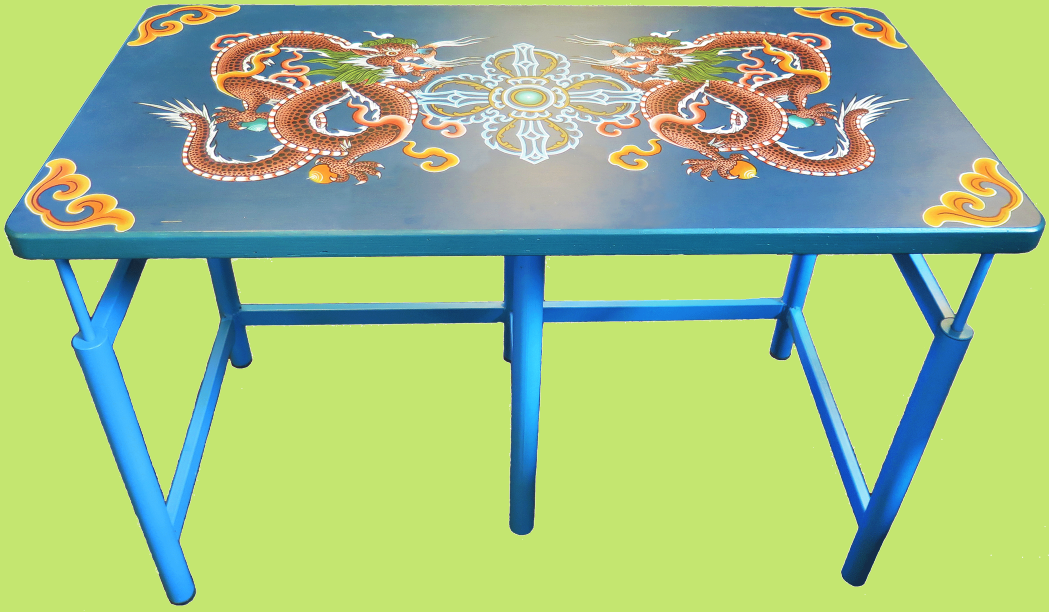
Made in Bhutan

The Earthquake Desk



GeoHazards International

“Collaboration at its best” – Ido Bruno

On a cold and overcast day in January 2016, Ido Bruno, an Israeli industrial design professor, and his former student Arthur Brutter arrived in Bhutan with a mission and a vision. They carried with them the design and specifications of the award-winning Earthquake Desk. Unlike a typical wooden school desk, this safety equipment can shelter two children when heavy debris falls during a big earthquake.

Awaiting their visit in Phuntsholing, Bhutan’s fledgling industrial center, a diverse group of welders, carpenters, engineers, furniture proprietors and government officials were gathered for the week to participate in a project conceived and coordinated by GeoHazards International. Their shared goal was to produce the Earthquake Desk in Bhutan. If everything came together at the end of the training, 14 desks would be produced and distributed as samples to the manufacturers and the Ministry of Education.

Ido and Arthur had their work cut out for them. The pilot project would test whether Bhutanese furniture manufacturers could accurately produce the Earthquake Desk at a price affordable to the Royal Government of Bhutan Ministry of Education (MoE). If so, the MoE would consider installing Earthquake Desks in its most vulnerable schools. Bhutan plans to upgrade all of its vulnerable schools, but this will take money and time. The desk would be a local solution, ready to protect children from dangerous conditions, should a great earthquake occur in the meantime.

Starting slowly and quickly gaining momentum, Ido and Arthur felt a significant change in atmosphere over the course of the training. The diverse participants became a team dedicated to creating lifesaving solutions for schoolchildren. They learned how and why to use jigs, a method that ensures accurate production of welded metal parts. The skilled craftsmen also contributed to an improved design of the tabletop in this “Made in Bhutan” collaboration.

The team saw the value in presenting a crush test to the manufacturing company proprietors and district officials. They mobilized resources, including a crane, a massive bag, and a collection of concrete chunks that totaled 422 kg. They dropped this assembled weight on top of a Made in Bhutan Earthquake Desk, and they dropped a lesser weight on a standard Bhutan school desk. The much-anticipated event had a dramatic and instructive finale.

You can watch this story, filled with hope and enthusiasm, unfold in the following pages. We hope to repeat it in many other countries, because millions of children attend schools worldwide that will be severely damaged in an earthquake. Wouldn’t you want them to have Earthquake Desks for protection?

--GeoHazards International, June 2016

For more information go to: www.geohaz.org

This journal and the pilot project that it documents were made possible by the generous support of AIR Worldwide, a Verisk Analytics Company.

Avner Shachar, CEO of AD Meraz, granted use of the Earthquake Desk design patent as a gift to the children of Bhutan.

Staples and Jattu Wood Industry, H&K Company, Namgay Wood Industry, Karma Steel and Wood Industry, and Chima Wood Industry were responsible for producing the first Made in Bhutan Earthquake Desks.

Karma Doma Tshering and Sonam Tenzin, of GeoHazards International in Bhutan, shepherded this project to life.

Ido Bruno and Arthur Brutter developed and conducted the hands-on training program for carpenters and welders in Bhutan. Ido supervised the Earthquake Desk design, manufacture, and testing. He is a professor of industrial design at Bezalel Academy of Art and Design, Israel, a member of the Relevant Design for Disaster (RDFD) research group, and principal of IDBruno Industrial Design. Arthur, a product designer based in Israel, designed the Earthquake Desk in collaboration with Ido. Originally called the “Earthquake Proof Table,” it won several design awards.

GeoHazards International (GHI) coordinated participation of the Bhutan manufacturers, Bhutan Ministry of Education (MoE), engineers in the MoE Schools Planning and Building Division, the designers, and the Israeli manufacturer that owns the design patent. GHI’s mission is to end preventable death and suffering from natural disasters in the world’s most vulnerable communities. GHI’s strategies focus on preparedness, mitigation, and building local technical capacities. Since 1991, the nonprofit organization has promoted strategies to reduce earthquake, tsunami and landslide risk in more than 40 countries. GHI has offices in Thimphu, Bhutan; Delhi, India; Cap Haitien, Haiti, and California, USA.

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Editing by Blake Hallanan and Julie Jomo of GeoHazards International

Learning to Make the Earthquake Desk:
Notes From Bhutan
by Ido Bruno
January 25–31, 2016

► Day 1: January 25

Day one was dedicated to making the initial visit to the training site, the Staples and Jattu furniture manufacturing company in Phuentsholing, Bhutan. The project team met with the Staples and Jattu proprietor and company supervisor, and with Engineers Diwaker and Lalit from Bhutan's Schools Planning and Building Division (SPBD).

