2015-2016 Lao PDR Traditional Cement Research

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Introduction

The Project to Restore and Research Buddhist Statues in the World Heritage Area of Luang Prabang, a collaborative project of Minobusan University and the Lao PDR Ministry of Information, Culture and Tourism, has reached its 20th year. Until now, the project has focused on restoration and research of wooden and bronze statues. However, in 2015, Vat Aphay requested the restoration of its 4-meter-high pathaipun Buddhist statue. Pathaipun is one of the many kinds of traditional Lao cements. In order to restore this statue, intensive study of the various kinds of traditional Lao cements was necessary. Therefore, Jill Strothman (hereafter JS), Yukina Ikeda and Phimpha Phongsavath (hereafter PP) spent two years gathering information and creating cements using the various recipes. In this paper the major discoveries will be revealed.

Materials and Methods Research

In 2015 we began research by interview. In the past, one famous teacher of cements, Mr. Photong, had explained how to create pathaipet to the Minobusan University research team at that time. Unfortunately, Mr. Photong died.

Therefore it was impossible to ask what the proportions of the ingredients should be. In 2015 we interviewed PP, Mr. Sintheva and Mr. Koppa and asked the materials and methods each used to create traditional Lao cements.

The four major kinds of Lao cement are pathaipet, pathaipun, pathaipunkhao and pathaifuan. The word "pathai" can mean either "cement" or "tool used to make cement." "Pet" means "diamond." Pathaipet is hard like a diamond. "Pun" means "limestone." Therefore, anything called "pathaipun" has limestone as a major ingredient. "Khao" means "white." Pathaipunkhao is very white in color. "Fuan" means "glutinous rice straw." Pathaifuan is mainly glutinous rice straw, stuck together with cement. It's used to make walls of houses. It allows the house to breathe and is easy to repair anytime.

Chart 1 shows the results of our 2015 research. Where possible, not only ingredients but also proportions are shown.

2015 research	Pathaipet		Pathaipun				Pathaipunkhao	Pathaifuan
teacher	Phimpha	Koppa	Phimpha	Sintheva	Koppa	Photon	Photon	Phimpha
Ingredient	Proportion		Proportion			Proportion		Proportion
Water Buffalo Hide Glue	1	○	1	1	○	1		2
Sugar Cane	1	○		1	○	1		
Powdered Yangbong Tree	1	○	1	1	○			1
Yangbong Water		○		1	○	1(boiled)		as needed
Limestone	1	○	2	12	○	4	○	2
Sand	2	○	1	12	○	2	○	2
Banana						1		
Glutinous Rice Powder	1							
Water						○	○	
Red Dirt (worm feces)		○						
Lacquer (raw)		○			○			
Maak KhorHang root water		○			○			
Maak fen leaf water		○			○			
Straw (glutinous rice)								max amount

To make, mix the dry ingredients (sand, limestone, yangbong powder) thoroughly before adding the wet ingredients (Sugar Cane Water, Water Buffalo

Hide Glue, plant waters).

Explanation of Materials

Water Buffalo Hide Glue (nang kuai)

how to make

1. Buy water buffalo skin
2. Chop into pieces about the size of a hand

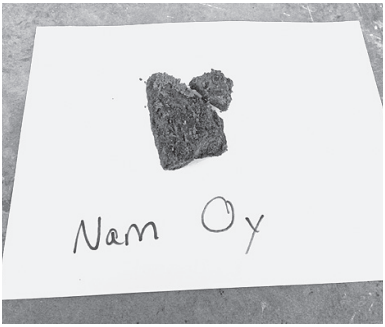
3. Burn to charcoal on the outside

   This makes it easy to remove the fur and blood vessels and dirt.
4. Put the burned skin in water
5. After the water soaks in, scrape off the burned part with a knife.

6. Boil for 3 days until the skin completely melts. It becomes gelatinous.
7. Pour into a long flat mold to harden.

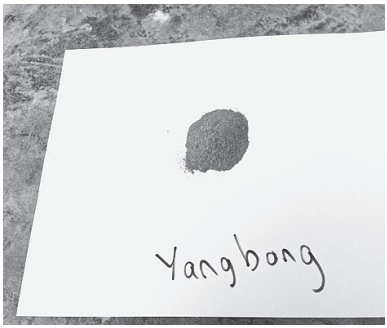
8. Leave for one year to dry thoroughly. It comes to have the color and texture of hard candy.

