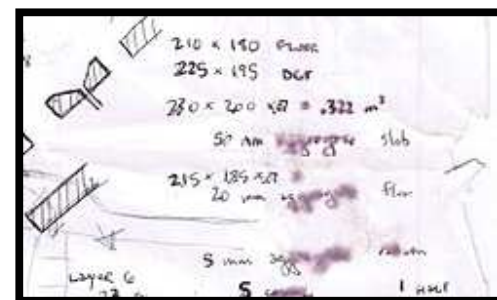




## A Dry Composting Toilet Design-Build Venture in Yunnan, China



Liberal Arts and Engineering Studies  
California Polytechnic State University, San Luis Obispo  
June 2011

# The Toilet Paper

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# Friendly E-mail to Senior Project

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In September 2008, I took a brief trip to Thailand to visit Geoffrey Wheeler and the Center for Vocational Building Technology (CVBT). I was traveling with Engineers Without Borders (EWB) to learn about CVBT's Interlocking Compressed Earth Block (ICEB) technology. We observed the production process at the center, began constructing an ICEB house, and designed a dry composting toilet (DCT).

## Friendly E-mail

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March 23, 2011

Hi Geoffrey!

How are you? And how's everything at CVBT? I just wanted to send you an email because I've been thinking about taking a short trip out to Thailand! It's all kind of up in the air, and it's still just an idea at this point, but I wanted to see if you'd be around in late April, so I could pay you a visit! Are you still working with Cal Poly EWB and Mechanical Engineering students?

At this point, I'm wrapping up my time at Cal Poly, and I'm thinking of incorporating my trip to Thailand as a sort of senior project. I'm finishing up a sort of hybrid degree in engineering and international development, and I thought it might make for a nice project to sort of tour around and do some case studies on different organizations working in development.

My original senior project plans sort of fell through, so now I'm just trying to figure out something that I can finish in the next two months and enjoy! If you have any thoughts or ideas, I would love to hear them, or if there is any way that I could act as a liaison between you and Cal Poly, if indeed you are still working with ME students or EWB, I might be interested in helping out in that capacity too. Anyway, it's all up in the air at this point, and I'm open to ideas!

Deb Go

PS How do you know Grace and Cody Neslen?

## Casual Invitation

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March 24, 2011

Dear Deb,

Just a short note: right now I'm in China. I'll be returning home to Thailand on April 19 or 20. I'd love to work with you on a senior project. I still do work with Cal Poly students and am looking forward to connect with the students coming to Thailand on their spring term.

I have a lot of ideas for senior projects. Please give me a better idea about the hybrid degree you've been working on. It seems to me you were focused on civil engineering. I have ideas in many fields. International development and engineering - that's where I've ended up.

Would you be interested in doing some more work on dry composting toilets? Appropriate technology? A technology intervention case study? Technology transfer in local languages?

I know Grace and Cody because someone told me about Grace's senior project; compressed earth blocks. I tracked her down and started corresponding about our work. She was supposed to be with me here in China. It would be great to have her here now because all my interpreters have left. I'm picking up Mandarin and Jinpaw - slowly. Grace is still doing very important support work for us. Please ask her more about what I'm up to.

OK, got to sleep, I'm helping more villagers tomorrow to learn about stabilized earth blocks. You are also welcome to come and help - do you know any Chinese??

Peace and papayas,

Geoffrey

## Wild Excitement Disguised As Moderate Interest

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March 24, 2011

Geoffrey,

I'd love to join you! Unfortunately, I know very little Mandarin, though I have always wanted to learn. If you were in Fujian, I might be of more help.

I'm slowly focusing in on the water, sanitation, and hygiene area of development. Ideally, I'd love to get hands on experience creating and managing water and sanitation solutions in a community, but I don't even really know what that would look like. What do you mean by technology intervention and technology transfer?

Do you plan on building a pilot DCT while you're out there or on a separate occasion? I've actually been thinking lately that working in some of the remote areas of China may be in my future, and I'd love to travel there and check it out.

I'm very familiar with appropriate technology, in part because of the time I spent with you in Thailand as well as one of my professors, Dr. Schwartz, who heads up a series of appropriate technology classes at Poly. I have also been in contact with him to see if he has any ideas for a senior project.

