Annual Report on the Research and Restoration Work of the Western Prasat Top

Dismantling Process of the Southern Sanctuary

II

Nara National Research Institute for Cultural Properties
2015

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Legend

1. This paper is the second report on the dismantling and reconstruction of the Western Prasat Top, which was implemented from August to December 2013 by Nara National Research Institute for Cultural Properties.

2. The dismantling and reconstruction work was implemented with full cooperation from APSARA (Authority for the Protection and Management of Angkor and the Region of Siem Reap), the local authority in charge of cultural property protection. It also received technical support from the Japanese Government Team for Safeguarding Angkor (Japan-APSARA Safeguarding Angkor: JASA).

3. This report was written and edited by Hiroshi SUGIYAMA and Yuni SATO, members of the Department of Planning and Coordination who were directly involved in the project, with counsel from other researchers concerned. Photos contained herein were taken by the above members and local Cambodian project managers.

4. Subsequent reports shall be published hereafter in accordance with the progress of the project.

I. Report of Conservation works

Chapter 1 Process of the Dismantling Work

Interim Report 1 on the dismantling work, issued previously, outlined the progress of the project, from the dismantling of N18, which constitutes the top surface of the lower platform, to the excavation of the inside of the lower platform. At the stage where the south stairways of the Central Sanctuary was found inside the lower platform of the Southern Sanctuary, the dismantling of the upper stone blocks of the lower platform was discontinued, and an investigation and documentation of the stairways was conducted during the latter half of FY2012. Thereafter, the dismantling of the upper blocks of the lower platform was resumed in FY2013. As of the end of FY2013, the dismantling of N25, the bottommost tier has been completed, and the stone lines discovered in the foundation have been investigated. This report covers the progress of the survey and restoration work up to the end of FY2013.

In June 2013, test earthfill was prepared for two places on the south side of the Southern Sanctuary to collect data for improving the foundation soil. In July, a conservation science survey was conducted, the mixing ratio for the consolidated filling soil of the foundation was decided, and preparations were made for producing laterite powder and clay powder. The basement digging ground was also investigated as required, and buried pottery was discovered. In September, N23 was dismantled. Upon completion of the dismantling of N23, it was decided that the connecting area between the upper blocks of the foundation of the Southern Sanctuary and the Central Sanctuary should be examined, and the Architecture Unit made an examination in October. A 3D survey was conducted once again in November by Kyowa Corporation, mainly of the connecting area with the Central Sanctuary. In November, after the rainy season had ended, the dismantling of N24 and N25 was begun. As these two tiers were made almost entirely with laterite and their dismantling and removal required the excavation of their surrounding area as well, an area roughly 1m around the outer circumference of the foundation was excavated. In that process, more buried pottery artifacts were discovered from two locations outside the south side of the foundation.

From January, the stone lines in the foundation were examined as needed, and preparations were made to rebuild and re-compact the foundation based on an examination of reassembly and re-compacting methods. Thereafter, efforts were made to produce two types of powders to improve the soil, and upon final confirmation of the work method in consideration of a proposal from ICC in June 2014, re-compaction of the foundation soil was begun in the latter half of June.

Fig. 1: Restoration of the south stairways of the Central Sanctuary

Fig. 2: Test foundation earthfill

Fig. 3: Survey by the Architecture Unit

Fig. 4: Boring test using a hand auger

Chapter 2 Dismantling of the Lower Platform

Section 1 Dismantling of the Upper Tiers (N19- N22)

N19

N19 is an assembly of stone blocks immediately below N18, which constitutes the paving stones of the lower platform. As the upper stone blocks of the foundation, they correspond to edging stones, and display moldings that are an inversion of the moldings on N21, which correspond to base stones.

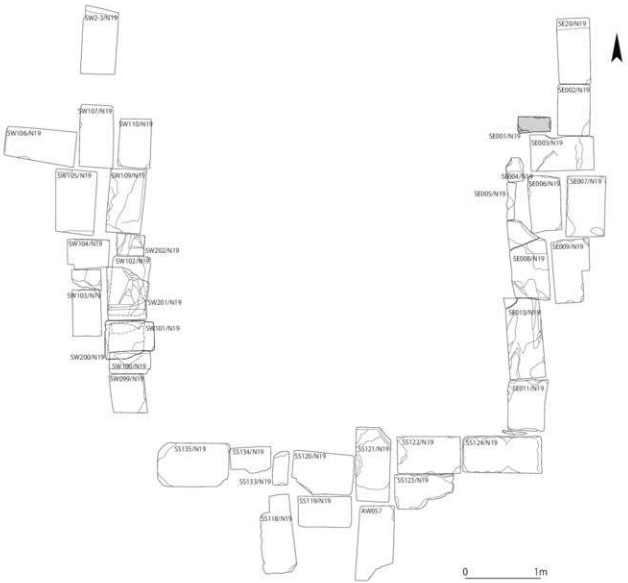


Fig. 5: N19 horizontal plan

Fig. 6: Photo of N19 (viewed from the south; taken on July 11, 2013)

Fig. 7: Northeast corner of the lower platform

N20

N20 corresponds to the stone panel for the upper blocks of the foundation. The single tier is therefore roughly twice the height of the other tiers, with two tiers of dry masonry in some areas on the inside. For this reason, the figure for N20 consists of two drawings, one of the upper dry masonry tier (Fig. 8 top) and one of the bottom dry masonry tier (Fig. 8 bottom). Many sandstone blocks that correspond to the outer side of the upper tiers of the base are missing particularly on the south and southeast sides, and are displayed as blank spaces in the figure.

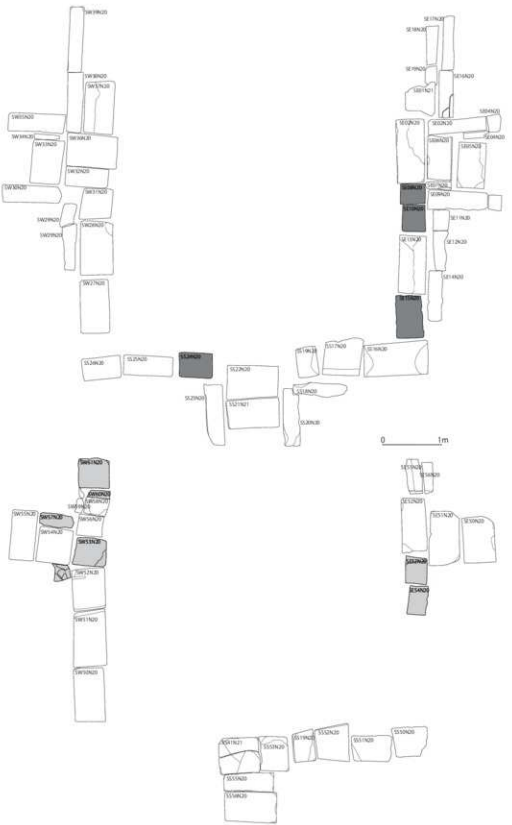


Fig. 8: N20 ground plan

Fig. 9: N20 overhead photo

Fig. 10: Connecting area with the Central Sanctuary (view of west side)

Fig. 11: Connecting area with the Central Sanctuary (view of east side)

N21

N21 are stone blocks that correspond to base stones of the upper block of the foundation. The bottom half displays moldings that project outward in an arc. As they serve as base stones, most are long and narrow blocks on the whole, and because they have moldings, they include few diverted stones. Blocks SW07 of the west stairways and SS05 of the south stairways, however, are clearly diverted blocks, as they have different moldings on the side that adjoins the inner face of the foundation. Block SS03 on the south side has scraping marks along the top surface of its width. In the current dismantling work, a sling for hoisting the block has been applied to coincide with the marks. The marks might perhaps have been made as a result of a similar application in ancient times.

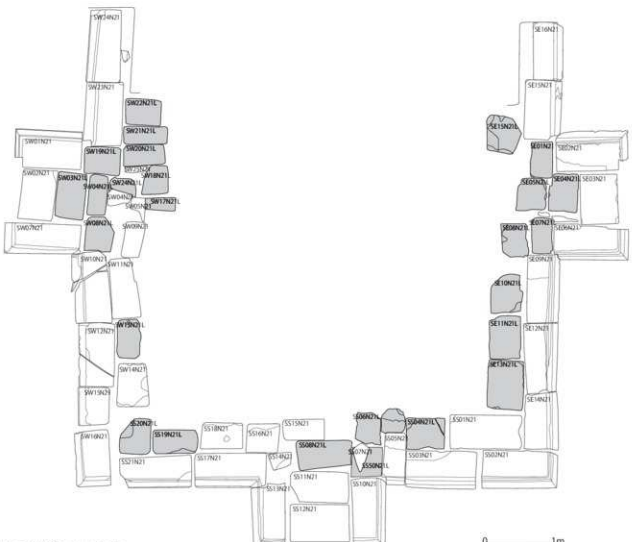


Fig. 12: N21 ground plan

Fig. 13: Moldings on the rear face of SW07N21

Fig. 14: Line engravings on SE03N21 and SE09N22

Fig. 15: N21 overhead photo

Fig. 16: Relationship between N21 and the southwest corner of the Central Sanctuary (viewed from the southwest)

N22

N22 corresponds to the first tier of paving stones below the base stones. As they are paving stones, they are cuboid block with no moldings. For this reason, the ratio of diverted blocks is high compared to N21. Three blocks were found with hoisting holes, which are hardly seen in other stone blocks at Western Prasat Top, and many other blocks of N22 are characterized by line engravings that might have been markings made when diverting the blocks.

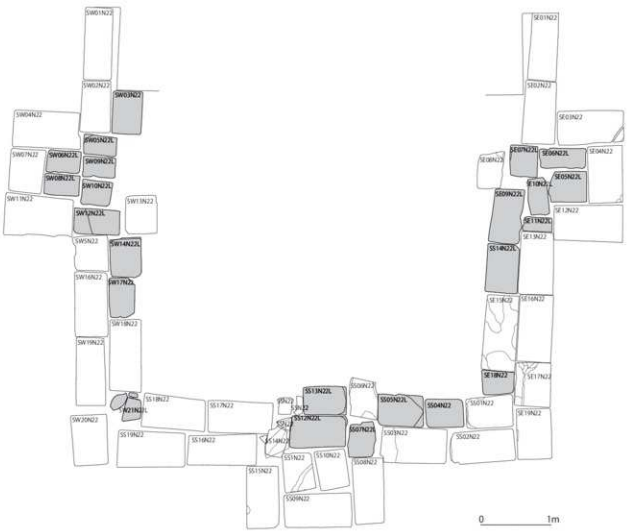


Fig. 17: N22 ground plan

Fig. 18: Line engravings on SE03N22

Fig. 19: Line engravings on SS09N22

Fig. 20: N22 overhead photo

Fig. 21: Relationship between the stone blocks on the south side of N22,
stone blocks of N23-N25 and the east-west stone line in the foundation

Section 2 Dismantling of the Basement of the Lower Platform (N23- N25)

N23

Tiers N23 to N25 constitute the lower part and basement of the lower platform, and are part of the base that lies buried in soil at present. Many diverted blocks are included, and blocks with crude surface processing were found, as shown in Fig.25. SW12 has moldings on its rear face, as well as holes for hoisting, and is thus clearly a diverted block (Fig. 22). Furthermore, as shown in Fig. 23, some other blocks mainly around the stairways display line engravings that mark the position of N22 blocks that come on top.

