Oxfam GB

Haiti Earthquake Response

Arup Assignment Report

ARUP

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Executive Summary

On the 12th January 2010 a magnitude 7.0 earthquake left Haiti devastated, killing 230,000 people and affecting 3million. In February 2010 Arup International Development were commissioned by Oxfam to carry out a 10 day assignment in Haiti to provide technical advice to inform their response. The objectives agreed were:

- Review existing residential building typologies and how they responded to the earthquake
- Trial the ATC-20 damage assessment form and make recommendations for its use in Haiti.
- Field training of Oxfam staff on damage assessment and provide recommendations on appropriate training methods in damage assessment of residential and other buildings.

Building Typologies and their response to the Earthquake

The most common building typologies for housing in Haiti are:

a) Concrete frame, hollow block flat slabs and un-reinforced hollow block masonry infill;

b) Concrete columns, unreinforced hollow block masonry with timber and Corrugated Galvanised Iron roof;

c) Unreinforced hollow block masonry with timber and CGI roof;

d) Timber and CGI walls and roof.

A smaller number of houses are stone masonry or Colombage (braced timber framing, brick infill). Foundations, retaining walls and perimeter walls are typically constructed of stone masonry.

Existing methods of building categorisation, such as FEMA 154, do not adequately represent the common building typologies in Haiti. Additional classifications have been proposed which could be used for damage assessments, and also for developing related proposals for repairs and retrofitting.

The performance of all of these building typologies ranged from no damage to total collapse. The extent of the damage was dependant on ground conditions, material quality, detailing and construction quality rather than any one system being decisively better than another. The performance of all of these building typologies could be significantly improved with relatively modest changes to their design and detailing.

Lightweight timber frame structures fared relatively well in the earthquake but are inherently vulnerable to hurricanes. Masonry (stone or hollow block) seems to be a ubiquitous construction technology, which suggests that confined masonry unit (CMU) and reinforced masonry are appropriate typologies for reconstruction.

There are no existing building codes or regulations in Haiti. International standards are relevant (e.g. International Building Code 2009 and Eurocode 8), but all assume a degree of sophistication in the construction industry that does not exist in Haiti. Such code requirements would need to be adapted to reflect the local context and building typologies. Any attempt to improve the quality of construction must include the informal sector, with training focused at labourers and artisans.

ATC-20 Damage Assessment and Recommendations

The Department of Public Works, with the support of UNOPS, have developed a damage assessment form based on the ATC-20. This was trialled by the team on a number of different typology residential properties (approximately 60), 2 community buildings (a school and an orphanage), 6 Oxfam partner facilities and 2 Oxfam warehouses.

Our experience of using the modified ATC-20 indicated that although it is possible to use, it has limited application in Haiti for a number of critical reasons:

a) The ATC-20 provides an assessment of the damage as a result of the earthquake to ascertain if the buildings are 'habitable' and can be reoccupied. However this does not mean they are 'safe' and can withstand future disasters. This is especially true the further you move from the epicentre.

   It is recommended that comprehensive assessment and retrofitting should be encouraged across the entire country.

b) The ATC-20 has been developed for use in countries such as the US where there is a clear follow up process that the ATC-20 feeds into. In the Haitian context however this does not exist. The ATC-20 does not provide occupiers of the assessed houses with sufficient information to make informed decisions about repairs, demolition or retrofitting.

   It is recommended that any damage assessments have a follow up strategy and are integrated into a wider recovery plan.

c) There is no process in place for the Government of Haiti to confirm the mandate and authority of those doing damage assessment, nor what to do with completed forms.

   There is a clear need for significant collaboration between any agencies carrying out damage assessments and integration with the policy being developed by the Haitian government.

d) The ATC-20 damage assessment has been designed to be undertaken by individuals with specialist earthquake engineering skills and prior experience of damage assessments. This is not an option available to the majority of organisations working in Haiti.

   It is recommended that specific targeted training is provided to Oxfam's technical staff to assess simple building typologies with obvious building assessment result of green (undamaged by the earthquake) or red (unsafe) ratings. Specialists will be required to assess the more complex urban areas of Port au Prince.

Damage Assessment Training

The damage assessments were carried out with two newly recruited Haitian Oxfam staff, both with a technical background, but not seismic knowledge. Training will be needed in order for Oxfam staff to undertake the damage assessments independently, even for simple building typologies. We recommend such training includes:

a) A clear strategic overview:
   - The purpose of the damage assessment
   - The relationship between damage assessment and government policy
   - The importance of follow up advice and training (ie not seeing the ATC-20 as a stand alone document)

b) Targeted training for using the ATC-20:
   - The limitation of the colour coding in terms of 'habitability' and 'safety'

- Building typologies, structural performance and types of damage to expect/ to look out for
- Critical junctions to inspect
- Completion of the ATC-20 assessment form
- Methods for engaging and informing the house occupiers

c) General training in seismic principles:

- This should be focused on Haitian building typologies
- Structural systems and load paths
- Understanding of retrofitting, repairs, demolition and temporary shoring and strapping

Reconstruction Considerations

In the course of this assignment a number of wider observations relating to reconstruction have been made. These include:

- The potential to recycle and re-use materials
- The need for master-planning in urban areas
- The potential to develop masonry as a locally appropriate construction technology
- Artisans and homeowners should be the main focus of any training efforts
- The need to develop tenant driven reconstruction approaches that establish clear tenant rights
- The complexity of urban reconstruction, as humanitarian shelter responses typical deliver single storey, detached housing which will not be appropriate in Haiti. Technical expertise will be required at every stage.

Finally it is critical to understand that the scale of the disaster in Haiti was a result of:

- poor construction and materials,
- lack of planning and building regulations and
- lack of awareness that earthquakes were a significant hazard in Haiti.

All three of these issues need to be addresses strategically through: raising awareness of hazards and appropriate methods of mitigation

- training at all levels
- appropriate policy change and enforcement

Acknowledgments

This report is dedicated to all those who died due to the unnecessary collapse of so many structures on 12th January 2010 when the magnitude 7.0 earthquake occurred.

Our thoughts are with all those who have lost loved ones and who are now facing the arduous task of reconstructing with the hope that Haiti will be built back better through our collective efforts.

We would like to make the following acknowledgements without whose support this work would not have been possible.

- Oxfam GB for giving us the opportunity to work with them in Haiti.
- Arup for enabling us to go on this mission and a special thanks to the management and staff of the Doha and Dubai offices for agreeing to release us from our existing work commitments. In particular we would like to thank the following Arup staff:
  - Allan Cantos for doing some drafting
  - Claire Noble for stitching photos together
  - Elizabeth Parker for proof reading and helpful comments
  - Victoria Batchelor and Jo da Silva for their help with the executive summary
- Our families.

Kubilay Hicyilmaz and Kathy Gibbs, Arup

March 2010

1 Introduction

This report provides a summary of the 10 day assignment carried out by Kubilay Hicyilmaz and Kathy Gibbs from Arup on behalf of Oxfam GB between 24 February and 6 March 2010. Both are chartered structural engineers with 10+ years experience including specialist expertise in damage assessment and seismic design. They were commissioned through Arup International Development which operates on not-for-profit basis.

The aim of this assignment was to contribute to the emergency response and recovery by providing technical guidance on how to conduct rapid damage assessment of residential buildings that had been damaged by the earthquake. This is important in order to encourage families to return home to houses which are habitable and/or repairable rather than linger in camps. More specifically Arup's objectives were:

- Review existing residential building typologies and how they responded to the earthquake
- Develop rapid and detailed evaluation procedures to enable local engineers, builders and architects to identify seismic damages to residential buildings based on *ACT-20-1 Field Manual: Post earthquake Safety Evaluation of Buildings: Second Edition.*
- Make recommendations on how to categorize safety risk
- Provide recommendations for safe construction practice when demolishing unsafe buildings.

On arrival in Port-au-Prince, Haiti this scope was amended since a Building Assessment Bureau within the Dept of Public Works (MTPTC) had been created with support from UNOPS, and a modified version of the standard ATC-20 structural rapid assessment form had been developed and translated into French. In response Arup's scope of work altered and it was agreed that the new objectives were:

- Review existing residential building typologies and how they responded to the earthquake
- Trial the ATC-20 form by carrying out damage assessment of a number of buildings, and make recommendations on its application in Haiti.
- Carry out in the field training of Oxfam staff on damage assessment and provide recommendations on appropriate training methods in damage assessment of residential and other buildings.

In carrying out this assignment, and based on our previous post-disaster experience, a number of other technical observations are made in this report which Arup consider important for Oxfam GB and other agencies to consider in developing their shelter and re-construction programmes. This includes:

- Natural Hazard Risk
- Planning and Building Regulations
- Current Construction Practices
- Other Considerations for re-construction

Finally we have made recommendations for potential activities that Oxfam GB or other humanitarian actors might consider to support recovery and re-construction.

2 Background

2.1 The Earthquake

At 16:53:10 local time on the 12th January, a magnitude 7.0 earthquake occurred about 25km west south west of the capital Port-au-Prince at a depth of about 13km (Ref [1]). The location of the epicentre and the distribution of damage are shown on Figure 1. The earthquake was shallow and there was a limited reduction in the levels of ground shaking by the time the earthquake arrived. However, the duration and rupture size of the earthquake were not as large as would have been expected from a magnitude 7.0 earthquake (See Reference [1]). Whilst the ground shaking was likely to have been associated with high levels of ground acceleration (due to the shallow depth of the vent), the duration was relatively short. The poor construction quality in Haiti is thought to have been the most critical factor for the extensive damage caused.

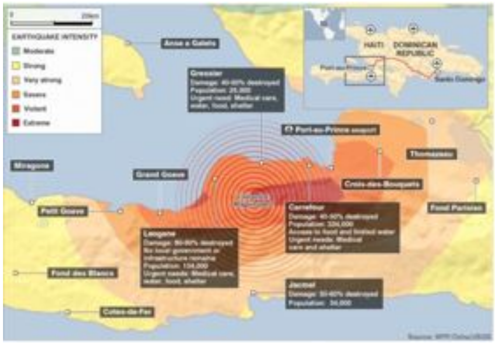


Figure 1 Location of Earthquake and Damage Distribution

Figure 2 Tectonic Setting of Haiti

Haiti occupies the western half of the island of Hispaniola which sits on the seismically active boundary between the Caribbean Plate and the North American Plate, as shown in Figure 2. This boundary is affected by two separate faults, one on the north of the island and one on the south, which delineate the Gonâve microplate. The recent earthquake occurred on the southern boundary, named the Enriquillo-Plantain Garden fault zone (EPGFZ). This is a left lateral strike-slip fault similar to the San Andreas Fault in California.

2.2 The Disaster

This earthquake caused major destruction to the built environment within the capital Port-au-Prince and nearby towns, resulting in the collapse of numerous buildings including the presidential palace, the main seaport and the UN mission. It is estimated that more than 230,000 people were killed (as of February 9th), approximately and approximately 3 million people have affected.

Records indicate that the last significant earthquakes in the region were in 1751 and 1770, therefore there was no inter-generational memory of earthquakes, with strong winds and flooding as a result of hurricanes posing a much more immediate and tangible risk. The last significant event being Hurricane Gustav which hit Haiti on the 5th September 2008, killing 698 people and affecting about 250,000 people.

The total lack of earthquake awareness was surprising especially in that there does not even appear to be any old stories within the community as to such a terrible event from the past. This is in stark contrast to many other regions from around the world where “Earthquake Myths” have traditionally been the means by which the earthquake message has been passed from generation to generation. Two such examples are shown in Figure 3.

Stories from western Vancouver Island and northern Washington tell of a struggle between thunderbird and Whale which are beings of supernatural size and power. The story says that all creatures rest on the back of a giant whale and that their struggle results in earthquakes, thunder-noise and water pours.

East Africa: A huge fish carries a rock on his back. A cow stands on the rock, balancing the earth on one of her horns. Once in a while her neck begins to hurt. To get rid of the ache, she tosses the earth from one horn to the other. That causes the earth to tremble.

Figure 3 Typical Earthquake Myths from around the world

This lack of earthquake awareness was compounded by limited of planning, poor quality construction, political instability, rapid urbanisation and extreme poverty. As a result very large numbers of buildings collapsed when the earthquake happened.

2.3 Who is affected by the Earthquake?

Those that were unfortunate enough to be living in very basic shelter before the earthquake were relatively fortunate because their dwellings fared well during the earthquake due to their lightness and flexibility. Even if part of these shelters fell off this was unlikely to cause serious damage. The housing for the wealthy, such as those living around Péitonville appears to have performed reasonably well in the earthquake.

However, the housing associated with middle classes as well as small to medium sized enterprises has been very hard hit. Our definition of “middle class” excludes only the extreme poor - who live in very basic shelter consisting of CGI or similar - and the very rich who live in well built houses in areas such as Péitonville. It was the people who had built using reinforced concrete and hollow concrete block masonry, and furthermore, people who had incrementally added to properties who appear to have been the worst hit.

An aspiration of the majority of Haitians is to have a house with a concrete frame and hollow concrete block walls as these houses were thought to be safe, particularly to resist storms.

However these middle class properties have been built without input from professionals and artisans with earthquake engineering awareness and skills. This informal construction has typically been undertaken by copying existing practices. In poorer communities buildings are generally similar due to the limited size of the properties. Wealthier houses are often architecturally more complicated, possibly multiple stories and will likely have been built incrementally.

An important question for INGOs is to define who their clients are. Normal practice for humanitarian workers is to provide support to the most vulnerable in societies. Within the post earthquake Haitian context who this may exactly be at the present moment in time is unclear.

3 Building Typologies

3.1 FEMA 154 Grouping

In order to give the building types we saw a clear classification the naming of housing types as per FEMA 154 has been adopted with an indication of the level of occurrence of the construction form in Haiti as shown in Table 1.

It is hoped that this may form a common platform across which agencies and organisations can work.

Table 1 Existing FEMA 154 building type descriptions

Label	Description	Occurrence in Haiti
W1	Light wood-frame residential and commercial buildings	Nearly None
W2	Light wood-frame buildings larger than 5,000 square	None
S1	Steel moment-resisting frame buildings	None
S2	Braced steel frame buildings	Very few
S3	Light metal buildings	Few
S4	Steel frame buildings with cast-in-place concrete shear walls	None
S5	Steel frame buildings with unreinforced masonry infill walls	None
C1	Concrete moment-resisting frame buildings	Many
C2	Concrete shear-wall buildings	Few
C3	Concrete frame buildings with unreinforced masonry infill walls	Few *
PC1	Tilt-up buildings	None
PC2	Precast concrete frame buildings	None
RM1	Reinforced masonry buildings with flexible floor and roof diaphragms	None
RM2	Reinforced masonry buildings with rigid floor and roof diaphragms	None
URM	Unreinforced masonry bearing-wall buildings	Few

* Generally, C3 type buildings are assumed to have solid slabs and a beam column framing, especially in seismic areas and were not that common. A rare example is shown in Figure 4.

A regular frame.

Beams are centrally located on columns.

Columns are larger than the beans

There were no obvious signs of any damage to this building. It also did not look like repairs had been undertaken after the earthquake.

Figure 4 A rare concrete frame building with unreinforced masonry infill walls

3.2 Suggested Haiti Specific Grouping

The Typical FEMA 154 categorisations are very specific to construction typologies in the United States of America. Therefore, within the Haitian context additional classifications are suggested as shown in Table 2.

Table 2 Suggested new building types specifically for the Haitian context

C4-HBFS-UHM	Concrete frame with hollow block flat slabs with un-reinforced hollow block masonry infill	Many
TCWR	Timber and corrugated galvanised iron walls and roof	Many
UHM-TCR	Unreinforced hollow block masonry with timber and CGI roof	Many
C4-HM-TCR	Concrete columns, unreinforced hollow masonry block infill with timber and CGI roof	Many
SMF	Stone masonry foundations	Nearly all
SMW	Stone masonry walls	Nearly all
SMH	Stone masonry houses	Some
CB	Colombage (similar to Himis in Turkey, Dhajji Dewari in Pakistan) – Braced timber framing with masonry infill.	Few
K*	Kay ate (Roof generally made of straw, thatch or palm leaves)	**
T*	Taudis (made from waste construction material, roof from palm leaves, corrugated metal sheets or cardboard, walls from whatever is available)	Similar to TCWR
A*	Ajoupas, found in rural areas made of thatch, straw or palm leaves	**

Note:

* As defined in the EERI, February 18 2010 report (See Ref [1])

** Within the urban context of our trip we did not visit the rural areas so did not see any of these houses our selves

Examples of the local building typologies are presented in the following sections.

3.2.1 C4-HBFS-UHM, Concrete Hollow Block Flat Slabs with Un-reinforced Hollow Block Masonry Infill

Figure 5 C4-HBFS-UHM, Concrete frame with hollow block flat slabs with un-reinforced hollow block masonry infill

Some, but by all means not complete considerations for this building type are:

- Needs proper foundations.
- Layouts to be balanced and simple in all directions.
- Masonry infill to be detailed so as to avoid short column effects.
- Floor construction has next to no punching shear capacity and is likely to be a significant reason for the total collapse of many such buildings. The use of flat slab type of floors should generally be avoided given the seismicity of Haiti. Where economic realities necessitate the usage of hollow concrete blocks in the floors they should certainly not be used near support points (columns or walls).
- Use seismic hooks everywhere as a basic principal of reinforced concrete detailing is seismic regions.
- Use much more closely spaced confinement hoops on beams and columns.
- Concrete preparation (ingredients and mixing), placement, vibration and curing to be properly controlled.
- Use band beams at sill, lintel and roof level to help tie all the infill walls together.
- Orthogonal masonry walls to be tied together using reinforced concrete stitches.
- Flat roofs to be waterproofed.
- Incremental additions to be stopped unless supported by engineering evidence of the adequacy of the building to take the extra loads.

3.2.2 TCWR, Timber and Corrugated Galvanised Iron Walls and Roof

This building is thought to have performed adequately during the earthquake. However it is a vulnerable construction type, especially to high winds.

Figure 6 TCWR, Timber and corrugated galvanised iron walls and roof (similar to type T) also.

Some, but by all means not complete considerations for this building type are:

- Drainage to be provided to avoid rainwater entering the houses (often with compacted earth flooring).
- Flooring should be raised above the surrounding ground inside the building.
- Foundations are required to anchor the building frame.
- A stone perimeter foundation band to be constructed on to which timber posts rests. This will prevent the timber being in direct contact with the ground.
- May benefit from the introduction of bracing to help stiffen the building.
- At roof level the introduction of a ring beam and straps will help keep the roof attached during heavy winds.
- Typically these buildings do not have latrines or cooking facilities and these activities take place in the surrounding area. Limited questioning appeared to suggest that external latrines exist roughly one between around 20 such houses.

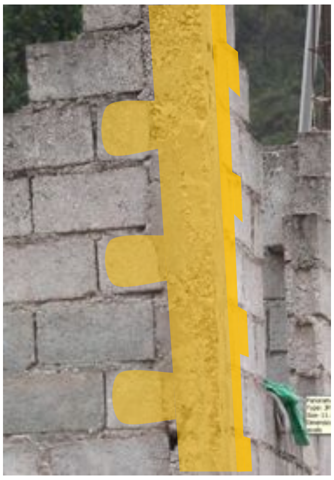
3.2.3 UHM-TCR, Un-reinforced Hollow Block Masonry with Timber and CGI Roof

Figure 7 UHM-TCR, Un-reinforced hollow block masonry with timber and CGI roof

Some, but by all means not complete considerations for this building type are:

- Drainage to be provided to avoid rainwater entering the houses (as they often have compacted earth flooring) – note the basic stone armouring around the base of these buildings and the undermining of the stone foundation.
- Proper foundations are required.
- Stone masonry to be improved to include through stones and band beams.
- At roof level the introduction of a ring beam and straps will help keep the roof attached during heavy winds. It may be possible to lay some thin reinforced concrete band beams more or less within the mortar joints of the concrete blocks.
- Masonry at corners and wall junctions to be interlocked and strategic stitching to be provided.
- Openings require proper lintel and sill beams where appropriate.
- Openings to be placed centrally in walls and be modest in size.
- The addition of vertical corner reinforcement and at major door openings would help tie the building together, especially if properly anchored to a wall ring beam.

3.2.4 C4-HM-TCR, Concrete Columns, Unreinforced Hollow Masonry Block Infill with Timber and CGI Roof



Confined masonry example showing clear flow of concrete into the masonry creating a solid bond (Source: Manual by Tom Schacher)

Figure 8 C4-HM-TCR, Concrete columns, un-reinforced hollow masonry block infill with timber and CGI roof

In many ways these buildings are similar to the UHM-TCR building previously discussed in Section 3.2.3. In fact these houses are more expensive than the masonry only version and have all the ingredients to make good quality seismically resistant houses. Attention to the workmanship should ensure that these buildings perform well. It is not thought that implementing the required improvements (similar to the ones described in Section 3.2.3) would need any additional funds.

One aspect that is crucial for these houses, especially when built on steep terrain is the quality of the stone masonry retaining walls and foundations. Stone masonry foundations are discussed briefly in the next section and further guidance on stone masonry is provided in Section 8.3.3.1.

It is possible that the columns are cast after the construction of the concrete block walls. However, it is unclear how and what attention is paid to how the concrete flow is detailed. The observed constructions may have the characteristics of confined masonry construction whereby it might be possible for the cast concrete to have flown into the void spaces of the concrete hollow blocks.

3.2.5 SMF, Stone Masonry Foundations

It is interesting to note that all technical earthquake engineering recognisance reports read by the authors to date have not made any mention of the role of stone masonry in Haiti.

Stone masonry is everywhere and there is hardly a single property without some components of stone masonry. Typical occurrences of stone masonry are:

- Many boundary walls are made entirely from stone masonry.
- As a minimum the base of most boundary walls are made from stone masonry.
- Most terrace retaining walls are stone masonry.
- Most levelling of building plots is done using stone masonry
- The base and foundation of most buildings is likely to include large amounts of stone.

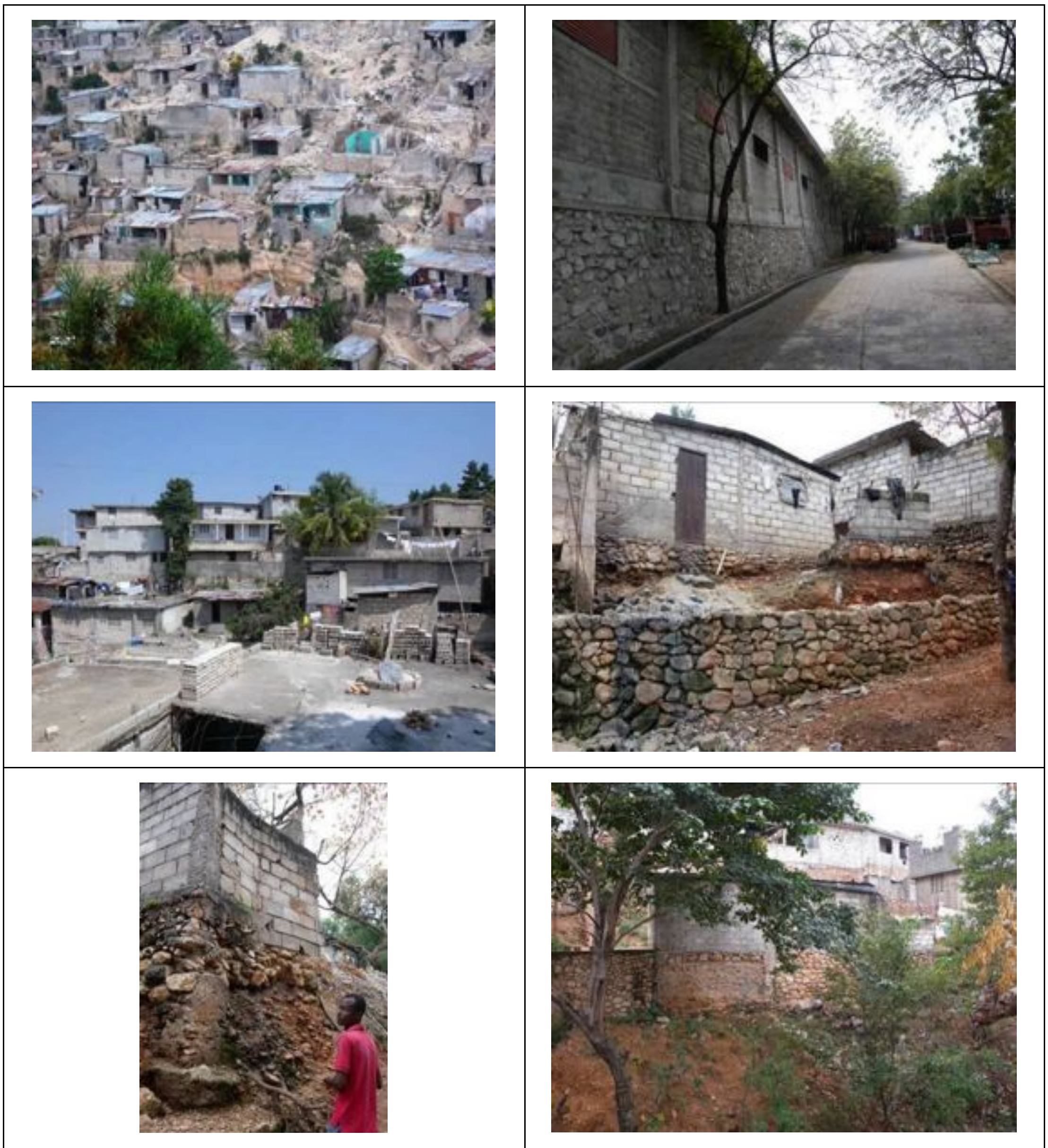


Figure 9 SMF, Stone masonry foundations

The limestone rock appears to be of reasonable quality. However, the quality of the stone masonry in Haiti is generally poor. Little attention is paid to its proper preparation or seismic detailing requirements. Section 8.3.3.1 of this report discusses stone masonry in greater detail.

3.2.6 SMW, Stone Masonry Wall

Figure 10 SMRW, Stone masonry walls, some under construction / being repaired

Perimeter walls are important in Haiti, especially given the political instability in the country. Therefore, construction of safe walls is an important consideration for Haitians in terms of reconstruction priorities. As with the previous section the rock is of good quality but its usage in terms of stone masonry is generally poor. Section 8.3.3.1 of this report discusses stone masonry in greater detail.

3.2.7 SMH, Stone Masonry Houses

The performance of stone masonry buildings varied from complete collapse to appearing untouched by the earthquake and examples are shown in Figure 11. The top two and middle left house being details of the German Embassy in Port au Prince which appears undamaged from these photos as does the stone masonry tower in the middle right picture. Both of these building appear to have followed at least some basic stone masonry principals and the stones were laid in a strong mortar and the corners were detailed to be stronger.

 Photo source: German Embassy Web Site	 Photo source: German Embassy Web Site
 Photo source: Silva Laufer	
	

Figure 11 SM, Stone masonry

The bottom two images in Figure 11, show collapsed stone masonry houses. The collapsed walls reveal that they were mainly constructed from random rubble, laid in mud mortar with no evidence of any preparation of the stones prior to them being used in the wall construction. There is no evidence of the use of through stones or other similar sensible stone masonry practices in their construction. Section 8.3.3.1 of this report discusses stone masonry in greater detail as it is believed to be an important material in the reconstruction efforts of Haiti, especially for those with limited economic means.

3.2.8 CB, Colombage (Gingerbread Houses)

Colombage houses have been found in the city of Port au Prince, Haiti as shown in Figure 12. Similar house types are found in Britain, France, Germany, Central America, South America, Turkey, Portugal and Italy. They are known as "**Half-timber**", "**Colombage**", "**Fachwerk**", "**Taquezal** or **Bahareque**", "**Quincha**", "**Hımış**"and "**Gaiola**" respectively. This form of construction is also known as **"Brick nogged timber frame construction"** in India and **"Dhajji Dewari"** in Pakistan.

<table>
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Photo Source: Conor Bohan</td><td>
Photo Source: Conor Bohan</td></tr>
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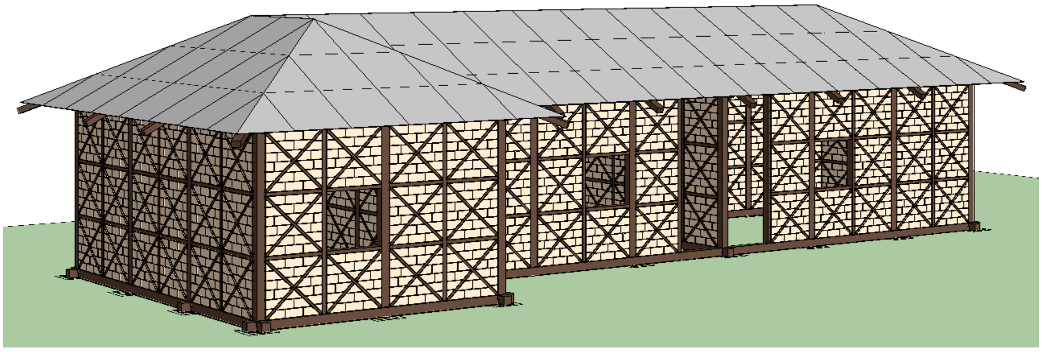
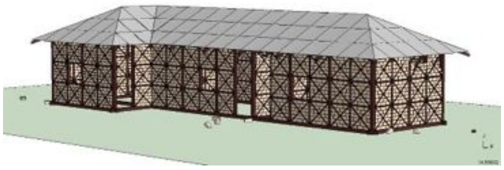
<tr><td colspan="2">Sketch source: http://www.alliance-haiti.com/societe/technique/architecture.htm</td></tr>
<tr><td colspan="2">Figure 12 C, Colombage</td></tr>
</table>

Over 100,000 Dhajji Dewari Houses have been built in Pakistan as part of the owner driven reconstruction program that sprung into action following the 8TH October 2005 Earthquake as reported by UN-HABITAT in Pakistan. Recent engineering assessment by Arup has indicated, that when these houses are properly detailed, that they possess significant qualities to safely resist earthquakes as shown indicatively in Figure 13.



Testing by University of Peshawar

Computer simulation by Arup



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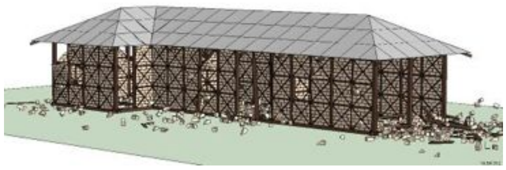


No Nails

Figure 13 Seismic Performance of Dhajji Dewari Construction from Pakistan, similar to Colombage construction as found in Port au Prince, Haiti. Computer simulations by Arup.

Such houses, made mainly from stone laid in mud mortar and a light timber frame are potentially very affordable and do not require sophisticated construction techniques and manufacturing methods. However there are maintenance requirements to ensure the timber frame does not degrade over time.

There are no formal western style of codes for these buildings, although they appear to survive earthquake well, assuming there are no underlying issues with the integrity of the timber.

4 Damage Assessment

4.1 Damage Assessment Methodology

The original objective of the assignment was to develop a rapid and detailed damage assessment that Oxfam could use as part of their relief efforts. However the Department of Public Works, with the support of UNOPS, had already created their own form, a modified version of the ATC-20 adjusted to the Haitian context as shown in Figure 14. Consequently it was decided with Oxfam that we trial this official form, rather than develop our own.

During our assessments, we were shadowed by two Haitian staff from Oxfam who had been recently recruited, one with an architectural background, the other had a civil engineering back ground but had not practiced for some years.

To successfully use such a form, there is an under lying assumption that the person doing the assessment is familiar with the engineering principles of earthquake engineering and has prior experience of inspecting damaged buildings. This is not the case in Haiti.

Further, in order to carry out the assessment effectively, we found we needed to engage with the building owners or the people renting the property, explain to them who we were, what we were doing, ask their permission to look at their property and answer their immediate questions.

Typically observed failures were discussed with Oxfam's Haitian staff to help them learn about the causes of typical failures and work out how to document them. Documentation techniques used include:

- Use of GPS to mark locations of assessed properties, (It was noted more training on all features of GPS equipment would be useful)
- Taking of relevant photos
- Note taking and sketching

Currently it is not known to whom completed assessment forms are to be provided to. Nor is it known what the legal framework for damage assessment is.

It is important that the GoH provides clear leadership with respect to damage assessment, especially on the plans for follow up.

We understand that UNOPS has updated the assessment forms on the 10th March and the latest version of the document is shown in Figure 15 and Figure 16.

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection
Id.Inspecteur : ____________ Date et Heure d'inspection_________ □ AM □ PM
Affiliation :______________ Zone inspectée: □ Extérieur uniquement □ Extérieur et intérieur

Description du bâtiment — **Type de construction**
Nom du bâtiment : □ Armature en bois □ Murs béton contreventés
Adresse : □ Armature en acier □ Murs non renforcés
□ Armature béton avec remplissage des parois □ Murs renforcés
Contact/Téléphone : □ Armature en béton □ Autre
Coordonnées GPS: Nombre d'étages : Nombre de sous-sol :

Spécification du bâtiment — **Type d'occupation**
Superficie approximative (mètre carré) □ Résidentiel- section unique □ Commerce □ Gouvernement
Nombre de résidences □ Résidentiel- section multiple □ Bureaux □ Historique
□ Assemblée publique □ Industriel □ Ecole
Nombre de locaux non habitables □ Services d'urgence □ Autre

Evaluation
Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés			
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé
□ aucun
□ 0-1%
□ 1-10%
□ 10-30%
□ 30-60%
□ 60-100%
□ 100%

Difficulté de la démolition : **Aucun/mineure** **Simple** **Moyenne** **Complexe**

Observations :

Signalisation
Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

□ **Inspecté (fiche verte)** □ **accès limité (fiche jaune)** □ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires
□ Barricades nécessaires dans la zone:_
□ Expertise détaillée recommandé : □ Structurelle □ Géotechnique □Autre
□ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte :
Observations:

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :
Date de début de construction: ______ Date de travaux importants de rénovation: ______
Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___
Inclinaison de construction : Plate__ Modérée _ Abrupte ___
Emplacement du bâtiment : Plage___ Rivière__ , Vallée___ Plaine___ Colline___ , Flan de coteau ___Sommet___
Base : Dalle/pose sur Grade, élevé sur Post, piles profondes.
Forme du plan : _O_ E_ H_ L_ T_ U_ autres
Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés_ Colonnes raccourcies___Martèlement de bâtiment adjacent

Figure 14 ATC-20 form as apparently approved by the Haitian Government (~ Feb 2010)

MINISTÈRE DES TRAVAUX PUBLICS TRANSPORTS ET COMMUNICATIONS

Evaluation rapide de bâtiments

DTP-BE #1

Inspection

Description du bâtiment | **Type de construction**

Structure | **Dalle** | **Plancher** | **Murs** | **Toiture**

Nombre d'étage :
Nombre de sous-sol :

Autre type

Spécification du bâtiment | **Type d'occupation**

Evaluation

Etat observé	Mineur/Aucun	Modéré	Grave	Dommage estimé

Difficulté de la démolition : Aucun/mineure | Simple | Moyenne | Complete

Observations :

Figure 15 Assessment form updated on the 10th march 2010 (received on the 11th March 2010), Page 1 of 2


SIGNALISATION

□ Inspecté (fiche verte) □ accès limité (fiche jaune) □ accès non autorisé (fiche rouge)

AUTRES VERIFICATIONS.

Observations:

Facteurs de vulnérabilité

Figure 16 Assessment form updated on the 10th march 2010 (received on the 11th March 2010), Page 2 of 2

4.2 Arup Damage Assessments

As noted in Section 1, during our visit we covered a number of different building typologies but our main focus was residential housing. A summary of the assessments we carried out for Oxfam is in presented in the Appendixes. This includes assessments carried out by Andy Thompson on his earlier visit to Haiti for Oxfam (See Ref [6]). Table 3 is shows a summary of our field activities and Figure 17 shows the route we took.

Table 3 Itinerary of Arup field time in Haiti 26th Feb to 4th March 2010

Date	Activity	See Section
26th Feb	Carrefour: Orphanage/Oxfam (facility for plastic sheeting processing); School	4.2.2
	Carrefour: Balncort Residences	4.2.1.1
27th Feb	Local Partner NGO Facilities (5 number)	4.2.3
	Morne Sion Hillside Community	4.2.1.2
28th Feb	Warehouses (2 number)	4.2.4
01st Mar	Beauboeuf Residences	4.2.1.3
	Pacot Hillside Community	4.2.1.4
02nd Mar	Delmas Residences (Golf Club Camp)	4.2.1.5
03rd Mar	Warehouse (1 number)	4.2.4
04th Mar	Local Partner NGO facility (I Number)	4.2.3

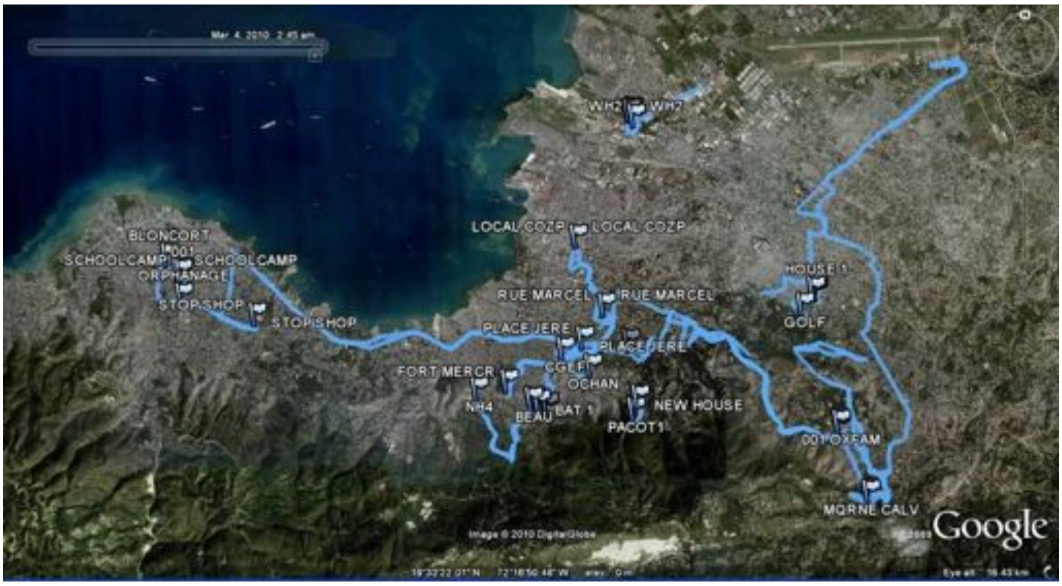


Figure 17 Way finding of our field trip using GPS tracking in and around Port au Prince.

