Technical Sub-Community of Practice

Construction Good Practices, Build Back Better & Durable Permanent Shelter & Housing

Webinar

Wednesday April 1st, 2026

GLOBAL SHELTER, LAND AND SITE COORDINATION CLUSTER

GLOBAL SHELTER CLUSTER
Coordinating Humanitarian Shelter and Settlements

Housing, Land and Property AoR

CCCM CLUSTER
Supporting displaced communities

WEBINAR

Reinforcing Shelter/Housing Construction Standards and Building Codes with Authorities, Private Sector & Civil Society

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April 1st 2026 - 13.00 to 14.30 (CEST)

Mathieu Gamba
Shelter, Infrastructure & DRR Advisor
MEDAIR

Bee Rowan
CEO
STRAW BUILD

Pierre Paya
Project Manager
BUILD CHANGE

Martin Hammer
Architect & Co-Director
BUILDERS WITHOUT BORDERS

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TIME	Description	Speakers	Duration
13:00	Welcome & Introduction	Mathieu Gamba – Facilitator, Medair	10 min
13:10	*“The Revision of Haiti’s National Building Code as a driver to strengthen the construction ecosystem”*	Pierre Paya – Project Manager, Build Change	20 min
13:30	*“Readiness for Post-Disaster Rebuilding: Building Codes and Safe Construction Practices Lessons from Pakistan, Haiti, Nepal”*	Martin Hammer – Architect & Co-Director, Builders Without Borders	20 min
13:50	*“Construction Technology: Lime Stabilized Soil (LSS)”*	Bee Rowan – CEO – Straw Build	20 min
13:10	QUESTIONS/DISCUSSIONS	Mathieu Gamba – Facilitator, Medair	15min
13:25	Next Step / Conclusion	Mathieu Gamba – Facilitator, Medair Liz Palmer, Save The Children	5 min

THE HUMANITARIAN RESET

2025

Triggered by severe funding cuts — including major reductions in US assistance starting in early 2025 — the ERC launched the Reset to make the system lighter and more efficient.

Fewer Clusters

From 11 standalone clusters to 8, with the new SLSC Cluster integrating Shelter, CCCM and HLP

Hyper-Prioritization

Operations refocused on the most critical life-saving needs; reduced number of people targeted

Power to Local Actors

Lighter sub-national coordination, more flexible funding and strengthened local leadership

Reduced Bureaucracy

Streamlined coordination systems and reporting requirements across the humanitarian response system

HUMANITARIAN RESET 2025 RESULTS

WHAT CHANGED

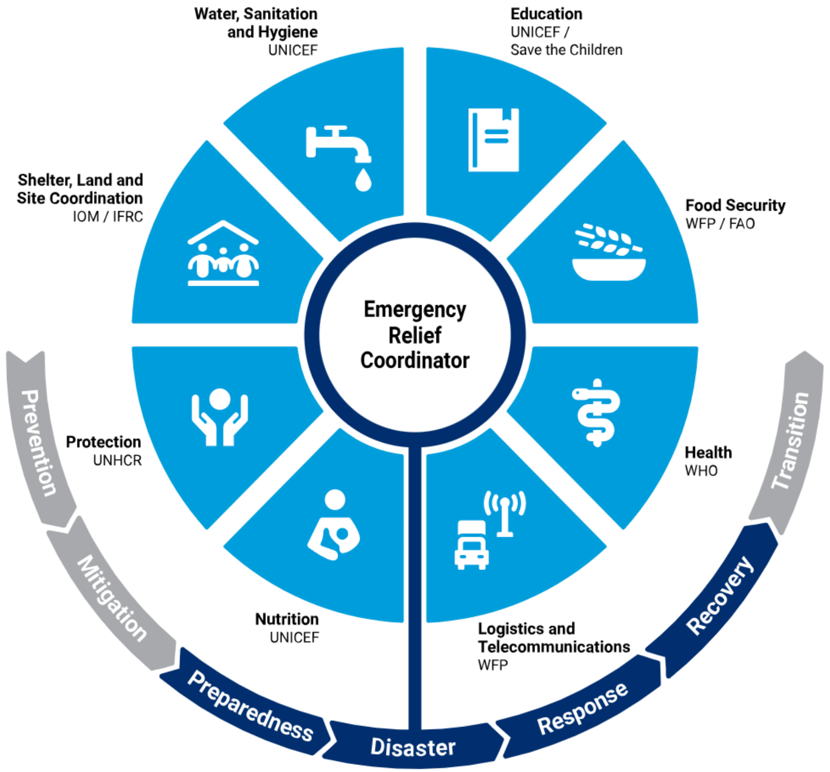
FROM		TO
11 standalone clusters	→	**8 clusters (as of 1 January 2026)**
Shelter Cluster: UNHCR/IFRC co-lead	→	**SLSC Cluster: IOM/IFRC co-lead**
Separate CCCM cluster	→	**Integrated Shelter + CCCM + HLP**
Conflict vs. disaster split between agencies	→	**IOM & IFRC jointly accountable for both**

SLSC THEMATIC AREAS

The new SLSC Cluster is an integrated coordination platform recognising that affected people live in diverse settings — camps, informal sites, host communities, urban and rural settlements — and need coherent support across all locations.

- Shelter & Essential Household Items
- Site and Settlement Planning
- Site and Area-Based Management & Coordination
- Community Engagement & Accountability
- Housing, Land & Property (HLP)
- Energy & Environment

THE CLUSTER APPROACH AND HUMANITARIAN RESET



KEY CHANGES

- From 11 standalone clusters to 8
- “New” Shelter, Land and Site Coordination (SLSC) Cluster
- The SLSC Cluster integrates Shelter, CCCM and HLP into a unified, place-based coordination platform supporting displaced people across all settings — camps, informal sites and host communities
- **To learn more about the Humanitarian Reset, access the FAQ**

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IFRC
IOM
UN MIGRATION

TYPES OF COORDINATION MECHANISMS

IDP Coordination
Cluster Approach

Applied in situations of internal displacement, typically conflict-induced. The cluster approach operates under the IASC framework.

Example: Haiti 2010 earthquake

Refugee Response
UNHCR-led / Sectors

For cross-border displacement, UNHCR leads within the Refugee Coordination Model. Sectors — not clusters — are used.

Examples: Ukraine (outside), Uganda

Mixed Situations
Combined approach

Where IDP and refugee populations coexist. Coordination spans both the cluster approach and refugee response frameworks.

Example: Nigeria

Migrant Response
Regional coordination

IOM leads regional platforms for mixed migration flows, such as the Regional R4V platform for Venezuela displacement.

Example: R4V Platform

HOUSE KEEPING

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- Use the **Q&A chat** to share questions adding to whom it is addressed *(not the usual chat)*
- Use the usual chat to **share reflections**, **comments** or **relevant resources** and **links**
- Please turn on your camera when you speak, if your connection allows
- Please **keep your microphone muted** when not speaking
- Be mindful of time and keep your contribution concise

Please note that the meeting is being recorded to be shared on the GSC Technical CoP webpage

The Revision of Haiti's National Building Code as a driver to strengthen the construction ecosystem

Build Change

Pierre Paya
Project Manager
Build Change

AGENDA

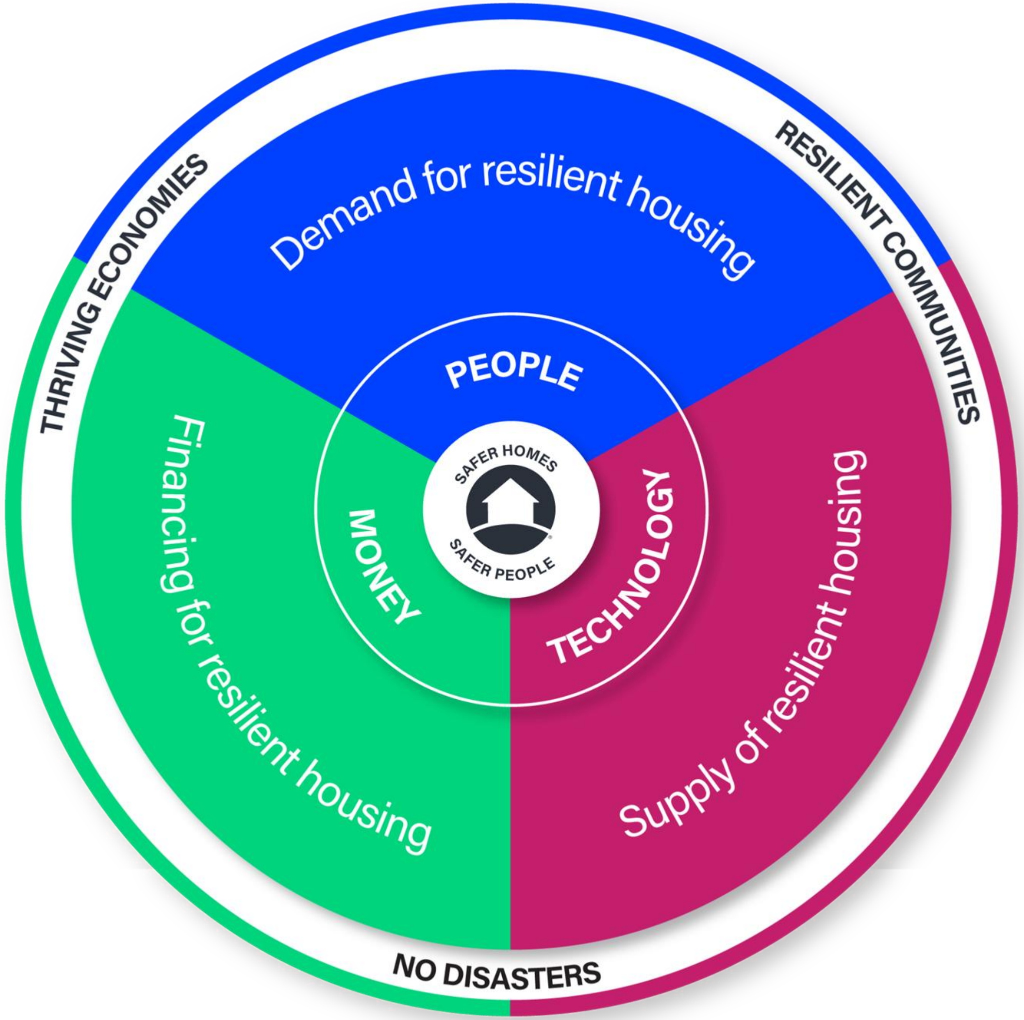
- Context and Rationale
- Importance of Building Code
- Code Revision Scope
- Engagement of stakeholders and dissemination
- Adaptation of International Standards to local context

Context and rationale

- Haiti is one of the most disaster-prone countries in the world.
- Earthquakes, hurricanes, floods, and landslides frequently cause significant damage.
- Informal construction and limited enforcement of regulations make buildings highly vulnerable.

Context and rationale

- We mobilize people, money, and technology to transform regulation, financing, and construction systems for the structural improvement of housing and the construction of new housing worldwide.



Context and rationale

Build Change has worked in Haiti since 2010 across all levels of the housing sector:

- Homeowners: Provided technical assistance to rebuild or retrofit 1,700 houses.
- Builders: Established competency-based construction training centers, training 1,500 builders.
- Material Providers: Supported 250 block factories through production training.
- Engineers & Architects: Trained 200 professionals in evaluation, design, and construction supervision.
- Local Authorities: Developed technical guides and resources to strengthen local governance.

Context and rationale

- Revision of the National Building Code and its dissemination
- 24 years + 6 months
- Project financed by the Coalition for Disaster Resilient Infrastructure though the IRIS program
- Project led by the MTPTC, with its implementing partners Build Change

Importance of Standards

- High informality in the residential sector, with little control and no common standards.
- Exposure to multiple hazards (earthquakes, hurricanes, floods).
- Private sector investment (including the informal sector) in permanent housing.
- Humanitarian sector investment in permanent housing for reconstruction.

Without a common framework, each actor develops their own standards.

Importance of Standards

- Building codes integrate the key factors of earthquake- and wind-resistant construction, including:
  - hazard intensity (earthquakes, hurricanes)
  - site conditions and soil types
  - building types and occupancy
  - construction systems and methods, including vernacular practices

They provide a common technical framework to guide safe construction.

Importance of Standards

- Building codes are designed around the concept of acceptable risk, which depends on the type of building.

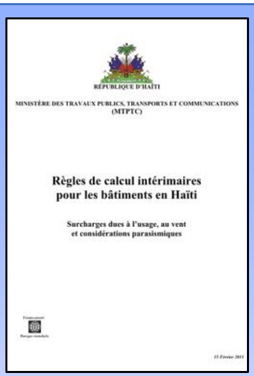
- For residential buildings, the objective is generally **life safety,** not zero damage.
  - Performance objective during earthquakes, strong winds, and heavy rainfall:
  - Low risk of fatalities
  - Low probability of building collapse
  - The structure resists major hazards such as seismic shaking, strong winds, flying debris, and heavy rain
  - Foundations and the building envelope remain stable
  - Some damage may occur

Importance of Standards

- Building codes serve three major functions:
  - Securing investments and life by reducing the risk of structural failure
  - Harmonizing practices by providing a common standard for NGOs, donors, and government
  - Strengthening the construction sector
    → Reinforcing the regulatory framework and construction actors
    → Creating a basis for resilience from design to construction

Code Revision Scope

Emergency Provisions



2010 Post-Earthquake Emergency provisions

Adopted IBC, CBC, Eurocode by Reference

Includes seismic and wind hazard information

Core Building Code

2012 CNBH (Jan 2013 Ed.)

Based on IBC and IRC

Part 0 Scope/Admin/Hazards

Part 1 Small Buildings
Follows IRC...

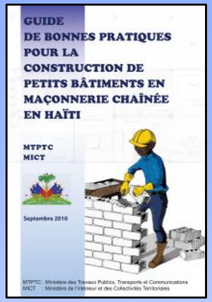
Part 2 All Buildings (including existing)
Mostly placeholder

Systems Building Code

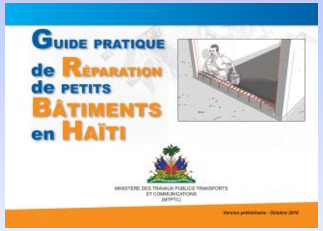
2018 CNPH and Supplement (2019?)

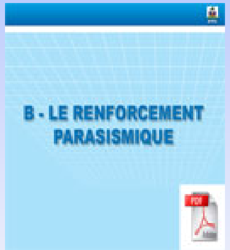
Local commentary /application document and translated version 2015 IPC (abbreviated?)

Guidelines



Confined Masonry Construction Guide (September 2010)
One-two story CM buildings





Repair Guide (October 2010)
Retrofit Guide (2013)
One-two story buildings

Timber frame and masonry infill Guide
One-two story masonry buildings

Code Revision Scope

The Haitian National Building Code has been progressively developed since 2012, but with some issues :

- Combination of code requirements and guidelines, which limited its recognition as a fully enforceable code
- Some sections were incomplete or outdated
- Limited consideration of cyclonic risk and climate change impacts
- Did not fully address some common construction systems (e.g., vernacular construction)
- Limited guidance on seismic and hurricane retrofitting

Code Revision Scope

Part 0
Preface

Preface
explaining how the Code works and how to ensure compliance.

Part 1
All Buildings

Code Application Document for IBC 2021
IBC translation and adaptation for Haiti, particularly regarding local hazards.

Part 2
Small buildings

Code Compliant Directives

Prescriptive directives for small buildings (up to 3 stories, 300 m² footprint, masonry, lightweight roof or slab)

Prescriptive directives for strengthening or reinforcing masonry buildings

Prescriptive directives for timber-frame buildings with masonry infill or for buildings with a timber-frame structure

Code Revision Scope

Main technical standards produced through the revision :

- Updated hazard assessment: revision of seismic and cyclonic risks using the most recent available data
- Improved seismic and cyclonic resistant design: revised percentage-of-required-walls method for confined masonry, light weight roof solutions
- Expanded building scope: buildings up to 3 stories, with possible commercial use at ground floor, and provisions for low to medium flood-risk areas
- Adaptation to local construction systems: timber frame with masonry infill, confined masonry
- Broader resilience considerations: guidance for retrofitting and extensions, improved accessibility, and gender considerations

Code Revision Scope

Lesson learned for developing standards :

- Building code development is a long-term process and cannot be completed in a single revision; it can be developed progressively, section by section.
- Establishing a general framework based on ICC codes through a Code Application Document allows for a coherent technical foundation with limited effort.
- Having a ICC licensing agreement to ensure long-term technical partnership beyond the project
- In parallel, develop prescriptive directives adapted to common construction typologies (such as vernacular construction and confined masonry), with clearly defined limitations.
- This approach allows multiple pathways to compliance with the standard, depending on building type and level of engineering.

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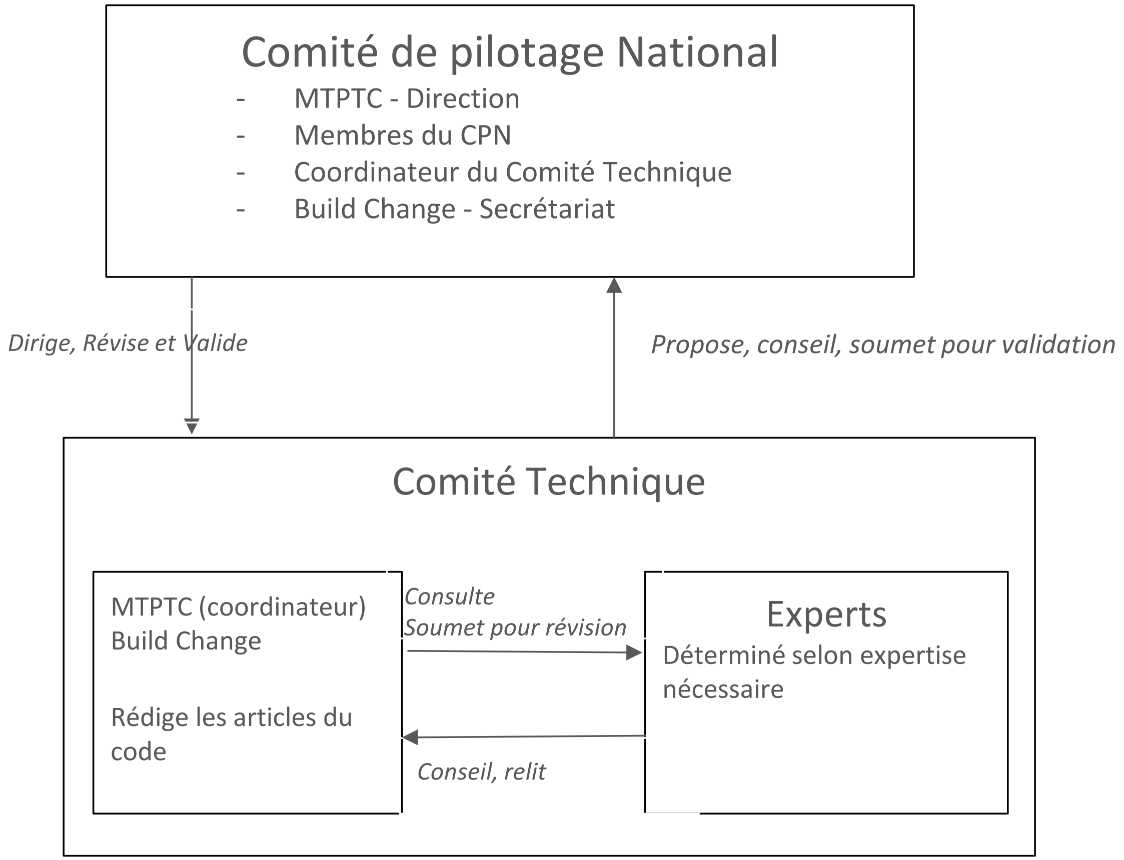
Stakeholder Engagement

