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Aceh Peoples Forum (APF)

Permanent House Design
Banda Aceh

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Indonesia
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Abstract

The Tsunami Relief and Rehabilitation Programme, set up following the devastating tsunami of 26 December 2004, allocated large international financial support to the reconstruction of houses lost in the disaster. Many NGOs are involved in the reconstruction programme of permanent houses in the Aceh region of Sumatra, Indonesia. Two years after the disaster, the Shelter Advisor visited a number of permanent housing projects funded in part by Trócaire (Ireland) to assess the technical aspects of the designs. Aceh Peoples Forum (APF) houses are relatively low-cost in comparison to other NGOs, a result of their management and implementation structure and their permanent house design. The box-frame house with stiffener columns at all wall junctions being built by APF has a lower construction cost than pre-cast concrete columns with infill masonry. Observations are provided on the technical design of the stiffener columns, pointing out common errors. Ventilation, material use and sanitation systems are also discussed.

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1. INTRODUCTION

On 12 February 2007, a meeting was held with Mr. Tarmizi, Aceh Peoples Forum (APF) Executive Director, during which photographic material and drawings of the APF houses under construction were reviewed.

During the site visits to various project areas by the Shelter Advisor, it became apparent that many permanent houses under construction had common shortcomings, including housing projects using stiffener columns. The observations in this paper are elaborated upon with supportive data from other (non-APF) building sites applying stiffener columns.

Stiffener columns are perfect for making an earthquake-resistant house, even for double storey buildings, provided there is proper execution of the reinforcement design and casting of the stiffener columns by the self-help builders or contractors. Once the tie-beams are cast, the actual reinforcement bars inside are hidden. The same holds true for the brick walls and stiffener columns; once they are plastered over, one cannot see whether they are well constructed or not. For that reason permanent site inspection is necessary.

A stiffener column in burned brick walls is made by casting concrete reinforcement bars in concrete. These stiffener columns are placed in log walls, at wall junctions and at wall ends.

Stiffener Column Cast

Stiffener Column between Two Doors

The information provided in this report serves two purposes:

- To provide technical information on the methodology of the APF housing design.
- To provide general information for other building projects using the same technology.

2. Construction Cost

One of the most important findings is that the 117 APF houses are being realised for almost half the cost as compared to houses from other NGOs or aid organisations. The following example was given: the Canadian Red Cross 45 m^2 house is costing Rp. 90 million (≈ 2 million/m^2), while the APF 42 m^2 house costs only Rp. 48 million (≈ 1.15 million/m^2). Both houses have an entrance porch. The following main factors are accredited to this situation (the estimated savings costs are indicated at the end of each point):

- The APF design has stiffener columns. These are of reinforced concrete and post-cast in between masonry walls (10 cm x 12 cm). Many other houses have pre-constructed reinforced concrete columns of 20 cm x 20 cm, in between which the walls are later masoned (≈ Rp. 10 million).
- For each house, a small building team consisting of five people (2 craftsmen and 3 labourers) is mobilised and trained by the SKS contractor. SKS only delivers the building materials to these teams (≈ Rp. 8 million).
- APF is building exclusively with one contractor (SKS), having no sub-contractors. A main contractor often sub-contracts the houses out to local contractors and usually requires 10-12% of the building cost (≈ Rp. 7 million).
- SKS and APF are both non-profit organisations, having lower overhead expenses than commercially operating contractors (≈ Rp. 4 million).
- The overall building speed with many small construction teams is rather slow, avoiding excessive pressure on the local building material market (≈ Rp. 2 million).
- The APF design has cemented floors, not tiled such as with the BRR houses (≈ Rp. 4 million).
- There is no sanitation unit incorporated in the design (≈ Rp. 5 million).
- There is no reserve budget in the planned budget for variations or adaptations (≈ Rp. 4 million).
- APF uses university engineer students (new graduates) as construction trainer-inspectors (≈ Rp. 2 million).

It can be observed from the above list that, although the technical building design has an important influence on keeping the building cost low (≈ Rp. 10 million = 15%), the institutional organisation plays even a greater role (≈ Rp. 20 million = 30%).