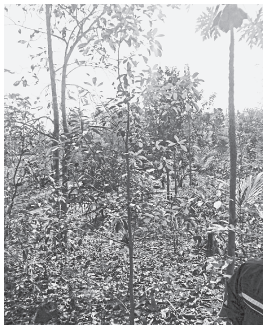
Sugar Cane water (nam oy)



Chunks of raw sugar are boiled in water to make a sticky glue that becomes hard when dried. The ph was 4. This is the most acidic ingredient.

Yangbong tree powder and water





The yangbong tree has traditionally been harvested in the Bomulao region. In the old days it grew naturally, but now it is planted. In this village it has been used as incense.

The yangbong tree is used in two ways. First, the powder of the bark can be used as a dry ingredient. Alternatively, the bark, branches and/or leaves can be soaked in water. In either case, when yangbong and water are mixed, the water becomes gelatinous, like slime. This slimy substance may have been useful in protecting Buddhist statues from cracking that naturally occurs with weathering. The ph of yangbong was 5.

Limestone (pun)

Traditionally, limestone was slaked in huge kilns. The photo below shows a traditional kiln for slaking limestone.

This kiln is more than twice the height of JS (164 cm, in photo).

Inside, limestone rocks are put on lateral brick pedestals and are completely surrounded by coal. In present-day technology, limestone is slaked by keeping the rocks at over 1000 degrees C for four hours. However, traditional Lao

kilns were made of bricks, and the spaces between the bricks allowed heat to escape. Therefore, Lao people slaked limestone for at least 3 days, at best one week.

When the limestone is heated sufficiently, it becomes white and the texture becomes like a brick. If the limestone is bluish it can't be used.

After sufficient heating, the limestone is put in water. It bubbles rapidly and the rock naturally breaks up into tiny particles like chalk. To aid separation of limestone and water, aluminum potassium sulfate (Hinsom in Lao, Myoban in

Japanese) is put in the water. As the water and limestone separate, the water is cast aside. Finally the limestone can be strained and dried to become powder. The ph was 11. Limestone was the most alkaline ingredient.

Sand

Two kinds of sand have traditionally been used. One kind is river sand.

River sand is white in color and the particles are round in shape. We took it from the Nam Khan River bank in Luang Prabang. The ph was 7.5. River sand flows more smoothly than mountain sand and was therefore the logical choice for construction.

The other kind is mountain sand. Mountain sand is brown in color and the particles have more corners than river sand. Mountain sand absorbs more water than river sand. We got this sand from the Ban Na-kam area of Luang Prabang, which is famous among Luang Prabang residents as the place to get the best sand. Mountain sand was used to make art objects. The ph was 7.

Plant water

Lao people have traditionally used many kinds of plant water in cement. To make this water, the necessary plant part is put in water for several days and pounded slightly. The water changes in color, fiber content is increased, and the ph changes. Mr. Koppa uses both Maak KhorHang root water and Maak Fen leaf water. PP swears by Maak Fen leaf water. Below is the Maak Fen plant, of the *burseraceae* family. Washing the leaves removes the good extract, so the leaves are put in water unwashed and soaked for one to three days. The resulting water has a ph of 8. According to PP, the sour taste of Maak Fen leaf water keeps insects from eating pathaipet despite the fact that it contains sugar. Maak Fen water has three advantages over ordinary water: the fiber, the sour smell and the fact that it's slightly alkaline.

Other kinds of plant waters have been used as well. For example, Mr. Sonbom uses San Mon leaves soaked in water.

2016 – deciding recipes

Pathaipet

PP's recipe for pathaipet makes an excellent, hard cement. This has traditionally been used for decorating the outside of temples and other artistic works. The recipe is as follows:

1. Boil 100 g nang khuai with 150 mm water until completely dissolved
2. Boil 100 g sugarcane with 130 mm water until completely dissolved
3. Put 500 g sand in tub
4. Add 100 g yangbong (dry state)
5. Mix thoroughly
6. Add 200 mm bai mak fen juice
7. Mix thoroughly
8. Add 160 g of (1) dissolved nang khuai. Add little by little, mixing
9. Add 57 g of (2) dissolved sugar cane. Again, little by little, mixing
10. Finished after kneading thoroughly

ingredients of pathaipet	ph
1. sand (saai)	mountain - 7, river - 7.5
2. sugar water (nam oy)	4
3. water buffalo hide glue (nang khuai)	5.5
4. bai mak fen (burseraceae leaf juice)	8
5. yangbong (pulverized yangbong tree)	5

Pathaipet created using this recipe has a ph of 7-8, with no significant difference in ph between mountain sand and river sand versions.