Dry composting toilets, compact sand filters, and gray water use all sound interesting to me. How compact is your compact sand filter design? Sand filters have always fascinated me, and they were the first appropriate technology to catch my attention.

Honestly, I'm a little averse to toilets (naturally, I think), but I would love to hear how your work with them has progressed since my last visit. How did the toilet turn out at Huan Yu Yen? I would especially love to learn about how to go about intervening with a technology like DCTs.

Deb

## Brainstorming

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March 25, 2011

Dear Deb,

I do not plan to do a DCT during my time here. The villagers are building a pilot building and then they have a larger building they're planning to do. We don't have the human resources to do it right away, the most important one being a supervisor. The DCT will come later.

It might work for you to come out now and continue to stay after I left. I doubt that it would suit your senior project needs though.

For a rough evaluation of our intervention and more info on appropriate DCT interventions please read <http://www.cvbt-web.org/uploads/Pubs/EMMAS%20ISx.pdf> an intervention study by Emma Scott. I think that the DCT would be a big improvement to the open latrines here. I think the housewives would love them. The implementation needs to be done a bit more carefully than our first try in Thailand. Thailand needs them too and we'd like to develop some material for doing them there.

There is one other project that needs finishing here: putting our ICEB production and construction manuals into the local languages of Thai, Lao and Khmer. We already have them somewhat in Indonesian and even a little bit in Chinese. This just needs some coordination and a little creativity. There is also an opportunity to set-up a network of producers in these countries.

I'd be happy to talk with you on Skype sometime.

OK, I've got a house design to finish for the villagers, got to go.

Courage and coriander,

Geoffrey

## Dogged Pursuit of a Project in China

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March 25, 2011

Geoffrey,

My senior project needs are actually quite flexible. As my advisor put it, "the Sr. Project can be anything from a long research report, to a short-term project, to a software creation, to a short film. We're pretty open about what you do, just as long as it is something tied in with your studies and that it creates something of a decent quality that might also help you secure some employment after leaving Cal Poly." So I might as well at least look into traveling out there and see how it goes. What is your nearest airport?

And of course, dry composting toilet and sand filter work interests me as well. Talking over Skype would be great.

Deb



## Senior Project

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March 26, 2011

Dear Deb,

I was thinking about your international development interests. The need for DCTs is very great. Recently I received a report about a major funder for community development. Their report showed they funded a lot for sanitation and hygiene. I contacted them to see what they'd done with DCTs. Nothing, no pilot projects or funding for research. It seems they felt they were unacceptable because it would take some extra time and care to introduce them.

If you wanted to do a project with a little more impact you could design and implement one intervention; do some preliminary evaluations and report on them. At the same time (or with a partner or two) you could see if any major sanitation/hygiene funders were doing anything with DCTs and formulate a strategy to encourage them to fund pilot interventions and research. The only major funder I know of doing things right now is GTI. But it would be neat to see DCTs implemented by World Vision, Habitat for Humanity or the Global Environmental Facility (a department in the UN).

Persistence and persimmons,

Geoffrey

# Makings of a Beautiful Project

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To say the project was impulsive would be an understatement. But that isn't to say it wasn't the perfect opportunity. All the pieces came together so beautifully; I couldn't say no.

## Nong Hom and Newfangled Toilets

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Nong Hom is a small sugarcane-harvesting village in southern China near the Burmese border. It is located between the towns of Zhangfeng (10 km southwest) and Jinghan (5 km northeast) in Longchuan County, Dehong Prefecture, Yunnan. Seng Hkum, two of his younger brothers, Madu and Janoe, and a few men from nearby villages had gathered to learn how to manufacture and use ICEBs from Geoffrey. When Geoffrey discussed the idea of a dry composting toilet with Seng Hkum and his wife, Mary, they said they would like one.



A composting toilet is a toilet in which human waste collects, composts, and is reused as fertilizer. Use of such toilets reduces contamination of water and food sources, conserves water and energy, and reuses what would otherwise be waste.