The project team introduced themselves and also provided background on the project and the 'story' behind the Earthquake Desk. Brief presentations on the training schedule and the training presentations (to be shown to participants on the first day of training) were made for any feedback/ inputs.

The team assessed training space, equipment, tools and materials on site as well as those procured for the training. Space was adequate, as Staples and Jattu had assigned the welding area, one carpentry area, and the conference room for the training.

Thoughts after Day 1

The proprietors and staff of Jattu and Staples were very cooperative and exhibited a willingness to learn and collaborate. It is clear that there is a genuine passion for development and learning of new methods and products. It is also clear that the family experience in the furniture industry, established in the 1960's by Tandin Bidha's father, gives them a perspective on the time it takes to incorporate new processes. A few possible training scenarios were elaborated in order to try and foresee problems and suggest planned remedies.

Initial assessments of factory space, equipment and tools:

The factory is spacious, very orderly and very clean. It is clear that a lot of emphasis is given to proper work processes. This is very important to the success of the project and raises hopes for a successful training session.

The factory contains many types of workspaces and professional workers needed to create complete wooden and steel furniture. These include all stages from receiving raw wooden logs from the forest up to painting/varnishing, upholstery and packing. It seems to be a reaction to the unavailability or economical downside of outsourcing.

Some challenges:

The general method of furniture fabrication in Bhutan is non-industrialized. This means that products are made on a part-by-part basis rather than by serially producing a number of identical parts at one time. This is a meaningful difference.

The metalworking tools are not up to standard. For example: the metal saw is a very basic disc saw that is difficult to adjust to precision. The drill press's main shaft is askew, and the chuck is not large enough to handle the relevant drill bits. For all practical purposes it is useless for the job. The welding machines are OK, but a MIG welder would greatly improve the speed and quality of the welding.

Initial assessment of materials:

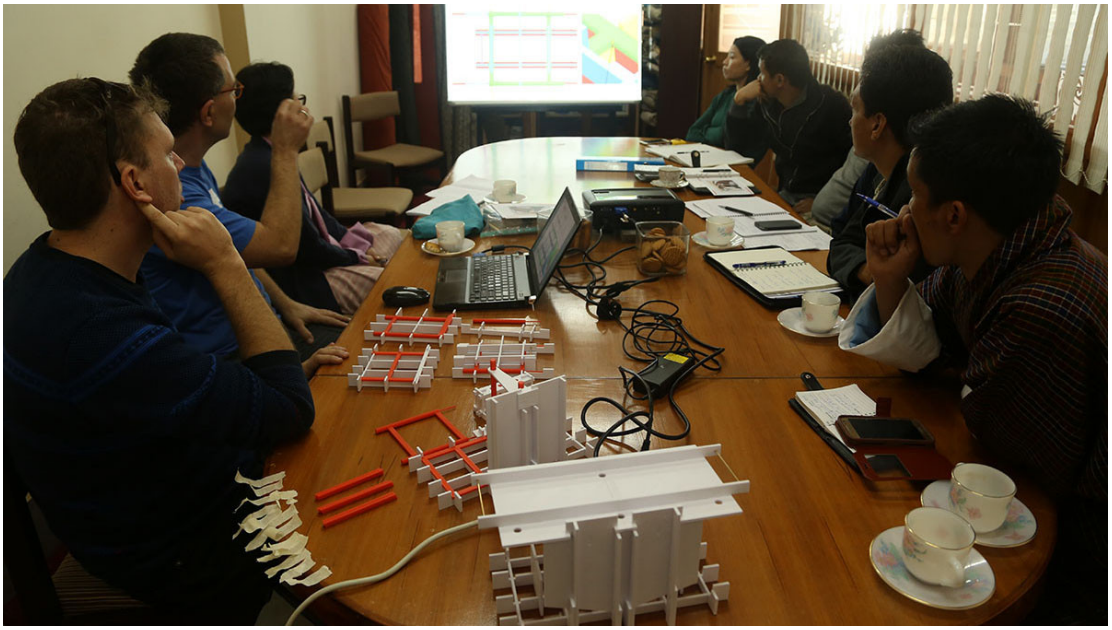
Turned leg discs and rods were pre-ordered for the training from Kolkata, India. They are of good quality. The rod diameter is 14.2mm rather than the predefined 13mm. This is OK for the functioning of the desk, but the plans will need to be altered. The local plywood seems to be of excellent quality, but at 19mm is thicker than expected. Very good for the quality of the desk, but again, requires alteration of the complete set of jig drawings and all plywood table parts.

Staples' proprietor suggested we make one set of welding jigs only. This comes as a reaction to what initially looks like an overwhelming amount of work on the jigs. We had planned to make one jig set for each participating manufacturing company, but making one set will require less time and effort and require all carpenters to collaborate. Suggestion accepted. This turned out to be a good move. One set was sufficient for creating 14 desks and allowed concentration of effort to make working jigs that were created relatively fast and passed on to the welders for their part.

The jigs hold parts precisely in place for welding. They ensure consistency and quality in production, so that the finished desks meet the design specifications.

After assessment of tools and materials, we understand the adaptations needed not only to the plans and drawings, but also to the itinerary of the training and the general timetable. Due to flight delays, the training will begin two full work days later than initially planned. It seems that this too supports the notion of making one set of jigs for all participants rather than one set for each of the 5 participating manufacturers.

The option to import pre-cut jig parts from India or China was discussed but not followed. Imported jig parts would be laser cut, delivered flat, and assembled at the factory in Bhutan. This was probably a thought that came before the full understanding of the work process with the jigs. After the first jig set is made, Staples and Jattu's proprietor requests SPBD to put the manufacturing and work with the jigs as a prerequisite for all manufacturers wanting to be certified to make the Earthquake Desks. He explains this will protect the special effort it takes to create a full set of working jigs.



Overview, using 3D models, of steps to build the Earthquake Desk. Photo: Solly Baba

Special Note 1: For future training sessions, one whole day should be set for observations, discussions and preparations before training begins.

Special Note 2: Most jig sets will be good to assemble hundreds of desks. The jig that gets most damaged by the welding is Jig A which tends to burn a bit. Some of its parts may need changing after a few hundred uses, but it can be protected quite easily. Also, when desks are being mass produced, it will be a good time to switch over to metal jigs, which will last for tens of thousands of desks.

