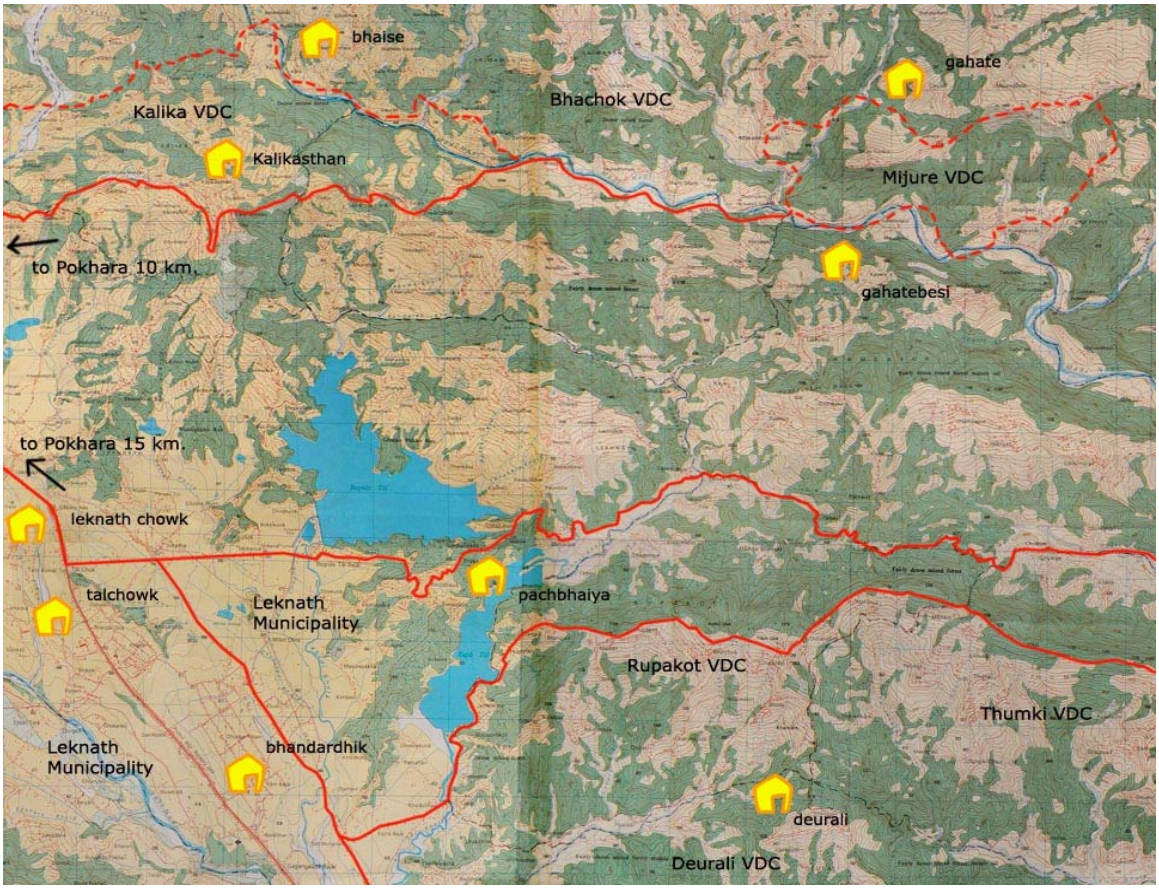
5. Soil Testing in Kaski District of Nepal

This chapter gives an overview of all the tested soil samples, which were taken from three different areas in Kaski District. Most have been tested quickly and on the spot, revealing an overall impression of the soil structure. Around 30 samples have been brought back to Pokhara where they have been examined more closely. These results are shown in the following paragraphs. The last paragraph gives some conclusions and recommendations for further research.

5.1 Taking Samples in Kaski District

At first, many soil samples were collected from the remote villages and hill areas where Smart Shelter Foundation was constructing earthquake resistant mountain schools. They are located in the Village Development Committees (sub-districts) of Deurali, Thumki, Rupakot, Kalika, Bhachok and Mijure. To have an idea about the distances; from Pokhara to the border of Thumki VDC is approximately 40 kilometers, which is 4 to 5 hours by bus over the steep and dusty mountain roads, or 6 to 8 hours of walking.