4.2.1 Residential Properties (See Appendix B)

Five residential communities with varying housing typologies were visited as shown in Table 4.

Table 4 Locations of visited residential houses	
Carrefour – Rue Blancort	Pacot
Morne Sion (Hillside Community)	Delmas (Golf course)
Beauboeuff	

4.2.1.1 Carrefour - Rue Blancort (See Appendix B1)

Our visit was guided by Bruno (Oxfam), a resident of the area. The building typologies we encountered were:

- C4-HBFS-UHM, Concrete frame with hollow block flat slabs with un-reinforced hollow block masonry infill.
- C4-HM-TCR, Concrete columns, un-reinforced hollow masonry block infill with timber and CGI roof.

The houses were of middle class homes consisting mainly of one to two storey houses with internal kitchens, toilet and wash spaces. However, external rooms for cooking and cleaning were also encountered. There was some evidence of stone masonry walls (SMW). We were not able to inspect the foundations of these buildings but it is likely that these will have contained stone masonry.

The Oxfam engineers were guided through their first experience of engaging with home owners by appropriate introductions explaining who we were, what we were wanting to do, who we worked for and importantly obtaining their permission to take photos and if possible to enter their homes.

The Haitian specific ATC-20 forms were completed for each property. In all we assessed five private residences at this location.

People were generally either staying in their houses or camping in the gardens of the houses.

4.2.1.2 Morne Sion Hillside Community (See Appendix B2)

Our visit was guided by Helen (Oxfam). The building typologies we encountered were:

- TCWR, Timber and corrugated galvanised iron walls and roof.
- UHM-TCR, Unreinforced hollow block masonry with timber and CGI roof.
- C4-HM-TCR, Concrete columns, unreinforced hollow masonry block infill with timber and CGI roof.
- SMF, Stone masonry foundations.
- SMW, Stone masonry walls

Houses in this community were basic, with the poorest being marginalised to the very sides of the community near the obvious natural drainage paths of the hilly landscape. The houses ranged from one to three rooms and made extensive us of stone masonry in the form of terraces and foundation bases. Generally all properties had timber roofs with CGI sheets.

A very rapid assessment was conducted with the help of local community leaders who had been briefed about the purpose of our visit. With their help families were informed about our work enabling rapid progress to be made. Due to the rapid nature of the assessments no ATC-20 forms were completed however these properties have been documented (40 houses and two community facilities) as shown in Appendix B2 which includes practical recommendations on repairing and retrofitting concepts for these buildings.

Because many of these properties are simple their general performance has not been catastrophic, although the structural stability of the terraces is a major concern. In the short term it is possible to reutilise many of these properties, with relatively minor repair and improvement works. This would get people back into homes and out of temporary shelters.

Long term issues of land rights and urban planning, drainage and slope stability need to be considered for this community to ensure their long term safety and viability.

4.2.1.3 Beauboeuf (See Appendix B3)

Our visit was guided by Emilio (Oxfam). We visited the camp at Beauboeuf where a sample of camp residents were selected for a review of their houses. In this area the houses assessed were considered lower middle class. They ranged from single room one storey masonry houses with CGI roofs to a 3 storey, incrementally built, concrete and masonry multi-family block. The building typologies we encountered here were:

- C4-HBFS-UHM, Concrete hollow block flat slabs with un-reinforced hollow block masonry infill.
- UHM-TCR, Unreinforced hollow block masonry with timber and CGI roof.
- C4-HM-TCR, Concrete columns, unreinforced hollow masonry block infill with timber and CGI roof.
- SMF, Stone masonry foundations.
- SMW, Stone masonry walls

Some of the housing we visited here was situated on tight urban spots with limited space for construction work. Whilst repairs and retrofits are possible to some of these homes overall urban planning considerations must be followed to ensure communities are built back better.

4.2.1.4 Pacot (See Appendix B4)

Our visit was guided by Emilio (Oxfam). Within the short time frame available a general overview of the village and the housing typologies was performed and then a focused assessment on one of the housing compounds was undertaken as shown in Appendix B4.

This small community was situated on a hill side. The houses were basic, ranging from single room shelters constructed in CGI to one or 2 room masonry walled houses with lightweight CGI roofs. Overall the building typologies we encountered were:

- TCWR, Timber and corrugated galvanised iron walls and roof.
- UHM-TCR, Unreinforced hollow block masonry with timber and CGI roof.
- C4-HM-TCR, Concrete columns, unreinforced hollow masonry block infill with timber and CGI roof.
- SMF, Stone masonry foundations.
- SMW, Stone masonry walls
- SMB, Stone masonry houses

The compact size of the community means that it is relatively easy to establish the potential number of beneficiaries and boundaries are likely to be reasonably clear. There is space for construction work to be undertaken and the community is accustomed to being self sufficient with a very high degree of self coping mechanism. Extensive use was made of stone masonry which had variable performance due to the general poor quality of the workmanship. The performance of the stone masonry was no worse that that done using modern construction methods and materials. The stones were undamaged after the earthquake and are able to be reused.

4.2.1.5 Delmas, Golf Club Gamp

Our visit was guided by Karin (Oxfam). A sample of residents from the Golf Club camp site had been selected by Oxfam's staff in order for us to inspect their properties to find whether their homes could be reused and thus help decongest the large camp on the Golf Club land. The properties we assessed were from what looked like the lower and middle classes. Overall the building typologies we encountered were:

- C4-HBFS-UHM, Concrete frame with hollow block flat slabs with un-reinforced hollow block masonry infill.
- UHM-TCR, Unreinforced hollow block masonry with timber and CGI roof.
- C4-HM-TCR, Concrete columns, unreinforced hollow masonry block infill with timber and CGI roof.
- SMF, Stone masonry foundations.
- SMW, Stone masonry walls

Some of the housing we visited here was situated on tight urban spots with limited space for construction work. Whilst repairs and retrofits are possible to some of these homes overall urban planning considerations must be followed to ensure communities are built back better.

An obvious way to improve the seismic resistance of many of the relatively undamaged incrementally constructed properties would be to strategically dismantle the top floor on many of these houses. This would result in an immediate reduction in the likely future seismic forces.

4.2.2 Orphanage and School (See Appendix C)

ATC-20 assessments were completed for an orphanage and a school. In addition a summary sheet was written for the facilities, detailing the observed damage and making wider commentary on the performance of the buildings with suggestions for possible repairs and retrofitting concepts.

We engaged the help of the caretaker and the head of the facility at the Centre d'Acceuile in order to improve our understanding of the buildings, when they were built, what they were built from and any modifications that had been undertaken.

4.2.2.1 Orphanage

The orphanage was unusual in that it had a concrete frame, what appeared to be solid concrete slabs and thick masonry walls made from fired clay bricks rather than the more modern hollow concrete blocks. The buildings had concrete bands around openings. The regularity of the buildings and the quality of the materials used for its construction were unusually high given all the buildings we had inspected.

4.2.2.2 The School

School was of reinforced concrete frame construction and had typical conceptual problems in its planning from an earthquake engineering aspect. The solid cross walls between class rooms, although not thought to have been seismically engineered, provided additional structural support and without them it is thought that significant higher levels of damage would have occurred.

4.2.3 Local Oxfam Partner NGO facilities (See Appendix D)

We assessed six partner NGO facilities: Five on the 27th February and one on the 4th March and our guide for both days was Emilio (Oxfam). Our findings and recommendations for these properties are documented in Appendix D.

4.2.4 Warehouses (See Appendix E)

Oxfam requested that we visit two warehouse facilities they are currently using and then a third they were considering using. These assessments were carried out without the Oxfam engineers. The visual inspections were written up as short memos and can be found in Appendix E.

The findings and recommendations from visiting these warehouses highlight the difficulty of operating in the earthquake affected region, even for well resourced INGOs having to balance short term needs and programme needs against earthquake risk and building damage levels. The recommendations are based on the agreement that in all instances Oxfam will be actively looking for safer warehousing.

4.3 Right to Tag Buildings

Only the Government of Haiti (GoH) or its approved representatives have the authority to tag buildings. However other organisations have been carrying out various types of damage assessment without the express approval of the GoH. It is recommended that a standard reporting format is developed so that all assessment results can be pooled to a central data base.

Typical tag to identify buildings those that need to be demolished.

Figure 18 Observed tagging with spray paint

There was a mention of an official Government of Haiti stencil but no markings of this nature were observed at the time of our visit.

We did not tag any buildings but have collated the results of our assessments so that this information can feed into the overall damage assessment work that is being carried out.

4.4 Suggested Modifications to ATC-20 to make it more Haiti Context Specific

Broadly the form we trialled is similar to the original ATC-20 form and relies on the skill and experience of the inspector as their judgement is needed to in complete the assessments.

What is apparent from our discussion with the inhabitants of many houses is that they do not know what the “ACT-20 Formulaire d’évaluation rapide de la sécurité des bâtiments” is. This seems to be because the assessments are not coordinated as part of a wider strategy and appear random and haphazard. There is limited communication with the inhabitants of the properties and people do not know how to use the findings.

The analogy is with a medical doctor and a room full of patient. The physician goes round from patient to patient (Engineer from building to building); the physician makes his notes and moves on. At the end of the day the physician knows how many patients he has seen and an understanding of the breakdown of illnesses. However, this overview level of detail is of no help to his patients. The reality is that patients need to know about their illness or sickness, not about the generalities of the affected area. This is the same with damage assessment. At present, the damage assessment appears to be collecting information in order to understand the extent of the building damage. However, this does not help the users of the damaged buildings to either demolish them or think about repairs and/or retrofitting.

Therefore, the follow up procedure is a crucial component to the ongoing assessments. In the US, where the ATC-20 assessment was developed, the follow up process is taken care of by professionals who are formally trained in the construction industry and the presence of building inspectors and municipality level planning authorities who mobilise and provide the follow up to the ATC-20 forms. This institutional support structure does not exist in Haiti. As a result there is no formal follow up process in place to communicate the findings with the affected people.

The importance of the follow up process is to inform the affected population of the findings, put them in touch with local resources and identify who can help them further. Typically most occupants will need to know what they can repair, how these repairs need to be done or how they should approach construction of new buildings.

Whilst earthquake damage data is being collected there is an opportunity to understand more about the cultural, economic and environmental features of housing with the local Haitian context. Therefore, consideration should be given to find out the answers to the following questions in order to enable more informed response to be provided to the affected population:

- Are they the property owner or do they rent?
- Does the house have a garden?
- Is there a toilet? If yes, is the toilet outside the house or inside?
- Can laundry be done indoors?
- Is the kitchen inside the house? If the kitchen is outside, is it covered or is cooking done in the open air?
- What fuels is used for cooking (electricity, wood, charcoal, natural gas, paraffin)?
- Did the house have piped water before the earthquake?
- Does the house have gutters? Did the house do rainwater harvesting?
- Did the house have mains electricity before the earthquake?
- Is there adequate drainage around the house?
- Do the windows have mosquito nets?
- Are there people with construction skills in the household?
- Was the property used also for doing business?
- What is their 1st priority in terms of reconstruction?

4.5 Right to Appeal

Property serves many purposes such as being a savings fund, a source of future income in old age as well as providing basic housing. Therefore where the owner of a property disagrees with a rating that has been applied (especially if the rating implies demolition) it is important that a mechanism is in place where the assessment findings can be fairly challenged and reviewed. It is important that this process is in place as property is often the single biggest asset of many Haitians.

4.6 Right to Rubble

An important aspect of the early recovery and reconstruction activities is what we have called the"Right for Rubble". Whilst, issues surrounding who owns the rubble, especially in the case of public buildings, renters etc...need to be clarified there are a number of technical considerations that need to be considered to ensure that only those materials that are fit for re use are recycled. This is to ensure that the use of already inadequate building material is kept to as low as possible. Further details on recycling of rubble are provided in Section 8.6.

4.7 Follow up to Damage Assessment

The follow up to the damage assessment is a key component. It is the opportunity to inform the occupants of a property what the diagnosis is, whether there is a cure (i.e. it can be repaired) and if so, what this may entail. Similarity, the assessment needs to identify the vulnerable buildings and minimise their usage to prevent possible further disasters from occurring.

In the short term a vital component of the damage assessment is to identify the better quality building stock so that these properties can be reoccupied. This will help reduce the drain on general relief requirements and help decongest the many camps that have sprung up in Haiti since the earthquake.

4.7.1 A Green Rating

With these buildings, assuming they were reasonably close to the main earthquakes epicentre, the logical conclusion is that they with stood the earthquake relatively unharmed. Because they were close it is further assumed that they would perform in a similar way to similar levels of ground shaking (i.e. similar earthquake)

Buildings located further away from the earthquake epicentre usually display lower levels of damage, the analogy being that the property was further away from the “bomb” and did not feel its full blast. Therefore, a property with a “Green” rating, further away from the epicentre does not mean that the property is adequately designed. In fact the assessment only states that the property was not affected by the event.

However, give the dire housing needs, it is important for the Haitian people to re utilise as many of the reasonable properties as possible.

Doing so will reduce the pressures on the relief activities and help free up resources for those most in need.

Equally, it is important that buildings with a “Green” rating receive a follow up to determine the level of seismic retrofitting a property may require in order to reduce its vulnerability to future earthquake events.

At present the follow up process for “Green” rated properties is not clear. It is recommended that a process is put into place to ensure buildings are adequately strengthened.

4.7.2 A Yellow Rating

In laymen’s terms a “Yellow“ rating typically means some further work is needed. This may lead to the conclusion that a property is unsafe and needs to be demolished or that repairs are needed to reinstate it to its original condition.

Given the seismicity of Haiti where buildings are repairable it is advisable to retrofit so that the repairs improve the fabric of the building to incorporate seismic design features to help reduce the vulnerability of the building stock to further seismic events.. The first step in this process is to identify the properties that can be repaired and even improved.

In order to be able to do repair work and retrofitting work it is also important to put in place actions to prevent the current state of damage on buildings from deteriorating any further and this is discussed in the next section.

4.7.2.1 Need to Shore

A significant portion of the buildings in the earthquake affected area can be repaired and improved. However, before any such work is undertaken there is a need to shore and strap many buildings in the temporary state. This is illustrated in Figure 19, a selection of shoring techniques employed in Europe after the 2002 Molise earthquake in Italy and Figure 20 a selection of observed practices in and around Port au Prince.

Typically this work is of a temporary nature as it is provides a stop gap measure until additional, longer term repairs are possible. Examples of such temporary works include:

- Propping to give property additional vertical support
- Lateral shoring to give the property additional sideways support
- Strapping to help tie a property together
- Bracing around openings to help strengthen any obvious weak spots

Figure 19 Shoring, Strapping examples from Italy after the Molise earthquake of 2002. (All photos by © Randolph Langenbach, 2003)

Typically the examples from Haiti indicate that there is room for improvement on the adopted techniques.

Figure 20 Temporary support concepts as seen in and around Port au Prince, Haiti

4.7.2.2 Repairing and Retrofitting

Typically doing repairs (building it back to its pre earthquake state) and structural improvements (i.e. retrofitting) are difficult as one has to work with a building that may have been damaged during the 12th January earthquake and its aftershocks. It is likely that the existing building will contain poor quality design features, workmanship and materials. Often, such work, similar to restoration work has to be done piece by piece otherwise the repair or retrofitting works may trigger further localised damage or even collapse.

Note: Safe shoring and propping will be a key component of repair and retrofitting projects.

Repairing

A basic menu, but by all means not complete list of repairs may include some or all of the following:

- Repair damaged masonry walls by removing the broken bits and replacing them with new components
- Re grouting of walls where feasible to do so
- Breaking out of damaged concrete and doing local repairs
- Re-tightening loose braces
- Re fixing loose connections
- Repairing damages walls

Retrofitting

Retrofitting is more intrusive than repairing and requires a clear understanding of structural load paths, both horizontally and vertically. Typical retrofitting strategies may involve some or all of the below:

- Increased stiffness by introducing new columns and or walls and or bracing.
- Adding new foundations to new columns and walls.
- Strengthening existing columns by jacketing (either with steel sections or extra layer of reinforcement).
- Adding strategic stitches at building corners and wall junctions piece by piece.
- Introducing ring beams, especially at the top of masonry walls where these did not previously exist.
- Removing mass, for example by the removal of the top storey from many of the incrementally constructed houses.
- Adding ductility to members be providing better confinement, typically to at the top and bottom of columns and likely splice locations.
- Strengthening existing reinforced concrete joints – though this is very difficult to do.
- Shot creating masonry walls with bonded reinforcement to the walls anchored into the surrounding structure.
- Addition of roof diaphragms in the horizontal roof plane at the level of the roof beam.
- Making connections across discontinuities where appropriate.
- Adding seismic joints between building components where possible to break down buildings into more manageable portions.
- Adding horizontal band beams to masonry walls so that they can properly arch between support points.
- Fixing reinforcement (vertical and horizontal) into existing walls, where possible to do so.
- Adding through stones in masonry construction, especially stone masonry work.
- Removing soft storeys by filling in large openings with reinforced concrete walls or masonry infill.
- Reducing the number of openings by filling them in paying attention to key brick block work into existing masonry.
- Additional of buttresses (external or internal) along vulnerable walls, including foundations.

It is evident that retrofitting requirements will need to be developed on a case by case basis as each is unique and will present its own set of challenges.

For many of the more modest homes, consisting of 1 to 4 relatively small rooms, it is possible to develop a typical menu of retrofitting concepts that could be rolled out across significant portions of the existing Haitian building stock.

4.7.3 A Red Rating

Where a building has received a clear “Red” rating this implies more often than not that the most economical course of action will be to demolish the property in more affluent economies. In the Haitian context it is likely that many buildings that receive a “Red” rating will most likely still be considered repairable, at least as an short to medium term measure. Arup does not typically engage in these activities, as this is the work of specialist demolition contractors but lists of key considerations are presented in the next section.

4.7.3.1 Need to Demolition

Where a building, after careful consideration has been condemned, it is important that it is demolished in such a way that it does not result in further damage to people or property. When possible, especially given the limited economic means of many Haitians, opportunities for salvaging construction materials should be sought. Typical issues surrounding recycling of construction materials are presented in Section 8.6.

A short list of principals relating to demolishing unsafe buildings is presented below:

- Establish that the person whose property is being demolished is the rightful owner of the property.
- Where unsafe buildings are occupied by tenants try and establish who the owner is to ensure any such work is carried out with the correct consents.
- Make the area around the property safe in case the property unexpectedly collapses it would not harm people or adjacent property.
- Make arrangements for safe rubble disposal prior to commencement of the activity.
- If possible find an engineer to inform the construction team of the existing load paths and identify safe sequence for doing the demolition work given the bespoke nature of each property and the available equipment.
- If possible use mechanical equipment, especially on larger buildings.
- If demolition has to be done by manually or mechanically it may be necessary to provide temporary shoring.
- Ensure all individuals engaged in demolition work have personal protective equipment.
- Brief all workers so that high risk activities are clearly identified.
- Given the urban setting of much of this work, consideration should be given to spraying the structure with water to limit the dust impact on the people in the vicinity, especially to those who are still camping outside.

4.8 Overcoming the "Fear Factor"

The immediate challenge for those involved in the recovery efforts is ensuring that there is enough safe shelter for everyone. This need is exacerbated by the impending rainy season and the risk of hurricanes.

It is important to note that there are many houses that have survived the January 12th earthquake and the following aftershocks and are in relatively good condition. However many of the owners/occupiers of these buildings are living outside for fear that their house may collapse. Even people who have had their buildings assessed and passed by engineers remain fearful and continue to sleep outside. It is not surprising that people are afraid to return to their homes as now they are fully aware that they were not designed to withstand earthquakes.

Properties rated GREEN using the ATC-20 rapid assessment method have survived the recent seismic event essentially undamaged. But the concern remains is that the GREEN rating in the rapid assessment does not say that the building will survive a different event that may be closer and or larger.

We have observed that many of the people who sleep outdoors and in the camps at night are returning to their houses during the day to carry out every day household activities. One could take the pragmatic view that necessity will overcome fears once the storms come, and people will chose the more secure shelter of their house over a temporary shelter made of plastic sheeting. But, the fear factor will remain ingrained.

One key step towards overcoming this is education. People need to be given sufficient information to enable them to make their own, sensible, personal safety risk assessments.

In the short term, consideration should be given to the production of simple guidelines on how to make their own basic assessments of their houses to determine how well they have done in the recent earthquakes. This will empower people by educating them about the varying signs which indicate damage levels of their homes. In an ideal world there will be sufficient numbers of engineering professionals to visit every house to make the assessment and advise the owner/occupier accordingly – but this may not be possible in the time available. At the same time people need to be made aware of the temporary measures they may be able to take, to ensure their houses are more secure - the implementation of basic retrofitting techniques, simple measures such as securing loose/heavy furniture, removing loose/heavy wall or ceiling fixtures, and learning about what to do in the event of an earthquake. Also, people need to be made aware of the risks to their health and personal security if they continue to stay outside.

In the medium and longer terms, more education for the general public about the seismic risk, what happens during an earthquake and the simple rules for construction that can help mitigate the risk of collapse will go a long way. Once people understand the hazard better they will be in a stronger position to deal with it and overcome their fears.

4.9 Return to Homes

In order for people to feel safe to return to their homes incentives for people to stay in the camps need to be removed by moving aid distribution back to the heart of the communities. In addition in a dense urban environment it is important that utility supplies for water, electricity, rubbish collections, sewerage and similar are back up and running as these services are essential requirements for urban living and well being.

5 Training

5.1 Training of Oxfam Staff

We were lucky in that we had two recently hired Oxfam staff to help us with our field work as this gave us some limited but first hand experience of the skill level within the local engineering profession.

Unfortunately, the briefness of our trip did not allow us to undertake any class room earthquake engineering training with the Haitian engineers, which no doubt would have been beneficial prior to conducting the building assessments we undertook.

The two engineers, whilst enthusiastic and eager to learn, were overwhelmed by the volume of knowledge that they needed to absorb on a daily if not hourly basis.

The skills required to identify building typologies, establish load paths and anticipate likely problem areas as part of a site assessment is very different from doing new designs in an office environment or undertaking new construction.

Field work requires tactful introductions and negotiating with building owners to allow them to understand the process. Often discussions with owners can reveal much of the hidden make up and history of buildings which helps inform the assessment process.

Working without drawings and calculations can often seem daunting to engineers as they are their normal tools.

Oxfam's engineering staff has a long journey ahead and they would greatly benefit from further intensive training opportunities which have been outlined in the next section.

5.2 Earthquake Engineering Training Requirements

Given the scale of events it is clear that there is a real opportunity to permanently improve the construction industry standards in Haiti. A key requirement of this is the implementation of appropriate training programmes across Haitian society so that people are better informed and empowered to make informed decisions. People in different roles have the need for varying levels of information and styles of training. It is believed that there are broadly five types of training requirements in Haiti with respect to building earthquake resistant construction. These are discussed in turn.

- Government of Haiti
- Existing engineers and architects
- Artisans and labourers
- Universities and Schools
- Home and business owners

5.2.1 Government of Haiti

Government employees need to understand the implications of earthquakes at the strategic and the implementation level.

5.2.1.1 Strategic level

This should be training targeted at senior decision makers and those who set policy. They need to be educated in the rigour and requirements of multi hazard assessments, implementation of national construction standards, setting course syllabuses, running emergency response services (fire, hospital, police and army) and the need to undertake country wide disaster risk reduction programmes that are going to take many years to implement. Urban planning and resilience issues were discussed in Section 7.

This group of people need to have an understanding of the stages of construction projects namely the planning, design, construction and management phases of a project. They also need to understand the time frames, and changing mix of skills required for the various phases of a construction project for achieving successful project outcomes, including evaluation after the nominal completion of the project.

5.2.1.2 Operational level

GoH employees need to understand the day to day application of earthquake engineering and how this needs to become part of the fabric of many other aspects of their work:

- Ensuring land rights issues are resolved.
- Ensuring urban planning is adequate, especially fire service provisions.
- Facilitate coordination of projects with utility suppliers (water, sewage, electricity, waste).
- The role of planning permits and buildings approvals.

5.2.2 Existing Engineers and Architects

Training for existing construction sector professionals needs to have a reasonably high theoretical technical engineering content. Typically one would expect these professionals to under go urgent re-training in the following disciplines:

- Earthquake myths
- Multi hazard considerations
- Seismology
- Earthquake engineering principals
- Geotechnical earthquake engineering
- Earthquake loading and structural dynamics
- Seismic design of reinforced concrete structures
- Seismic design of masonry (brick, block, stone)
- Seismic design of timber
- Seismic design of buried structures
- Quality Control
- Role of testing
- Technology transfer
- Conducting vulnerability tours
- Doing damage assessment

It is feasible that a basic course over 3 – 5 days would be able to cover the above at a sufficient level to act as a reasonably intense introduction to earthquake engineering. Clearly trips into the field and subsequent review of the work by engineers and architect will require additional time and resources.

5.2.3 Artisans and labourers

Artisans are typically not used to learning from documents or through classroom based teaching. The importance of practical, on the job training will be essential for this group of people. This will, if done correctly, be the single most effective method of changing the quality of construction, not only in the formal construction industry but also in the construction of new informally constructed housing stock.

A selection of photos as seen in Figure 21 to Figure 25 shows how classroom theory with substantial field workshops can be undertaken to provide training to artisans and informal construction professionals.

Figure 21 Learning why earthquakes happen and the importance of symmetry and regularity in the design of houses.

Initial class room sessions are usually used to initiate the learning process, starting by the obvious question of why earthquakes happen followed by discussions of building layout and the consequence of it to the structural performance of structures under earthquake loads.

Figure 22 Practicing building layout on paper and in the field

Often, full scale practicing is the most effective way to plan a building, as traditionally this is likely to mimic current construction planning practices.

Workshops, for example, in timber joinery help identify robust details. Such training sessions help identify the most skilled artisans within communities which is an important aspect of trying to celebrate best practice.

Figure 23 Good quality timber joinery and testing.

Seismic steel fixing (seismic detailing for reinforced concrete construction) is practiced, helping to enforce basic earthquake engineering detailing principals to be adopted.

Figure 24 Practicing seismic detailing of reinforcement

A half built demonstration (by NSET) is a very useful tool to supplement classroom and workshop lessons as shown in Figure 25.

Figure 25 Half complete demonstration building is an ideal teaching aid

5.2.4 Universities and Schools

5.2.4.1 Universities

It is important that universities teach earthquake engineering and that an earthquake engineering curriculum suitable for the Haitian context is developed so that teachings are directly applicable. There is likely to be little merit in the detailed teaching of seismic design of supplementary damping devices or similar and western syllabuses of earthquake engineering, developed with western levels training and construction industry skills in mind as this is not a priority within the Haitian context. Whilst western, modern standards do have their place, they will exclude the vast majority of the population from ever being able to comply.

Therefore, a developed earthquake engineering curriculum's need to work for Haiti and be achievable by Haitians given the skills base and the resources available to repair, retrofit and reconstruct.

Universities should rapidly develop capability in the testing of construction materials to support the upcoming construction boom within the country. This may require collaboration and partnering with the private sector to achieve required levels of capacity.

5.2.4.2 Schools

Consideration should be given to developing multi hazard based awareness education to school children; of which earthquake engineering would be one of many important social considerations.

5.2.1 Home and business owners

Home and business owners (including renters) should be involved in earthquake engineering training. Certainly an introduction to why earthquake happen, building layout considerations and a review of good and bad construction practices will be very beneficial. These people will become wiser in the selection of artisans and engineers for construction of their homes and businesses. Renters will become more critical and informed about accommodation that they may choose to live in.

6 Hazard Risk

Apart from earthquakes Haiti suffers from a number of other natural hazards. It lies in the middle of the hurricane belt and is subject to severe storms from June to October each year. Haiti is also subject to occasional flooding and landslides. Hurricane Flora killed over 8000 people in 1963, making it the 6th most deadly hurricane ever. In 2008 over 800 people were killed by four consecutive tropical cyclones (Fay, Gustav, Hanna, and Ike), in August and September. Furthermore, most Caribbean islands are prone to tsunamis, either as a result of submarine earthquakes, volcanic eruptions or landslides. Since 1692 there have been 4652 recorded deaths in the Caribbean directly as a result of tsunami events. In 1842 Haiti was hit by a tsunami which resulted in the loss of 300 lives. A summary of the multi hazards over the last 12 years is presented in Figure 26.

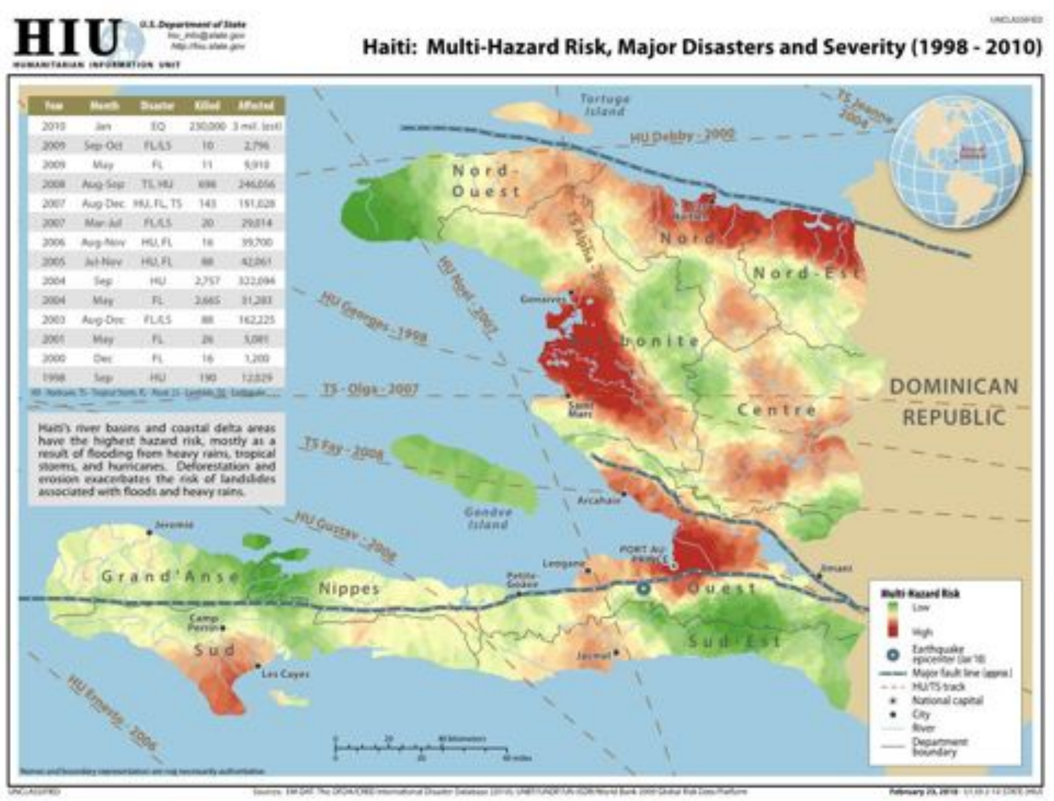


Figure 26 Multi Hazard Risk experienced by Haiti over the last 12 years (1998 to 2010)

There is an important need to understand all types of hazards faced by Haiti and these are discussed in this section.

6.1 Natural Hazards

6.1.1 Earthquakes

6.1.1.1 The Threat

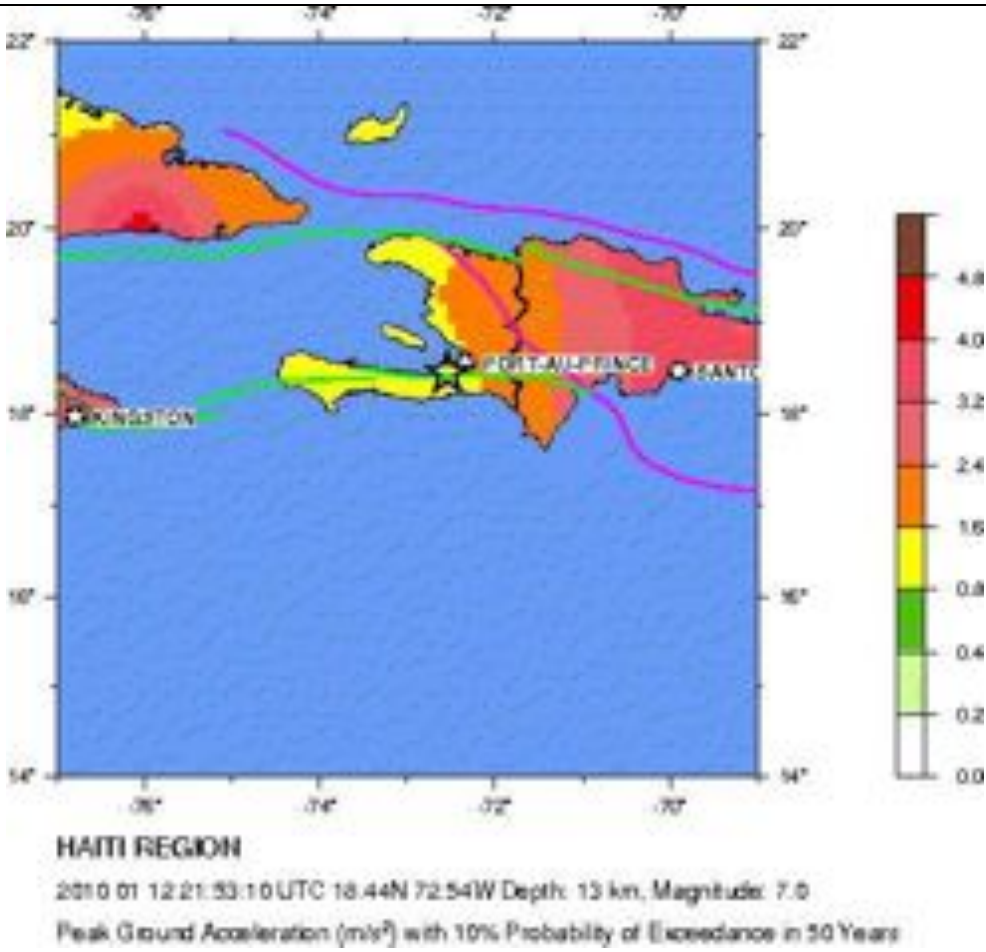
Earthquake induced strong ground shaking is a hazard across the entire region.

The Caribbean has had a long history of major earthquakes. One of the most severe occurred on the 7th June 1692 and struck Port Royal, Jamaica. About 2,000 people died as a result of the earthquake and tsunami; about another 3,000 died of injuries and disease in the following days. The distribution of historical earthquakes is shown in Figure 4, based on a catalogue developed by Garcia et al (2003). Records indicate that the last significant earthquakes to occur in the region were in 1751 and 1770. It is reported that both these earthquakes were strong enough to destroy Port-au-Prince.

A map of historical earthquakes from the region is shown in Figure 27

Figure 27 Tectonic Setting of Haiti

Various recent studies on what the expected peak ground acceleration level may be for Haiti are shown in Figure 28 and Figure 29. It is very evident from these plots that there are large differences which need to be understood in order to develop a definitive guidance on what the appropriate seismicity for Haiti should be.



