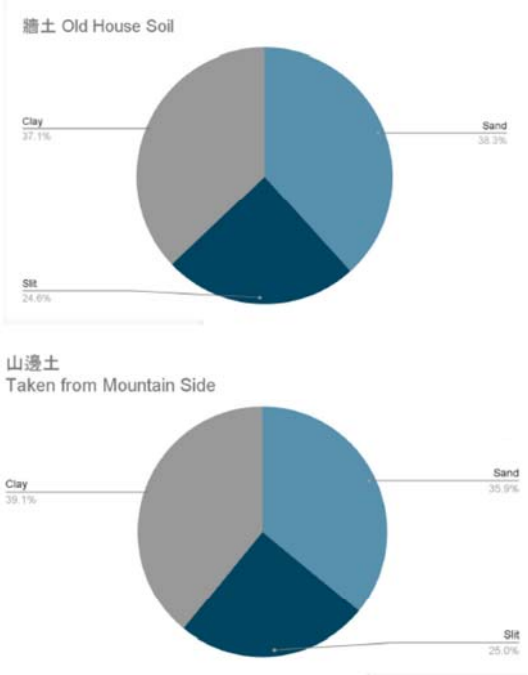
2.2 Soil characteristic in Mui Tsz Lam

To build a sustainable structure, a good soil source is crucial. The proportion of silt, clay, sand and gravels needs to be optimum to provide best strength.

Two sources of soil in Mui Tsz Lam were tested with their composition:

Old house soil has less clay content comparing to Mountainside soil, too much clay would lead to cracks in the wall due to its water absorbing properties; Organic matter was also found in mountain side soil which is not preferable in a wall.

The result has shown that ‘Old house soil’ is more suitable than ‘Mountain side soil’ since there is less clay content, and no organic matter.

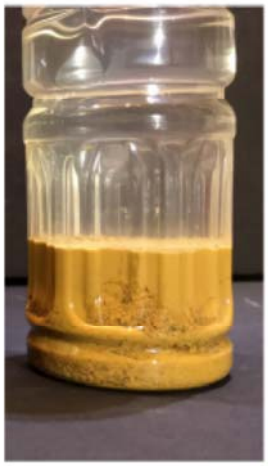


Soil composition percentage diagram

Sample A: Hill soil

1

2



3

Observation: (proportion in height)

Clay: 52.50%
Silt : 47.50%

Clay: 55.00%
Silt : 45.00%

Clay : 45.06%
Silt : 11.36%
Sands : 43.58%

Sample B: Old house soil

4

5

6

Clay: 15.69%
Silt : 63.64%
Sands : 20.67%

Clay: 35.79%
Silt : 64.21%

Clay: 38.56%
Silt : 61.44%

Rammed earth wall of the old house

2.3 Rammed earth wall in Mui Tsz Lam

Rammed earth walls are most commonly found in Mui Tsz Lam Village. Old house has the most signature earth wall. Still standing after at least 200 years, the traces of floor decking, beams, windows are still visible.

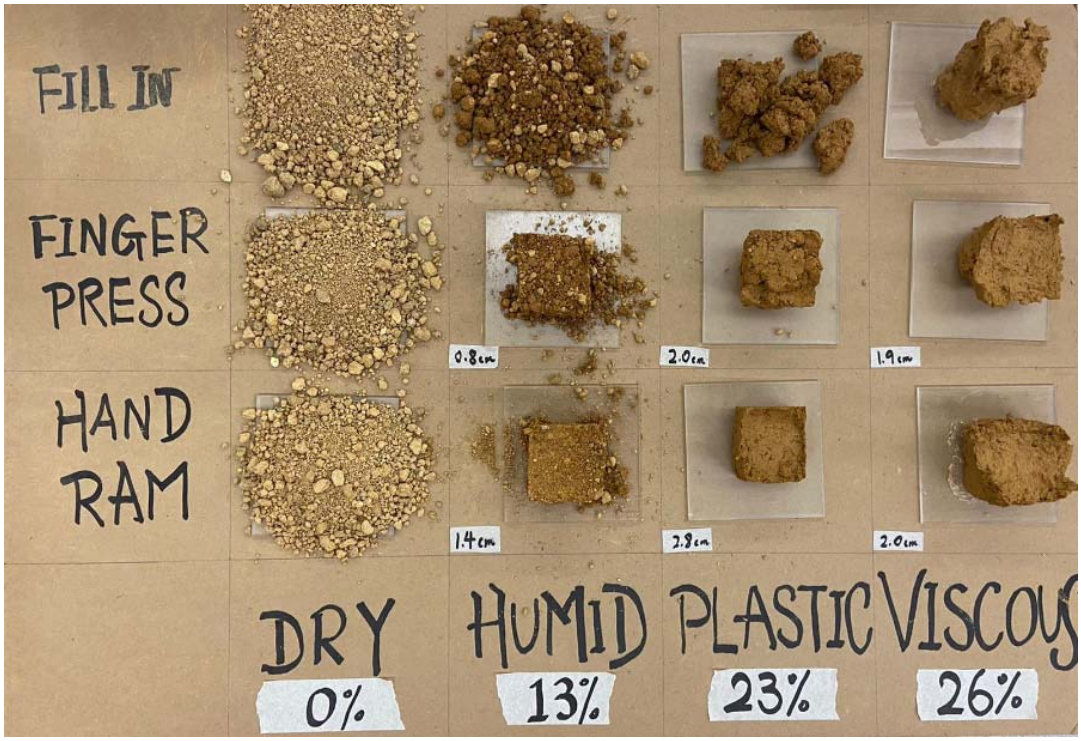
Our aim of project is to find out how it can withstand without adding chemicals or cement, analyses it, and recreate them. Combining old methods with new technology, we experiment to see the possibility of re-building in Mui Tsz Lam village.

