University of Applied Sciences
of Southern Switzerland

Department of Environment Construction & Design

Institute for Applied Sustainability to the Built Environment

World Habitat Research Unit

Dhajji Research Project

Report of field visit in Pakistan

From 17 to 31 August 2008

By Tom Schacher, 15 September 2008
(tom.schacher@adhoc.ch)

Aims of the field visit

- Assessment of technical issues related to Dhajji houses and which need theoretical or lab verification
- Assessment of the training impact on Dhajji construction and of its successes and shortcomings

Aim of this report

1. Give an overview of the multitude of execution details as encountered during the visit.
2. Provide picture material as a basis for the creation of realistic lab samples.
3. Highlight issues which have to be verified through calculations or lab testing.
4. Highlight issues where training was insufficient and which can/should be improved for the future.

Places visited:

In AJK: Islamabad - Dirkot – Bagh; Bhedi; Bagh – Sudanghali – Hattian – Muzaffarabad

In NWFP: Battal – Sacha Kalan – Jibori; Battagram – Shamlai; Balakot – Jared (Konhar Danna)

Overview of main observations

1. **Foundations**
   - Foundations are generally not coming out of the ground enough, particularly on the side of the slope.
   - A smooth cement mortar finish on top is not ideal as water gets trapped between that top and the base plate.
2. **Base plate (dasa)**
   - Timber of the base plate should be made of a particularly water resistant wood or at least be treated against rotting.
3. **Wall types**
   - Square patterns are most common. But when the wall height is subdivided into two parts only, the squares become rather big, leading to oversized infill panels which can fallout during an quake.
   - Other existing subdivision patterns (Z and V shapes) should be investigated to know their potential.
4. **Bracing**
   - Bracing boards are often too thin. When squares are big, thicker boards or a finer subdivision should be used.
   - Big diagonal bracings in the corner should not be part of the dhajji vocabulary. They are causing an imbalance by making this part of the frame stiffer than the rest of the dhajji structure, annihilating the dhajji damping effect.
5. **Wall plate**
   1. They are rarely thinner than 4”, which is good news.
   2. Are horizontal braces in the corners necessary with all walls being rigid themselves?
6. **Vertical connections**
   - Vertical dasa-post connections are nailed and sometimes a strap is added. Mortise and tenon joints are very rare.
7. **Horizontal joints (base plate and wall plate)**
   - Short lap joints and butt joints are still frequent. Training should aim at eradicating them.
8. **Corner connections**
   - Joints which are only nailed are probably too weak.
   - ‘Added-block joints’ seem to be a good alternative
   - Short corner braces: are they good or causing excessive stress in the corner?
9. **Straps**
   - Straps are generally too short or with an insufficient number of nails.
10. **Drainage and retaining/back wall**
    - More care must be taken to keep the dhajji wall away from the humidity of the retaining wall..
    - Good drainage details are rare.
11. **Roof and carpentry issues**
    - There is no tradition of good carpentry work in the area. Carpentry training would seem to be an important issue, particularly with regard to basic carpentry concepts.
    - Flat roofs with heavy timber beams might be dangerous with a standard 4” thick dhajji structure. Must be verified and rules defined.
12. **Openings**
    - People often put all openings of a house on the same (valley) side. This weakens the earthquake resistance of the building. Maximum size and number of openings must be defined (through lab testing?).
13. **Infills**
    - Often too much mud (50% mud, 50% stone). To ensure the dampening potential of the dhajji structure, more stones must be used and placed with care (not a kind of ‘situ’ concrete).
14. **Plaster**
    - In general good, but the addition of straw or pine needles should be promoted.
15. **Composite structures**
    - Where original RC structures are used with dhajji infills, connection problems arise between RC and timber. Solutions should be developed.

1. FOUNDATIONS

- Foundations are made throughout in stone masonry.
- Anchor rods for the ‘dasa’ (base plate) are embedded in the foundations (depth unknown) and are placed at approximate intervals of 6ft as suggested by the training.
- Foundation height out of the ground is between zero and one foot. The side towards the slope is frequently too low, exposing the base plate to running water and snow (see Fig. 1a).
- In most cases the foundations are topped with a smooth mortar bed (as per ERRA regulations?) which isn’t ideal as rain water gets trapped under the base plate causing rotting. The upper surface of the foundation should be rough and slightly irregular (natural stone) to ensure voids under the base plate where water can flow off or evaporate (see Fig. 1b and 1c).
- According to new information received from UN Habitat, dhajji houses before the earthquake were not anchored to the foundations, allowing for an independent movement during an earthquake. Foundations in turn were larger to allow for this movement without the house falling off. This is an interesting and important aspect, as with a similar solution the impact of earthquake energy onto the structure is reduced. It might be worthwhile to think of a way how to stop excessive movement of the building to keep it on the foundations while still allowing for a certain freedom.

Figure. 1a: Foundations too low and base plate in contact with the ground. Note sufficient height of foundation towards the valley

Figure 1b: smooth mortar finish on top of foundation traps water under base plate. Lower left: irregular top surface allowing for water to dry off. Lower right: interesting detail of detaching base plate through spacers

Figure 1c) dry stone masonry without top mortar, leaving room for the water to dry off.