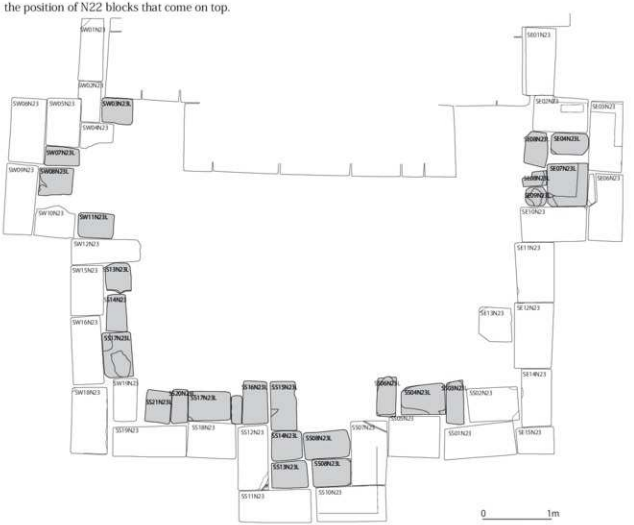


Fig. 22: N23 ground plan

Fig. 23: Moldings on the rear face of SW12N23

Fig. 24: Line engravings on SE03N23

Fig. 25: SE02,03N23

Fig. 26: N23 overhead photo

Fig. 27: N23 and the south stairways of the Central Sanctuary

N24

Practically all blocks of N24 are made of laterite. Tiers above N24, down to N23, comprise the upper blocks of the foundation, so N24 and N25 are assumed to be laterite blocks that were installed as the base of the above sandstone blocks. The paving is rather disorderly, with the blocks of the east stairways paved most carefully and blocks of part of the west stairways missing altogether. The laterite blocks of the south stairways are also disorderly, but SS17 and SS19 on the inside are sandstone Sema stones. Heretofore, 12 Sema have been discovered from the upper foundation, as reported in the previously-published restoration report. The two recently-discovered Sema were also installed in the stairways, with their head in the direction of the foundation. Since they seem to have been arranged in this way with conscious awareness of their function as a Sema, it can be assumed that they had some ritualistic meaning(see Articles Chapter 3 p.56-64).

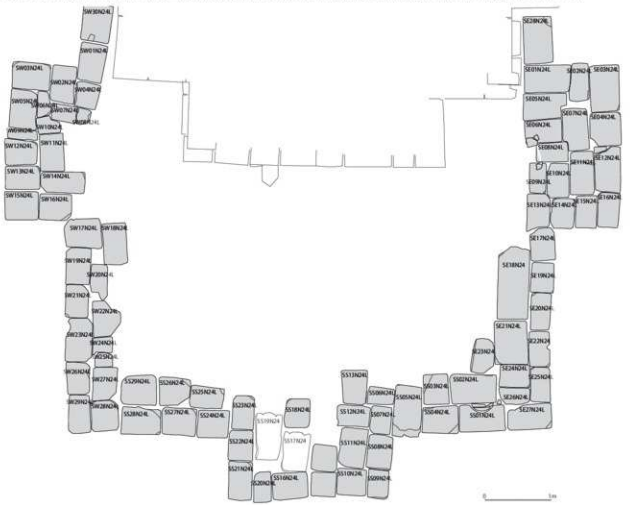


Fig. 28: N24 ground plan

Fig. 29: N24 Sema stones; left: SS19, right: SS17

Fig. 30: N24 viewed from the north

Fig. 31: Sema stones diverted for use in N24 (viewed from the east)

N25

N25 is a stone line in the bottommost tier of the lower platform. It is comprised entirely of laterite, although some parts in the northwest and southwest areas are empty. As it is an intermittent line of stones, it is regarded as part of the base work along with N24, rather than foundation stones. In this sense, as shown in Fig. 21, the top surface of the stone lines in the foundation is practically aligned with N25, and could also be regarded as part of the foundation work accompanying the installation of N25.

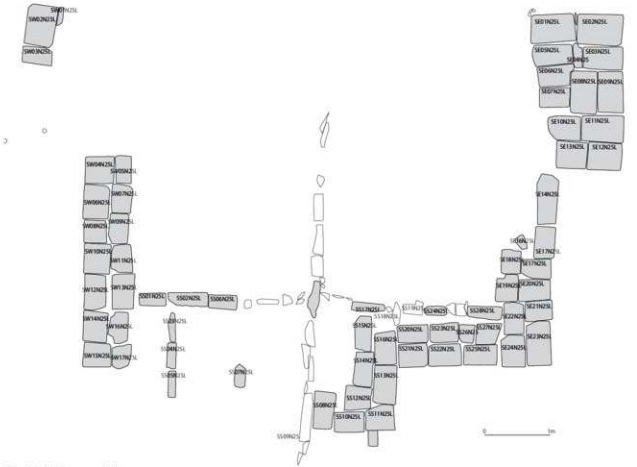


Fig. 32: N25 ground plan

Fig. 33: Sculpture diverted for use in the stone line in the foundation

Fig. 34: Relationship between N25 and the stone lines in the foundation

Fig. 35: N25 overhead photo (taken on Jan. 24, 2014)

Fig. 36: Stone line on the west side of N25 and the stone line in the foundation

Chapter 3 Restoration Work

Section 1 Restoration of the South Stairways of the Central Sanctuary

Prior to reassembly the Southern Sanctuary, the south stairways of the Central Sanctuary were partially restored, as it would be buried within the foundation. The stairways were buried in the earthfill of the foundation of the Southern Sanctuary when the sanctuary was built, and N18 was paved on top of the lower platform of the Southern Sanctuary. On top of N18 stood the main structure of the sanctuary. Platform stone SN133 and two other stones paved immediately below the structure were cracked or fractured in the southwest direction, corresponding to the settlement and inclination direction of the entire structure. In the recent restoration work, these three blocks were restored and returned to their original positions.

The west half of SN133N18 shown in Fig. 38 was broken, so the original block was bonded together. SN137 behind it was also broken in the southwest corner, but unlike SN133, it was broken into small pieces, so it was bonded using new materials. Immediately below SN133, the stone block with moldings that was found among the edging stones of N19, was used as it is, as the stone itself was only minimally damaged. The N20 stone panel displayed a special state of damage in the southwest corner as shown in Fig. 39, so that portion was replaced with new material. On the west side of the stone panel, as shown in Fig. 41, details of the moldings were damaged and the stone was cracked into three pieces. Judging that sufficient strength cannot be restored even if the block is bonded, it was replaced with a new material.

Fig. 37: South stairways of the Central Sanctuary after restoration

Fig. 38: Before restoration

Fig. 39: Damage to a stone panel

Accompanying this restoration work, part of the south stairways of the Central Sanctuary was dismantled, and a diverted sandstone was discovered, as shown in Fig. 43. The fact that it resembles the diverted blocks found in N21 and N23, as will be discussed later, is a source of interest.

Fig. 40: South stairways of the Central Sanctuary after restoration(Left: west side, Right: south side)

Fig. 41: South stairways of the Central Sanctuary
original stone of the west side of N20

Fig. 42: South stairways of the Central Sanctuary
view of the west top surface after restoration

Fig. 43: South stairways of the Central Sanctuary diverted stone blocks on the inner side of the west sleeve area

Section 2 Bonding of Sandstone Blocks

In conjunction with the dismantling of the Southern Sanctuary, damaged stone blocks were bonded one after the other. Two holes 10 ～ 20 cm deep were made in the bonding faces, stainless steel bolts were inserted in them, and the two parts were secured with epoxy resin. This method is commonly used in the restoration of the Angkor monuments, and was also adopted as the method for bonding stone blocks in this project. Gaps between the bonded faces were filled with spacer material made of epoxy resin and sandstone powder, and the excess resin that leaked out from the edges was scraped away after it hardened.

Fig. 44: Restoration of stone block SS058N15 left: before restoration; right: after restoration

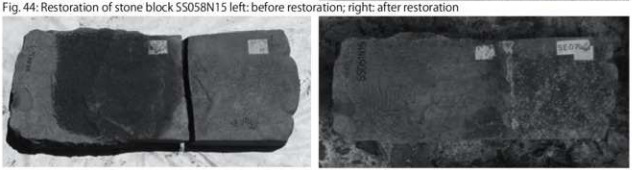


Fig. 45: Restoration of stone block SS061N15 left: before restoration; right: after restoration

Fig. 46: Restoration of stone block SN101N15 left: before restoration; right: after restoration

Fig. 47: Restoration of sandstone SS065N15 left: before restoration; right: after restoration

Chapter 4 Survey of the Foundation

Section 1 Survey of the Digging Work

Stone lines in the foundation

Stone lines were discovered in the foundation, as shown in Fig. 48, basically with a cruciform ground plan. The cruciform lines divide the platform digging ground into four compartments. Inside the southwest compartment are two stone lines in the north-south direction, and inside the southeast compartment is a stone line also in the north-south direction. The lines are a mixture of sandstone and laterite stones, and include blocks diverted from a statue of an old woman in the east-west line. The height of the stone lines measures approximately 1.45m from the top surface of the stones to the bottom surface of N18, and measures approximately 0.6m between the largest stone to the bottom of the foundation digging work. In other words, the lines are installed in the middle of the foundation ground. Their purpose thus poses a question. A number of possibilities can be conceived, including their use as retaining stones for the compacted soil in the digging work, or as a reference for marking north-south and east-west lines in the digging work. However, any conclusion shall be made after acquiring more similar examples.

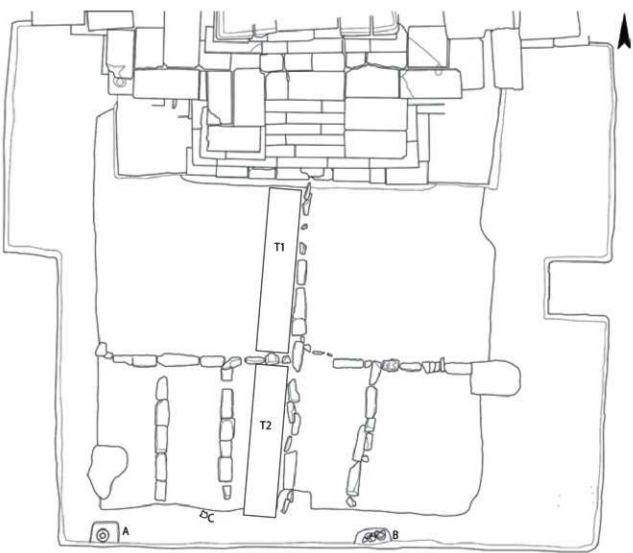


Fig. 48: Stone lines in the foundation ground plan

The stone lines in the foundation were decided to be excavated no further, but basically preserved as they are. For this reason, a detailed investigation of all stone lines was foregone, but a partial trench was opened on the west side of the north-south line of stones in the center to examine its cross section. The cross section is shown in the figure below.

The five northern stones and one southern stone are relatively large, flat stones arranged vertically. The height of these six stones is practically aligned with each other. Other small stone blocks, however, vary in size and shape, and are uneven in height. As a result of this survey, the state of the digging line and the bottom of the basement digging ground was ascertained in part. The basement digging ground has been dug down diagonally, and the bottom is considerably uneven.

Fig. 49: Stone line in the foundation north cross-section (viewed from the west)

Fig. 50: Stone line in the foundation south cross-section (viewed from the west)

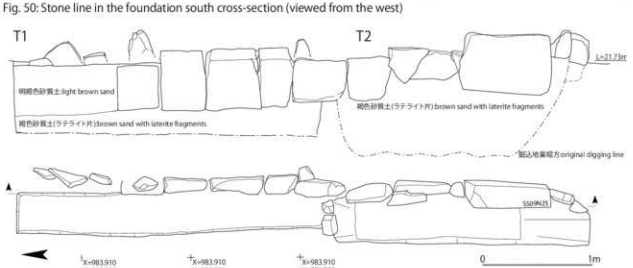


Fig. 51: Stone line in the foundation north-south cross-section

Fig. 52: Digging work and the stone lines in the foundation overhead view

Fig. 53: Digging work and the stone lines in the foundation (viewed from the south)

Fig. 54: Digging work and the stone lines in the foundation (viewed from the east)

Fig. 55: Digging work and the stone lines in the foundation (viewed from the west)

Fig. 56: Digging work and the stone lines in the foundation (viewed from the southwest)

Fig. 57: Digging work and the stone lines in the foundation (viewed from the southeast)

Section 2 Buried Pottery

Four pottery pieces belonging to three pottery remains were discovered. The pottery remains are assumed to have been buried from the outside of the southern digging line of the digging work.

Buried pottery A (Fig. 59) A black-glazed wide-mouthed Jar was excavated from outside the southwest corner of the digging work of the foundation. As shown in Fig. 63, it was installed upright in a recess created in a layer believed to have been the ground surface when the Southern Sanctuary was built. The mouth and neck portions are missing, and are thought to have been destroyed intentionally when burying the pottery. There is black glaze on the shoulder but not on the body, although there are apparent drips from the shoulder. Although no lid was discovered, it was thought to have a wooden lid. As the inside of the pottery was filled with soil, the soil was carefully removed, but all that the Jar contained were a few laterite and sandstone fragments that had probably fallen to the bottom of the Jar.