In some houses in Mui Tsz Lam, we found different organic ingredients added apart from soil, e.g. sticky rice, grain, lime, brown sugar, straw (chopped into 5cm long).

Not all walls are as strong and as lucky as the Old House, many interior rammed earth wall e.g. at Mural House had been destroyed over the years. In our research, we would like to find out the pros and cons of traditional method, can optimize it to re-create rammed earth wall without additional chemicals, hopefully can retain the traditional characteristic but at the same time increase the strength and appearance.

Grains found in earth wall

Grains found in earth wall



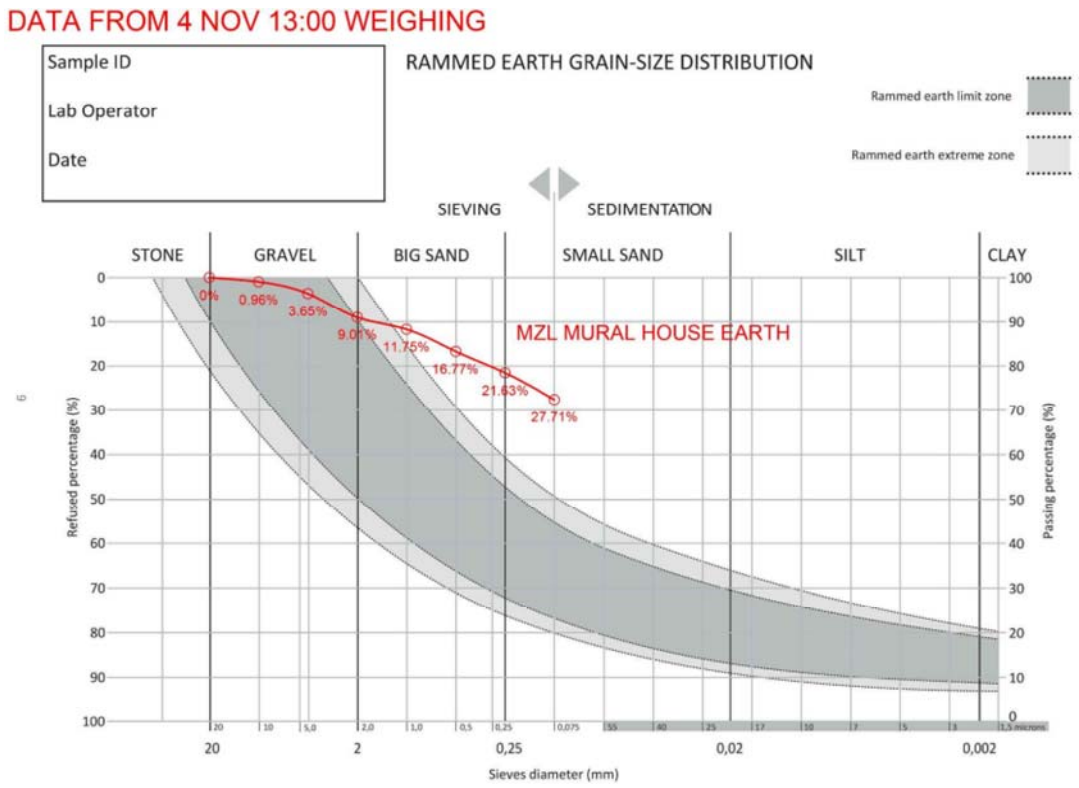
Carazas test by students

3.1 Mui Tsz Lam earth composition

3.1.1 Carazas test

Carazas test was done to see the form and appearance of soil with different water content and pressing method. The aim of this exercise is to observe the diversity of materials that can be obtained by changing the hydric state of earth (dry, humid, plastic, viscous or liquid) and the mechanical action applied on it (to fill, to press or to compact layer by layer). Participants can grasp by handling and observe the impact of some key processing parameters for various soils and fibers: consistancy, water absorption, compactibility, gesture, etc.