2. BASE PLATE (DASA)

- Size of dasa is usually 4x4” as per ERRA guidelines. Sometimes the dasa is bigger (4x6, 5x5 or 6x6”)when timber from former house is recovered (Fig. 2a).
- Timber used for base plates is the same as used for the rest of the structure, that is, pine wood. It might be difficult for people to find (and be able to pay for) a more resistant timber for this important part of the building. Very probably the aspect of using a stronger wood for the dasa has not been raised by the trainers, but should become part of a future training.
- Treatment: Base plates are rarely treated against rotting, which is a issue of concern. In only a few occasions (mostly in SDC and UN Habitat demo buildings) treatment is done through used engine oil (Fig. 2b). Question: How good is used engine oil really? Are there other accessible solutions/treatments? An interesting solution for a passive protection is shown in Figure 2c where a stone skirt leads the water away from the base plate.


Figure 2a: 99% of new base plates are 4x4”, with rare exceptions where salvaged timber is used (right).


Figure 2b: base plate treatment with old engine oil;

Figure 2c: Passive protection through run off skirt

3. WALLS

- Pattern:
  - Of the different subdivision patterns of the wall panels, squares containing cross braces have been observed most frequently (Fig. 3a). This might be due to the fact, that many of the areas visited didn't have a pre-earthquake dhajji tradition. The influence of the engineer-trainers might also be responsible for the predilection of braced squares. Sometimes half braced squares have been observed (Fig. 3b)
  - In the UNHabitat HRC demo buildings, the wall height has been subdivided into 4 parts (Fig. 3a)
  - In most buildings seen in AJK, walls height was subdivided into 3 parts (Fig. 3c).
  - In some parts (AJK and NWFP) wall height is divided into 2 parts (Fig. 3d).
  - In Sacha Kalan, an area where SRSP training took place, half height dhajji walls could be observed. They seem to reflect a local pre-quake tradition (Fig. 3e)
  - In areas visited in October 2006 (Bagh Thub and Bagh Topi) other subdivision patterns (zig-zag or V shaped) could be observed, even in new buildings under construction (Fig. 3f and 3g).
  - On some occasions (in AJK), non-systematic subdivision patterns were observed (Fig. 3h).
  - An example of braced rectangles is given in Figure 3i.
- Spacing of main posts or between main and secondary posts is mostly in the order of 2 feet, thus correct. There are places however, where the distance is significantly higher (3 to 4 feet) (see Fig. 3d). Apart from making the whole structure weaker, the size of the individual panels is also increased and the out-of-plane behaviour of the infills becomes problematic (problematic also the in-plane usefulness of the infills).
- Size of timber members: posts are mainly 4x4", sometimes bigger up to 6x6" if timber from old houses has been salvaged and used. Secondary posts are 2x4" and bracing boards are mostly 1" thick, but can vary from ½" to 4", depending on what kind of timber was available. There is a tendency of using boards which are too thin (1/2"). Thick braces are rare and do occur only where such timber hs been salvaged from previous houses. More care must be paid to instruct people to use 1" to 1-½" boards for bracing.

Figure 3a): braced squares pattern, wall height divided into 4 parts

Figure 3b: examples of 'half-braced' small squares

Figure 3c): braced squares, wall height divided into 3 parts in Bhedi (AJK)

Figure 3d) braced squakres, wall height divided into 2 parts. The walls in the lower picture are quite shaky.

Figure 3e: Braced squares, half height dhajji on half height stone walls (dhajji base plate tied to foundation through stone wall with tie rod).

Figure 3f: Zig-zag braces and close spacing of vertical posts (boards)

Figure 3g: V-shaped braces with main posts, with or without secondary subdivision

Figure 3h: irregular bracing and use of salvaged timber

Figure 3i: braced rectangles

4. BRACINGS

- *Board thickness:* Bracing boards subdividing the wall panels are usually about 1 inch thick. However, thinner boards are frequent. Care should be taken to inform people that thin boards might not be strong enough to brace the building.
- *Crossing:* Sometimes much care is taken to cut the cross-bracing boards as shown in the piture below. This might not only be a waste of energy, but counterproductive as the boards become weaker.
- *Big braces:* in some places people do use big, diagonal braces over most or the whole wall height. Such braces belong to another type of structure (braced frames) and should be avoided in dhajji. They create an imbalance because they are too strong and do not allow for an equal distribution of forces throughout the entire wall panel and do not allow the dhajji structure to get into its 'dampening mode' (hyposthesis).

Figure 4a: Thin bracing boards (less than 1" thick) are frequent, but should be avoided

Figure 4b: lapped bracings: good or bad?

Figure 4c: Irregular fill-in with long corner braces, creating an imbalance.

5. WALL PLATE

- Size of wall plate: wall plate height is mostly 4”, but 2” plates apparently are also found (Fig. 5a). Such plates are too thin for the necessary overlaps in corners and where plates are jointed (Fig. 5b). Equally, where rafters do no fall exactly on top of the posts, the wall plate must be able to support that load.
- Horizontal braces at ceiling level to ensure horizontal diaphragm rigidity are rarely used. Are the necessary? (Fig. 5c and 5d).
- Capitals on posts: the use of capitals on freestanding posts (veranda posts) is still frequent (Fig. 5e). Capitals help to distribute the load on a longer portion of the wall plate, which is particularly useful where there is not stone infill (i.e. in verandas). This detail must be maintained/promoted.