A urine-diverting or dry composting toilet is a composting toilet in which the urine and feces are channeled away separately upon release. The urine, diluted with water, can safely be used to water and enrich plant-bearing soil. Diverting the urine aids in safe and successful composting by reducing the nitrogen content and odor in the composting chamber.

## How to Use the Toilet

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Remove the lid from the active chamber. Men and women should use the same chamber for each 9 month rotation.



Squat over the channel, defecate into the chamber hole, and urinate into the sloping channel.



Throw toilet paper in the composting chamber.



Cover feces with sawdust, ash, leaves, or weeds. Flush the urine channel with water. Do not pour water in the composting chamber.



Replace the lid over the chamber hole.



## How to Use the Waste

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Place a thick layer of organic materials such as sawdust, weeds, straw, grass, and brush in the composting chambers before beginning use to aid in the decomposition process. These carbon-based, bulk materials balance the high nitrogen content of feces and create space for oxygen to flow. Composting accelerates and increases in temperature when the composting chamber maintains a carbon to nitrogen ratio of approximately 30:1 and is exposed to plenty of oxygen.

After completely filling one chamber, cover the hole and begin using the second chamber. Wait at least 9 to 10 months after the last defecation before using the first chamber's compost. Potentially harmful pathogens will die off with both heat and time during the composting process, so the longer a full chamber is left to compost, the better. Each chamber should be designed to hold at least 9 to 10 months of waste for the family.

Dilute urine at a water to urine ratio of roughly 9:1 before applying to plants.



## When Needs and Wants Meet

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The current toilets in Nong Hom are essentially enclosures for open defecation. Geoffrey described Seng Hkum and Mary's toilet as a small room with a rectangular hole in the floor adjacent to the back wall. The hole slopes down toward the rear of the toilet, where waste collects in an open pool of sludge. Seng Hkum's younger brother, Madu, uses a toilet that is little more than an area of the earth sectioned off by a few makeshift walls (shown below to the left).

Not only did Seng Hkum and Mary need a new toilet, the couple told Geoffrey they *wanted* a new toilet. I couldn't say no. It isn't every day that development workers see a need that the developing community has also made a priority. Because of this, many development efforts fail because development workers make assumptions and provide for needs that the community doesn't completely agree upon and the new technology is abandoned. Even in our modern American society, no one feels any obligation to maintain, let alone use, a gift they never wanted in the first place.





## The Relationship: Geoffrey

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When I contacted Geoffrey, he had already been in Nong Hom for almost two months (since the beginning of February). Even without a working knowledge of Mandarin or Jinpaw, the local dialect, he had become part of the family there. With this bond already established, the potential for a successful project increased. I would be more likely to get genuine feedback on my design and a finished product with which Seng Hkum, Mary and I were all satisfied.



## The Language: Grace

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One glitch in my plan was that neither Geoffrey nor I spoke Mandarin, and hardly anyone in Nong Hom speaks English. However, Geoffrey and I happened to discover that we have a mutual friend amidst our rapid-fire e-mails. Grace Neslen and I had both hung around a similar friend group at Cal Poly, and she had also done the structural engineering for Geoffrey's ICEB construction project in China.

Furthermore, she had originally intended to travel to Nong Hom with Geoffrey in February but got sick right before her departure and could not go. Afterward, she and her husband, Cody, decided it wouldn't be wise for her to travel there alone. She speaks Mandarin and had already obtained her visa and immunizations, but she needed a travel buddy. I, too, needed a travel buddy, preferably one that speaks Mandarin. It was a perfect match.







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Open Defecation to Dry Composting Toilet

## Tour de Toilets

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As we made our way from urban Guangzhou to rural Nong Hom, the toilets became increasingly more rustic. The toilets were no longer the flushing, ceramic, squat toilets set into the bathroom floor that we used in the airport but rather simple holes in a concrete floor or a dedicated patch of dirt.

Out of all the people I spoke with in Nong Hom, no one would admit to liking their toilet. I suppose a tell-tale sign of an affluent culture is a group of people who like the fixture in which they defecate. In this area of rural China, the style of toilets is simply what they know how to build. From their perspective, the toilets smell and feel dirty, and from my perspective, the open toilets are likely leading to contamination of their food and water sources.