Dry sieving and wet sieving test by students



Data Sheet

(Documented on 04/11/2021)

3.1.2 Size distribution curve

Dry sieving and wet sieving test were done to distinguish the grain size of Mui Tsz Lam soil accurately. According to the grain size distribution graph, Mui Tsz Lam's earth does not lie perfectly in the curve, which need additional gravel and stone to balance.

3.2 Adobe bricks

In addition to testing the feasibility of rammed earth wall, adobe bricks were also tested. These bricks are widely used in Lai Chi Wo to build and renovate houses.

With the help of Lai Chi Wo's experienced craftsman, old wall soil was first demolished and roughly sieved, then it was soaked in water for a week before making the bricks. After a week, soil can be mixed with soaked straw (soak for around 1 week) and sand.

GOAL 目標

To find the smoothest mud brick slipped off the molding
制訂最佳的泥磚配方

SIZE 尺寸

150mm(W)*380mm(L)*250mm(H)

INGREDIENTS 材料

Saturated Soil soaked for 7 days 已浸七日的土
Straw grass soaked for 1 month 已浸 1 個月的禾桿草
Dry fine sand 乾細砂

PROCEDURES 過程

1. According to Woody's experience, prepare adequate amount of saturated soil, soaked straw and dry sand.
2. Mix them in a bucket by machinery. Use feet to mix and compress the soil till the soaked straw could not be seen.
3. Add water whenever it is too dry and add sand whenever it is too muddy.
4. Pour the mixture into the mould and compress it .
5. Flatten and shave off excess mixture. Remove mould

1. 根據師父的經驗，預備適當的已浸過的土，禾桿草和乾細砂。
2. 用機器攪拌桶子內的泥漿。
3. 用腳將其攪拌均勻。
4. 當混合物過乾時加水；當混合物過黏時加砂。
5. 達到適合的稠度後，把混合物倒進模具裡並用工具壓實泥磚。
6. 把泥磚的平面掃平和撥走多餘的混合物。
7. 一人用雙手拿起模具的對角，脫模。

ADVANTAGES 優點

1. Easy to control 容易控制泥團的稠度

ISADVANTAGES 缺點

1. Difficult to quantify when craftsman only judge the mixture by experience and feeling
2. Most trials that demold smoothly cracks due to high water content

1. 因為師父只以經驗和感覺添加材料，故此難以量化材料的比例。
2. 水份多能令泥磚順滑脫模，過多水份卻導致泥磚在風乾的過程中裂開。

REMARKS 備註

1. Soak the straw grass in termite medicine beforehand to prevent eat away of grass by insects to affect brick structure
2. Make sure the mud brick surface is smoothened without protrusion, or else it may affect stacking of brick wall

1. 禾稈草要提前用白蟻藥浸泡過，以防含草量較高的泥磚被蟻蟲侵蝕
2. 泥磚表面寧願凹陷也不要凸起，以免影響上層磚塊的堆疊

Adobe brick traditional practice

Demolition

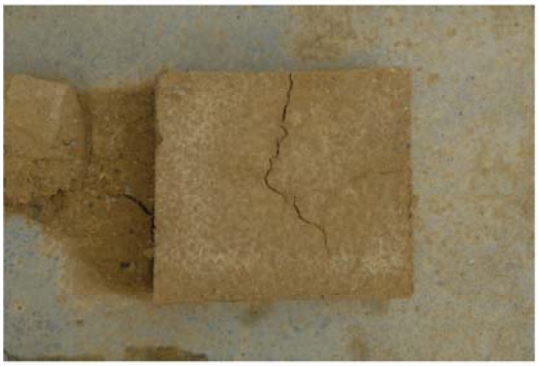
Preparation

Mixing

Making

10/7/2021: Fresh out of molds 剛脫模時的狀態

17/7/2021: After 7-days drying 七天風乾後的狀態



Trial 10

Trial 11

Adobe bricks' quality are difficult to controlled, due to its high water content: Problems like cracking and deformation occurred during trials.

Cracking due to:
- Clay absorbs and release water vigorously during the process, drawing out water excessively will pull soil particles apart and form cracks if there isn't sufficient fiber to hold the bricks together internally.