Figure 5a: wall plates are mostly 4x4”


Figure 5b: proper connection and insufficient strength of laps due to insufficiently high wall plates

Figure 5c: horizontal corner bracing useful?

Figure 5d: Horizontal floor bracing

Figure 5e: Capitals on veranda posts are often seen

6. VERTICAL CONNECTIONS (BASE PLATE TO POSTS AND POSTS TO WALL PLATE)

- *Connections between posts and base plate*: posts are mostly nailed on the base plate (Fig. 6a). Mortise and tenon joints are very rare (Fig. 6b). In walls with infills already put in place it is difficult to assess whether 2 or 4 nails have been used to fix the posts to the dasa. In general people however confirm that they used four 6” nails. Lateral wood blocks as suggested in the ERRA poster are rare to find (Fig. 6c).
- *Connection posts – wall plate:* Mostly a vertical 6” nail through the dasa. A similar connection without a strap (and even with a strap) is quite weak as nails put into the head of a beam (i.e. in the sense of the fibres) cannot ensure a strong connection (Fig. 6d). Long lateral nails (6”) are better (Fig. 6e). Additional straps are recommended.
- Corner lap joints are often cut off and the joint is only held by a vertical nail through the wall plate to the post (Fig. 6f). If the nail is 6” long and the wall plate 4” high, then the nail goes only 2” into the post. Training should insist that such vertical nail connections are weak.
- Bracings of veranda posts to the wall plate have only been observed once (Fig. 6g).

Figure 6a: Most joint are simply nailed, mostly with four 6” nails

Figure 6b: Mortise and tenon joint

Figure 6c: lateral blocks as suggested by ERRA

Figure 6d: Insufficient number of nails and nails too short (example after earthquake)

Figure 6e: Fixing through one or two lateral nails

Figure 6f: insufficiently strong corner connection (hold only through vertical nails)

Figure 6g: Rare example of bracings on veranda posts

7. HORIZONTAL JOINTS (BASE PLATE AND WALL PLATE)

- *Joints:* Scarf/Kashmiri joints (Fig. 7a) or long lap joints (Fig. 7b) are frequent and are due to the training. However, short lap joints (Fig. 7c) are still common as are butt to butt joints (Fig. 7d). Simple scarf joints are rare (Fig. 7e). Training must insist more on the importance of correct joining techniques. Scarf joints have become fashionable (because they look sophisticated?) but in fact are less strong than long lap joints. Scarf joints maintain 1/3 of the cross section of a timber piece, while a lap joint maintains ½ of the section and therefore resists traction better. The number and size of nails however is important and must be calculated and taught accordingly.

Figure 7a: Interlocking or splayed scarf joints (Kashmiri joints)

Figure 7b: Long lap joints

(Unnecessary complication)

Figures 7c: Short lap joints are insufficient

Figure 7d: Butt to butt joint

Figure 7e: Simple scarf joint

8. Corner Connections

Corner connections posts – base plate:

- the most common corner detail observed in AJK is a simple nailed connection (Fig. 8a).
- In few cases, mortise and tenons have been used, which isn't an ideal solution as the base plates are weakened by the mortise (Fig. 8b).
- Cut off base plate ends are frequent, weakening the corner (Fig. 8c).
- Added blocks of the inside of the corners as promoted by the ERRA poster can be seen sometimes (Fig. 8d)., though the usefulness of these blocks without their outer counterparts is not clear (Fig. 8e).
- Blocks only on the outside are also found. This might be a reasonable solution, as the posts are blocked on the inside by the wall infill (Fig. 8f). This detail is quite frequent in the Kagan valley.
- Complete inner and outer blocks *plus* a diagonal board acting as a strap, as promoted by the SDC training, has never been observed in the field (Fig. 8g). However, the suggested diagonal board has sometimes been replaced by a diagonal strap.
- Sometimes the connection is secured by angle irons. For such irons to work properly, they have to be rather thick and the first nails must be as near to the corner as possible. The angle iron in Fig. 8h is probably useless.
- In some places a short corner brace has been promoted and implemented by the people. However, there might be doubts that this brace acts as a lever, adding additional strain to the corner connection it is supposed to strengthen (Fig. 8i).

The same observations are valid for the post – wall plate connections.

In the light of the above observations, research is needed to define the best (most effective end economic) corner connection detail.

Figure 8a: Nailed connection (four 6" nails)

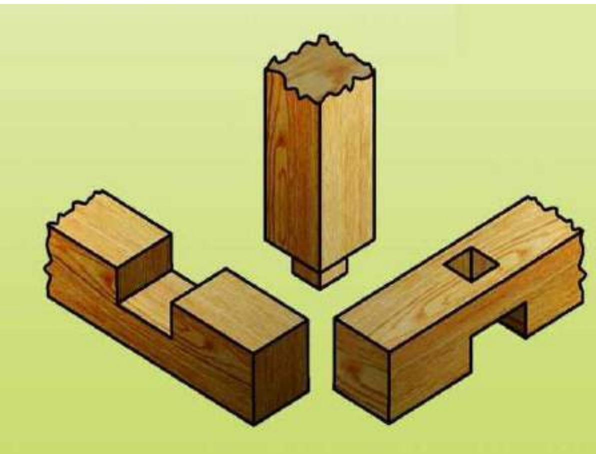


Figure 8b: Mortise and tenon joint. Top left: ERRA poster; Top right: probable joint as per ERRA poster; Lower row: weakening of corner joint through mortise and tenon.