2a. Contracting

The decision whether or not to employ contractors or local building teams for the construction depends on the local situation, availability of skilled labour and the overall situation of the building market.

APF was able to keep the construction costs low by working with only one contractor (SKS), being a non-governmental organisation with relatively low overhead costs.

It was explained that open/public tendering often resulted in big contractors being awarded contracts for a large number of houses, but then sub-contract the work in smaller portions to local contractors. The local contractors then need to realise the same construction for about 10% less. These local contractors sometimes further sub-contract the construction to local masons, taking a 10% profit. The result of this sub-contracting process is often that the initial main contractor does not exercise sufficient quality control over its sub-contractor and disappears with its advance finance. To avoid such and to improve quality control, the following is recommended.

Recommendations

- ➢ *It is advisable to stipulate in contracting agreements that the contractor self-implements the house construction and cannot fully sub-contract the work to third parties. Sub-contracting certain components of the supplies or construction may be permissible provided the contractor remains fully responsible for the execution of the work.*

- *Advances paid to the contractor must be under true bank guarantees and be recoverable in case of non-compliance or failure by the contractor. A financial reservation of 5-10% should be kept on the progress payments as a quality guarantee.*

- *Inspection teams from the Principal (financer) should be able to make independent observations on the quality of the work, and not be influenced by the contractor. These inspectors should team up with the beneficiaries and capacitate them in quality inspection because they are permanently on site. The Principal and the inspecting beneficiary should have a reporting procedure for each construction phase and guidelines to follow when incompliance of construction standards by the contractor is identified.*

- *Well-defined quality-control lists in the local language should be available for the building inspectors and the beneficiaries to serve as reference for the quality inspection. The Principal's building inspector should review the quality-control lists with the local site inspectors and beneficiaries at a prototype house to ensure a good understanding of the criteria.*

2b. <u>Size and Finishing Quality</u>

Houses built entirely from locally available timber are much cheaper than brick houses, but such houses are considered "semi-permanent" by the villagers. The wooden houses, if unpainted, can be realised for Rp. 10 million. This is one-quarter of the cost of a house built in durable materials. Durable wood with an authentic logging certificate is becoming a scarce commodity. Often timber having a "logging certificate" is not from sustainable forests. In addition, due to the high demand of wood, it is often fresh wood and the quality is reducing.

In the early days after the tsunami, several NGOs built houses similar to those the villagers lost. However, after this initial period, NGOs and the BRR started to build complete houses with reinforced concrete columns and brick walls fully plastered. From then onwards, houses having the upper part from timber were called "semi-permanent" and the brick and reinforced concrete houses were called "permanent houses". The villagers henceforth strongly expressed to the NGOs their desire for a "permanent house".

The first wooden houses were in many cases better than what the people lost.

Discussion about house size became complicated for NGOs building the standard 42–45 m^2 houses when in the same region another NGO began building 60 m^2 houses. Beneficiaries often go shopping for the best NGO.

Recommendation

A firm and clear agreement should exist among the NGOs with regard to minimum-maximum house sizes, indicating the total floor and wall area (including the porch, kitchen and sanitation). In addition, the precise finishing details and quality of the walls, floors, ceiling, doors, windows and fittings[1] *must be specified in order to reduce competition.*

> "The locals know that a lot of money has come to Aceh, so they want their share and do not accept temporary shelters or semi-permanent houses anymore."

2c. Supervision

The building method influences the overall delivery speed of the houses. In the case of APF, SKS (as a non-profit contractor organisation) not only delivered all the building materials, but also mobilised teams of five persons (2 craftsmen and 3 labourers) for each of the 117 houses being constructed. In addition, they hired engineering students from the university to act as construction supervisors cum trainers. APF monitors the work, while occasional site inspection is provided by the local government through the BRR inspectors.

Regular inspection by BRR qualified building inspectors is the ideal situation. Inspection of reinforced concrete constructions should be realised before casting the concrete. However, the vast number of houses being built in the many locations made it impossible for the BRR inspectors to be always there in time. The quality of the contractor and inspection from the Principal therefore are essential elements in ensuring proper reinforcement and concrete quality.