Deformation/ Collapsing/ Difficulty in getting out of mold due to:
- Adding too much water
- High humidity affects drying process

	Saturated soil	粗砂	幼砂	山泥(黏土)	老屋牆泥	+乾禾桿5g	+濕禾桿5g
Amount	3/5 桶	2.5 瓢	5 瓢	2 瓢	2 瓢		
Amount (cm3)	15543	6375	12750	5100	5100		
Ratio	3	1.25	2.5	1	1		
Simplified Ratio	12	5	10	4	4		

After trials and errors, it was found that mud bricks are less suitable for large scale wall construction in Mui Tsz Lam due to the following reasons:

- Labor intensive: Each mud brick needs human power to mix and press with foot. Removing the mold also require strength. More workers might be needed to hire to build an entire wall.

- Time consuming: Mud bricks are made one by one, at least 50 are needed to build a small wall. Mud bricks also need more time to dry before assembling to a wall.

- Inadequate space: Mud bricks need sheltered and well-ventilated space to dry. Mui Tsz Lam village does not have enough sheltered space at the moment, which make it difficult to implement.

- Soil properties not right: As seen from the trials, most of the bricks have cracks, meaning the clay content in the soil mixture is too high. Adjustments have to be made to create better brick.

	Rammed earth 夯土	Mud bricks 泥磚
Difficulty in making 製作難度	Lower, easier to control with lower water content and with help of machinery 難度較低；因其含水量較容易控制，而且大部分過程有機器輔助	Higher, difficult to obtain perfect recipe due to higher water content with fluctuating soil humidity 難度較高；因其高含水量較難控制，當天泥土濕度對製作影響頗大
Duration of pre-construction preparation 備料時間	2 days for soil mixture to settle 需時兩天燜土	More than one week for the bricks to dry 需要超過一周
Labour 勞動力	Less labour-intensive (machinery-dominant) 少許勞動力	More labour-intensive for handmade mud bricks (individual molding) (if continuous construction) 勞動密集
Construction area 場地需要	Only the site area 只在建築工地	Large vacant land required to dry bricks Temporary roofing required in case of bad weather 需要大片空地風乾磚頭和臨時屋頂避免惡劣天氣帶來的破壞

3.3 Rammed earth trials

After comparing mud bricks with rammed earth, we found that rammed earth is a more suitable technique than mud bricks to be applied in Mui Tsz Lam earth construction due to the following reasons:

Water Content Test of Rammed Earth - Trial 2 13/7 夯土的水分測試

To find the ideal water content with the best strength and adhesives 配合黏合劑,尋找最牢固的理想含水量度

Water added	8%	10%	12%	14%	16%
Volume (m x m x m)	100 x 100 x 100	100 x 100 x 100	100 x 100 x 100	100 x 100 x 100	100 x 100 x 100
Initial Weight (g)	1934	1856	1966	1940	1874
Weight 4 Days after (g)	1495 (-439)	1664 (-191)	1594 (-372)	1699 (-241)	1597 (-277)
Density lost (kg/m3)	13.96%	14.12%	13.58%	14.12%	14.78%
Observation	Light colour Depleted more severely	Light colour Depleted more severely	Light colour	Light colour	Light colour Hardened No clear depletion

Preparing sample cylinder for compression test
(The left sample was made with 1:1 soil-stone proportion while the right one has 1:2 soil-stone proportion.)

Compression test in HKUST

In order to build a wall in Mui Tsz Lam, strength is one of the biggest concerns, especially with only all natural ingredients (soil, sand, gravel) without any additional chemical (cement).

Hence, two sample rammed earth blocks were made with different soil proportion and was sent to the Civil and Environmental Engineering Lab in the Hong Kong University of Science and Technology for a compression test.

3.4 Adjustment in proportion

Since building the rammed earth wall requires mixture of soil and stone; Soil can be found extensively in Mui Tsz Lam with recycled old wall soil, while stone finding is a greater problem in Mui Tsz Lam. From the experiments and the grain size distribution curve, it is found that stone/gravel with 5cm or smaller are the optimal size. In Mui Tsz Lam, big stones can be found, however smaller size are very rare and sometimes hard to distinguish between small stone or scattered concrete block.

Hence, the project team bought a stone crushing machine and crushed the big rocks in Mui Tsz Lam to 5cm or smaller gravels, hoping to build the rammed earth wall. This requires a lot of labour to search for stones and transport them, as well as extremely time consuming.
Even though the proportion of soil: stone 1:2 has slightly better performance, we adopted the 1:1 proportion because of the lack of local stones and labour.

The test result for the compression test is:

	Soil: Stone – 1: 2	Soil: Stone – 1: 1
Final failure strength	1.193 mPa	1.097 mPa