Figure 8c: cut off ends of dasa weakening the corner, even with a strap.

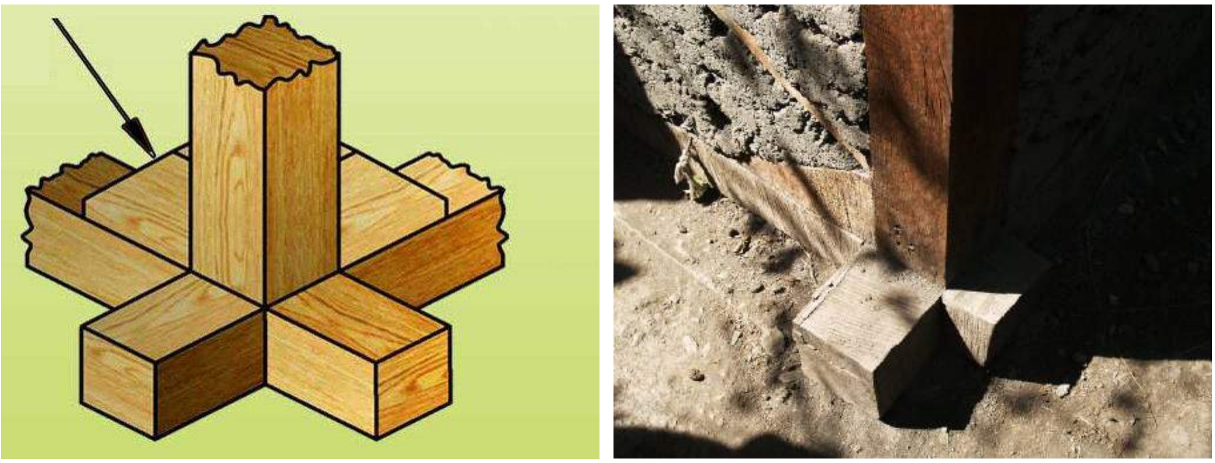


Figure 8 d: block only on the inside of the post (usefulness?)

Figure 8e: Corner blocks inside and outside of the post.

Figure 8f: Corner blocks only on the outside

Figure 8g: Joint with inner and outer blocks secured with a diagonal strap (timber board or metal strap)

Figure 8h: corner secured by an angle iron: problematic.

Figure 8i: Short corner braces: a good thing or causing an dangerous lever that adds more strain to the corner?

Figure 8j: simple straps in addition to nails might not be strong enough (to be tested)

Figure 8k: Same issues at the post – wall plate level. Top: Solution proposed by SDC demonstration model

9. STRAPS

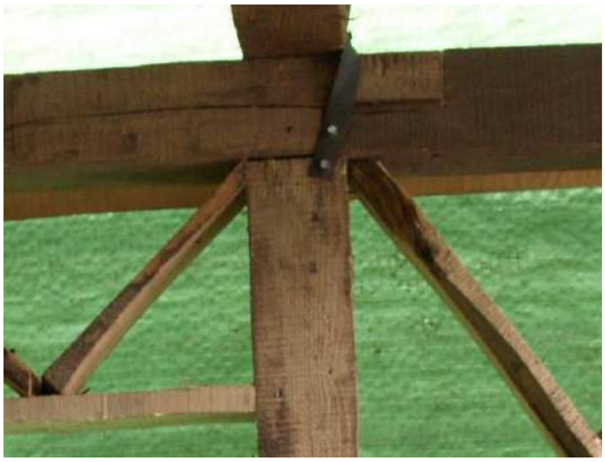
Wall posts are frequently fixed to the base plate with straps.

- But straps are often fixed with one nail in one piece (e.g. base plate) and two nails in the other (e.g. post).
- Straps are often very short, allowing for only one nail in each piece to hold.
- Straps are rarely pulled around the piece they want to fix.
- Strap material is often very thin (one has the impression that a strip of CGI sheet is sometimes used.
- Straps are often used alternatively on every second or third post.

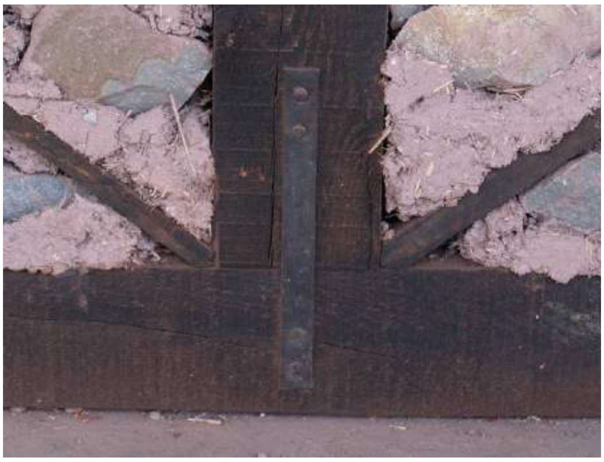
Conclusion: Straps are important, but they way they are used, their effectiveness is dubious. More training must go into the reason for their use.