Recommendation

In a disaster reconstruction programme and with a shortage of qualified site inspectors, it is a good idea to make agreements with technical universities to have graduating students get involved in the building site inspection. It is not only economical, but provides the project with knowledgeable young professionals able to grasp technical instructions quickly. For the students, the practical experience gained will be beneficial to their future career.

2d. Building Teams

According to the information obtained, the APF housing project was based on the idea that each house would be realised by its own construction team, involving the future house owner as much as possible.

In a large disaster-relief reconstruction programme, the need for quick delivery of the houses is an important criterion for the victim, the government and the donor. However, the need for every villager to build his/her own house or to become skilled in construction is not a criterion as this requires additional training needs and will bring too many semi-skilled people into the building market. A good option is for a few villagers from each community to be trained so they can use the acquired skills after the housing project has ended. The organisation of one building team per house may include many unskilled workers, which certainly makes the project rather slow and requires a lot of supervision.

An advantage of self-help construction is that the house owner can later extend the house using the acquired skills, rather than hiring an external contractor (high cost). As usual, a balance is required between the need for fast construction and empowering the population in resolving their own housing needs. If there is a constant external pressure to produce the houses quickly, the inclination will be to hire external contractors. If funds are limited, the choice will lean towards self-building.

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[1] There is a wide variety of door/window fittings and paints available in the market. It is therefore essential to specify brand names to ensure reasonable quality. For paint finishing, the Bill of Quantity should specify the painting procedure for timber and cement walls.

Recommendation
To increase the speed of construction, a select number of building teams should build the houses in series, rather than trying to build all the houses at once and having one team per house. First, a series of foundations (one after the other) should be realised, then walls, roofs, floors, etc. In this way, as the craftsmen obtain more practical experience and routine skills, the overall delivery speed will increase and the need for close supervision will reduce over time.

2e. Material Delivery

The SKS contractor is supplying the building materials to each building site. The efficiency, and therefore the cost of this delivery service, depends on the organisation of transport, security of the materials after delivery, and the collaboration of the villagers in keeping track of the supplies.

Recommendation
Bulk delivery of building materials should be organised to clusters of houses to improve on the efficiency of transport. It is recommended to deliver some materials to community-managed central storage facilities, which provides safety (doors, windows, fittings, paint, sanitation) and dry storage for cement. The building teams can then collect the materials from these local depots depending on their advancement in construction and certification of progress.

2f. Budget

The budget of the 117 houses is committed to the particular sites, but apparently has no flexibility for changes or adjustments in the design. The overall construction cost of the self-help houses or working through a non-profit contracting organisation is so much lower than contractor-built houses that having some reserve funds would go a long way to making eventual adjustments or additions.

For example, when many of the new APF houses were flooded during a rainy period, the first consideration for the remaining houses would be to build them 40 cm higher. This obviously would cost money. However, without any budgetary flexibility, the decision cannot be taken without first going back to the donor.

Although it is the responsibly of the local authorities to supply water and sanitation, it is not always realised in time. Either the people occupy the permanent houses with provisional solutions or remain living in the temporary shelters. Because of budget constraints, these facilities cannot be supplied as part of the housing package.

Recommendations
- *In future budgeting of houses, some reserve should be included to allow for eventualities, such as raising the floor, adding steps or changing the sanitation option.*
- *Water and Sanitation (WatSan) should always be included as part of the overall house design, whether part of the main building or separate. In new settlements, consideration must be given to the population and housing density to ensure safe collection of good-quality drinking water and safe disposal of sewerage.*

3. House Design

The community was presented with and agreed upon a house design. From various discussions, it appears the community might have been shown only one design. In addition, as women do not usually participate in community meetings, it is most likely that the design was only presented to the men.

An important aspect of the community consultation is that the community (sometimes through the village headman) agrees on a particular house design and construction method. This agreement, however, does not always signify that the villagers have a full understanding of the size or layout of the design, but accept the proposal from the donor on their assumption of its technical expertise.