## Something I Learned About Mary

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I had an extended discussion with Mary. We covered everything from what she likes and dislikes about her current toilet, what she would like in her new toilet, where she would like her new toilet, and how the new toilet would work.

I pried for information on cultural acceptability and personal taste, trying to uncover any hesitation or hint that a dry composting toilet was something I wanted more than Mary did. Many an effort to improve sanitation has been tried before and failed, but as long as Mary and I understood each other completely, I trusted we would succeed. After a while we did reach a point of mutual understanding, and Mary decided she didn't really want a dry composting toilet.

It had actually been proposed to me multiple times since I arrived (and even before I had arrived) that Madu really wanted a dry composting toilet as well. It was presented as more of a suggestion, based on uninformed optimism that we could pump out two new toilets in less than two weeks. In retrospect, those suggestions may have been subtle hints that I should design a toilet for Madu and his wife, Mabau, rather than Seng Hkum and Mary

Madu's toilet was in worse shape than Mary's. While Mary had a concrete channel toilet, Madu simply had a small, semi-private enclosure for open defecation.

## Talking Toilets with Madu

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Many homes in Nong Hom, including Mary's home, have separate bathrooms for men and women, but I hadn't anticipated that Madu would insist on separate bathrooms for his new toilet.

**The fear of being walked-in on by someone of the opposite sex.** This is a legitimate fear that even Americans hold in public, gender-specific restrooms that, unlike toilets in Nong Hom, have locking bathroom doors. Whenever I was using Mary's toilet and heard footsteps outside, I found comfort in knowing if someone pulled back the woven sheet of plastic covering the doorway, that someone would be one of the ladies.

**The embarrassment of sharing a toilet with the opposite sex.** With non-flushing toilets, when a woman is menstruating or has diarrhea, it's no secret, and it is a little embarrassing.

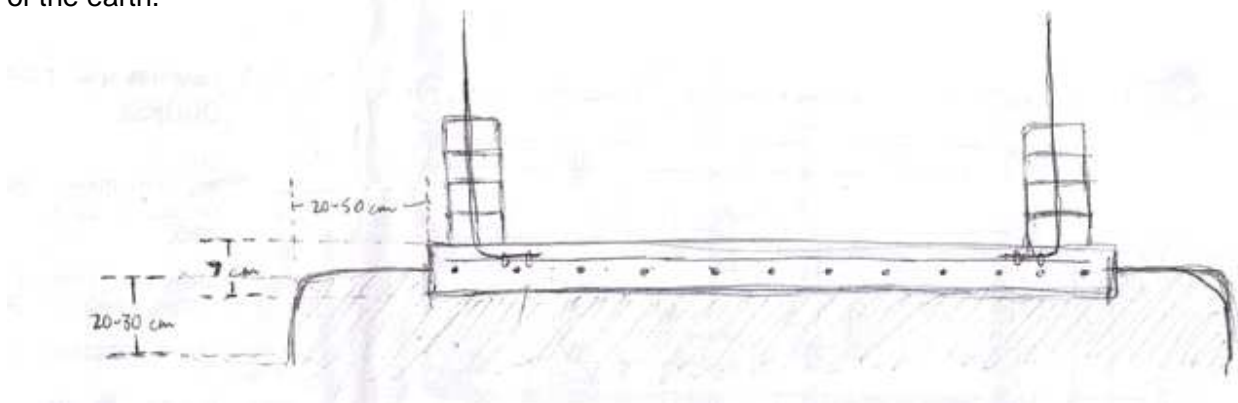
**The repercussions of open defecation.** Madu reminded me that in a region plagued by contaminated food and water sources, diarrhea prevails. An extra toilet allows others to use the restroom when one family member needs the toilet for an extended period of time.

## Recipe for a Dry Composting Toilet

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**Build up the earth** on which you plan to construct the toilet. This reduces the risk of the chambers flooding during heavy rains and spreading contaminants in the area surrounding the toilet. Build up roughly 20 cm of soil on an area the size of the anticipated slab with an additional 20 cm on each side. Be sure to wet the soil and pack it back down before beginning construction to prevent uneven settling of the earth.