10. DRAINAGE AND RETAINING BACK WALLS

- Because of the steep geography, people tend to build against or on top of retaining walls. This might not cause structural problems as such, but is favouring humidity in the rooms and in the dhajji structure if there is not proper ventilation of the back wall. This in turn will cause the structural timber to rot, then causing structural problems in the future (see fig. 10a).
- People try to keep water away by covering the gap with a concrete slab. This might work if there is no water coming through the ground, and all details are made with great care (Fig. 10b-e).
- Proper channels are rarely done (Fig. 10f).
- If the lower part of the back wall is in stone masonry, the risk to the dhajji timber structure is less important. It might be worthwhile trying to promote a standard solution going into this direction (Fig. 10g).

Figure 10a: Dhajji wall very close to retaining wall, void covered by a roof and added wall against snow and rain

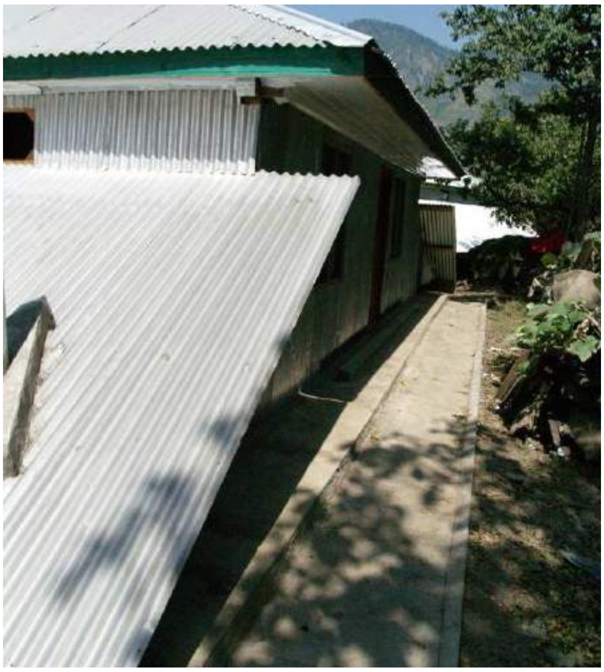


Figure 10b: backside of second storey, ground floor against retaining wall. Ground floor back wall identical with retaining wall?

Figure 10c: A dhajji wall against a retaining wall?

Figure 10d: Lower part stone masonry, upper part dhajji, against a retaining wall, all covered by a concrete slab.

Figure 10e: Dhajji back wall against retaining wall. The upper part of the dhajji wall has been kept without races to allow for storage (i.e. weak dhajji wall).

Figure 10f: a well done channel between a retaining wall and a dhajji back wall

Figure 10g: Back wall in stone masonry, here because a damaged stone masonry house has been transformed in a dhajji house, leaving the lower part of the stone wall.

11. ROOF

Form:

- Most new roofs are hipped or pitched (Fig. 11b-d), sometimes made in a particular shape which is locally known as ‘tower roof’. Roofs are covered with CGI sheets (Fig. 11a).
- Traditional flat roofs covered with mud however can be found in the Manoor valley (Kagan valley), even on new buildings (Fig. 11e). These flat roofs with their heavy beams have been taken over from their traditional timber post and stone masonry houses (which have collapsed during the earthquake). They are too heavy for the newly introduced dhajji constructions except if thicker posts and bracings are used. During this field trip it was not possible to visit and analyse such buildings. (for more illustrations see also section 12).

Figure 11a: ‘Tower roofs’ in AJK and NWFP

Figure 11b: Hipped roofs in AJK and NWFP

Figure 11c: Other roof types in AJK and NWFP

Figure 11d: Pitched roofs in the Kagan valley

Figure 11e: Flat roof on new and old building, in NWFP

Roof slope:

- there is no clear rule for the slope of roofs in relation to the possible snow load. Roof slopes are dictated by tradition. Carpenters don't use height per width ratios (e.g. 1/6, 1/3), but fixed heights for king posts which are correct for average roof widths.

Structure:

- Roof structures depend on the roof shape.
- Tower roofs' are frequent and much appreciated as they allow for storage room with a comfortable height.
- Spacing of rafters often seems too great to support any serious snow load, which people say are frequent (6-10ft of snow!). The same is true for purlins which are often quite far apart. However, few incidences of collapsed roofs have been reported. This might be due to the fact that snow is sliding or melting quickly on CGI sheet roofs.
- Cross sections of rafters seem correct and beams are used in the right sense (height greater than width).
- Tie-beams: their role and correct execution is not understood (Fig. 11f-g). This is not particularly surprising as both the ERRA poster and the training model do show a wrong detail (Fig. 11h).Only two correct examples have been observed, i.e. tie-beam or boards nailed laterally against rafter (Fig. 11i).
- The role of a (hanging) king post is not understood (Fig. 11j). Posts are used under compression (to prop up the roof structure) or under flexion, never under traction (Fig. 11k-l). A post working under traction and to which a beam can be suspended is a concept difficult to grasp.
- Diagonal bracings are completely absent!