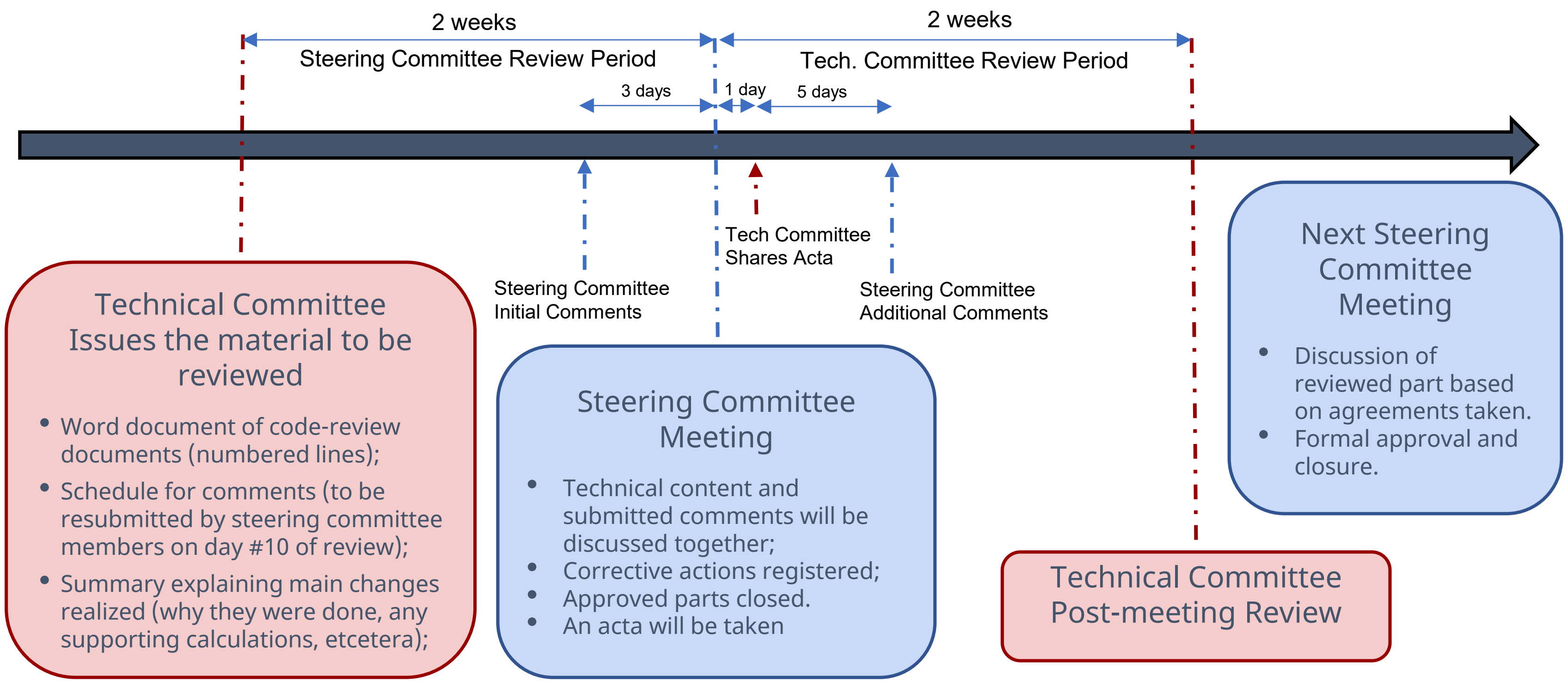
- The key success of code and standards is its application by the construction sector
- Project developed since the beginning as a way to engage local construction sector
- Project led by the Ministry of Public Work (MTPTC) ensuring government commitment
- Before the revisions start 6 engagement period to understand the stakeholders priorities.

Stakeholder Engagement

- Institutionalization of a Steering Committee, with clear term of reference
- Representatives from government, professional associations, and universities
- Strategic direction of the CNBH revision
- Ensure stakeholder needs are considered
- Review and approve the code
- Continue beyond the project for future updates
- Technical committee with local and international experts, peer reviewing process



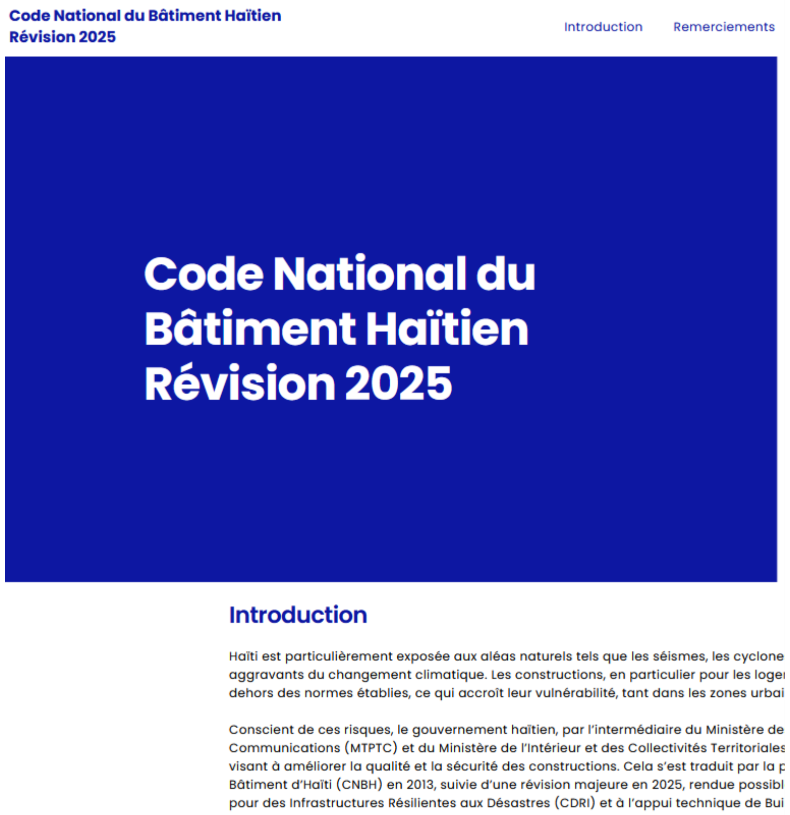
Stakeholder Engagement



- Approval per section in each Steering Committee, with sufficient time to review
- Tracking system of decision made, and comments on the document
- Ensure the final approval is a formality as everything has been approved before

Stakeholder Engagement

- Pre-publication of the code for public review, allowing all engineers to make comments before approval
- Use of a dedicated website for dissemination (~3,400 visitors)
- Organization of webinars with universities, associations, and the Shelter Cluster so everyone is aware of the code and can still make comments
- Help to prepare the “real” awareness campaign



https://cnbh2025.com/

Stakeholder Engagement

- Awareness campaign through multiple media (radio, television, social media, press)
- Official validation ceremony of the CNBH
- Participation to public events organized with key institutions (Civil Protection, College of Engineers)

Stakeholder Engagement

- Training sessions for all actors (engineers, architects, builders, homeowners)
- Collaboration with universities and professional associations to integrate the CNBH in the curriculum
- Online training webinars for those we can't attend
- More than 2,000 professional trained

Stakeholder Engagement

Lesson learned for Stakeholder Engagement :

- Stakeholder engagement is essential at every stage of the project
- Institutionalize a steering committee to ensure continuity beyond the project
- Combine dissemination and public review to allow engineers and professionals to provide comments
- Use webinars and outreach activities to promote the code and its standards
- Use all communication channels
- Government-led projects to implement the code and enforce it in law.

Adaptation of International Standards to local context

3 Examples of Adapting International Standards in Haiti :

- Design of lightweight roofs, based on the WFC manual.
- Design of confined masonry, using a PSM method instead of element-by-element shear calculation.
- Integration of a vernacular typology, based on seismic testing and a prototype approach.

Adaptation of International Standards to local context

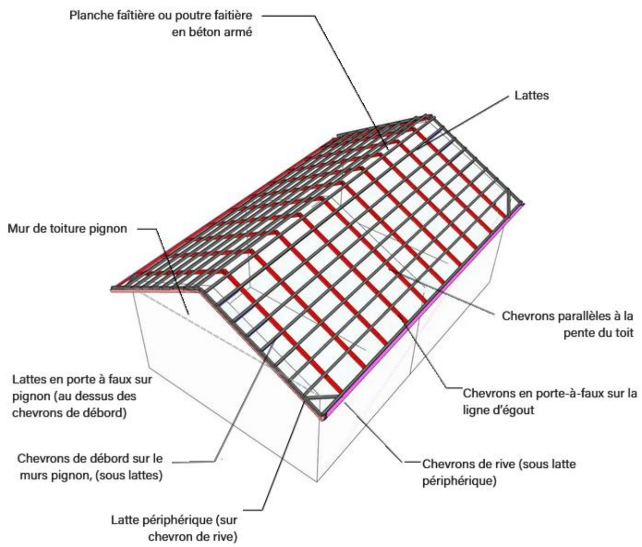
Cyclonic resistant Light Weight Roof

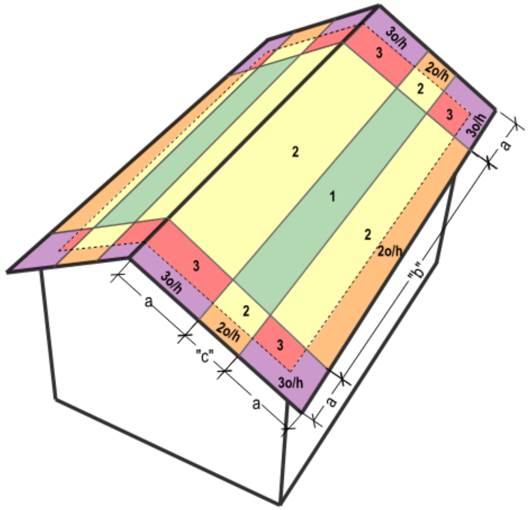
Adaption of the Wood Frame Construction Manual and the National Design Specification (NDS) from the American Wood Council to the Haitian context, taking into account local specificities including

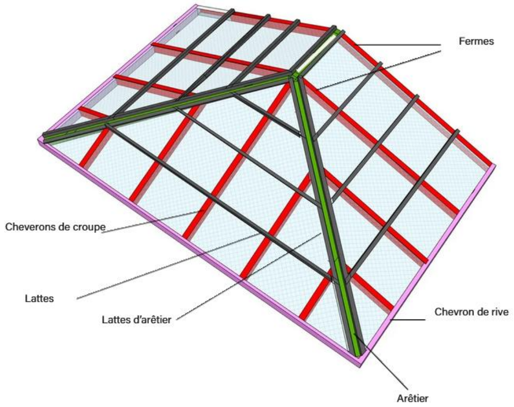
- Absence of structural diaphragms (such as plywood or CGI)
- Limited availability of connectors (nails, metal straps mostly),
- Limited timber sizes (2x4, 2x6 southern pine)

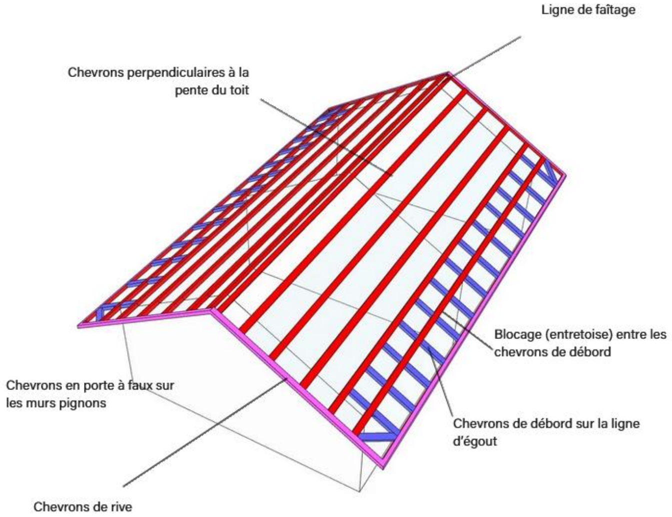
Adaptation of International Standards to local context

Various roof solutions have been developed.
Determined the size and spacing of structural elements (rafters, purlins, trusses).
Defined the fastenings between CGI panels, structural elements, and walls.
Ensures structural integrity and suitability for local conditions.





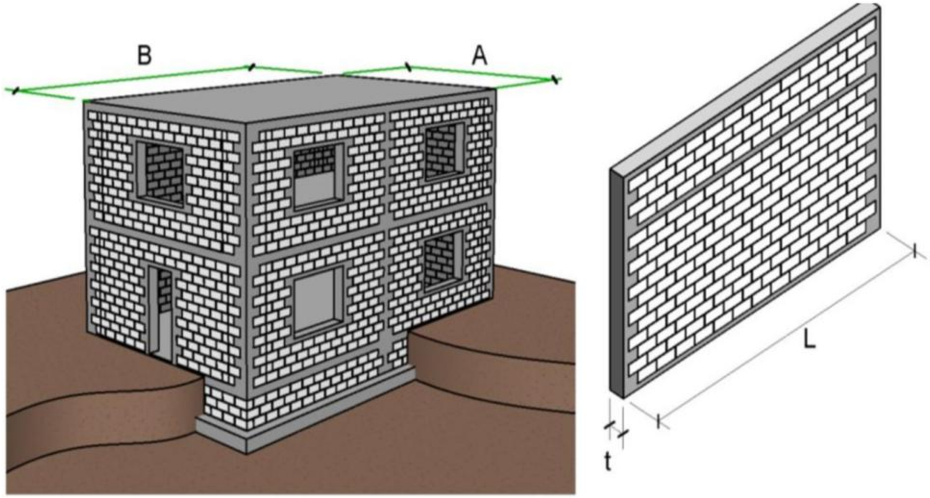




Adaptation of International Standards to local context

Confined Masonry Buildings

- Confined masonry is not explicitly covered in IBC, ASCE 7, TMS 402/602, or ACI 318
- These standards require full seismic force calculation, structural analysis, and stress verification



CNBH Approach

- Use of a Wall Area Percentage method for confined masonry design
- Defines minimum required wall percentage based on seismic hazard, block type and wall thickness, number of stories

Adaptation of International Standards to local context

- Advantages
  - Prescriptive design method easier to apply in practice
  - Allows engineers to verify seismic resistance without full structural analysis
- Technical Basis
  - Derived from principles of IBC, ASCE 7, TMS 402/602, ACI 318
  - Calibrated using experimental test data from confined masonry walls representative of Haiti
  - Applicable within defined building limitations studied in CNBH Part 2

Adaptation of International Standards to local context

- Based on local knowledge, skills, and construction intelligence
- Supported by a long serie of projects, scientific studies seismical test, and lessons learned, building on the TCLA approach developed after the January 12, 2010 earthquake
- Based on a guide approved by the MTPTC

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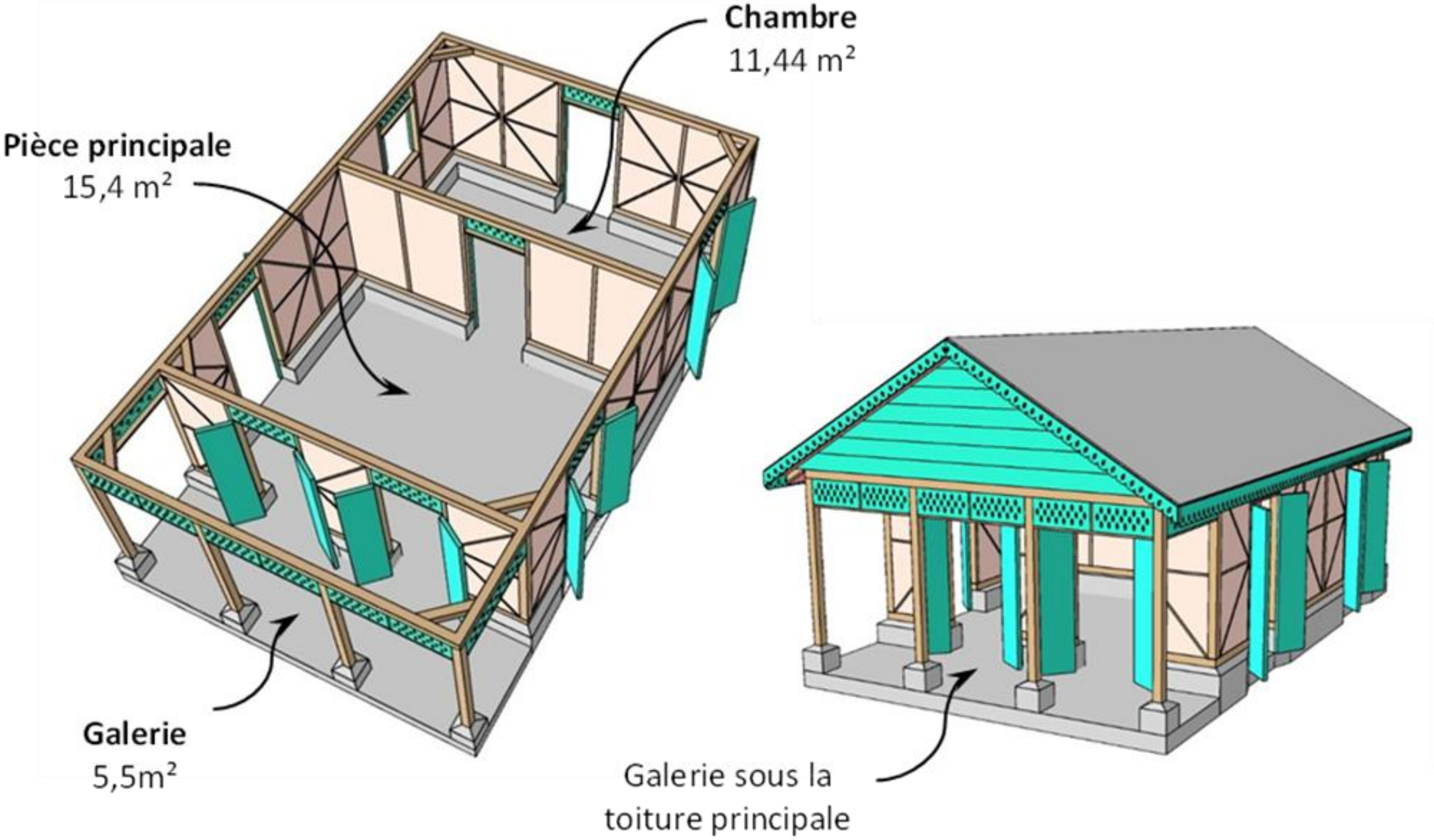
Adaptation of International Standards to local context

- Timber frame walls braced on vertical (walls) and horizontal (ceilings, floors) planes
- Braced roof structure, fixed to the top wall band.
- Roofing materials attached to purlins, which are fixed to the roof trusses.
- Energy dissipation through ductile connections
- Progressive and controlled degradation of sacrificial elements (infills, cladding, roofing components)

Adaptation of International Standards to local context

- A prototype is defined, in the code with certain dimensions
- Less flexibility for the design in the code but gives guidelines to go beyond



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Technical Community of Practice (TCoP)

Thank you




Readiness for Post-Disaster Rebuilding: Building Codes and Safe Construction Practices Lessons from Pakistan, Haiti, Nepal

Builders Without Borders

Martin Hammer
Architect and Co-Director
Builders Without Borders
martin@builderswithoutborders.org

2005 Kashmir earthquake killed 86,000, injured 130,000 and left 3.5 million homeless in northern Pakistan

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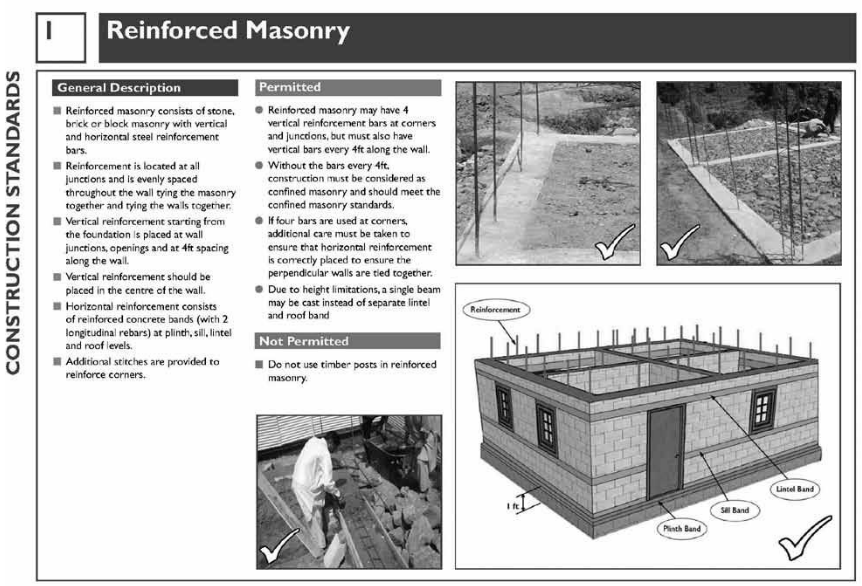
Pakistan's Earthquake Reconstruction and Rehabilitation Authority (ERRA) approved 3 wall systems for rebuilding rural housing