3a. <u>Floor Height</u>

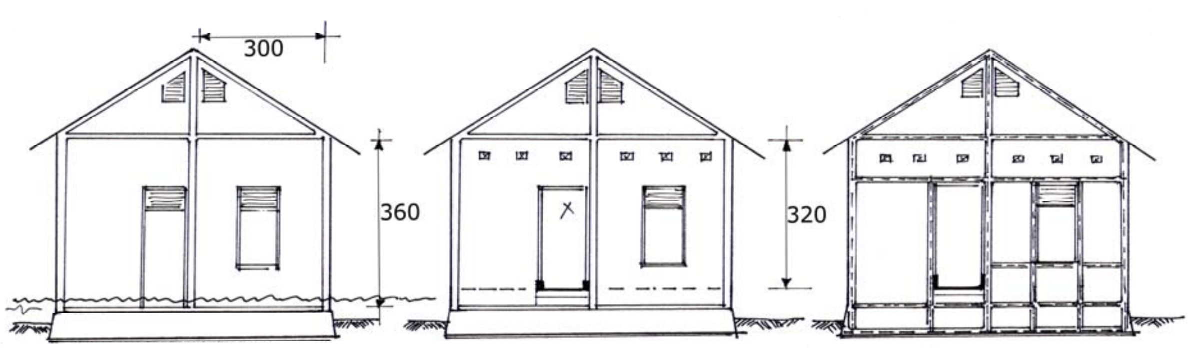
In comparison to other houses, the APF house has a particularly high ceiling (3.60 m) instead of the usual (recommended) 3.00 m. The additional height was realised to reduce the heat radiation from the metal roof onto the plywood ceiling. However, when the space between the metal roof and the suspended ceiling is well ventilated and the rooms are reasonably ventilated as well, the ceiling height of 3.00 m is adequate.

Most houses were being rebuilt on the original plot (land owned by the beneficiary). The floor of the house was only one or two steps above the soil level. With the heavy rain in January 2007, many of the new APF houses were flooded above the floor level for several days. Although the villagers considered this as exceptional, a recurrence is highly likely.

<u>*Recommendations*</u>

- *With the 3.60 m room height, the cement floor in the existing houses can be raised 40 cm to keep it above any future flooding. In this case, the ventilation vents above the doors should be reduced and the door raised along with the floor.*

- *The floor of new houses built should be 40 cm higher (two steps) than the current houses to avoid recurrence of flooding. The room height should be 3.00 m from floor to suspended ceiling and the ground floor should be adequate in height to avoid floods (four steps above the soil level).*

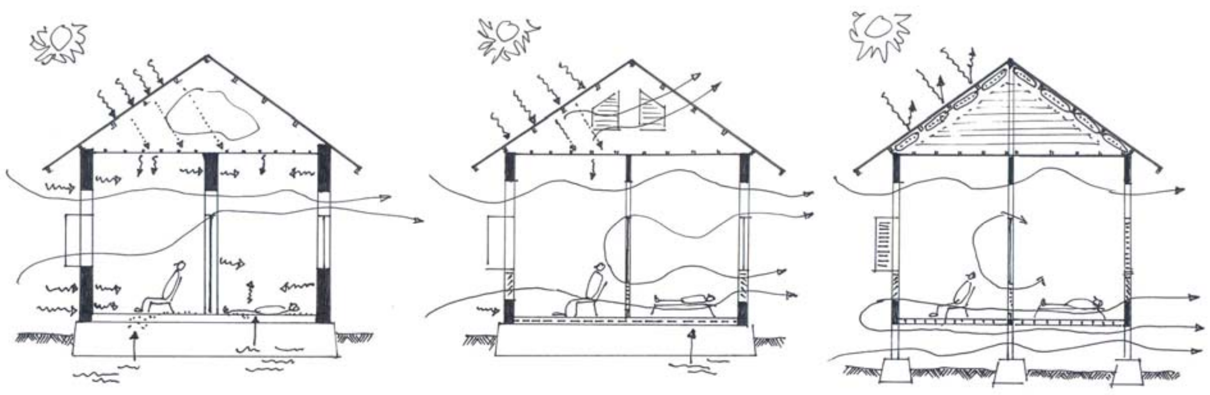


Left:	The APF house design. Some building site areas are subject to flooding.
Centre:	The same house design with the floor raised by 40 cm, now higher than the seasonal flood level. The ventilation vents above the door are removed to provide space for the raised front door. The frame of the front door should have spur-stones or cemented footings to minimise moisture affecting the doorframe.
Right:	This sketch shows the principle of a fully earthquake-resistant house design with thin stiffener columns along all window and door openings, lintel beam and gable. In such a design, the stiffener columns can be the width of the wall with only two reinforcement bars per column.