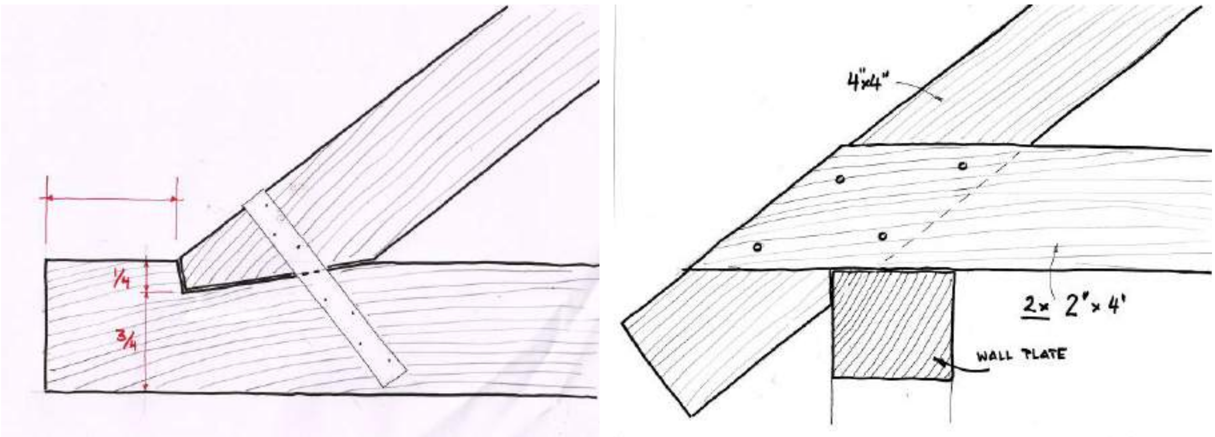


Figure 11f: Correct detail of a tie beam as taught in the trainings.

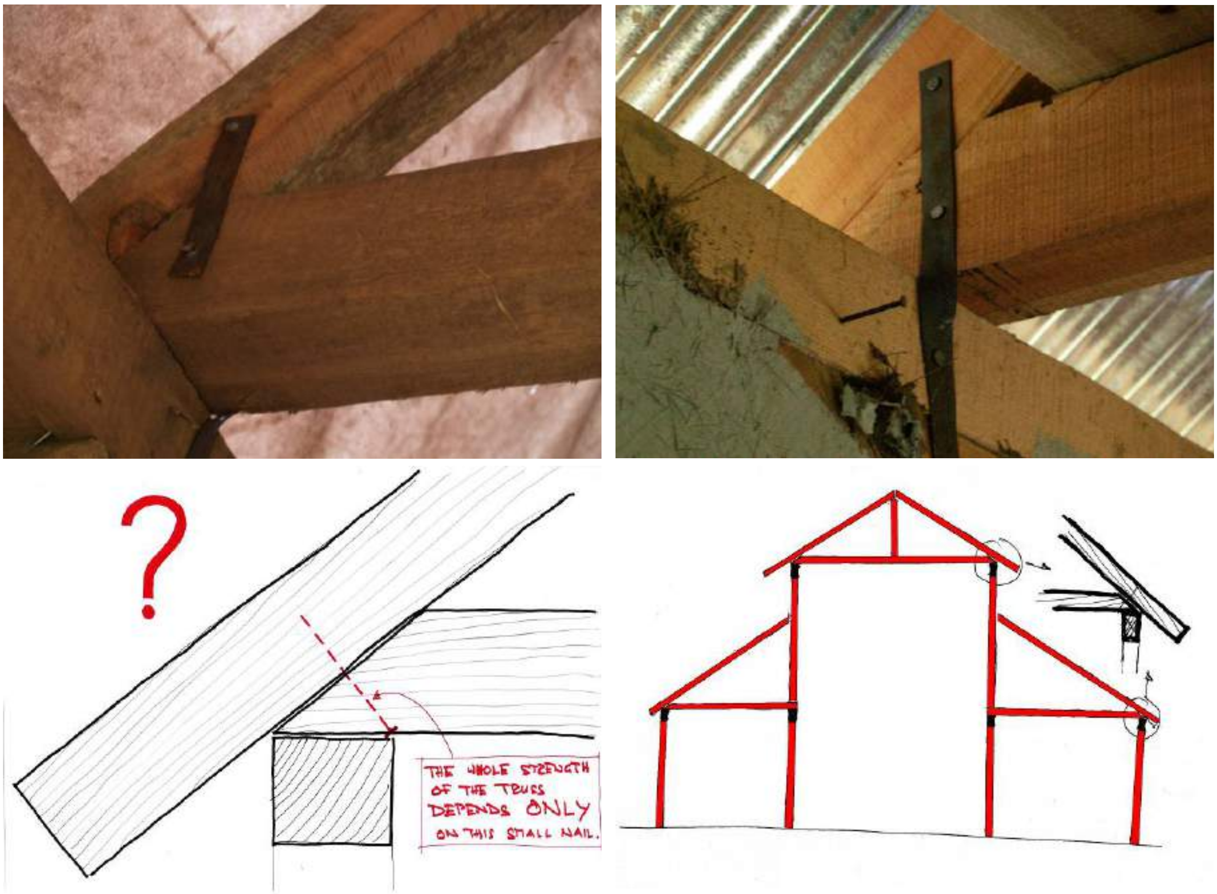


Figure 11g: Incorrect detail of tie beam as seen in most places.