Pathaipun

The Vat Aphay statue is made of pathaipun and therefore pathaipun was the focus of our study. An interview of Shigehiko Saito, associate professor of Yamanashi University and a specialist in concrete and in structure, led to the following guidelines:

1. Sampling should be done using uniform square or rectangular molds.
2. Sand should be measured. We used 0-1 mm sand and 0-3 mm sand for comparison. (As reference, clay is 0-1 mm and anything over 5 mm is called a rock, not sand.)
3. At least three samples should be taken. Only one is not conclusive. If two are different, there's no way to know which is standard. Therefore, at least three samples are necessary.
4. The ph of concrete is 10-12. Metal supports rust over time, but when in an alkaline environment, the rusting is protected. We also are planning to use metal support for the Vat Aphay statue, and therefore, we also need an alkaline environment.
5. Durability should be tested after leaving the samples for one year.

Sampling

Following the above guidelines, JS did sampling. The same amounts of the liquid ingredients, Maak Fen leaf water and water buffalo hide glue (nang khuai), were used. Historically, the ratio of lime to sand has been 1:2 or 1:3 for construction purposes, but going back to ancient Rome, a ratio of 1:1 was also used. Therefore, JS made the following versions of pathaipun. Variations were made with river sand 0-1mm, river sand 0-3mm, mountain sand 0-1mm and

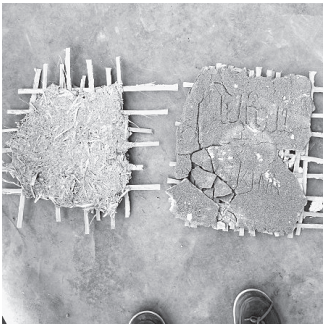
mountain sand 0-3mm. Three samples of each were made. All versions formed hard bricks. These will be tested for strength in 2017.

1:1 ingredients	1:2 ingredients	1:3 ingredients
sand 500 grams	sand 666 grams	sand 750 grams
limestone 500 grams	limestone 333 grams	limestone 250 grams
bai mak fen liquid 150 cc	150 cc	150 cc
nang khuai 100 grams	100 grams	100 grams

All samples were highly alkaline, with ph ranging from 10-11.

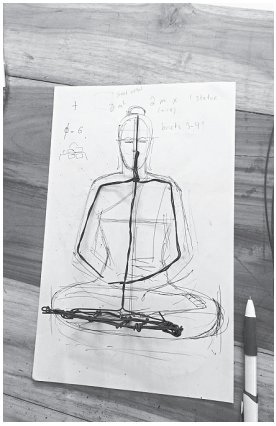
Pathaifuan

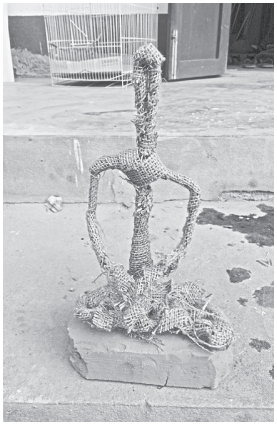
Pathaifuan is made by mixing a large amount of glutinous rice straw with pathaipun. The photo below shows pathaifuan (on the left) and pathaipun (on the right) that were attached to a bamboo slat base in 2015 and left for one year. Basic Lao PDR houses were constructed by making a simple inner structure as in the photo and using pathaifuan as cover. As can be seen in the photo, the fiber in the straw makes pathaifuan much more durable than simple pathaipun. Pathaipun alone cracks easily when a thin layer suffers weathering.



Research Specifically for Vat Aphay Statue

The current construction of the Vat Aphay 4-meter Buddhist statue is as follows. A brick base is covered with pathaipun, with wooden beams supporting. Layers of pathaipun cover this, with an outside coating of paint and gold leaf. To get a better idea of what would be needed to restore the statue, we experimented by creating similar mini-statues.





On the left is the actual statue. In the center is the design for the mini-statue, drawn up by Mr. Phone Sith of the Vientiane University of Fine Arts. Following this drawing, we made wire supporting for the statue, wrapped the sup-

porting in hemp so that the cement would attach to the supporting, and cut brick to use as the base. The resulting central portion of the statue is pictured on the right.

