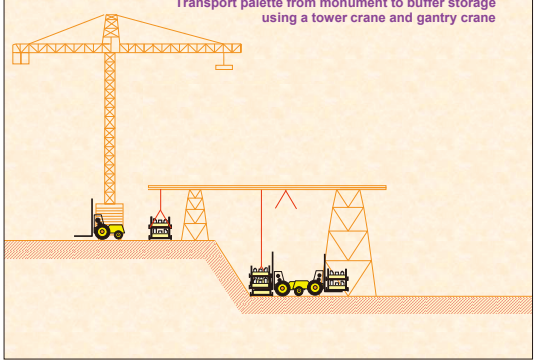
Transporting stone blocks using a tower crane and forklift

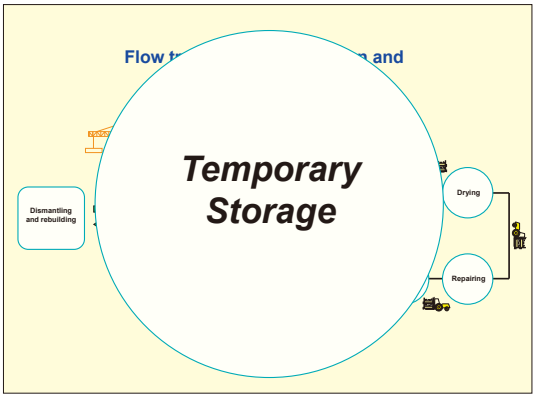


Transporting palette from tower crane to gantry crane

Pallets containing demolition stones ready to be taken to treatment area with gantry crane

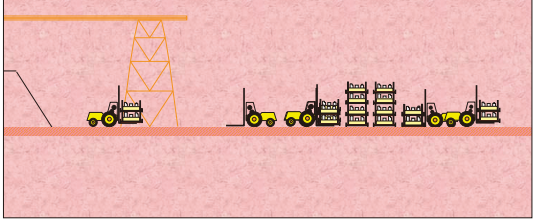
Transport palette from monument to buffer storage using a tower crane and gantry crane





Pallets containing demolition stones moved from *gantry crane* to *fork lift*

Transportation of pallets to the temporary storage



Arrangement & registration of pallets in the temporary storage

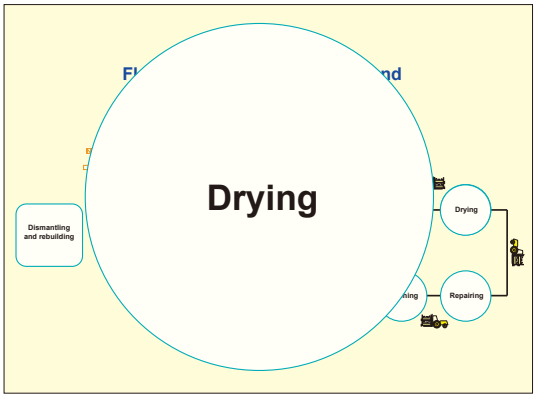
Temporary storage location

Dry Cleaning

Wet Cleaning

Chemical liquid AC-322 on the stone surface for cleaning

Checking for PH of water that use for stone cleaning



Dry chamber after stones has been cleaned

Repairing

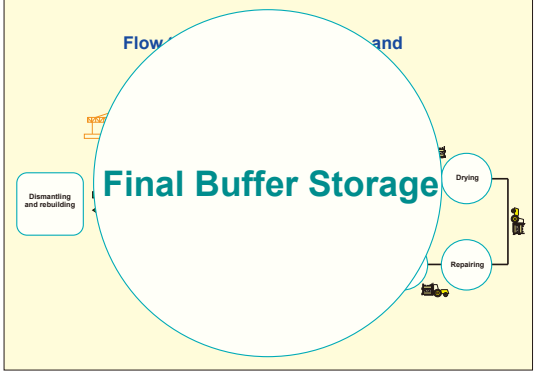
Stone bonding using epoxy resin

Restoration work for stone damage

Repairing of Buddha statue with brass anchor

Finishing

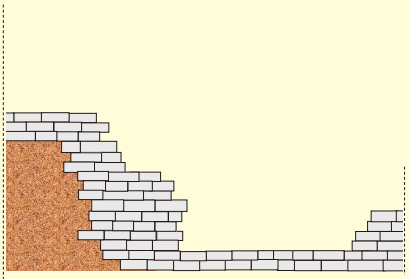
Preserving the stone using chemicals (fungicides and herbicides)