GSHAP (1999) (http://neic.usgs.gov/neis/eq_depot/2010/eq_100112_rja6/neic_rja6_w.html)

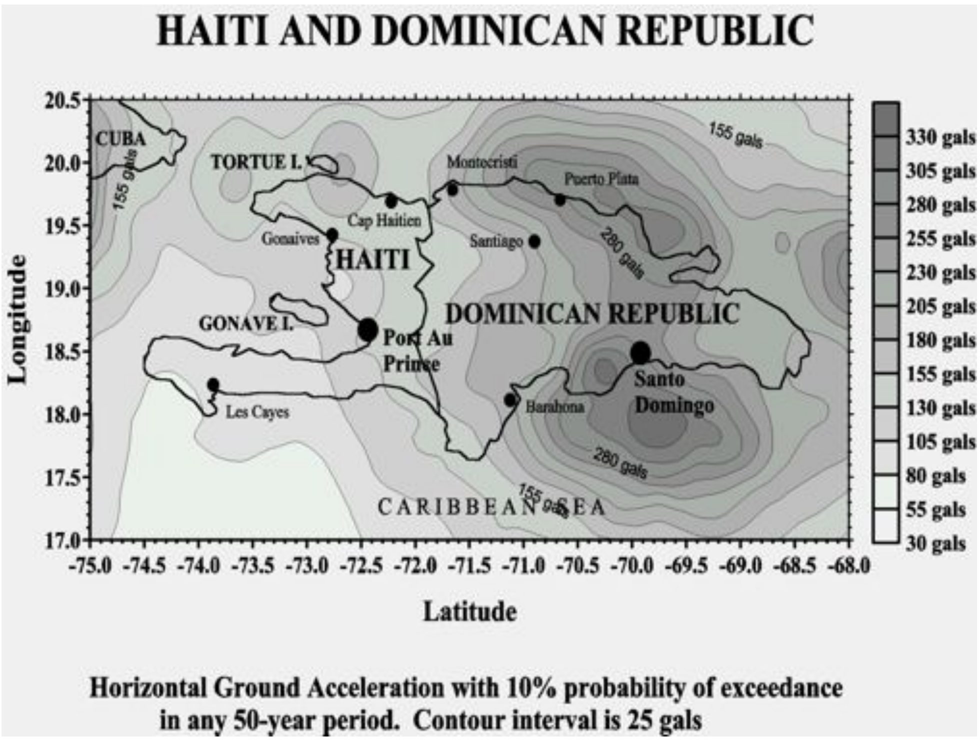


Figure 28 Seismic Hazard Maps for Haiti

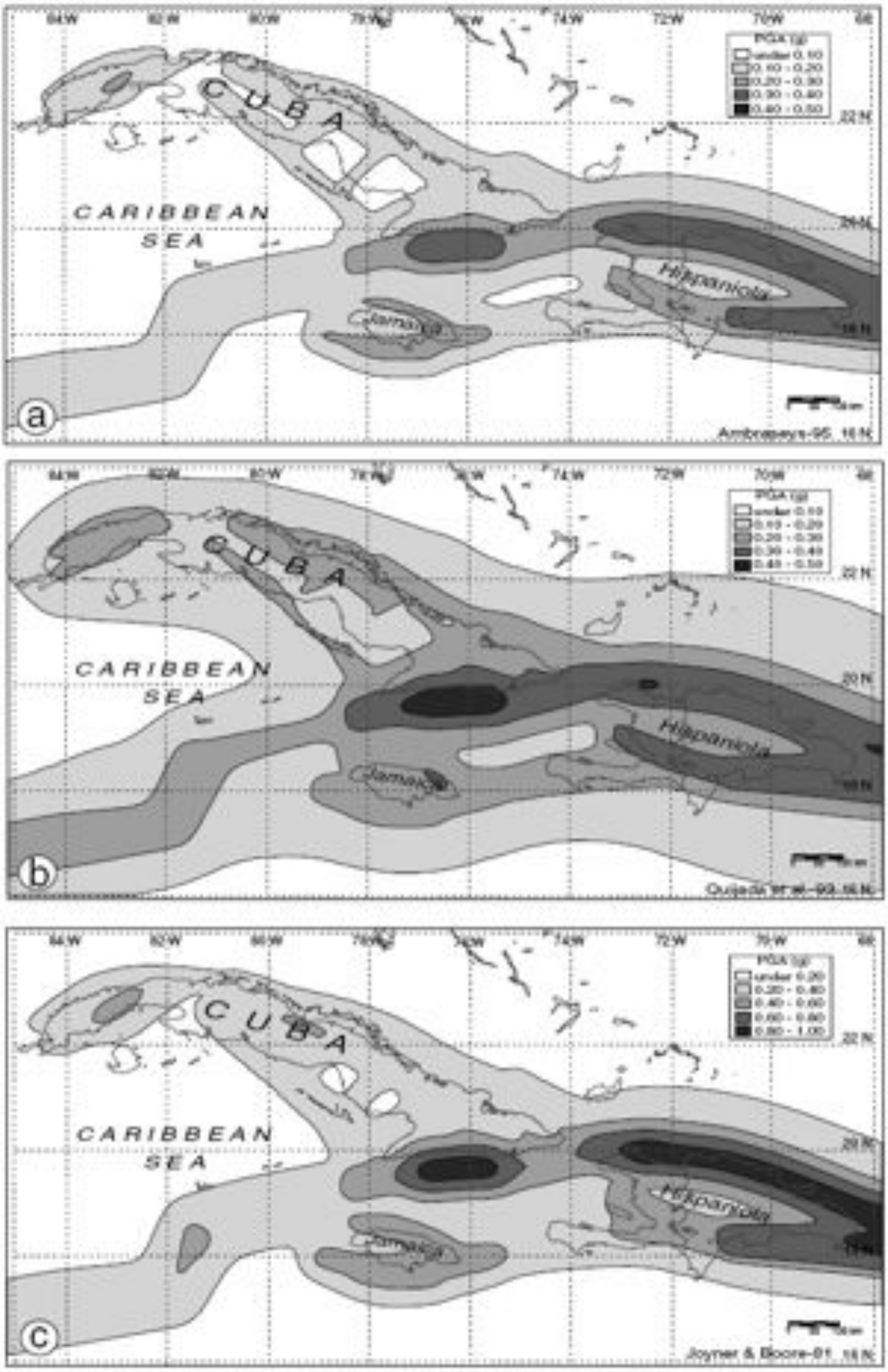


Figure 16. Horizontal PGA (in gravitational acceleration) with a 475-year return period considering (a) the Ambraseys (1995), (b) the Quijada *et al.* (1993), and (c) Joyner and Boore (1981) attenuation relations for average soil with σ.

Figure 29 Seismic Hazard maps by Ambraseys, Quijada et al and Joyner & Boore

6.1.1.2 The Solution

An appropriate seismic hazard assessment needs to be conducted for the whole of Haiti. The logistics and technical skills for this are not currently available in country. Therefore, it is important that a mechanism for funding, procurement and peer reviewing of this work is developed between the Government of Haiti, the various UN agencies, the World Bank and the many INGO and NGOs operating in Haiti. This work will set the “Code” designed standard for future projects in the country.

Apart from the need for the above mentioned work there are four principal hazards which can result from an earthquake:

Ground Shaking

This is the motion of the ground due to the earthquake. It is the principal earthquake effect which causes structures to collapse. Appropriate design to the latest seismic codes and competent construction should ensure adequate structural performance.

Liquefaction

This is the loss of strength in saturated sand deposits due to cyclic loading. It can cause both significant settlement and lateral movement of foundations. The key here is to identify the location of liquefiable deposits and either avoid those areas, improve the density of the ground or provide suitable deep foundations to a competent stratum below.

Figure 30 Sand boils due to liquefaction at the port facilities possibly leading to marine slope failures with sinking of land.
Photo Source: Eduardo Fierro (Haiti_Earthquake_20100127_UC_Berkeley.pdf)

Fault Rupture

This is relative movement across the fault that generated the earthquake. Depending on the nature of the fault it could either result in vertical or horizontal movements. Structures should be located at least 15m away from an active fault to mitigate its effects, according to the 1972 Alquist-Priolo Act.

Landslides

These are often caused as a result of earthquakes. It is therefore imperative that structures are not built on susceptible slopes or near edges of cliffs.

6.1.2 Tsunami

6.1.2.1 The Threat

Tsunami is a Japanese word represented by two characters, the first character, "tsu," means harbour, while the second character, "nami," means "wave". Most Caribbean islands are prone to tsunamis, either as a result of submarine earthquakes, volcanic eruptions or landslides. Since 1692 there have been 4652 recorded deaths in the Caribbean directly as a result of tsunami events. In 1842 Haiti was hit by a tsunami which resulted in the loss of 300 lives.

6.1.2.2 The Solution

Designing structures for tsunami with water heights of more than a couple of metres is both difficult to achieve and costly. The optimum solution is therefore to locate structures away from exposed coastline areas. However, local economics and social needs dictate that people will tend to relocate back to where they lived previously. For smaller more common events, the combination of planting and landscaping of the coastline can be used to protect vulnerable communities. Wherever possible, housing should be built away from the sea on higher level ground. If this threat is real, early warning systems and safe refuge area may also be considered.

6.1.3 Hurricanes

6.1.3.1 The Threat

The Caribbean basin is annually visited by tropical cyclones, known as Hurricanes in the North Atlantic and the Americas. Haiti is exposed to these as was shown in Figure 26.

The definition of a Hurricane is a tropical storm with average sustained wind speeds in excess of 74 mph however the highest intensity hurricanes have sustained wind speeds exceeding 156 mph. They are regularly of the order of 300 miles in diameter and advance at speeds of 10-15 mph. These events are therefore associated with high winds (and associated flying debris); down burst, tornadoes and water spouts; severe low pressure; storm surge; heavy rain leading to flooding and sometimes to landslides.

Contour plot of likely wind speeds for the Caribbean region are shown in Figure 31 and design wind speed levels for various return periods are shown in Figure 32.

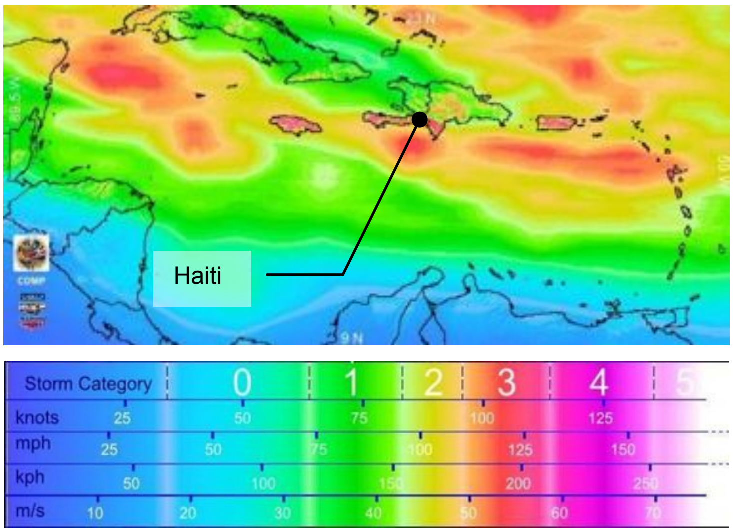


Figure 31 Maximum 50 year return wind speeds for the Caribbean Basin (CDMP/USAID)

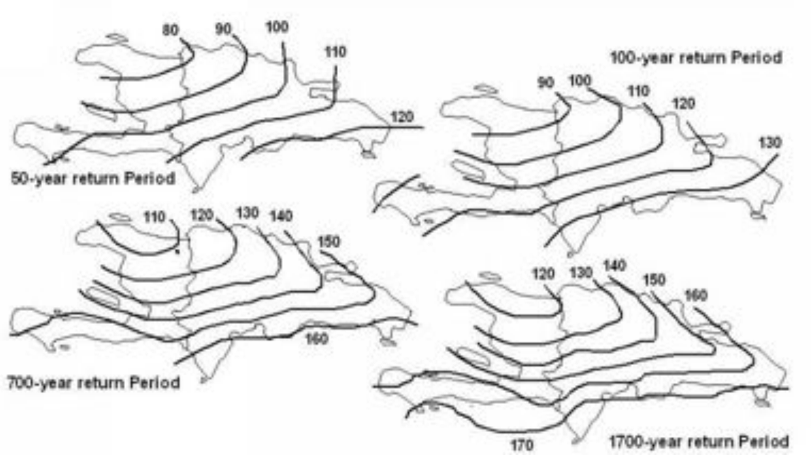


Figure 32 Contours of peak gust wind speeds (mph) at a height of 10m in flat open terrain for various return periods for the island of Hispaniola. (Wind speed maps for the Caribbean for application with the wind load provisions of ASCE 7 – OFDA/USAID)

6.1.3.2 The Solution

Hurricane preparedness can be relatively straightforward as predictability of anticipated wind loads is high and there are already very good storm forecasting mechanisms in place. The key is sufficient adequate shelter which, in the current context of Haiti, is a major issue.

With respect to the phenomena experienced in a hurricane – ways to mitigate those hazards unique to cyclonic activity - high winds and storm surge - are discussed in more detail below. Flooding and landslides are discussed in Section 6.1.5 and 6.1.7.

High Winds

In general it is widely understood in Haiti that heavier structures tend to fare better that light structures during hurricanes. (This is of course at odds with seismic design recommendations.) However, it is not unreasonable to expect lighter structures to do well in hurricanes which can be taken care of by appropriate design, detailing and workmanship.

Storm surges

Storm surge is the offshore rise in sea level which occurs during low pressure weather events such as tropical cyclones. It is primarily caused by the direction of the wind on the water but is also contributed to by the low pressure and rainfall etc... Contributing factors are shown in Figure 33.

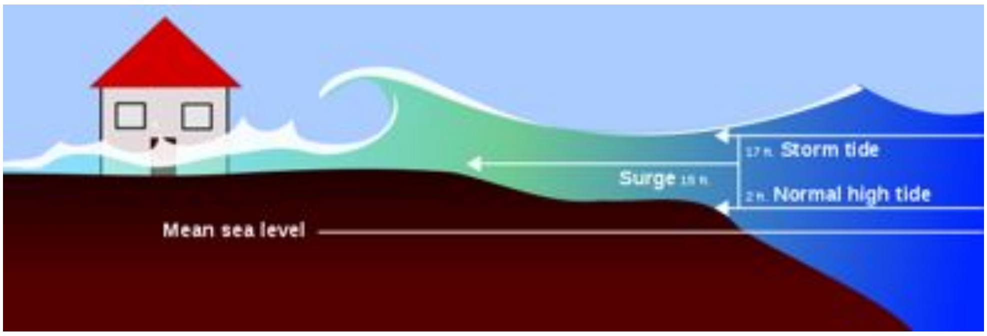


Figure 33 Images Describing Storm Surge (Image Source: Pierre CB)

In general, globally, in the most severe, category 5 storms, surge can potentially reach up to around 6m or more.

In a similar vane to Tsunamis (see section 6.1.2) it is very difficult and costly to design against storm surges. It is best to locate away from the coast. Evacuation measures to secure locations further inland and/or on higher ground should be employed.

Estimates of storm surge heights, as shown in Figure 34 indicate that for Haiti the levels may be as little as about a 1.0m increase in water levels. However, it is recommended that these values are verified and that the GoH sets the actual levels after undertaking the necessary work to make an informed decision on this matter.

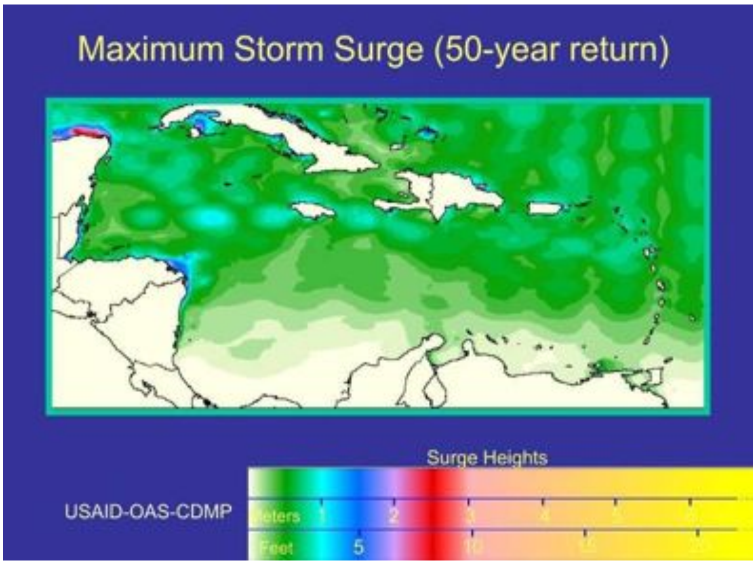


Figure 34 Storm Surge estimates by USAID – OAD – CDMP appear to indicate surges in the region of 1.0m for the majority of Haiti.

6.1.4 Volcanoes

6.1.4.1 The Threat

It is not thought that there is a threat from active or dormant volcanoes in Haiti, but this should still be considered in a multi hazard assessment for the area.

6.1.4.2 The Solution

In the event that it is an issue for Haiti and since the probability of a major event may be very small, it often proves neither politically nor economically viable to prohibit building within the zone at risk

Initially it is not thought that volcanoes are an applicable design criteria within the Haitian context but involvement of an appropriately qualified volcanologist or similar would confirm the status of this concern.

6.1.5 Flooding (Rainfall)

6.1.5.1 The Threat

Haiti has a generally hot and humid tropical climate. The north wind brings fog and drizzle, which interrupt Haiti's dry season from November to January. But during February through May, the weather is very wet. Northeast trade winds bring rains during the wet season.

The average annual rainfall is 140 to 200 centimeters, but it is unevenly distributed. Heavier rainfall occurs in the southern peninsula and in the northern plains and mountains. Rainfall decreases from east to west across the northern peninsula. The eastern central region receives a moderate amount of precipitation, while the western coast from the northern peninsula to Port-au-Prince, the capital, is relatively dry. Temperatures are almost always high in the lowland areas, ranging from 15° C to 25° C in the winter and from 25° C to 35° C during the summer.

Source: http://worldfacts.us/Haiti-geography.htm

Figure 35 General rainfall information for Haiti

The region is susceptible to large water run-off that could lead to flash flooding. The establishment of many ad hoc camps in the earthquake affected zone, has increase the risk of flooding because a number of the camp locations are in flood planes

6.1.5.2 The Solution

Adequate drainage must be provided to reduce the effect of flash flooding. Locating housing on high ground reduces the impact of flooding. Where developments are built on slopes, it is important that terraces and drainage channels are sufficiently engineered to ensure their stability. It is should be noted that the cost of properly designed engineering works to create suitable sites for housing development from steep hillsides, is very significant.

Given the acute short term need to ensure the safety of people in camps, coordinated efforts need to be made by the Government of Haiti and the international organisations to develop flood maps of the region and a super imposed the location of all the current camps in order to identify the most vulnerable camps such that alternative shelter locations can be found for these people.

6.1.6 Flooding (Plate Movement)

6.1.6.1 The Threat

Flooding can also occur due to changes in topography following major earthquakes. This effect can have a dramatic effect on towns where large areas can be lost to the sea or are partially underwater or highly susceptible to tidal flooding. The situation where the land rises is clearly less problematic.

At present it is not know if this issue exists for Haiti, given the predominantly strike-slip nature of the recent earthquake.

6.1.6.2 The Solution

Expert studies are required to establish the extent of this issue for Haiti and if applicable identification of the extent of likely affected areas.

Where there has been significant loss of coastline due large scale plate movements, one must consider the future viability of the affected settlements. Engineering solutions can be provided, but they will require detailed investigations and significant civil engineering works to provide a safe, flood free environment. Hydrological and topographical surveys will be needed to assess the validity of potential re-location sites, and re-location carefully planned to ensure access to utilities, community facilities and livelihood activity. If only part of a community wishes to re-locate, consideration needs to be given to the on-going care and maintenance of the fragmented community which remains, as well as those who re-locate.

6.1.7 Slope Stability

6.1.7.1 The Threat

Much of the affected built up area is on relatively steep slopes. Non engineered slopes are prone to catastrophic slope stability failures, especially when the ground is saturated because the water reduces the ability of the soil to carry vertical and horizontal loads, noting that earthquakes will rapidly accelerate dormant slope stability issues as shown in Figure 36

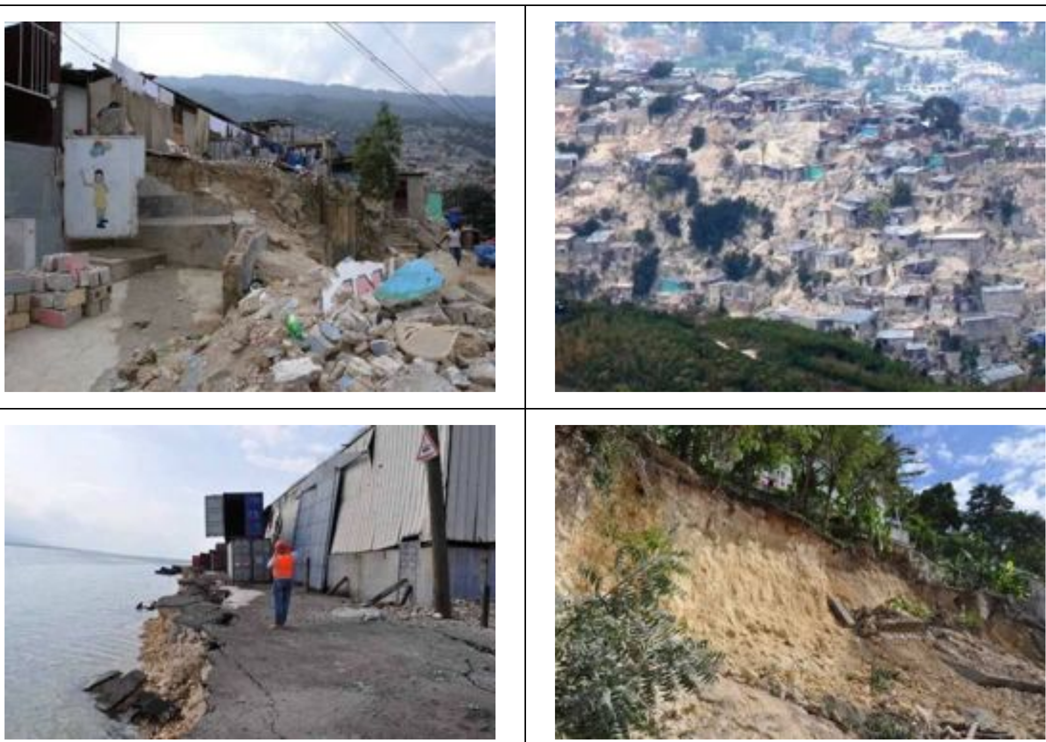


Photo Source: Eduardo Fierro (Haiti_Earthquake_20100127_UC_Berkeley.pdf)

Photo Source: Eduardo Fierro (Haiti_Earthquake_20100127_UC_Berkeley.pdf)

Figure 36 Slope failure in Haiti during the earthquake

6.1.7.2 The Solution

Expert studies are required to establish the extent of likely vulnerable slopes. Typically slopes with thick layers of soil will be more susceptible to slope stability problems compared to rock slopes.

In the outskirts of Port au Prince much of the landscape is terraced by human activity which presents a similar risk to slope stability problems and is discussed in more detail in Section 6.2.2 of this report.

6.2 Man Made Hazards

Unplanned and ill informed human activity in the built environment can significantly increase the vulnerability and exposure of people to hazards. A few of these are discussed here.

6.2.1 Security

6.2.1.1 The Threat

Political instability and the harsh economic realities in Haiti means that the protection of property is a key concern amongst the Haitian population. This is evident in the prioritisation of many people in and around Port au Prince to reconstruct their perimeter boundary walls; in effect trying to secure their property before any other work is carried out. This is more of an issue the bigger the property or facility is.

Figure 37 Construction of Strong perimeter walls

6.2.1.2 The Solution

In the long term, political and improved economic conditions will help reduce the perceived need for large walls. However, in the short term, rapid wall construction is going on. It is important that these walls are properly founded in competent ground. The use of intermediate reinforced concrete columns and horizontal band beams are encouraged. Where stone masonry is utilised it is essential that through stones are used regularly in order to bond the two faces of the walls together.

6.2.2 Terraces

6.2.2.1 The Threat

The steep terrain of much of the land on to which people have been building necessitates the creation of manmade terraces as shown in Figure 38. These terraces, if not done well, will have a failure mechanism similar to a geotechnical slope stability problem. Once the mechanism is activated the falling debris / terrace material will quickly slide down hill. This may lead to a domino effect whereby downhill house terraces are made to fail by being caught up in the moving material.

Figure 38 Manmade terraces for founding building on

6.2.2.2 The Solution

First of all ensure geotechnical stability of the slopes, though this may require the appointment of a geotechnical engineer who knows how to assess seismic slope stability.

The next step is to construct terrace walls in such a manner they themselves are stable given the soil and building weight that they retain. In Haiti, many houses are founded on a stone masonry base, and often terrace walls are made from stone masonry too. Specific issues regarding stone masonry are discussed in Section 8.3.3.1.

6.2.3 Inappropriate Construction

6.2.3.1 The Threat

It is evident that the collapse of many building was the cause of so much of the suffering from the 12th January Earthquake.

6.2.3.2 The Solution

Building back better using appropriate standards and training and engineering principles is the only way to avoid a repetition of this outcome from future earthquakes. It is important to recognise that *"Earthquakes do not kill people but building can"* as has been evident in Haiti. In particular it is important to recognise that most houses in Haiti are built by artisans and home owners and are not formally engineered. Specific issues surrounding the construction of property in Haiti is discussed in more detail in the rest of this report.

6.3 Conclusions about the Various Types of Hazards

There are a number of natural and manmade hazards that need to be considered in Haiti before embarking on any form of reconstruction. It is important that a holistic multi hazard approach is taken.

6.3.1 Short Term

In the short term the biggest risk is from heavily damaged buildings that have not yet collapsed, collapsing under further earthquakes or severe wind conditions. Appropriate damage inspections should help identify such structures within the community. This is touched up on in more detail in Section 4.

In addition there are camp communities who have chosen very dangerous sites from a flooding perspective. Immediate hydrological and topographic mapping should be undertaken to identify the at risk camps with a view to finding a more suitable environment to mitigate against a further layer of disaster.

6.3.2 Medium to Long Term

1. Multi-Hazard studies to be undertaken by or for the Government of Haiti to inform the future construction processes across the country. It should be noted that these studies and strategies need to be developed for the entire country and not just Port au Prince and the immediate surrounding areas. These studies, will inform the future planning processes for Haiti.

2. The consequences of volcanoes and large tsunamis are impractical, if not impossible to design against, and can realistically only be mitigated through management, education and planning. This includes early warning systems, evacuation plans and routes which should be accounted for in urban planning and site layouts.

3. Risks including flooding, landslides, fault rupture can be avoided completely by locating houses away from these hazards. However, this is not always possible, particularly where people wish to re-build on their own land. Alternatively these risks can be mitigated to some extent by providing well engineered drainage systems, and earthworks. The need, cost and timescale for carrying out such works, must be considered at the outset as part of a site selection process.

4. Earthquakes remain the most significant catastrophic risk in Haiti. To date it appears that no liquefaction surveys have been carried out in Haiti, and these should be undertaken in order to inform the location and foundation design of larger structures, but are less critical for housing. For housing, ground shaking is the most significant issue, as this can lead to collapse. It is therefore essential that the design is appropriate, correctly engineered and embraces appropriate legislation, guidance and good practice and that the quality of construction does not compromise the design intent.

5. There are many structures within Haiti which survived the 12th January 2010 earthquake, but that could still be susceptible to the effects of a future major earthquake. Ideally all structures, especially those such as hospitals and schools, should be assessed by qualified earthquake engineers and if necessary a seismic retrofitting program be initiated. It is likely that such a programme would optimistically take 10-20 years to implement across the country. Therefore, identification of the highest risk facilities and developing affordable retrofitting plans and time scales is an important requirement for the post earthquake strategic response by the Government of Haiti.

7 Planning and Building regulations

7.1 Urbanisation and Urban Planning

Whilst some of Port au Prince seems to have been laid out deliberately as can be seen in the horizon of Figure 39, much of the developments appear adhoc as shown in Figure 40, Figure 41 and Figure 43.

Figure 39 Panoramic view of Port au Prince indicating some sort of original master planning

Figure 40 Unplanned urban growth on the outskirts of Port au Prince

Figure 41 Area of heavily damaged, relatively un planned urban growth of 1 to 2 storey mainly residential houses

A planning process would help define the relationship and provision of infrastructure (roads, water and sewage, electricity, fire stations, police stations etc...), community facilities (schools, hospitals, libraries, parks etc...), retail, industrial facilities and the large residential housing requirements of the affected region.

Housing along the outskirts of Port au Prince (consisting of one to two storey houses) shows them to be built along the natural contours of the hills as shown in Figure 42. The density of the housing is high, there are no apparent shared drainage / water flow arrangements, and there is limited vehicular access to name a few of the obvious hazards that have been built into the fabric of these communities. The need for urban planning is very real especially in terms of basic infrastructure provision (roads, utilities and fire truck access) to these urban developments.

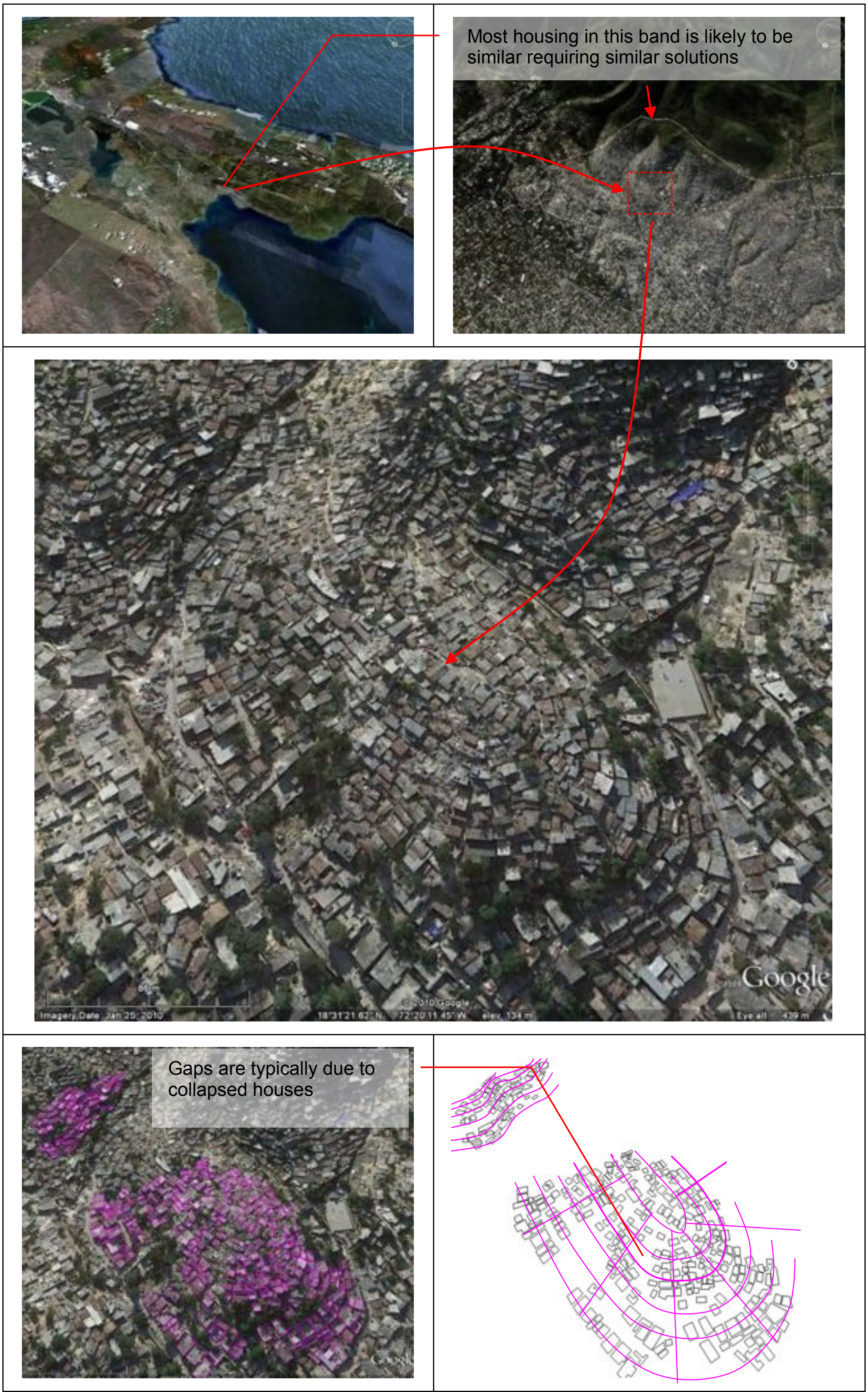
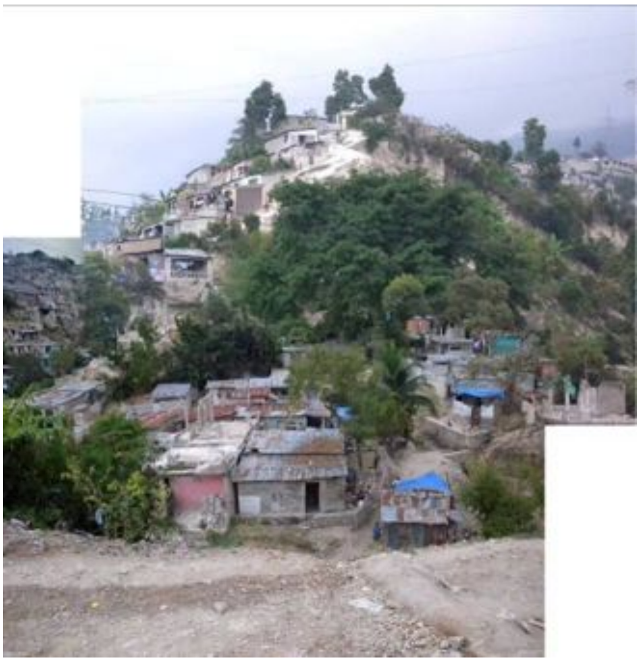


Figure 42 Typically dense urban housing with limited roads and social facilities in a radial arrangement on hills following natural contours (drafting thanks to Allan Cantos)



No planned drainage.

No vehicular access, especially fire trucks.

Dense housing in danger of cascading on top of each other as has happened in some parts in the vicinity as shown in Figure 41.

Figure 43 Steep urban housing along the entire inland perimeter to Port au Prince.

(Stitching images thanks to Claire Noble)

The requirements for proper road planning, especially for access by fire trucks, are discussed in Section 7.1.3 of this report.

7.1.1 Required studies for urban master planning and urban resilience work

An outline of sensible steps to help in the urban master planning and urban resilience work consist of the following requirements:

- Topographic surveys to pick up current features such as streams, man holes, low points, utility arrangements/surveys for electricity, gas, telephone, water and sewage arrangements.
- Population estimates
- Likely utility consumption estimates
- Current available space for utilities
- Climate data to establish rainfall and wind conditions
- Historical data on flooding
- Anecdotal evidence of flood prone areas that the current population knows about.
- Sea inundation risks
- Ground water levels and potential rising of ground water level leading to flooding
- Basic geotechnical information
- Micro zoneation
- Livelihoods distribution

7.1.2 Land Tenure

Prior to any external organisation to Haiti engaging in repairs, retrofitting or reconstruction activities it is essential that land right issues are addressed. Failure to do so will attract severe criticism and ill feeling further down the road. Whilst it is understood that land ownership prior to earthquake was uncertain and not adequately documented the situation is now worse.

The international community should be engaging with the GoH to best work out how to support the existing systems or help set up new system for the GoH to deal with the potentially contentious issue of land rights.

7.1.3 Civil Defence Requirements

There is a requirement for easy fire truck access in any city but many parts of Port au Prince and the surrounding area are currently inaccessible to fire trucks. Historic examples of major cities being engulfed by uncontrollable fires following a major earthquake are shown in Figure 44. The bottom two images of housing we visited where the owners claimed that their houses had caught fire after the earthquake.

This clearly illustrates the need to plan emergency service access routes to the whole of the city as there is a real danger of a potentially minor fire consuming large parts of the city.

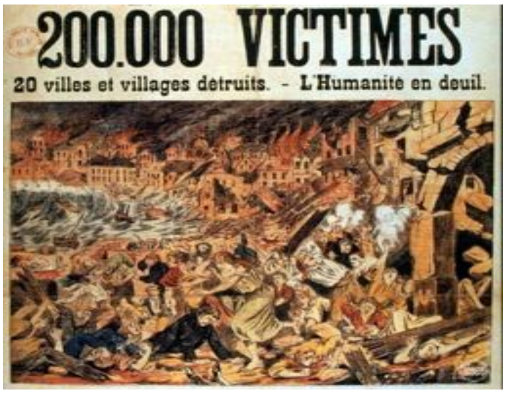
 http://www.goethezeitportal.de/fileadmin/Images/db/wiss/goethe/schnellkurs_goethe/k_1/erdbeben_lissabon.jpg Lisbon, Portugal, 1st November 1755	 Image Source: unknown San Francisco, USA, 18th April 1906
 Image Source: unknown Mesina, Italy 28 December 1908	 Image source: Unknown Kobe, Japan, 17th Jan 1995
	
Evidance of local fires after the 12th of January 2010 earthquake in and around Port au Prince	

Figure 44 Post Earthquakes fires and inability of fire services to reach the flames from around the world.

7.1.4 Decongestion

It seems inevitable that in order to build improved transport and infrastructure some land will need to be made available. This is especially true within the existing unplanned dense urban parts of Haiti.

How this is going to happen is currently unclear but it would be sensible to undertake the required supporting studies mentioned in Sections 7.1.1 to help inform this decision making process.

7.1.4.1 Space to move

One of the many challenges facing the relief and reconstruction efforts is the lack of space within the dense urban environment. All previously available public spaces have been taken over by the many spontaneous camps that have sprung up such as those shown in Figure 45. Therefore there is a critical need to identify additional space for reconstruction activities.

Figure 45 Spontaneous camps in Haiti

The least affected housing is located away from the earthquake. Therefore, in terms of decongestion, initially it is likely to be easier to identify housing that could be re utilised that is away from the earthquake epicentre.

Away from the epicentre some of the affected houses will need to be repaired. It is also highly likely that most houses will need to be retrofitted to have their earthquake resilience enhanced. Certainly the work needed to rapidly bring abandoned homes back into use should work from the outside in as shown in Figure 46. The analogy is with crowed control measures where one can only move the congested part if space has been made further back in the queue.

Equally, the population further away from the epicentre is less traumatised and are more likely to start reusing their properties once they have been assessed.