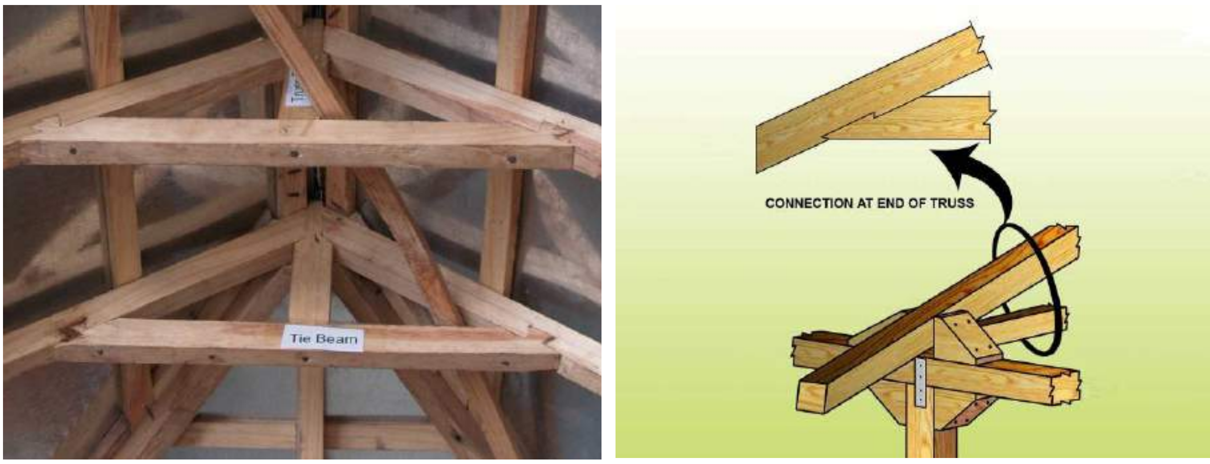


Figure 11h: Incorrect detail on training material and ERRA poster

Figure 11i: Rare examples of tie-beams nailed laterally to the rafters

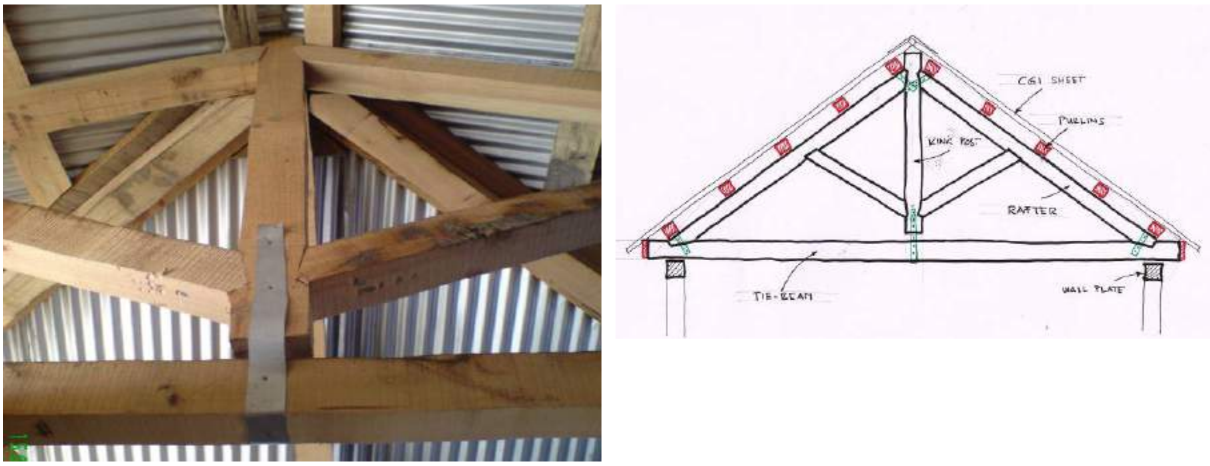


Figure 11j: Proper (hanging) kingposts have only been observed once.

Figure 11k: approximate kingpost on the left, false (standing) kingpost on the right

Figure 11 l: typical roof structures with standing posts

12. OPENINGS

- Particularly in houses built against a slope, all opening are often concentrated on one single wall, the one looking towards the valley. This layout can weaken this wall. Rules about the maximum number of openings and the size of wall peers in between must be better communicated.

Figure 12a: High number of openings on the front side, which can become problematic.

13. INFILLS

- Infills are often done with too much mud mortar and not enough stones. The exact proportion of stone might have to be determined by tests, but it should probably be near or above 2/3 of stone and 1/3 of mud. The proper way of placing the stones might also be important. Infills should not be a kind of ‘situ’-concrete made of mud and stones, but proper stone masonry with mud mortar.
- Infill should be tightly packed to ensure the typical dampening of a dhajji structure.