* Use of ERRA-approved construction system allowed access to rebuilding funds from the World Bank ($3000 USD per house)



CONSTRUCTION STANDARDS

1 Reinforced Masonry

General Description

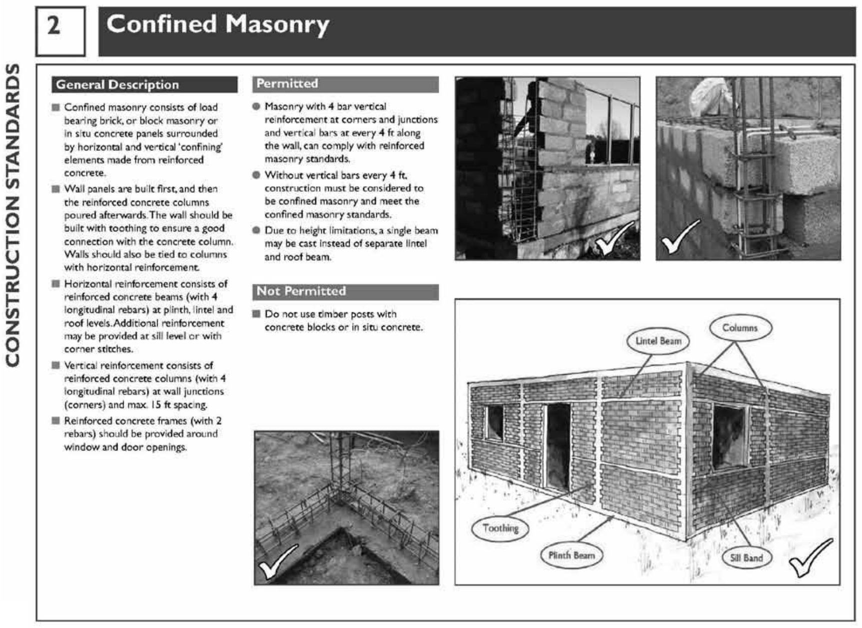
- Reinforced masonry consists of stone, brick or block masonry with vertical and horizontal steel reinforcement bars.
- Reinforcement is located at all junctions and is evenly spaced throughout the wall tying the masonry together and tying the walls together.
- Vertical reinforcement starting from the foundation is placed at wall junctions, openings and at 4ft spacing along the wall.
- Vertical reinforcement should be placed in the centre of the wall.
- Horizontal reinforcement consists of reinforced concrete bands (with 2 longitudinal rebars) at plinth, sill, lintel and roof levels.
- Additional stitches are provided to reinforce corners.

Permitted

- Reinforced masonry may have 4 vertical reinforcement bars at corners and junctions, but must also have vertical bars every 4ft along the wall.
- Without the bars every 4ft, construction must be considered as confined masonry and should meet the confined masonry standards.
- If four bars are used at corners, additional care must be taken to ensure that horizontal reinforcement is correctly placed to ensure the perpendicular walls are tied together.
- Due to height limitations, a single beam may be cast instead of separate lintel and roof band

Not Permitted

- Do not use timber posts in reinforced masonry.



CONSTRUCTION STANDARDS

2 Confined Masonry

General Description

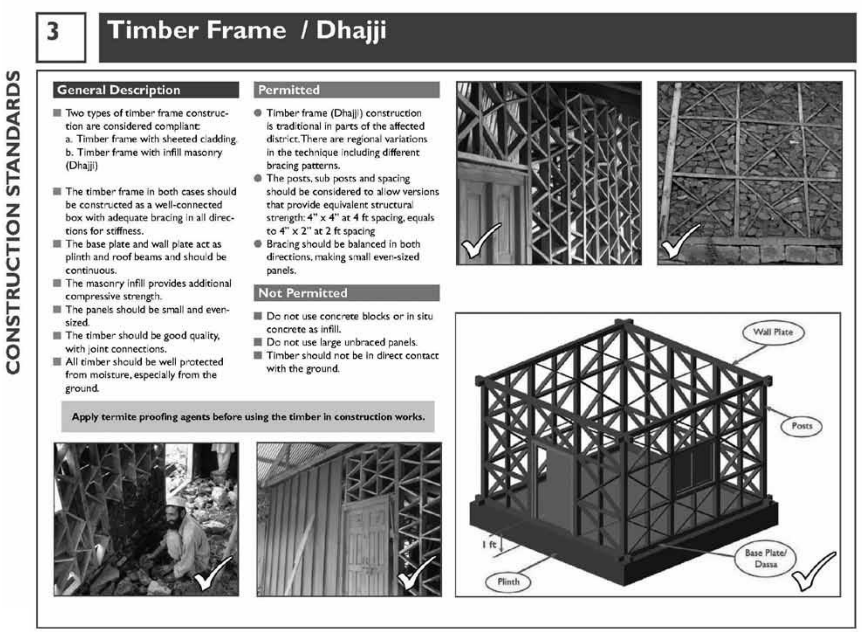
- Confined masonry consists of load bearing brick, or block masonry or in situ concrete panels surrounded by horizontal and vertical 'confining' elements made from reinforced concrete.
- Wall panels are built first, and then the reinforced concrete columns poured afterwards. The wall should be built with toothing to ensure a good connection with the concrete column. Walls should also be tied to columns with horizontal reinforcement.
- Horizontal reinforcement consists of reinforced concrete beams (with 4 longitudinal rebars) at plinth, lintel and roof levels. Additional reinforcement may be provided at sill level or with corner stitches.
- Vertical reinforcement consists of reinforced concrete columns (with 4 longitudinal rebars) at wall junctions (corners) and max. 15 ft spacing.
- Reinforced concrete frames (with 2 rebars) should be provided around window and door openings.

Permitted

- Masonry with 4 bar vertical reinforcement at corners and junctions and vertical bars at every 4 ft along the wall, can comply with reinforced masonry standards.
- Without vertical bars every 4 ft, construction must be considered to be confined masonry and meet the confined masonry standards.
- Due to height limitations, a single beam may be cast instead of separate lintel and roof beam.

Not Permitted

- Do not use timber posts with concrete blocks or in situ concrete.



CONSTRUCTION STANDARDS

3 Timber Frame / Dhajji

General Description

- Two types of timber frame construction are considered compliant:
  a. Timber frame with sheeted cladding.
  b. Timber frame with infill masonry (Dhajji)
- The timber frame in both cases should be constructed as a well-connected box with adequate bracing in all directions for stiffness.
- The base plate and wall plate act as plinth and roof beams and should be continuous.
- The masonry infill provides additional compressive strength.
- The panels should be small and even-sized.
- The timber should be good quality, with joint connections.
- All timber should be well protected from moisture, especially from the ground.

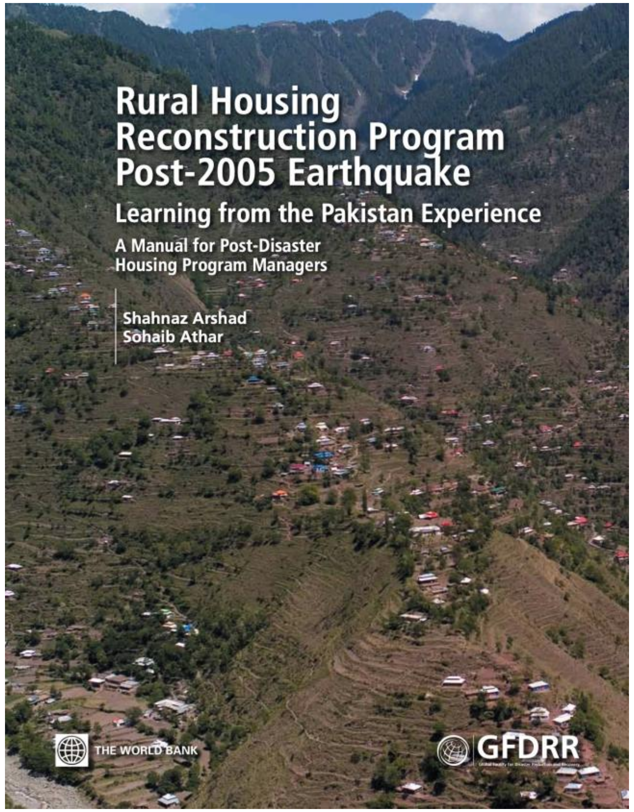
Permitted

- Timber frame (Dhajji) construction is traditional in parts of the affected district. There are regional variations in the technique including different bracing patterns.
- The posts, sub posts and spacing should be considered to allow versions that provide equivalent structural strength: 4" x 4" at 4 ft spacing, equals to 4" x 2" at 2 ft spacing
- Bracing should be balanced in both directions, making small even-sized panels.

Not Permitted

- Do not use concrete blocks or in situ concrete as infill.
- Do not use large unbraced panels.
- Timber should not be in direct contact with the ground.

Apply termite proofing agents before using the timber in construction works.



The traditional earthquake-safe Dhajji Dewari system was championed for inclusion by Swiss architect Tom Schacher* and Pakistani engineering professor Qaisar Ali

* With Swiss Agency for Development and Cooperation (SDC)

Builders Without Borders

What Is Natural Building?

Durable, safe building systems of low environmental impact, using materials close to their natural state, that create healthy human environments, and return to the earth without harm

Examples of Natural Building

Bamboo

Wood Frame

Straw Bale

Pre-Fab
Straw Panel

Fiber

Earth

Straw-Clay

Wattle & Daub

Adobe

Cob

Examples of Natural Building

Fiber

Earth Bag

Compressed Earth Block

Stone Masonry

Lime-Stabilized Earth
and Rammed Earth

Earth

A Pakistan straw bale house costs half the same-sized ERRA* approved reinforced concrete block house.

$3000 USD vs. $6000 USD (Year 2009)

*Earthquake Reconstruction and Rehabilitation Authority

Reinforced Concrete Block House - 2007

PAKSBAB Straw Bale House - 2009

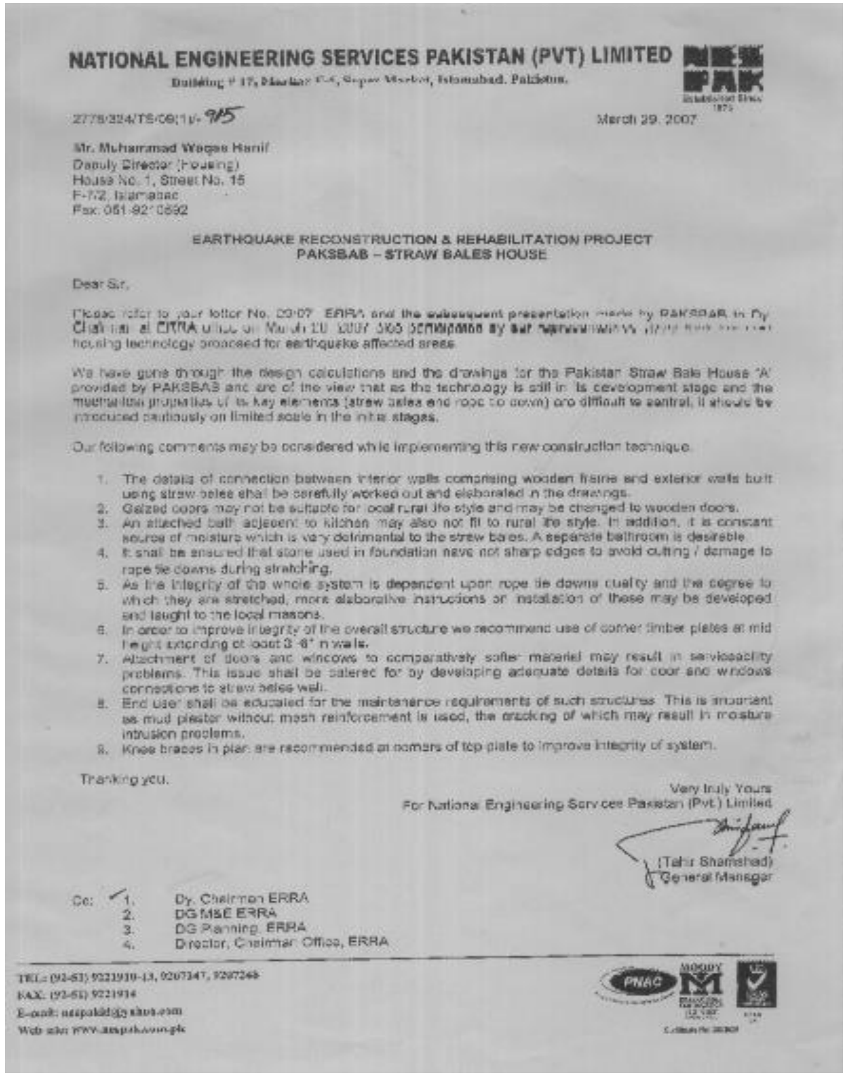
And . . .

- Provides better thermal comfort
- Needs 80% less fuel to heat (and improves air quality)
- Is more resource efficient with less environmental harm

Pakistan Straw Bale and Appropriate Building

2006 Meetings with Government Officials and National Engineering Services Pakistan (NESPAK)

NESPAK Review of Straw Bale House 'A' Approval of 12 Houses



NATIONAL ENGINEERING SERVICES PAKISTAN (PVT) LIMITED

Building # 17, Markaz F-6, Super Market, Islamabad, Pakistan.

2778/324/TS/08(1)/- 985 — March 29, 2007

Mr. Muhammad Waqas Hanif
Deputy Director (Housing)
House No. 1, Street No. 15
F-7/2, Islamabad
Fax: 051-9210692

EARTHQUAKE RECONSTRUCTION & REHABILITATION PROJECT
PAKSBAB – STRAW BALES HOUSE

Dear Sir,

Please refer to your letter No. 03/07 ERRA and the subsequent presentation made by PAKSBAB in Dy Chairman at ERRA office on March 20, 2007 [illegible] housing technology proposed for earthquake affected areas.

We have gone through the design calculations and the drawings for the Pakistan Straw Bale House 'A' provided by PAKSBAB and are of the view that as the technology is still in its development stage and the mechanical properties of its key elements (straw bales and rope tie down) are difficult to control, it should be introduced cautiously on limited scale in the initial stages.

Our following comments may be considered while implementing this new construction technique.

1. The details of connection between interior walls comprising wooden frame and exterior walls built using straw bales shall be carefully worked out and elaborated in the drawings.
2. Glazed doors may not be suitable for local rural life style and may be changed to wooden doors.
3. An attached bath adjacent to kitchen may also not fit to rural life style. In addition, it is constant source of moisture which is very detrimental to the straw bales. A separate bathroom is desirable.
4. It shall be ensured that stone used in foundation have not sharp edges to avoid cutting / damage to rope tie downs during stretching.
5. As the integrity of the whole system is dependent upon rope tie downs quality and the degree to which they are stretched, more elaborative instructions on installation of these may be developed and taught to the local masons.
6. In order to improve integrity of the overall structure we recommend use of corner timber plates at mid height extending at least 3'-6" in walls.
7. Attachment of doors and windows to comparatively softer material may result in serviceability problems. This issue shall be catered for by developing adequate details for door and windows connections to straw bales wall.
8. End user shall be educated for the maintenance requirements of such structures. This is important as mud plaster without mesh reinforcement is used, the cracking of which may result in moisture intrusion problems.
9. Knee braces in plan are recommended at corners of top plate to improve integrity of system.

Thanking you.

Very truly Yours
For National Engineering Services Pakistan (Pvt.) Limited

(Tahir Shamshad)
General Manager

Cc:
1. Dy. Chairman ERRA
2. DG M&E ERRA
3. DG Planning, ERRA
4. Director, Chairman Office, ERRA

TEL: (92-51) 9221910-13, 9207347, 9207248
FAX: (92-51) 9221914
E-mail: nespakhi@yahoo.com
Web site: www.nespak.com.pk

"We have gone through the calculations and drawings for Pakistan Straw Bale House 'A' . . . as the technology is still in its development stage . . . it should be introduced cautiously on limited scale in the initial stages."

GLOBAL SHELTER, LAND AND SITE COORDINATION CLUSTER

GLOBAL SHELTER CLUSTER
Coordinating Humanitarian Shelter and Settlements

Housing, Land and Property AoR

CCCM CLUSTER
Supporting displaced communities

2009 Shake Table Test at University of Nevada

Withstood 1.4 x the peak ground acceleration
of the 2005 Kashmir Earthquake (.82g)

PAKSBAB

EERI

University of Nevada, Reno

SEISMIC PERFORMANCE OF
INNOVATIVE STRAW BALE WALL SYSTEMS

Pakistan Straw Bale and Appropriate Building (PAKSBAB)
P.O. Box 1083, Truckee, CA 96160
www.paksbab.org

Principal Investigator:
Darcey Donovan, P.E., PAKSBAB C.E.O.

Research Associates:
Shannon Whitnack
Surkhab Khan
Bill Donovan

Sponsored by:
Earthquake Engineering Research Institute (EERI)

November 5, 2009

NSF

nehrp

NEES

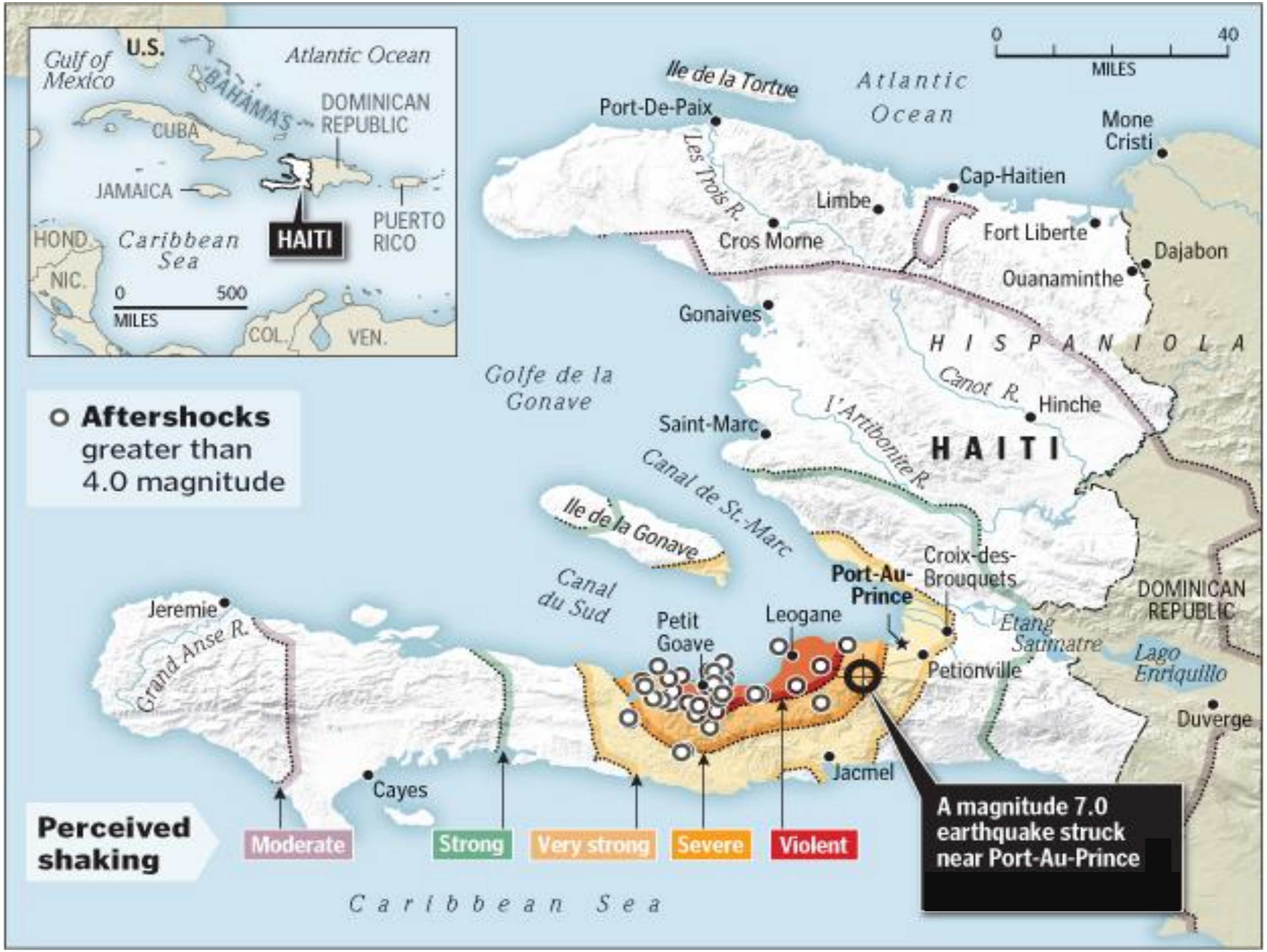
Pakistan
Straw Bale and
Appropriate
Building

PAKSBAB

PAKSBAB built 40 projects (incl. 38 homes) 2006-2015

Pakistan
Straw Bale and
Appropriate
Building

PAKSBAB



Builders Without Borders

Port-au-Prince   February 28, 2010

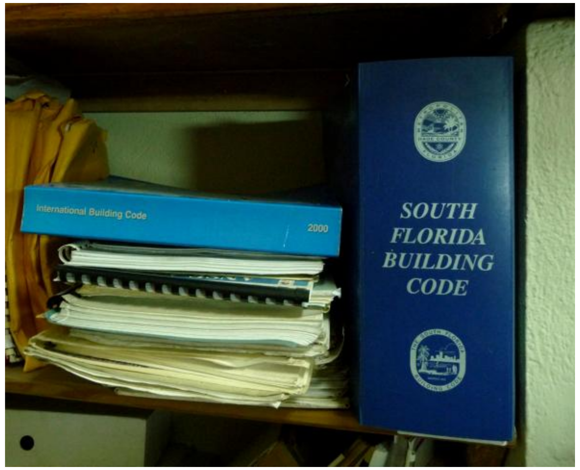
"Don't say we don't have a building code.
We have a building code.
We just need a better building code."