►Day 2: January 26

Day two was the first day of the training. Participants (welders, carpenters and supervisors) were from five furniture manufacturing companies: Staples and Jattu, Karma Steel, H & K Company, Chima Wood, and Namgay Wood.

Morning Session

Introductions
Presentation on desk function and development
Presentation of parts and materials
Planning with participants for workshop practical set up
Presentations including tea break took approximately 3.5 hours total

Afternoon session

Welders – Begin cutting the metal parts to size
Carpenters – Begin to prepare the jigs
Conclusions for the day and de-brief session

Thoughts after Day 2

SPBD senior engineer Mr. Diwaker Lama proves to be a great asset to the team as he happily and effectively takes on the role of translator and co-presenter. As the presentation evolves we learn that the participants are "quadro-lingual": Dzongkha, Nepali, Hindu, and English. Diwaker's Nepali translation is very helpful. The translation is accompanied with an enthusiasm that is at least as important as the verbal translation.

After approximately an hour of presentation, it seems that the "ice is breaking." A significant change in atmosphere is felt when it seems that we have managed to convey to the participants that they are becoming a part of a team dedicated to creating lifesaving solutions for schoolchildren.

Jigs are a new concept, and participants are not able to totally understand the value of using jigs for manufacturing. For welders, cutting with precision and measuring metal parts after cutting was crucial. Participants used the presentation handouts (step by step guide/ manual) to cut the parts and also to make jigs. They were able to easily follow the instructions and drawings, and they were also able to point out any errors. Carpenters were using the small 3-D printed models of the jigs while using their hand tools/ chisels to make the jigs.

One significant realization from this day was that although the factory is quite well equipped with power woodworking machinery, 95 percent of the jig parts are made with hand saw and chisel. We were extremely pleased to discover that this method not only does **not** compromise precision, but also allows for quick and efficient on-the-spot fine tuning of the jigs.

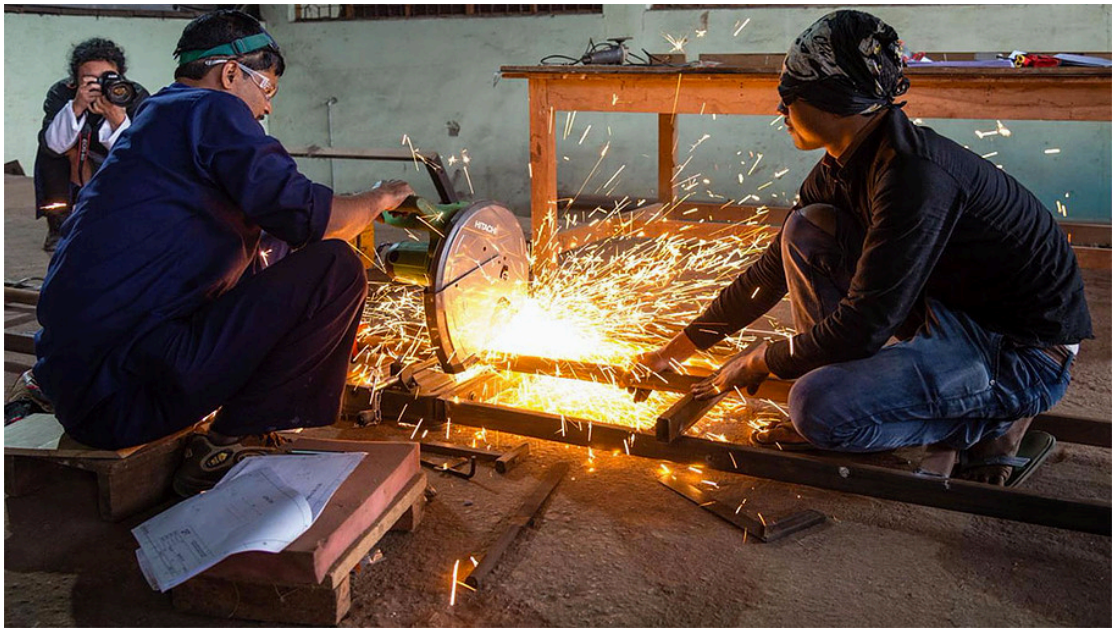
Another significant outcome of Day 2, which was the first day of actual training, was getting all participants in line with the expected precision required for the manufacturing of the desks. After a successful morning, some precision problems were discovered in the afternoon. These had to do with the machine set-up as well as the need to further stress the required precision. Corrections were made and fully understood. By the end of the day we are still missing drill bits for the 14mm and 42mm holes. Procurement on the "Indian side" will be attempted the next day.

► Day 3: January 27

Participants continued to cut metal parts and make jigs. Most of the day was spent still working on Jig A. We are missing the proper drill bits. Staples and Jattu foreman Dorje traveled to Jaigaon, India and purchased new 14mm and 15mm drill bits. They look good, but the drill press chuck is too small. We spent a couple of hours in the morning finding a neighbor with a lathe and downsizing the drill bit shank to the proper size.

We solved the unavailability of a 42mm drill by chiseling out 42x42mm squares in the jigs. Finally by the end of the day the carpenters were able to make Jigs A and B, and they worked overtime to make Jigs C and D. Also by the end of the day, a quantity of all the different steel parts of the table were cut and measured. Four frames that came out of Jig C look very good, same for parts coming out of Jig D.

Almost all the parts for Jig E are ready. During the day, Arthur is at the laptop creating an updated part list for the desk, updating plans and creating a new set of drawings for Jig F, and creating a totally new drawing for the new "Bhutan Model" table top.



Cutting the first steel leg for the Earthquake Desk. Photo: Ido Bruno

Thoughts after Day 3

Participants were finally able to see whether the metal parts fitted into the jigs, and they actually used the jigs for welding the first set of welded steel parts. Finally using the jigs made both the welders and carpenters realize the value of jigs – they create a production process and at the same time serve as a tool for quality check.

One of the highlights of the day was Sukumar's steel jig. Sukumar is a metal fabricator/welder from Karma Steel. When he realized that the work is delayed due to problems with obtaining the proper drill bits for making the wooden Jig A, he created his own, ingenious, temporary jig for making the parts intended for Jig A. With a bit of advice from Arthur this improvised jig helped make some of the parts before Jig A was ready. For us this was extremely important, seeing Sukumar and some of his colleagues take the initiative and further develop the jig system to their advantage.