3b. Ventilation and Insulation

Traditional houses have light walls and ample ventilation through the rooms. The palm-leaf roofs are not very durable (need to be replaced every five years), but are climatologically cool and well ventilating. Metallic roofs require a suspended ceiling to reduce the heat radiation.

Recommendation
The amount of heat transfer from metallic roofs is reduced by creating ample space under the roof and having this space well ventilated. When the distance between the metallic roof and the ceiling is less than 20 cm, a layer of thermal insulation material is required. Such an insulation layer can be made from agriculture polypropylene (PP) fibre bags filled with coconut-husk fibres or empty PET water bottles.



HEAVY WALL DESIGN — LOW + TOP VENTILATION — TRADITIONAL DESIGN

Heavy Wall Design has large heat accumulation during the day and requires good ventilation to cool off the walls. Because there are no low ventilation openings, warm air is removed only from under the ceiling. With lack of ventilation under the roof, the ceiling gets very warm and heats the rooms. The cement floor does not stop rising moisture from the ground, making the rooms moist.

Low + Top Ventilation is introduced here. Plastic foil is placed under the floor before casting, keeping the cement floor dry. The walls are less heavy and the inside wall is lightweight, allowing for rapid cooling in the evening.

Traditional Design has all the properties of a comfortable house. Because the lightweight floor is raised, it cools off rapidly in the evening. When metal roofing sheets are used, thermal insulation can be placed under the roofing sheets to stop the heat radiation.

3c. Ventilation Openings

The villagers preferred larger windows in the house than were originally designed. Based on experience, the interior of houses with large windows is drier than houses with small windows. This is correct because large windows allow for better cross ventilation, creating a drier interior. For comfort of the occupants, low-positioned ventilation openings would provide air circulation at sitting and sleeping height. The lower ventilation is often omitted in the new house designs.

Recommendations

- *The design of the windows should consider ventilation openings to remove the warm layer of air from under the ceiling, as well as low ventilation openings under the windows, to provide a cooling airflow at sitting or sleeping level. Ventilation vents should be installed in the lower part of the internal doors. Ventilation openings under the windows should be fitted with mosquito mesh to prevent the entry of snakes and creepers.*

4. Stiffener Columns

Most house designs observed in the newly reconstructed villages are ground-floor-only houses. For this design, the possible earthquake impact is rather limited and does not require heavy wall reinforcement, such as 20 cm x 20 cm reinforced concrete columns. The 10 cm x 12 cm stiffener columns of the APF houses, combined with foundation ring beams, upper lintel ring beams and fitted with a lightweight roof (red painted 0.3 mm sheet metal), are more than adequate to withstand an average earthquake, provided the stiffener columns are anchored into the brick walls.

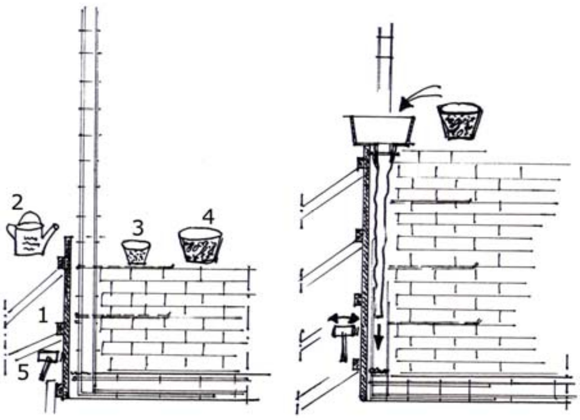
A benefit of using stiffener columns is that it is easier and cheaper to extend the house than when pre-cast reinforced concrete columns are used. Stiffener columns are cast against and in between the masoned brick walls, whereas the 20 cm x 20 cm square reinforced concrete columns require large amounts of formwork and concrete, both expensive elements. The adherence between the wall and the stiffener column is automatically achieved, while special anchorage needs to be made to connect the masoned wall to the square concrete columns.