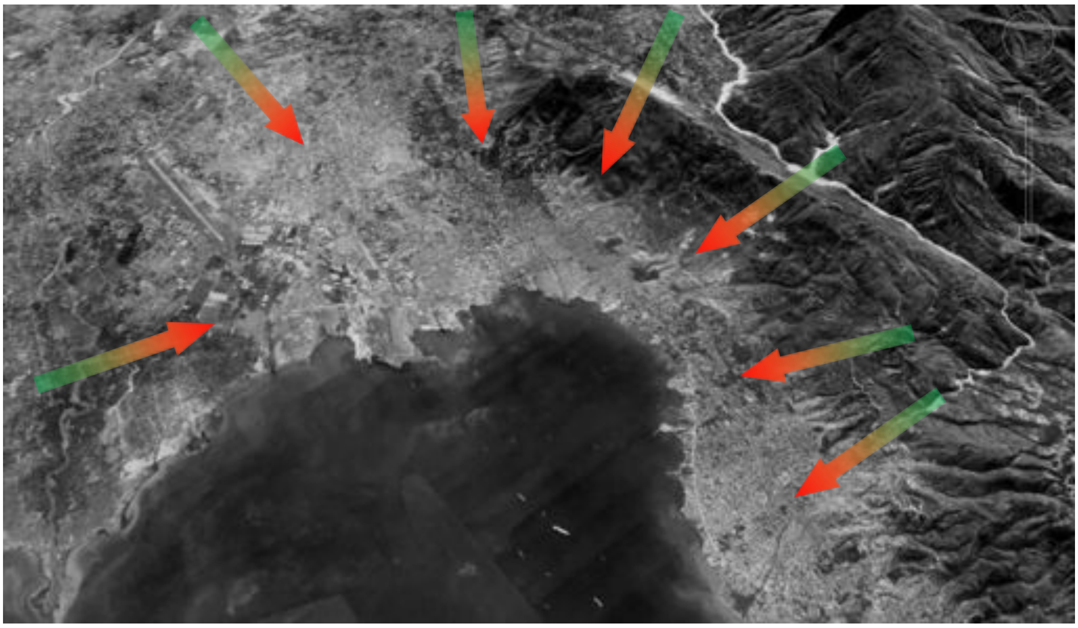


Figure 46 Work from the outside in

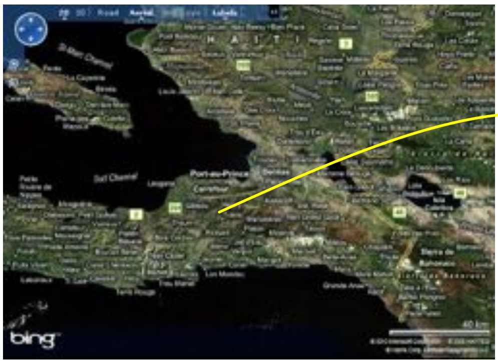
A secondary reason why working from the outside in is advised is because the engineering community in Haiti is currently experiencing a very steep learning curve in all aspects of earthquake engineering (as discussed in Sections 5.2 and 8.10). The skills of the local engineering profession to carry out damage assessments and provide follow up (advice in terms of repair and retrofitting concepts and sketches) are being developed through training programmes. As the housing typologies on the outskirts of the city are smaller and simpler it will make it easier to assess buildings and identify repair and retrofitting concepts.

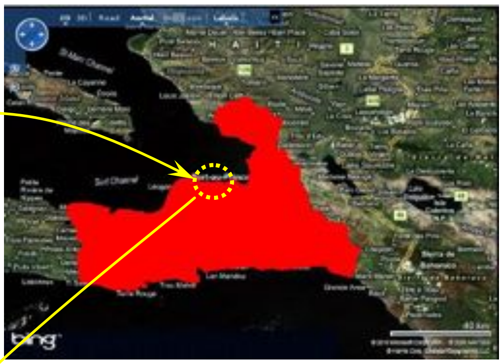
As efforts move closer towards the centre of the city the experience and skills of the local engineering professionals will be increasing to match the complexity of the urban challenges.

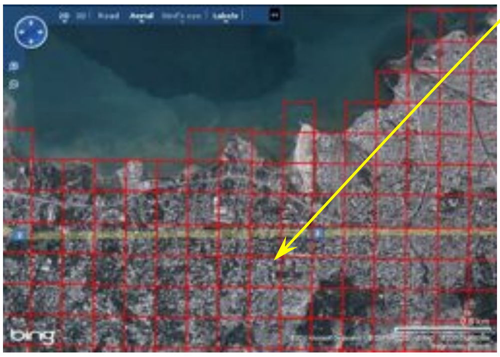
Such a strategy would be helped by redirecting aid distributions away from the current camps to regions where the current building stock is relatively intact (However, this does not mean the buildings are earthquake resistant).

7.1.5 Coordination / Coverage

As earthquake engineers we were asked to participate in a remote damage assessment exercise organised by the Virtual Disaster Viewer as shown in Figure 47.







Note:

Each time you click CHECK OUT a GRID, a grid gets assigned to you and MUST be completed because it is locked to your username, and as such, no one is assigned the same grid. Unless you complete the grid, you are not assigned a new one.

Border conditions in Grid- Complete top and Left sides of grid if there are buildings straddling the boundaries. We have been following this consistently.

Figure 47 Remote damage assessment by http://virtualdisasterviewer.com/

Whilst there are attempts to verify the accuracy of this work by the World Bank and earthquake engineering community what was interesting about this was the potential control it offered to ensuring coverage of the affected area as explained under the note in Figure 47.

As an outsider it is clear that all coordination of agencies and organisations should be taking place through the United Nations cluster system. However, given the fact that there are estimated to be over 800 agencies involved in some form of relief work there are clearly massive gaps to be plugged in terms of coordination between agencies.

The remote earthquake damage assessment methodology, of dividing the affected area into grids and then having a system of checking a grid out and thus taking responsibility for that grid appears to be a very sensible way of ensuring proper coverage of the affected area whilst also avoiding duplication of efforts.

The orthogonal grid adopted for mapping purposes may not however work well with on the ground realities of how communities work. As an alternative it is suggested that an organic grid based on rivers and roads could be created and for each of the main recognised categories of Transitional Shelter, Community Labour, Household NFIs, Information centre, Cash Loans, Contracted Labour, Direct labour, Shelter NFIs, Technical expertise, Vouchers and Capacity building a layer is created.

Agencies could then check out a grid based on their capacity and take ownership of delivering the identified relief activity. This system would allow for global coverage to be assessed and communicate areas of responsibility between agencies.

Equally, this system would identify gaps in the provision of relief and further assessment could be undertaken to identify the needs of the uncovered areas with the hope of finding other organisations to provide basic relief services.

7.2 Building regulations

The poor performance of construction to the earthquake has identified the need for mass training programmes at all levels of Haitian society to help ensure that the built environment is built back better. The training will need to be tailored to the differing roles people have in Haitian society. A list of the various groups of people who will need to be trained is presented below:

- Government of Haiti
- Existing Engineers and Architects
- Artisans and labourers
- Universities and Schools
- Home and business owners

There is a very real opportunity for a step change in Haiti to try and embed a comprehensive approach to building standards that embraces education, professional training, availability and enforcement of standards.

More detail on what the training may look like within the Haitian context is provided in Section 5.2 but it is important to recognise that implementing earthquake engineering principals will require more effort than just developing an earthquake code for Haiti or publishing guidelines; though these activities are essential and important steps in the process of building back better. The critical issue is their implementation and adoption by artisans, labourers, building owners and government officials.

A brief look at the code and guidelines listed below is provided in this section with a conclusion on the issue of establishing a comprehensive approach to building standards, education, professional training and enforcement of the standards.

- Current Haitian building regulations and construction standards
- Standards within the general region
- International Standards
- Guidelines

Many of these guidelines are still relatively technical documents and therefore are more likely to be used by local building practitioners than by the average home owner.

The vast majority of more simplified guidance available in the Caribbean with respect to building safer homes is specifically referencing hurricane resistant design and not earthquake resistant design. Therefore, care is needed when picking up codes or guidelines to ensure their limitations are understood.

7.2.1 Current Haitian Building Regulations and Construction Standards

We had limited opportunity to engage in discussions with the appropriate ministry from the Government of Haiti to determine the existing building regulations, planning procedures enforcement methods. The information we do have comes from conversations with engineers/practitioners working in Haiti either for local institutions and organisations or external agencies to Haiti such as the World Bank and UN etc..

Broadly, the conclusion of our enquiries is that building standards and codes do not exist in Haiti. However, the local practitioners (educated overseas or in country) tended to follow the following regulations in the absence of formal Haitian codes:

- French code Beton Arme aux Etats Limites (BAEL) which it is believed does not include any provisions for seismic design.
- American Concrete Institute (ACI) 318 – 99 (gravity load component only)

In many cases it is evident that no specific standards were followed within the construction industry. Additionally although it is thought that there is a legal requirement for building permits and inspections these are neither followed nor enforced (Fouce 2010).

It is important to remember that much of Haiti has been built by artisans with an informal training in construction. Engineering principals and rigorous engineering quality control procedures will have rarely been used on construction projects in Haiti and this is discussed in more detail in Section 5.2 and 8.

It is understood, from discussions in our meeting with Yolène Surena at the Ministry of the Interior (UCP/DPC-BM), that the World Bank had been planning to fund the development of design and construction codes specific to Haiti for several years and that the process was being progressed actively in the months leading up to the January 12th earthquake. The consultants, apparently a Canadian/Haitian joint venture, assigned the task to do the work, had apparently signed the contract, coincidentally, on the day of the earthquake. At that time the expectation was that work would start in earnest with meetings the following day. (The events of the afternoon of January 12th put a temporary halt to progress with the tragic passing of the joint venture's representative who was killed during the earthquake in the Hotel Montana though none of this has been independently verified and nor were we able to find out if this work was proceeding or going to be re-awarded or similar.

7.2.2 Standards Within the General Region

This section looks at what is in place in the wider region particularly in the context of seismic design.

7.2.2.1 Dominican Republic

The International Association of Earthquake Engineering indicates that Haiti's immediate neighbour, the Dominican Republic, has had a seismic code since 1979, but no similar standard exists in Haiti. It is also understood that the seismic code from the Dominican Republic does not apply to buildings 4 stories or less.

7.2.2.2 The Caribbean Region as a Whole

There are several different standard traditions in the Caribbean.

There are many who refer to standards from their former colonial ruler for example for British Standards to be referred to in the Commonwealth states and French Euro Norms to be referred to in the French Antilles. A designer's preference for the standards they use is likely to be dictated by where they studied and practiced their profession.

The Caribbean Uniform Building Code (CUBiC) which has been produced for the Commonwealth Caribbean is in existence in the region though it is unclear if this code has much uptake in the region.

The Association of Carribean States (ACS) have started to developed model codes for wind and earthquake loading (apparently based on Eurocodes), which are available on the internet (See Ref [9]). It should be noted that there are currently no approved seismic zone or wind speed maps for the region in the ACS sponsored standards and that the standards developed to date have not included Haiti.

For further information of the different regional standards and codes see Ref [8]. It should be noted however that this document also makes no mention of Haiti.

7.2.3 International Standards

There are many earthquake engineering codes that are commonly used around the world. The usual documents for consideration are:

- Eurocode 8: This has been written so that any country can choose the value of many of the parameters to suit their aspirations / economic realities and perceived sense of what risk they are prepared to take).
- International Building Code 2009: from the USA
- Uniform Building Code 1997: This has now been super seeded by IBC but is still referenced by many countries.

There are also many other countries with long established seismic codes that could provide useful precedents such as China, Japan and New Zealand etc...

However as these codes all assume that the construction industry is at a relatively sophisticated level care must be taken with their interpretation.

Broadly these assumptions are:

- The Engineering and Architecture communities are trained in earthquake engineering.
- There is a planning and approvals process in place based on the submission of master planning and design information supported by relevant studies.
- That there is a good control on the quality of the base materials for construction (steel, cement, aggregate, concrete, timber, masonry).
- That designs are built to specification implying a rigorous quality assurance and quality control procedures are in place.
- That the properties of any in situ construction is confirmed by appropriate testing such as cube samples for concrete, strength tests for rebar and weld tests for welding to name a few.

Whilst it is acknowledged good practice to have established construction codes, there has to be recognition of the current economic realities in Haiti for the vast majority of people to achieve such high levels of safety in construction.

It is likely that for the majority of Haitians engaged in the construction of their own homes sensible guidelines and rules of thumb will be more appropriate as they are more likely to be achievable.

However, for any construction undertaken by non Haitians then it is expected that these projects will be compliant with a recognised international standard as well as any minimum standard that may be defined by the GoH.

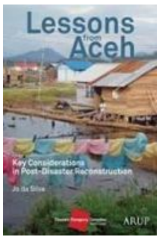
7.2.4 Guidelines

Recognising the low level of economic means of most Haitians and the fact that virtually all housing construction is undertaken by artisans it is imperative that practical advice and guidance is provided to modify current construction practices in an achievable manner to achieve lasting improvements in the construction industry.

It is likely that the artisans and labourers will not be able to read engineering codes or be used to learning from written documents or class room type of teaching. Therefore, the importance of practical on the job training will most likely be the single most effective method to mobilise the vast resource and important role these people are going to play in the reconstruction of Haiti. A selection of useful guidelines is presented in Table 5.

Note: Note that generally these guidelines deal with the repair / construction of a single property. They do not touch upon wider issues building homes, communities, land rights, how training can be done, site selection, site preparation, planning, how to go about the construction process (procurement) or similar which are all required to build back better and make safe homes and communities.

A recently published report by Arup the Disaster Emergency Committee based on lessons from Aceh provides insight into post disaster reconstruction considerations.



Lessons from Aceh, by Jo da Silva, Arup

(http://arup.com/Publications/Lessons_from_Aceh.aspx)

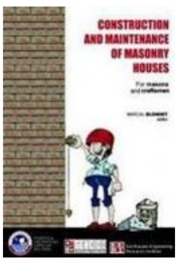
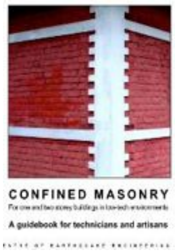
Table 5 Selection of Guidelines Suitable for the Haitian context.	
	"CariSBIG – Caribbean Conservative Multi-hazard Small Building Design and construction Guide" produced by a consortium led by Antilles Controles (based in Martinique)
	"Construction Parasismique des maisons individuelles aux Antilles" Produced by Association Francaise du Génie Parasismique (AFPS) – (Anti seismic construction of houses in the French Antillies).
	"Gujarat Relief Engineering Advice Team", Repair and strengthening guide for earthquake damaged low rise domestic buildings in Gujarat, India (GREAT). Good tips on basic repair techniques to stone and masonry buildings. Appendixes are relevant to the Haitian context.
	IITK BMTPC Earthquake Tips 1 to 24 Good explanation about earthquakes and safe design, very much within an Indian context but principals are universal (http://www.nicee.org/EQTips.php)
	"Construction and Maintenance of Masonry Houses" for masons and craftsmen by Marcial Blondet. Practical guidance for master builders, engineers. Has a high relevance to Haiti. (http://www.world-housing.net/)

Table 5 (continued) Selection of Guidelines Suitable for the Haitian context.	
	"The Seismic Performance of Reinforced Concrete Frame Buildings with Masonry Infill Walls" by the World Housing Encycopedia, Publication Number WHE-2006-03 Somewhat technical and more academic in nature but provides good explanation of principal, relevance to Haiti is high.. (http://www.world-housing.net/)
	Confined Masonry for one or two storey buildings in low-tech environments, A Guide for technicians and artisans written by Tom Schacher and published by the National Information Centre of Earthquake Engineering (NICEE). Good quality sketches, communicating principals in a number of ways. Limited to 1 to 2 storey houses. High relevance to Haiti (Available from NICEE, Translation into French in progress – funding required for publication)
	Earthquake-resistant Confined Masonry Construction by Svetlana Brzev published by NICEE. Somewhat technical but good theoretical explanations of confined masonry construction and is complementary to the manual by Tom Schacher. High relevance to Haiti. (http://www.nicee.org/confinedmasonry.php)
	"How to make a safe wooden house" – produced by INTERTECT (Fred Cuny) Does not address earthquake loads
	"Hurricanes and Houses – Safety tips for building a board [wooden] house" Produced for use in Jamaica by Construction Resources and Development Centre (CDRC) (Stephen Hodges).. [These are documents based on those originally produced by INTERTECT] See appendix...
	"Safe roof construction workshop" Produced by Organisiation of American States and the United States Agency of International Development.
	Cyclone resistant houses for developing houses 1988 Building Research Establishment (BRE), Department of the Environment. Does not address earthquake loads

It should be noticed that some of the listed documents are over 20 years old. The failure to implement these sound principals is not due to the lack of technical information but by a failure on behalf of our efforts to date to engage with the actual people who build. This is discussed in Sections 5.2 and 8.10.

8 Current Construction Practices

In this section observations on current construction practices are offered with indications on how these habits can be modified so as to help improve the quality of the raw materials, how they are handled and eventually mixed and assembled into structures. The following materials and workman ship issues surrounding them are discussed:

- Reinforced concrete (cement, sand, aggregate, water, concrete mix, reinforcement) and its workmanship (steel fixing, formwork and false work, concrete mixing and placement).
- Steel Frame
- Masonry (concrete block, solid brick, stone)
- Timber Frame
- Soil

8.1 Reinforced Concrete

Concrete is a very commonly used building material in Haiti. However, safe reinforced concrete construction is a sophisticated construction process necessitating the need to pull many processes and skills together, much like making an elaborate cake. To make good concrete it is important to have good quality raw ingredients but equally important is how these materials are prepared, placed and cured to ensure that a project ends up with good quality reinforced concrete. It goes without saying that making bad concrete is easy and requires the same ingredients as making good quality concrete assuming one has enough of the basic raw materials to start with. Therefore, there is significant opportunity to get things right given the proper training and insistence on quality. Each of the main ingredients for concrete are now discussed.

8.1.1 Cement

Haiti's local cement production is limited to grinding of imported clinker which in 2005 made up for 45% of cement used in Haiti (Global Cement Report). The balance of cement is imported from overseas with some coming from neighbouring Dominican Republic. Conversations with a couple of Haitians imply that one can purchase varying qualities of cement at varying prices at hardware stores.

Figure 48 Cement being transported in Port au Prince

Transportation of cement appears to be done in open top lorries as shown in Figure 48. Whilst it is likely that cement will be correctly stored initially (i.e. prevented from getting damp or even wet) it is unlikely that much more consideration is given to the safe transportation and storage of the cement bags.

Purchasers of cement should not be afraid to reject bags of cement that are already hard.

8.1.2 Sand and Aggregate

From our observations and conversations with Haitians, sand and aggregate is commonly sourced from local quarries and river beds (See Figure 52). Although we did not see it, there is a reasonable chance that beach sand will have also been used in construction which must be avoided due to the high salt content and generally smooth nature of beach sand.

Visual examination of aggregate piles next to construction activities indicates that the majority of the aggregate is limestone as shown in Figure 52 . Limestone with an adequate density will make a good quality concrete if done properly.

Standard aggregate tests (physical and chemical) are required on the available aggregate to determine its suitability for construction as part of one of the main ingredients of concrete.

 Rock quary (note that this is not a landslide)	 (Rocks and aggregate waiting to be used)
 Gravel in the form of smooth stones is not good (likely to be sourced from river beds due to the rounded shape of the stones)	 Sand fraction appears to have been derived from crushing the gravel – does not appear to contain much dust. Appearance is very angular.

Figure 49 Typical aggregate piles in Haiti

We discovered a local press article (See Figure 50) that discussed the quality of quarried sand which alleges that this material has been classified as being unsuitable by the Government of Haiti since the earthquakes. This has not been confirmed and without test data to confirm this view such statements should be treated as suspect information.

It should be noted that river sand may also have problems, especially if it contains many fines (silt and clays) or it is very smooth in nature.

The adequacy of any aggregate should be investigated by undertaking appropriate aggregate tests prior to its use.

The Associated Press Published: February 14, 2010

PORT-AU-PRINCE, Haiti - Haiti's government is banning a commonly used sand from structural construction in an attempt to improve building safety.

The public works ministry issued a notice today warning that the use of "La Boule"-type white quarry sand to make concrete for structural elements would be punishable under Haiti's penal code and recommends using river sand.

It is not clear how the edict will be enforced.

Poor construction is blamed for the collapse of many buildings in the Jan. 12 earthquake that killed more than 200,000 people.

The mountains around Port-au-Prince are scarred with the white caverns left by extraction of the loose white sand. Bricks made with the poorly mixed cement are brittle and break off at the touch.

Source: http://www2.tbo.com/content/2010/feb/14/haiti-bans-quarry-sand-construction-materials/

Figure 50 Article from Associated Press about quality of sand in Haiti

Some other generally observed quality issues are:

- Aggregate grading: In standard good concrete practice, generally the maximum aggregate size used for reinforced concrete is ~20 mm (to ensure good compaction around reinforcement) and 40 mm for mass concrete structures (where there is less restriction for the flow of concrete). In some cases grading of aggregate had not taken place as can be seen in
-
-
- Figure 51.

The image on the right was taken from a reinforced concrete framed building. Not only have large boulders been used in the construction of this column there was also no apparent reinforcement present, certainly not that could be seen without further investigation.

Figure 51 Example of a poorly graded concrete mix with large rocks evident in the mix.

- Sand and aggregate cleanliness: all aggregate should be washed to ensure that it is free from organic material, fines (silts and clays) and salts – all which will cause a poor bond with the aggregate and/or degrade the quality of the concrete. Current practice of storing aggregate does not indicate any pro-active measures to protect clean material from becoming contaminated. Unprotected piles of aggregate were observed in several locations around the city (see Figure 49).
- Storage: This should ensure the cleanliness of the material and maintain the grading and water content so that that when water is added during the mixing of concrete in the right proportions to make workable, durable and strong concrete.
- The sand piles generally indicated "sharp" sands, i.e. very granular ands. Typically such sands are hard to work and require more water to get a workable concrete mix. Typically in western countries this is overcome by either adding ~40kg/m³ of additional cement to the mix to help create a more mobile paste or plasticisers are used to help improve the workability of the concrete. In Haiti it is unlikely that either of these methods will have

been adopted and it is thought that that workability will have been achieved simply by the use of larger quantities of water. This will increase the chances of the cement paste from seeping out of the imperfect formworks and reducing the strength and durability properties of the concrete.

8.1.3 Water

Water is an important part of a concrete mix. It is important that it is clean and free from any impurities which may affect the hydration process of the cement. Normally water that is good enough to drink is suitable. It is sometimes noted that seawater is used however this is only suitable for mass concrete (i.e. without any steel reinforcement).

Discussions with locals would suggest that the quality of the water used in concrete is not generally checked. Furthermore some mentioned that sea water has been used in concrete used for reinforced concrete construction. Unfortunately, such statements are typical in many countries and the value of educating the artisans is an important aspect of making sure that good quality water is used in the preparation of concrete.

8.1.4 Concrete Mix

The mix design, i.e. the proportions of the component materials is an important factor in determining the strength of the material.

It is thought that the concrete mix design often has lower proportion of cement to aggregate ratio than is recommended. It is understood that it is not uncommon for people to mix 1 portion of cement with 10 portions of ungraded mix of sand and aggregate.

Typical volume batching ratios (See Ref [7]) and the probable strength are given below for three concrete mixes (cement / sand / 20mm aggregate):

1 : 1.5 : 3 gives about 40Mpa concrete

1 : 2 : 4 gives about 30Mpa concrete

1 : 3 : 6 gives about 20Mpa concrete

Anecdotal evidence suggests that the general grade of concrete in Haiti is very low and may be more like 10 to 15MPa (assuming it is half decent concrete unlike much of the observed concrete).

It should be noted that ACI 318 stipulates a minimum concrete cylinder strength of 20Mpa for reinforced concrete construction is seismic areas. It is likely that much of the observed in situ concrete in Haiti will fall well short of this minimum strength requirement.

Mixing of concrete by hand is the general practice, especially on smaller house projects. Although it is more difficult to ensure a good mix using this method it remains feasible to produce adequate concrete for small projects. In these cases, the training of the artisans is even more critical so that they understand the need for pre mixing the dry ingredients and the time they have to place, compact and cure the freshly placed concrete.

Figure 52 Mixing of concrete using a small mechanical mixer and by the more conventional hand method

8.1.5 Reinforcement bars and steel fixing

It is understood that reinforcing steel is imported primarily from the Dominican Republic. In many instances it is noted that many will reuse reinforcement found from other sites. These reinforcing bars will be stressed, fractured and bent, rendering them unsuitable for use and the merits of recycling reinforcement bars is presented in Section 8.6.1 .

The use of both smooth and deformed bars has been observed in Haiti. However we have noted in many instances the inappropriate use of smooth bars. Whilst smooth bars are acceptable as hoop reinforcement they are totally unacceptable as any longitudinal reinforcement in any structural member.

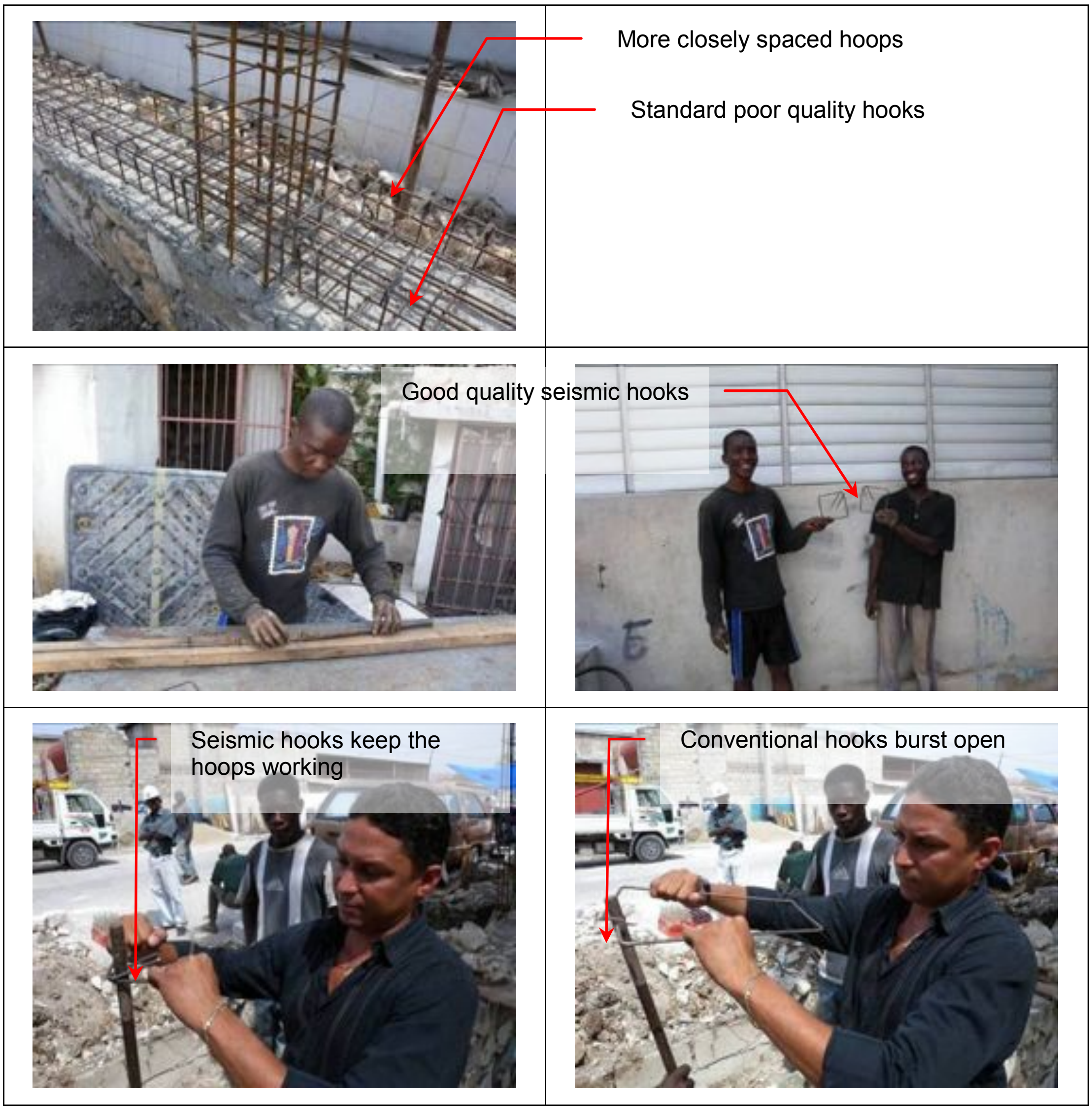
Reinforcement bars for use in construction require a clear bar mark and test certificates. In seismic conditions it is important that the reinforcement bars have adequate elongation properties to help ensure ductile response of reinforced concrete members during earthquakes.

Figure 53 to Figure 55 illustrate current reinforcement fixing practices as encountered in Haiti. Modification to current practices will help solve many problems in reinforced concrete buildings.

Pre earthquake construction (short hooks are available on the internal links) This was the only instance of seeing any form of hooks on the links. Surprisingly the vertical reinforcement was more than just one bar at each corner too.

Preparation of a column reinforcement cage for a boundary wall – note the standard hooks and the short anchorage length for the vertical bars.

Figure 53 Observed steel fixing practices



Post earthquake repair work, practicing the use of links with full seismic hooks with demonstration to show how the hooks prevent the links from bursting open unlike the details currently used

Figure 54 Observed steel fixing practices and demonstration of possible modifications to current methods.

Figure 55 Observed triangular reinforcement for columns with very widely spaced links.

8.1.5.1 Formwork and Falsework

Formwork for floors slabs seems to consist of a standard sized ply wood sheet with a centrally attached post a bit like a advertisement sign post. These are appearing to be recycled from project to project and with time significant damage is encountered along the edges as shown in Figure 56. These gaps allow the cement paste to seep out of the freshly cast floors which negatively impacts on the quality of the final cast and cured concrete.

Figure 56 modular formwork system, that is constantly recycled

During our field work we did not see any actual concrete pours taking place so our observations are limited at this stage.

8.1.5.2 Concrete placement

Placement of concrete is quite a skill and it is often done very poorly. Unfortunately this is the case in Haiti too. Leaking formwork, sloppy mixes (to get the concrete to flow) and no compaction and vibration of the concrete typically result in poor quality concrete as shown in Figure 57.

Figure 57 Example of poorly graded and poorly compacted concrete

Whilst we did not see any concrete being poured, it is thought that compaction and vibration equipment is not usually used by the artisans. With some practice modification it will be possible to achieve much better concrete results without incurring any additional costs.

8.2 Steel Frame

We did not see any residential steel framed construction in Haiti. The only structures we saw with steel sections were industrial facilities, petrol station roofs and similar as typically shown in Figure 58. As it is not thought that Oxfam will be involved in any of these types of buildings they are not discussed any further except that generally the structural steel parts appear to have performed well. However, major weaknesses in the connection of the structural steel through brittle connections to more conventional reinforced concrete frames were observed.

Figure 58 Typical buildings with structural steel buildings

8.3 Masonry

8.3.1 Hollow Concrete Blocks

During our field surveys we were not able to visit any concrete block making facilities. However the general appearance of the blocks (granular and porous looking) gives them a sense of being a weak material. Typically failed blocks are being placed on to the streets for rubble collection. Recycling aspect of these blocks is discussed in Section 8.6.3.1.

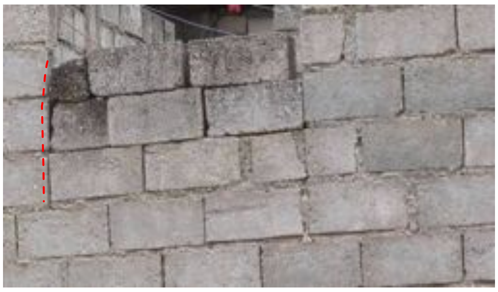
It is advisable that independent tests are carried out on the concrete blocks as currently sold by various manufacturers in Haiti in order to determine their engineering properties.

It is also advisable to modify how these blocks are used. In many ways they are ideal for the inclusion of additional vertical reinforcement bars to enhance the out of plane properties of walls made using these blocks.

Simple modifications to the blocks would allow the simpler inclusion of horizontal reinforcement to be placed between various courses of block work.

8.3.2 Solid Fired Clay Bricks

The only solid fired clay bricks we saw came from an old building. Therefore, it is unclear if such bricks are still manufactured in Haiti. As with blocks, mechanical testing of the bricks is necessary to establish their engineering properties.



Discontinuities in the masonry bonding patterns.

No mortar in the vertical masonry joints.

No evidance of strengthening at corners or wall junctions.

Figure 59 Typical poor quality block work construction

Figure 60 Missing Lintel beams across openings in the hollow concrete block constructions

8.3.3 Stone Masonry

This was by far the most common form of construction observed with respect to foundations and retaining walls. It was also observed in the masonry walls of some houses and as perimeter free standing walls. This is an important type of construction in Haiti – particularly as stone is essentially free if you have the labour to excavate it. There is a more detailed discussion on the role of stone masonry in Section 8.3.3.1.

The observed stone masonry typically had the following characteristics:

- Stone was not cut to shape.
- There appeared to be no use of through stones.
- Strengthening corners and wall junctions by the use of higher quality stones was the exception rather than the norm.
- Round stones were used all too often.
- Stone masonry walls laid in sand / cement mortar must have weep holes whereas dry stone walls are naturally permeable.
- It is not known to what depth foundations are generally built to in Haiti but it is suspected that generally foundations are very shallow.

- Use of strategic reinforcement (using timber or reinforced concrete does not appear to be practiced)

Further details on stone masonry are provided in Section 8.3.3.1

8.3.3.1 The Role of Stone Masonry

Stone masonry should play an important role in the reconstruction of Haiti as shown by the extensive use of stones, at least in the formation of foundations and retaining walls to terraces as shown in Figure 61. The intrinsic value of the stone has been clearly recognised by the Haitian people as discussed in Section 8.6.3.3.

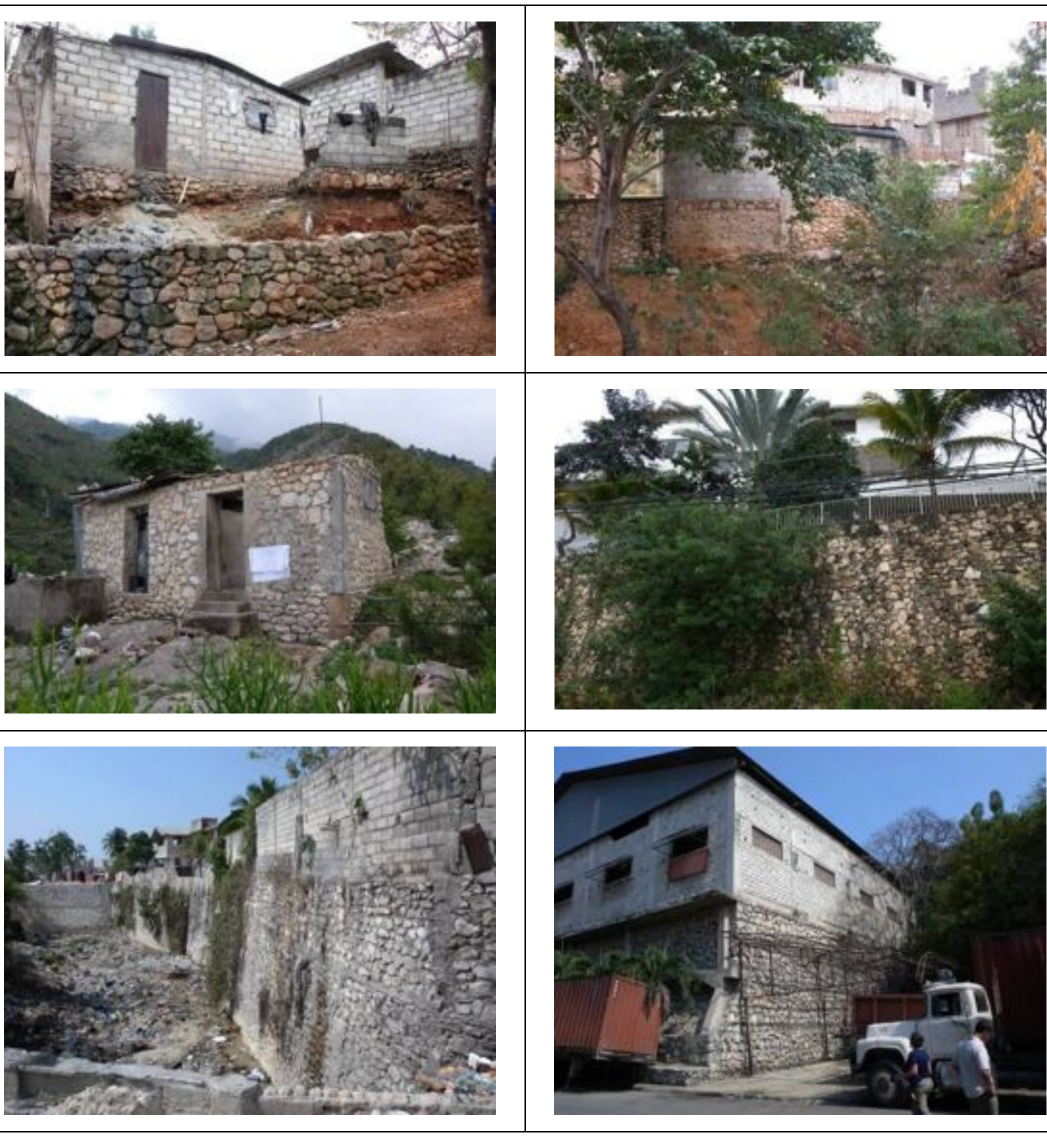


Figure 61 Common Occurrence of Stone Masonry in Haiti

8.3.3.2 Existing Knowledge of Stone Masonry

Stone masonry is rarely studied by the engineering profession and is quickly dismissed by earthquake engineers as a suitable material for construction in seismic zones. There are a number of reasons why this position by the earthquake engineering community should be questioned in the Haitian context.

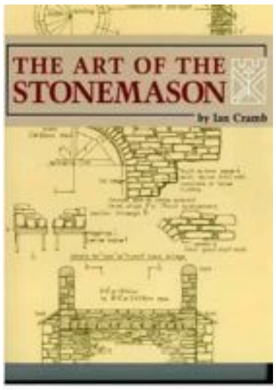
1. Most structures by ancient civilisations are made from stone masonry and have proven to reliably withstand the rigours that nature has thrown at them including earthquakes.