**Prepare the formwork for the base slab.** Set your formwork to create a 2.3 m long by 2 m wide by 10 cm thick slab. Measure the diagonals to ensure the corners are square. Line the inside of your formwork with a plastic sheet to prevent leaching from the compost chambers to the earth. Weave a net out of 2 cm wide strips of bamboo, leaving about 20 cm between strips, to place inside your formwork and on top of the plastic layer for reinforcement.



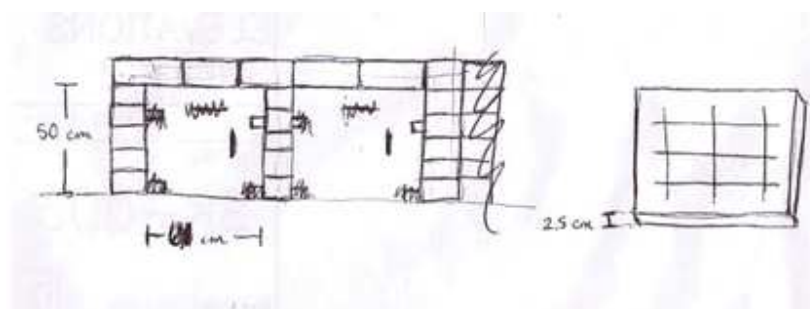
**Prepare vertical rebam** (bamboo reinforcement) by heating and bending additional 2 cm wide strips of bamboo, 20 cm longer than the height of the toilet, bending the excess 20 cm to create a perpendicular foot for the vertical rebam. Tie the foot into the bamboo net to secure the vertical reinforcement. The vertical rebam should be placed in each corner of the slab, where any walls intersect, and on each side of any doorways, including the chamber doorways. Carefully center each piece of vertical rebam 10 cm from any slab edge to ensure the rebam clears the reinforcement holes in the ICEBs.





**Mix and pour the base slab.** Wait for the concrete to set.

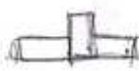
**Pour the chamber doors and lids** while waiting for the concrete to set. The two chamber doors are each 50 cm tall by 64 cm wide by 2 cm thick and reinforced with a small bamboo net. Each door also has a rebar handle tied into the bamboo net. The chamber lids are 24 cm square by 2 cm thick, are not reinforced, and have a rebar handle.





**Set and mortar the first layer** of blocks onto the base slab. The footprint of the toilet measures 2.25 m by 1.95 m. The two chambers run lengthwise and are sized to hold an estimated 10 months worth of feces for Madu's family. Where the chamber dividing wall intersects the outer wall, follow the cobra pattern shown below. Build 5 layers of the outer walls and chamber dividing wall, leaving openings for the chamber doors, ventilation pipes, and urine diverting pipe.

COBRA



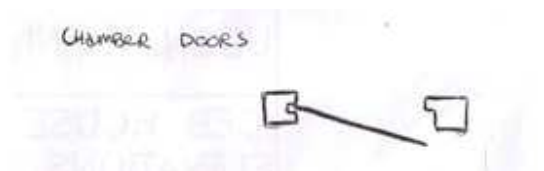
**Place PVC piping** for urine diversion and ventilation. The urine piping should extend the length of the bathroom along the chamber dividing wall. Two vertical pipes, one from each bathroom, feed into the main horizontal pipe which carries the urine to a collection container outside the bathroom. The ventilation pipe for each chamber acts as an outlet for odors, flies, and other insects. Each pipe should be outfitted with a drooping section of a mosquito net to catch escaping insects and prevent other insects from entering.







**Chisel out door jambs** for the chamber doors. ICEBs have grooves on each end that are 2 cm wide by 2 cm deep by the height of the block. These are the same holes that are filled in with grout at each channel block layer. With a little machete work, these grooves provide perfect seating for the chamber doors.



**Secure piping** by chiseling blocks and filling gaps with mortar. Also use mortar to create lips on the inside top and bottom of the chamber door openings to block off any gaps between the door and wall.