The photo right (not an APF house) shows a typical problem related to the casting of stiffener columns in between burned brick walls. The columns are cast in three phases, each about one meter high. Yet the casting is incorrect due to three reasons:

1) The bricks are inadequately watered before casting, thus absorbing large amounts of cement water from the concrete. With cement and water taken out of the concrete, it will leave the concrete porous and weak. The porous concrete will not provide sufficient protection to the reinforcement bars against corrosion, especially not in coastal areas with salty sea air.

2) The casting is not primed with a bucket of strong cement sand slurry (1:3) that coats the reinforcement bars and provides an amount of cement mortar to rise with the concrete when the column is cast.

3) When casting the columns, the concrete itself or the formwork is not adequately vibrated to ensure that the concrete settles in all corners and around all reinforcement bars.



The sketch left shows the same issues.
Step 1 – strong form work
Step 2 – watering the bricks
Step 3 – priming with cement-sand slurry
Step 4 – casting concrete
Step 5 – vibrating the formwork or concrete

For casting from a height greater than one meter, a funnel is required to avoid dis-aggregation.

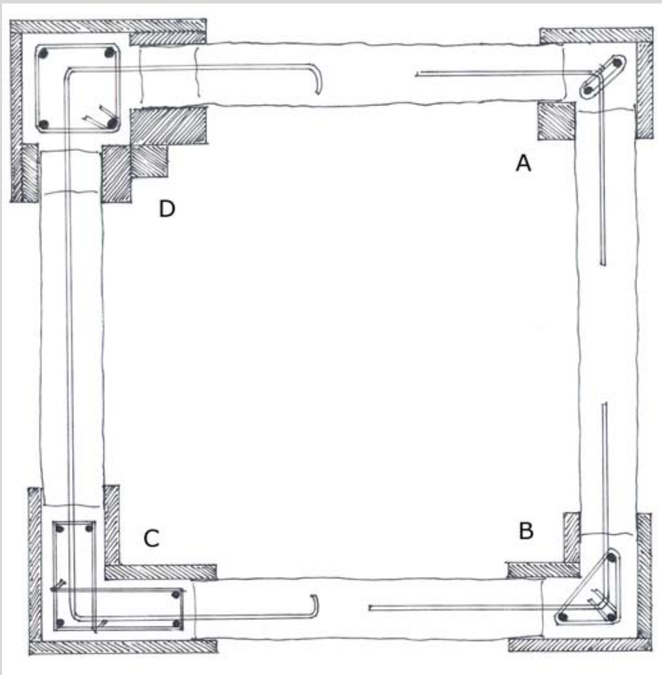
The photo right (not an APF house) shows some typical problems related to the execution of the stiffener columns. The reinforcement of the vertical columns and the horizontal tie-beams are not sufficiently long enough to anchor into each other and will be pulled out of the junction during an earthquake. Such technical faults can be avoided by adequate drawings detailing the reinforcement and by constant site inspection and control of the labourers. The financing NGO should ensure frequent site inspection to avoid mistakes, especially when the villagers are self-building the houses.

Recommendation
For ground-floor-only houses, the wall reinforcement design with stiffener columns at all wall junctions, in combination with ring beams at floor and lintel level, is adequately strong enough to withstand average earthquakes. The stiffener columns should have horizontal anchorage into the masoned walls.

Options for Stiffener Columns Cast Alongside 10 cm Burned Brick Walls

Corner A: Minimum solution with only two bars. When applied along all openings (including door and window frames) and with horizontal tie-beam reinforcements, this is an earthquake-resistant and low-cost option.

Corner B: Wider and heavier stiffener columns. This allows for **L-**, **T-** and **X-**shaped wall junctions and intersections, and has an increased number of reinforcement bars and stiffness. Horizontal reinforcement is required for good earthquake resistance.