Fig. 58: Southwest corner of the digging work

Fig. 59: Buried pottery A excavated state

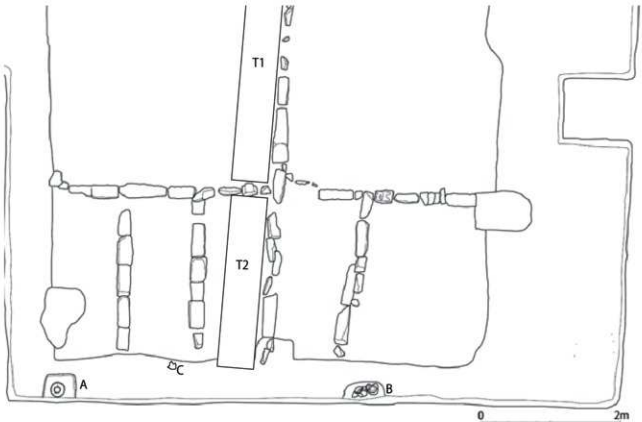


Fig. 60: Buried pottery locations

Fig. 61: Buried pottery A photo

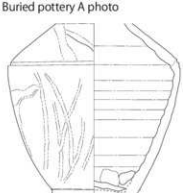


Fig. 62: Buried pottery A drawing

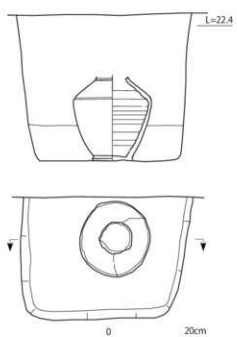


Fig. 63: Buried pottery A drawing of excavated state

Buried potteries B (Fig.68,B1,B2)　A round-bottomed Jar made of reddish-brown clay resembling earthenware was found in its complete form from the south side of the basement digging ground of the foundation, along with the top half portion of a long-necked vase also made of Haji-type reddish-brown clay.

Buried pottery B1 is a round-bottomed Jar. It is 13.6cm in diameter at its mouth, 15.4cm high, and 18.7cm in diameter at the widest part of its body. Unlike regular round-bottomed pots, it rises in a somewhat convex manner above its maximum diameter, and has a shallow, round bottom. There are two grooves around the neck. The rim shows a slight undulation. The clay and firing are both good.

Buried pottery B2 is a long-necked Jar. It has a mouth that is 10.8cm in diameter and a neck that is 9.8cm long. The part below the neck extends widely outward. Roughly one-third of the vase has been found. There are four grooves around the shoulder, with sawtooth patterns carved between the grooves. The part below the grooves is decorated with a zigzag pattern made with long strokes, and between each two zigzag patterns are triangular impressions made with a triangular tool. The outer surface of the body other than the parts with zigzag patterns displays rough linear rubbing marks. The inside of the neck displays marks made when shaping the neck by squeezing. The clay and firing are both good.

Buried pottery C (Fig.68,C)　The kendi is 10.8cm in diameter around the neck and 24.0cm in diameter at the widest part of the body. A spout approximately 4cm in length is attached to the shoulder. There are two deep lines in the horizontal direction around the attachment of the spout. The entire vessel was first shaped, and then a hole was made where the spout is to be attached using a circular rod. Clay was wound around this rod to shape the spout. The clay of this pottery is more refined that that of the above two vessels.

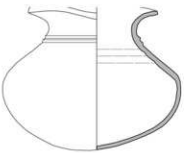
These buried pottery remains were all placed along the south side of the basement digging ground, and buried pottery A was found ensconced in a pit made in the same surface as the basement digging ground, so it is thus assumed that these pottery vessels were all buried at the time the basement digging ground was prepared. Such observation can be said to provide valuable reference for studying the dates of earthenware.

Fig. 64: Buried pottery B excavated state

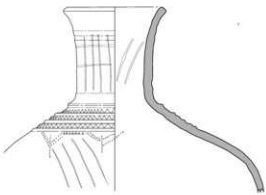
Fig. 65: Buried potteries B excavated condition

Fig. 66: Buried pottery C excavated state

Fig. 67: Buried pottery C excavated condition



B1



B2

C

Fig. 68: Buried potteries B & C
drawings and photo

Section 3 Ground Survey of the Foundation Soil around the Stone Lines in the Foundation

Prior to reassembly the foundation soil, a ground survey was conducted around the stone lines in the foundation. On June 10 and 11, 2014, a simple penetration test, permeability test and a boring test using a hand auger were performed in two locations at the stone lines. Results of the tests are provided in a separate ground survey report.

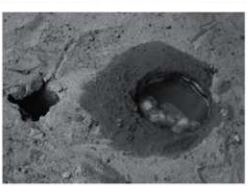


Fig. 69 (top left): Simple penetration test
Fig. 70 (top right): Hand auger test
Fig. 71 (left): Permeability test

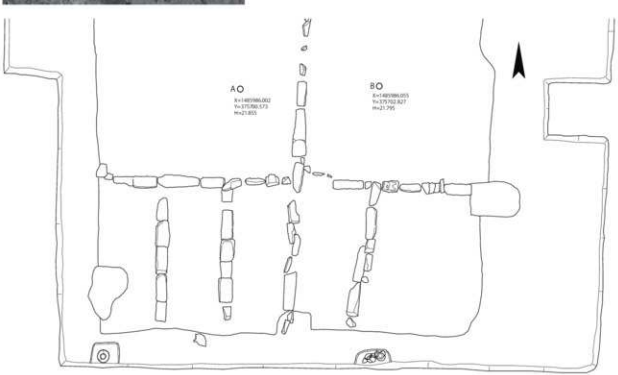


Fig. 72: Ground survey locations

Chapter 5 Progress of Restoration Work

Section 1 Progress of Trial Assembly

A trial assembly was conducted together with the dismantling work to examine the combination and fit of each block. A trial assembly yard was prepared in two locations, in the south and west, but in consideration of the work progress and space constraint, the trial assembly was implemented in order by part. The framework was finished being assembled most quickly, and is placed in the south trial assembly yard in its assembled state. The upper foundation was assembled over the period from the second half of FY2012 to the first half of FY2013 in the west trial assembly yard. After confirming the fit of newly supplemented sandstone, it was dismantled once to secure space for the repair of sandstone.

Trial assembly of the lower platform was commenced in the beginning of FY2014, and is currently ongoing.

Fig. 73: Trial assembly of the framework (viewed from the northeast)

Fig. 74: Trial assembly of the upper foundation (viewed from the northwest)

Fig. 75: Trial assembly of the lower platform (viewed from the west; June 10, 2014)

Section 2 Reassembly of the Platform Basement

Presently, the restoration work has been stopped after dismantling N25, and the top portion of the stone lines in the foundation lies exposed. Excavation of the foundation was decided to be terminated at this point, in order to preserve the original position of the stone lines in the foundation and maintain the original bearing capacity of the soil by leaving the bottom of the foundation digging ground as it is. At the 23rd Technical Session of the International Coordinating Committee held in June 2014, the necessity of exhibiting and disclosing the progress of the state of restoration was discussed, and the use of geotextile to rebuild the lower platform was recommended. Given this result, approaches were hastily made to Dr. Yoshinori Iwasaki, Chairman of Geo-Research Institute, and Dr. Mitsuharu Fukuda of Taisei Geotech to seek their onsite guidance, and policies for reassembly the lower platform using consolidated soil and geotextile were decided as described below.

Hereafter, full-fledged reassembly work is planned to begin after June. First, a compacted layer approximately 10cm deep made of consolidated soil will be laid on top of the stone lines in the foundation on the basement digging ground to protect the stones and attempt to stabilize N25. Then, reassembly work will begin in sequence from N25, with plans to complete reassembly tiers up to N22 during the first work period, which will run up to the next rainy season in September 2014. In that condition, reassembly work will be suspended during the rainy season, but the consolidated soil will be prepared. After the rainy season, N21 to N18 will be rebuilt during the second work period up to December 2014, and N17 and above will be reassemblied during the third work period. Reassembly of the Southern Sanctuary in its entirety is thus planned to be completed by the end of FY2014.

Fig. 76: Schematic diagram of the lower platform reassembly work

II. Articles

Chapter 1 Examination of Restoration Methods for the South Sanctuary of Western Prasat Top

Taisei Geotech Mituharu FUKUDA

Section 1 .Structure and Foundation of the South Sanctuary of West Prasat Top

Among the West Prasat Top remains, the South Sanctuary shall be restored first. The South Sanctuary is composed of an upper foundation and lower platform as shown in Fig. 2, and a main sandstone structure on the upper foundation as shown in Photo 1. The original soil below the lower platform digs into the natural ground at depths below N22, and is composed of three-tiered sandstone side walls and stone lines below the walls, which further dig into the ground to a depth of approximately 80cm. The sandstone side walls of the lower platform stops immediately above the stone lines, below which is a bare hole with no sandstone walls.

The main sandstone structure distributes its load from the stones that pave the central level to the soil inside the foundation. As shown in the diagram of the side structure (Fig. 2), the sandstone side walls of the upper and lower platforms are arranged around the perimeter of the main sandstone structure, and do not directly receive the load of the main structure. Additionally, the side walls of the lower platform are positioned outside the width of the side walls of the upper foundation, so the loads of the two side walls do not overlap. The two tiers of side walls are thus supported by the foundation and natural ground beneath the walls.

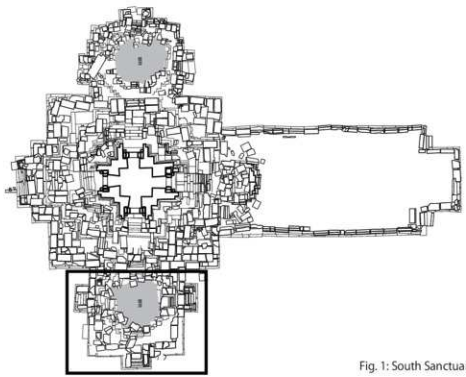


Fig. 1: South Sanctuary of West Prasat Top

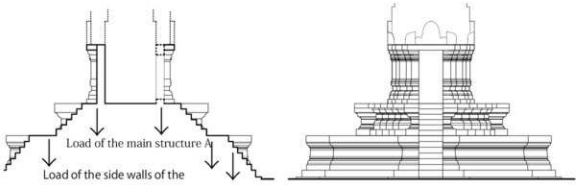


Fig. 2: Structure of the South Sanctuary

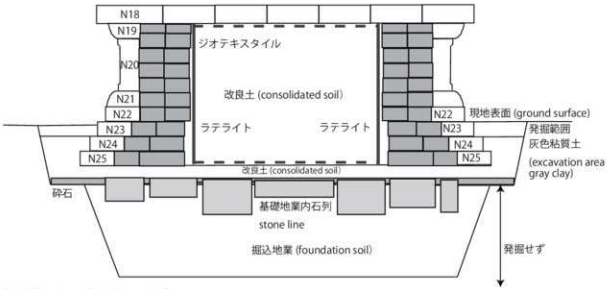


Fig. 3: Structure of the lower platform

Photo 1: Temporary assembly of the main structure of the South Sanctuary

2. Deformation of the South Sanctuary of West Prasat Top

Photos 2 and 3 show the South Sanctuary viewed from the east. On the whole, no major deformation is seen in the height level of the lower platform. The main structure is tilted from the north to the south side, and the upper foundation is also tilted from the north side of the main structure to the south side as though in response to the tilting of the main structure. However, the upper foundation practically maintains a level height from the north side of the South Sanctuary to the north side. There is no major bulging in the east face of the upper foundation, and the tilting is predominantly seen in the north-south direction.

Photo 4 shows subsidence of the upper foundation, and Photo 5 shows subsidence of the central area of the sandstone pavement of the surface of the lower platform. Measured from the sandstone side walls on both sides, it is sunken approximately 56cm at the most. However, the subsidence is minimal on the north side, which connects with the Central Sanctuary. Since it has been found in an excavation survey that the south stairways of the Central

Sanctuary have not shifted from its original position, the subsidence is most predominantly observed at the base of the South Sanctuary. The lower platform displays sandstone side walls that are level on the whole, but local subsidence is especially conspicuous in the center.