Before taking the mountain soil samples, we inquired in the villages where they collect the soil that they use for their construction purposes, such as the mud mortar in the stone walls. Usually it is taken directly from the building sites, in some cases it is collected from an excavation area that is locally well known for its ‘mato ramro’, meaning ‘beautiful soil’. The left picture on the next page shows an example.
In many cases samples had to be rejected, as they contained too much organic matter. People mostly live from farming activities and therefore classify agricultural land as ‘mato ramro’, which is understandable from their point of view.

Mountain soil on slopes, and especially soil adjacent to the mountain roads, generally has a very layered, but rocky texture. The outer surface of these walls is constantly exposed to the weather, making these rocks are quite soft and crumbly. These rocks may be in some state of erosion or transition phase between rock and soil. Such rocky soils have not been sampled and tested as they are unsuitable for making stabilized soil blocks.

The second batch of samples was taken from the area between the city and the mountain villages, better known as the plain area of Leknath Municipality. This former river bed and flooding area is very fertile and commonly used for agricultural practice. Recently, more and more land is being utilized for construction purposes. Samples were mostly taken from slopes next to rivers and former river beds, and from foundation trenches of newly built houses.

Thirdly, many samples have been examined which were taken from within and closely around the city of Pokhara. Here the soil turned out to be very hard and it contains a lot of big rocks and stones. I specifically looked at construction sites and the many drainage works that took place all over Pokhara. This saved me a lot of hard work of digging holes, and for our purpose it also makes sense to test soil at construction sites. This will give an idea whether soil blocks can be a good alternative for the common construction practice. The picture on the left is made at a typical building site and it shows that already at one feet deep, the soil becomes very rocky. The picture on the right shows a small landslide and confirms that many parts of the city area are built on rock ground with just a thin top layer of finer soil of about one or two feet thickness.

5.2 Test Results of Mountain Area Soils

The first impression of all mountain soils is, that the texture is very fine and that the samples hardly contain coarse particles. This could already be seen during the on-site sensitive tests, and the more precise sieving tests at home confirmed this, as can be seen in the schedule below.

location	depth	particle size %	classification	remarks
Deurali, Deurali VDC, +650	1 feet	10-15-50-25	clayey **silt**	
Deurali, Deurali VDC, +650	2 feet	10-15-45-30	clayey **silt**	
Gahate, Mijure VDC, +1100	on slope	5-25-20-50	**clay**	soft rock
Gahatebesi, Mijure VDC, +650	on slope	5-10-50-35	clayey **silt**	
Gahatebesi, Mijure VDC, +500	on slope	10-25-30-35	silty **clay**	soft rock
Kalikasthan, Kalika VDC, +1150	2 feet	5-20-40-35	clayey **silt**	soft rock
Bhaise, Kalika VDC, +750	2 feet	5-25-40-30	clayey **silt**	very fine sand
Pachbhaiya, Rupakot VDC, +650	2 feet	15-10-30-45	silty **clay**	soft rock
Pachbhaiya, Rupakot VDC, +750	2 feet	15-30-30-25	**silt**	soft rock

Generally we can say that the mountain soils are easy too excavate, especially away from slopes and roads. Needed for the most common earth techniques (adobe, stabilized blocks and rammed earth) is a ratio of coarse particles versus fine particles of around 70 to 30%. But after testing it appeared that the ratio of the mountain soils usually is the other way around; sometimes even 15% coarse versus 85% fines! So unfortunately the texture of most tested samples is too fine for our proposed techniques.

The fact that mountain soils are very fine can be seen in the direct surroundings as well. In the dry season the mountain roads are covered with a thick layer of dust, sometimes up to a feet thick. The sky can become very hazy and visibility is low when the wind blows these fine particles into the air.

What is also worrying, is that almost all samples contain pieces of soft rock. They look like stones and gravel, but certainly are not. Different types of rock have been identified, which on the outside all look very hard, but which can be crumbled easily by pressing them between the fingers. Of course the bigger pieces can be sieved out easily. But it will be very difficult, if not impossible, to sieve out the smaller but soft rocky particles. These particles are likely to have a negative effect on the quality of stabilized blocks, which may not achieve the necessary compression during pressing. Also they may be sensitive to breaking and to erosion of its surfaces.