Corner C: This solution can be used when columns need to be stronger or when the distance between columns becomes greater than 4.00 m. Because of the increased distance between the bars, a 10 mm bar diameter can be used, having the same moment resistance as slimmer columns with thicker bars.

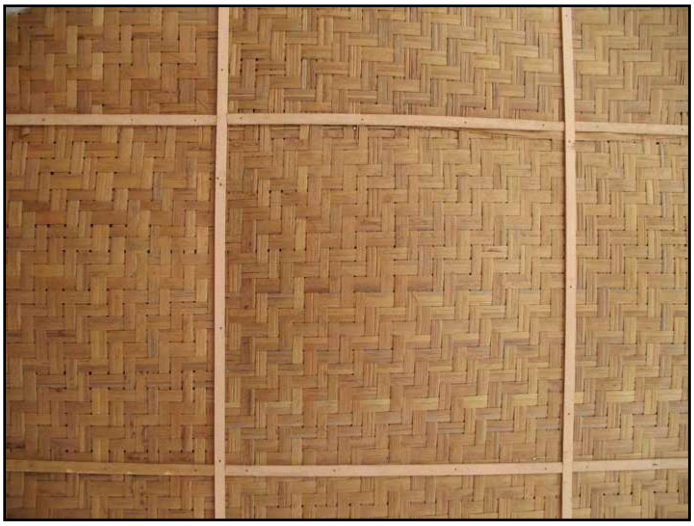
Corner D: Option for casting wider (20 cm x 20 cm) columns onto existing brick walls of 10 cm. This is an option when heavier reinforcement bars are needed (12 mm) or when the columns are to be part of an autonomous support frame.

5. Material Use

5a. <u>Ceiling Sheets</u>

In some construction sites, the plywood (triplex) suspended ceiling panels were being applied without first whitewashing the hidden side. Whitewashing provides preservation against insects or fungus, and reduces the vulnerability of the ceiling sheets to moisture. With only painting the underside, warping will easily occur.

<u>*Recommendation*</u>
The ceiling panels should preferably be made from fibre-cement sheets (asbestos-free Kalsiplank, 3 mm). When ceiling panels are made from waterproof plywood sheets, these sheets need to be whitewashed on the hidden side before fitting to reduce their susceptibility to humidity absorption (and warping). Other ceiling materials can be used – bamboo, reinforced gypsum panels and decoratively woven bamboo mats. Bamboo mats should be varnished before application.



(Bamboo ceiling mat)

5b. <u>Timber Preservation</u>

In various locations, it was noted that timber for the roofs was of low quality and does not have the necessary wood preservative to provide extended lifetime. Once the roofs are finished and suspended ceilings applied, it will be difficult to observe possible damage to the wood by fungus, termites or other deteriorating factors.

<u>*Recommendation*</u>
The roof structure should be treated with wood preservative, especially when these are later covered with a suspended ceiling. The support timber for the suspended ceiling also needs to be well treated with wood preservative, especially because this is commonly of lesser quality timber.

5c. <u>Reducing the Amount of Timber Use</u>

"Legal timber" is becoming difficult to obtain. The amount of wood in the house design can be reduced by replacing timber with:

- Light gauge galvanised profiles for roof trusses.
- Plastic door and door frame for the sanitation unit. This door is often wet and the plastic door will not rot as with a wooden door.
- NACO glass laminates in GI turning frames for windows instead of wooden sashes.
- Fibre-cement boards (asbestos free) for suspended ceilings.
- Light gauge galvanised profiles with fibre-cement boards for internal walls.
- Cement ventilation blocks under and above the windows.
- Spur-stones or foot pieces under all doorframes.