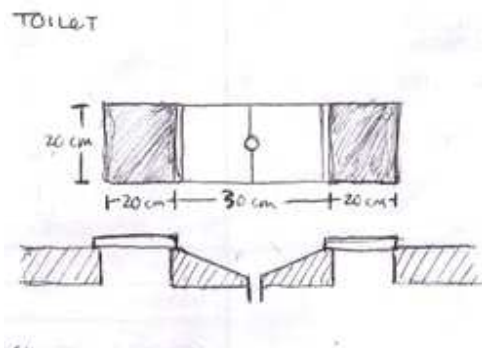
**Lay channel blocks** as the sixth layer, bridging the gaps for the chamber doors. Fill the small rectangular holes in the ICEBs with grout, bend and lay 8 mm rebar in the channels, and fill the channels with grout.

**Prepare the formwork for the floor slab.** Cut holes in the bottom of the formwork to accommodate the urine diverting pipes and box off holes in the floor for defecating into the chambers. Each chamber hole is located about 40 cm from the center of the urine drainage pipe. Create a rebar net using 8 mm rebar, set 20 cm apart, and tied together with steel ties.





**Pour the floor slab and shape the toilets.** The toilets in the male and female bathrooms are identical. Each toilet is composed of two holes (one hole opening to each compost chamber) connected by a urine channel that slopes in toward a urine diverting pipe. The chamber holes for each toilet are 20 cm square surrounded by a raised lip to keep water out. The toilet is similar in style to a typical Nong Hom concrete channel toilet to maintain ease and comfort of use.



**Set and mortar the next layer** of blocks onto the floor slab. Continue building the outer walls and bathroom dividing wall, leaving openings for the bathroom doors. Lay channel blocks at least every 10 layers, following the same procedure as the sixth layer.





**Leave the rest to Madu.** We reached the 20<sup>th</sup> of 27 layers, and it was time for Grace and I to head home. Having already finished the toilet floor, I really had little left to offer Madu and his family. The rest of the toilet was basic ICEB construction, and Madu had both the construction skills and the perfectionist mindset to complete the remainder of the bathroom beautifully.



Madu finished the walls, added stairs and a roof, put buckets of ash in both rooms, and covered the women's doorway with a woven plastic sheet. He indicated he felt that doors are not necessary. Madu also put bricks for feet indicators and to show which chamber is in use. The bricks also elevate the posterior to avoid coming in contact with the chamber lips while defecating.



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## Wrapping Up



## The Interview

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I was fortunate enough to have Geoffrey conduct the follow-up interviews after I had left and the toilet had been used daily for about 2 weeks. Geoffrey interviewed Madu, Mabau, and their 7 year old daughter Jasan through a translator, Thomas, on May 16<sup>th</sup>, 2011. Not only did the interview provide me with important feedback, it also allowed Geoffrey to remind the family about required maintenance procedures and help them troubleshoot any unanticipated problems.



### **Why did you want a new toilet?**

Mabau asked Madu for a new one many times. The old toilet looked dirty and smelled. But especially it was dirty. Madu wanted a better and special one from Geoffrey. He's glad he can now build one himself.

### **What do you like about your new toilet?**

It is clean, special, and has no smell. The old toilet smelled both from feces and urine. The new toilet only smells from urine.

### **How do you feel about having separate holes for the urine and feces?**

No problem. Jasan likes it and can use it easily straddling the poop hole and letting the urine go down the other hole. She used the dormant poop chamber hole and Madu is going to mortar it shut until it is time to use it.

### **How do you feel about using bamboo as reinforcement?**

Madu is happy to use the bamboo but finds rebar more convenient. "Bamboo is okay if we're short of money."

### **Do you think Seng Hkum will want one for his house?**

Thomas likes it and would like one but thinks it is expensive. Madu thinks it is not expensive.

### **If you were to build another toilet, what would you do differently?**

Madu forgot to put lips on the chamber lids to better seal the chamber holes. He also used pipes that were too big. He thinks smaller pipes would reduce odor.



## Knowing Language Lessons from Grace

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There was a point in time when I thought I would have been perfectly capable of traveling to Nong Hom and working on this toilet independently. I couldn't have been more wrong. Set aside, for a moment, concerns for the safety of a young woman traveling alone in a foreign country. What hindered me most was my inability to speak the language.