These pictures show four different types of rock, which were found in the samples of Pachbhaiya. They could all be crumbled simply by hand.

5.3 Test Results of Plain Area Soils

The results of the tested samples in the plain area are similar to those from the mountain areas. Which is quite understandable, since a large part the plain area used to be a former river bank. Also it gets flooded during monsoon by water that comes from the mountains, bringing down enormous amounts of fine particles. The plain area is considered to be very fertile ground for agricultural purposes.

Many houses are currently been built on these former paddy fields, close to the highway between Kathmandu and Pokhara. This made it very easy to collect samples from the foundation trenches. Unfortunately many samples had to be rejected right away, as they contained too much organic matter, which was to be expected.

location	depth	particle size %	classification	remarks
Bhandardhik, Lekhnath, +550	3 feet	15-25-40-20	**silt**	very fine sand
Lekhnath Chowk, +700	1,5 feet	10-10-50-30	clayey **silt**	
Lekhnath Chowk, near river bank	on slope	5-15-50-30	clayey **silt**	
Talchowk, Lekhnath, +650 m	2 feet	2-13-55-30	clayey **silt**	
Seti River Bank, near Manipal	1 feet	1-59-35- 5	silty **sand**	organic matter

Some samples were also taken at the Seti river bank outside of Pokhara, because more sand was expected here. Which turned out to be correct, but the problem was that the soil is merely a thin layer of top soil directly situated on the bedrock, and it contained a large amount of organic matter. Also many soft but shiny particles were visual, which could be mica, see the left picture. It is impossible to make strong blocks when mica is present in the soil.

Similar as in the mountain areas, the tested soils are too fine to be utilized for compressed stabilized soil blocks. Also these samples contained a lot of soft stone particles, which may have a negative effect on the compression strength of the blocks. The right picture shows an example from Lekhnath Chowk, where the particles that look like gravel can easily be grinded to powder between the fingers.

5.4 Test Results of City Area Soils

In the city area of Pokhara the results of the samples was slightly different, but not much better than the samples from the mountains and the plain area. The soil in the Pokhara region is very rocky with a relative thin layer of top soil. Also the city area of Pokhara used to be agricultural land, so in many cases the top layer has mostly fine particles such as silt and clay, and it contains lots of organic matter.

location	depth	particle size %	classification	remarks
Simal Chowk, drainage 800+	4 feet	10-15-45-30	clayey **silt**	soft rock
Phoolbari, house construction 1A	1 feet	10-15-45-30	clayey **silt**	organic matter
Phoolbari, house construction 1B	2 feet	10-30-40-20	**silt**	soft rock
Phoolbari, house construction 2A	1 feet	5-10-35-50	silty **clay**	former agri land
Phoolbari, house construction 2B	2 feet	15-20-40-25	**silt**	soft rock
Basker school 1	1 feet	5-10-50-35	clayey **silt**	former agri land
Basker school 2	2 feet	10-15-35-40	silty **clay**	soft rock
Manipal House construction	2 feet	5-10-45-40	silty **clay**	mustard seeds
Manipal Biogas tank construction	5 feet	20-55-10-15	**sand**	soft rock

The high presence of rock means that it is difficult to dig in the ground, and many stones must be removed by sieving the earth. The ratio of stones versus soil is often more than 50%, so the yield of useable soil will be relatively low and labour costs will be high.

Some samples were taken from deeper, like 4 or 5 feet deep, and these contained more sand and gravel. After closer examination, the gravel again turned out to be soft rock that seems to be in a state of erosion and easily falls apart after applying a light pressure. Such as being the case for the mountain and plain area soils, the city soils will be difficult to use for stabilized compressed earth blocks.

The pictures below show a typical stone as found in many samples in the city, in this case in the city area named Phoolbari. Many houses are being constructed here recently, on former paddy rice fields.