Roger Laplanche, architect
February 28, 2010

"I'll be frank. We have no building code."

Roger Laplanche, architect
March 13, 2010

Building Codes / Permits / Inspections in Haiti
Before the 2010 Earthquake



Outside codes sometimes used voluntarily

* No national building code in force

* Some engineers, architects, builders voluntarily used U.S., French, or Caribbean codes, especially for large commercial or institutional structures

* Vast Majority of structures built without benefit of a code, permits or inspections

Construction deficiencies led to enormous destruction and death from Haiti's moderate 7.0 magnitude earthquake:

* Insufficient or no engineering

* Poor quality materials (concrete block, cement, sand)

* Poor workmanship (concrete mixing, water : cement ratio, curing; lapping, and coverage of reinforcing)

* Cost-cutting (eliminate needed reinforcing, cheap materials)

Building Codes / Permits / Inspections in Haiti
3 years after the 2010 Earthquake

Outside codes sometimes used voluntarily

* No national building code in force

* Some engineers, architects, builders voluntarily used U.S., French, or Caribbean codes, especially for large commercial or institutional structures

* Vast Majority of structures built without benefit of a code, permits or inspections

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* Poor workmanship (concrete mixing, water : cement ratio, curing; lapping, and coverage of reinforcing)

* Cost-cutting (eliminate needed reinforcing, cheap materials)

Significant training efforts after the earthquake by NGOs in cooperation with the Haitian government *nominally* improved construction quality.

January 2013, the 2012 Code National du Batiment d'Haiti went into effect, based on U.S. codes, and guidelines for the common concrete and block structures that killed over 200,000 in the earthquake.

HAITIAN vs. U.S. CEMENT COMPRESSIVE STRENGTH TEST RESULTS - IB

Conducted By: C.E. Professor Mark Aschheim, Juan Vargas; Santa Clara University
Test Date: 9/7/12
Cure Time: 28 days
Cube Size: 2" x 2" x 2" (Using plastic cube molds)
W/C Ratio: 0.7
Cement / Aggregate Mix: approx. 1:6 (14.1% cement) WITH FINE and COARSE AGGREGATE

BRAND of PORTLAND CEMENT	AVG. COMPRESSIVE STRENGTH (PSI) (four samples each)	COEFFICENT OF VARIATION	% of U.S. Cement's Strength
US-01: QUIKRETE I/II	2448.3	11.4%	100%
HC-04: VARREUX	1844.2	18.2%	75.3%
HC-02: KOLOS (D.R.)	1462.8	10.2%	59.7%
HC-03: CINA - CIMENTERIE NATIONALE	1389.1	6.5%	56.7%
HC-01: VARREUX - CEMEX	1022.8	17.3%	41.8%

Building Back Better : Government of Haiti's Home Expo – July 2011

GLOBAL SHELTER, LAND AND SITE COORDINATION CLUSTER

Presidents Clinton & Martelly

Home Expo Opening

Over 40 building systems and home designs – But most too costly or using entirely imported materials

Builders Without Borders

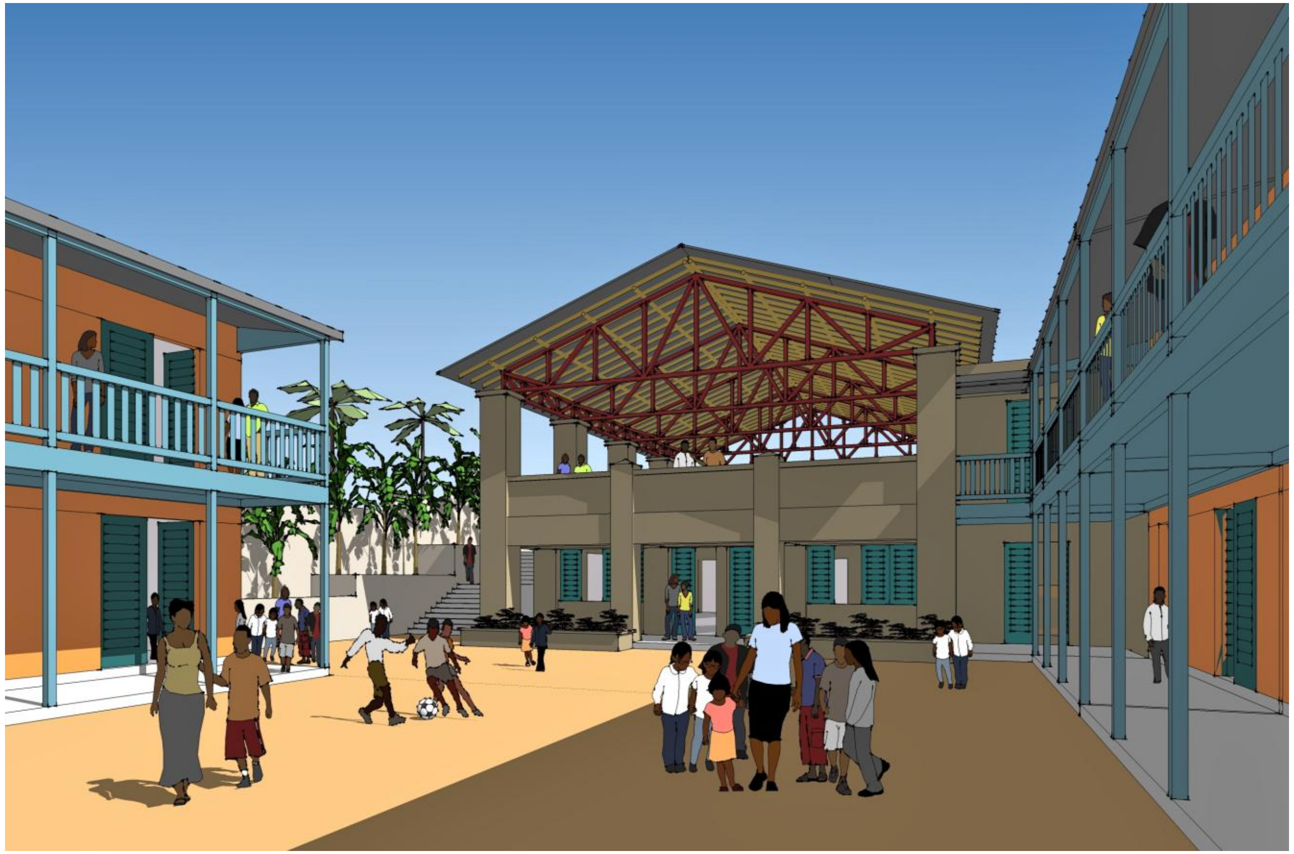
SUSTAINABLE (RE)BUILDING SOLUTIONS FOR HAITI

Ti Kay Pay – Small Straw House

The First Straw Bale Building in Haiti

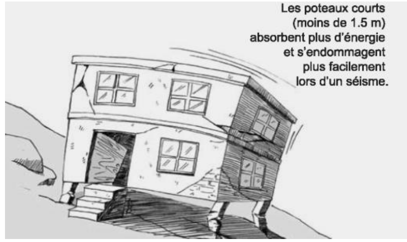
Builders Without Borders

Contract Design Work for NGOs



K-13 School for the What If Foundation
Port-au-Prince, Haiti

Community Center for Help Hayti
Terre Froide, Haiti



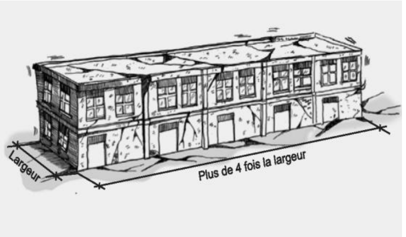
5. *Poteaux courts*

6. *Cadres partiellement remplis créant des poteaux courts*

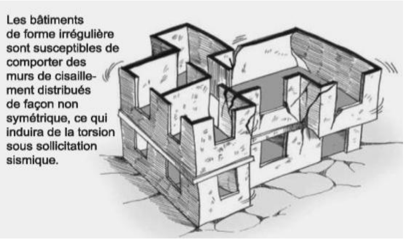
7. *Formes irrégulières en plan*

8. *Configuration non compactes*

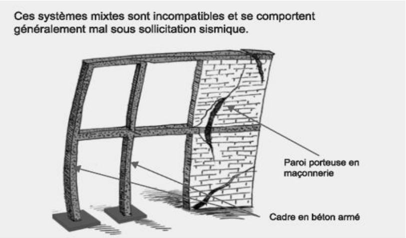
9. *Espaces insuffisants entre deux bâtiments contigus*



10. *Rapports longueur/largueur trop élevés*



11. *Murs de cisaillement distribués de façon non symétriques*



12. *Systèmes mixtes colonnes maçonnerie porteuse*

Figure 1.4.8.2 - Configurations et actions à éviter (MTPTC, MICT, 2010)

Article 1.8.3.11 Bandes parasismiques

L'espacement maximal entre deux bandes parasismiques (bandes de renforcement horizontales, cf. article 1.6.2.6) est de 1 200 mm. Puisque la maçonnerie doit être confinée autour des ouvertures pratiquées dans les murs par des bandes de renforcement verticales et horizontales, il est pratique de disposer les bandes parasismiques au niveau des allèges et linteaux de fenêtres et de les prolonger sur toute la longueur du mur, même dans les segments de mur qui ne contiennent pas d'ouvertures (figure 1.8.3.11a).

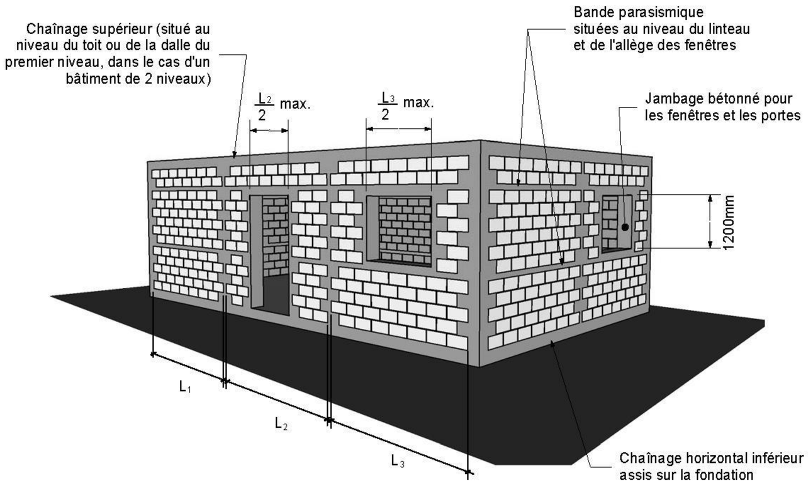
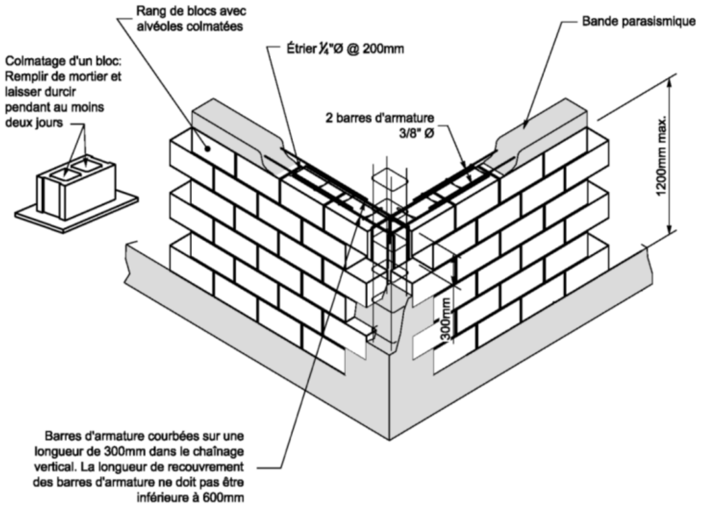


Figure 1.8.3.11.a - Disposition typique des bandes parasismiques et ferraillage d'ouvertures dans un bâtiment en maçonnerie

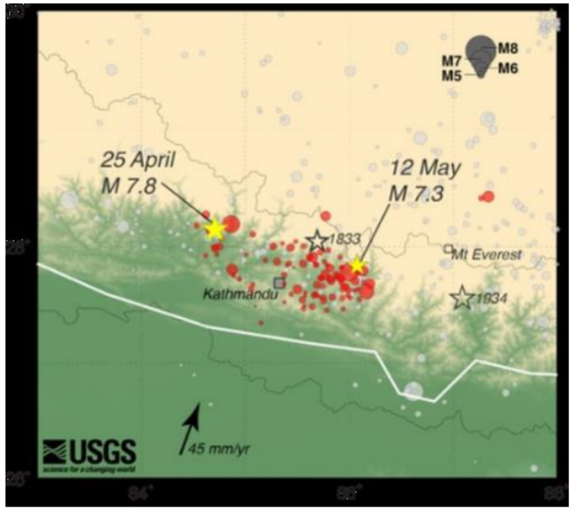


Now the Problem is not the Code, but insufficient Use and Enforcement.

- **Population - 27 Million (86% in agriculture)**
- **Area : 56,827 sq.mi. (size of New England)**
- **93 ethnic groups and languages**
- **Dominant religions – Hinduism, Buddhism**
- **GDP : 35% agriculture, 29% remittances,**
- **20% industry, 4% tourism**
- **Active NGOs : 1500+**

Nepal Earthquakes

- April 25, 2015: M7.8 earthquake struck Gorkha district in Nepal, 80km (50 mi) from Kathmandu
- May 12, 2015: M7.3 major aftershock struck near Kodari, Nepal
- Shaking Intensities:
  - April 25: VI (Strong) to IX (Violent)
  - May 12: V (Moderate) to VIII (Severe)
- PGA: 0.8g (April 25), 0.6g (May 12)
  - Nepal Building Code design acceleration was 32g maximum



Source: Tim Hart, PE, EERI

Nepal Earthquakes

- Largest earthquakes in Nepal since 1934
- Over 9,000 deaths and 23,000 injuries in April 25 earthquake
- Additional 200+ deaths and 2,500+ injuries in May 12 aftershock
- Over 500,000 houses completely destroyed & another 269,000+ partially damaged (per NSET)
- Over 450,000 people displaced
- Approximately 7,000 public schools destroyed

Source: Tim Hart, PE, EERI

Predominant Contemporary Building System in Kathmandu Valley

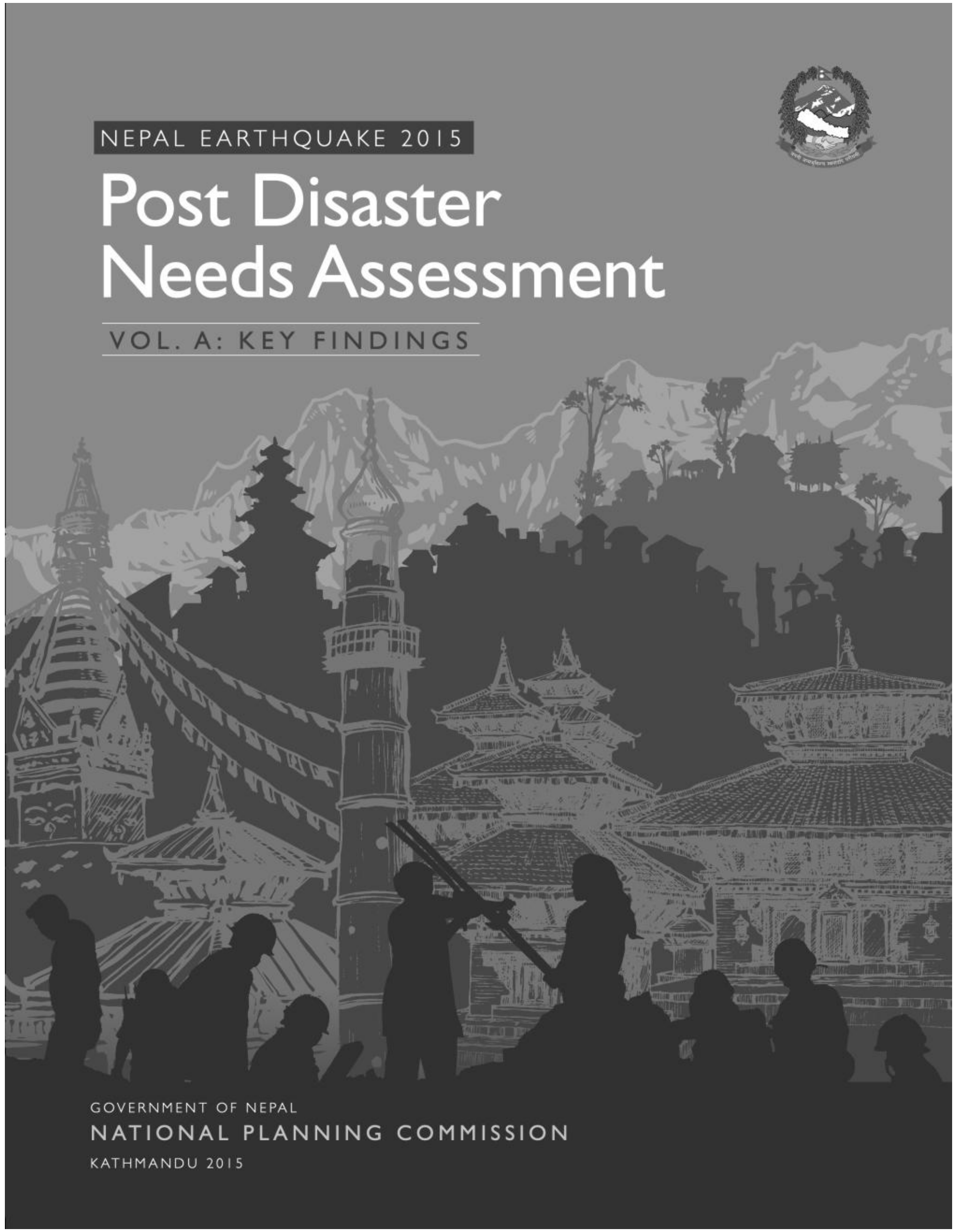
Reinforced concrete frame with unreinforced brick infill, plaster finish