Photo 6 shows the stone lines below the lower platform. As the natural ground exists approximately 80cm below these lines, the foundation material fills the 80-centimeter space below the stone lines. Irregular-shaped flat sandstone is divided by the stone lines, but no evident signs of subsidence can be observed. The south stairways of the Central Sanctuary to the north of the stone lines basically maintain a level height. Thus, it is clear that the foundation material has subsided on the south side of the south stairways of the Central Sanctuary, from the upper and lower platforms above the natural ground, and that this subsidence is the direct cause of the deformation of the South Sanctuary.

Photo 2: The Central Sanctuary and South Sanctuary viewed from the east

Photo 3: South Sanctuary viewed from the east

Photo 4: Subsidence of the top surface of the upper foundation

Photo 5: Subsidence of the paving stones on the surface of the lower platform

Photo 6: Stone lines directly beneath the lower platform

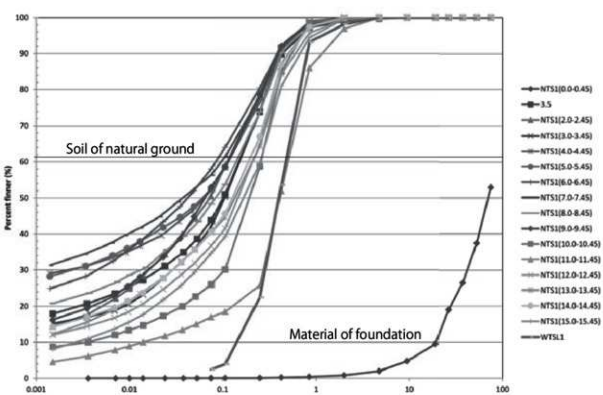


Fig. 4: Grain size distribution of the foundation material at the South Sanctuary

3. Foundation Material and Degree of Compaction

The foundation material is coarse sand with readily erodible properties. The solid line in Fig. 4 represents the grain size distribution of the foundation material. The dotted lines show the grain size distribution of sample soils collected from a natural ground boring survey conducted at Western Prasat Top. The foundation material is composed mostly of coarse grains that are more than 0.1mm in diameter. Contrarily, soils from the natural ground are composed mostly of fine grains.

As the grain size characteristics are not readily apparent by the above graph alone, the grain size distribution curves shall be expressed in terms of a representative index, although details will be omitted. That is, in terms of representative diameter, a diameter index of 10-2mm or more expresses the property of sand, 10-3 to 10-2mm the property of silt, and 10-3mm or less the property of clay. Fig. 5 shows an overview of the representative diameter index. The representative diameter index of the natural ground, according to the figure, is (1 to 2) × 10-2mm in the surface layer and lower layers, which indicates sand layers, and ranges between (3 to 7) × 10-3mm in the intermediate layers, which indicate silt layers. Meanwhile, the representative diameter index of the foundation material is 1.1 × 10-1mm, which represents sand, and indicates that the foundation material is made of coarser sand compared to the sand layers of the natural ground.

Fig. 6 shows the relationship between representative diameter index and soil properties. In this figure, liquefaction refers to the runoff of sand accompanying the runoff of water from the ground surface caused by a rise in the pore pressure of sand layers due to an earthquake. In other words, sand that is susceptible to liquefaction has properties that make it easy for it to run off along with the runoff of water. Photo 7 shows a ground subsidence that occurred due to liquefaction and the runoff of sand in Urayasu in the wake of the Great East Japan Earthquake of March 11, 2011. The ground around the building, which is supported by piles, had subsided, making the concrete foundation appear as though it is floating.

The representative diameter index of soils susceptible to liquefaction ranges from 2 × 10-2mm to 5 × 10-1mm. Thus, while the sand layers of the natural ground do not fall within the scope of liquefaction, as they contain rather fine grains, the foundation material has properties that make it susceptible to liquefaction. It can thus be assumed that the sand in the foundation material has properties that make it susceptible to runoff accompanying the runoff of water.

Photo 8 shows the bare hole of a permeability test performed on the lower platform. The hole maintained its shape in wet condition, but when water was quietly applied, the area around the hole eroded as though to melt, and the hole lost its shape.

Photo 9 shows a state of compaction by watering. After a loading test was performed in wet condition, sprinkling water around the load plate caused immediate subsidence, or collapse, of the soil.

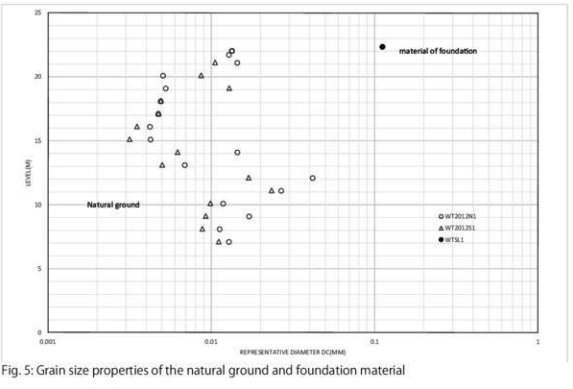


Fig. 5: Grain size properties of the natural ground and foundation material

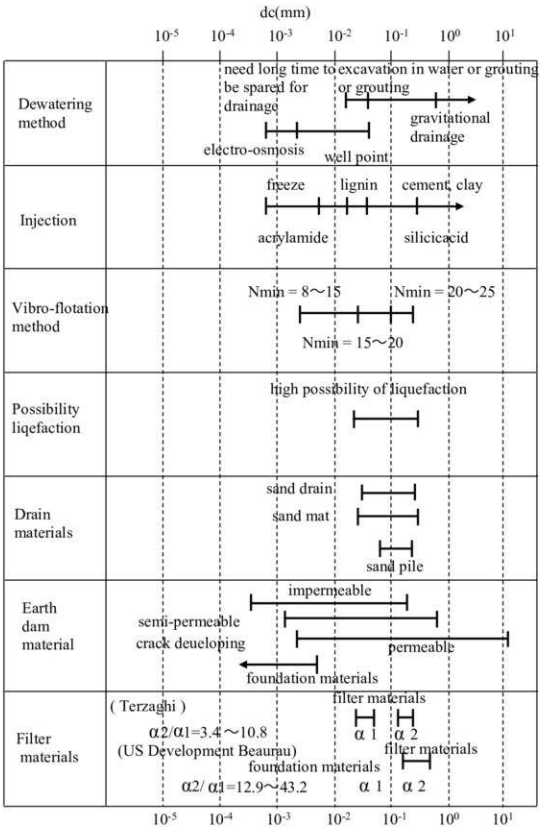


Fig. 6: Representative diameters and soil properties

Photo 7: Ground subsidence caused by liquefaction in Urayasu in the wake of the Great East Japan Earthquake

Photo 8: Erosion of the material of the lower platform

Photo 9: Water sprinkling around the load plate in a loading test

The possibility of a material that is susceptible to liquefaction actually liquefying is reduced if it is thoroughly compacted and solidified. To examine this theory, a penetration test was performed. Fig. 7 shows N values. The N value of the lower platform is less than 5, and the N value of the soil below the stone lines is between 5 and 10. There is thus a clear difference in density between the soil material of the lower platform and the soil below the stone lines. Table 1 shows a classification of density based on N values by Terzaghi and Peck. According to this table, the N value of the surface layer corresponds to "very loose" density, and the soil below the stone lines is classified as having "loose" density. Again, there is a clear difference between the material of the lower platform and the soil below the stone lines, with the soil below the stone lines being more compacted compared to the soil above it.

The figure also shows the N values of the natural ground. As a whole, it has an N value of over 10. A grain size test showed that it contains a rather large amount of fine grains compared to the sand of the foundation material, so a simple comparison cannot be made, but it is more solid than the material of the lower platform.

The loose foundation material can be confirmed by the results of an onsite density test. Table 2 shows the results of the test. The foundation material has a dry density of less than 1.5g/cm3, and is thus loose. Loose density and coarse sand can be expected to deliver only low bearing power and a high coefficient of permeability.

Fig. 8 shows the result of a loading test performed on the lower platform. Ultimate bearing capacity is approximately 340kN/m2, and much smaller than that of the soil materials of the Angkor Monuments. Fig. 9 shows the result of an onsite permeability test. The coefficient of permeability of the loose and coarse sand of the lower platform is 1×10-1cm/s, but that of the rather solidified soil below the stone lines is 2×10-2cm/s and one order lower.

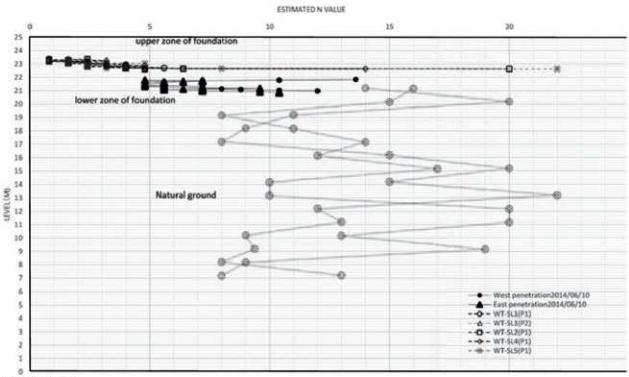


Fig. 7: N values

N value	Relative density by Terzaghi and Peck
0 ~ 4	very loose
4 ~ 10	loose
10 ~ 30	medium
30 ~ 50	dense
>50	very dense

Table 1: Relative density by Terzaghi and Peck

WTSL				
Location	Density method	Wet density (g/cm3)	Water content (%)	Dry density (g/cm3)
WTSL3(D1)	Sand replacement	1.68	4.94	1.60
WTSL2(D1)	Ring	1.43	2.03	1.40
WTSL1(D1)	Ring	1.54	2.94	1.50
WTSL5(D1)	Ring	1.49	2.76	1.45
WTSL5(D2)	Ring	1.46	2.86	1.42
Average		1.52	3.10	1.47

Table 2: Density of the lower platform of the South Sanctuary of West Prasat Top

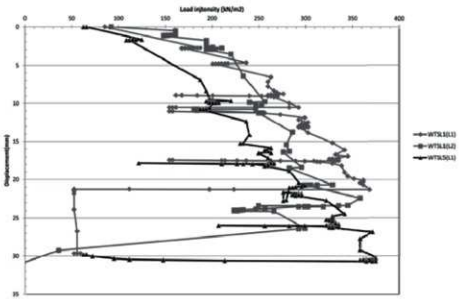


Fig. 8: Loading test result

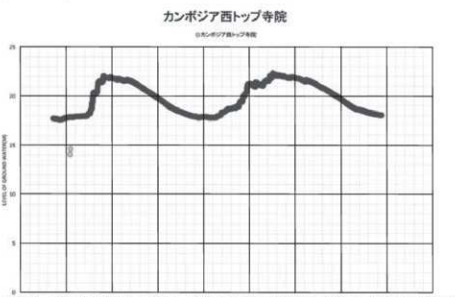


Fig. 9: Annual changes in groundwater level

The figure also shows the coefficient of permeability of consolidated soils used as test soils, as will be discussed later. The coefficient of permeability of test soil A is 2×10^{-3}cm/s, and that of test soil B is approximately 2×10^{-2}cm/s.

Judging by samples collected in a hand auger test, the material of the lower platform and the soil below the stone lines have the same soil qualities, and are both composed of coarse sand. However, the two layers are classified differently based on their N value and coefficient of permeability, and the soil below the stone lines is estimated as having higher density. It needs to be examined why two soil materials that have the same qualities and are both found in a foundation have such different properties.

Fig. 10 shows changes in the level of groundwater in the natural ground over a period of two years. It shows that it reached approximately 22m at the highest during the rainy season. Since the stone lines are found at a height of roughly 22m, the soil below the stone lines went below and above the groundwater level at different times and was naturally compacted by watering. This change in groundwater level might also be an effective factor in the consolidation of the soil below the stone lines.

4. Required Bearing Capacity at the South Sanctuary

The fact that the deformation of the South Sanctuary of West Prasat Top is mainly a result accompanying the runoff of sand caused by gully erosion of the foundation material has so far been documented. However, the erosion is a runoff that occurs due to the material being loose, coarse sand. The condition of loose, coarse sand can also be assessed by its low-intensity bearing capacity. Thus, consolidation of the foundation material plays an important role in the restoration of the South Temple.