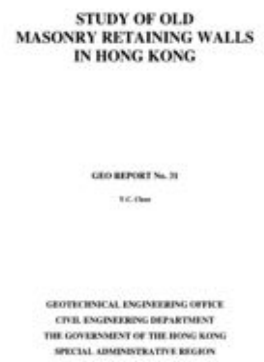
2. Many of the collapsed buildings in Haiti were made from modern materials (reinforced concrete and hollow concrete blocks) and trying to follow sophisticated engineering principals.
3. There are no codes for stone masonry which engineers can use.
4. Stone masonry is thought to be primitive and backwards – i.e. not what you do if trying to develop.
5. There is no factory controlled manufacturing requirements to make rock unlike modern materials such as structural steel, rebar, cement, concrete blocks, carbon fibre, kiln dried timber etc…
6. The material is highly durable.
7. Total monetary pledges for Haiti is about 1.5 billion USD for roughly 3 million affected people. This means there is roughly 500USD per person for all the emergency response and subsequent needs. Assuming 5 people per house this gives a sum of 2500USD / family. Prior to the earthquake, construction of warehousing was thought to be around 800 USD per square metre. Therefore, the total funds, if it was only for construction is enough for about 3m2 of floor area. Clearly reconstruction using western norms (i.e. Code engineered buildings) is never going to be possible within the economic realities of Haiti for the vast majority of the population.
8. It is available relatively cheap which is ideal.
9. Stone masonry requires a lot of manual work. Given Haiti's high unemployment levels stone masonry construction may provide significant employment opportunities.
10. Stone masonry tools are cheap.

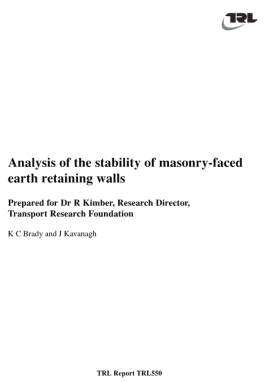
Given these sobering observations, stone masonry ought to have a significant role in the building back better of Haiti notwithstanding the significant architectural aesthetics of stone masonry buildings.

Clearly stone masonry construction has its limits and is likely to be only be suitable for residential type houses of up to 3 storeys. A selection of guidelines on stone masonry is shown in Figure 62. It should be noted that all of these, except for the tutorial being developed by the World Housing Encyclopaedia, are for gravity load design of stone masonry. It could however be said that many stone masonry retaining walls are able to carry significant horizontal loads from lateral soil loads.

The photos shown in Figure 61 give an indication of the ground reality that stone masonry is already in significant use in Haiti and that in many instances the stone masonry performed well during the earthquake. Obviously there are instances where stone masonry did not do well but that is no different to modern construction methods and is in its self not a rational reason to ignore stone masonry.







Stone masonry tutorial currently under review, expected to be published in June 2010 for the World Housing Encyclopaedia.

(Authors: Jitendra Bothara, Svetlana Brzev)

Figure 62 Stone masonry guidelines from around the world

8.3.3.3 Precedents for Earthquake Engineering and Stone Masonry

After the 8th October 2005 earthquake in Pakistan, stone masonry was widely used in the reconstruction efforts. Construction stages of a demonstration stone masonry house by NSET are shown in Figure 63 and Figure 64.

Figure 63 Preparation of foundations for a seismically resistant stone masonry house

It is evident from these figures that it is feasible to construct seismically resistant buildings using traditional stone masonry that has been strategically enhanced by the selective use of reinforced concrete.

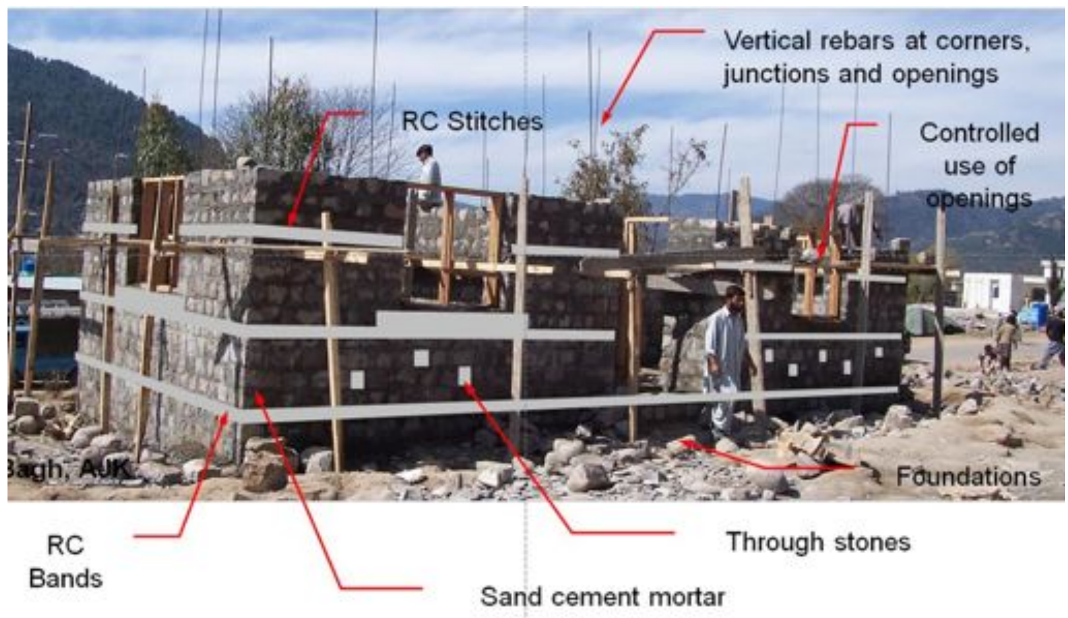


Figure 64 First floor of a house using stone masonry and strategic seismic strengthening

It is important that such buildings are designed to respect simple engineering principals. The strategically placed strengthening enhances the behaviour of the stone masonry to help increase its ability to resist significant horizontal earthquake forces. Public demonstration models of a conventional and strategically enhanced stone masonry building are shown in Figure 65.

Figure 65 Public shake table test of a conventional and strategically strengthened stone masonry building by NSET in Bagh, Pakistani Administered Kashmir.

8.3.3.4 Stone masonry details

It is not within the scope of this report to be a guidance document on stone masonry. However, like all construction methods attention to detail is required. Stone masonry has the advantage that if a stone is broken during preparation it can still be used as there is a significant need for filling stones and the like. In other words stone is unlikely to go to waste with smaller fractions such as aggregate being able to be utilised in the construction.

Practicing stone masonry with vertically placed reinforcement and regular use of "through" or "bonding" stone to interlock the two leafs of the masonry wall, a simple practice that has not been observed in Haiti.

Figure 66 Through Stones and Vertical Reinforcement.

8.4 Timber Frame

Timber frames were observed most commonly as roof structure for housing. Timber frame construction was also observed in Colombage construction in more historic buildings though these were not assessed in detail during the course of our work.

8.4.1 Material

Wood is a scarce and valuable resource in Haiti. In recent years much of the wood in Haiti has been harvested. It is used primarily for fuel, either in its raw state or as charcoal and is the main fuels source in the poorer households. Evidence that trees have been over harvested is clear, much of the rural area suffers from chronic deforestation and any young trees do not reach maturity before being harvested.

At this point the author does not have sufficient information about the local timber species to comment on their properties but typical timber sections, as shown in Figure 67, were unfortunately a common sight in Haiti.

It is understood that a lot of the structural timber in Haiti is sourced from the Dominican Republic. This is yet to be confirmed. It is thought likely that timber from North America will start coming into Haiti.

Figure 67 Trees and branches being prepared for reconstruction works

The original timber framing as observed in some of the Gingerbread houses appears reasonably sophisticated. However, the art of timber joinery appears to have more or less completely died up. Typical basic timber roof arrangements of housing as observed during our field surveys are presented in Figure 68.

Figure 68 Typical Timber Framing in Haitians Poorer communities.

8.5 Soil

Many of the retaining walls, made to form terraces, onto which houses were built have probably some sort of soil back fill. It is not known how these terraces were built but it is unlikely that they were filled and compacted in layers as they should be.

To help ensure the stability of many of the terraces it would be sensible to build in gravel channels or similar for the water to go through, ideally directing such flows away from the foundation of a house into a pre determined drainage channel or similar

8.6 Recycling of Construction Materials

It is important to recycle good quality materials and reject poorer materials for the repair, retrofitting or reconstruction of property. Commonly encountered construction materials in and around Port au Price are discussed in this section.

8.6.1 Reinforcement Bars

Figure 69 Recycling of old reinforcement bars

Old reinforcement is being stockpiled as seen in Figure 69. Under no circumstances is it recommended to use old reinforcement bars in any construction. Some portions of these bars will experience high levels of deformation during the earthquake and subsequent demolishment activities. These bars will typically have many micro cracks and fissures and could fail at much lower than expected force levels.

It is recommended that rebar from damaged buildings be fully recycled by sending the material to an iron smelter where it can be re forged to form fresh steel products using factory levels of quality control.

8.6.2 Structural Steel

We did not come across any recycling of structural steel members apart from the many railway track rails that have been previously used to support many of the retaining walls in Petionville in the past.

8.6.3 Masonry

8.6.3.1 Hollow Concrete Block

Hollow concrete masonry units are a very popular in Haiti and ready stockpiles are everywhere as shown in Figure 70. However, where these blocks have been damaged, they are of no further use because of their weakness as shown by the building rubble in the bottom images in Figure 70.

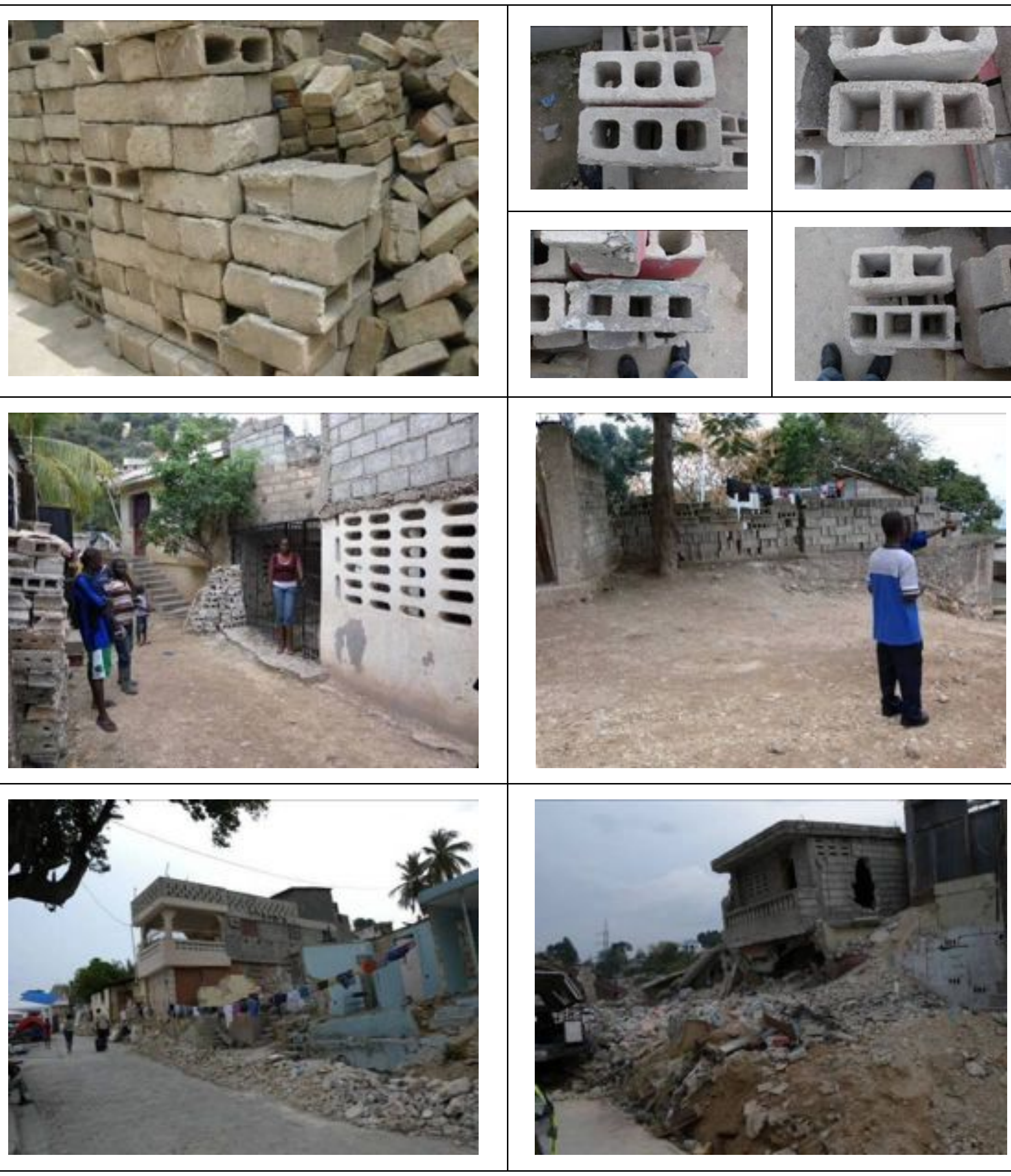


Figure 70 Hollow Concrete Block Masonry

The concrete block masonry generally appears weak. There are no known instances of the blocks being reinforced with rebar and concrete to help improve their seismic resistance. Likewise the blocks have no grooves for reinforcement to be placed to help in their seismic resistance once assembled into walls.

It is unlikely that the rubble will be suitable for use as aggregate in the making of new concrete blocks. However it would be prudent to make trial samples and test them to see what strength levels can be obtained.

It must be remembered that appropriate structural design may be able to accommodate weaker than generally accepted material strengths by making the necessary design adjustments to take into account the weaker base building blocks.

8.6.3.2 Solid Fired Clay Brick

Figure 71 Fired Clay Brick Masonry

We came across very few fired clay brick and a rare sample of salved bricks is shown in Figure 71. These bricks looked to be of reasonable quality and are well worth salvaging. Testing of such bricks will be necessary to establish their engineering properties.

8.6.3.3 Stone

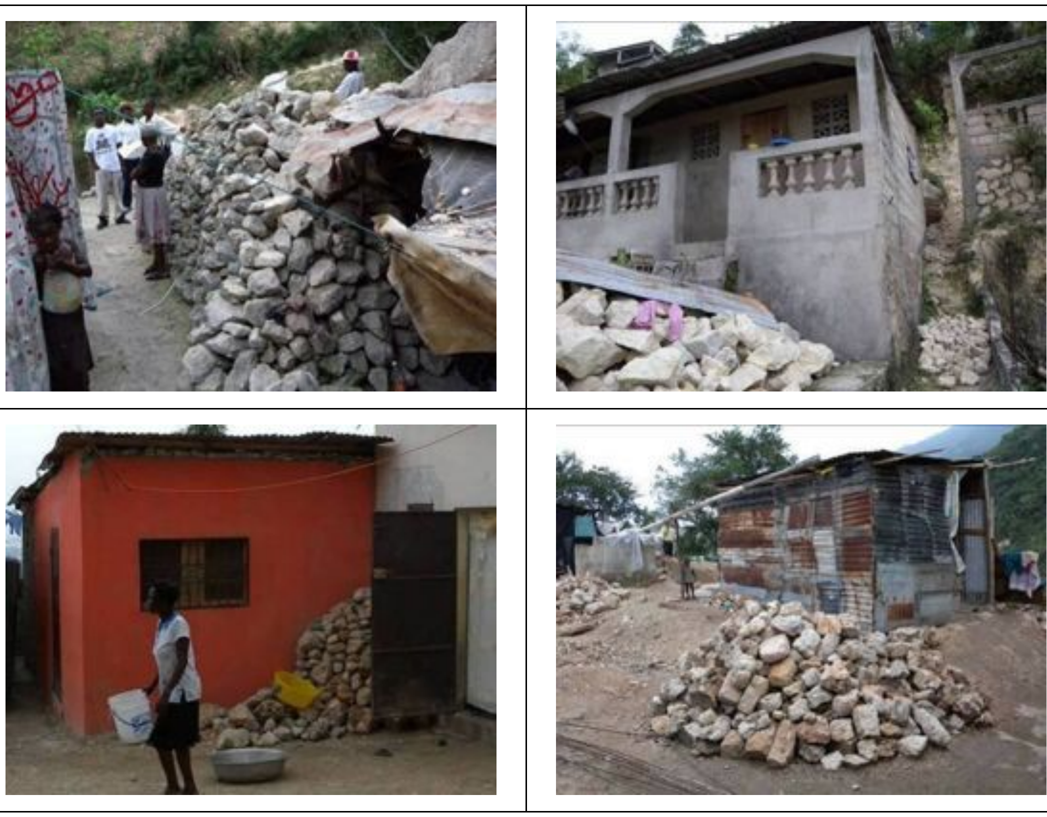


Figure 72 Typical stone masonry piles

The prevalence of stone masonry (generally thought to be limestone) is widespread as shown in Section 3.2. The rock appears to be of reasonable quality and is widely available. The material is durable and likely to be relatively cheap. The affected population clearly understand the inherent quality of the material and are stockpiling as shown in Figure 72. Unlike the modern construction materials- concrete and concrete blocks- the rocks have performed well as individual building components.

Rocks assembled as stone masonry will as a minimum form the foundations for most boundary walls, terrace retaining walls and many properties in Haiti. However, stone masonry is currently not a recognised construction material by typical modern earthquake engineering codes. Current stone masonry practices and improvements to the present practices are presented in Section 8.3.3.1.

8.6.4 Timber


Figure 73 Timber for recycling

Generally timber appears to have only been used in the older houses apart from the roofs (typically referred to as Ginger bread houses) in Haiti. Any timber that is unaffected by rotting, fungal growth, and termite infestation or similar will be suitable for recycling. New timber appears to consist of the harvesting of very young trees and this is symptomatic of the high levels of deforestation. Use of timber, its availability and sourcing will need to be carefully assessed and monitored by all parties to prevent further deforestation of Haiti.

8.6.5 Corrugated Galvanised Roof Sheeting

Figure 74 store of corrugated galvanised iron sheets

Only one instance of a stock pile of corrugated galvanised iron (CGI) sheets was seen during our visit as shown in Figure 74. Whilst this material is potentially valuable it is important the gauge of the sheets is checked to ensure they are adequate for the use for which they are intended. Recycled CGI sheets also need to be checked to ensure that they do not have previous fixing holes in the wrong places. In many instances it may be more appropriate to return damaged sheets for proper recycling so that new steel products can be forged.

8.7 Waterproofing

Current water proofing practices are discussed and possible modifications are presented in order to help avoid the repetition of poor construction detailing surrounding rainfall and the various methods employed to keep water away from the properties.

	Emergency shelter: Whilst this individual has recognised the need for ample drainage around his shelter the implementation of this is not across the site and nor are the trenches armoured in any way to minimise the risk of scour action. It is also not clear where the rain water will drain in to. Clearly, in camp situations overall site drainage must be evaluated and temporary drainage provided.
	Timber and corrugated galvanised iron walls and roof: This property, built on and around rock should have a stone masonry band to raise the base of the building above the current plot level. As there is no guttering to the roof, it is especially important that an armoured drainage trench be constructed, possibly out of stone masonry. This will help minimise damage near the property base. Consideration needs to be given where the rainfall water from this site is directed to so as not to cause a problem further downhill.
	Dense urban construction: Flat slab roofs all have a two block high perimeter parapet. There is no waterproofing to the flat slabs or any obvious thought out drainage. As these houses are built incrementally, the current roof is considered to be a future floor rather than a roof. This means it is laid flat without any a slope to direct rainfall water to a drainage point. A sloping screed and waterproofing will help minimise corrosion damage to the reinforced concrete roof. Currently there is limited application of this for these types of houses.
	High end house: Clay tiles, overhanging roof and large gutters and drainage pipes are sensible details to ensure water stays away from the building fabric.

Figure 75 Typical waterproofing practices in Haiti.

8.8 Access to services

In this section we have documented some of the non structural arrangements of the residential properties we visited as they are essential components of making homes. Whilst these initial observations are only exploratory, they are equally important in any repairing, retrofitting or reconstruction activities that Haiti will be engaging in.

8.8.1 Water and Sanitation

8.8.1.1 Latrines / Wash facilities

Figure 76 Typical Latrines and Wash facilities in the residential housing units we visited

Generally only the bigger houses have western style toilets. Whilst many have hole in the ground type latrines in their homes, they are dark, poorly ventilated and non of the concrete or cement plaster has been protected with proper tiling. This makes these toilets near impossible to clean and a likely continuous source of re-infection and chronic disease within the communities of Haiti.

Even, in what appears to be relatively central middle class properties, external latrines are not unusual.

Clearly the required reconstruction activities offer an opportunity to build back toilet and wash facilities to a better standard.

Emergency Latrines

External latrines to middle class properties

Latrines 1 between 20 houses as indicated by the local community

Figure 77 External Latrines

Figure 78 Washing lines in Urban and near rural settings

Washing facilities are shared with latrine spaces in many of these houses. Whilst this is not a problem in principle, the poor state of cleanliness does make this a significant issue that needs to be addressed during the reconstruction work.

8.8.1.2 Drinking Water

Although Haiti has significant levels of rainwater the natural resource appears to be poorly managed and generally unavailable to many. Clearly the earthquake will not have helped in this regard but many of the issues pre date the earthquake.

Rainwater Harvesting

Figure 79 Rainwater harvesting into Stone or block masonry Tanks

Harvesting of rainwater is actively done in the more rural communities. Concrete block water tanks with a cement lining, typically about 1m² on plan, can be seen next to most houses on the hilly outskirts Port au Prince. Many of these tanks did not have secure lids to prevent animals and other forms of contamination getting in to the water reservoir. In the more urban settings rain water harvesting was not observed but clearly there is significant potential for this, especially in the design of new housing that is no doubt going to take place.

Emergency water provision

It is unclear how much piped water was provided prior to the earthquake but it is clear that the network must have been affected.

Provision of emergency water through bladders and standpipes as typically provided by Oxfam.

Sale of plastic water pouches by local firms also appeared to be big business.

Figure 80 Emergency water supply in the spontaneous camps

It is important that the water distribution network is properly assessed from a structural point of view. Where necessary there will be a requirement to fit flexible connections at certain points along the network to prevent future loss of service due to differential movement demands on the pipe network. Typically this will be at locations of discontinuity for the pipes such as when exiting the ground and entering a building.

It is important that engineers engaged in the construction of water networks or similar take into account the seismic requirements of buried pipes. This is equally applicable to the sewage and drainage network in Haiti.

Oxfam should evaluate the adequacy of their water and sanitation services and if necessary arrange for technical training of their WATSAN staff so that they are aware of seismic design requirements for pipes, storage tanks and similar.

It is interesting to note that many water tanks of houses in Petionville do not appear to have toppled over or suffered any significant damage during the earthquake as shown in Figure 81

Figure 81 Un toppled roof top tanks in Petionville

8.8.2 Energy

8.8.2.1 Electricity

It is evident that there were supply problems existing pre earthquake because there are private diesel and petrol generators adjacent to many properties - from large industrial units to supply electricity for industrial facilities to small generators for charging mobile phone.

It is not thought that mains electricity is available in all houses, but electric wires and crude wiring are not far from being implemented in many of the homes. Whilst the national grid of Haiti needs to be assessed, weak spots identified etc… it is not clear what other types of support Haiti is receiving with respect to its basic electricity network. Clearly this is beyond the scope of this document. However, as far as residential housing is concerned it appears that the expectation is that electricity should be available.

Figure 82 Private Electricity Generators are everywhere to supplement the grid supply

How electricity is going to be provided from here onwards and how this is going to integrate into the reconstruction activities needs careful strategic planning and communicating. As having working utility connections is one aspect to make properties become homes.

8.8.2.2 Cooking

Most cooking facilities we observed involved the burning of poor quality charcoal as shown in Figure 83. Typically these kitchens, many of them outside, do not have any surfaces, sink facilities or similar. However, every home requires a kitchen and how these will be provided during the reconstruction needs to be carefully considered, especially the investment in methods that are more efficient in terms of burning scarce charcoal resources. Whilst kitchens will not influence the earthquake response of buildings, many open fires can have potentially devastating effects on cities, especially after large earthquakes. This historical precedence's for large post earthquake fires are graphically illustrated, mainly through art work in Section 7.1.3.

Figure 83 Typical kitchen facilities in many of the 1-4 room single storey houses (Types UHM-TCR and C4-HM-TCR)

8.8.3 Solid Waste Management

The earthquake has clearly affected the waste removal services in Haiti though it is unclear to what extent.

Such uncontrolled dumping of rubbish, apart from the immediate chronic health problems and pollution of water courses present the additional hazard of being a ready source of fuel that may burn out of control.


Figure 84 Typically natural water courses have been used for dumping household waste.

Whilst in some parts of the town rubbish is not being collected due to the earthquake in many other parts of the city, especially as illustrated in Section 7.1 access is not possible by vehicles. Therefore in all those communities there is unlikely to be any reasonable way to collect domestic waste.

8.9 Incremental Construction

Incremental construction is the norm in most of Haiti. This is especially true for the poorer sections of society who typically start by building their homes one room at a time. As in much of the world column reinforcement for the next increment of construction is left sticking out of the temporary building roof until sufficient funds are available to build the next extension as shown in Figure 85.

During our field surveys, especially in the middle class residential areas, the quality of subsequent levels appears to be of significantly lower quality than the original one or two storeys. A quick way to rapidly improve the likely performance of many incrementally constructed buildings would be for building owners to:

- Stop building further increments to their houses (this will help stop the problem form getting worse)
- Demolish the last floor that was added, especially the half complete/half damaged levels. This will lead to an immediate reduction of the most damaging seismic mass which was at height.
- Where incremental construction is carried out sideways, either the additional space needs to be fully structurally connected to the old building portion or constructed with an adequate seismic gap.
- Where there are plans to build an additional storey allowance must be made in the base design of the house for this extra load both in terms of foundation loads and seismic lateral force capacities. In addition rebar should extend at least to the mid height of the next level and be encased so as to be protected from corrosion.

Figure 85 Housing ready for the next level

Incremental construction has mainly been observed in the residential sector. However, from our visit to a number of warehouses, it is also apparent that industrial facilities have been expanded incrementally without any regard for seismic movement requirements or the magnitude of the forces at these building junctions.

8.10 Local skills and capacity

8.10.1 Trained Sector

It is evident that a large skilled workforce is lacking in Haiti.

With respect to building safer homes the initial impressions are that the formal engineering sector is in professional shock. Haitian civil and structural engineers have just discovered that they were completely unaware of the need for earthquake engineering. The analogy would be as if doctors, having studied medicine at university, were unaware of antibiotics as a tool to help them apply their trade. Unfortunately many civil and structural engineers will have woken up realising that they were indeed unaware of earthquakes.

In addition to this the formal engineering sector is generally removed from the day to day activities of construction. Therefore it is likely that Haitian engineers currently lack the practical technical know how about earthquake engineering. This does not give them the confidence to take the leading role they should have in the reconstruction efforts.

It is also likely that engineers will have been mainly accustomed to “managing” jobs rather than doing and delivering jobs. As a result typically engineers will on the whole not have the necessary interaction with the artisans who do most of the construction.

In other words, engineers need time and support to internalise the events of the earthquake and be given theoretical and as much hands on training as possible to start equipping them with the repair, retrofitting and reconstruction challenges that lie ahead.

Motivation and willingness to take responsibility for construction projects is likely to be a major factor which the formally educated engineers will need to learn to shoulder.

Within this process, the art of constantly doing simple tests and actually caring about what happens on construction sites will need to be understood and also implemented.

With the right support this group of construction professionals should become an important part of the reconstruction backbone of Haiti.

8.10.2 Informal Sector

The informal sector consisting of artisans, home owners, self builders and labourers are unlikely to have received any formal training in construction. Typically they will have learned by copying the practices around them, which in the Haitian context is unfortunately a rather low standard.

This sector, from past experience, is highly motivated, familiar with hard work on site and willing to learn. However learning will mainly happen by modifying their current practices during live construction. Formal courses will help accelerate the learning process but historically this group of the construction work force will be unused to formal education and will need to unlearn many bad habits and relearn good earthquake engineering principals and general construction practices.

It is noted that Haitians are proud of their art work as shown in the cover page of this report. Therefore, the connection between workmanship and quality is in actual fact a long established tradition in the art world of Haiti. We now need to adopt the expertise from the art scene and give the same sense of purpose and dedication to the artisans engaged in construction.

8.10.3 NGO and INGO Sector

The NGO and INGO sector typically are humanitarian workers with limited experience of construction. The Aceh tsunami of 2004 has given a flavour of some of the INGO's of the difficulties of construction. Typically INGOs are not geared up for such work and will have limited technical in house civil or structural construction capabilities.

It is important to note that much of the required engineering public health campaigns may need engineering input to help define the education material and check the technical accuracy of such messages, NGOs and INGOs given the correct training could resource significant training programs in earthquake engineering. Part of such training would be to recognise when such organisations will have reached the limits of their technical expertise. In such situations it will be important for organisations to have links to technical people who can help facilitate responses and provide further information.

8.10.4 UN and World Bank Sector

It is unclear what technical skills the UN and World bank sector will be bringing to the reconstruction efforts to help the GoH define a clear reconstruction strategy and methodology. However, as organisations with significant resources it is important that these are put to good use. Possibly in the commissioning of some of the expert services required to undertake wider issues around urban planning and the design of resilient cities.

8.10.5 UN-HABITAT

UN-habitat played a significant part in the reconstruction efforts in Pakistan after the 8th October 2005 earthquake. Whilst not clear it is currently understood that UN-Habitat will be gearing up for a larger role in the reconstruction efforts in Haiti. Early discussions with UN-Habitat, possibly outlining their key recommendations to the GoH could be tentatively summarised into the following bullet points:

- No NGO / INGO construction to be done for private housing.
- NGO / INGO construction may be possible for community assets (Schools, Health Centres, community centres).
- GoH is planning to decongest Port au Prince by relocating people to other parts of Haiti.

- The reconstruction approach should be owner driven construction (with the hope that this will most successfully embed seismic resistant construction skills into the general fabric of the community).
- Land rights need to be addressed.
- Right of people renting needs to be addressed.
- Studies (micro zonation, topographic surveys, hydrological studies) need to be done and could be done by outsiders.
- No pamphlets, or similar to be distributed until GoH has decided on their official approach in order to avoid confusion amongst the population.

Whilst the above is a rough 1st draft, it clearly demonstrates the need to NGOs, INGOs, UN, WB and GoH to collaborate and work in a way that is supportive of the GoH.

Note that this was the position as of the first week of March 2010, so things will likely have moved on since then.

8.10.6 Military

The Haitian situation is complicated by the presence of Haitian forces, UN forces and the US military. Notwithstanding the political tensions this may be creating it should be recognised that various military units are usually well organised, self contained units with access to significant heavy equipment such as diggers, dump trucks, cranes and engineering divisions. The expectation would be to engage the engineering arms of these organisation and assign projects to them such as fixing project power cables, or reinstating the port complex of Port au Prince or similar.

Clearly the GoH should have the final say on the extent these organisation might be able to offer and every opportunity should be sought to make the best us of the engineering and logistics resources of these various military units that are currently in Haiti.

9 Potential Activities to Support re-construction

9.1 General

The next stages of the recovery efforts will be critical to ensure that a disaster of that scale, caused not only by the earthquake but also poor quality construction and design, will not happen again. It is important to remember that 230,000 plus people died because buildings collapsed and that nearly all the humanitarian response to date, whilst absolutely necessary, does very little to address the actual cause of the disaster.

Only by investing in training and development in the construction sector will a repeat of this event on the same scale or worse be averted (it is worth noting that the magnitude 7.0 earthquake whilst destructive was not relatively very powerful).

Oxfam recognises the importance of supporting their humanitarian work with technical earthquake engineering know how as this skill is essential to understanding why so many buildings collapsed to help formulate the best way forward.

Our conclusions, based on our field time, are organised into three parts.

- Part 1 Conclusions on our Oxfam scope.
- Part 2 Important wider reconstruction considerations.
- Part 3 Practical recommendations

9.2 Part 1 – Oxfam Scope

At this point a recall of our scope required us to provide guidance to help achieve the following:

"To facilitate the voluntary return of displaced families to their original neighbourhoods a better understanding of building damage is needed."

"To contribute to the rebuilding of earthquake damaged homes through technical guidance on how to conduct rapid damage assessment of residential buildings."

9.2.1 Summary of key residential building typologies and how they responded to the earthquake

- There is a wide variety of housing typologies in Port au Prince and its surrounding areas.
- The encountered buildings have been classified to a suggested set of Haiti specific building typologies and the seismic response of them has been summarised as shown in Table 6.

Table 6 Summary Building Typologies and their typical Seismic Response

Code	Description	Typical seismic response
C4-HBFS-UHM	Concrete frame with hollow block flat slabs with un-reinforced hollow block masonry infill	Slab construction method is brittle and prone to shear failure. This construction method must be modified to work or else abandoned. Often suffers from weak and soft storeys effects Infill often creates short column effects No seismic detailing of the concrete frames Poor quality workmanship, especially of the concrete members
TCWR	Timber and corrugated galvanised iron walls and roof	Don't appear much affected but are unlikely to pass minimum SPHERE shelter standards.
UHM-TCR	Unreinforced hollow block masonry with timber and CGI roof	Separation of orthogonal wall panels Out of plane failure of walls Failure over openings due to lack of lintel and band beams
C4-HM-TCR	Concrete columns, unreinforced hollow masonry block infill with timber and CGI roof	Poor quality workmanship, especially of the concrete members. Separation of orthogonal wall panels Out of plane failure of walls Failure over openings due to lack of lintel and band beams
SMF	Stone masonry foundations	Wall leafs separate and fall apart. Use of uncut stone makes it easy for stones to fall out of the walls. Walls fail out of plane due to lack of band beams
SMW	Stone masonry walls	
SMH	Stone masonry houses	
CB	Colombage (similar to Himis in Turkey, Dhajji Dewari in Pakistan) – Braced timber framing with masonry infill.	Generally good performance unless timber decay was present in which case the timber frame disintegrated leading to partial or total collapse
K*	Kay ate (Roof generally made of straw, thatch or palm leaves)	We did not see such houses
T*	Taudis (made from waste construction material, roof from palm leaves, corrugated metal sheets or cardboard, walls from whatever is available)	See TCWR
A*	Ajoupas, found in rural areas made of thatch, straw or palm leaves	We did not see such houses

9.2.2 Application of ATC-20 to residential buildings in Port au Prince including guidelines for categorizing building risk based on ATC-20-1.

The main purpose of ATC-20 rapid damage assessment is to determine whether damaged, or potentially damaged, buildings are safe for continued use, or if entry should be restricted or prohibited mainly from a structural safety point of view. The assessments also allow responding authorities to get a feel for the extent and level of the disaster for disaster response planning purposes.

Our conclusions on the assessment being undertaken in Haiti are:

- There is no process in place for the GoH to confirm the mandate and authority of those doing damage assessment.
- Remote damage assessment and the large number of agencies in the field have already quantified in broad terms the extent of the damage.
- There does not appear to be a plan of what to do with the damage assessment data.
- ATC-20 style rapid damage assessment works within the US context where there is a clear follow up resource available but this is clearly not the case in Haiti. A clear follow up strategy needs to be formulated and communicated to all.
- Assessments should concentrate on finding assets that can be repaired and retrofitted to limit further damage to properties by unnecessary demolishing work and help get back into circulation as much of the undamaged building stock as possible.
- Damage assessments appear to be done with no central planning and strategy of priories being in place. If coordinated activities are ongoing it was not visible during our time in the field.
- Assessment in dense incrementally constructed urban places is complicated and likely to be beyond the current skills many Haitian engineers, including Oxfam's recently hired technical staff.
- Undamaged buildings, whilst an indicator close to the epicentre, does not mean that the buildings are adequate to resist future design earthquake loads. Comprehensive assessment and retrofitting should be encouraged across the entire country.
- Many of the people who have left the earthquake affected zone have moved to areas unaffected by the earthquake. This means the weak building stock in the unaffected areas have not been identified. This means that whilst many of the affected have moved away from the disaster zone they are likely to be exposing them selves to higher levels of seismic risk.
- Damage assessment should identify repair and retrofitting concepts that should be communicated to the affected people for as many buildings as possible.

9.2.3 Training of Oxfam staff to undertake ATC type assessments

- Oxfam's current Haitian engineering resources only have the skills to assess simple buildings and obvious assessments (i.e. the building assessment result is either a clear green or red rating)
- Should Oxfam, continue to do damage assessment it is recommended, that this is done in areas with simple housing typologies, typically being of 1 storey and varying from 2 to 3 to 4 to 5 rooms (made from masonry or masonry and reinforced concrete).
- Intensive class room training in earthquake engineering principals is required before doing any further damage assessments
- Oxfam's staff require significant amounts of class room and field training in repairing, retrofitting techniques.
- Training in temporary shoring, strapping and similar methods is required to prevent damaged properties from being further damaged.
- Such training should be developed based on Haitian building typologies and achievable repairing and retrofitting concepts for Haiti.
- Oxfam should enhance their team with experienced artisans to complement their engineers and develop the necessary dialogue between engineers and artisans.

9.3 Part 2 - Important Wider Reconstruction Considerations

The following important wider reconstruction considerations must be considered and resolved by all before implementing any activity to do with repairing, retrofitting or new construction in Haiti.

- There is a pressing need for the formation of a Haitian Earthquake Reconstruction and Rehabilitation Authority (HERRA).
- Urban master planning and resilient design principals must be developed, especially with respect to flood and fire risk.
- Multi hazard assessment studies are required to inform all future developments.
- There is a need for a comprehensive approach to building codes, education and enforcement of standards within Haiti.
- Owner driven reconstruction may work well in rural settings where building plots and owner ship are clearly defined.
- In much of the dense urban environment of the affected area owner driven reconstruction is unlikely to work because many people are not the owners of the damaged properties.
- Consideration should be given to community based reconstruction around housing blocks or units.
- Land right issues must be resolved.
- Tenant rights needs to be established to protect their right for continued tenancy, especially as many of these people will be needed to undertake repair, retrofitting and reconstruction work. Without this legal protection tenants will see little reason to build assets for others.
- The middle classes, typically tenants have been hugely affected by the earthquake but are unlikely to qualify for aid under many standard beneficiary selection criteria as adopted by humanitarian agencies.