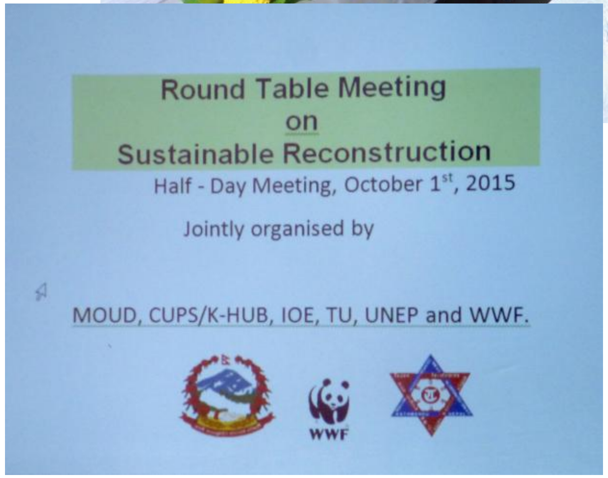
Predominant Building System in Rural Nepal

Stone and clay mortar, clay plaster with lime wash

Two-story plus attic
Separate or attached kitchen
Separate toilet
1st floor: meeting room, guestroom, storage + veranda
2nd floor: bedrooms, storage

Attic: grain storage/drying, loft sleeping


NEPAL EARTHQUAKE 2015
Post Disaster
Needs Assessment
VOL. A: KEY FINDINGS
GOVERNMENT OF NEPAL
NATIONAL PLANNING COMMISSION
KATHMANDU 2015

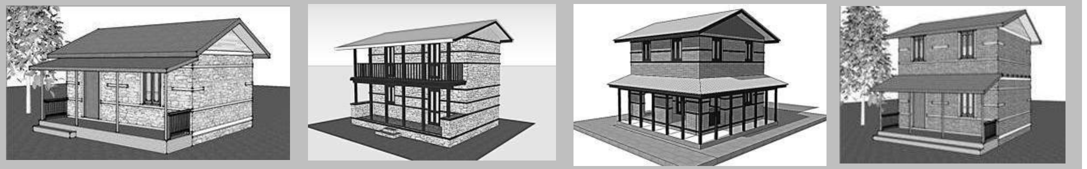

Round Table Meeting
on
Sustainable Reconstruction
Half - Day Meeting, October 1st, 2015
Jointly organised by
MOUD, CUPS/K-HUB, IOE, TU, UNEP and WWF.
WWF

GLOBAL SHELTER, LAND AND SITE COORDINATION CLUSTER

DESIGN CATALOGUE FOR

RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

Volume



October, 2015 (Aswin, 2072)

Nepal Housing
Reconstruction Programme

Government of Nepal
Ministry of Urban Development
Department of Urban Development and Building Construction
Babarmahal, Kathmandu

Builders
Without
Borders

List of Model Houses

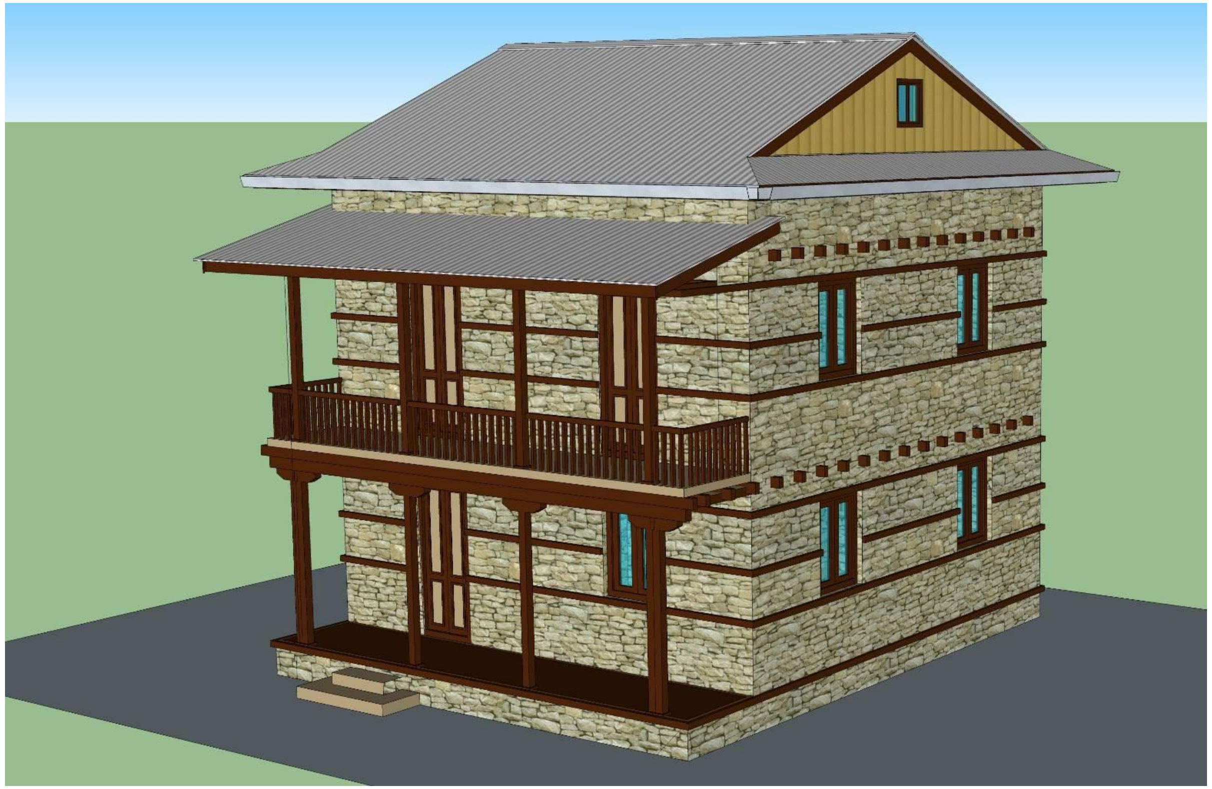
housing model **Volume I**

Structural Type	No. of Floor	Model No.	Designed by	Page
Stone masonry in cement mortar, P5- SMC	1	SMC-1.1	JICA	9
	1	SMC-1.2	JICA	15
	2	SMC-2.1	JICA	21
	2	SMC-2.2	DUDBC	27
	2	SMC-2.3	DUDBC	33
	2	SMC-2.4	DUDBC	39
	2+ATTIC	SMC-2.5	DUDBC	45
	2+TERRACE	SMC-2.6	DUDBC	51
		Technical details		57
		Flexible design		67
Brick masonry in cement mortar P71- BMC	1	BMC-1.1	JICA	75
	1	BMC-1.2	JICA	81
	2	BMC-2.1	JICA	87
	2	BMC-2.2	DUDBC	93
	2	BMC-2.3	DUDBC	99
	2+ATTIC	BMC-2.4	DUDBC	105
	2+TERRACE	BMC-2.5	DUDBC	111
		Technical details		117
		Flexible design		125
Stone masonry in mud mortar, P129- SMM	1	SMM-1.1	DUDBC	135
		Technical details		141
		Flexible design		143
Brick masonry in mud mortar, P147- BMM	1	BMM-1.1	DUDBC	153
		Technical details		159
		Flexible design		161

Builders Without Borders

Model SMC-2.5: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY+ATTIC



CONSTRUCTION MATERIALS AND MANPOWER

LEVEL	MAN POWER		MATERIALS							
	Skilled	Unskilled	Stone	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	GI SHEET	Rod
	Md	Md	Cu.m.	Bags	Cu.m.	Cu.m.	Cu.m.	Bundel	Rm.	Kg
Up to Plinth Level	72	261	48	91	18	5	0.00	0.0	0	282
SUPERSTRUCTURE	294	468	90	215	41	6	3.97	0.0	0	596
ROOFING	52	17	0	0	0	0	2.48	5.22	32	0
TOTAL	418	745	138	306	59	11	6.45	5.22	32	878

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.5	SCALE: NONE	DATE:	SMC-2.5
	DRAWING TITLE: PERSPECTIVE AND ESTIMATION	DESIGNED BY: DUDBC		1/4

Builders Without Borders

Model SMC-1.1: STONE MASONRY IN CEMENT MORTAR

ONE-STOREY

CONSTRUCTION MATERIALS AND MANPOWER									
Manpower		Materials							
Skilled (Md)	UnSkilled (Md)	Stone (cu.m)	Cement (bags)	Sand (cu.m)	Aggrade (cu.m)	Local wood (cu.m)	Ply wood (sq.m)	Rebar (kg)	CGI sheet (bundle)
90	120	25	130	18	3	35	10	273(12mm) 130(6mm)	5

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-1.1	SCALE: None	DATE:
	DRAWING TITLE: PERSPECTIVE AND ESTIMATION	DESIGNED BY: JICA	SMC-1.1 1/4

GLOBAL SHELTER, LAND AND SITE COORDINATION CLUSTER

GLOBAL SHELTER CLUSTER
Coordinating Humanitarian Shelter and Settlements

Housing, Land and Property AoR

CCCM CLUSTER
Supporting displaced communities

Catalogue for Alternative Construction Materials and Technologies

DESIGN CATALOGUE FOR RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

VOLUME II





MARCH, 2017 (FALGUN,2073)

GOVERNMENT OF NEPAL
MINISTRY OF URBAN DEVELOPMENT
DEPARTMENT OF URBAN DEVELOPMENT AND BUILDING CONSTRUCTION
BABARMAHAL, KATHMANDU

Builders Without Borders

Model SB-1.1: STRAW BALE CONSTRUCTION — ONE-STOREY

CONSTRUCTION MATERIAL AND MANPOWER

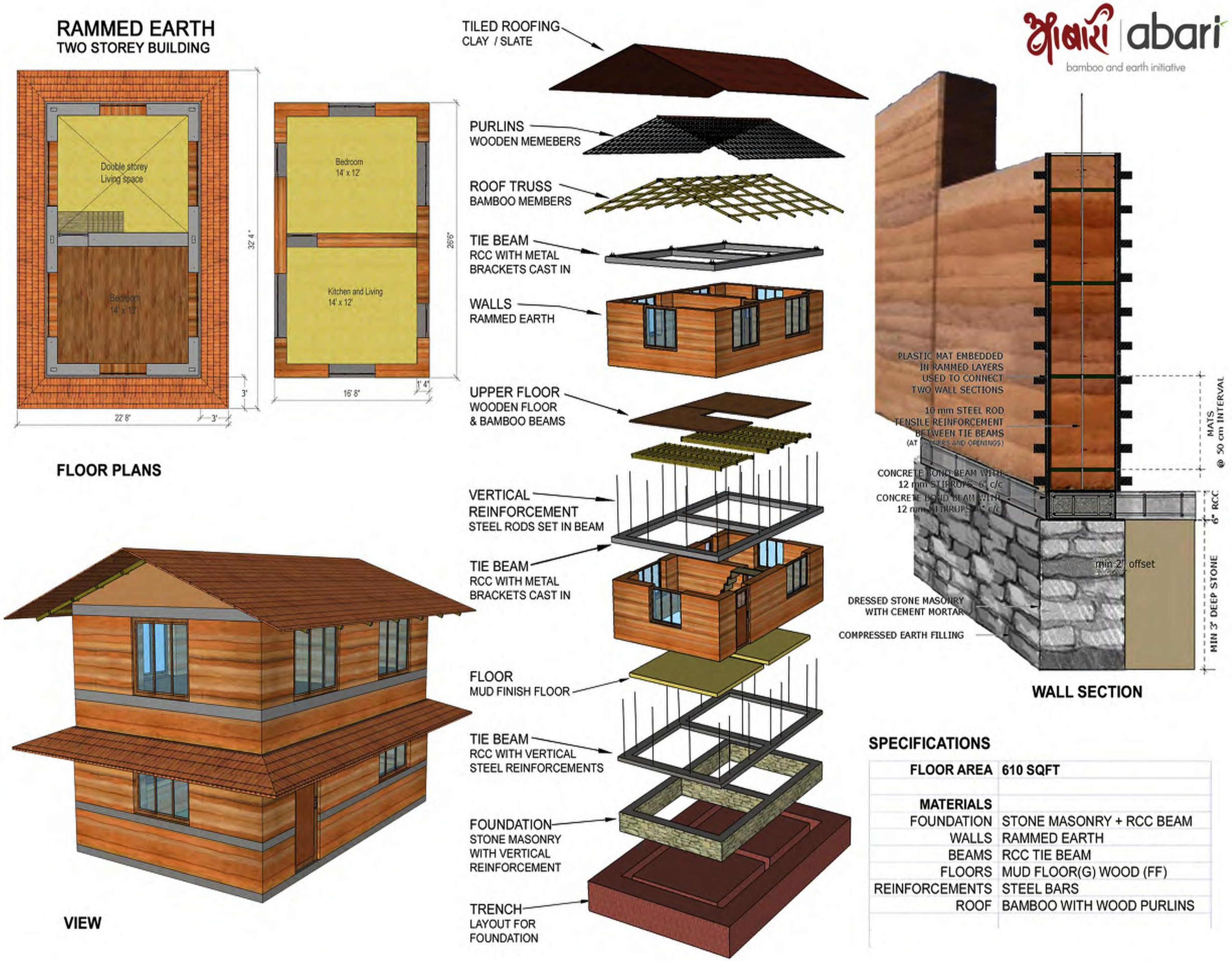
LEVEL!	MAN&POWER!		MATERIALS!							
	Skilled!	Unskilled!	STONE!	CEMENT&	SAND!	AGGREGATE&	WOOD!	STRAW!	CGI&SHEET!	GI&SHEET&
	Md!	Md!	Cu.m!	Bags&&25kg!	Cu.m!	Cu.m!	Cu.m!	KG!	&Bundel!	Rm.!
Up&to&Plinth&Level!	30&	30&	15&	10&	6&	9&	0&	0&	0&	0&
Ground&Flor !	60&	60&	0&	15&	12&	17&	.3&	2500&	0&	0&
Roofing&work!	40&	40&	0&	0&	0&	0&	4.2&	0&	6.5&	2&
TOTAL!	130&	130&	15&	25&	18&	26&	4.5&	2500&	6.5&	2&

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SB-1.1	SCALE: None	DATE: 2 Dec 2015	SB-1.1
	DRAWING TITLE: PERSPECTIVE AND ESTIMATION	DESIGNED BY: Builders Without Borders		1/4

DUDBC expressed interest in this proposal, especially for Nepal's straw-rich Terrai region.

But was not accepted, citing the absence of straw bale buildings in Nepal at the time

Builders Without Borders



FLOOR AREA	610 SQFT
MATERIALS	
FOUNDATION	STONE MASONRY + RCC BEAM
WALLS	RAMMED EARTH
BEAMS	RCC TIE BEAM
FLOORS	MUD FLOOR(G) WOOD (FF)
REINFORCEMENTS	STEEL BARS
ROOF	BAMBOO WITH WOOD PURLINS

abari
bamboo and earth initiative

GLOBAL SHELTER, LAND AND SITE COORDINATION CLUSTER

Unclear why DUDBC did not accept this rammed earth proposal with bamboo roof, as well as others, such as wattle-and-daub.

Rammed earth and bamboo residence outside Kathmandu
Nripal Adhikary, architect,
and ABARI Builders

Builders Without Borders

ABARI Builders – Twenty Schools Post-Earthquake

In cooperation with national and/or local government

2 Rammed Earth, 18 Compressed Earth Block
All with Bamboo Roof Framing

Rammed earth with bamboo roof framing *was* approved for 20 schools

TABLE OF CONTENT

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PREFACE	**II**
BACKGROUND	**III**
INTRODUCTION	**IV**
LIST OF MODEL HOUSES	**V**
INTERLOCKING BRICK MASONRY	**1-26**
CONFINED HOLLOW CONCRETE BLOCK MASONRY	**27-39**
HOLLOW CONCRETE BLOCK MASONRY	**40-52**
COMPRESSED STABILIZED EARTH BLOCK MASONRY	**53-71**
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BAMBOO AND STONE MASONRY HYBRID STRUCTURE	**90-105**
RAT TRAP BOND MASONRY	**106-117**
EARTH BAG MASONRY	**118-130**
LIGHT GAUGE STEEL STRUCTURE	**131-148**
STEEL STRUCTURE	**149-161**
TIMBER STRUCTURE	**162-170**
DEBRIS BLOCK MASONRY	**171-180**

MODEL C.S.E.B-4.1, COMPRESSED STABLILIZED EARTH BLOCK MASONRY — ONE STOREY

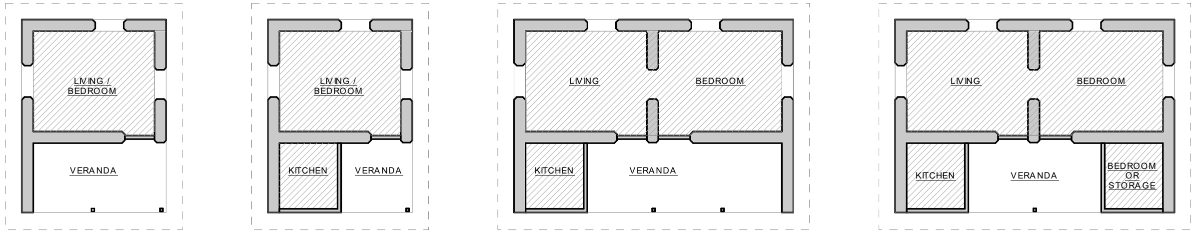
LEVEL	MATERIALS					
	Stabilized block	Cement	Sand	Reinforcing Bar	Wood	Bamboo
	No.	Bags	Cu.m.	Kg.	Cu.m.	Nos
Up to Plinth Level	1,758.0	17.0	2.3	-	-	-
Super Structure	1,500.0	7.2	1.4	237.3	0.2	25.5
Roofing	-	-	-	-	2.4	31.0
TOTAL	**3,258.0**	**24.2**	**3.7**	**237.3**	**2.6**	**56.5**

MINISTRY OF URBAN DEVELOPMENT
DEPARTMENT OF URBAN DEVELOPMENT AND BUILDNG CONSTRUCTION

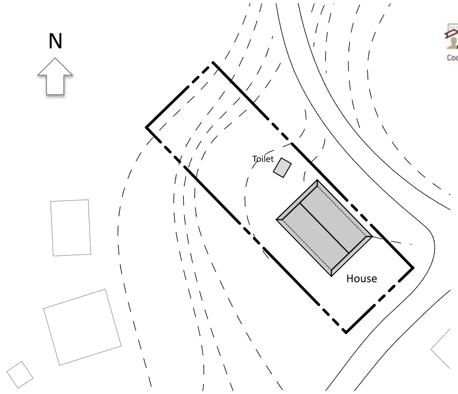
HOUSING TYPE: CSEB-4.1 | SCALE: NONE | CSEB-4.1

DRAWING TITLE: ESTIMATE AND 3D-VIEW | DATE: | 1/8

GLOBAL SHELTER, LAND AND SITE COORDINATION CLUSTER



PHASE 1 PHASE 2 PHASE 3 PHASE 4



SITE PLAN Near KHANDBARI – Elevation 950 m
1:500

Design Description, Context and Features:

This 1-1/2 story Straw Bale House accommodates 3-6 people, and can be built in 4 phases. It consists of two rooms with dimensions of 4290 X 3530, a kitchen 2030 X 2300, a multi-purpose room 2030 X 2300, and a veranda 4670 X 2500. It features **a useable attic** for crop drying and storage. The **total floor area** including veranda but excluding attic is **65 m2 (700 ft2)**.