As shown in Fig. 2, the maximum load of the South Temple is the load of the main structure that bears upon the upper foundation. The loads of the side walls of the upper foundation and side walls of the lower platform are respectively transmitted vertically downward, but these loads are small. Therefore, it suffices for the foundation material to have enough bearing capacity to safely support the load of the main structure of the South Temple. However, as the final appearance of the South Temple has not yet been clarified, the load was calculated as shown in Table 3 by scaling up the appearance of the Central Temple and estimating a larger load than reality. The required maximum ultimate bearing capacity was calculated as approximately 200kN/$m^2$to 300kN/m^2However, when assuming a safety factor of 3 to safely secure this bearing capacity, an ultimate bearing capacity of approximately 900kN/m^2 is required.

Compared to this 900kN/m^2 required maximum ultimate bearing capacity, the 340kN/m^2 ultimate bearing capacity obtained in the loading test performed on the lower platform is extremely small, and can be evaluated as having a bearing capacity with a safety factor of 1 or so. Thus, it is clear that the bearing capacity of the foundation material must be significantly improved compared to its present strength. A large bearing capacity would also lead to stronger resistance against gully erosion.

Scale	Drawing (cm)	Scale	Length (m)	Mass (kN)	Max. load strength (kN/m2)
Present height	8.7	100	8.7	197.0	197.0
Restored height	9.6	150	14.4	326.1	326.1
Upper tier width	10.2	100	10.2		
Lower tier width	19.1	100	19.1		
Present height from top tier	6.3	100	6.3	142.7	
Restored height from top tier	7.5	150	11.25	254.8	
Wet density (kN/m3)	22.6				

Table 3: Design requirement of ultimate bearing capacity

5. Consolidation and Authenticity of the Restored Soil Material

The basic principle for securing authenticity in the preservation of monuments is to reutilize the materials that have been excavated and to restore the monuments to their initial appearance. However, the original foundation material at the South Temple is coarse sand with loose density, which makes it susceptible to gully erosion and subsidence caused by the load of the main structure. Therefore, it is impossible to restore the temple with the soil in the loose condition that was found at the time of dismantlement.

A possible method for securing bearing capacity and preventing gully erosion was to provide support by inserting a concrete box culvert-like structure inside the foundation, but this would not necessarily adhere to the authenticity of preservation. A measure was thus sought to slightly improve the coarse sand excavated from the foundation and apply it to the restored foundation. If the foundation material could be improved by making a slight improvement to the sand, authenticity could be protected. Therefore, a measure was ultimately taken to strengthen gully erosion resistance by mixing a small amount of clay to the coarse sand that was excavated and promote grain cohesion by mixing slaked lime and laterite powder, and thereby improving erosion resistance and enhancing bearing capacity.

Another possible method was to try to prevent soil runoff using geotextile instead of improving the coarse excavated sand, but as coarse sand is difficult to compact, sufficient bearing capacity cannot be expected. It was also conceivable to use geotextile to reinforce bearing capacity, but restoring the foundation using coarse sand that is susceptible to gully erosion would leave cause for concern. For this reason, it was reasonable to first consider improving the coarse sand.

Fig. 10 shows the result of a compaction test. The solid lines represent the relationship between water content and dry

density. The dotted lines are the result of a Yamanaka hardness test that was performed to examine the strength property of the compacted soil, and represent the relationship between water content and the Yamanaka hardness index. The ● symbol in the figure represents the coarse excavated sand. The compaction curve does not show a clear peak, and remains flat. This means that the material is difficult to compact. The compaction curve becomes convex when clay is mixed at a ratio of 1 and 0.3 to the volume of the coarse sand, and optimal compaction condition changes according to the material. At the same time, the Yamanaka hardness index also becomes convex, and strength also increases. Fig 11 shows this change in the form of grain size distribution curves.

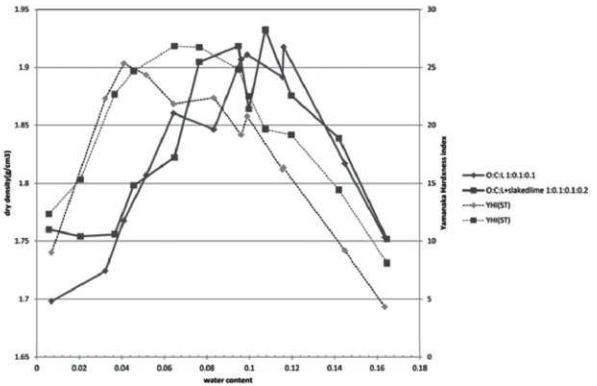


Fig. 10: Compaction test

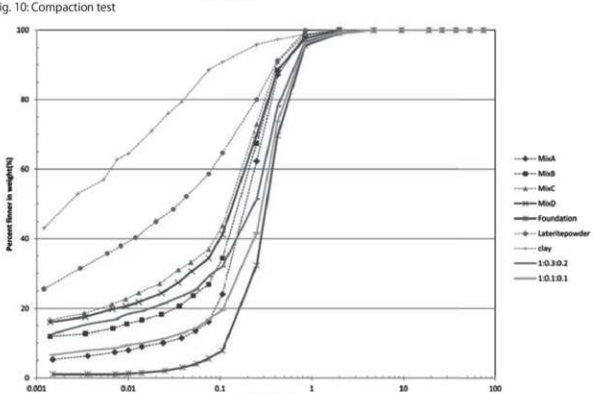


Fig. 11: Consolidation of the excavated soil

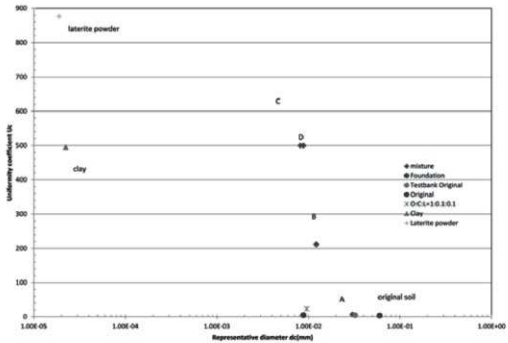


Fig. 12 : Consolidation of the coarse excavated sand by mixing clay

Fig. 12 shows that the foundation material is composed of coarse sand. It also shows the grain size distribution curves when clay and laterite powder are respectively mixed with the coarse sand. Laterite power is expected to provide cohesion between clay particles. The grain size distribution curves of the two mixtures are shown below.

Original : clay : laterite powder = 1 : 0.3 : 0.2

Original : clay : laterite powder = 1 : 0.1 : 0.1

MixA to MixD in the figure are grain size distribution curves showing mixture effects accumulated in the restoration of the Angkor Monuments. It is clear that soil mixture (A) is similar to MixB, and soil mixture (B) is similar to MixA.

The excavated soil used in the compaction test was mixed with a small amount of fine particles with a representative diameter of 6×10^{-2}mm, as shown in Fig 12. The representative diameter of the clay to be mixed with the excavated soil is 2×10^{-5}mm, and that of laterite powder is also 2×10^{-5}mm. Based on this, the representative diameter of soil mixture (B) above becomes 1×10^{-2}mm. Compared to the range of liquefaction shown in Fig. 6, the excavated soil falls within the range of liquefaction, but soil mixture (B) falls outside it, and shows that erosion resistance has been reinforced.

6. Confirmation of Bearing Capacity and Erosion Resistance of Test Soils

Test foundations were created to confirm the quality of soils that are consolidated by mixing clay and laterite powder to the coarse excavated sand. The main objectives were to confirm the mechanical features of the soil mixtures, and to accumulate experience in people who engage in foundation work. The blending ratio and test conditions are shown below. The grain size distribution curve of test soil B is shown in Fig. 13.

Test soil A Excavated soil : clay : laterite powder = 1 : 0.1 : 0.1

Test soil B Excavated soil : clay : laterite powder : slaked lime = 1 : 0.1 : 0.1 : 0.2

Compaction was performed using a rammer called "elephant's foot" and a round rammer. Photos 10 to 27 show the progress of the test foundation work. In Photo 10, large rubbles and foreign matters contained in the excavated soil were removed and sifted so that a uniform material is left. The soil mixtures were prepared according to volume ratio, and their initial water content and water absorption were measured.

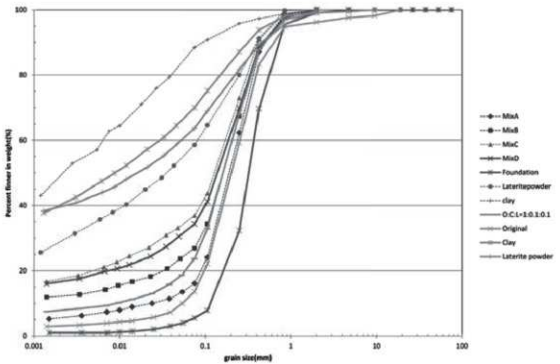


Fig. 13 : Consolidation of the coarse excavated sand by mixing clay

Using a rammer, the test soils were compacted from a spreading depth of 10cm to a compacted depth of 6cm. Then, after compacting the areas that come into contact with laterite, a Yamanaka hardness meter was used to control the degree of compaction. After confirming that the control conditions are satisfied, the soils were applied and compacted in sequence. Once the prescribed thickness was obtained, a simple penetration test, loading test, permeability test and density test were conducted to inspect the quality of the test foundation.

To verify the quality of the test foundation, a Yamanaka hardness test, simple penetration test, loading test, permeability test and local density test were performed immediately after completion of the test foundation and after roughly a month of curing. The erosion resistance of bare holes and side walls were also examined by pouring or sprinkling water.

Table 4 shows the result of the local density test. The dry density of the lower platform is 1.47g/cm^{3}as shown in Table 2, but as test soil A and test soil B of the test foundation had dry densities of 1.55g/cm^3 and 1.7g/cm^3, respectively, a considerable improvement in density was achieved particularly in test soil B.

Fig. 14 shows the result of the loading test. A limiting value could not be obtained due to a shortage of reaction force, but it was estimated from mutual similarity in a cone test. The result showed that an ultimate bearing capacity of more than 1500kN/m2 could be expected immediately after completion of the test foundation. This ultimate bearing capacity far exceeds the 900kN/m2 and more ultimate bearing capacity required by the foundation material of the South Temple, and verified that a large safety factor could be ensured even immediately after completion of the test foundation. Additionally, in the erosion resistance test performed by pouring and sprinkling water, no case of erosion was observed as that seen in a same test on the excavated soil, so erosion resistance was achieved.

	Test A		Test B	
	1	2	1	2
Wet density (g/cm3)	1.626	1.771	1.819	1.911
Water content (%)	9.80	8.69	9.71	9.53
Dry density (g/cm3)	1.481	1.630	1.658	1.745
Average dry density (g/cm3	1.555		1.701	

Table 4: Local density

Fig. 15 shows a test that was performed to verify the increase in strength of the test foundation, after roughly a month of curing. The consolidated soil contains slaked lime, so strength was expected to increase. This was confirmed in Fig. 14. The dashed lines represent N values immediately after completion of the test foundation, and the solid lines represent N values after a month of curing. From the relationship between N values and ultimate bearing capacities accumulated in restoration projects at the Angkor Monuments, the following formula has been obtained in regard to materials containing fine particles.

$$q_f = 150N \quad (kN/m^2)$$

When assuming an N value of 20 immediately after completion of the test foundation, an ultimate bearing capacity of approximately 3000kN/m2 can be expected. On the other hand, after a month of curing, the N value of test soil A was approximately 50, and that of soil B was approximately 250, so an increase was seen in the strength of the test foundation, although the values largely vary according to the mixing condition of the materials. Test soil A, which is a mixture of excavated soil and slaked lime, and test soil B, which is a mixture of excavated soil, clay, laterite powder and slaked lime, showed a roughly ten-fold increase in strength immediately after completion of the test foundation. The effectiveness of mixing clay and laterite powder is thus apparent.