Figure 13a: Infills should mainly be of stones with a limited amount of mud.

14. PLASTER

- Plaster is generally good, but sometimes too much water had been added, resulting in big cracks (Fig. 14a).
- In one example, an excessively thick layer of mud has been added to the wall, resulting in cracking (Fig. 14b).
- Reinforcement of mud with straw or pine needles unfortunately is rare (Fig. 14c).
- Internal plaster is mostly well done. Only if painted in white, cracks between infills and timber trucutre become apparent.

Figure 14a: excessive water in the plaster mixture results in cracks when drying.

Figure 14b: excessive thickness of a single plaster layer results in cracking.

Figure 14c: added straw or pine needles are rarely found (left: pre-EQ building; right: external plaster on a new house)

Figure 14d: top left: good rustic plaster; top right: perfect plaster; bottom left: cracks between structure and infill only visible when painted white; bottom right: decorative cuts to hide cracks

15. Composite structures

- People tried to recover concrete structures put up before dhajji was introduced. The connection between concrete columns and the dhajji timber structure is not obvious and some development work is needed to suggest good solutions.

Figure 15a: composite structures concrete - dhajji

Attachment 1: Day by day activities during the field trip

Day	*Date*	*Activity*	*Persons met*
Sunday	17.8.08	Flight Zurich – Islamabad (dep. home 09.30h, arr. I'bad 09.00h)	
Monday	18.8.08	Meeting Rural Housing Coordinator Un Habitat	M. Stephenson (UN Habitat)
Tuesday	19.8.08	Meeting UN Habitat team in Islamabad office, meeting Rural Housing Coordinator ERRA, visit demo buildings on new ERRA premises, project and security briefing at SDC HQ	UN Habitat team M. Waqas (ERRA), Nicole Ruder SDC
Wednesday	20.8.08	Meeting Country Prgm Manager UN Habitat, Trip to Bagh via Dirkot (visit HRC Dirkot), Seen demo bldg by Craterre	A. Yachan, A. Pont, S. Moghaddam
Thursday	21.8.08	Trip Bagh – Bheddi, visit new Dhajji constructions in Bheddi	UN Habitat field team
Friday	22.8.08	Trip Bagh – Sudanghali – Hatian (HRC) – Muzaffarabad, visit new Dhajji constructions along the way	UN Habitat field teams
Saturday	23.8.08	Visit Muzaffarabad old town and new Confined Masonry constructions, trip to Mansehra	UN Habitat engineers
Sunday	24.8.08	Mansehra SDC office, trip to Battal – Kodar – Sacha Kalam – Jibori – Mansehra	SDC team leader T. Fisler
Monday	25.8.08	Mansehra – Battagram – Shamlai – Mansehra, visit Dhaji demo house in Shamlai	SDC field team
Tuesday	26.8.08	Mansehra – Balakot (HRC) – Jared – Konhar Danna – Mansehra	SDC field team
Wednesday	27.8.08	Trip to Peshawar. Visit EQ engineering Centre at UET	Dr. Qaisar Ali and his team
Thursday	28.8.08	Meeting Dr. Qiasar Ali and team to define dhajji testing content and schedule, trip to Islamabad,	Dr. Qaisar Ali and team
Friday	29.8.08	Write up test content and schedule at SDC, meeting SKAT reps for vertical kiln project, debriefing with SDC team leader	M. Pecnik (SKAT) T. Fisler (SDC)
Saturday	30.8.08	Wrap up discussion with Maggie UN Habitat, visit Skat office,	M. Stephenson (UN Habitat), D. Wyss (SKAT),
Sunday	31.8.08	Return flight dep. Hotel at 0.30h, arrival home 17.00h (+4hrs)	

Attachment 2: Proposed lab tests

Dhajji Research Project SUPSI-UET 2008-9

Tentative dhajji testing schedule after discussion with Prof. Dr. Qaisar Ali, UET-P

	Test activity	*Numerical*	*Shake table*	*Press*	*Test date*
	Full scale wall samples				
1	Numerical theoretical model of a full scale wall sample	X			
2	Full scale wall in-plane testing (good infill: ¾ stone – ¼ mud infill)			X	
3	Correction of numerical model on the basis of test evidence	X			
4	Full scale wall in plane testing (bad infill: ½ stone – ½ mud)			X	
5	Testing of influence and correct location of openings	X			
6	If timber still useable, test of openings in sample wall			X	
	Shake table tests with scale 1/3 models				
7	Base line test of model according to ERRA guidelines		X		
8	Numerical model of 2 storey building (verification of post sizes)	X			
9	Shake table test of single room two storey building		X		
10	Test of typical Dhaji house layout, single storey with 3 rooms, one of which 20 ft long.		X		
11	Additional shake table test to be defined		x		
	Testing of corner connections				
12	Testing of different dasa-post connections, in corners and wall centres: - connection just with nails - with added boards of blocks - with short bracings - above three with and without straps	X		X	

Tom Schacher, Islamabad, 29 August 2008