- Many developed world construction techniques are unsuitable for Haiti either due to their high cost or required technical complexity
- Stone masonry, if properly done, appears to be about the only locally available construction material available in large quantities.
- Rubble rights need to be established
- Consideration should be given to starting to work from the outside inwards
- Availability of relief should be targeted around communities and neighbourhoods away from the camps.
- Training of artisans and head of families will be essential to build back better.
- Foreign Agency spending mandates and time constraints pose a real risk of leading to actions that are not supported or authorised by the GoH. The importance to work through the GoH cannot be over emphasised. External parties should consider the unnecessary pressure and destabilising effect to distribute funds quickly may have on the medium to long term rehabilitation and reconstruction achievements.

9.4 Part 3 – Practical Recommendations

9.4.1 Training actions

Should Oxfam decide to undertake any of the suggested ideas below it is assumed that appropriate coordination and agreement with the GoH will be undertaken to ensure that Oxfam's activities receive the full support of all, including any earthquake engineering curriculum that Oxfam wishes to adopt.

1. Provide training of engineers
2. Provide training to artisans
3. Provide training is seismic retrofitting techniques
4. Provide training in the repair of buildings
5. Once trained Oxfam's team could look to be a trainer for other organisations to help further build capacity
6. Fund the development of a stone masonry tutorial specifically for Haiti
7. Provide earthquake engineering awareness training for the general community.
8. Fund the translation of already existing training material into French and Creole
9. Fund public demonstration shake table tests
10. Fund testing equipment and the training of technicians to use such tools
11. Fund basic tool kits for artisans
12. Provide funding to help provide nominal monetary support for artisans and similar who complete training in earthquake engineering.
13. Run vulnerability tours for home owners and similar
14. Fund some of the big picture back ground studies that are required to help inform the required wider master planning processes for Haiti.
15. Help identify buildings that can be repaired.
16. Fund the printing and distribution of appropriate earthquake engineering related guidance documents.

9.4.2 Construction Actions

Based on the assumption that Oxfam is aware of wider reconstruction issues the following actions may want to be considered by Oxfam in their ongoing relief efforts.

1. Help implement repairs to houses.
2. Provide construction materials to beneficiaries.
3. Help implement retrofitting programs.
4. Construct new homes (various procurement options to be considered)
5. Construct community facilities such as schools or health centre

10 People and Organisations we met

Who	Title	Organisation
Martin Bjerregaard	Director of Rubble Recycling	Disaster Waste Recovery
Pierre Bonneau	Director	Establissement Public de Gestion d'Entretien et d'Exploitation
Jean-Christophe Adrian	Urban Specialist	Cities Alliance (UN-HABITAT)
Yves Cole	Local Haitian Building Contractor	
Tony Gibbs	Consultant	Consulting Engineers Partnership Ltd
Deidre Grant	Communications and Development Consultant	Haven
Elizabeth Hausler	Founder and CEO	Build Change
Mike Meaney	Associate Director Operations & disaster Response	Habitat for Humanity
Scott Miles	Assistant Professor & Director The Resilience Institute Department of Environmental studies Huxley college of the Environment	Western Washington University (Earthquake Engineering Research Institute EERI)
Robert B Olshansky,	Professor, Department of Urban and Regional Planning	University of Illinois (Earthquake Engineering Research Institute EERI)
Grenville Phillips II	Director	Consulting Engineers Partnership Ltd (Habitat for Humanity)
Kevin Rowell		The Natural Builders
David A Strand	Operations Manager	Build Change
Dr Dana Van Alphen	Regional Adviser Disaster Management Programme	Pan American Health Organiastion/ world Health Organisation (PAHO/WHO)
Erik Vittrup	Senior Human Settlements officer United Nations Human Settlements Programme	UN-HABITAT
Dr J. M. Yolène V. Surena	Coordonnateur	Ministere de L'Interieure - Direction du Protection Civile – Unité de Coordination du Project de Gestion des Risques et des Desastres

REFERENCES

[1] (http://earthquake.usgs.gov/earthquakes/recenteqsww/Quakes/us2010rja6.php)

[2] http://www.jsg.utexas.edu/news/rels/011310.html

[3] The Mw 7.0 Haiti Earthquake of January 12, 2010: USGS/EERI Advanced Reconnaissance Team Report v.1.0, February 18, 2010-03-15

[4] Preliminary Reconnaissance Report – 12 January 2010 Haiti Earthquake by Eduardo Fierro and Cynthia Perry of BFP Engineers, Inc.

[5] Haiti Earthquake 2010, remote damage assessment

[6] Oxfam GB, Haiti Post-Earthquake Damage Assessment, Study findings, Arup, February 2010.

[7] Structural Engineer's Pocket Book by Fiona Cobb

[8] Comparison of Building "Codes" and practices which are in use in the Caribbean (principally Bahamas, CUBiC, Dominican Republic, French Antilles, OECS) focussing on design and construction of healthcare facilities"

http://www.unesco-ipred.org/gtfbc/No.1_Codes-Practices(Report)A4.pdf

[9] Association of Caribbean States (ACS) http://www.acsaec.org/Disasters/Projects/ACS_ND_001/building_codes_eng.htm.

Appendix A

ATC-20 Inspection Forms and Summary Table

ARUP

Ref Number: 212323/KHG
Date: 16/03/2010

Haiti Earthquake 12 January 2010

Summary list if structures assessed by Arup for Oxfam - Revision 1

No.	Date of assessment	Location	Building type	Item number for location (community assessment only)	Grid Reference			Assessor	ATC Rating	ATC form?	Owner/ Occupier	Address Details (if available)	Other info
					Latitude	Longitude							
1		Petionville	Office		N 18° 32.150'	W072° 16.617'		AT	Red		Oxfam	Marcadieu Street	Old Oxfam Office
2		Petionville	Office		N 18° 32.150'	W072° 16.617'		AT	Yellow		Oxfam	Marcadieu Street	New Oxfam Office, risk from collapse of adjacent building
3		Paco	Guesthouse					AT	Yellow		Used by Oxfam		Damaged stairways
4		Delmas	Guesthouse		N 18° 32.158'	W072° 18.628'		AT	Green		Used by Oxfam		For the main Building
5		Delmas	Guesthouse		N 18° 32.158'	W072° 18.628'		AT	Yellow		Oxfam		Damage to walls around pool
6		Delmas	Guesthouse		N 18° 32.158'	W072° 18.628'		AT	Red		Potentially to be used by Oxfam		Link Bridge is damaged
7		Mexico Embassy	Office					AT	Green		Potentially to be used by Oxfam		
8			Guest House					AT	Yellow		Potentially to be used by Oxfam		
9		Petionville	Office		N 18° 31.017'	W072° 16.676'		AT	Green		Potentially to be used by Oxfam		Repair to perimeter wall required
10			Guest House		N 18° 30.958'	W072° 16.187'		AT	Yellow		Potentially to be used by Oxfam		Significant damage to masonry walls
11			Guest House					AT	Green		Potentially to be used by Oxfam		White House
12			Guest House					AT	Green		Potentially to be used by Oxfam		
13			Guest House		N 18° 32.564'	W072° 16.854'		AT	Green		Potentially to be used by Oxfam		Garden House
14		Delmas	Guest House		N 18° 32.140'	W072° 16.962'		AT	Green		Potentially to be used by Oxfam	Delmas 83 #1	
15		Delmas	Guest House		N 18° 32.135'	W072° 16.947'		AT	Green		Potentially to be used by Oxfam	Delmas 83 #2	
16		Mont Noir	Guest House		N 18° 32.101'	W072° 17.064'		AT	Green		Potentially to be used by Oxfam	Mont Noir	
17		Oxfam Intermon	Guest House		N 18° 30.049'	W072° 16.950'		AT	Green		Used by Oxfam/Intermon		House # 1
18		Oxfam Intermon	Guest House		N 18° 29.986'	W072° 17.063'		AT	Green		Used by Oxfam/Intermon		House # 2
19		Oxfam Intermon	Office					AT	Green		Used by Oxfam/Intermon		Office
20		Oxfam Intermon	garage					AT	Yellow		Used by Oxfam/Intermon		Needs repairing
21		Sandra	Staff House		N 18° 32.574'	W072° 16.848'		AT	Yellow		Used by Oxfam/Intermon		Needs repairing
22	26/02/2010	Carrefour	School/ Orphanage		N 18°32'14.73"	W 72°24'24.04"		L/C/KG/KH	YELLOW	Yes*	Centre D'Accuile		Main Building 1
23	26/02/2010	Carrefour	School/ Orphanage		N 18°32'14.65"	W 72°24'23.03"		L/C/KG/KH	YELLOW	Yes*	Centre D'Accuile		Main Building 2
24	26/02/2010	Carrefour	School/ Orphanage		N 18°32'14.54"	W 72°24'22.01"		L/C/KG/KH	YELLOW	Yes*	Centre D'Accuile		Main Building 3
25	26/02/2010	Carrefour	School/ Orphanage		N 18°32'14.39"	W 72°24'21.01"		L/C/KG/KH	YELLOW	Yes*	Centre D'Accuile		Main Building 4
26	26/02/2010	Carrefour	School/ Orphanage		N 18°32'15.31"	W 72°24'22.44"		L/C/KG/KH	YELLOW	Yes*	Centre D'Accuile		Link building
27	26/02/2010	Carrefour	Storage Facility		N 18°32'13.33"	W 72°24'22.78"		L/C/KG/KH	GREEN	Yes*	Centre D'Accuile/ Oxfam		Single storey storage
28	26/02/2010	Carrefour	Storage Facility/ Kitchens?		N 18°32'12.86"	W 72°24'22.43"		L/C/KG/KH	GREEN	Yes*	Centre D'Accuile		Single storey storage
29	26/02/2010	Carrefour	School		N18° 32.489'	W72° 24.412'		L/C/KG/KH	YELLOW	Yes	Lycee de Carrefour		
30	26/02/2010	Carrefour	Residence	1	N 18°32'36.54"	W 72°24'31.50"		L/C/KG/KH	RED	Yes	[N/A]	Lamantin 54, Rue Bloncourt #132	Two Storey House
31	26/02/2010	Carrefour	Residence	2	N18° 32.620'	W72° 24.521'		L/C/KG/KH	YELLOW	Yes	Sultana Belange	Lamantin 54, Rue Bloncourt #771 - 1	One Storey house - at risk because of risk of collapse from adjacent building
32	26/02/2010	Carrefour	Residence	3	N 18°32'37.34"	W 72°24'31.54"		L/C/KG/KH	RED	Yes	Sultana Belange	Lamantin 54, Rue Bloncourt #771 - 2	Two Storey House
33	26/02/2010	Carrefour	Residence	4	N18° 32.630'	W72° 24.531'		C/KH	YELLOW	Yes	Mme Anelia Paul	Lamantin 54, Rue Bloncourt #772	One Storey house
34	26/02/2010	Carrefour	Residence	5	N18° 32.621'	W72° 24.540'		L/KG	GREEN	Yes	Kethly G Bloncort	Lamantin 54, Rue Bloncourt #133	One Storey house
35	27/02/2010	Carrefour Feuille	School/ Office		N18° 31.401'	W72° 21.081'		L/C/KG/KH	GREEN	Yes	COZPAN	Fort Mecredi, Carrefour Feuille #116	
36	27/02/2010		Office		N18° 32.799'	W72° 20.359'		L/C/KG/KH	GREEN	Yes	COZPAN	Rue Paxee #109	
37	27/02/2010		Office/ Residence		N18° 32.151'	W72° 20.076'		L/C/KG/KH	RED	Yes	Friendship	Ruelle Marcelin #27	
38	27/02/2010	Carrefour Feuille	Office/ Residence		N18° 31.718'	W72° 20.493'		L/C/KG/KH	RED	Yes	REJEFE	Carrefour Feuille Rue Bacassime #61	
39	27/02/2010		Office		N18° 31.550'	W72° 20.204'		L/C/KG/KH	RED	Yes	OCHAN	Rue Constant Nicolas #42	
40	27/02/2010	Morne Sion Hill Community	Residence	1	N18° 31.331'	W72° 21.373'	*	L/KH	YELLOW		M. Lanes		Leger Notes 1
41	27/02/2010	Morne Sion Hill Community	Residence	2	N18° 31.331'	W72° 21.373'	*	L/KH	YELLOW		Mme. Philisitin		Leger Notes 2
42	27/02/2010	Morne Sion Hill Community	Residence	3	N18° 31.331'	W72° 21.373'	*	L/KH	GREEN		M. Louisme Oly		Leger Notes 3
43	27/02/2010	Morne Sion Hill Community	Residence	4	N18° 31.331'	W72° 21.373'	*	KH	YELLOW				
44	27/02/2010	Morne Sion Hill Community	Residence	5	N18° 31.331'	W72° 21.373'	*	L/KH	YELLOW		Olene Proforiefaire		Leger Notes 4
45	27/02/2010	Morne Sion Hill Community	Residence	6	N18° 31.331'	W72° 21.373'	*	L/KH	YELLOW		Gerneus Senold		Leger Notes 5
46	27/02/2010	Morne Sion Hill Community	Residence	7	N18° 31.331'	W72° 21.373'	*	KH	YELLOW				
47	27/02/2010	Morne Sion Hill Community	Residence	8	N18° 31.331'	W72° 21.373'	*	KH	YELLOW				
48	27/02/2010	Morne Sion Hill Community	Residence	9	N18° 31.331'	W72° 21.373'	*	KH	YELLOW		Gerneus Remold		Leger Notes 6
49	27/02/2010	Morne Sion Hill Community	Residence	10	N18° 31.331'	W72° 21.373'	*	L/KH	YELLOW		M. Oneu		Leger Notes 7
50	27/02/2010	Morne Sion Hill Community	Residence	11	N18° 31.331'	W72° 21.373'	*	L/KH	GREEN		Mme. Zou		Leger Notes 8
51	27/02/2010	Morne Sion Hill Community	Residence	12	N18° 31.331'	W72° 21.373'	*	KH	GREEN				
52	27/02/2010	Morne Sion Hill Community	Residence	13	N18° 31.331'	W72° 21.373'	*	L/KH	GREEN		Mme. Andreese		Leger Notes 11
53	27/02/2010	Morne Sion Hill Community	Residence	14	N18° 31.331'	W72° 21.373'	*	KH	GREEN				
54	27/02/2010	Morne Sion Hill Community	Residence	15	N18° 31.331'	W72° 21.373'	*	L/KH	GREEN		Mme. Logete Laurent		Leger Notes 13
55	27/02/2010	Morne Sion Hill Community	Residence	16	N18° 31.331'	W72° 21.373'	*	L/KH	GREEN		Mme. Marie Marthe Edmond		Leger Notes 14
56	27/02/2010	Morne Sion Hill Community	Residence	17	N18° 31.331'	W72° 21.373'	*	KH	GREEN				
57	27/02/2010	Morne Sion Hill Community	Residence	18	N18° 31.331'	W72° 21.373'	*	KH	YELLOW				
58	27/02/2010	Morne Sion Hill Community	Residence	19	N18° 31.331'	W72° 21.373'	*	KH	RED				
59	27/02/2010	Morne Sion Hill Community	Residence	20	N18° 31.331'	W72° 21.373'	*	KH	RED				
60	27/02/2010	Morne Sion Hill Community	Residence	21	N18° 31.331'	W72° 21.373'	*	KH	YELLOW				
61	27/02/2010	Morne Sion Hill Community	Residence	22	N18° 31.331'	W72° 21.373'	*	L/KH	YELLOW		M. Leickher		Leger Notes 15
62	27/02/2010	Morne Sion Hill Community	Residence	23	N18° 31.331'	W72° 21.373'	*	L/KH	GREEN		M. Annoux		Leger Notes 16
63	27/02/2010	Morne Sion Hill Community	Residence	24	N18° 31.331'	W72° 21.373'	*	L/KH	RED		M. Jean Claude Mejustin		Leger Notes 17
64	27/02/2010	Morne Sion Hill Community	Residence	25	N18° 31.331'	W72° 21.373'	*	KH	GREEN				
65	27/02/2010	Morne Sion Hill Community	Residence	26	N18° 31.331'	W72° 21.373'	*	KH	YELLOW				
66	27/02/2010	Morne Sion Hill Community	Residence	27	N18° 31.331'	W72° 21.373'	*	KH	YELLOW				
67	27/02/2010	Morne Sion Hill Community	Church	28	N18° 31.331'	W72° 21.373'	*	L/KH	YELLOW		Eglise Evangelistique de Sion		Leger Notes 18
68	27/02/2010	Morne Sion Hill Community	Residence	29	N18° 31.331'	W72° 21.373'	*	L/KH	RED		M Belle Couleur		Leger Notes 19

ARUP
Ref Number: 212323/KHG
Date: 16/03/2010

Haiti Earthquake 12 January 2010

Summary list if structures assessed by Arup for Oxfam - Revision 1

No.	Date of assessment	Location	Building type	Item number for location (community assessment only)	Grid Reference			Assessor	ATC Rating	ATC form?	Owner/ Occupier	Address Details (if available)	Other info
					Latitude	Longitude							
69	27/02/2010	Morne Sion Hill Community	Residence	30	N18° 31.331'	W72° 21.373'	*	C/KG	GREEN				
70	27/02/2010	Morne Sion Hill Community	Residence	31	N18° 31.331'	W72° 21.373'	*	C/KG	YELLOW				
71	27/02/2010	Morne Sion Hill Community	Residence	32	N18° 31.331'	W72° 21.373'	*	C/KG	YELLOW				
72	27/02/2010	Morne Sion Hill Community	Residence	33	N18° 31.331'	W72° 21.373'	*	C/KG	YELLOW				
73	27/02/2010	Morne Sion Hill Community	School/Church	34	N18° 31.331'	W72° 21.373'	*	C/KG	YELLOW		Community Building		
74	27/02/2010	Morne Sion Hill Community	Residence	35	N18° 31.331'	W72° 21.373'	*	C/KG	RED				
75	27/02/2010	Morne Sion Hill Community	Residence	36	N18° 31.331'	W72° 21.373'	*	C/KG	RED				
76	27/02/2010	Morne Sion Hill Community	Residence	37	N18° 31.331'	W72° 21.373'	*	C/KG	YELLOW				
77	27/02/2010	Morne Sion Hill Community	Residence	38	N18° 31.331'	W72° 21.373'	*	C/KG	YELLOW				
78	27/02/2010	Morne Sion Hill Community	Residence	39	N18° 31.331'	W72° 21.373'	*	C/KG	RED				
79	27/02/2010	Morne Sion Hill Community	Residence	40	N18° 31.331'	W72° 21.373'	*	C/KG	YELLOW				
80	27/02/2010	Morne Sion Hill Community	Residence	41	N18° 31.331'	W72° 21.373'	*	C/KG	YELLOW				
81	27/02/2010	Morne Sion Hill Community	Residence	42	N18° 31.331'	W72° 21.373'	*	C/KG	GREEN				
82	28/02/2010		Warehouse		N18° 34.081'	W72° 19.824'		KG/KH	RED		Mr Padburg/ Oxfam	Warehouse B4	
83	28/02/2010		Warehouse		N18° 33.968'	W72° 19.773'		KG/KH	RED		Mr Padburg/ Oxfam	Warehouse H2	
84	01/03/2010	Beauboeuf	Residence	1	N18° 31.210'	W72° 19.737'		L/KG	GREEN	Yes	Josma Dieumete	Impasse Beauboeuf	3 storey apartment
85	01/03/2010	Beauboeuf	Residence	2	N 18°31'10.23"	W 72°20'39.55"		L/KG	RED	Yes	Yolane Louis Jeunne	Impasse Eddy prolonge	Rating based on condition of location not of structure (yellow otherwise)
86	01/03/2010	Beauboeuf	Residence	3	N 18°31'10.35"	W 72°20'39.72"		L/KG	RED	Yes	Destine Charls		Rating based on condition of location not of structure (green otherwise)
87	01/03/2010	Beauboeuf	Residence	4	N 18°31'10.22"	W 72°20'39.31"		KG	RED				Rating based on condition of location not of structure (green otherwise)
88	01/03/2010	Beauboeuf	Residence	5	N18° 31.194'	W72° 20.842'		C/KH	GREEN	Yes	Iaibhen Shella	Rue Mgt Guilloux Imp, Leonard #10	
89	01/03/2010	Beauboeuf	Residence	6	N18° 31.145'	W72° 20.847'		C/KH	YELLOW	Yes	Natacha Murat	Imp. Leonard Leonard #6	
90	01/03/2010	Beauboeuf	Residence	7	N18° 31.203'	W72° 20.845'		C/KH	GREEN	Yes	Sanelle Borgela	Imp. Leonard Leonard	
91	01/03/2010	Pacot	Residence	1	N18° 31.179'	W72° 20.656'		C/L/KH/KG	RED	Yes	**Oscar Pierre**	Rue Pacot Prolongeen, Haut Vieux Kay	
92	02/03/2010	Delamas (Golf Course)	Residence	1	N18° 32.271'	W72° 17.854'		C/KH	YELLOW	Yes	Marie Sylvain	Delmas 48 Rue Laurier #48	
93	02/03/2010	Delamas (Golf Course)	Residence	2	N18° 32.401'	W72° 17.632'		C/KH	GREEN	Yes	Wilford Louis	Delmas 69, Ruelle Cypress #20A	
94	02/03/2010	Delamas (Golf Course)	Residence	3	N18° 32.423'	W72° 18.257'		C/KH	GREEN	Yes	Ebel Deluxe	Delmas 40B Rue Petion, Inp Ferme #28	
95	02/03/2010	Delamas (Golf Course)	Residence	4	N18° 32.294'	W72° 17.950'		L/KG	GREEN	Yes	Vivia Andre	Delmas 42 Prolonge, Cite Frederic	
96	02/03/2010	Delamas (Golf Course)	Residence	5	N18° 32.297'	W72° 17.949'		L/KG	GREEN	Yes	Jean Jolicoeur Voltaire	Delmas 42	
97	02/03/2010	Delamas (Golf Course)	Residence	6	N18° 32.286'	W72° 17.931'		L/KG	RED	Yes	Mme Mendes Yrica	Delams 42	Earthquake and Fire Damage
98	02/03/2010	Delamas (Golf Course)	Residence	7	N18° 32.365'	W72° 17.916'		L/KG	RED	Yes	Barosy Jean Sony	Delmas 42	
99	02/03/2010	Delamas (Golf Course)	Residence	8	N18° 32.292'	W72° 17.916'		L/KG	RED	Yes	Rober Paul Polynice	Delmas 42	
100	03/03/2010		Warehouse		N18° 34' 3.92"	W72° 18' 14.47"	*	KH	RED		Patrick Angus Cowley Warehousing		Part 1
101	03/03/2010		Warehouse		N18° 34' 3.92"	W72° 18' 14.47"	*	KH	RED		Patrick Angus Cowley Warehousing		Part 2
102	03/03/2010		Warehouse		N18° 34' 3.92"	W72° 18' 14.47"	*	KH	YELLOW		Patrick Angus Cowley Warehousing		Part 3
103	03/03/2010		Warehouse		N18° 34' 3.92"	W72° 18' 14.47"	*	KH	YELLOW		Patrick Angus Cowley Warehousing		Part 4
104	03/03/2010		Warehouse		N18° 34' 3.92"	W72° 18' 14.47"	*	KH	GREEN		Patrick Angus Cowley Warehousing		Part 5
105	04/03/2010		Nursery/ Office		N18° 31' 40.26"	W72° 20' 40.39"		KH	GREEN		Aprosifa		

Key:

AT	Andy Thompson (Arup)
KH	Kubilay Hicyilmaz (Arup)
KG	Kathy Gibbs (Arup)
C	Nacier Claude Herby (Oxfam)
L	Frantz Leger (Oxfam)
	GPS reading from AT
	GPS reading from KG
	GPS reading from C/L
	Grid ref from Google Earth
	Grid ref provided by other
*	General Grid reference given for community and not for individual property
	Position cross checked with KG GPS reading

#2

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id.Inspecteur : Tom, OXFAM Shelter Date et Heure d'inspection 26 [illegible] 10:00 ☑AM ☐ PM

Affiliation : OXFAM Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment | **Type de construction**

Nom du bâtiment : Centre d'Accueil
Adresse : Carrefour
Contact/Téléphone :
Coordonnées GPS: N 18° 32.221 W72°24.[illegible]

☐ Armature en bois
☐ Armature en acier
☐ Armature béton avec remplissage des parois
☑ Armature en béton
☐ Murs béton contreventés
☐ Murs non renforcés
☐ Murs renforcés
☑ Autre Briques

Nombre d'étages :
Nombre de sous-sol :

Spécification du bâtiment | **Type d'occupation**

Superficie approximative (mètre carré)
Nombre de résidences 7
Nombre de locaux non habitables

☐ Résidentiel- section unique
☐ Résidentiel- section multiple
☐ Assemblée publique
☐ Commerce
☐ Bureaux
☐ Industriel
☐ Services d'urgence
☐ Gouvernement
☐ Historique
☑ Ecole
☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés			
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés	—	✓	
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé
☐ aucun
☑ 0-1%
☐ 1-10%
☐ 10-30%
☐ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☑ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☐ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone:
☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐Autre
☐ Autres recommandations ou restrictions tel qu'inscrit sur la pencarte :
Observations:

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ______ Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_, E_, H_(L)_, T_, U_autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 29

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id.Inspecteur : Plan ouFem Shelb Date et Heure d'inspection 4:00 □ AM ☑PM

Affiliation : OxFam Zone inspectée: □ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment	**Type de construction**	
Nom du bâtiment : Lycée de Carrefour	□ Armature en bois	□ Murs béton contreventés
Adresse : Carrefour	□ Armature en acier	☑ Murs non renforcés
	□ Armature béton avec remplissage des parois	□ Murs renforcés
Contact/Téléphone :	☑ Armature en béton	□ Autre
Coordonnées GPS: N 18° 32' 4.87" W 072° 24.412	Nombre d'étages : 2	Nombre de sous-sol :

Spécification du bâtiment	**Type d'occupation**		
Superficie approximative (mètre carré)	□ Résidentiel- section unique	□ Commerce	□ Gouvernement
Nombre de résidences	□ Résidentiel- section multiple	□ Bureaux	□ Historique
	□ Assemblée publique	□ Industriel	☑ Ecole
Nombre de locaux non habitables		□ Services d'urgence	□ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave	Dommage estimé
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché				□ aucun
Murs intérieurs et extérieurs fissurés et effondrés		✓		□ 0-1%
Colonnes, pilastres et corbeaux fissurés et émiettés		✓		□ 1-10%
Plaques, poutres , solives fissurées et écaillées				☑ 10-30%
Parapets, gables, terrasses et escaliers endommagés				□ 30-60%
Fissures ou mouvement du sol				□ 60-100%
Autre (spécifier)				□ 100%

Difficulté de la démolition :	**Aucun/mineure**	**Simple**	**Moyenne**	**Complexe**

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

□ **Inspecté (fiche verte)** ☑ **accès limité (fiche jaune)** □ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Des réparations sont nécessaires

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

□ Barricades nécessaires dans la zone: ______

□ Expertise détaillée recommandé : □ Structurelle □ Géotechnique □Autre ______

□ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte : ______

Observations: ______

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ______ Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet____

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes.

Forme du plan : , O_, E_, H_, L_, T_, (U)_ autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 30 - (Carrefour Residence 1) #1

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : Claude H Date et Heure d'inspection 2:45 ☐ AM ☑ PM

Affiliation : OXFAM Zone inspectée: ☑ Extérieur uniquement ☐ Extérieur et intérieur

Description du bâtiment **Type de construction**

Nom du bâtiment :

Adresse : Lamentin St-Rue Blanchard #132

Contact/Téléphone :

Coordonnées GPS: N 18°32.696 W 072°24.533

☐ Armature en bois ☐ Murs béton contreventés

☐ Armature en acier ☑ Murs non renforcés

☐ Armature béton avec remplissage des parois ☐ Murs renforcés

☑ Armature en béton ☐ Autre

Nombre d'étages : X 2 Nombre de sous-sol : 0

Spécification du bâtiment **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences 1

Nombre de locaux non habitables 1 étage Construite en 1957

☐ Résidentiel- section unique ☐ Commerce ☐ Gouvernement

☑ Résidentiel- section multiple ☐ Bureaux ☐ Historique

☐ Assemblée publique ☐ Industriel ☐ Ecole

☐ Services d'urgence ☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés			✓
Colonnes, pilastres et corbeaux fissurés et émiettés			✓
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☐ 1-10%
☐ 10-30%
☑ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe
Observations :	✓			

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☑ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone: ____

☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre ____

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pencarte : ____

Observations: ____

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: 1957 Date de travaux importants de rénovation: ____

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___ Rivière__ Vallée___ Plaine___ Colline___ Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Pirat, piles profondes.

Forme du plan : , O_ E_ H_ L_ T_ U_autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés_✓_Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 31 - (Carrefour Residence 2)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : Claude H. — Date et Heure d'inspection 3:03 — ☐ AM ☑ PM

Affiliation : exFATS [illegible] — Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment — **Type de construction**

Nom du bâtiment : [illegible]

Adresse : [illegible] 54, Rue [illegible] #771

Contact/Téléphone :

Coordonnées GPS: N 18° 32.620 W 072° 24.531

☐ Armature en bois
☐ Armature en acier
☑ Armature béton avec remplissage des parois
☐ Armature en béton
☐ Murs béton contreventés
☑ Murs non renforcés
☐ Murs renforcés
☑ Autre Tôles

Nombre d'étages : X 1 — Nombre de sous-sol : 0

Spécification du bâtiment — **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences 1

Nombre de locaux non habitables

☑ Résidentiel- section unique
☐ Résidentiel- section multiple
☐ Assemblée publique
☐ Commerce
☐ Bureaux
☐ Industriel
☐ Services d'urgence
☐ Gouvernement
☐ Historique
☐ Ecole
☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés		✓	
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☑ 1-10%
☐ 10-30%
☐ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ Inspecté (fiche verte) ☑ accès limité (fiche jaune) ☐ accès non autorisé (fiche rouge)

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone: ___

☐ Expertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre ___

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte : ___

Observations: ___

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ___ Date de travaux importants de rénovation: ___

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes.

Forme du plan : , O_ E_ H_ L_ T_ U_autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés_Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 32 - (Carrefour Residence 3)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : Claude H.
Affiliation : OXFAM

Date et Heure d'inspection 3:06 ☐ AM ☑ PM
Zone inspectée: ☑ Extérieur uniquement ☐ Extérieur et intérieur

Description du bâtiment

Nom du bâtiment : Sultana Belange
Adresse : Lamatin 54 Rue Blancourt #771
Contact/Téléphone : 3476-9916
Coordonnées GPS: N18°32.620 W072°24.520

Type de construction

☐ Armature en bois
☐ Armature en acier
☑ Armature béton avec remplissage des parois
☐ Armature en béton
☐ Murs béton contreventés
☑ Murs non renforcés
☐ Murs renforcés
☐ Autre

Nombre d'étages : 2
Nombre de sous-sol : 0

Spécification du bâtiment

Superficie approximative (mètre carré)
Nombre de résidences 1
Nombre de locaux non habitables

Type d'occupation

☑ Résidentiel- section unique
☐ Résidentiel- section multiple
☐ Assemblée publique
☐ Commerce
☐ Bureaux
☐ Industriel
☐ Services d'urgence
☐ Gouvernement
☐ Historique
☐ Ecole
☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			✓
Murs intérieurs et extérieurs fissurés et effondrés			✓
Colonnes, pilastres et corbeaux fissurés et émiettés			✓
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☐ 1-10%
☐ 10-30%
☐ 30-60%
☑ 60-100%
☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☑ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone:
☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre
☐ Autres recommandations ou restrictions tel qu'inscrit sur la pencarte :
Observations:

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ______ Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_, E_, H_, L_, T_, U_autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés ✓Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 33 - (Carrefour Residence 4)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : Team Oxfam Shelter Date et Heure d'inspection 3/15/[illegible] ☐ AM ☑ PM

Affiliation : Oxfam Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment — **Type de construction**

Nom du bâtiment : [illegible] Amelia Paul

Adresse : 772, Rue Blanchet

Contact/Téléphone : 3487 8564

Coordonnées GPS: N 18°32.[illegible] W 72°27.530

- ☐ Armature en bois
- ☐ Armature en acier
- ☐ Armature béton avec remplissage des parois
- ☑ Armature en béton
- ☐ Murs béton contreventés
- ☑ Murs non renforcés
- ☐ Murs renforcés
- ☐ Autre

Nombre d'étages : 1

Nombre de sous-sol :

Spécification du bâtiment — **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences 1

Nombre de locaux non habitables

- ☑ Résidentiel- section unique
- ☐ Résidentiel- section multiple
- ☐ Assemblée publique
- ☐ Commerce
- ☐ Bureaux
- ☐ Industriel
- ☐ Services d'urgence
- ☐ Gouvernement
- ☐ Historique
- ☐ Ecole
- ☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

- ☐ aucun
- ☐ 0-1%
- ☑ 1-10%
- ☐ 10-30%
- ☐ 30-60%
- ☐ 60-100%
- ☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations : Des réparations sont nécessaires et urgentes

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☑ **accès limité (fiche jaune)** ☐ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

- ☐ Barricades nécessaires dans la zone: ___
- ☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre ___
- ☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte : ___

Observations: ___

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: 1996 Date de travaux importants de rénovation: ___

Sols de l'emplacement : Sable de plage __ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___ Rivière__ Vallée___ Plaine___ Colline___ Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_ E_ H_ L_ T_ U_ autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés_Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 34 - (Carrefour Residence 5)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : 003-551-151-4 Date et Heure d'inspection 3:24 ☐ AM ☑ PM

Affiliation : OXFAM Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment **Type de construction**

Nom du bâtiment : Kettaly G. Blancourt

Adresse : LAMATIN 54, Rue Blancourt #133

Contact/Téléphone : 3414-8170

Coordonnées GPS: N 18°32.621 W0 72°24.540

☐ Armature en bois ☐ Murs béton contreventés

☐ Armature en acier ☐ Murs non renforcés

☑ Armature béton avec remplissage des parois ☐ Murs renforcés

☐ Armature en béton ☐ Autre

Nombre d'étages : ~~X~~ 1 Nombre de sous-sol : 0

Spécification du bâtiment **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences 1

Nombre de locaux non habitables

☑ Résidentiel- section unique ☐ Commerce ☐ Gouvernement

☐ Résidentiel- section multiple ☐ Bureaux ☐ Historique

☐ Assemblée publique ☐ Industriel ☐ Ecole

☐ Services d'urgence ☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés		✓	
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☑ 1-10%
☐ 10-30%
☐ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition : Aucun/mineure Simple Moyenne Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☑ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☐ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone:

☐ Expertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte :

Observations: Réfection du toit nécessaire

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: 1957 Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet____

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_, E_, H_, L_, T_, U_autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 35

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : ____________ Date et Heure d'inspection [illegible] ☑ AM ☐ PM

Affiliation : [illegible] Zone inspectée : ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment **Type de construction**

Nom du bâtiment : [illegible]

Adresse : [illegible]

Contact/Téléphone : [illegible]

Coordonnées GPS : [illegible]

☐ Armature en bois
☐ Armature en acier
☐ Armature béton avec remplissage des parois
☑ Armature en béton
☐ Murs béton contreventés
☐ Murs non renforcés
☐ Murs renforcés
☐ Autre

Nombre d'étages : 1 Nombre de sous-sol : [illegible]

Spécification du bâtiment **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences : 1

Nombre de locaux non habitables

☐ Résidentiel- section unique
☐ Résidentiel- section multiple
☐ Rassemblée publique
☐ Commerce
☐ Bureaux
☐ Industriel
☐ Services d'urgence
☐ Gouvernement
☐ Historique
☑ École
☐ Autre [illegible]

Évaluation

Étudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

État observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres, solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☑ 1-10%
☐ 10-30%
☐ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☑ **inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☐ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées :

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone : ____________

☐ Inspection détaillée recommandée : ☐ Structurelle ☐ Géotechnique ☐ Autre ____________

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte : ____________

Observations ____________

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction [illegible] Date de travaux importants de rénovation ______

Sols de l'emplacement : Sable de plage __ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate_ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___ Rivière__ Vallée___ Plaine___ Colline___ Flan de coteau ___ Sommet___

Base : Cellule/dalle sur Grade, élevé sur Post, piles profondes.

Forme du plan : O_ E_ H_ L_ T_ U_ autre?