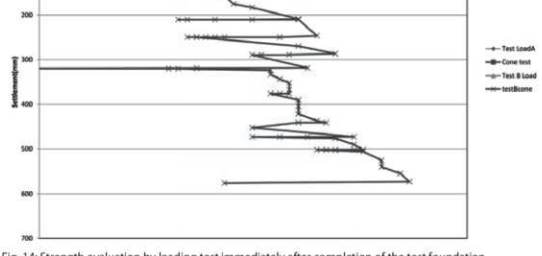


Fig. 14: Strength evaluation by loading test immediately after completion of the test foundation

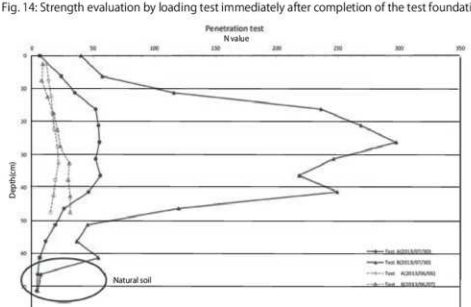


Fig. 15: Effectiveness after a month of curing

Photo 10: Removing foreign matter

Photo 11: Weighing the blended soil

Photo 12: Blending

Photo 13: Measuring the water content of a soil mixture

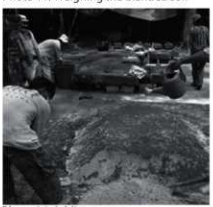


Photo 14: Adding water

Photo 15: Soil spreading thickness and compacted thickness

Photo 16: Leveling and compacting using a round rammer

Photo 17: Compacting using an "elephant's foot" rammer

Photo 18: Compacting the areas that come into contact with laterite

Photo 19: Compaction control using a Yamanaka hardness meter

Photo 20: Delamination prevention of the compacted soil surface

Photo 21: Quality inspection by a simple penetration test immediately after completion of the test foundation

Photo 22: Quality inspection by a loading test immediately after completion of the test foundation

Photo 23: Inspection of quality change by adding water

Photo 24: Adding water to a bare hole to see if it can keep its shape

Photo 25: Strength test on the side walls after curing

Photo 26: Water supply test after curing

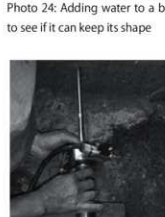


Photo 27: Confirmation of erosion resistance and inspection of the side walls after curing

A	Requried load and deformation conditions	Unit	West top	Remarks
	Estimated maximum load intensity	kN/m^2	326	
	Requried bearing capacity	kN/m^2	978	Safety factor=3
	Allowabte settlement	mm	5	
	Coefficient of subgrade reaction	kN/m^3	195600	
B	Requried mixing conditions for compacted soil layers			
	Dry density(Pd)	g/cm^3	1.8	
	Water content of blended soil(W)	%	10	
	Mixing rate of dry weteht for base soil	%	100	
	Mixing rate of dry weight for laterite powder!	%	10	
	Mixine rate of dry weight for attended clay soil	%	10	
	Mixing rate of dry weight for slaked lime	%	20	Weight of blended soil=100
C	Compacting			
	Initial thickness	cm	10	
	compacted thickness	cm	6	
D	Requrted initial mechanical properties of compacted soil layers immidiatlv afetr compacted			
	Uniaxial strength	kN/m^2	978	
	Elastic deformation regidity	kN/m^2	258219.8	E_{50}=294.1(q_u-100)
	N value	blows	6.5	qf=150N
	YI(Yamanaka hardness inspctor)		25	
E	Estimated final properties after curing period of 90days			
	Uniaxial strength	kN/m^2	3292	qu=400+26(d-1)
	Elastic deformation rigidity	kN/m^2	938767.2	E_{50}=294.1 (q_u-1OO)
	Coefficient of subgrade reaction	kN/m^3	1304886.4	K =1.39/B*E_{50} (B=1m)
	Predicted settlement caused by weight of tower	mm	0.7	

Table 5: Soil control criteria

A test will be conducted on the test foundation once more immediately before commencing restoration work to examine the relationship between the foundation preparation method and control criteria as shown in Table 5.

7. Thorough Prevention of Foundation Material Runoff Using Geotextile

Deformation of the South Temple of West Prasat Top is assumed to be caused by the loose, coarse sand of the foundation. Thus, rather than using the coarse sand as it is, its strength and erosion resistance could be fully increased by mixing it with clay and laterite, treating it with slaked lime, and controlling it under the criteria shown in Table 4. However, to ensure safety, a nonwoven textile for runoff prevention will be applied to control runoff accompanying wastewater discharge from the foundation material. Fig. 16 shows an example of applying unwoven textile. In this case, the textile prevents clay from flowing into and clogging the drainage pipe accompanying the flow of external water into the drainage pipe.

In the case of the foundation of the South Temple of West Prasat Top, the unwoven textile would be placed along the side walls of the foundation to prevent the runoff of fine particles from inside the foundation. In consideration of the fact that groundwater level reaches the height of the lines of stones during the rainy season, and that such changes in groundwater level strengthens the soil below the line of stones, the unwoven textile would be laid on the bottom surface of the foundation as though to cover the stone lines. This would also convey to later generations that West Prasat Top was excavated down to this surface. The following are four general parameters for selecting an unwoven textile product.

1) Weight (g/m2)
2) Thickness (mm)
3) Coefficient of permeability in the vertical direction (cm/sec)
4) Apparent opening size (mm)

Opening size is determined by the grain size of the soil that is to be prevented from flowing in or out, and could be roughly defined as D85/Opening size of the textile > 1. D85 is the maximum diameter of 85% of the particles that pass through the textile in terms of the grain size distribution curve. With reference to Fig. 13, an opening diameter of roughly 0.2mm (200μm) can be obtained. A plastic board drain is also used in some cases for improvement of clayey ground. In this case, the core material is covered with unwoven textile to prevent clay particles from getting into the core material. The average opening diameter of this unwoven textile would be 50μm.

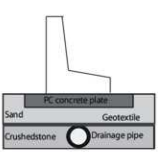


Fig. 16: Unwoven textile application example

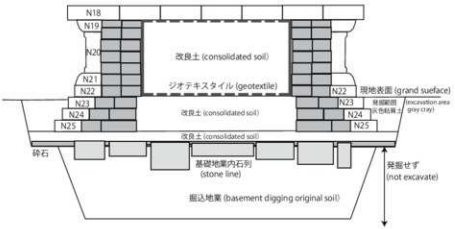


Fig. 17: Covering the foundation material with unwoven fabric

Chapter 2 The Western Top Temple's Stone Blocks

(Preliminary Introduction to the Inscriptions, Graffiti, Marks and Sketched Designs)

Researcher of Nara Institute Cambodian Project Sok Keo Sovannara

1. History and Research

Prasat Top Lec or Western Top temple and known as Monument 486 is located in Angkor Thom area, about 500m in the south-west of Bayon temple. It can be reached though the western gate of the wall of the Angkor Thom complex.

Western Prasat Top is not the original name given to the site. It was coined by later generations, and means "small temple in the west" . The current visible structures known as three sandstone towers , sandstone Buddhist terrace and laterite enclosure, have been primarily thought to be dated at least 16th -17th centuries, after the empire of Angkor collapsed around the first half of 15th century. But after finding some Chinese white porcelain and some Khmer green glaze ceramics, Prof. Sugiyama and his colleagues have considered that the central tower was probably in 14th century, while the two other towers were a bit later .

Khmer people had occasionally changed from Hinduism and Mahayana Buddhism to Hinayana Buddhism known as Theravada. Some of temples in Cambodia, especially in Angkor Thom area, had been temporarily changed and particularly added for accepting to the concepts of new religion.

Western Top is one of those temples. Historically, the evidences of remain structures indicate that there was approximately a former tower of a temple already constructed on the place of the present central tower. The existed structure is a laterite basement that was covered by modulation-decoration sandstone wall of central tower. The former tower is thought to be built probably in 10th century, because evidentially according to the laterite basement structure and other sandstone blocks such as pillars and four lintels confirm that it is similar to the style of Banteay Srei temple, which dates to 10th century or in the reign of the King Jayavarman V (968A.D-1001A.D). The groups of sandstone blocks are very close to the blocks of Banteay Srei temple . But after a clearance done by Henri Marchal in 1924, an inscription was found in the south-east of the sub-basement of the north tower. There are about 23 lines of the text, while about 18 lines are visible . The inscription was written in mainly Sanskrit and a few lines of Khmer, about an erection of a statue of Visnu and the foundation of the temple by a maternal uncle of king Yaçovarman, who named Çrī-Samaravikramam. This inscription should be in the reign of this prince dated between 889A.D-908A.D. This is a problem for dating the former tower or structure. Basing the inscription, there would be a temple constructed and a statue also erected during the reign of this prince (end of 9th to beginning of 10th centuries). But evidentially, comparing to the sandstone blocks found using with the later sandstone central tower, it indicates that the former building seems to be built in the late 10th century. Finally, when after the former building collapsed, the 14th or 16th-17th century towers were constructed and added surrounding to the former remain structure known as probably the inner laterite basement.

However, this is a big problem that needs more time to discuss about the progress of constructions of the former and newer buildings.

Western Top was primarily described and invented as Monument 486 by a French scholar named Lunet De Lajonquère . Probably, he had a mistake with his description of the three towers of the temple. He wrote that the three towers of Western Top were built of brick. Surely, the three towers were constructed by sandstone and some laterite blocks. At that time, he also mentioned that there was not any inscription found at the temple.

In 1924, Henri Marchal came and cleaned up the soil and stone ruins around the building in order to check the plan of the temple. Fortunately, a 23-line inscription was found in the north-east corner of the central tower. The inscription was later studied and published by another French scholar named Louise Finot.

After Marchal, from 1940s through 1960s there was little scholarly investigation or research on the Western Top temple site.

From the year of 2002, the Nara National Research Institute for Cultural Properties (Japan) began a new project on conservation and restoration works at this temple, after finishing a research work on ancient Khmer ceramic kiln at Tani village site. In the same year, a draft topographic map had been done for the area around the temple and some collections were also done for some ceramic fragments remaining on the ground surface. Starting in 2003, a primary excavation was conducted in the south of an eastern Buddhist terrace, which measured about 3m from east to west and11m from north to south , in order to check the relation between that terrace and the outer laterite wall surrounding the temple complex.

Step by step, the continuous excavations had been done for different places around the whole temple area in the aims of understanding and checking the strategraphic layers of the soils and underground structures of the temple and eastern terrace. Till the end of 2011, totally 13 times of archaeological excavations were done around the temple site.

From March 2012, the Nara Institute cooperated with Apsara Authority began the restoration work for this temple. The project will be held during five years. Now we are under the removing work of the stone blocks from the southern tower. Basing on our observation some blocks of the stones from the southern tower and scattered area contain some graffiti, marks and decorations. Some of the decorated blocks indicate that they are the reused blocks that were probably brought from any fallen temple. It is not yet clear about these graffiti and marks. However, this primary study is a part of our research and restoration works that can bring us to understand the process of the Western Top temple's constructions and its stone material resources.

2. Restoration Work and Stone Arrangement

The western Top temple consists of three towers and one eastern Buddhist terrace. Our work plan is to conduct the restoration work during 5 to almost 10 years. It was started from March 2011 to firstly 2017 and begun with the southern tower of the temple. All the blocks including the blocks from the complex towers and scattered areas around the temple are systematically recorded and invented separately according to the areas where the blocks originally exist. We recognized the areas for the temple complex as Central tower, Southern tower, Northern tower, Eastern terrace, Southern Scattered Area or Assembly South, Assembly West, Assembly North and Assembly East.

When we started to dismantle the stone blocks from the southern tower, the Alphabet S was used to recognize the blocks from southern tower. And then E, S, W and N were also combined with S to understand about the blocks from which side or part of the tower. For example, we gave the number to the stone from 001, so the first block from the northern part would be SN001 and so on. The layer of the stone blocks would be called from the upper part down to the lower part by using N to understand the number of layer. For example SN001/N1.

3. The collections of scripts, marks and designs

A-Inscription

The first inscription of western Top temple was found by Henri Marchal in 1924, in north-east corner, during his clearance around the temple. Then it was registered in Khmer Inscription list as number K.576 and studied and translated by Louis Finot in 1925 . The inscription contains 23 lines including Sanskrit and Khmer at the last three lines. There are only 18 lines readable. The inscription was written without date, but according to the text talking about the establishment of a statue of Vishnu and the foundation of the temple by the maternal uncle of the king Yasovarman I (889AD-908AD), named as Çrīsamaravikrama.