Today (and over the next few days) work slowly transformed from a random process of feedback and correction on particular details, to a comfortable work procedure that had a noticeable effect on both the metalworkers and the woodworkers. Metalworkers got into the habit of cutting/welding a few pieces and then checking with Ido or Arthur to see that they have reached the precise requirements before continuing to fabricate the rest of the required quantity. Woodworkers (jig builders) – got into a habit of building the jigs slightly "tight" and working with Arthur and Ido on fine-tuning the jigs after the metal parts were inserted.

This also allowed Arthur and Ido to discover slight discrepancies and inaccuracies in the drawings or instructions, correct them in real-time, and take notes to make the required changes in the final digital version.

After initially contemplating the possibility of manufacturing a small quantity or even only a single desk, the team now feels confident that at least 8 desks can and should be manufactured: one for each manufacturer, one for a crush test, and one as a gift to the Royal Family or the Minister of Education. Toward the end of the day, an optimism created by the more efficient profile cutting, and the advance in completion of jigs, a decision is made to cut parts for 10 more desks. A total of 14 desks will be manufactured.

After observing some of Solly Baba's previous video work, a mutual decision is made to ask him to be the editor of the videos that will be created after the training. After getting to know the various participants better, it becomes clear that interviewing fabricators, SPBD engineers, proprietors and other team members would be a great contribution to the videos and the understanding of the variety of viewpoints in the project. Solly Baba, the team photographer, begins making personal interviews in the Jattu and Staples conference room.

Special Note 3: The highlight of the third day is the full realization that the introduction of the jigs as a fabrication method is of major significance. It is a totally new concept and raised some concern as to the value of such a time consuming investment. But by the end of the day it seems that all parties totally perceive the value of the jigs:

1. *Workers* have a precise and easy-to-use tool to manufacture errorless parts; they can deliver high quality work quickly and receive approval from their superiors.

2. *Manufacturers* are delighted to see that there are few errors and therefore little time and material is lost.

3. *SPBD engineers*, who seemed worried that the burden of Quality Assessment on this product would be overwhelming, realize that the jigs are in practice a great QA tool - parts will not pass from stage to stage (jig to jig) if they are not properly fabricated.

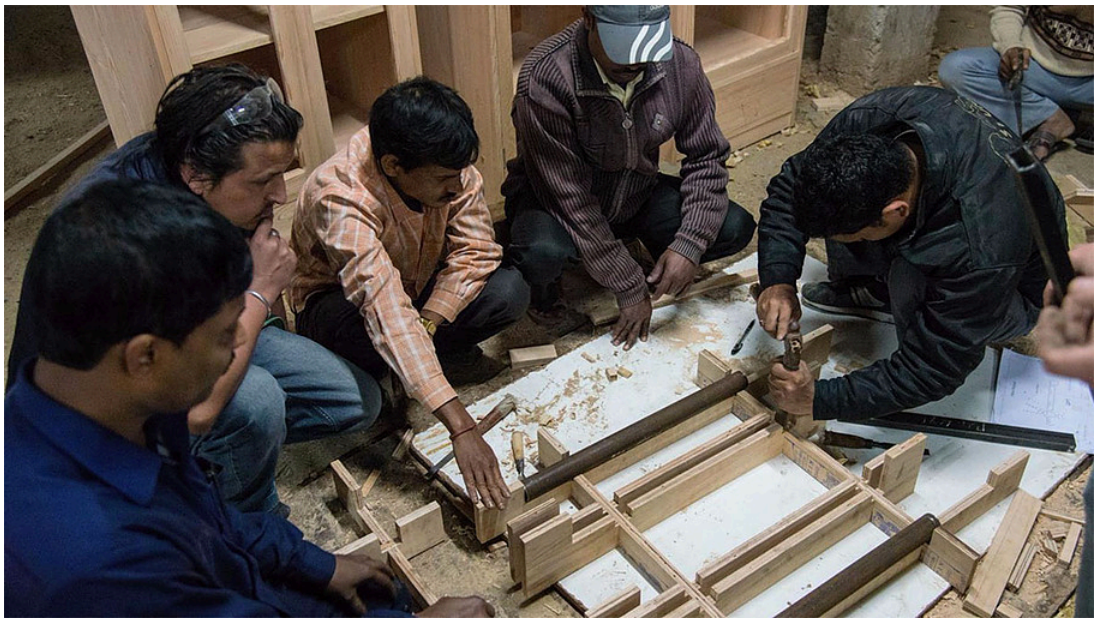
4. The *whole team* is satisfied that there is an objective tool that allows confidence in producing the desks to a precise standard.

► Day 4: January 28

Arthur and Ido travel with Mr. Karma Sonam and Mr. Diwaker to visit Phuentsholing Lower Secondary School with Principal Mr. Ngawang Dorji, and Phuentsholing Higher Secondary School with Principal Ms. Yangki Dema. This enlightening tour

includes meetings and discussions with the headmasters, plus on-site understanding of school architecture, furniture and challenges.

There is a presentation on the Earthquake Desk to all five furniture-manufacturing company proprietors and a visit by the Director General (DG), Department of School Education, Ministry of Education to the training venue.



Fine-tuning Jig C: the jigs hold parts precisely in place for welding and ensure consistency and quality in production, so that the finished desks meet the design specifications. Photo: Ido Bruno

Special Note 4: "Fine Tuning stage" - For future training - 1-3 hours of Fine Tuning for each jig are needed after its completion until it is ready for serial production. This is best made by the carpenters and the metal fabricators collaborating, each contributing their knowledge and experience, with the carpenters working "hands on" until everything fits perfectly. This is a crucial stage for Arthur and Ido as well as for the SPBD engineers' inspections.

Special Note 5: SPBD Chief, Mr. Karma Sonam was present through the whole day listening, learning and contributing. This was extremely valuable in many ways, especially as a preparation for the visit of the Director General of the Department of School Education, Mr. Karma Yeshey, scheduled for tomorrow afternoon.