Irrégularités verticales : Étage souple __ Dénivelé__ Murs contreventés coupés__ Colonnes raccourcies__ Martèlement au bâtiment adjacent

ITEM 36

27/12/2010 #2

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection
Id Inspecteur : Team OXFAM
Affiliation : oxfam
Date et Heure d'inspection 11:38 ☑ AM ☐ PM
Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment	**Type de construction**	
Nom du bâtiment : CORSAM	☐ Armature en bois	☐ Murs béton contreventés
Adresse : Rue Rosiée, #10	☐ Armature en acier	☑ Murs non renforcés
	☐ Armature béton avec remplissage des parois	☐ Murs renforcés
Contact/Téléphone : 445-8502	☑ Armature en béton	☐ Autre
Coordonnées GPS: N 19°32.239 W 072°20.399	Nombre d'étages : 3	Nombre de sous-sol : 0

Spécification du bâtiment	**Type d'occupation**		
Superficie approximative (mètre carré)	☐ Résidentiel- section unique	☑ Commerce	☐ Gouvernement
Nombre de résidences 1	☐ Résidentiel- section multiple	☑ Bureaux	☐ Historique
	☐ Assemblée publique	☐ Industriel	☐ Ecole
Nombre de locaux non habitables		☐ Services d'urgence	☐ Autre

Evaluation
Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché	✓		
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées		✓	
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé
☐ aucun
☐ 0-1%
☑ 1-10%
☐ 10-30%
☐ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition :	**Aucun/mineure**	**Simple**	**Moyenne**	**Complexe**

Observations : Des réparations sont nécessaires

Signalisation
Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☑ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☐ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires
☐ Barricades nécessaires dans la zone: ____
☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre ____
☐ Autres recommandations ou restrictions tel qu'inscrit sur la pencarte : ____
Observations: ____

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :
Date de début de construction: 1992 Date de travaux importants de rénovation: ____
Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___
Inclinaison de construction : Plate__ Modérée _ Abrupte ___
Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline ✓, Flan de coteau ___Sommet___
Base : Dalle/pose sur Grade, élevé sur Post, piles profondes.
Forme du plan : _O_ E_ H_ L_ T_ U_ autres ✓ rectangulaire
Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 37

27/02/2010 #3

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id.Inspecteur : ____________ Date et Heure d'inspection 12:00 ☐ AM ☑ PM

Affiliation : oxfam Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment **Type de construction**

Nom du bâtiment : Bâtiment Friendship ☐ Armature en bois ☐ Murs béton contreventés

Adresse : Ruelle Marcelin #27 ☐ Armature en acier ☑ Murs non renforcés

☐ Armature béton avec remplissage des parois ☐ Murs renforcés

Contact/Téléphone : 3711-5897 ☐ Armature en béton ☐ Autre ✓ Maçonnerie

Coordonnées GPS: N 18 32 151 W 072 20.076 Nombre d'étages : 0 Nombre de sous-sol : 0

Spécification du bâtiment **Type d'occupation**

Superficie approximative (mètre carré) ☑ Résidentiel- section unique ☐ Commerce ☐ Gouvernement

Nombre de résidences 1 ☐ Résidentiel- section multiple ☐ Bureaux ☐ Historique

☐ Assemblée publique ☐ Industriel ☐ Ecole

Nombre de locaux non habitables ☐ Services d'urgence ☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			✓
Murs intérieurs et extérieurs fissurés et effondrés			✓
Colonnes, pilastres et corbeaux fissurés et émiettés			✓
Plaques, poutres, solives fissurées et écaillées			✓
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

- ☐ aucun
- ☐ 0-1%
- ☐ 1-10%
- ☐ 10-30%
- ☐ 30-60%
- ☑ 60-100%
- ☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☑ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

____

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone: ______________

☐ Expertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐Autre ______________

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte : ______________

Observations: ______________

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: 1957 Date de travaux importants de rénovation: 1987 (adding of new construction)

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate___ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet____

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_ E_ H_ L_ T_ U_ autres ✓

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 38

27/02/2010

#4

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : ________ Date et Heure d'inspection 12:40 ☐ AM ☑ PM

Affiliation : OXFAM Zone inspectée: ☐ Extérieur uniquement ☐ Extérieur et intérieur

Description du bâtiment — **Type de construction**

Nom du bâtiment : [illegible]

Adresse : Carrefour Feuille Rue Bocozelle #61

Contact/Téléphone : 3847-7147 / 3557-4520

Coordonnées GPS: [illegible]

☐ Armature en bois
☐ Armature en acier
☐ Armature béton avec remplissage des parois
☑ Armature en béton
☐ Murs béton contreventés
☐ Murs non renforcés
☐ Murs renforcés
☑ Autre Maçonnerie

Nombre d'étages : 2 Nombre de sous-sol : 1

Spécification du bâtiment — **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences 1

Nombre de locaux non habitables

☐ Résidentiel- section unique
☑ Résidentiel- section multiple
☐ Assemblée publique
☐ Commerce
☐ Bureaux
☐ Industriel
☐ Services d'urgence
☐ Gouvernement
☐ Historique
☐ Ecole
☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			✓
Murs intérieurs et extérieurs fissurés et effondrés			✓
Colonnes, pilastres et corbeaux fissurés et émiettés			✓
Plaques, poutres , solives fissurées et écaillées			✓
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☐ 1-10%
☐ 10-30%
☐ 30-60%
☑ 60-100%
☐ 100%

Difficulté de la démolition : Aucun/mineure Simple Moyenne Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☑ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone: ________

☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre ________

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte ________

Observations: ________

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction 1986 Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate_ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage__, Rivière__, Vallée__, Plaine__, Colline__, Flan de coteau __Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_ E_ H_ L_ T_ U_autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 39

27/01/2010 #5

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : 003-851-151-4 Date et Heure d'inspection 1:00 ☐ AM ☑ PM

Affiliation : DAFAM Zone inspectée: ☑ Extérieur uniquement ☐ Extérieur et intérieur

Description du bâtiment **Type de construction**

Nom du bâtiment : église

Adresse : Rue Constant Nicolas # 47

Contact/Téléphone : 3464-3047

Coordonnées GPS: N 18°31.550 W 072°20.366

☐ Armature en bois
☐ Armature en acier
☐ Armature béton avec remplissage des parois
☐ Armature en béton ✓
☐ Murs béton contreventés
☑ Murs non renforcés
☐ Murs renforcés
☑ Autre - CDI Roof

Nombre d'étages : 1 Nombre de sous-sol : 0

Spécification du bâtiment **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences 1

Nombre de locaux non habitables

☐ Résidentiel- section unique
☐ Résidentiel- section multiple
☑ Assemblée publique
☐ Commerce
☐ Bureaux
☐ Industriel
☐ Services d'urgence
☐ Gouvernement
☐ Historique
☐ Ecole
☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés		✓	
Colonnes, pilastres et corbeaux fissurés et émiettés		✓	
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé
☐ aucun
☐ 0-1%
☐ 1-10%
☐ 10-30%
☑ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition : **Aucun/mineure** **Simple** **Moyenne** **Complexe**

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☑ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone:

☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte :

Observations:

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ______ Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate_ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline ✓, Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes

Forme du plan : , O_ E_ H_ L_ T_ U_autres : rectangulaire

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

Zone : Beauboeuf

ITEM 84 - (Beauboeuf Residence 1)

#1

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id.Inspecteur : Team Oxfam
Affiliation : Oxfam

Date et Heure d'inspection 11h16 1er mars 2010 ✓AM □ PM
Zone inspectée: □ Extérieur uniquement ✓ Extérieur et intérieur

Description du bâtiment

Nom du bâtiment : Josma Dieu Merle
Adresse : Impasse Beauboeuf

Contact/Téléphone : 3740 6282

Coordonnées GPS: N: 18°31.210 W 072°20.737

Type de construction

□ Armature en bois
□ Armature en acier
□ Armature béton avec remplissage des parois
✓ Armature en béton
□ Murs béton contreventés
✓ Murs non renforcés
□ Murs renforcés
□ Autre

Nombre d'étages : 3
Nombre de sous-sol :

Spécification du bâtiment

Superficie approximative (mètre carré)
Nombre de résidences
Nombre de locaux non habitables

Type d'occupation

□ Résidentiel- section unique
✓ Résidentiel- section multiple
□ Assemblée publique
✓ Commerce
□ Bureaux
□ Industriel
□ Services d'urgence
□ Gouvernement
□ Historique
□ Ecole
□ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés	✓		
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

□ aucun
□ 0-1%
□ 1-10%
□ 10-30%
□ 30-60%
□ 60-100%
□ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations : Réparation du parapet est nécessaire - fissures

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

✓ **Inspecté (fiche verte)** □ **accès limité (fiche jaune)** □ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

□ Barricades nécessaires dans la zone:
□ Eexpertise détaillée recommandé : □ Structurelle □ Géotechnique □Autre
□ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte :
Observations:

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: 1991 Date de travaux importants de rénovation: 2009
Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___
Inclinaison de construction : Plate__ Modérée _ Abrupte ___
Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet___
Base : Dalle/pose sur Grade, élevé sur Post, piles profondes.
Forme du plan : , O_ E_ H_ L_ T_ U_ autres Rectangulaire
Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 85 - (Beauboeuf Residence 2)

#2

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id.Inspecteur : Team OxFam — Date et Heure d'inspection 11h44 — 15 mars 2010 — ☑ AM ☐ PM

Affiliation : OxFam — Zone inspectée: ☐ Extérieur uniquement ☐ Extérieur et intérieur

Description du bâtiment — **Type de construction**

Nom du bâtiment : Yolande Louis Jeune

Adresse : Impasse Baddy prolongé

Contact/Téléphone : 38162598 / 3660 3499 — 31.171

Coordonnées GPS: N: 18°31.143 W: 72°20.653

Type de construction:

- ☐ Armature en bois
- ☐ Armature en acier
- ☐ Armature béton avec remplissage des parois
- ☑ Armature en béton
- ☐ Murs béton contreventés
- ☑ Murs non renforcés
- ☐ Murs renforcés
- ☑ Autre CDI et [illegible]

Nombre d'étages : 1 — Nombre de sous-sol :

Spécification du bâtiment — **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences

Nombre de locaux non habitables

- ☑ Résidentiel- section unique
- ☐ Résidentiel- section multiple
- ☐ Assemblée publique
- ☐ Commerce
- ☐ Bureaux
- ☐ Industriel
- ☐ Services d'urgence
- ☐ Gouvernement
- ☐ Historique
- ☐ Ecole
- ☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés		✓	
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées		✓	
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier) : Toiture partiellement effondré		✓	

Dommage estimé

- ☐ aucun
- ☐ 0-1%
- ☐ 1-10%
- ☐ 10-30%
- ☑ 30-60%
- ☐ 60-100%
- ☐ 100%

Difficulté de la démolition : Aucun/mineure — Simple — Moyenne — (Complexe) [circled]

Observations : Zone à risque - Risque d'éboulement

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☒ **accès limité (fiche jaune)** ☑ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

- ☐ Barricades nécessaires dans la zone:
- ☐ Eexpertise détaillée recommandé : ☑ Structurelle ☑ Géotechnique ☐ Autre
- ☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte :

Observations:

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ______ Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___ Rivière__ Vallée___ Plaine___ Colline___ Flan de coteau ___Sommet____

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes.

Forme du plan : . O_ E_ H_ L_ T_ U_ autres rectangulaire

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 86 - (Beauboeuf Residence 3) #3

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : Team OXFAM — Date et Heure d'inspection 1er Mars 2010 — ☐ AM ☑ PM

Affiliation : OXFAM — Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment — **Type de construction**

Nom du bâtiment : Destine Charles — ☐ Armature en bois — ☐ Murs béton contreventés

Adresse : (37633158) — ☐ Armature en acier — ☐ Murs non renforcés

☐ Armature béton avec remplissage des parois — ☐ Murs renforcés

Contact/Téléphone : 3763-3158 / 3776-3122 — ☐ Armature en béton — ☐ Autre

Coordonnées GPS: N: 18° ... 173 W: 72° ... 662 — Nombre d'étages : — Nombre de sous-sol :

Spécification du bâtiment — **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences

☑ Résidentiel- section unique — ☐ Commerce — ☐ Gouvernement

☐ Résidentiel- section multiple — ☐ Bureaux — ☐ Historique

☐ Assemblée publique — ☐ Industriel — ☐ Ecole

Nombre de locaux non habitables — ☐ Services d'urgence — ☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

- ☐ aucun
- ☐ 0-1%
- ☐ 1-10%
- ☐ 10-30%
- ☐ 30-60%
- ☐ 60-100%
- ☐ 100%

Difficulté de la démolition : Aucun/mineure — Simple — Moyenne — (Complexe)

Observations : Pas de fissure apparente – Zone à risque – Risque d'éboulement

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☑ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone: ___

☐ Eexpertise détaillée recommandé : ☐ Structurelle ☑ Géotechnique ☐ Autre ___

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pencarte : ___

Observations: ___

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ___ Date de travaux importants de rénovation: ___

Sols de l'emplacement : Sable de plage___ Sol mou_ Sol ferme_ Roche___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes.

Forme du plan : , O_ E_ H_ L_ T_ U_autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 88 - (Beauboeuf Residence 5)

1-3-2010

#1

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : ____________ Date et Heure d'inspection: 12:00 ☐ AM ☑ PM

Affiliation : OCTAR Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment / **Type de construction**

Nom du bâtiment :

Adresse :

☐ Armature en bois ☐ Murs béton contreventés

☐ Armature en acier ☐ Murs non renforcés

☐ Armature béton avec remplissage des parois ☐ Murs renforcés

Contact/Téléphone :

☑ Armature en béton ☑ Autre

Coordonnées GPS:

Nombre d'étages : 1 Nombre de sous-sol :

Spécification du bâtiment / **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences

Nombre de locaux non habitables

☑ Résidentiel- section unique ☐ Commerce ☐ Gouvernement

☐ Résidentiel- section multiple ☐ Bureaux ☐ Historique

☐ Assemblée publique ☐ Industriel ☐ Ecole

☐ Services d'urgence ☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés		✓	
Colonnes, pilastres et corbeaux fissurés et émiettés	✓		
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☐ 1-10%
☑ 10-30%
☐ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition : Aucun/mineure Simple Moyenne Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☑ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☐ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

____

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone: ____________

☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre ____________

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pencarte : ____________

Observations: ____________

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ______ Date de travaux importants de rénovation: _______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet____

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_, E_, H_, L_, T_, U_,autres ✓

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 89 - (Beauboeuf Residence 6)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id.Inspecteur : ____________ Date et Heure d'inspection 12:15 ☐ AM ☑ PM

Affiliation : ____________ Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment | **Type de construction**

Nom du bâtiment :

Adresse :

Contact/Téléphone :

Coordonnées GPS:

☐ Armature en bois ☐ Murs béton contreventés

☐ Armature en acier ☐ Murs non renforcés

☐ Armature béton avec remplissage des parois ☐ Murs renforcés

☑ Armature en béton ☐ Autre

Nombre d'étages : 1 Nombre de sous-sol : 1

Spécification du bâtiment | **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences 1

Nombre de locaux non habitables

☑ Résidentiel- section unique ☐ Commerce ☐ Gouvernement

☐ Résidentiel- section multiple ☐ Bureaux ☐ Historique

☐ Assemblée publique ☐ Industriel ☐ Ecole

☐ Services d'urgence ☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché		✓	
Murs intérieurs et extérieurs fissurés et effondrés			✓
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☐ 1-10%
☐ 10-30%
☐ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☑ **accès limité (fiche jaune)** ☐ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées.

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone: ____________

☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐Autre ____________

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte : ____________

Observations: ____________

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: 1992 Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate_ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière___, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_, E_, H_, L_, T_, U_autres ✓

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

86 1-3-2010 #3

ITEM 90 - (Beauboeuf Residence 7)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id.Inspecteur : ____________ Date et Heure d'inspection ______ ☐ AM ☑ PM

Affiliation : ____________ Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment | **Type de construction**

Nom du bâtiment : ____________

Adresse : ____________

Contact/Téléphone : ____________

Coordonnées GPS: N 18°31.063 W 072°...

☐ Armature en bois
☐ Armature en acier
☐ Armature béton avec remplissage des parois
☑ Armature en béton

☐ Murs béton contreventés
☐ Murs non renforcés
☐ Murs renforcés
☐ Autre

Nombre d'étages : 1   Nombre de sous-sol : 0

Spécification du bâtiment | **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences 1

Nombre de locaux non habitables

☑ Résidentiel- section unique
☐ Résidentiel- section multiple
☐ Assemblée publique

☐ Commerce
☐ Bureaux
☐ Industriel
☐ Services d'urgence

☐ Gouvernement
☐ Historique
☐ Ecole
☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

État observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☐ 1-10%
☑ 10-30%
☐ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☑ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☐ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

____

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone: ____________
☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐Autre ____________
☐ Autres recommandations ou restrictions tel qu'inscrit sur la pencarte : ____________
Observations: ____________

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ______ Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_, E_, H_, L_, T_, U_autres ✓

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 91 - (Pacot Residence 1) -3-2010

PACOT MESANS (old man) #4

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : ____________ Date et Heure d'inspection 3:05 ☐ AM ☑ PM

Affiliation : ____________ Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment — **Type de construction**

Nom du bâtiment : OSCAR Pierre

Adresse : Rue ... Haut ...

Contact/Téléphone : 3717-3077

☐ Armature en bois
☐ Armature en acier
☐ Armature béton avec remplissage des parois
☑ Armature en béton
☐ Murs béton contreventés
☑ Murs non renforcés
☐ Murs renforcés
☐ Autre ✓ C.D.I. ...

Coordonnées GPS:

Nombre d'étages : 0

Nombre de sous-sol : 0

Spécification du bâtiment — **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences 1

Nombre de locaux non habitables

☑ Résidentiel- section unique
☐ Résidentiel- section multiple
☐ Assemblée publique
☐ Commerce
☐ Bureaux
☐ Industriel
☐ Services d'urgence
☐ Gouvernement
☐ Historique
☐ Ecole
☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés			✓
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☐ 1-10%
☐ 10-30%
☐ 30-60%
☑ 60-100%
☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'... Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☑ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées.

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone: ____________

☐ Eexpertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐Autre ____________

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pencarte : ____________

Observations: ____________

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: 2007 Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage __ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate_ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___ Rivière__ Vallée___ Plaine___ Colline___ Flan de coteau __Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_ E_ H_ L_ T_ U_autres ✓ rectangulaire

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 92 - (Delmas (Golf Course) Residence 1)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id.Inspecteur : ____________ Date et Heure d'inspection ______ □ AM ☑ PM

Affiliation : ____________ Zone inspectée: □ Extérieur uniquement □ Extérieur et intérieur

Description du bâtiment — **Type de construction**

Nom du bâtiment : — □ Armature en bois — □ Murs béton contreventés

Adresse : — □ Armature en acier — ☑ Murs non renforcés

□ Armature béton avec remplissage des parois — □ Murs renforcés

Contact/Téléphone : — ☑ Armature en béton — □ Autre

Coordonnées GPS : — Nombre d'étages : 3 — Nombre de sous-sol :

Spécification du bâtiment — **Type d'occupation**

Superficie approximative (mètre carré) — □ Résidentiel- section unique — □ Commerce — □ Gouvernement

Nombre de résidences — ☑ Résidentiel- section multiple — □ Bureaux — □ Historique

□ Assemblée publique — □ Industriel — □ Ecole

Nombre de locaux non habitables — □ Services d'urgence — □ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			✓
Murs intérieurs et extérieurs fissurés et effondrés		✓	
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

- □ aucun
- □ 0-1%
- □ 1-10%
- □ 10-30%
- ☑ 30-60%
- □ 60-100%
- □ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

□ **Inspecté (fiche verte)** ☑ **accès limité (fiche jaune)** □ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

____

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

□ Barricades nécessaires dans la zone: ______________________

□ Expertise détaillée recommandé : □ Structurelle □ Géotechnique □ Autre ______________

□ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte : ______________

Observations: ______________________

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ____ Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___ Rivière__ Vallée__ Plaine__ Colline__ Flan de coteau __ Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : , O_ E_ H_ L_ T_ U_ autres ✓

Irrégularités verticales : Etage assoupli ___ Dénivelés___ Murs contreventés couplés_ Colonnes raccourcies__ Martèlement de bâtiment adjacent

ITEM 93 - (Delmas (Golf Course) Residence 2)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

ID Inspecteur : ____________ Date et Heure d'inspection : [illegible] ☑AM ☐PM

Affiliation : [illegible] Zone inspectée : ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment

Nom du bâtiment : [illegible]

Adresse : [illegible]

Contact/Téléphone : [illegible]

Coordonnées GPS : [illegible]

Type de construction

☐ Armature en bois ☐ Murs béton contreventés

☐ Armature en acier ☐ Murs non renforcés

☐ Armature béton avec remplissage des parois ☐ Murs renforcés

☑ Armature en béton ☐ Autre [illegible]

Nombre d'étages : [illegible] Nombre de sous sol :

Spécification du bâtiment

Superficie approximative (mètre carré)

Nombre de résidences : 1

Nombre de locaux non habitables

Type d'occupation

☑ Résidentiel- section unique ☐ Commerce ☐ Gouvernement

☐ Résidentiel- section multiple ☐ Bureaux ☐ Historique

☐ Assemblée publique ☐ Industriel ☐ École

☐ Services d'urgence ☐ Autre

Evaluation

Etudier les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché	✓		
Murs intérieurs et extérieurs fissurés et effondrés			
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres, solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☑ 1-10%
☐ 10-30%
☐ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement critique. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCÈS NON AUTORISÉ. Les états modérés et peu graves peuvent permettre une signalisation (situation restreinte). La signalisation INSPECTÉ doit être affichée à l'entrée principale. Les signalisations ACCÈS LIMITÉ et ACCÈS NON AUTORISÉ doivent être placées à toutes les entrées.

☑ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☐ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions exactes qu'indiquées :

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone : ____________

☐ Expertise détaillée recommandée : ☐ Structurelle ☐ Géotechnique ☐ Autre ____________

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte ____________

Observations : ____________

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date du début de construction : [illegible] Date de travaux importants de rénovation ______

Sols de l'emplacement : Sable de plage __ Sol mou __ Sol ferme __ Roche __

Inclinaison de construction : Plate __ Modérée __ Abrupte __

Emplacement du bâtiment : Plage __ Rivière __ Vallée __ Plaine __ Colline __ Flan de coteau __ Sommet __

Base : Semelle sur Grade, mur sur Pieu, piles profondes

Forme du plan : □, ⊏, H, L, T, ⊥, autres [illegible]

Irrégularités verticales : Étage souple __ Décalages __ Murs contreventés couplés __ Colonnes raccourcies __ Martèlement de bâtiment adjacent

#3

ITEM 94 - (Delmas (Golf Course) Residence 3)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : ______________

Affiliation : ______________

Date et Heure d'inspection 1:35 □ AM ☑ PM

Zone inspectée: □ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment / **Type de construction**

Nom du bâtiment :

Adresse :

Contact/Téléphone :

Coordonnées GPS:

□ Armature en bois □ Murs béton contreventés
□ Armature en acier □ Murs non renforcés
□ Armature béton avec remplissage des parois □ Murs renforcés
□ Armature en béton □ Autre

Nombre d'étages : 1 Nombre de sous-sol : 0

Spécification du bâtiment / **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences 1

Nombre de locaux non habitables

□ Résidentiel- section unique □ Commerce □ Gouvernement
□ Résidentiel- section multiple □ Bureaux □ Historique
□ Assemblée publique □ Industriel □ Ecole
□ Services d'urgence □ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres, solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

□ aucun
□ 0-1%
□ 1-10%
□ 10-30%
□ 30-60%
□ 60-100%
□ 100%

Difficulté de la démolition :	Aucun/mineure	Simple	Moyenne	Complexe

Observations :

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☑ **Inspecté (fiche verte)** □ **accès limité (fiche jaune)** □ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

____

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

□ Barricades nécessaires dans la zone: ______________

□ Expertise détaillée recommandé : □ Structurelle □ Géotechnique □ Autre ______________

□ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte : ______________

Observations: ______________

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ____ Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___ Rivière__ Vallée___ Plaine___ Colline___ Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes.

Forme du plan : . O_ E_ H_ L_ T_ U_autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

Terrain de golf

#1

ITEM 95 - (Delmas (Golf Course) Residence 4)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : Jean Oxfam

Affiliation : Oxfam

Date et Heure d'inspection 2 Mars 2010 ☑ AM ☐ PM

Zone inspectée: ☐ Extérieur uniquement ☐ Extérieur et intérieur

Description du bâtiment

Nom du bâtiment : Villa André

Adresse : Delmas 42 prolongé, Golf Frédéric

Contact/Téléphone : 3456-5513

Coordonnées GPS: N 18°32.294 W 72°17.750

Type de construction

☐ Armature en bois

☐ Armature en acier

☐ Armature béton avec remplissage des parois

☐ Armature en béton

☐ Murs béton contreventés

☑ Murs non renforcés

☐ Murs renforcés

☑ Autre CPI and Wood

Nombre d'étages : 1

Nombre de sous-sol :

Spécification du bâtiment

Superficie approximative (mètre carré)

Nombre de résidences

Nombre de locaux non habitables

Type d'occupation

☐ Résidentiel- section unique

☑ Résidentiel- section multiple

☐ Assemblée publique

☐ Commerce

☐ Bureaux

☐ Industriel

☐ Services d'urgence

☐ Gouvernement

☐ Historique

☐ Ecole

☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres, solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun

☐ 0-1%

☑ 1-10%

☐ 10-30%

☐ 30-60%

☐ 60-100%

☐ 100%

Difficulté de la démolition : Aucun/mineure Simple Moyenne Complexe

Observations : Besoin de Réparation

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☑ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☐ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone:

☐ Expertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre

☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte :

Observations:

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction ___ Date de travaux importants de rénovation: ___

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate_ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___, Rivière__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : . O_ E_ H_ L_ T_ U_ autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés_ Colonnes raccourcies___Martèlement de bâtiment adjacent

#2

ITEM 96 - (Delmas (Golf Course) Residence 5)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : Team OXFAM — Date et Heure d'inspection 12h11 — 2 Mars 2010 — □ AM ✓PM

Affiliation : OXFAM — Zone inspectée : □ Extérieur uniquement □ Extérieur et intérieur

Description du bâtiment — **Type de construction**

Nom du bâtiment : Jean-Jolicoeur Voltaire

Adresse : Delmas 42

Contact/Téléphone : 3624-4803

Coordonnées GPS : N : 18° 32.297 W : 072°. 17.949

□ Armature en bois
□ Armature en acier
□ Armature béton avec remplissage des parois
✓ Armature en béton
□ Murs béton contreventés
✓ Murs non renforcés
□ Murs renforcés
□ Autre

Nombre d'étages : 2 — Nombre de sous-sol :

Spécification du bâtiment — **Type d'occupation**

Superficie approximative (mètre carré)

Nombre de résidences

Nombre de locaux non habitables

□ Résidentiel- section unique
✓ Résidentiel- section multiple
□ Assemblée publique
□ Commerce
□ Bureaux
□ Industriel
□ Services d'urgence
□ Gouvernement
□ Historique
□ Ecole
✓ Autre location

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			
Murs intérieurs et extérieurs fissurés et effondrés	✓		
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres, solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

□ aucun
□ 0-1%
✓ 1-10%
□ 10-30%
□ 30-60%
□ 60-100%
□ 100%

Difficulté de la démolition : Aucun/mineure — Simple — Moyenne — Complexe

Observations : Réparation mineure

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

✓ **Inspecté (fiche verte)** □ **accès limité (fiche jaune)** □ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

□ Barricades nécessaires dans la zone:

□ Eexpertise détaillée recommandé : □ Structurelle □ Géotechnique □ Autre

□ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte :

Observations:

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ______ Date de travaux importants de rénovation: ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___ Rivière__ Vallée___ Plaine___ Colline___ Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes.

Forme du plan : , O_ E_ H_ L_ T_ U_autres Rectangulaire

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

#3

ITEM 97 - (Delmas (Golf Course) Residence 6)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : Team CK Fam

Affiliation : CK Fam

Date et Heure d'inspection 12.6.2010 — □ AM ✓PM

Zone inspectée: □ Extérieur uniquement ✓ Extérieur et intérieur

Description du bâtiment

Nom du bâtiment : Mme Mondesir Y'ves

Adresse : Delmas 9?

Contact/Téléphone : 3830-7452 / 3467-3469

Coordonnées GPS: N: 18°33.286 / W: 072°17.931

Type de construction

□ Armature en bois — □ Murs béton contreventés

□ Armature en acier — ✓Murs non renforcés

□ Armature béton avec remplissage des parois — □ Murs renforcés

□ Armature en béton — ✓Autre CDF and wood

Nombre d'étages : 1

Nombre de sous-sol :

Spécification du bâtiment

Superficie approximative (mètre carré)

Nombre de résidences

Nombre de locaux non habitables

Type d'occupation

□ Résidentiel- section unique — ✓Commerce — □ Gouvernement

✓Résidentiel- section multiple — □ Bureaux — □ Historique

□ Assemblée publique — □ Industriel — □ Ecole

□ Services d'urgence — □ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché		✓	
Murs intérieurs et extérieurs fissurés et effondrés			✓
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres, solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

□ aucun
□ 0-1%
□ 1-10%
□ 10-30%
□ 30-60%
✓60-100%
□ 100%

Difficulté de la démolition : Aucun/mineure — Simple — (Moyenne) — Complexe

Observations : A démolir

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

□ **Inspecté (fiche verte)** □ **accès limité (fiche jaune)** ✓ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

□ Barricades nécessaires dans la zone:

□ Expertise détaillée recommandé : □ Structurelle □ Géotechnique □Autre

□ Autres recommandations ou restrictions tel qu'inscrit sur la pencarte :

Observations:

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: 1991 Date de travaux importants de rénovation ______

Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plat ___ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___ Rivière__ Vallée___ Plaine___ Colline___ Flan de coteau ___Sommet____

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes.

Forme du plan : O_ E_ H_ L_ T_ U_autres Rectangulaire

Irrégularités verticales : Etage assoupli ___Dérivelés___Murs contreventés couplés_Colonnes raccourcies___Martèlement de bâtiment adjacent

ITEM 98 #4 **- (Delmas (Golf Course) Residence 7)**

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id.Inspecteur : Team OxFam   Date et Heure d'inspection 12h56 2 MARS 2016   ☐ AM ☑ PM

Affiliation : OxFam   Zone inspectée: ☐ Extérieur uniquement ☑ Extérieur et intérieur

Description du bâtiment

Nom du bâtiment : Barossy Jean Sony

Adresse : Delmas 42

Contact/Téléphone : 3780-2685

Coordonnées GPS: N 18° 32.365 W 072° 17.916

Type de construction

☐ Armature en bois
☐ Armature en acier
☐ Armature béton avec remplissage des parois
☐ Armature en béton
☐ Murs béton contreventés
☑ Murs non renforcés
☐ Murs renforcés
☑ Autre CDF and wood

Nombre d'étages : 1   Nombre de sous-sol :

Spécification du bâtiment

Superficie approximative (mètre carré)

Nombre de résidences 3 (3 ch)

Nombre de locaux non habitables

Type d'occupation

☐ Résidentiel- section unique
☑ Résidentiel- section multiple
☐ Assemblée publique
☐ Commerce
☐ Bureaux
☐ Industriel
☐ Services d'urgence
☐ Gouvernement
☐ Historique
☐ École
☐ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché			✓
Murs intérieurs et extérieurs fissurés et effondrés		✓	
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

☐ aucun
☐ 0-1%
☐ 1-10%
☐ 10-30%
☑ 30-60%
☐ 60-100%
☐ 100%

Difficulté de la démolition : Aucun/mineure Simple (Moyenne) Complexe

Observations : Zone à risque – Construction près d'une ravine

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

☐ **Inspecté (fiche verte)** ☐ **accès limité (fiche jaune)** ☑ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées:

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

☐ Barricades nécessaires dans la zone:
☐ Expertise détaillée recommandé : ☐ Structurelle ☐ Géotechnique ☐ Autre
☐ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte :
Observations:

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction: ____ Date de travaux importants de rénovation: ____

Sols de l'emplacement : Sable de plage __ Sol mou_ Sol ferme_ Roche ___

Inclinaison de construction : Plate__ Modérée _ Abrupte ___

Emplacement du bâtiment : Plage___ (Rivière)__, Vallée___, Plaine___, Colline___, Flan de coteau ___Sommet___

Base : Dalle/pose sur Grade, élevé sur Post, piles profondes,

Forme du plan : ,O_, E_, H_, L_, T_, U_autres

Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés__Colonnes raccourcies___Martèlement de bâtiment adjacent

#5

ITEM 99 - (Delmas (Golf Course) Residence 8)

ACT-20 Formulaire d'évaluation rapide de la sécurité des bâtiments

Inspection

Id Inspecteur : Team oxfam
Affiliation : oxfam

Date et Heure d'inspection 1/27 — 2 Feb 2010 □ AM ✓PM
Zone inspectée : □ Extérieur uniquement ✓ Extérieur et intérieur

Description du bâtiment

Nom du bâtiment : Robert Paul Polyxie
Adresse : Delmas 42
Contact/Téléphone : 3330-2685
Coordonnées GPS :

Type de construction

□ Armature en bois
□ Armature en acier
□ Armature béton avec remplissage des parois
□ Armature en béton
□ Murs béton contreventés
✓ Murs non renforcés
□ Murs renforcés
✓ Autre CGI and wood

Nombre d'étages : 1
Nombre de sous-sol :

Spécification du bâtiment

Superficie approximative (mètre carré)
Nombre de résidences
Nombre de locaux non habitables

Type d'occupation

✓ Résidentiel- section unique
□ Résidentiel- section multiple
□ Assemblée publique
□ Commerce
□ Bureaux
□ Industriel
□ Services d'urgence
□ Gouvernement
□ Historique
□ Ecole
□ Autre

Evaluation

Etudiez les bâtiments pour vérifier leur état et cochez la colonne appropriée ci-dessous

Etat observé	Mineur/Aucun	Modéré	Grave
Bâtiment effondré, partiellement effondré ou déplacé Bâtiment ou étage penché		✓	
Murs intérieurs et extérieurs fissurés et effondrés			✓
Colonnes, pilastres et corbeaux fissurés et émiettés			
Plaques, poutres , solives fissurées et écaillées			
Parapets, gables, terrasses et escaliers endommagés			
Fissures ou mouvement du sol			
Autre (spécifier)			

Dommage estimé

□ aucun
□ 0-1%
□ 1-10%
□ 10-30%
✓ 30-60%
□ 60-100%
□ 100%

Difficulté de la démolition : Aucun/mineure Simple (Moyenne) Complexe

Observations : A démolir – structure instable

Signalisation

Choisissez une signalisation basée sur l'évaluation et le jugement d'équipe. Les conditions graves mettant en danger tout le bâtiment sont des raisons pour en interdire l'accès par la signalisation ACCES NON AUTORISE. Les états modérés et peu graves peuvent permettre une signalisation Utilisation restreinte. La signalisation INSPECTE doit être affichée à l'entrée principale. Les signalisations ACCES LIMITE et ACCES NON AUTORISE doivent être placées à toutes les entrées.

□ **Inspecté (fiche verte)** □ **accès limité (fiche jaune)** ✓ **accès non autorisé (fiche rouge)**

Enregistrez toutes les restrictions telles qu'indiquées.

Autres vérifications. Cochez les cases ci-dessous seulement si d'autres actions sont nécessaires

□ Barricades nécessaires dans la zone: ____
□ Expertise détaillée recommandée : □ Structurelle □ Géotechnique □Autre ____
□ Autres recommandations ou restrictions tel qu'inscrit sur la pancarte : ____
Observations: ____

Facteurs de vulnérabilité (cochez tout ce qui s'applique) :

Date de début de construction ____ Date de travaux importants de rénovation ____
Sols de l'emplacement : Sable de plage ___ Sol mou_ Sol ferme_ Roche ___
Inclinaison de construction : Plate_ Modérée _ Abrupte ___
Emplacement du bâtiment : Plage___ Rivière__ Vallée___ Plaine___ Colline___ Flan de coteau ___Sommet___
Base : Dalle/pose sur Grade, élevé sur Post, piles profondes
Forme du plan : , O_ E_ H_ L_ T_ U_autres
Irrégularités verticales : Etage assoupli ___Dénivelés___Murs contreventés couplés_Colonnes raccourcies___Martèlement de bâtiment adjacent

Appendix B

Residential Property

B1 Carefour – Rue Blancort

B2 Morne Sion Hillside Commuity

B3 Beauboeuf

B4 Pacot

B5 Delmas

South elevation (west side). delamination of stone masonry wall supporting 1st floor concrete slab

South elevation (east side). Some evidence of drift in lower storey.

North elevation. Note all architectural, hollow masonry infill have fallen out in the panel at lower storey. Unsymetric shape is evidant.

Column shear failure at the top of the lower storey due to small column size and limited longitudinal and confinement reinforcement

East elevation showing failure of lower storey. Evidence of permanent drift.

Extensive cracking and failure of internal partitions at ground level.

Building Coordinates	Lat: N18°32.609’, Long: W72°24.525’
Building Name:	LAMANTIN 54 Rue Blancourt #132 (Owner not present)
Site	Level ground. Two storey house with small out buildings in the grounds.
Building Description	Reinforced concrete frame with inflill hollow concrete block masonry. Built on stone masonry foundations in ~1957.
Assessment Findings	Visible failure of the lower columns and major cracking and failure of the majority of masonry panels at ground level.
Rating	RED
Recommendations	Evacuate people camping in grounds surrounding house, cordon off the area and demolish using safe techniques.

2 storey house on left and 1 storey house on right. Lower storey of the 2 storey house is comprimised. Concret column failure is evedient

Severe cracking of internal partitions of 2 storey house at ground floor level.

Cracking through column at the front of the 2 storey house.

One storey house – cracks in internal partitions

Back view of the west elevation of the 2 storey house

One storey house – cracks in internal partitions

Building Coordinates	Lat: N18° 32.620', Long: W72° 24.521' Lat: N18° 32.622', Long: W72° 24.526'
Building Name:	LAMANTIN 54 Rue Blancourt #771 (Owner/Occupier: Sultana Belange)
Site	Level ground. Two houses adjacent to each other (one one storey and the other two storey) and separate kitchen/outhouse building.
Building Description	One storey house: Reinforced Concrete frame with infill block masonry. Built on stone masonry foundations. Lightweight timber frame roof with galvanised sheeting roof. Two storey house: Reinforced concrete frame with infill block masonry. Original house was single storey but 2nd storey was recently added. (Out house – single storey unreinforced masonry structure with light weight roof)
Assessment Findings	One storey house: Minor cracking in internal blockwork partitions. No other visible signs of structural distress. Two storey house: Major failure of the structure and infill blockwork to lower storey. The added second story possibly compromised the structure by adding significant mass at high level. Out house/kitchen structure: Masonry walls are not adequately tied together and there is evidence that one side is severely cracked and in danger of collapsing onto single storey house which is adjacent.
Rating	One storey house: YELLOW (This house may need to be rated RED depending on how neighbouring structures are dealt with.) Two storey house: RED Out house/kitchen structure: RED
Recommendations	The two storey house and the out house have been severely compromised by the earthquake and need to be demolished. The entire property should be cordoned off with protection provided to the single storey house and the 2 storey house and kitchen out house structure then demolished using safe techniques. Before demolition of adjacent buildings access to single storey house should be very limited and only to the south west corner of the house. Once dangerous structures in the compound are dealt with adequately, repairs to internal partitions in single storey can take place. Damaged blockwork to be replaced with new masonry panels.