It wasn't long after landing in Guangzhou that I realized I would have trouble making it through the airport, let alone making it across China, without Grace. And, as if basic directions and instructions weren't difficult enough, I still needed to communicate construction, engineering, and toilet ideas if and when I arrived in Nong Hom. On top of all of that, tack on the importance of discussing not only how but also why this strange toilet is what it is. Needless to say, I left China inspired to learn Mandarin.





## **Taking Ownership**

### **Lessons from Madu**

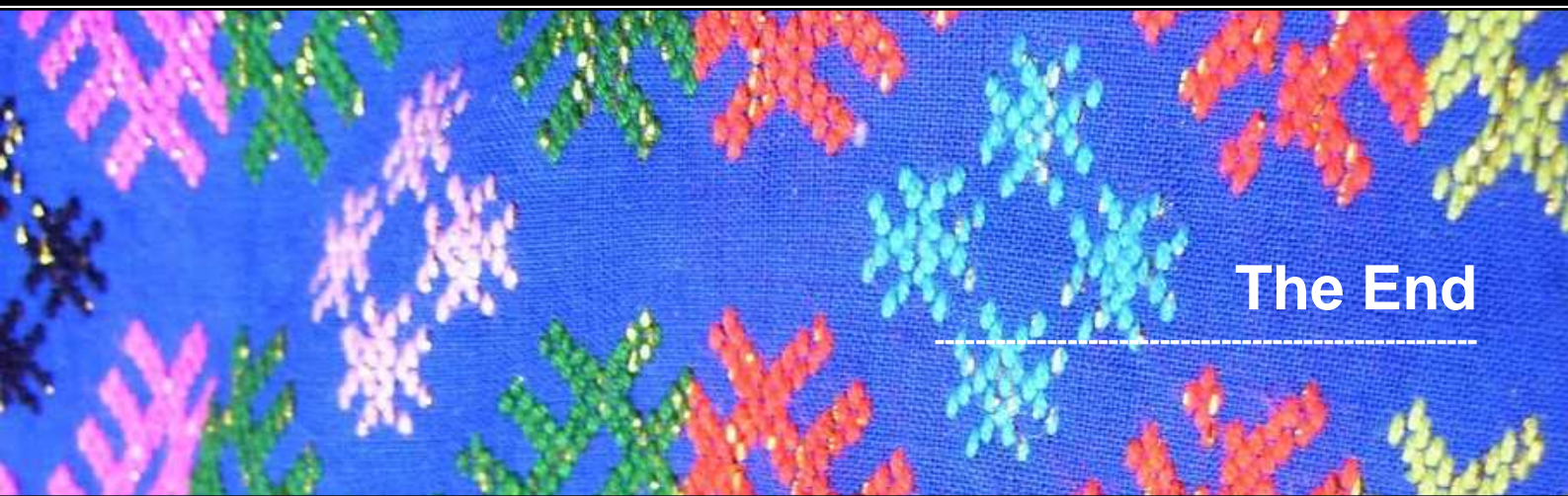
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One hard-and-fast development rule is that the community must take ownership of the project. In Nong Hom, I saw that principle in action. Madu clearly wanted this toilet, as I heard many times even when I was planning on designing the toilet for Seng Hkum. It was Madu that was initiating the work, learning the ins and outs of the design, purchasing materials. He was thoroughly committed to and invested in this toilet. This was his project.

Although he had taken complete ownership, Madu remained humble. I had thought that developing communities generally resent foreigners, and rightfully so, for coming in and telling them what to do as if we always know better. So I played the consultant and deferred to Madu on many decisions, maintaining the mindset that when it comes to local construction methods, the older, wiser locals know best. But Madu, understanding there is oftentimes an optimal course of action, would simply turn around and ask me to tell him the best route and to be assertive about it.

Though Madu's knowledge of local construction far exceeded mine, he still recognized the value in learning how to construct, use, and maintain this newfangled dry composting toilet. By acting in humility, we were able to learn from each other and continue to propagate that knowledge within our own spheres of influence.





The End