5.5 Recommendations for Further Testing

The test results of all soils in the mountains, the plain area and in the city are not too hopeful as it comes to suitability for making compressed earth blocks. And that is a pity, as this technique is the easier one to make earthquake resistant; an absolute must given the high risk of earthquakes in Nepal! The soils are either too fine and silty, sometimes with quite an amount of organic matter. The organic soils should be rejected, and the fine soils must be complemented with large quantities of coarse sand, thus increasing the price of the method. On the other hand many soils are too rocky, usually containing soft rock pieces that look like gravel. These may affect the compressibility of the blocks negatively. But perhaps some of these soils can be used for making rammed earth or adobe blocks.

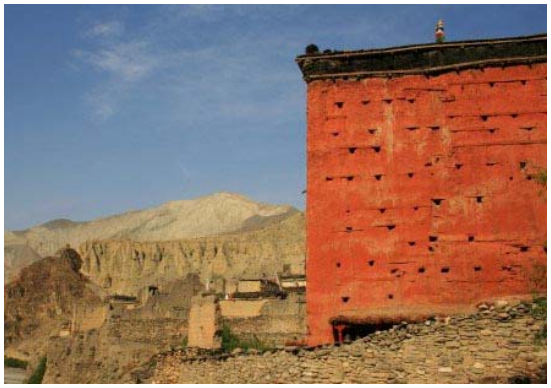
The first recommendation is regarding compressed soil blocks. What should be done is to purchase or find a block press and make a few test blocks with different mixtures. Soils can be used with and without the soft rock particles, and different ratios of sand can be added. After curing they need to be taken to a polytechnics or university, where they can be tested with a compression machine. Only then the actual behavior of the soil and the real strength of the blocks will be known.

There is a great possibility that the mountain soils, and the soils around Pokhara are unsuitable (or very difficult at the least) for making compressed blocks. Still, that does not mean that the technique cannot be used in Nepal at all. Sonam Wangchuk of SECMOL and Satprem Maïni of Auroville Earth Institute in India have built several earthquake resistant schools with compressed earth blocks in the Terai region. Their websites can be found in the bibliography. It has to be mentioned that the soil here was difficult to work with as well. Shown are 2 pictures of an earthquake resistant school made with CSEB in Bardiya.

And this is an example of a social housing project at Kanchanpur in the far west of Nepal, carried out by Shelter and Local Technology Development (SLTD) Centre in Kathmandu.

If the mountain soil indeed turns out to be unsuitable for pressing blocks, then it is worth to take a look at the other earth techniques. So the second recommendation is to explore the behavior of rammed earth for the rocky soils and adobe blocks for the finer soils.

Many castles, forts and monasteries which have been built with rammed earth can be found in different parts of the Himalaya. Some of them are already centuries old, but are still standing strong and many monasteries are still in use today. In Ladakh, the northern province of India, many fine examples can be seen in Leh, Shey and the historic site of Basgo. The picture on the left shows the Basgo Rabtan Lhartsekhar Castle. In Nepal many fine examples can be found in the Mustang region and on the Annapurna Circuit north of Pokhara, in the villages of Kagbeni, Jharkot and Muktinath, where the technology is still being practiced. The picture on the right shows the Kag Chode Thupten Samphel Ling monastery in Kagbeni, which was established over 500 years ago. An interesting website about historic rammed earth is listed in the bibliography.



The other technique of interest is adobe, where blocks are made by forming soil with simple moulds and then leave them to dry in the sun. This technique is especially suitable for the finer soils containing more clay and silt; soils up to 50% of clay particles can be used. A stabilizer may be needed, such as sand, straw or rice husk. At first a variety of different mixes should be prepared, in order to test which ratio of ingredients develops the least shrinking and cracking. The Nepali organization Abari is doing interesting work with adobe, and with rammed earth as well, as can be seen on the left picture. Their website is mentioned in the bibliography. The picture on the right shows a Nepali worker, who is making adobe bricks with a simple wooden mould. Please be aware that adobe blocks are relatively brittle and that it is not easy to make such structures earthquake resistant!

It is my belief that there are more than enough possibilities for earth construction techniques in Nepal, and everywhere in the world as well. So let's continue exploring this beautiful, cost-effective and eco-friendly material!

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Historic Rammed Earth: www.historicrammedearth.co.uk.

Abari Nepal: www.abari.org