Having made the central portions, we experimented with types of sand. We made two versions, one with river sand and one with mountain sand. The inner layer is simple pathaipet, made using this recipe. For both the inner and outer layers, the proportions of water in the water buffalo hide glue (nang khuai) and sugar cane water (nam oy) were kept constant with the recipe for pathaipet shown above.

inner layer of pathaipet, made March 6, 2016
sand = 500g (for both mountain and river versions)
Yangbong = 100g
Bai Mak Fen = 200 cc
Nang Khuai = 160g
Nam Oy = 57g

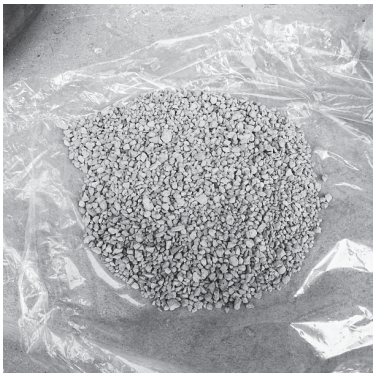
This was made and affixed by JS to the central portions, making two inner statues.

On the left is the mountain sand statue and on the right is the river sand statue.

These were left to dry completely for two days. Then we prepared the outer layers using the following recipe.

outer layer of pathaipet
sand = 500g (for both mountain and river versions)
Yangbong = 100g
Bai Mak Fen = 100 cc
Nang Khuai = 160g
Nam Oy = 57g
200 g dried bricks pulverized to 3-5 mm and immersed in water
Bai Mak Fen was reduced because of the water the bricks absorbed
100 g of brick absorbed 32.5 cc of water

Pulverized brick was used as a coarse aggregate because it has been traditionally used in this way in Lao PDR.



The pulverized brick was mixed in to the pathaipet, adjusting water amounts as explained above. The resulting mixture of pathaipet and brick was used to

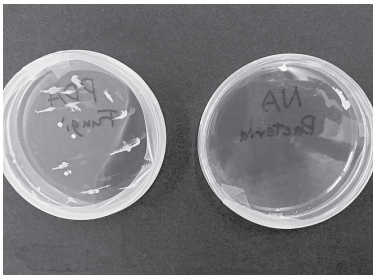
create the outer layers of the statues.

PP made the mountain sand version and Yoshitaka Suzuki made the river sand version. They used different processes. Yoshitaka Suzuki poured a small amount of water on the dried inner layer to make the outer layer stick better. PP painted the inner layer with water buffalo hide glue before attaching the outer layer. The effectiveness of these two methods will be observed in 2017.

On the left is the Suzuki river sand statue, and on the right is the PP mountain sand statue. The surface of the river sand statue is smoother; however, it has been suggested that the round river sand particles break off more easily than the square mountain sand particles. This is another point that must be observed in 2017.

Change in Pathaipet after 18 months

After 18 months, a sample of pathaipet made by PP in 2015 developed a white coat. JS took it to Yamanashi University to test it to find out what the white substance was. Keiko Katayama-Hirayama, Ph.D. tested it in her laboratory using the steps listed below.



Step 1: using a sterilized cotton swab, the white substance was scraped off.

Step 2: the substance was mixed with a small amount of distilled water.

Step 3: the mixture was spread on two kinds of culture mediums:

A: ATCC Medium – 3 Nutrient Agar/Broth, commercially available from BD as BD 213000 and BD cat 234000. This was used to test for bacteria.

B: Potato Dextrose Agar – 70139 Sigma-Aldrich. This was used to test for mold, yeast, and such fungi.

Step 4: the culture mediums with the mixture spread on them were warmed for a few days in a warming machine.

Results: The growth of bacteria in the 3 Nutrient Agar/Broth was present, but minimal. The growth of yeast fungus in the Potato Dextrose Agar was clearly visible. Therefore, the conclusion is that after 18 months, pathaipet made using the 2015 PP recipe develops fungus.

Conclusions and Future Research Themes

Many points became clear in the course of this research. First, the different kinds of traditional Lao cements exist for different purposes, and the ingredients match the requirements of use. Pathaipet is hard but the ph is 7-8. This is not alkaline enough for use in construction; however, pathaipet was not

used for construction. It was shaped and molded for decorative purpose. The sugar cane makes a nice sharp shape. However, it was found to develop fungus after 18 months and therefore is not suitable for long-term use. On the other hand, pathaipun was used to make large objects which required support. The high alkaline nature of pathaipun protected any supporting material. And pathaifuan is clearly the best material for walls. The strength is negligible, but the fiber keeps the shape for a long time and the straw allows air to flow without letting rain into the house.

There are many points left to be researched in 2017. While all the versions of pathaipun made by JS in sampling created firm, strong bricks, how will these hold up after a year of being left to weather naturally? Which of the many versions is most appropriate for use in Buddhist statue creation? And when applying a new coat of cement to an older, dried coat, what is the best way to ensure that the new coat will stick properly, without cracking? These are among the many questions that must be answered through further research.