Final Buffer Storage

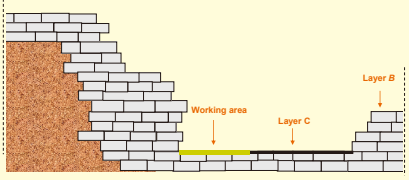
Dismantling and rebuilding

Example of stone were not dismantle

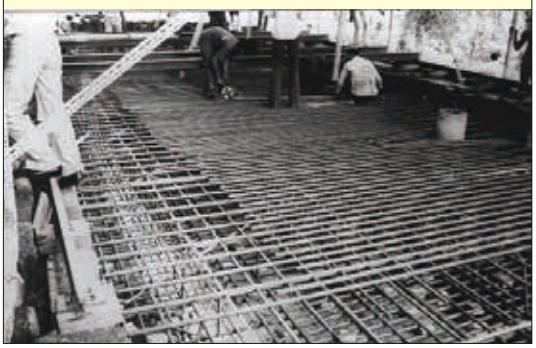


Preparation and setting up working area

Beginning of reconstruction

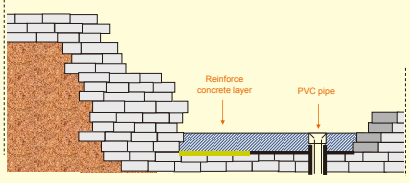


Reinforcement concrete foundation



Activity for reinforcement

Construction of concrete and drainage pipes

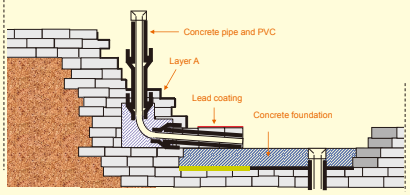


Waterproofing coating using araldite tar

Concrete pipe construction

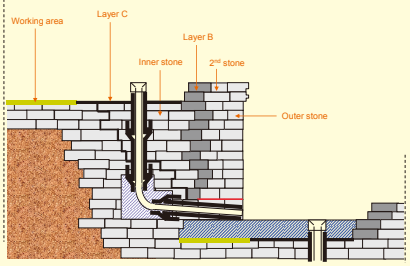
Construction lead coating

Construction of drainage system



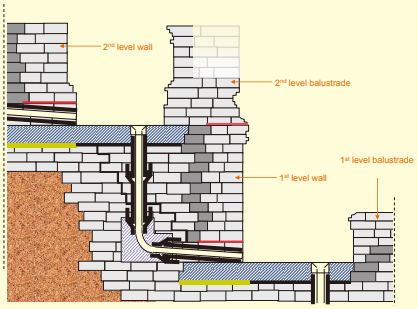
Reassembling outer stone

Reassembling inner stone, layer B, and outer stone



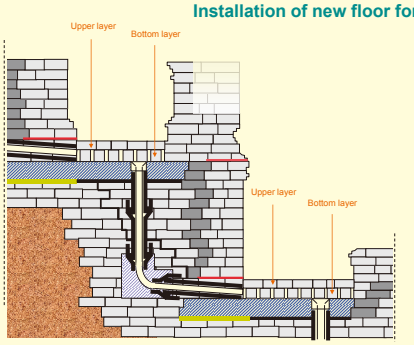
Basic conditions before being installed floor

Reassembled wall stone and balustrade



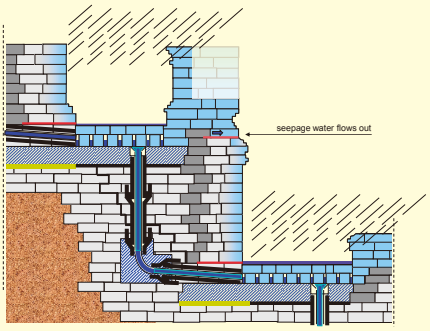
floor construction which consists of two layers, the lower layer are spaced at intervals of 3-4 cm