The second inscription was found in 2012 during our clearance and datum point setting up in the south the eastern Buddhist terrace, inside the laterite enclosure, near the southern twin Sema stones. The inscription consists of a line written on the inner surface of a decorated stone as a tray, but there is not any date. Basing on the character of the scripts and inscription's meaning indicates that it dates in middle Khmer period or post Angkor period.

Fig.1-dakkhine kassapo buddho

The Kassapo Buddha is in the southern direction.

Hypothetically, this sandstone object was made for storing something offering to the Buddha named Kussapo(Turtle), who was in the southern direction. In Theravada Buddhism, four Buddhas already existed such as Nagomano(Naga), Kuksantho(Cock), Kassapo and Samanakottama(Ox).

We have found two other broken pieces of sandstone that have same characters to the first tray-shaped inscription. These blocks are recognized as number 3 and 4. The block number 3 contains only pacca(?) probably originated from paccima (west direction). The block number 4 remains only the last sentence of the inscription, as kyamuni(?), means the name of Buddha.

Basing on the discovery of these three middle period inscriptions, there could be another block of the inscription for another direction.

Fig.2 bacca (?)

Fig.3 kyamuni(?)

B-Graffiti

Graffiti is referred to the script or word that was written by the stone cutter or sculptor as the personal work or block, or sometime the different person who tried to make any mark of the stone block. Mostly, the graffitis have no meaning.

Primary observation indicates that the graffiti scripts are mainly found on the basement blocks of the southern tower from the upper to the lower basements. Separately, the southern tower was built on three stairways of the basements; the upper basement consists of three layers (N9, N10 and N11); the middle basement contains six layers (N12, N13, N14, N15, N16 and N17) and the lower basement has six layers (N18, N19, N20, N21, N22 and N23).

Several kinds of the graffiti are found mainly on the wall sides of the stone blocks including e, eka, era, ka, and ba(?). Some of these graffiti scripts are not clearly recognized. The word eka (Fig.2, 3 and 4) is from Sanskrit means number one . Some other single scripts are the vowels and consonances that have no exact meaning (Fig.5, 6, 7, 8, 9 and 10), but probably the signs or remarked characters of the person who cut or made the stones. On the other hand, most of these scripts cannot be well understood as to which consonance. But these consonances look like the Angkorian period scripts than the scripts found in the three middle period inscriptions. For example, ka (Fig.11, 12 and13) or ba(?) (Fig.14, 15 and 16) can be compared to the Khmer consonances in Angkor period .

Some of these graffiti are often found on some stone blocks of Bayon temple (Fig.19).

Fig.4

Fig.5

Fig.6

Fig.7

Fig.8

Fig.9

Fig.10

Fig.11

Fig.12

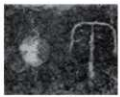


Fig.13

Fig.14

Fig.15

Fig.16

Fig.17

Fig.18

Fig.19

C-Mark

There are several marks noticed on the stones. These marks are not sure to be sketched originally when the stones taken from the stone quarry or the other period when different people who came to build this temple tried to carve on the blocks that they moved from the other places or temples. Some stone blocks' characters, especially the remains of the decorations, show that most of the blocks of Western Top temple are reused stones that probably blocks from the previous fallen down temple on site or from other temples inside Angkor Thom area. This is the problem for us to know where the stones of Western Top temple were from. However, these marks below cannot be described or interpreted about the meanings.

Fig.20

Fig.21

Fig.22

Fig.23

Fig.24

Fig.25

Fig.26

Fig.27

Fig.28

Fig.29

Fig.30

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Fig.54

Fig.55

Fig.56

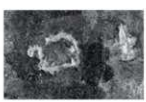

Fig.57

Fig.58

Fig.59


Fig.60


Fig.61


Fig.62


Fig.63


Fig.64


Fig.65


Fig.66


Fig.67


Fig.68


Fig.69

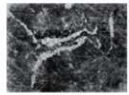
Fig.70


Fig.71


Fig.72


Fig.73

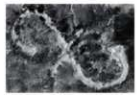
Fig.74


Fig.75

D-Decoration and Sketched Design

We found not only the decorated stone blocks of the southern tower, but also some of the central tower's sandstone blocks are decorated with praying-human image that were mostly put the decorated sides to the inner parts of the walls of the tower. The inner pillar's head of the eastern door, northern side, of the southern tower was arranged by a decorated block of sandstone (Fig.104). It is a line of lotus petals different from the other lotus flower designs of the three towers of the Western Top temple. One block of sandstone from the second basement of the southern tower, (SW086/N17), remains a good decoration of fire-vine with some human images inside the circle shapes of the fire-vine design (Fig.76).


Fig.76- Fire-vine design with human images

These two examples of the decorated sandstone blocks can be used to confirm about the re-utility of the used stone from the previous temple.

Moreover, there are some other sketched designs that look like the images drawn and carved in the middle period or in the other time when other people came and tried to sketch the image of the animals and especially the images of sitting Buddha on the inner wall of the southern tower and the door frame of the eastern door of the southern tower. The animal images are mainly found on the wall sides of the sandstone block of the basements. We also found such kind of sketched images on the collapsed stones in the southern scattered area (or called South Assembly) and western scattered area (or called West Assembly).

These sketched images can be divided into three categories. One is belonged to the human or Buddha images, while another is referred to animal figures. And the last one includes the images of flowers, fruits and unknown design.

The human or Buddha images are found on the wall sides of the eastern door of the southern tower. A few south assembly stone blocks also have Buddha images. These Buddha images are not good looking figures. They were probably sketched by simple people who came for praying and wanted to show their supports to the Buddhism by making these Buddha images on the wall of the tower. But was that possible some of the Buddha images were sketched before the southern tower's construction? Sometime we found the Buddha image on the basement sandstone block, for example a block SE01/

N23 from the third basement, contains an image of sitting Buddha. The trace of the image is looked well with the decoration at the head area, but the sitting position is not so neat (fig.77).


Fig.77


Fig.78


Fig.79


Fig.80


Fig.81

The animal figures are visibly looked like the images of deers. Some others are clearly the elephants. One elephant figure is found on a block of the northern wall, inner side, of the southern tower, with red color that seems to be applied by some red lacquer (Fig.89).


Fig.82


Fig.83


Fig.84


Fig.85


Fig.86

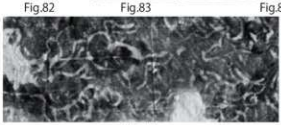
Fig.87

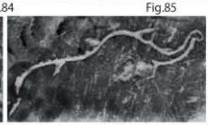
Fig.88

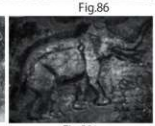
Fig.89

The last sketched images found at Western Top temple are thinkable figures suchas flower and fruit designs. Some others are geometrical motifs and unrecognizable carving. We do not surely know the meaning of these sketched figures.


Fig.90


Fig.91


Fig.92


Fig.93


Fig.94


Fig.95


Fig.96

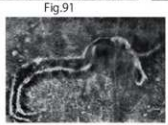
Fig.97

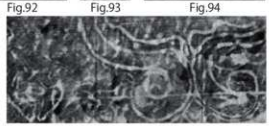
Fig.98

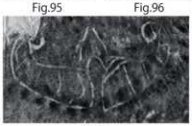
Fig.99

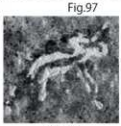
Fig.100


Fig.101


Fig.102


Fig.103

Fig.104

Fig.105

Summery and Discussion

This draft introduction to the inscriptions and the graffiti found at western Top temple is a part of our continuous study and research about the process of the constructions of Western Top temple. Previous researches concluded that at least two stages of this temple's constructions were done. Firstly, the inner part of the laterite basement of the central tower was probably and approximately was built in the late of 9th century by a maternal uncle of the king Yasovarman I, according to the inscription found by Henri Marchal in 1924. Secondly, the outer sandstone tower was added surround the former collapsed tower in early 15th or 16th centuries. At that time, two other towers, in the south and north, were also thought to be constructed. But basing on our recent dismantlement of the southern tower it is make us clear that the southern tower was additionally added continuously to the south by covering the southern stair of the central tower as its lower basement.

The study of the graffiti, marks and decorated sandstone blocks can reveal some information of the sandstone materials that were used to build up this three sandstone tower or including the eastern Buddhist terrace, as well.

The graffiti and the marks are not so important to understand the originality of the sandstone blocks, because there are not so many evidences of these items can be compared. But some decorated sandstone blocks found inside the southern tower and its basement can be assumed that some of the Western Top temple's stone blocks were probably brought from the Bayon temple, after some parts of the Bayon temple fell down (see the examples of fig.104 and fig.105). This is just my primary assumption. The further research will be done and exactly discussed for the originality of the sandstone blocks of the Western Top temple.

References

(1) Nara Institute, Western Prasat Top Site Survey Report, 2012, Phnom Penh, p.14

(2) In his brief description in Inventaire Descriptif des Monuments du Cambodge, E. LUNET DE LAJONQUIÈRE wrote that the three towers were built by brick.

(3) Primarily, through the cultural layers of trench FA01, which was excavated in July 2007, nearby the north-west corner of the central tower, some white porcelain fragments were discovered inside the basic soil layers of basement of the laterite and sandstone basements of the central tower. According to these fragments, actually from De Fua kiln, in South-east of China, they consider the central tower is 14th century and two other towers are not so late from the construction of the central tower.

(4) Henri Marchal, Notes Sur Le Monument 486 D'Angkor Thom, BEFEO, Tome XXV, Hanoi, 1925, pp411-416

(5) Louise Finot, Inscription d'Angkor Thom, BEFEO, Tome XXV, Hanoi, 1925, pp 298-410.

(6) Lunet De Lajonquère, Inventaire Descriptif des Monuments du Cambodge, Tome Troisième, Paris, 1911, p.74

(7) APSARA Authority, Department of Culture, Report of Excavation Work at Western Top Temple, Siem Reap, 2003, page 1. (written in Khmer)

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Chapter 3 New Elements of Theravada Buddhism Found at Western Prasat Top

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Introduction

In past studies, it was thought that Western Prasat Top was built in the 9th century, as inferred from inscriptions, and lasted until the 15th to 16th centuries, corresponding to the post-Angkor period following the fall of the Angkor period. However, no detailed archaeological studies have been made to date, and the only a few researches that is relevant is one conducted by M. Giteau and A. Thompson based on an iconographic perspective (1, 2). In recent years, Nara National Institute for Cultural Properties has launched an ongoing study of Western Prasat Top from the perspectives of archaeology, architectural history and conservation science (3). The monument deserves particular attention, as it includes buildings and architectural decorations that are associated with periods after the post-Bayon period in the last years of the Angkor period. For example, seated Buddha images in the buhusparsa-mudra (earth-touching mudra) that are displayed on pediments and standing Buddha images depicted on the false doors of the Northern Sanctuary could be regarded as representative icons of Western Prasat Top that belong to after the post-Bayon period. It is conceivable that these icons belong to a considerably early stage of Theravada Buddhism in the Angkor region (4). Due to instability of their main structure and other such factors, the three sanctuaries of Western Prasat Top were decided and restored and the dismantling of the South Sanctuary was begun as the first step. This dismantling work yielded new discoveries, however, as introduced below.

Section 1 Sema stones discovered in the platform of the Southern Sanctuary

Western Prasat Top today consists of the Central Sanctuary in the center flanked by the Southern and Northern Sanctuaries, with a terrace in the east of the Central Sanctuary. Laterite enclosures and Sema stones mark the temple grounds as though to enclose the sanctuaries (Fig. 1). Surveys so far have found Sema stones placed in the four corners of the laterite enclosure and in the center of each side. A multiple number of Sema stones have also been found anew among the components of the upper and lower platforms, accompanying the series of dismantling work of the Southern Sanctuary.

From the upper foundation, these stones include three from N12 (Fig. 2), two from N14 (Fig. 3), three from N15 (Fig. 4) and five from N16 (Fig. 5). From the lower platform, two have been found in N24 (Fig. 6). Details of the dimension of each block are provided in the Annual Report on the Research and Restoration Work of the Western Prasat Top (5), but as a whole, almost all Sema stones that were recently found at the Southern Sanctuary had heads curved into three arches (Fig. 7). The parts that lay exposed aboveground were carefully shaped, but their bases that were hidden underground remained unshaped. The Sema stones that demarcate the Western Prasat Top site today do not have gouged heads into three, but are generally shaped in the form of ammunition resembling a lotus petal, and differ from the tripartite Sema stones that were recently discovered (Fig. 8).