Thoughts after Day 4

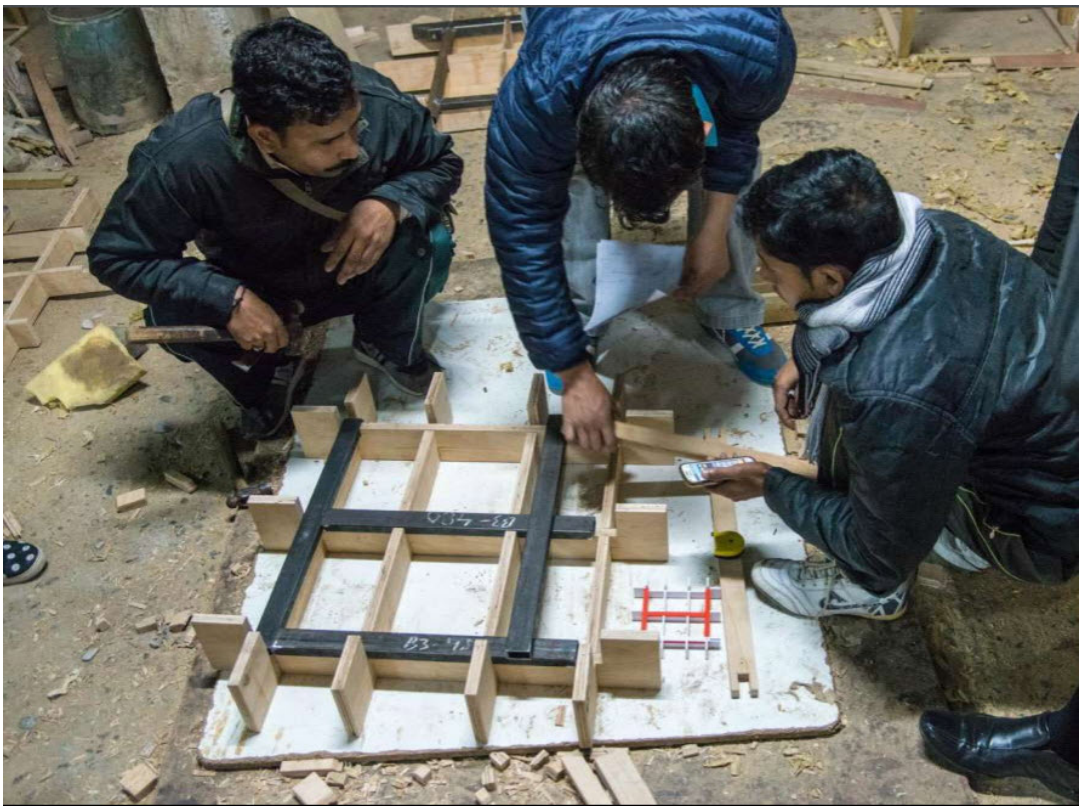
The tour of the schools was very important for understanding the wider picture. At both schools, massive building of new classes is underway. We are told that there is a constant growth in the number of pupils. It is clear that the headmasters are having a difficult time replacing old/broken down furniture when it is needed. They are describing the various methods they use to manage to fix and or replace the broken desks. The furniture is definitely heavily used, some looks very old. Both are enthusiastic about the idea of having safer desks in their old buildings. Conclusions from this visit will serve a better understanding of the ways to assist implementation of the desks in the Bhutan educational system.

There is a short tour of the facilities and a long presentation and discussion for all manufacturer representatives. The furniture manufacturers were made to realize the high seismic risk, the importance of having safe furniture, and contribution it has to enhance school safety. The manufacturers were also able to listen to the SBPD engineers and their plans and views on how to sustain the training and desk manufacturing process.

During the discussion it seems that there is a growing understanding of our motivation; we are gaining their trust. The manufacturers are sharing their difficulties in creating a sustainable commercial environment regarding school furniture. They describe their difficulties in making a profit on school furniture.

The Director General's visit is highly important. What was scheduled for approximately an hour turned into a more than two-hour discussion and long tour of the premises. The DG is highly curious, attentive and enthusiastic about the project and very much interested in the potential of the jig method for this and other applications. The DG was able to understand the project background, learn about the desk and the manufacturing process, and most importantly discuss with the SPBD and the manufacturers about issues regarding sustainability, cost, etc.

In the process of training participants, both welders and carpenters saw the value of making jigs and the role jigs play in ensuring precision and quality. It is now clear that a crush test at the end of the training will be highly effective. It is also becoming clear that, due to good progress, it will be possible time-wise.



Calculating measurements for Jig C. Almost all of the jig parts were made with a hand saw and chisel. Note the white and orange 3D model of the jig. Photo: Ido Bruno

► Day 5: January 29

On the fourth day of the training, Jig F is finished by the carpenters, following which the welders manage to complete 14 "T" table frames in 20 minutes. By the end of the day Jig G is satisfactorily completed. We discover in time that the laser-cut template intended for Jig G we brought from Israel is inaccurate! To correct the template, the holes that it was supposed to help us mark are marked by hand and double-checked for accuracy. Arthur apologizes to the carpenters.

The videographer hired for the project conducts more interviews of the participants.

The team could see the value of having a preliminary crush test, which would happen before the final test to be witnessed by all the manufacturing company proprietors and MoE, Department of Disaster Management (DDM), and district officials. Based on this, the team started mobilizing resources for the crush tests, such as – heavy lifting crane, sturdy bags to carry the load, ropes and a knife to cut the rope. A list of actions and preparations was made:

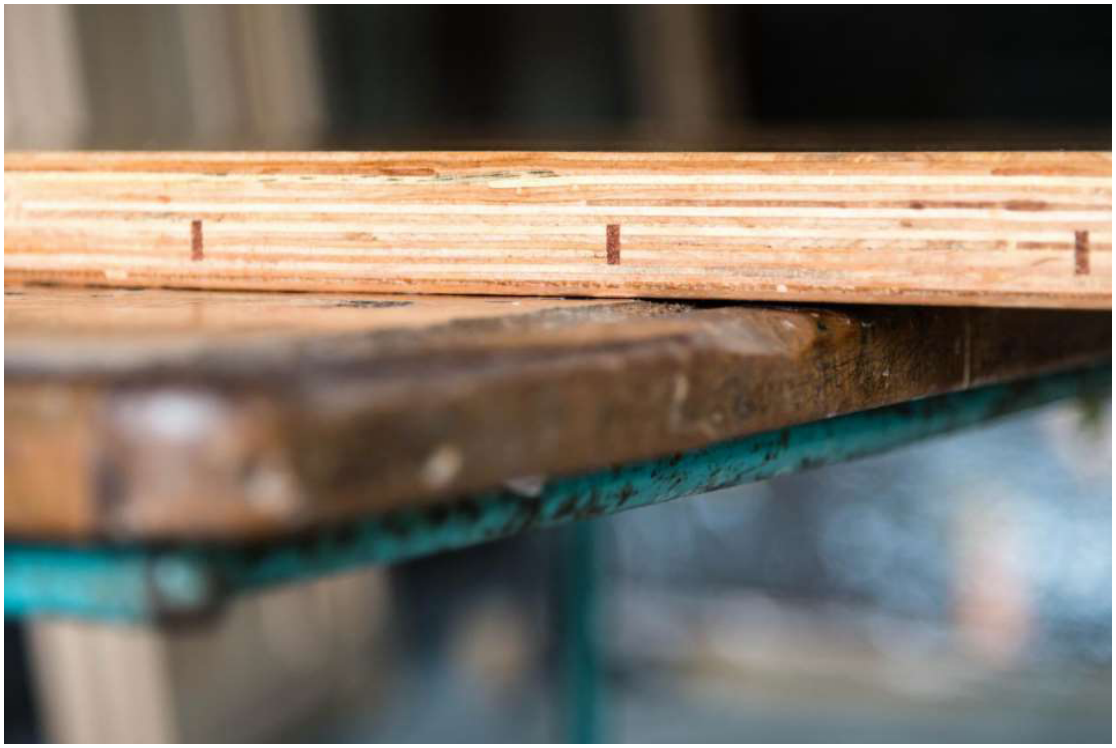
Strong rope
Big bags
Weights
A crane
A steady base for the test in the yard
A pole and knife