Installation of new floor for gallery

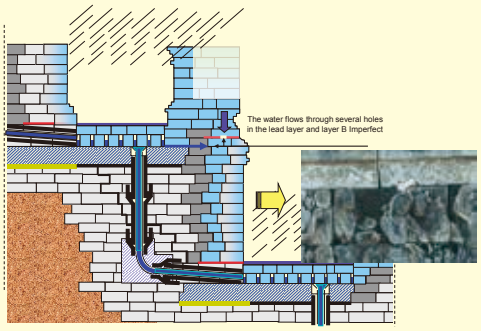


Gallery floor after repairing

Drainage system with good condition

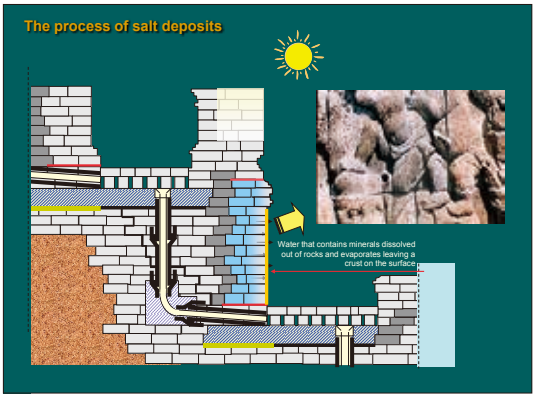


Drainage system function is not perfect



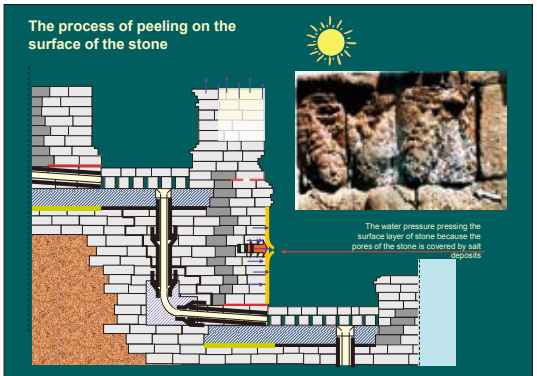
Repair by dismantling, water seepage balustrade on it and re-use superimposed Araldite tar

The process of salt deposits

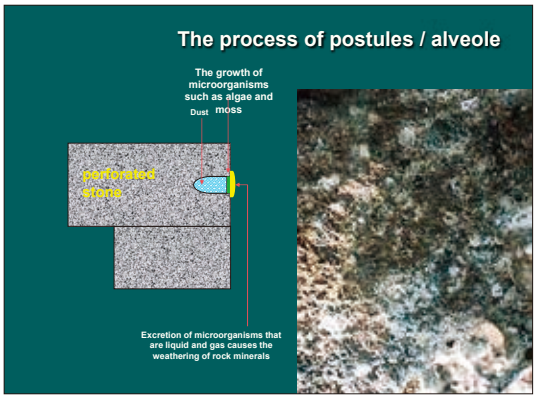


Cleaning Salt Deposits

The process of peeling on the surface of the stone

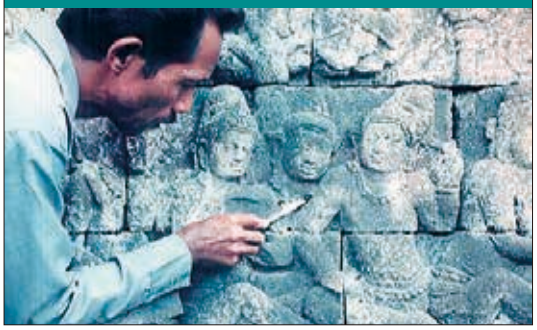


The process of postules / alveole

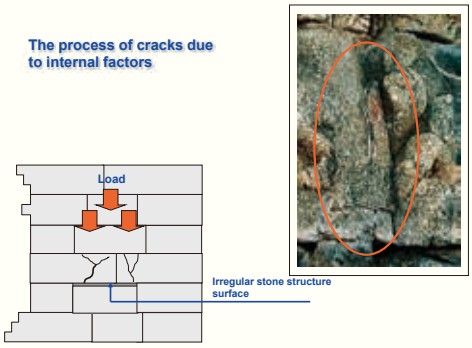


Patching Alveolar

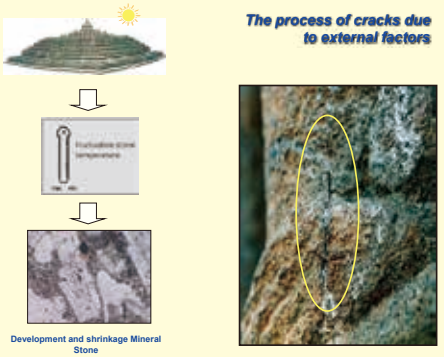
The alveoli are directly cleaned using herbicides. Then alveole holes filled with mortar mix Epoxy Resin Euroland FK-20 + Sand



The process of cracks due to internal factors



The process of cracks due to external factors



The Handling of Cracks

Epoxy Resin is injected directly into the cracks of stone

- Finished -