6. Sanitation Systems

Under the current contract agreement with APF, the sanitation system is located outside the houses. The agreement with the local authorities and the design of the house assumes that the people will realise the sanitation systems themselves. To do this, the villagers should have the funding and the knowledge to design and implement adequate systems; systems that also remain operational during periods of flooding. From observations and discussions, this does not seem to be the case. The following points can be mentioned:

- From interviews with female villagers, it seems that many want the sanitation attached to or inside the house because they consider it inappropriate for other people to see one entering or exiting the toilet.
- Villagers have insufficient capital (after tsunami) to realise their own sanitation.
- If villagers are given a standard amount to realise their own sanitation, the sum should only be paid upon correct completion of the unit; otherwise it is highly likely that they will only realise the cheapest solution.
- There is insufficient knowledge within the communities to realise safe sanitation systems that can withstand seasonal flooding and remain operational.
- A number of households use the surrounding bush, open water and fields for defecation. Defecation in open water may negatively affect large populations (diseases such as typhoid).
- Increased population densities require improved sanitation systems as compared with those commonly used in the former lower density villages.
- Many sanitation systems incur recurrent expenses for operation and maintenance, while the former systems in the low-density settlements had none.

In order to resolve these issues, local authorities are now trying to contract INGOs for the installation and delivery of water supply and sanitation systems (WatSan).

<u>*Recommendations*</u>

➢ *For the rehabilitation housing projects, WatSan should always be included and not left up to the local population to solve in the traditional way. The designs need to be negotiated with the local government planning and health authorities, as well as with the settlement communities, to find safe and sustainable solutions.*

<u>Photo Left</u>: An open septic tank made from concrete rings. The foot of the rings is widened to avoid floating in high groundwater level.

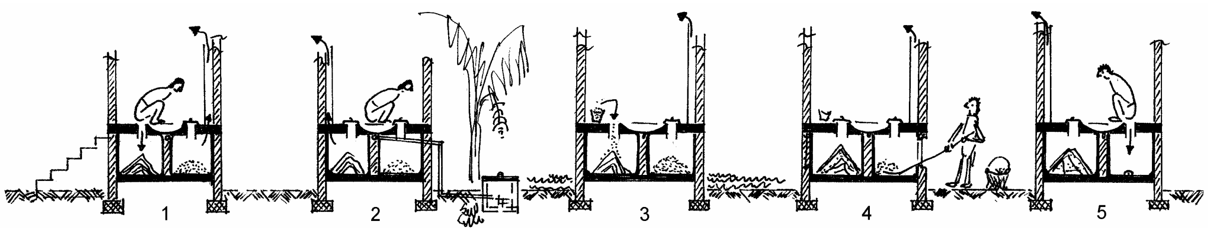
<u>Photo Right</u>: The complete system with the effluent flow bed. The effluent bed should be planted with sugarcane, banana or other plants that thrive in nutrient-rich overflow water. When the groundwater level is subject to regular flooding, the system should be built higher above ground. This implies that the toilet inside the house also needs to be built higher.

- *In areas where the population draws groundwater from on-site water wells, the distance between the well and sink pits or soak-aways (after a septic tank) should be great enough to ensure safe well water. Soil conditions and infiltration speed must be taken into consideration, as well as their position to the WatSan of the neighbouring plots.*

- *Systems that required high maintenance costs for the population (such as electric pumps or regular washing of biological filters) are not recommended. On-site sewerage piping from the toilet towards the septic tanks or soak-away should be well protected from sunlight and possible damage. PVC may not be exposed to the sun.*

- *Systems that require regular emptying of sealed septic tanks should only be installed when it can be assured that the septic tank slurry will be safely processed and disposed of without health hazards or groundwater pollution in other areas. The emptying equipment must have free access to the septic tanks.*

- *In areas flooding annually, for either short or extended periods, the WatSan solutions need to be adequate to withstand these floods without overflowing or allowing effluents to escape into the surface water. Systems such as elevated closed septic tanks and Ecosan toilets should be promoted for flood-prone areas. Systems with biological filtration ponds for post-septic tank effluent can handle high groundwater levels.*



TWO-PIT ECOSAN TOILET SYSTEM

Sketch 1: Two ventilated water-sealed chambers above the ground – one in use and one closed for composting.
Sketch 2: After defecation, anal washing is done over the central pan (urine drain).
Sketch 3: Add wood ash or dry clay to fresh faeces and close squatting hole with lid.
Sketch 4: After ½ year, remove compost from the closed chamber.
Sketch 5: Close the full chamber (for ½ year) and start using the empty chamber.

- *The introduction of new sanitation systems needs to be decided upon in the beginning phase of the housing projects because it requires extensive motivation and education of the population.*

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