Apparently “big bags” for the crush test are unavailable off-the-shelf in Phuentsholing. Ido makes a quick design sketch, and we go downtown to look for the right textile and webbing. Eventually the right material is found in Jaigaon. Work commences with the Staples and Jattu upholsterer to sew two “big bags,” one for the preliminary test, the other for the final public demonstration.

Time has come to properly finish the adaptations of the tabletop design to the local material and work methods. This is a source of great satisfaction, as some limitations in previous production facilities of the desk prevented us from making some slight but important improvements to the tabletop. In essence, this was the ability to create small notches in the tabletop edging that would allow it, upon impact, to break into many small non-sharp pieces rather than long sharp ones.

The Bhutan conditions were perfect to attempt these changes:
• Highly skilled carpenters
• Excellent quality plywood of the right thickness (18mm which is actually 19mm)
• Motivation of the proprietors to make a good quality product.

This allowed the “Bhutan Model” tabletop to be born. It is a unique tabletop, optimally suited for the Phuentsholing manufacturers, with small notches every 12cm, and one long notch that helps the tabletop break along the middle. These notches augment the functionality of the table under impact. The notches are filled with small redwood pieces that have both a functional and an aesthetic role.



Bhutan Model tabletop edge detail. The notches are filled with small redwood pieces that have both a functional and an aesthetic role. Photo: Ido Bruno

Thoughts after Day 5

It has become clear that by the end of the training we would be able to perform vertical crush tests. Individual interviews with participants provided evidence that they were motivated by the objective of enhancing safety of schoolchildren through the use of Earthquake Desks. Participants also expressed clearly that they found the training important and said they understood the importance of ensuring precision for quality and performance and the use of jigs in the manufacturing process.

At the end of the day we discovered that one of the diagonal steel crossbars was not cut properly. This was due to a combination of the difficulty in obtaining precision from the metal saw, and a measurement that was not properly marked on the drawings. The problem was actually discovered through the mismatch of the parts when put in the jig. The parts were remade and the drawings corrected. A good example of how working with the jigs creates a natural quality control tool. At a certain point it became clear that the tabletop edging is not glued in the correct way to the tabletops. Corrections were made. A note should be made to make sure proper instructions are given regarding the proper way to glue the tabletop parts.

Special Note 6: Recheck and make sure that all drawings are specified according to available tools and methods. Some of the drawings were made for laser cutting rather than hand tools, and therefore were missing some relevant details.
Special Note 7: The unique tabletop is a good example of how projects like the Bhutan training can bring about improvement to the design of the desk itself.

► Day 6: January 30

A full day of many actions and touring of other production facilities in Phuentsholing. We visited three out of the four remaining furniture companies, though unfortunately due to time limitations we could not visit Karma Steel and Wood. We also had an enlightening visit to Bhutan Ply and Board manufacturing facility.

Some observations:

It seems the manufacturers we visited specialize in locally designed wooden furniture; facilities for steelwork seem very limited. We look forward to seeing the production of the Earthquake Desks go hand-in-hand with the development of up-to-date steel manufacturing facilities. Bhutan Ply and Wood looks like a very sound industry. We have been able to closely observe their yards, machinery, large amounts of materials in different stages of production, and fine examples of high quality end products. We are confident that the plywood coming out of this factory will contribute to the quality of the Earthquake Desks.

Preliminary Test:

A truckload of stones, boulders, and concrete pieces was brought in from the river, weighed and marked. Bags to hold the weights were designed and stitched in the Staples and Jattu upholstery workshop. A "Hydra" crane is in place, on loan from the neighbor. Proper rope was scouted and purchased. A mechanical scale was brought from the nearby recyclers to weigh the weights properly. A 10mm thick steel plate was moved by rollers and levers from the metal workshop to the yard to serve as stable base for the test.

We have not managed to source the proper adhesive we need for gluing the tabletops to the steel structure. Glue specially brought from an Indian supplier was proven to be of the wrong type. As this is at the last moment, we resolve to use an inferior temporary alternative: screws. For the public test we will use freshly bought RTV Silicon sealant, good enough for our tests, but not the recommended adhesive (which is polyurethane based) for the mass-produced desks. We have not been able to find the adhesive we specified in the Phuentsholing area. For future production, the correct adhesive will have to be imported from India or elsewhere.

The first test sack is sewn and ready. It is tested for strength and functionality and found good. A small improvement for tomorrow: add a textile loop to the bottom for tying a plumb bob. The locally made desk is finally put to test. The preliminary crush test is conducted successfully with a 400 kg weight.

Some remarks for tomorrow:

The steel plate has some flexibility and seems to act a bit like a trampoline, causing the desk to jump a little bit after the impact. For the next test, sand will be put underneath to dampen the effect. The preliminary test was conducted without the specified rubber leg caps. Off-the-shelf caps of the correct size were found in the Staples and Jattu storeroom, and were easily adapted to the desk legs, for use in tomorrow's test. They will serve to create better friction between desk and steel plate. These proved to be so good that they are specified for use for mass production as well.

We analyzed the crushed desk and showed the fabricators some of the important points, focusing especially on some of the critical welding points, emphasizing the importance of high workmanship and accuracy. The leg cylinders did not break during the test. Some of the participants were worried that they were not fabricated properly. This may have been due to our remark in previous days that the welding of the discs was slightly stronger than required, which may affect functionality. This was put to a test manually by slamming a 24 kg piece of concrete on the desk corner. The cylinders functioned as expected and broke on impact. Instructions for proper welding of this feature were reviewed and explained with a good example at hand.