Context: The design is shown on an unbuilt site in Khandbari in **Sankhuwasabha** district at an elevation of 950 meters, and is derived from the local architecture. Khandbari is the population center of an agricultural region that suffered moderate earthquake damage. However, this design is relevant in many regions of Nepal, at altitudes 500 to 3000 meters wherever rice, wheat, or barley are grown and bamboo is available. Similar social, climate, economic, material, and architectural contexts can be found in other earthquake-affected districts such as **Gorkha, Dhading, Nuwakot, Sindhupalchok and Ramechhap.**

The design uses local materials of stone, bamboo, straw (paral), wood, sand and clay-soil.
The straw bale walls are highly insulating, **keeping the interior warm** in winter and cool in summer.

Building Components:

Foundation: stone masonry with mesh-reinforced cement plaster,
Walls: stacked straw bales (compressed straw blocks, see sheet 2) stiffened with thru-tied vertical bamboo, covered with mesh-reinforced clay or lime plaster, and with a wood top plate. Inexpensive nylon fishing net from Kathmandu or other population centers can be used for plaster mesh.
Attic Floor: bamboo truss chords and bamboo joists, split bamboo subfloor, light clay-straw floor
Roof: bamboo trusses and rafters, wood purlins, and CGI roofing

The earthquake-resistant design is based on a house design and construction method used by Pakistan Straw Bale and Appropriate Building (PAKSBAB) since 2007 which was **shake-table tested** at the University of Nevada, USA in 2009, and is consistent with the **2015 International Residential Code, Appendix S – Strawbale Construction**. Architectural and material adjustments were made for the context of Nepal. Earthquake-resistant measures include **shock-absorbing straw bale walls** with through-tied **bamboo stiffeners** and **mesh-reinforced plaster**, a CGI roof diaphragm, and well-connected components from roof to foundation. A seismic analysis and the roof framing design were done in accordance with the **Nepal National Building Code** and the **Indian Standard** for Structural Design Using Bamboo.

Straw bale buildings have been constructed in all 50 U.S. states and over 50 countries worldwide, including every climate and in high seismic regions. Some buildings from the early years of its invention in the U.S are over 100 years old.

PERSPECTIVE

Builders Without Borders : Berkeley, CA, USA : Martin Hammer, Architect : martin@builderswithoutborders.org

Nepal Engineers' Association Rural Housing Design Competition In collaboration with the Ministry of Urban Development and UNDP

1-1/2 Story Straw Bale House Design Khandbari vicinity in Sankhuwasabha District

Builders Without Borders

Date: 27 December 2015

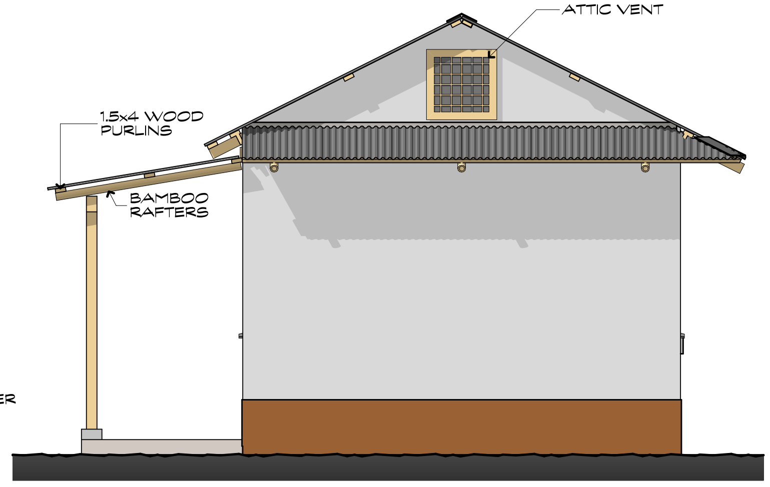
GLOBAL SHELTER, LAND AND SITE COORDINATION CLUSTER

GLOBAL SHELTER CLUSTER Coordinating Humanitarian Shelter and Settlements

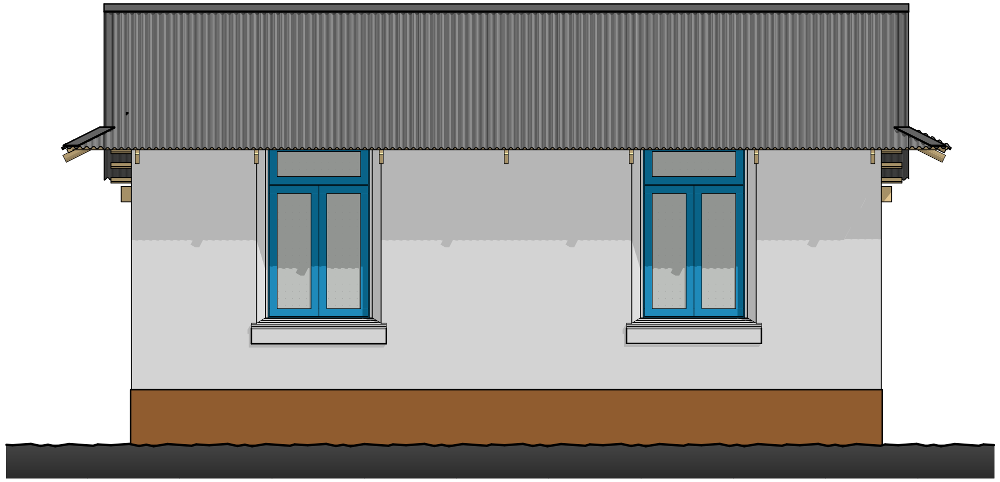
Housing, Land and Property AoR

CCCM CLUSTER Supporting displaced communities

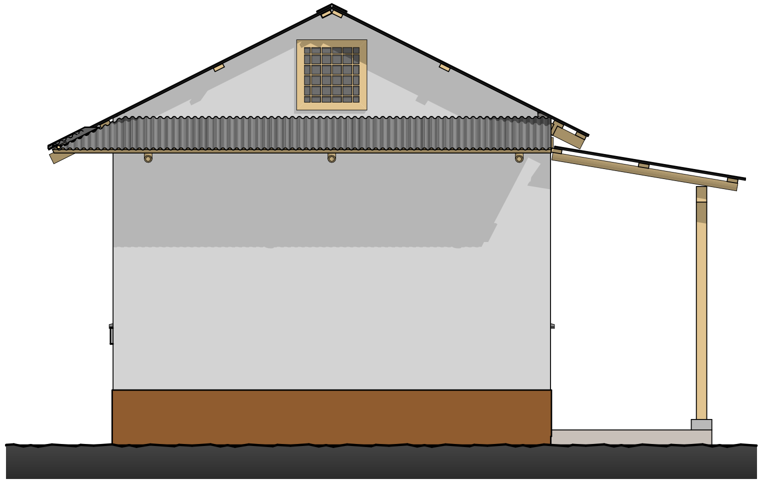
FRONT ELEVATION
1 : 50



RIGHT SIDE ELEVATION
1 : 50



REAR ELEVATION
1 : 50



LEFT SIDE ELEVATION
1 : 50

Straw Bale Classroom or Two-Room House – for KRMEF Nepal

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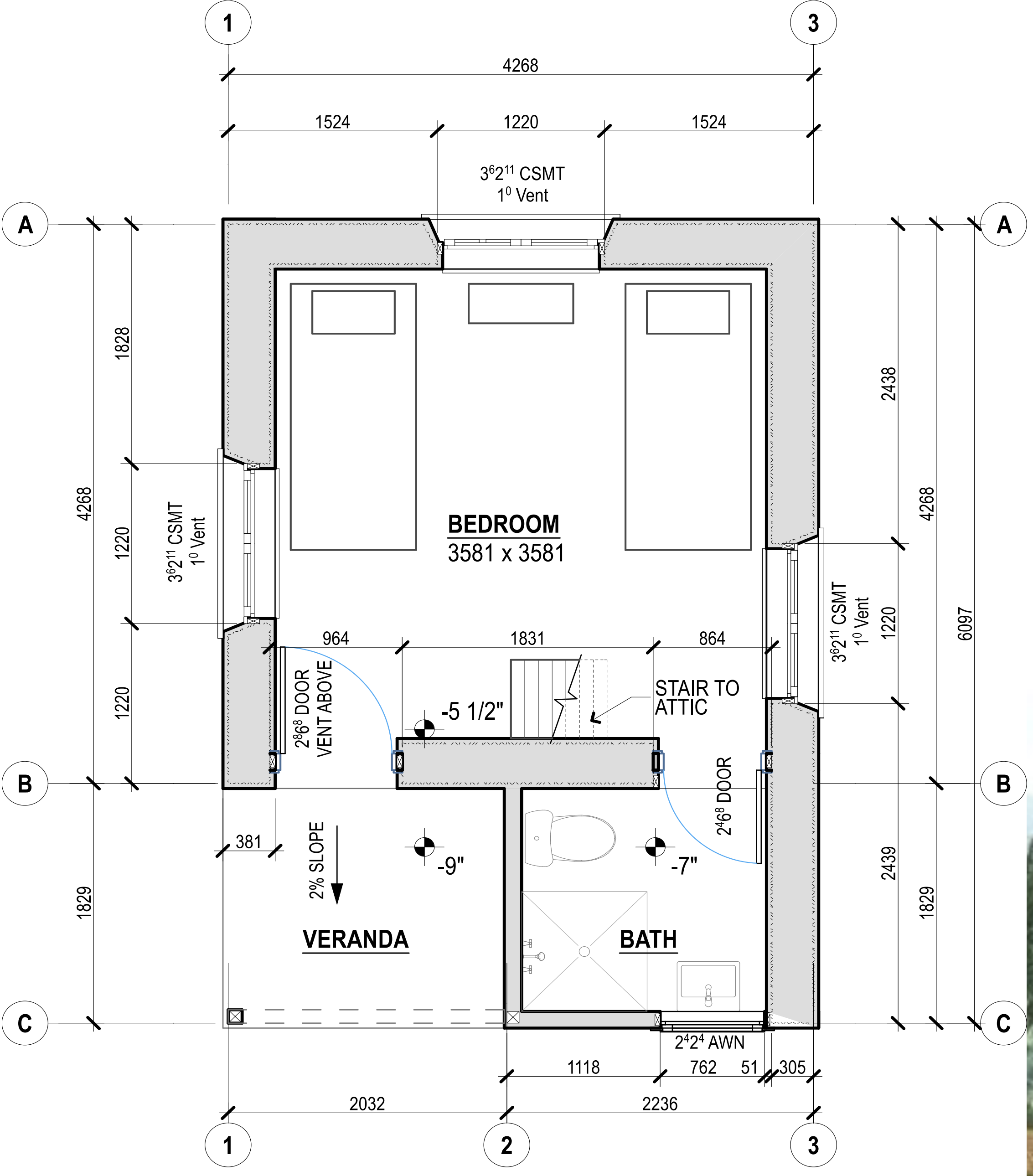
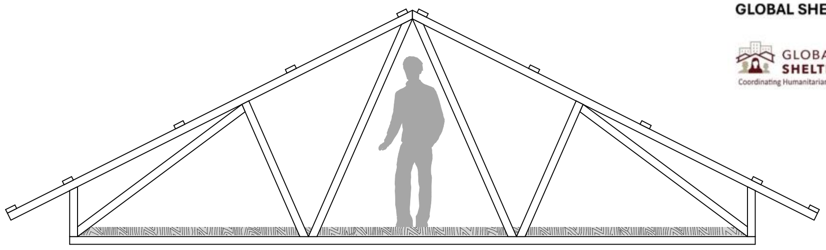
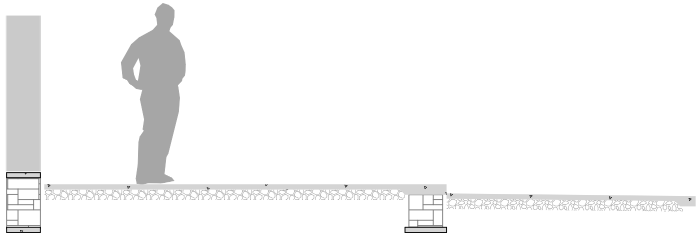


Two-Room House with Habitable Attic

For KRMEF in 2018





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Mortared stone foundation with nylon fishing net reinforcing

Stacked straw bales with opposing bamboo pins

Double wood top plates

Bamboo roof trusses with wood purlins

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Bamboo attic floor framing

Split bamboo subfloor

Lime-stabilized cob attic floor installation

Bamboo attic floor structure as ceiling of room below

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Tamping straw-clay into slip forms

Two lifts of straw-clay

Slaking quicklime to make lime putty

Troweling clay-lime plaster over split bamboo lath

Under Construction

Complete

'Paral Ko Ghar' – Straw House

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Supporting displaced communities

KRMEF has built 18 homes in their community with Government approved steel-reinforced Compressed Stabilized Earth Blocks

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The I-Codes are the basis for the building codes in the U.S. and are available for adoption and use worldwide,
but must be adapted accordingly

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‘Natural Building’ Appendices in the International Residential Code

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APPENDIX **BI**

LIGHT STRAW-CLAY CONSTRUCTION

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

User notes:

About this appendix: *While heavier forms of straw-clay construction have been used in various parts of the world for thousands of years, light forms of straw-clay construction began to appear in Europe in 1950 and in the United States in 1990. These lighter forms of straw-clay construction are intended as infill materials in nonload-bearing walls. The advantages of light straw-clay construction, such as regulated by Appendix BI, include thermal performance and low environmental impact.*

SECTION BI101—GENERAL

BI101.1 Scope. This appendix shall govern the use of *light* straw-clay as a *nonbearing* building material and wall *infill* system in *Seismic Design Categories* A and B. Use of *light* straw-clay in *Seismic Design Categories* C, D_0, D_1 and D_2 shall require an *approved* engineered design by a *registered design professional* in accordance with Section R301.1.3.

BI101.2 Flood hazard areas. In flood hazard areas established in Table R301.2, *buildings* using *light* straw-clay *infill* shall meet the requirements of Section R306.

Scan for Changes 01431d2

SECTION BI102—DEFINITIONS

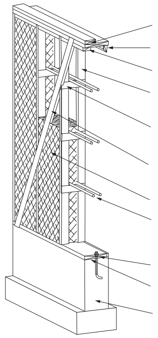
BI102.1 General. The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 for general definitions.

CLAY. Inorganic soil with particle sizes of less than 0.00008 inch (0.002 mm) having the characteristics of high to very high dry strength and medium to high plasticity.

CLAY SLIP. A suspension of clay or *clay subsoil* particles in water.

CLAY SUBSOIL. Subsoil sourced directly from the earth or refined, containing clay and not more than trace amounts organic matter.

FIGURE BI103.2.4(1)—LIGHT STRAW-CLAY WALL WITH LARSEN TRUSSES



APPENDIX **BJ**

STRAWBALE CONSTRUCTION

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

User notes:

About this appendix: *The use of strawbale construction has steadily increased since the 1980s such that there are now buildings of strawbale construction in every state in the United States and in more than 50 countries around the globe. Estimates are that there are over 1,000 buildings of strawbale construction in California alone, including both residential and commercial buildings. Appendix BJ provides prescriptive requirements for the construction of exterior and interior walls, both structural and nonstructural, in buildings that are under the scope of this code.*

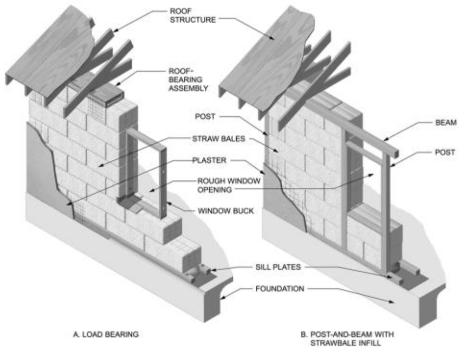
SECTION BJ101—GENERAL

Scan for Changes b0b65d4

BJ101.1 Scope. This appendix provides prescriptive and performance-based requirements for the use of baled *straw* as a building material. Other methods of *strawbale* construction shall be subject to approval in accordance with Section R104.2.2 of this code. *Buildings* using *strawbale* walls shall comply with this code except as otherwise stated in this appendix.

BJ101.2 Strawbale wall systems. *Strawbale* wall systems include those shown in Figure BJ101.2 and *approved* variations.

FIGURE BJ101.2—TYPICAL STRAWBALE WALL SYSTEMS



Note: See Figures BJ105.1(1) through BJ105.1(4) for detailed views and section references. Other strawbale wall systems or variations are permitted as *approved*.

BJ101.3 Flood hazard areas. In flood hazard areas established in Table R301.2, *buildings* using *strawbale* wall systems shall meet the requirements of Section R306.

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APPENDIX **BK**

COB CONSTRUCTION (MONOLITHIC ADOBE)

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

User notes:

About this appendix: *Cob construction has been used for thousands of years around the world, notably in England and Northern Europe, the Middle East, West Africa, China and the Southwestern United States. An estimated 20,000 cob homes are still inhabited in the English county of Devon alone, some dating from the 15th century. The term “cob” derives from an Old English word for “lump,” since historical structures were often constructed one handful at a time.*

SECTION BK101—GENERAL

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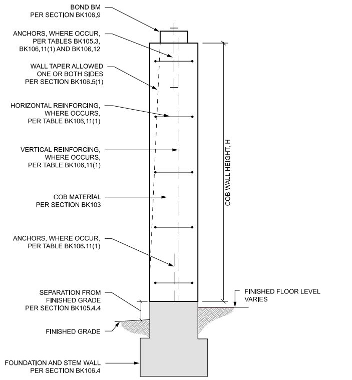
BK101.1 Scope. This appendix provides prescriptive and performance-based requirements for the use of *natural cob* as a building material. *Buildings* using *cob* walls shall comply with this code except as otherwise stated in this appendix.

BK101.2 Intent. In addition to the intent described in Section R101.3, the purpose of this appendix is to establish minimum requirements for *cob* structures that provide flexibility in the application of certain provisions of the code, to permit the use of site-sourced and local materials, and to permit combinations of historical and modern techniques.

BK101.3 Tests and empirical evidence. Tests for an alternative material, design or method of construction shall be in accordance with Section R104.2.2.5, and the *building official* shall have the authority to consider evidence of a history of successful use in lieu of testing.

BK101.4 Cob wall systems. *Cob* wall systems include those shown in Figure BK101.4 and *approved* variations.

FIGURE BK101.4—TYPICAL COB WALL



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Adobe Masonry in the International Building Code

SECTION 2109—EMPIRICAL DESIGN OF ADOBE MASONRY

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2109.1 General. Empirically designed adobe masonry shall conform to the requirements of Appendix A of TMS 402—16, except where otherwise noted in this section.

2109.1.1 Limitations. The use of empirical design of adobe masonry shall be limited as noted in Section A.1.2 of TMS 402—16. In *buildings* that exceed one or more of the limitations of Section A.1.2 of TMS 402—16, masonry shall be designed in accordance with the engineered design provisions of Section 2101.2 or the foundation wall provisions of Section 1807.1.5.

Section A.1.2.3 of TMS 402—16 shall be modified as follows:

A.1.2.3 – *Wind*. Empirical requirements shall not apply to the design or construction of *masonry* for *buildings*, parts of *buildings*, or other *structures* to be located in areas where V_{asd} as determined in accordance with Section 1609.3.1 of the *International Building Code* exceeds 110 mph.

2109.2 Adobe construction. *Adobe construction* shall comply with this section and shall be subject to the requirements of this code for Type V construction, Appendix A of TMS 402—16, and this section.

2109.2.1 Unstabilized adobe. *Unstabilized adobe* shall comply with Sections 2109.2.1.1 through 2109.2.1.4.

2109.2.1.1 Compressive strength. Adobe units shall have an average compressive strength of 300 psi (2068 kPa) when tested in accordance with ASTM C67. Five samples shall be tested and individual units are not permitted to have a compressive strength of less than 250 psi (1724 kPa).

2109.2.1.2 Modulus of rupture. Adobe units shall have an average modulus of rupture of 50 psi (345 kPa) when tested in accordance with the following procedure. Five samples shall be tested and individual units shall not have a modulus of rupture of less than 35 psi (241 kPa).

2109.2.1.2.1 Support conditions. A cured unit shall be simply supported by 2-inch-diameter (51 mm) cylindrical supports located 2 inches (51 mm) in from each end and extending the full width of the unit.