At a glance, the Sema stones appear to be stacked randomly, but they also seem to be placed mainly in positions that are important as gateways, such as near the stairways of foundations. This trend is especially conspicuous in N24. The Sema stones found in N24 are clearly placed immediately below the bottommost stairway of the lower platform stairways of the Southern Sanctuary, and were probably placed in those positions intentionally. Sema stones are originally closely associated with Buddhism, and have religious significance to the formation of Buddhist temple and terrace sites. At the Southern Sanctuary, they are used as diverted blocks, but it is likely that they were placed and incorporated into the Southern Sanctuary in consideration of their ritualistic and religious meaning.

The fourteen Sema stones found in the Southern Sanctuary could be assumed to be diverted blocks, but from which monument they were diverted is not clear. Nevertheless, since the Southern Sanctuary was built no later than the 14th century, there is the possibility that the stones had been used in a certain Theravada Buddhist temple or Buddhist terrace some time before that. In other words, the stones suggest that Theravada Buddhism may have flowed into the Angkor region before the 14th century.

The aforementioned research by Giteau provides the only available classification of Sema stones in Cambodia (6), but it focuses mainly on highly decorative Sema stones of Theravada Buddhist temples built after the middle period, and does not provide a detailed classification of Sema stones belonging to Buddhist terraces that were seen toward the end of the Angkor

period and in Angkor Thom. Given this situation, a list was decided to be made of Sema stones of major terrace temples, called Buddhist terraces, within Angkor Thom, to compare them with the Sema stones of Western Prasat Top, as an initial activity that could be implemented at the present stage. Not all Sema stones in Angkor Thom were verified, but roughly on the whole, it seems they can be classified into three types according to the shape of the stone exposed aboveground. For convenience, they shall herein be referred to as Types A, B and C. Type A has a tripartite head; Type B is shaped like ammunition and is hardly decorative; Type C has a lotus bud at the top of its ammunition-shaped head.

It is too early yet to conclude at the present stage whether the differences between the three types are due to the differences in their year of construction. However, among the Sema stones found at Western Prasat Top, the fourteen stones found in the Southern Sanctuary correspond to Type A, and those that were found in their original positions as markers of the West Prasat Top site correspond to Type B. Among the terrace temples of Angkor Thom, Type A stones were found at Kok Thlok (Fig. 9), Type B at Tep Pranam (Fig. 10) and Vihear Prampil Loven (Fig. 11), and Type C, which were most numerous, at Preah An Thep (Fig. 12), Preah Ngok (Fig. 13), Vihear Prampil Loven (Fig. 14), Vihear Prambuon Loven (Fig. 15), and Preah Pithu (Fig. 16). Two types of Sema stones were confirmed at Vihear Prampil Loven.

The recent discovery anew of more Sema stones accompanying the dismantling of the Southern Sanctuary of Western Prasat Top might perhaps provide important clues to revealing the process of formation of Theravada Buddhist temples in Angkor Thom and the state of affairs during the transition from the post-Bayon period to the post-Angkor period.

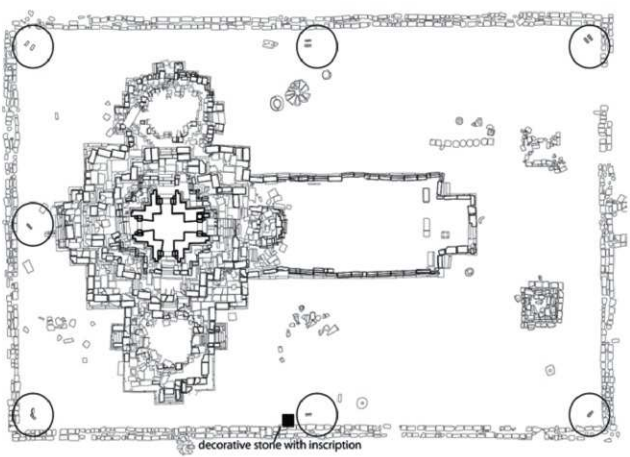

Fig. 1: Locations of Sema stones at Western Prasat Top

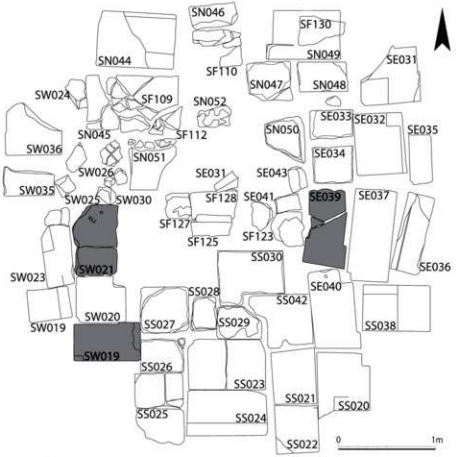

Fig. 2: Locations of Sema stones in Southern Sanctuary N12

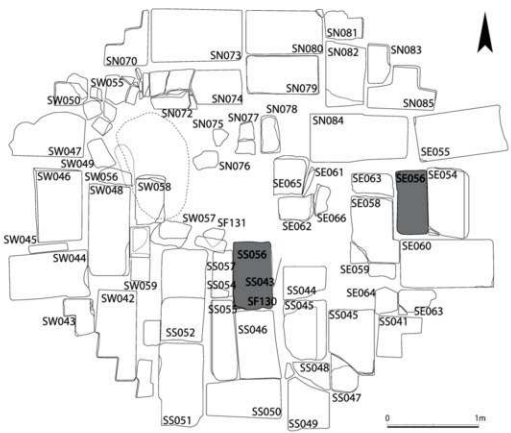

Fig. 3: Locations of Sema stones in Southern Sanctuary N14

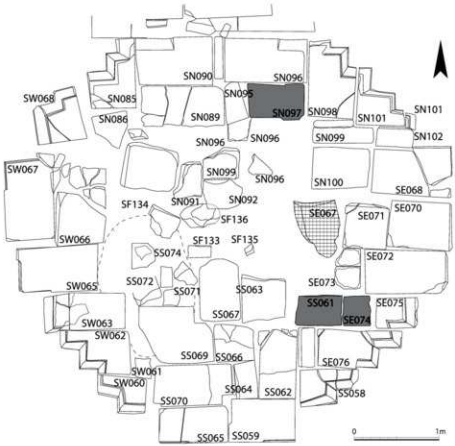

Fig. 4: Locations of Sema stones in Southern Sanctuary N15

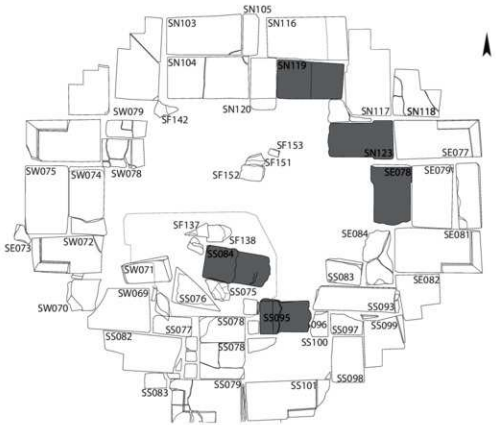

Fig. 5: Locations of Sema stones in Southern Sanctuary N16

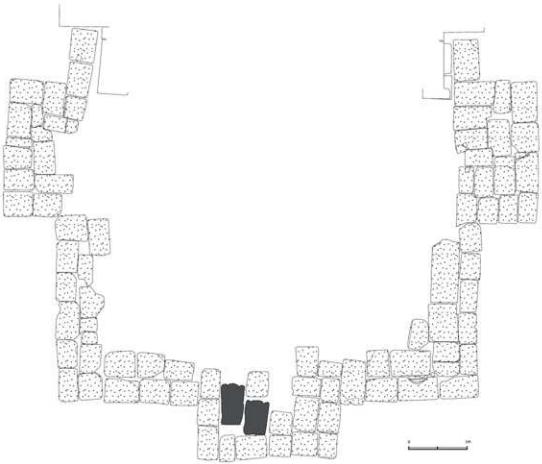

Fig. 6: Locations of Sema stones in Southern Sanctuary N24

Fig. 7: Excavated state of Sema stones in Southern Sanctuary N24

Fig. 8: The actual state of Sema stones in the center of the north side of Western Prasat Top

Fig. 9: Sema stones at Kok Thlok

Fig. 10: Sema stones at Tep Pranam

Fig. 11: Sema stone 1 at Vihear Prampil Loven

Fig. 12: Sema stones at Preah An Thep

Fig. 13: Sema stones at Preah Ngok

Fig. 14: Sema stones 2 at Vihear Prampil Loven

Fig. 15: Sema stones at Vihear Prambuon Loven

Fig. 16: Sema stones at Preah Pithu

On July 24, 2012, a decorative sandstone with an inscription was found while installing a new alignment marker accompanying the restoration work. It was found in close proximity to the Sema stone in the center of the south side, placed in a 10cm or so recess in the present ground surface.

It has a decorative contour in the shape of lotus petals, and was found with a rectangular mortise in the top surface (Fig. 17). When it was carefully picked up to examine the bottom surface, a single line of inscription was found (Fig. 18). The stone measures 66.3cm at its longest, 45.3cm at its widest, 11.5cm high and approximately 40kg in weight. There is no consensus regarding its purpose, but it might have been an offering made with the inscription side facing up, or a pedestal for wooden sculpture with the morise side facing up. No other examples of similar decorative sandstones have been found so far from archaeological sites other than Western Prasat Top.

The content of the inscription is described in the previous chapter by Mr. Sovannnara, but at this stage it is interpreted as shown below.

Original inscription: dakkhiṇe kassapo buddho

English translation: Kassapao in the south

Judging by the character style, it is presumed to be an inscription from a period between the last years of the Angkor period and the middle period.

Kassapao Buddha is the sixth in the past seven Buddha. The first three Buddhas are Alamkarakapla and the latter four are called Buddhas of the present bhadrakalpa. The seventh Buddha is Sakyamuni, and an added eighth is Maitreya. The four past Buddhas, in particular, are frequently associated with the four directions. These four Buddhas are widely worshiped in today's Cambodia as the four past Buddha. With Maitreya in the center, the four Buddhas occupy the north, south, east and west, with Kassapao Buddha normally positioned in the south. As I mentioned above, this sandstone artifact was unearthed from near sema stones situated in the central part of the south laterite enclosure, it might have been placed there with a conscious awareness of the south direction.

With regard to the four past Buddhas, it is known that the four past Buddhas were widely worshipped in Bagan , Myanmar (7). In Cambodia, however, no records or examples exist that indicate four past Buddhas worship flourished during the height of the Angkor period, but there is the possibility that four past Buddhas worship was widespread from the end of the Angkor period to the post-Angkor period. A prime example of this is the four Buddha images in the Bakan in the central sanctuary of Angkor Wat. Angkor Wat was originally built as a Hindu temple, but it was modified to a Theravada Buddhist temple in the middle period. The symbolic transformation brought a change in the main deity of the central temple from an image of Visnu to the four Buddha images, as also seen at Wat Nokor (8).

The inscription "Kassapao Buddha in the south" found at Western Prasat Top might perhaps also suggest the possibility that the four-Buddha philosophy was ingrained in Western Prasat Top. Although this is a theory at best at the present stage, the three sanctuaries together(the Central, Southern and Northern Sanctuaries)might have been regarded as the "center" or as Maitreya and the four past Buddhas placed to its north, south, east and west. As discussed by Mr. Sovannnara in the previous chapter, fragments of sandstones with the same decorations as those recently discovered have been found, but the numerals and characters of their inscription are hardly legible. If the remaining fragments could be found in future surveys, it would lead to a further understanding of the content of the inscriptions. In this respect, the recent discovery can be said to be an invaluable example that provides a vestige of early Theravada Buddhism in the late years of the Angkor period and a new step toward an understanding of the overall picture of early Theravada Buddhism in Cambodia.

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Fig. 17: Excavated decorative stone (viewed from the northwest)

Fig. 18: Inscribed face

Fig. 19: Mortise

Fig. 20: Overhead photo