All in all, the local desk performed very well. We are satisfied and ready to finish preparations for tomorrow's public test.

Table Design and final production:

Four colors were chosen from locally available paint catalogues. The idea is to allow for some flexibility according to taste and local availability while retaining some level of unity. Two greens and two blues were chosen. This was done on collaboration with proprietors to ensure their approval of type and color.

All 14 tables have been welded to satisfaction. Sizes and angles are measured and approved. All tables are given a coat of base paint.

We discover that we forgot to make sure the topside of the steel frame is left unpainted. This is important for the adhesive that connects the steel and the plywood. The team rolls up sleeves, and in half an hour all is corrected, steel clean and waiting to be glued. Frames are painted in chosen colors. They look beautiful. "Bhutan Model" tabletops are finished and glued to the steel structures.

More Interviews with SPBD engineers and furniture manufacturers were conducted. The team also prepared a draft press release for the next day's final crush test event, as there was a possibility of local media reporters covering the event.

School officials, local residents and manufacturers gather in anticipation of the Earthquake Desk crush test. Photo: Solly Baba

Thoughts after Day 6

In the interviews with SPBD engineers and furniture manufacturers, we were able to understand their issues and concerns and also to discuss the next steps. The preliminary crush test provided the whole training team and the participants with the confidence that the table manufactured during the course of the training in Phuentsholing met required standards.

Special Note 8: Availability of proper adhesive can be an issue and should be secured well in advance of the training (for next time).

Special Note 9: Rubber end-caps, to prevent the desk from slipping, may be adapted from locally available stock.

► Day 7: January 31

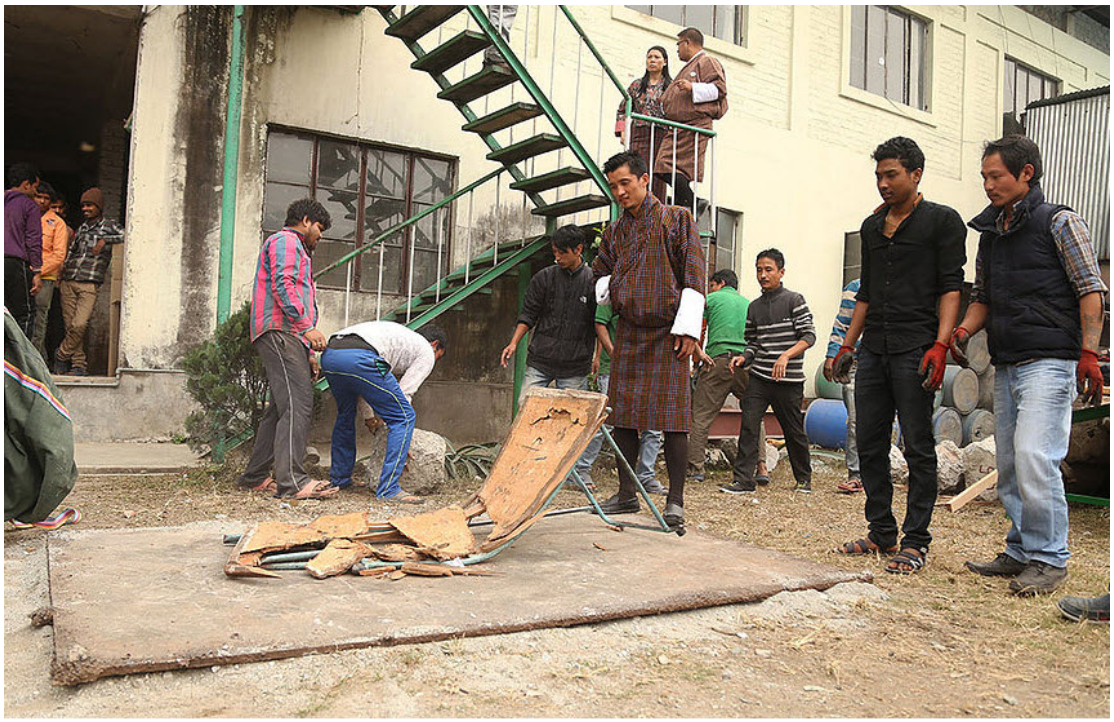
Last day of training, and the day of the public crush test. Clear safety zones were marked in preparation for the visitors. Painters finished spray-painting all frames. A display of jigs and desks was created in the yard for the visitors.

It was exciting to see Mr. Lalit conducting a guided tour explaining to more than a dozen Vocational Training Institute trainees the production methods and outcome. Many other guests had the opportunity to see the various stages of the work and understand the process. Among the spectators were Department of School Education, Department of Disaster Management, District Officials, Principals, manufacturing company proprietors, training participants and a few students. The event began with an introduction by GHI's Karma Tshering followed by a short description of the process of the training by Ido Bruno.

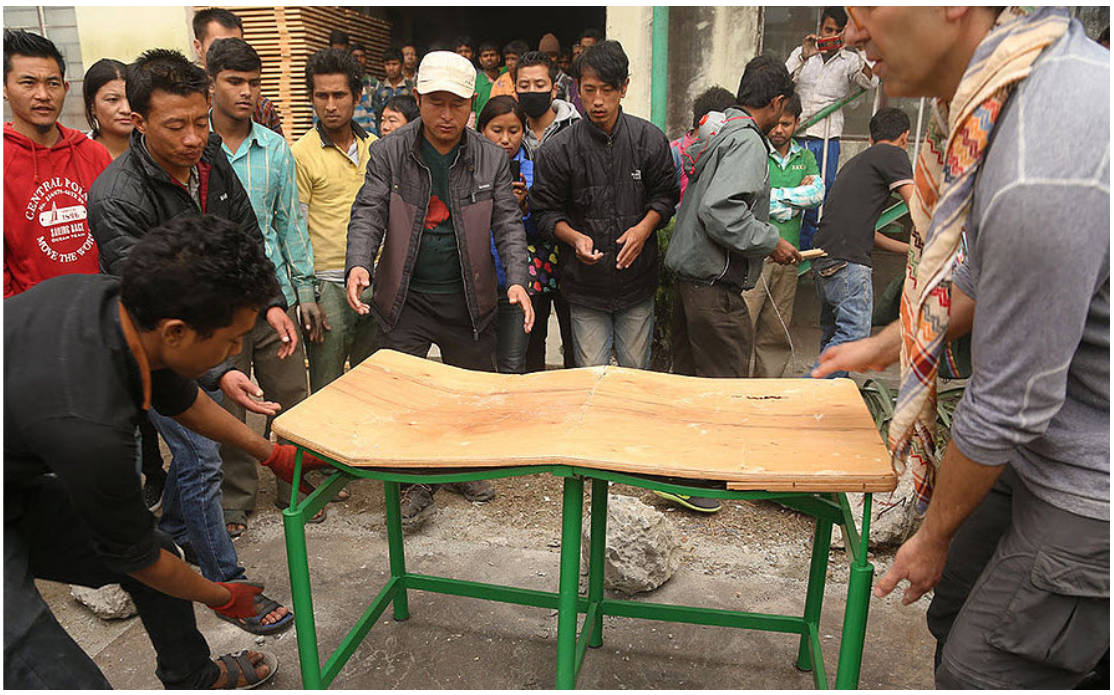
The first crush test was done on a normal/standard Bhutanese school desk with a 356kg load. The standard table was totally damaged. The final crush test on an Earthquake Desk manufactured in Bhutan was done with a 422kg load.