2109.2.1.2.2 Loading conditions. A 2-inch-diameter (51 mm) cylinder shall be placed at midspan parallel to the supports.

All contain provisions or limitations for seismic and wind design

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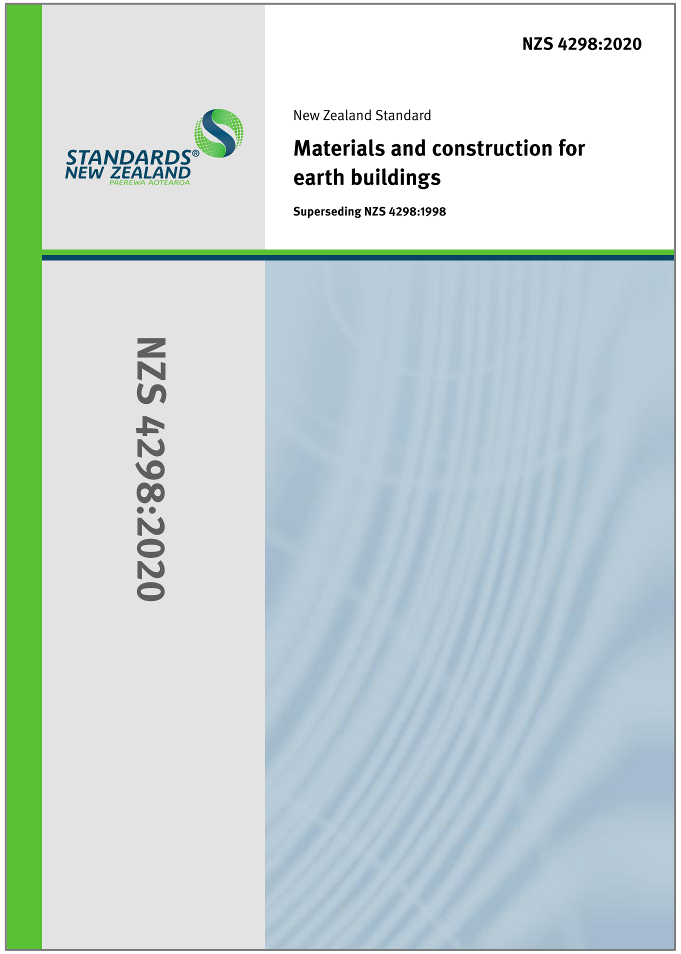
Be aware of codes from other countries for potential adoption or use elsewhere

New Zealand 3-Volume Earth Buildings Standard



Colombia - Requirements for Guadua Bamboo Structures

NSR-10 – Capítulo G.12 – Estructuras de guadua

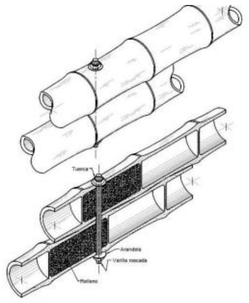


Figura G.12.8-2 - Detalle conectores secciones compuestas

G.12.8.12 — **APLASTAMIENTO**

G.12.8.12.1 — Los esfuerzos de compresión perpendicular a las fibras (f_p), deben verificarse especialmente en los apoyos y lugares en los que haya cargas concentradas en áreas pequeñas. El esfuerzo de compresión perpendicular a las fibras actuante no debe exceder al esfuerzo admisible de compresión perpendicular modificado por los coeficientes a que haya lugar.

G.12.8.12.2 — El esfuerzo a compresión perpendicular a la fibra actuante se calcula con la formula G.12.8-11

$$f_p = \frac{3RD_e}{2t^2 l} \; \square \; F_p\square \qquad \text{(G.12.8-11)}$$

En donde:

F_p□ = esfuerzo admisible en compresión perpendicular a la fibra, modificado por los coeficientes a que haya lugar, en MPa
f_p = esfuerzo actuante en compresión perpendicular a la fibra, en MPa
D_e = diámetro externo promedio de la sección de guadua rolliza, en mm
t = espesor promedio de la sección de guadua rolliza, en mm
l = longitud de apoyo, en mm
R = Fuerza aplicada en el sentido perpendicular a las fibras, en N

G.12.8.12.3 — Todos los cañutos que estén sometidos a esfuerzos de compresión perpendicular a la fibra, deben estar rellenos de mortero de cemento, en el caso en que esto no se cumpla el valor del esfuerzo admisible F_p□ se debe reducir a la 4 parte $(F_p\square/4)$.

G.12.9 — DISEÑO DE ELEMENTOS SOLICITADOS POR FUERZA AXIAL

G.12.9.1 — **GENERAL** — Los elementos que serán diseñados por fuerza axial son aquellos solicitados en la misma dirección que el eje longitudinal que pasa por el centroide de su sección transversal.

G-119

Indian Standard for Structural Bamboo

IS 15912 : 2012

Indian Standard

STRUCTURAL DESIGN USING BAMBOO —

CODE OF PRACTICE

ICS 91.100.10

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Building Construction Practices Sectional Committee had been approved by the Civil Engineering Division Council. Bamboo is a versatile resource possessing high strength-to-weight ratio and cost ratio and offers considerable ease in working with simpler tools. Resilience coupled with light weight makes bamboo an ideal material for housing in disaster prone/earthquake prone areas. The application of bamboo as a constructional material is largely based on established traditions and intuitions of forefathers throughout the tropical and sub-tropical regions. A need is now felt for design and construction code for bamboo to cater to a number of social and trade advantages, engineering recognition and the improved status. Research Institutes of repute across the country have been engaged in bamboo research in the country to establish its silviculture, botanical, entomological and pathological aspects besides creating a utilization base.

The bamboo culm has a tubular structure consisting of nodes and inter-nodes. In the inter-nodes the cells are axially oriented while the nodes provide the transverse inter-connections. This disposition of the nodes and the wall thickness are significant in imparting mechanical strength to bamboo. In a circular cross-section, bamboo is generally hollow and for structural purposes this form quite effective and advantageous. While utilizing the information as given in the National Building Code of India – 2005', SP 7 : 2005 (Part 6, Section 3B) for structural designing with bamboo, was of considerable assistance in developing this separate standard on the design and construction using bamboo. The information contained in this standard is systematized based on the R&D carried out earlier at institutes like FRI, Dehradun, IPIRTI, Bangalore the technical literature by the International Network for Bamboo Rattan INBAR) and national and other International Standards. For specific technical details, reference be them. Reference was also made to ISO 22156 : 2004 'Bamboo-structural design'.

The composition of the Committee responsible the formulation of this standard is given at Annex B. Figures 1 to 4 providing joint types are for information only. For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960
'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

World Housing Encyclopedia

www.world-housing.net

A project of the Earthquake Engineering Research Institute

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CCCM CLUSTER

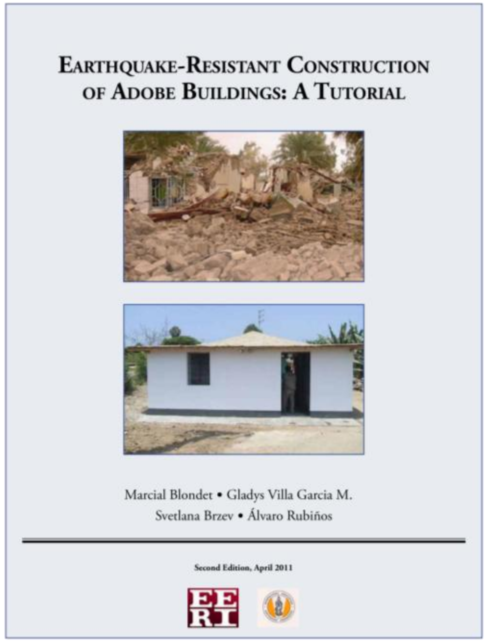
Supporting displaced communities

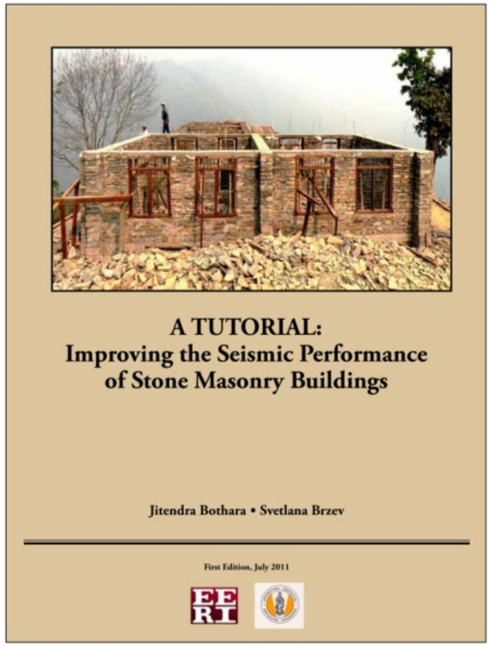
HOUSING REPORTS - 156 reports, 40 countries

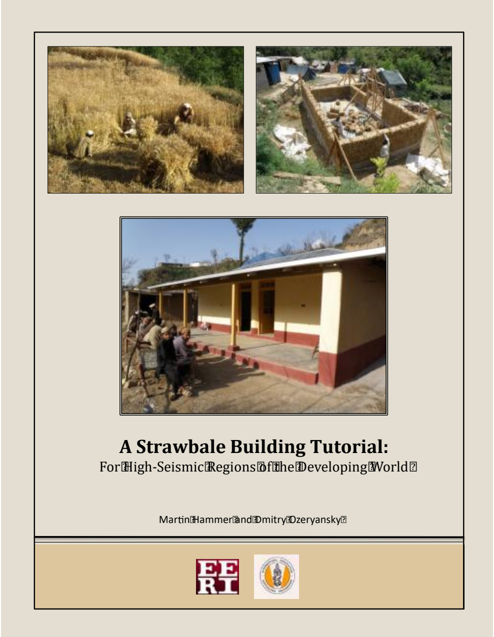
CONFINED MASONRY NETWORK

TUTORIALS

Reinforced Adobe
Confined Masonry
Reinforced Concrete Frame
Adobe Houses with Geomesh
Stone Masonry Buildings
Dhajji Dewari
Strawbale Construction (in development)







Housing Reports and Tutorials are free downloadable

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Summary of Lessons Learned – Post-Disaster Rebuilding

- Be Prepared
- Understand the Needs, Culture, and In-Country Resources
- Be Present – as soon, and for as long as possible
- Develop Relationships/Partnerships – Governmental and NGO
- Governmental approvals and access to funding
- Culturally appropriate, cost-competitive solutions
- Durable, safe, replicable solutions that perform
- Deliver

Shukriya **Mesi Anpil** **Dhanyabad**

Thank You

Martin Hammer
Architect and Co-Director
Builders Without Borders

martin@builderswithoutborders.org

Lime Stabilized Soil in Post-Disaster Shelter Construction (LSS)

Straw Build

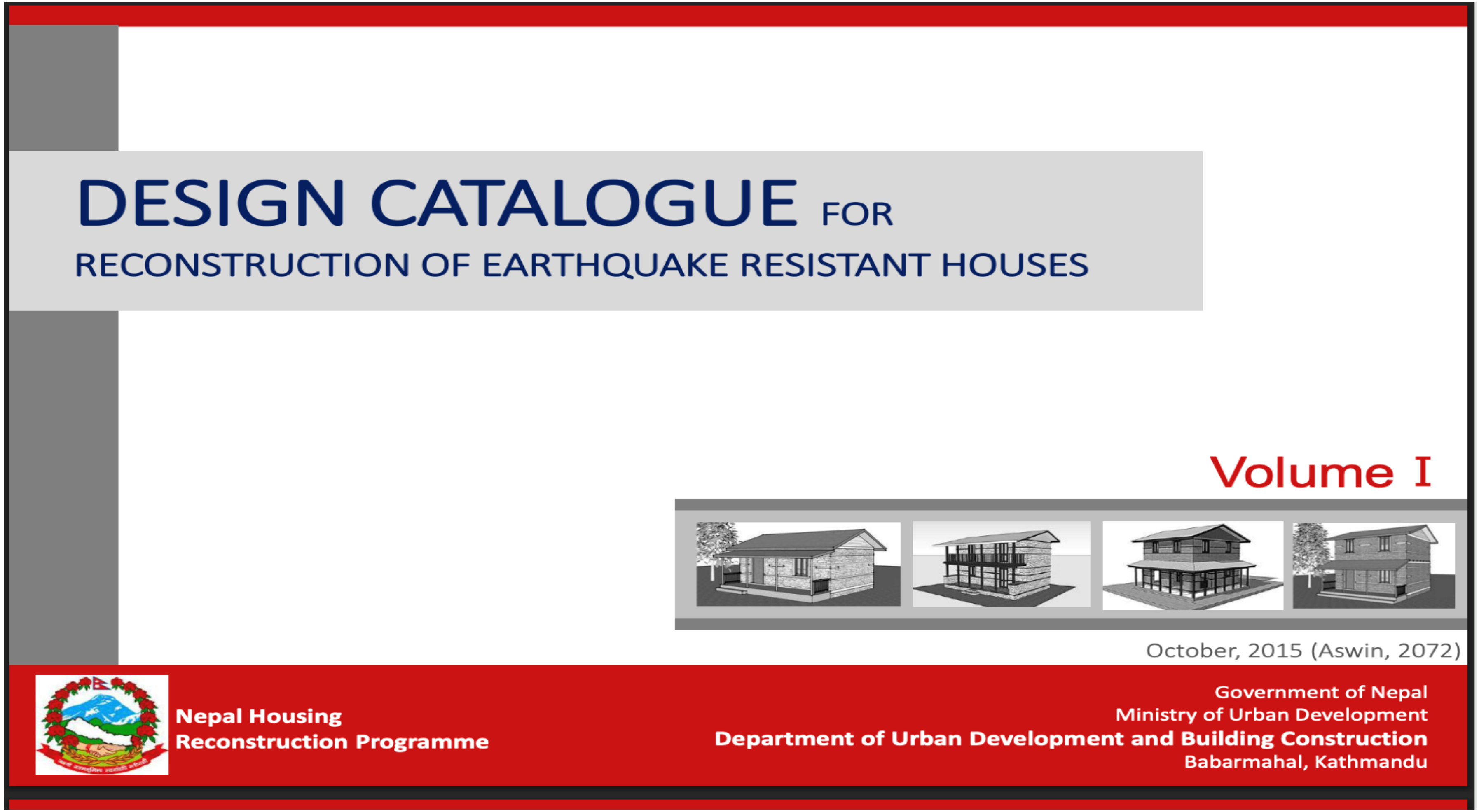
re-alliance.org

Bee Rowan
CEO
STRAW BUILD
Beerowan@gmail.com

Opportunities and Challenges in Approval and Use

From Building Codes to Building Practice

- Codes ensure safety
- Provide structure and accountability
- Struggle with non-conventional materials

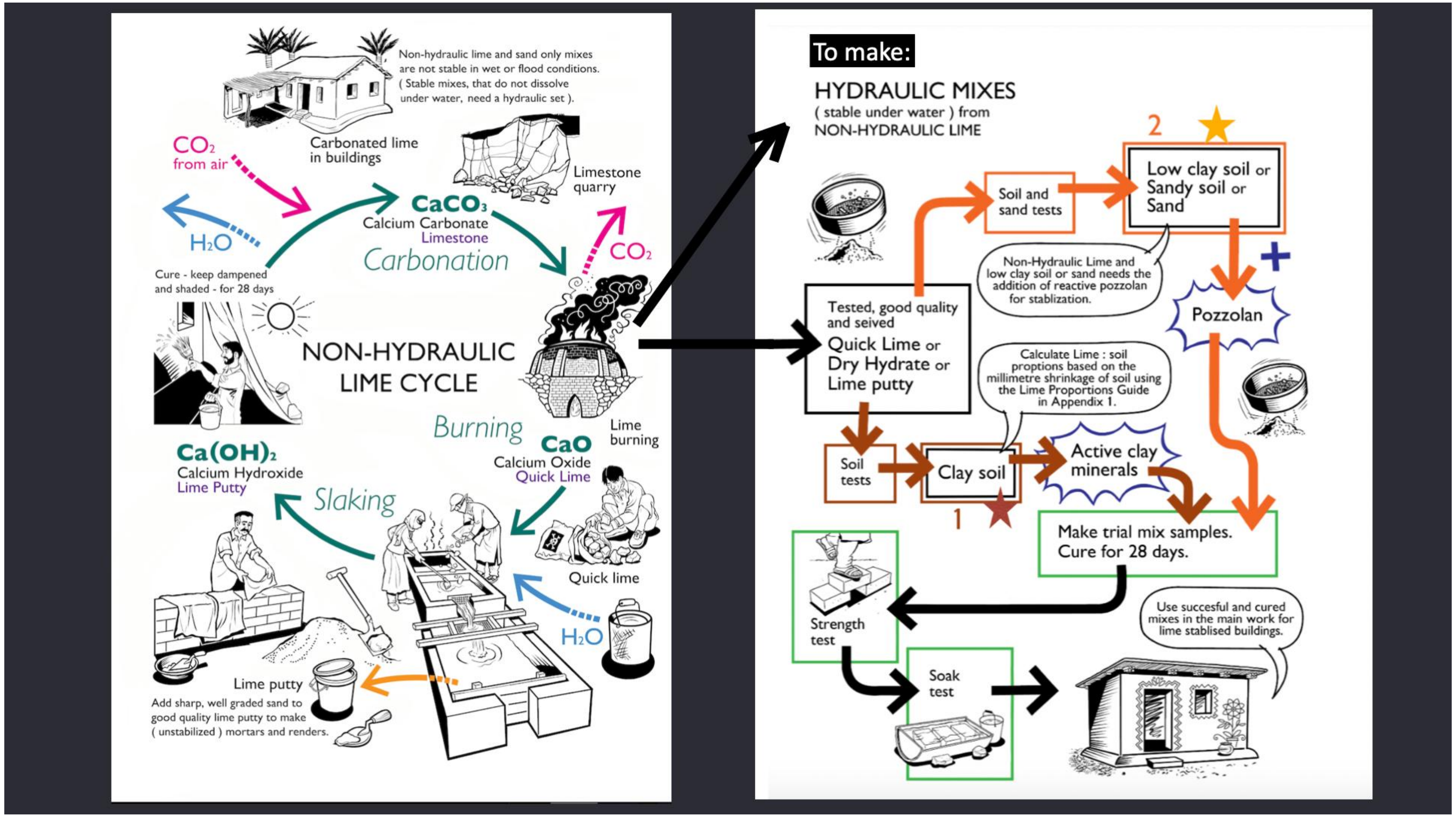


A Key Challenge

- How do we enable safe use of local materials?
- Why are proven materials difficult to approve?

What is Lime-Stabilized Soil?

- Soil and lime create stabilisation
- Improves strength and water resistance
- Used in blocks walls floors and plasters



What Does LSS Do?

- Reduces plasticity
- Increases strength
- Improves water resistance
- Enhances durability
- Fire resistant

A Proven Approach

- Used globally for decades
- Strong historical precedent
- Supported by modern engineering

Why It Matters in Disaster Contexts

- Local materials
- Lower cost and logistics
- Supports skills and livelihoods
- Low carbon
- Climate relevance

So Why Isn't It Widely Used?

- Technical viability not main barrier
- Limited uptake
- Approval systems are the issue

Barriers to Use

- Doesn't fit codes
- Testing slow and expensive
- Material variability
- Risk perception
- Speed vs Quality: Programme/Donor deadlines

A Shift in Perspective

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- Not: Are these materials safe?
- But: How can systems evaluate them?