We chose not to put more weight for the test because the "big bags" were made of a textile that seemed to be limited in its ability to carry more weight. Further testing is required to determine whether the desk itself can withstand heavier weights as tested at University of Padova's materials testing facility.

Some post-test observations:
The safety zones underneath the desk remained unchanged as required.
The tabletop remained glued to the frame as required.
The "Bhutan model" tabletop performed very well and as expected.
A standard Bhutan school desk was flattened under a 365 kg load.
A Made in Bhutan Earthquake Desk withstood the 422 kg crush test.



A standard Bhutanese desk was destroyed in the crush test. Photo: Solly Baba



The Bhutanese manufactured Earthquake Desk withstood the 422kg crush test.
Photo: Solly Baba

Thoughts after Day 7

The event provided us with an opportunity to advocate for the importance of reducing risk and enhancing school safety, and the need for safe/protective furniture in schools. Witnessing the actual crush test was a powerful means of communicating the need for earthquake preparedness and to show the effectiveness of the desk.

► Final Conclusions

The introduction of the jig as a fabrication method is of major significance:

- Workers have a precise and easy-to-use tool to manufacture errorless parts; they can deliver high quality work quickly and receive approval from their superiors.
- Manufacturers are delighted to see that there are few errors and therefore little time and material is lost.
- SPBD engineers discovered a great quality assessment tool - parts will not pass from stage to stage (jig to jig) if they are not properly fabricated.
- The whole team is satisfied that there is an objective tool that allows confidence in producing the desks to a precise standard.

The genuine enthusiasm and willingness of the manufacturers (proprietors and workers) to learn new methods created a highly positive learning environment, which allowed for quick and efficient progress.

Time and effort lost on inadequate tools and materials was usually quickly regained due to good sense of improvisation and excellent real-time problem solving shown by all participants. **This is an important point, as problems will always arise; the ability to find quick and sound solutions is a great asset to a manufacturing environment**.

Some industrial grade tools will need to be purchased by the manufacturers to allow for better quality and more efficient production. These will be carefully chosen and specified in a separate document taking into account reasonable costs.

It seems that apart from these small improvements, this local budding industry is fully capable of handling the production of good quality Earthquake Desks. The SPBD team seems enthusiastic regarding the introduction of the Earthquake Desks into the schools. They seem more than capable of carrying out the required quality assessment procedures, greatly aided by the jig system they now fully know and understand.

In the production stage, steady, reasonably sized orders for manufacturing desks will allow for pre-planned, more cost effective procurement of imported materials. It seems that the GHI team has an important role in assisting the writing of a fair and balanced tender for supplying Earthquake Desks to Bhutan schools. A good and balanced tender will allow the manufacturers to earn enough to make the production worthwhile, and at the same time allow the Bhutan Government to equip its schools with low-cost, high-quality safety equipment. **This is a highly important issue and any assistance on bridging possible gaps will have the greatest effect on the rate and overall success of providing protective desks for Bhutan's children.**

Viewing the Earthquake Desks as safety equipment rather than as school furniture is a highly effective concept with both manufacturers and SPBD engineers. It looks like a key point for future discussions.

► Follow-up Steps

A final folder with the following files has been updated and shared with SPBD and all the manufacturers:

1. Setup and tools for manufacturing
2. Bill Of Materials for materials and parts required for a single desk
3. Technical Drawings of all desk parts
4. Preparation Procedures for all metal parts
5. Technical Drawings of all jig parts
6. Assembly Procedures of all welding jigs
7. Assembly and Welding Procedures of all metal parts
8. Other technical data sheets:

Coordinate distribution of the 14 manufactured desks as discussed with Ido Bruno, SPBD, proprietors and the participants.

Work with SPBD to come up with a draft standards/specification for tender of the manufacture of desks – estimated manufacturing cost, material, equipment and set up requirements, etc.

Work with Staples and Jattu to calculate the cost in terms of material costs, labor and transportation. There are also some initial costs such as tools/equipment, making of jigs, etc. to be considered.

Discuss with the videographer for the production of videos. Three types of videos/documentary could be developed:

- 3 mins long that would be geared towards awareness raising;
- 7-9 mins that could be more like a museum/ showcase piece; and
- 30-45 mins that would capture the many layers of the project.

Ido and the videographer would need to have many Skype sessions initially to develop the initial story and outline and then a larger group could be involved to provide feedback and inputs. GHI should already start working on and writing up the credits as this would need some time and is important.

Planning for a Vocational Training Institute (VTI) training – this needs to be discussed further with SPBD. The time, venue, program, costs etc. need to be worked out.

An aspirational timetable for putting the desks into schools in Bhutan can be chalked out. Target of having one class fully equipped with Earthquake Desks could be September 21, 2016 (the anniversary of the 2009 earthquake).

Participants

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Tenzin Drukpa, Proprietor, Chima Wood Industries, Phuentsholing,
Tandin Bidha, Proprietor, Staples and Jattu Wood Industry,
Karma Jigme, Proprietor, Staples and Jattu Wood Industry,
Sonam Wangchuk, Manager Director, H&K Company
Porimol Mondal, Welder, Chima Wood Industries
Huber Joshi Dhan, Foreman, Chima Wood Industries
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Nandu Saturdhar, Carpenter, Namgay Wood Industries
Sarmila Rai, Accountant, Namgay Wood Industries
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