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Enabling Better Use

- Pre-approved guidance
- Faster testing
- Shared evidence
- Early authority engagement
- Open knowledge systems

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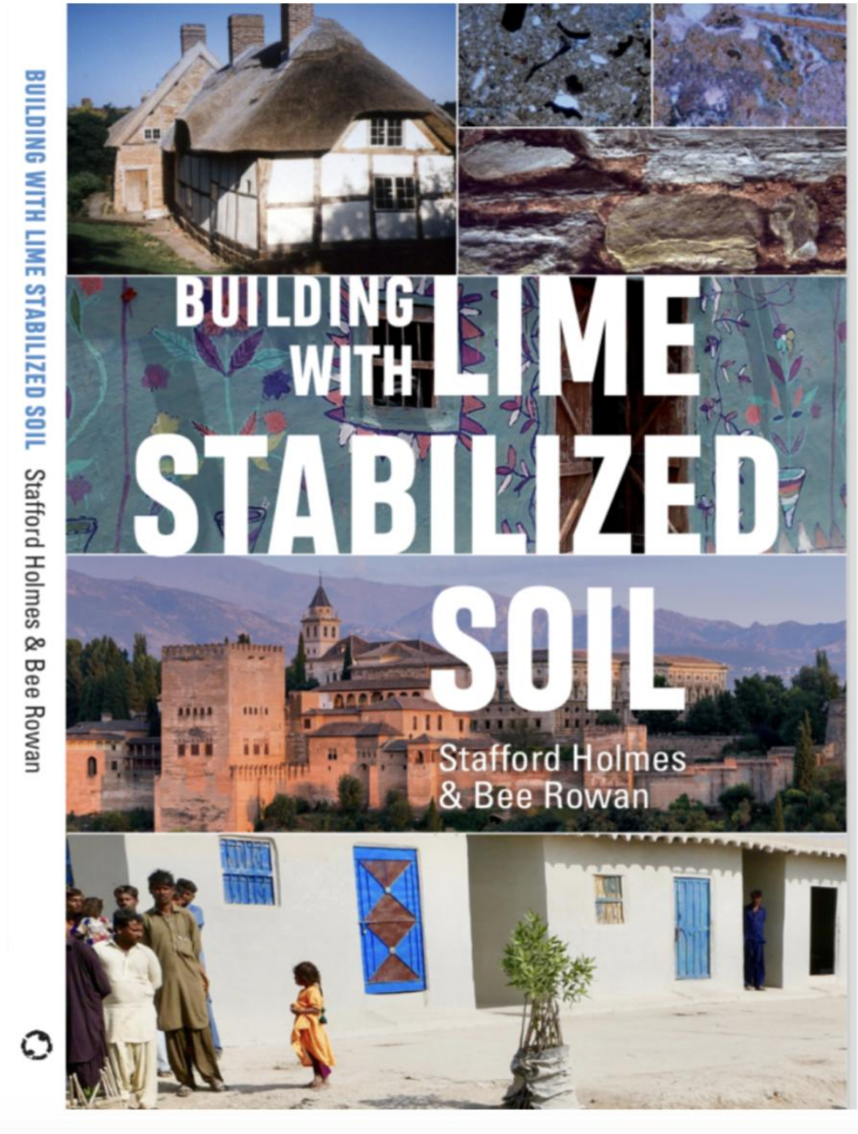
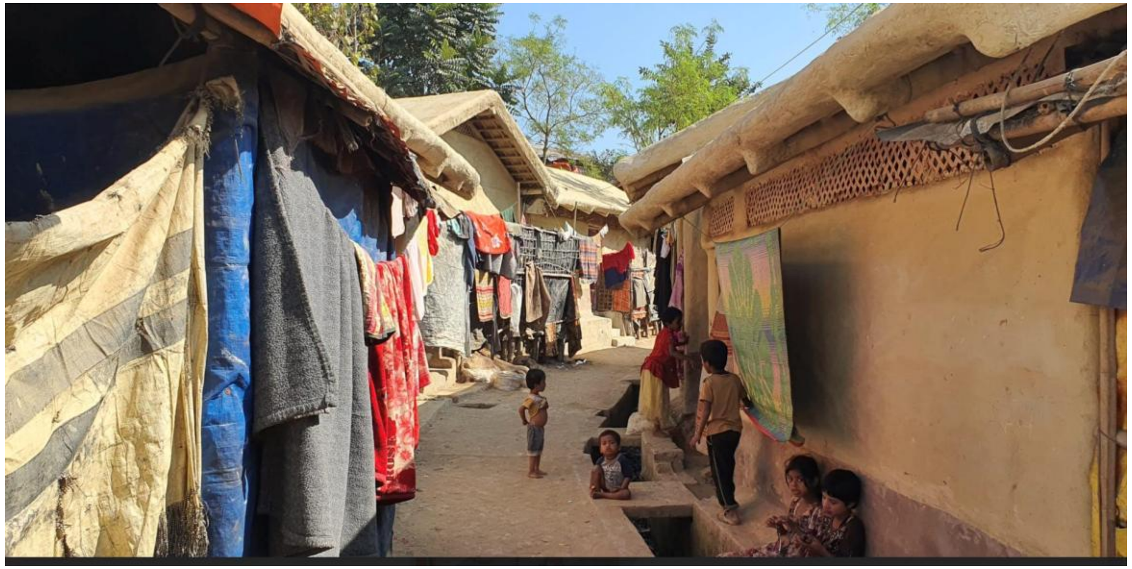
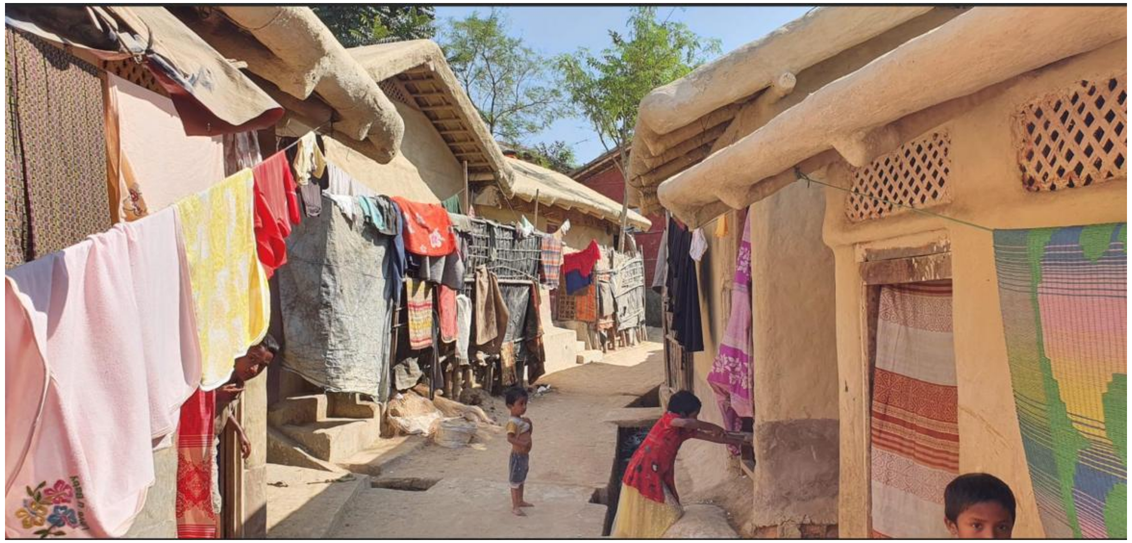
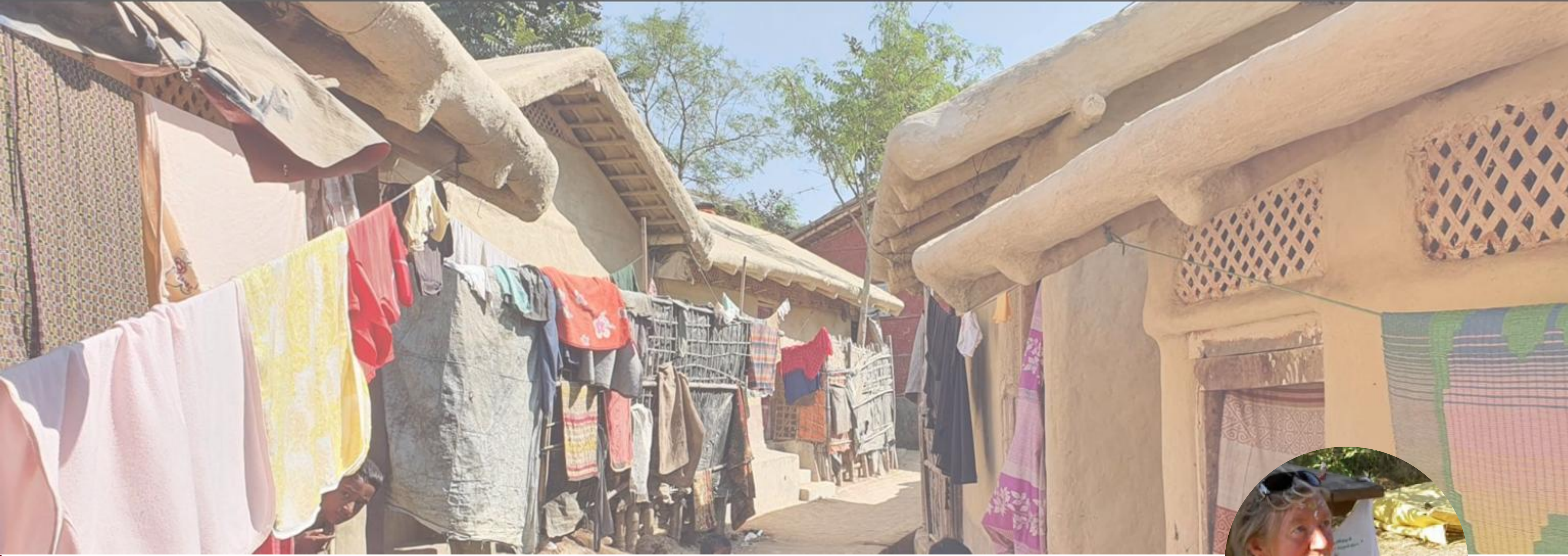


Closing Thought

- Materials exist
- Challenge is enabling use
- Approval systems shape outcomes







THANK YOU

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Re-Alliance | Regenerative humanitarian response, beyond sustainability

Bee Rowan

CEO

STRAW BUILD

Beerowan@gmail.com

QUESTIONS / DISCUSSION

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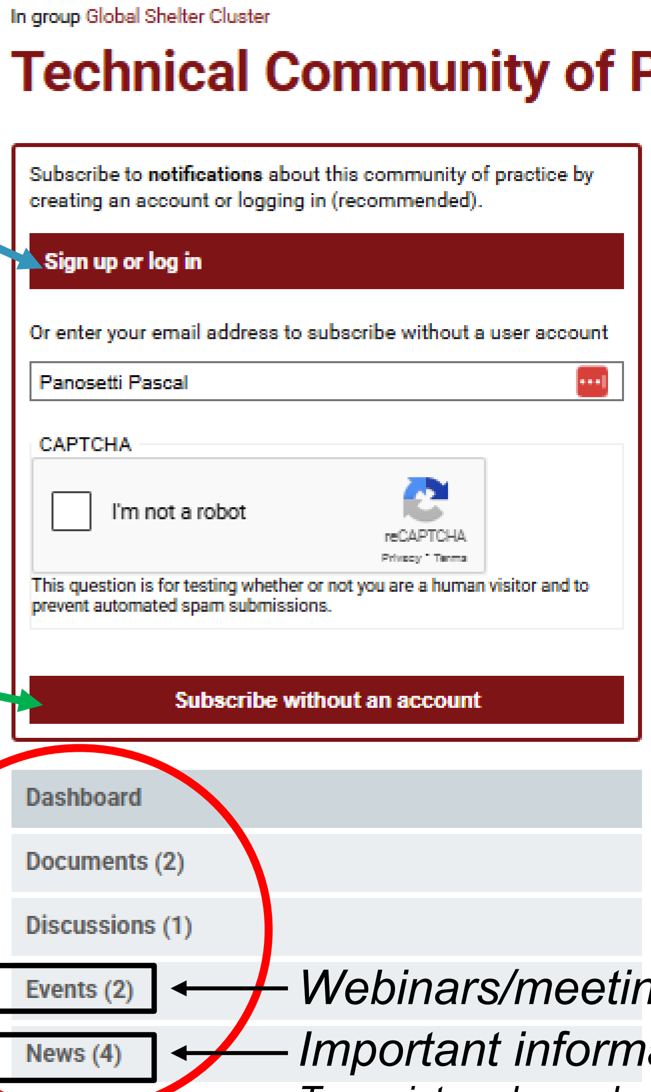
NEXT STEPS

Register to the Technical CoP

BEST OPTION :
by creating a GSC account

- Subscribe to the Technical CoP to receive **automatic** notifications, when new **Documents**, **Discussions**, **Events** and **News** are published.

without and account
not recommended !!



Webinars/meetings calendar
Important information shared
To registered members

[Technical CoP webpage]

We recommend to follow also of the [Technical Toolkit] which contain resources concerning the thematics discussed within the Technical CoP > Click 'Follow' on the left-hand side of the page

Shelter Cluster website

In group Global Shelter Cluster

for Communication and Webinars

Technical Community of Practice

- ▸ ADD CONTENT
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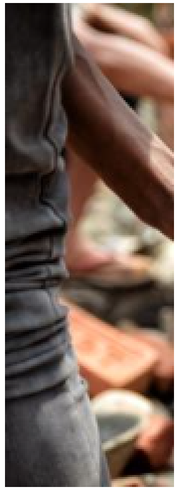
- Un-follow this community of practice
- Dashboard
- Documents (3)
- Discussions (1)
- Events (2)
- News (6)
- Followers (43)

MEETINGS +

- Webinars Technical CoP
  - Webinars Damage Assessment
  - Webinars Emergency and Temporary Shelter Technical Specification Resources
  - Webinars NFIs / EHIs technical specifications
  - Webinars Permanent / durable shelter / housing
  - Webinars Good Construction Practices / Build Back Better (BBB)
  - Webinars Greener Shelter
  - Webinars Fire Safety

OVERVIEW



PURPOSE

The Shelter Clus
programs. It est
technical aspec

STRUCTURE

IFRC will moder
specifications, c
actively.

Link : Technical Community of Practice

In region Resources and in group Resources

for Resources

Technical Toolkit

- ▸ ADD CONTENT
- Administer Group
- Un-follow this toolkit
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- Documents (3)
- Followers (1)

TECHNICAL THEMES +

- Damage Assessment Resources
- Emergency and Temporary Shelter Technical Specification Resources
- Durable Permantent Shelter & Housing (Sustainable Solutions) Resources
- Good Construction Practices / Build Back Better (BBB) Resources
- NFI/EHI Technical Specification Resources
- Greener Shelter Resources
- Fire Safety Resources
- Settlement Planning Resources

ADDITIONAL RESOURCES +

- IEC Compendium
- Technical Resources curated
- Flood technical documents

Link: Technical Toolkit

Technical CoP (webinars/comm.)

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Technical Community of Practice

Technical Community of Practice

Technical CoP webpage

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- Events (5)
- News (10)
- Followers (51)

MEETINGS +

- Webinars Technical CoP
  - Damage Assessment - T.Sub-CoP
  - Emergency and Temporary Shelter Technical Specifications - T.Sub-CoP
  - NFIs / EHIs technical specifications - T.Sub-CoP
  - Durable Permanent Shelter & Housing - T.Sub-CoP
  - Construction Good Practices / Build Back Better (BBB) - T.Sub-CoP
  - Greener Shelter - T.Sub-CoP
  - Fire Safety - T.Sub-CoP
  - Hosting Assistance - T.Sub-CoP

TECHNICAL TOOLKIT +

- Technical Toolkit

DAMAGE ASSESSMENT - T.SUB-COP

PARENT PAGE

- Webinars Technical CoP

All recorded meetings and webinars concerning **Damage Assessment** will be published on this page including the HNPW 2025 session : Striking the right balance: Rapid vs. Detailed Damage Assessments for Effective Shelter Programming.

Note: viewing the recording on YouTube allows you to select the chapters of the session.

All resources concerning this theme can be found on the Technical Toolkit page on the left menu.

Damage Assessment Technical Sub-CoP committee :

Pascal Panosetti - IFRC/GSC - pascal.panosetti@ifrc.org - chair

Regina Wenk - SDC/SHA, Shelter Expert Group - regina.wenk@aarau.ch - co-chair

Arnold Njogu - UNDP - arnold.njogu@undp.org - co-chair

Mamuney Legesse Nigusse - IOM Ethiopia - mnigusse@iom.int - co-chair

Showing 1–2 of 2 documents.

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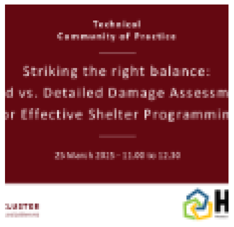
HNPW 2025_SESSION REPORT_ STRIKING THE RIGHT BALANCE_ RAPID VS. DETAILED DAMAGE ASSESSMENTS_GSC

25 Mar 2025 · English · Shelter Cluster



HNPW 2025 SESSION PRESENTATION : STRIKING THE RIGHT BALANCE: RAPID VS. DETAILED DAMAGE ASSESSMENTS FOR

25 Mar 2025 · English · Shelter Cluster

HNPW 2025 Striking the right balance Rapid vs Detailed Damage Assessments - Global Shelter Cluster

Copy link

Technical Toolkit (resources)

GLOBAL SHELTER, LAND AND SITE COORDINATION CLUSTER

GLOBAL SHELTER CLUSTER – Coordinating Humanitarian Shelter and Settlements · Housing, Land and Property AoR · CCCM CLUSTER – Supporting displaced communities

In region Resources and in group Resources

Technical Toolkit

Follow this toolkit

Dashboard

Documents (3)

TECHNICAL THEMES +

- Damage Assessment Resources
- Emergency and Temporary Shelter Technical Specification Resources
- Durable Permantent Shelter & Housing (Sustainable Solutions) Resources
- Construction Good Practices / Build Back Better (BBB) Resources
- NFI/EHI Technical Specification Resources
- Greener Shelter Resources
- Fire Safety Resources
- Settlement Planning Resources

ADDITIONAL RESOURCES +

- IEC Compendium
- Technical Resources curated
- Flood technical resources

[Technical Toolkit webpage]

DAMAGE ASSESSMENT RESOURCES

Documents related to damage assessment

Showing 1–10 of 10 documents.

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EVALUATION DÉTAILLÉE DES DOMMAGES HAITI 2020 - MANUEL DE TERRAIN

Resources

1 Aug 2025 · French · Shelter Cluster and Miyamoto International

Technical Support and Design | Assessment, Monitoring, and Evaluati... | Technical Guidance

HOUSEHOLD AND BUILDING DAMAGE ASSESSMENT (HBDA) OVERVIEW - 2025

27 Jun 2025 · English · Shelter Cluster UNDP

Technical Support and Design | Assessment, Monitoring, and Evaluati... | Technical Guidance

QUESTIONNAIRE HOUSING BUILDING DAMAGE ASSESSMENT (HBDA) - UNDP - VANUATU EARTHQUAKE 2024

1 Jun 2024 · English · Shelter Cluster UNDP

Technical Support and Design | Assessment, Monitoring, and Evaluati... | Curated

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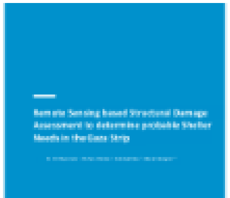
RDNA STATE QUESTIONS_UKRAINE CABINET OF MINISTERS - 2024

Bangladesh Flash Flood 2022

1 May 2024 · English · Shelter Cluster

Technical Support and Design | Assessment, Monitoring, and Evaluati... | Shelter Programming

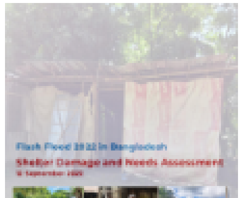


REMOTE SENSING STRUCTURAL DAMAGE ASSESSMENT TO DETERMINE PROBABLE SHELTER NEEDS IN THE GAZA STRIP - 2024

Palestine

7 Mar 2024 · English · Shelter Cluster and Miyamoto International

Information Management | Technical Support and Design



★ SHELTER DAMAGE AND NEEDS ASSESSMENT - FLASH FLOOD 2022

Bangladesh Flash Flood 2022

15 Sep 2022 · English · Shelter Cluster

Technical Support and Design

Technical Community of Practice

THANK YOU

GLOBAL SHELTER, LAND AND SITE COORDINATION CLUSTER

GLOBAL SHELTER CLUSTER
Coordinating Humanitarian Shelter and Settlements

Housing, Land and Property AoR

CCCM CLUSTER
Supporting displaced communities