APPENDIX SECTION A2.1 – LAMANTIN 54, RUE BLANCOURT #772

Minor cracking around blockwork windinw

Diagonal cracking in hollow concrete block wall damage is repairable

Shear damage in hollow concrete block walls

Failure of blockwork portion due to complete lack of masonry bnding between adjacent wall panels and the fact that a lintel beam or similar was not used

Building Coordinates	Lat: N18° 32.630', Long: W72° 24.531'
Building Name:	LAMANTIN 54, Rue Blancourt #772 (Owner/Occupier: Anelia Paul)
Site	Level ground. Single storey house. Built in 1996.
Building Description	Single storey concrete frame with concrete hollow block infill masonry panels. Concrete roof (likely to contain hollow blocks as void formers). House was rectangular and had many internal walls. Relatively rigid roof diaphragm will have mobilised all walls to help resist the earthquake.The fact that the 2nd floor had not been built was very luck. Building was being used during the day. Unclear if people slept in it during the night.
Assessment Findings	Shear failure of hollow concrete infill blocks.
Rating	YELLOW
Recommendations	Repairs required to internal partitions. Damaged blockwork to be replaced with new masonry panels. Add lintel beams or similar where necessary. Do not construct a second level unless significant strengthening work is undertaken.

View of east wing of the house

View of both east and west wing of the house with a roof link

Very minor cracks evident in stone masonry panel at front of house

View of west wing of the house. Stone masonry looks as if it is a facade

Minor cracking at orthogonal wall junction and opening

Cracking at the head of the walls where one would normally find ring beam or timber head element – posibly there is one present

Building Coordinates	Lat: N18° 32.621', Long: W72° 24.540'
Building Name:	LAMANTIN 54, Rue Blancourt #133 (Owner/Occupier: Kethly G Bloncourt)
Site	Level ground. Single storey house.
Building Description	Single storey building (built in 1957) has two wings which are linked by a covered area in the centre. Building is a appears to be a combination of reinforced concrete and hollow concrete block masonry. House has been incrementally increased in size on plan. Roof is a slanting light weight timber frame roof with metal sheeting in a poor state of repair.
Assessment Findings	Some minor cracking in stone and block masonry, however much of these could have been prior to earthquake. Concrete blocks are laid in even courses using strong mortar in both the horizontal and vertical joints.
Rating	GREEN
Recommendations	Owner had plans to replace the roof due to its poor state of repair since before the earthquake with a new lightweight roof. The owner should at the same time review the state of the perimeter walls when the current roof is removed and replace any masonry which appears cracked and loose. Before installation of new roof the owner needs to ensure that there is an adequate ring beam structure at the top of the walls.

ARUP

To	Rick Bauer (Oxfam GB) Paul Neale	Reference number	212323/KMOH
cc	Jo da Silva	File reference	
From	Kubilay Hicyilmaz x 61351 (Dubai) Kathy Gibbs x 61030 (Doha)	Date	18 March 2010
Subject	MORNE SION, HILL COMMUNITY – RAPID ASSESSMENT 27 February 2010		

1 Introduction

A rapid assessment at Morne Sion, referred to as the hill side community, as shown in Figure 1 was performed on the 27 February 2010 with a view to document the existing housing typology of this community, the observed construction methods and typical earthquake damage patterns of the buildings we came across. Outline repairing and retrofitting concept are presented on the assumption that more detailed work will be needed to implement the proposed concepts, including ensuring issues of land rights and urban planning and similar are properly taken care of in the process.

The approximate coordinates of the community we visited is: Latitude: N18°31.331, Longitude: W72°21.373.

2 Housing Categories

The housing we observed at this community has been grouped into the following three building categories and one foundation category:

Building Category

- TCWR, Timber and corrugated galvanised iron walls and roof
- UHM-TCR, Un-reinforced hollow block masonry with timber and CGI roof
- C3-HM-TCR, Concrete frame with un-reinforced hollow masonry block with timber and CGI roof

Foundation Category

- SMF, Stone masonry foundations

2.1 Specific property details

To document our observations of the houses we have prepared a stand alone entry for each property, with some representative photos. For each property we have identified the housing category in line with the above descriptions, made a note of the main failures and or weaknesses. Finally for each house a few repair / retrofitting ideas are suggested.

It should be noted that the property specific data and recommendations do not take into account wider issues of master planning and land rights or many other similar issues which must be considered in the process. In particular the stability of the whole hill side and all the individual plot terraces needs careful evaluation before any further development is encouraged within this community.

One difficult thing to evaluate is the adequacy of the existing terraces stone masonry terraces and repair and retrofitting needs for these to ensure that the ground underneath the buildings will likely remain stable during a future earthquake event.

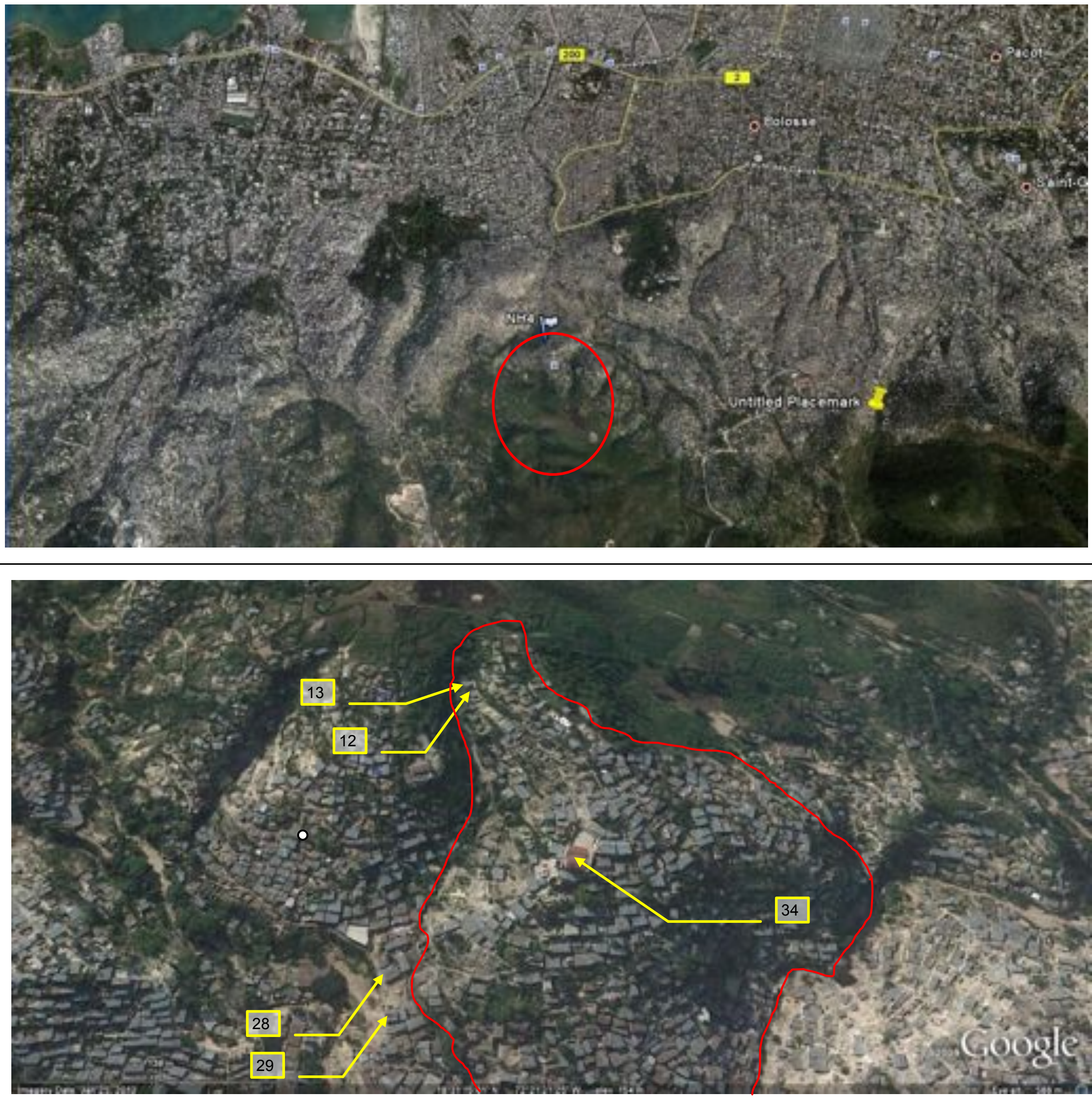


Figure 1 Satellite imagery with an overlay of some of the way finding points from the visit to this community (note that the bottom image has been rotated).

2.2 Repairing and Retrofitting

Within the limited time frame available it has not been possible to develop sketches to outline the suggested possible repair and retrofitting ideas.

Should this suggestions be implemented it is suggested that the techniques are practiced prior to their actual implementation on the properties in question. This is to ensure that workman ship and construction issues (such as temporary stability) considerations are adequately appreciated and provided for.

Checking stability of the hill and terrace retaining walls in likely to be beyond the capability of most local engineers. Expert input into issues surrounding slope stability, including stability of stone masonry terraces, is required.

Property 1, Housing Type (C3-HM-TCR)

Observations

- Foundation is made of stone masonry.
- Building frame does not appear to be anchored into the foundations.
- Roof level diaphragm missing on the front, possibly veranda portion.
- Top of walls in the portion with a roof does not appear to have a ring beam.
- Roof overhang is small, providing limited protection to the walls from heavy rain.
- Building is built very close to terrace edge.
- No lintel beams over doors.
- Not apparent that roof is adequately strapped to the walls and columns.

Recommendations

- Move front veranda wall back from the edge of the terrace.
- Add lintel beams across doors.
- Add roof ring beam across all walls (connecting into the columns).
- Provide strapping to tie roof to ring beam.
- Repair cracked blocks with new masonry blocks.
- Do not ever extend upwards.
- Provide proper framing around windows and doors.
- Add gutters to the roof.
- Anchor walls into the foundations (this will require temporary shoring and is tricky work).

Property 2, Housing Type (C3-HM-TCR)

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Observations

- Building was incomplete at the time of the earthquake.
- Foundation is made of stone masonry.
- Building frame does not appear to be anchored into the foundations.
- Rear building wall is built against the slope.
- Next to no mortar in the vertical masonry joints.

Recommendations

- Move back wall away from the back slope.
- Provide regular cross walls / buttresses to walls (ensure blocks are interlocked).
- New RC members to make use of seismic hooks
- Add lintel beams across doors.
- Add roof ring beam across all walls (connecting into the columns).
- Provide strapping to tie roof to ring beam.
- Do not ever extend upwards.
- Provide proper framing around windows and doors.
- Add gutters to the roof.

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</table>

Property 3, Housing Type (TCWR)

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Observations

- Appears unaffected by the earthquake
- Currently not habitable due to the dirt inside the building.
- Foundation is made of stone masonry (terrace front wall)

Recommendations

- Building to be cleaned
- May require a new floor
- Building frame to be strengthened
- Gutters are required
- Holes to be patched
- See basic shelter guidelines

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</table>

Property 4 Housing Type (C3-HM-TCR)

	**Observations** • Foundation is made of stone masonry. • Building frame does not appear to be anchored into the foundations. • One wall face built on same line as the terrace wall. • Next to no mortar in the vertical masonry joints. **Recommendations** • Move wall away from the front terrace wall • Provide regular cross walls / buttresses to walls (ensure blocks are interlocked). • New RC members to make use of seismic hooks • Add roof ring beam across all walls (connecting into the columns) and strap roof to the ring beam. • Do not ever extend upwards. • Add gutters

Property 5 Housing Type (C3-HM-TCR)

Observations

- Building was partially incomplete at the time of the earthquake.
- Foundation base is SMF.
- Building frame does not appear to be anchored into the foundations.
- Rear building wall is partially built against the slope.
- Next to no mortar in the vertical masonry joints.

Recommendations

- Move back wall away from the back slope.
- Provide regular cross walls / buttresses to walls (ensure blocks are interlocked).
- New RC members to make use of seismic hooks
- Add lintel beams across openings.
- Add roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam.
- Do not ever extend upwards.
- Add gutters to the roof.

Property 6 Housing Type (UHM-TCR)

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Observations

- Foundation system unknown.
- Rear building wall appears to be built against the slope.
- Size approximately 3x3m
- Next to no mortar in the vertical masonry joints.

Recommendations

- Move back wall away from the back slope.
- Add roof ring beam across all walls (connecting into the columns) that doubles as lintel beam.
- Provide strapping to tie roof to ring beam.
- Do not ever extend upwards.

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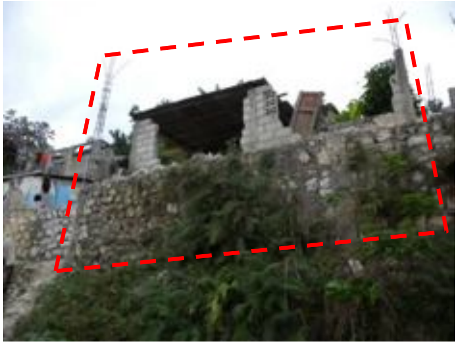
</table>

Property 7 Housing Type (C3-HM-TCR)

<table>
<tr><td></td><td>

See Recommendations for property 5 – In reviewing the photo this is probably property 5 photographed one level further down the hill.

Note the extensive stone masonry walls to form the terraces.

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</table>

Property 8 Housing Type (TCWR)

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Observations

- Appears unaffected by the earthquake
- See basic shelter guidelines
- Repair stone masonry walls if so required.

</td></tr>
</table>

Property 9 Housing Type (TCWR)

	**Observations** • Appears unaffected by the earthquake • In danger of rock fall from higher ground • See basic shelter guidelines as these will be more appropriate for this type of property

Property 10 Housing Type (C3-HM-TCR)

  	**Observations** • Building was partially incomplete at the time of the earthquake. • Foundation base is SMF (certainly for the terraces. • Rear building wall is built against the slope. • Rear wall was made from stone masonry that appears to be undamaged • Next to no mortar in the vertical masonry joints. **Recommendations** • Move back wall away from the back slope if possible to do so • Provide regular cross walls / buttresses to walls (ensure blocks are interlocked), may want to introduce small buttress lines to internal cross walls. • Add lintel beams across openings. • Add roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam. • Do not ever extend upwards. • Add gutters to the roof.

Property 11 Housing Type (C3-HM-TCR)

Observations

- Foundation base is SMF (certainly for the terraces.
- Rear building wall is built partially built against slope.
- Next to no mortar in the vertical masonry joints.
- Roof held down by rocks.
- Openings are small and central

Recommendations

- Move back wall away from the back slope if possible to do so.
- Add lintel beams across openings.
- Add roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam.
- Do not ever extend upwards.
- Add gutters to the roof.
- Consider adding reinforced concrete stitches at corners

Property 12 Housing Type (TCWR)

Observations

- Appears unaffected by the earthquake
- Terrace walls are virtually non existent.
- See basic shelter guidelines as these will be more appropriate for this type of property.
- (There were 3-4 children under the aged of 5/6 in this house without adults during the day)

Property 13 Housing Type (TCWR)



Observations

- Appears unaffected by the earthquake
- This building plot was fairly unique in that the plot appears to have been carved into the rock.
- Even the plot wall appears to have been carved out of the rock.
- Plot is on the edge of the community close to the natural drainage path of the hillside.
- See basic shelter guidelines as these will be more appropriate for this property.
- Residents were adamant that their rock piles had not fallen over during the earthquake.
- It is possible that the residents traded in the stones, though this was not totally clear during the brief visit to the property.
- Kitchen is outside
- The plot has a latrine which was on the whole unusual for this community.

Property 14 Housing Type (TCWR)

Observations

- Appears unaffected by the earthquake
- Lower terrace wall was carved into the hillside and is the rear wall for property 13.
- See basic shelter guidelines as these will be more appropriate for this type of property.

Property 15 Housing Type (TCWR)

Observations

- Appears unaffected by the earthquake
- Lower terrace wall was carved into the hillside.
- See basic shelter guidelines as these will be more appropriate for this type of property.

Property 16 Housing Type (TCWR)

Observations

- Appears unaffected by the earthquake
- Lower terrace wall was carved into the hillside.
- See basic shelter guidelines as these will be more appropriate for this type of property.
- Note the rock armour around the building base

Property 17 Housing Type (C3-HM-TCR)




Observations

- Building appears in relative good condition.
- Some bulging of walls perpendicular to the hill
- Foundation base is SMF.
- Rear building wall is partially built against the slope.
- Next to no mortar in the vertical masonry joints.

Recommendations

- Provide regular cross walls / buttresses to bulging walls (ensure blocks are interlocked).
- Add lintel beams across openings if this does not exists.
- Add roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam (currently rocks are being used to help hold the roof down.
- Do not ever extend upwards.
- Add gutters to the roof.
- Consider post installing reinforced concrete stitches to better link the columns to the masonry
- Entrance door appears to be on a low point within the building plot. This is not good in terms of preventing water entry during heavy rainfall.

Property 18 Housing Type (C3-HM-TCR)

	**Observations** • Building was not complete. • Hollow block walls appear to have failed. **Recommendations** • If house is to be completed, good opportunity exists to strengthen and complete using appropriate seismic design features. • Evaluate stability of front terraces and rear plot face which appears to have been cut into the hill.

Property 19 Housing Type (C3-HM-TCR)

	**Observations** • Location is also next to the water course which is why it looks as though it has been abandoned • Building was not complete and even then what is here looks to be in poor state. **Recommendations** • In all probability do not consider building at this location due to proximity to water path.

Property 20 Housing Type (C3-HM-TCR)

	**Observations** • Unclear why it looks as though it has been abandoned. • Building was not complete and even then what is here looks to be in poor state. **Recommendations** Evaluate safety of the plot before doing anything else.

Property 21 Housing Type (C3-HM-TCR)

<table>
<tr><td rowspan="1"></td><td>

Observations

- Unclear why it looks as though it has been abandoned.
- Building was not complete

Recommendations

Evaluate safety of the plot before doing anything else. Terrace front and rear walls need to be built.

</td></tr>
</table>

Property 22 Housing Type (UHM-TCR)

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Observations

- Side walls appear to have fallen though masonry appears undamaged. Either way the side is closed by plastic sheeting.
- Foundation base is SMF.
- Rear building wall is partially built against the slope.
- Next to no mortar in the vertical masonry joints.

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Recommendations

- Add lintel beams across openings if this does not exists.
- Add roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam (currently rocks are being used to help hold the roof down.
- Do not ever extend upwards.
- Add gutters to the roof.

Consider post installing reinforced concrete stitches to better link the columns to the masonry

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</table>

Property 23 Housing Type (C3-HM-TCR)

Observations

- Simple one room house (~3x3m, max 4x4m)
- Foundation base is SMF.
- Surprisingly there is mortar in the vertical masonry joints.
- Some sort of timber wall ring beam is present.
- Light roof, no gutters
- External latrine is present, again made from stone masonry.

Recommendations

- Add roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam (currently rocks are being used to help hold the roof down.
- Do not ever extend upwards.
- Add gutters to the roof.
- Consider post installing reinforced concrete stitches to better link the columns to the masonry

Property 24 Housing Type (C3-HM-TCR)

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Observations

- Two room house (rooms are ~3x3m, max 4x4m)
- Foundation base is SMF.
- Next to no mortar in the vertical masonry joints.
- Light roof, with some sort of gutters
- External latrine is present, again made from stone masonry.
- Rear wall has nearly failed out of plane and is showing severe levels of bulging. No ring beam present.
- Property has been built incrementally
- No lintel beams were used.

Recommendations

- Rebuild rear wall.
- Add roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam (currently rocks are being used to help hold the roof down.
- Do not ever extend upwards.
- Add gutters to the roof.
- Consider post installing reinforced concrete stitches to better link the columns to the masonry
- Stability of plot rear soil wall to be evaluated – could be unstable and result in small local slope stability problem.

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</table>

Property 25 Housing Type (C3-HM-TCR)

Observations

- Foundation base is made from stone masonry
- Next to no mortar in the vertical masonry joints.
- Light roof
- Property has been built incrementally (door has been boarded up
- No lintel beams have been were used though some sort of a timber ring beam is present

Recommendations

- Add roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam (currently rocks are being used to help hold the roof down.
- Do not ever extend upwards.
- Add gutters to the roof.

Consider post installing reinforced concrete stitches to better link the columns to the masonry

Property 26 Housing Type (C3-HM-TCR)

Note the triangular column reinforcement cages with next to no hoops.

Observations

- Incomplete 2 to 3 bed room property
- Foundation base is made from stone masonry
- Next to no mortar in the vertical masonry joints.
- Assume it would have had a light roof
- No lintel beams have been were used and concrete ring beams are not present over the masonry walls which have started to fail out of plane.
- Rear wall is built against the slope (this may have limited the levels of free vibration of the building during the earthquake.

Recommendations

- Add roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam (currently rocks are being used to help hold the roof down.
- Rebuild columns and properly anchor them into the foundations.
- Add gutters to the roof.
- Consider post installing reinforced concrete stitches to better link the columns to the masonry

Property 27 Housing Type (C3-HM-TCR)

Observations

- Foundation base is made from stone masonry which appears undamaged
- Surprisingly there is mortar in the vertical masonry joints though the mortar looks more like soil mortar than sand cement mortar
- Light roof
- No lintel beams have been were used though some sort of a timber ring beam is present
- Out of plane failure of walls present
- The blocks that were used look second hand
- No apparent connection between the concrete and block masonry wall construction and the stone masonry foundations.

Recommendations

- Add roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam (currently rocks are being used to help hold the roof down.
- Add gutters to the roof.
- Consider post installing reinforced concrete stitches to better link the columns to the masonry
- Consider extending the foundation base so that the building is not so much on the edge of the wall.

Property 28 - Church Housing Type (C3-HM-TCR)

Observations

- Foundation base is made from stone masonry which appears undamaged
- Timber roof truss only building with a larger span in this community
- No lintel beams appear to have been used
- A timber ring beam is present at the top of the walls
- Out of plane failure of walls was not observed.
- Very few opening and then they are small
- Regular shape

Recommendations

- Strengthen roof ring beam across all walls (connecting into the columns) and properly strap to tie roof to ring beam (currently rocks are being used to help hold the roof down.
- Add gutters to the roof.
- Consider post installing reinforced concrete stitches to better link the columns to the masonry
- Consider extending the foundation base so that the building is not so much on the edge of the wall.
- Consider adding horizontal in plane bracing to the roof trusses and vertical cross bracing between the centre of adjacent trusses
- Repair damage masonry blocks by replacing them with new blocks.

Property 29 Housing Type (C3-HM-TCR)

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Observations

- Foundation base is made from stone masonry
- Only two storey building seen within this community
- No lintel beams appear to have been used
- Wall ring beam are missing
- Out of plane failure of upper walls was observed.
- Very many openings and irregular shape (surprising that it did not collapse)

Recommendations

- Community should reconsider having a building straddling the community walkway.
- Building needs proper foundations
- Suggest removal of the top storey and the portion over the path – Consider only retaining the section shown within the red box.
- Walls to be strengthened against out of plane failure (add extra posts or masonry buttresses to the existing masonry walls

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</table>

Property 30 Housing Type (C3-HM-TCR)

Observations

- Foundation is made of stone masonry.
- No apparent significant damage
- Light timber sloping roof
- Wall ring beam missing
- Limited mortar in the vertical masonry joints.

Recommendations

- Evaluate stability of front terrace wall
- Add wall ring beam if it is missing

Property 31 Housing Type (C3-HM-TCR)

Observations

- Foundation is made of stone masonry.
- Start of separation at poorly interlocked wall junctions
- Limited mortar in the vertical masonry joints.

Recommendations

- Consider rebuilding wall corners in reinforced concrete that is stitched into the existing walls.
- Add lintel beams across openings
- Add roof ring beam across all walls (connecting into the columns).
- Provide strapping to tie roof to ring beam.
- Do not build a second floor

Property 32 Housing Type (UHM-TCR)

Observations

- Foundation is made of stone masonry.
- Top of walls does not appear to have a ring beam.
- Roof is not adequately strapped to the walls
- Separation of walls at wall junctions (poor interlock of walls)

Recommendations

- Provide regular cross walls / buttresses to walls (ensure blocks are interlocked).
- Consider post installing members in corners (make use of seismic hooks) and bond into existing wall panels
- Add roof ring beam across all walls (connecting into the columns).
- Provide strapping to tie roof to ring beam.
- Do not ever extend upwards.
- Add gutters to the roof.
- Repair cracked blocks with new masonry blocks.

Property 33 Housing Type (C3-HM-TCR)

Observations

- Foundation is made of stone masonry.
- Top of walls does not appear to have a ring beam.
- Out of plane failure of cantilevering wall portions observed

Recommendations

- Provide capping beams to half height walls to help restrain them against out of plane failure
- New RC members to make use of seismic hooks
- Add lintel beams across door and windows.
- Add roof ring beam across all walls (connecting into the columns).
- Provide strapping to tie roof to ring beam.
- Do not ever extend upwards.
- Add gutters to the roof.

Property 34 – Community Hall / School/ Church Housing Type (C3-HM-TCR)

Observations

- High stone masonry perimeter wall. Block work wall built on top partially collapsed probably pulling top portions of the stone wall down with it
- Foundation of building is made of stone masonry.
- Roof in one portion is concrete block and beam slab construction (C4-HBFS-UHM)
- One support column removed for room size alteration
- Building is built very close to terrace edge.
- Not sufficient top restraint to large internal block work walls.

Recommendations

- Provide regular cross walls / buttresses to walls (ensure blocks are interlocked).
- Add lintel beams across doors and windows
- Add roof ring beam across all walls (connecting into the columns).
- Provide strapping to tie roof to ring beam.
- Do not ever extend upwards.
- Provide horizontal bracing at wall level
- Add gutters to the roof.
- Move front veranda wall back from the edge of the terrace.
- Repair cracked blocks with new masonry blocks

Property 35 Housing type (C3-HM-TCR)

	Broadly see comments for property 27

Property 36 Housing type (C3-HM-TCR)

	
Broadly see comments for property 27	

Property 37 Housing Type (UHM-TCR)

	
Broadly see comments for property 32	

Property 38 Housing type (C3-HM-TCR)

Broadly see comments for property 27

Property 39 Housing Type (C3-HM-TCR)

Broadly see comments for property 27

Property 40 Housing type (C3-HM-TCR)

Broadly see comments for property 27

Property 41 Housing Type (UHM-TCR)

	
Broadly see comments for property 32	

Property 42 Housing Type (UHM-TCR)

	
Broadly see comments for property 27	

General

	**Observation** Severe cracking in concrete block wall due to movement of the terrace foundation. Collapse of this terrace could trigger a cascading effect like a small rock avalanche. It is possible that many such walls are close to their limit and their performance is crucial, therefore, there assessment and repair/retrofitting are very important.
	**Observation** Note the steep nature of the hills. These house do appear to be built on rock but in other communities this does not appear to have been the case leading to catastrophic cascading failures over many properties
	**Observation** Typical dense urban housing consisting of 1 to 2 to 3 to 4 bedrooms. Generally all 1 storey tall. Constructing higher within the observed construction should not be allowed. Fire truck access is presently impossible.

		
Position of the building (on right of picture) in context: Narrow alley; congested area	View of north side of house. (Structure on right of picture is adjacent property.)	View of south east corner of house. (Adjacent building on the left)
		
Some cracking of plaster observed in only a couple of locations on ground floor.	Cracking in parapet at corner juction due to separation of orthogonal walls	First floor level. No visiable damage.
	Aerial view image taken from Google Earth showing location of house (outlined in white). Image indicates that building to west of the property in question may be a collapsed or unfinished structure (see yellow arrow). (This building to the west was not visited.) All other buildings immediately adjacent to building in question appear relatively secure. (Image date 25th Jan 2010.)	

Building Coordinates	Lat: N18° 31.210', Long: W72° 19.737'
Building Name:	Impasse Beauboeuf (Owner/Occupier: Josma Dieumete)
Site	Built up area with narrow alleyways. Sloping ground. Three storey building with little or no outdoor perimeter space.
Building Description	Three storey, incrementally built house. Each level built as a separate apartment at different dates. First part of building built in 1991. Last part of construction started in 2009. Foundations are stone masonry. Reinforced concrete frame with block and beam slabs. Unreinforced blockwork infill panels.
Assessment Findings	Cracking in plaster in a couple of locations on ground floor however no evidence of damage to structural elements. Crack in parapet on top floor (2nd floor) roof balcony.
Rating	GREEN
Recommendations	This property was marked GREEN on the day because of minimal evidence of damage to the structure and no evidence of imminent danger from adjacent structures. However the follow is noted: • The incremental nature of the construction of the building has added significant mass and has introduced some unusual geometry in the stair well to the north of the building. Local strengthening may be required and a qualified engineer should be able to advise on this. • Though there was no evidence of building being effected by buildings to the west and south, because of their proximity it is advised that the owner liaise with neighbours to understand the extent of any damage to their property and any plans for demolition/ reparation work to be done. It is noted that the owner was in the process of planning repairing the parapet at 2nd floor level at time of visit. It is recommended that for these repairs the alley below needs to be temporarily cordoned off in case there is danger of the parapet falling during the process of repair. The owner is advised to remove localised corner masonry at the junction and use new corner reinforcement link the two wall sides. Recommend capping masonry with a reinforced concrete band and intermediate columns to properly link the parapet to the roof slab Roof water proofing is required as otherwise roof steel will corrode.

		Aerial view image taken from Google Earth showing location of house (outlined in white). (2 other properties assesed in vacinity indicated in yellow dotted line.) (Image date 25th Jan 2010.)
		
View looking up the slope to the west of the house. (Building on right in picture is house adjacent to house in question.)	View of east side of house showing the single storey house (outlined in blue) at the top of a vertical retaining wall which is approximately 2 plus storeys high relative to the ground level in front of the wall.	Photo looking down at base of retaining wall – soft material with rocks easilly removed by kicking. No evidence of foundation construction.
		
View of west side of house.	View of south east elevation of house. No apparent lintel or wall ring beams	View of houses on adjacent slope. House in question on left in foreground of picture.
		
Temporary support to roof which is holding up the roof which is on the verge of collapse. (It is uncertain whether the roof condition was questionable before the event.)	Base of temporary support for roof.	Cracking of masonry at top of wall below timber capping member. Note that the lintel across the door inadeqaute.

Cracking in masonry above door opening. (Timber lintel over door.)

Cracking at the junction between the floor and the walls in the room to the east side of house which is directly above the retaining wall. Possible evidence of subsidance of the ground behind the retaining wall.

Building Coordinates	Lat: N18° 31.171', Long: W72° 20.659'
Building Name:	Impasse Eddy Prolongé (Owner/Occupier: Yolande Louis Jeune)
Site	Steep sloping ground. Terraces formed using stone masonry retaining walls. Relatively congested built up area given the steep topography. No obvious access for fire trucks.
Building Description	Single storey house built at the top of a stone masonry retaining wall (which approximates 2 stories in height). The house is incrementally built in plan with rooms added over time. Foundations of house appear to be stone masonry construction. Possibly reinforced concrete columns with unreinforced concrete block panels. Timber frame roof with metal roofing sheeting.
Assessment Findings	There is apparent settlement of the ground behind the retaining wall. There is also some evidence of minor cracking the in masonry walls. The roof structure in one room has failed and is on the verge of collapse. Retaining wall does not appear to be fissured however the base is easily undermined. There is evidence from aerial imagery of landslides in the vicinity. Interview with neighbour indicates this area prone to runoff from heavy rains draining down the slope (neighbours house had previously been destroyed in this manner and has been rebuilt.)
Rating	RED
Recommendations	Normally given the cracking observed within the building one would give this a YELLOW rating, however, given the hazards of the site, and, in particular, the uncertainty of the stability of the slope and retaining wall, this property is given a RED rating. (It is noted that the retaining wall has survived the earthquake.) In general the slopes stability in this area should be investigated. The retaining wall in question should be examined further. Investigations should include establishment of the base of wall. Remedial measures may be required to strengthen the wall and ensure its stability. This may include introduction of drainage through the wall etc. Drainage routing around the property needs to also be considered. Once the slope stability checked and retaining wall has been passed as OK the remedial work to the structure of the house should take place. This will involve removing the roof that is on the verge of collapse and any masonry which may be affected. Masonry replaced with new blocks and tie beam needs to be constructed at the top of the wall before building the new roof. It is recommended that the roof be of lightweight timber frame and metal sheeting construction and not a heavy roof which will add mass to the structure (and provide further surcharge behind retaining wall). Timber frame should be of good quality. Until investigations on wall are done and any necessary remedial works to wall and building are complete it is advised that access to the building is limited.

Aerial view image taken from Google Earth showing location of house (outlined in white). (2 other properties assesed in vacinity indicated in yellow dotted line.) (Image date 25th Jan 2010.)

View looking up the slope to the west of the house. (House on right of picture.)

View of east side of propert adjacent to house in question. The house in question is directly behind where the arrow is pointing. The adjacent property is a single store house at the top of retainingwall which is approximately 2 stories high.

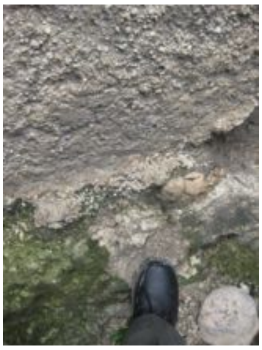
Photo looking down at base of retaining wall – soft material with rocks easilly removed by kicking.

View of houses on slope adjacent.

View of south elevation of house

Building Coordinates	Lat: N18° 31.173', Long: W72° 20.662'
Building Name:	Impasse Eddy Prolongé (Owner/Occupier: Destine Charls)
Site	Steep sloping ground. Terraces formed using stone masonry retaining walls. Relatively congested built up area given the steep topography.
Building Description	Single storey house built on terrace. The house is a single room abode. Foundations of house appear to be stone masonry construction. Masonry wall construction. Timber frame roof with metal roofing.
Assessment Findings	There is no apparent damage to this property from the earthquake. There is evidence of a little settlement behind the retaining wall which creates the terrace. The wall does not appear to be fissured however the base is easily undermined. There is evidence from aerial imagery of landslides in the vicinity. Interview with owner/occupier indicates this area prone to runoff from heavy rains draining down the slope - house had previously been destroyed in this manner and has been rebuilt.
Rating	YELLOW (However take into account the recommendations)
Recommendations	Given the hazards of the site, and, in particular, the uncertainty of the stability of the slope and retaining wall which forms the terraces, this property maybe founded on very weak foundations. Whilst in the immediate short term the property may be considered for usage, until a slope stability assessment is carried out it will not be known if there is a fundamental slop stability or terrace stability issue that would need to be taken care of. The retaining wall in question should be examined further. Investigations should include establishment of the base of wall. Remedial measures may be required to strengthen the wall and ensure its stability. This may include introduction of drainage through the wall etc. Drainage routing around the property needs to also be considered. Once the slope stability checked and retaining wall has been passed as OK this building can be rated as GREEN. It is possible that the studies establish problems with the site and the terraces and the risk of continuing living in this property would need to be re-evaluated.

Aerial view image taken from Google Earth showing location of house (outlined in white). (2 other properties assesed in vacinity indicated in yellow dotted line.) (Image date 25th Jan 2010.)

		
View looking up the slope to the west of houses on terace above house in question.	View of single storey house at top of terrace and approximately 2 storeys high retaining wall which forms the western boundary of the property.	Photo looking down at base of retaining wall – soft material with rocks easilly removed by kicking.
		
View of houses on slope adjacent.	View of front elevation of house	Evidence of minor cracking in the house.

Building Coordinates	Lat: N18° 31.170', Long: W72° 20.655'
Building Name:	Not available
Site	Steep sloping ground. Terraces formed using stone masonry retaining walls. Relatively congested built up area given the steep topography.
Building Description	Single storey house built at the base of a stone masonry retaining wall (which approximates 2 stories in height). The house is a single room abode with front covered area. Foundations of house appear to be stone masonry construction. Unreinforced concrete masonry panels. Timber frame roof with metal roofing.
Assessment Findings	There is apparent settlement of the ground behind the retaining wall (evident in property at top of the wall). Retaining wall does not appear to be fissured however the base is easily undermined. There is evidence from aerial imagery of landslides in the vicinity. Interview with owner/occupier in terrace above indicates this area prone to runoff from heavy rains draining down the slope (neighbours house had previously been destroyed in this manner and has been rebuilt.) Minor cracking in one wall panel.
Rating	YELLOW
Recommendations	Given the hazards of the site, and, in particular, the uncertainty of the stability of the slope and retaining wall which forms the terraces, this property maybe founded on very weak foundations. Whilst in the immediate short term the property may be considered for usage, until a slope stability assessment is carried out it will not be known if there is a fundamental slope stability or terrace stability issue that would need to be taken care of. The retaining wall in question should be examined further. Investigations should include establishment of the base of wall. Remedial measures may be required to strengthen the wall and ensure its stability. This may include introduction of drainage through the wall etc. Drainage routing around the property needs to also be considered. Once the slope stability checked and retaining wall has been passed as OK this building can be rated as GREEN. It is possible that the studies establish problems with the site and the terraces and the risk of continuing living in this property would need to be re-evaluated.

		Aerial view of Pacot (hamlet) from Google Earth (image date 25th January 2010). (Compund where interviews and assesment took place is circled.)
		
View at bottom of hill leading up to Pacot	House 1 in the compound (south west elevation)	House 1 in the compound (south west elevation)
		
House 1 in the compound. (South west elevation with detail of roof to column connection.)	House 1 in the compound. View of the north side of house. Masonry infill panels have failed and collapsed.	House 1 in the compound. View of South east of the house showing severe cracking in the masonry infill panel
		
House 2 in the compound. Apparently under construction	House 2 in the compound. Masonry walls which had been constructed collapsed. Temporary “walls” installed.	House 2 in the compound. Masonry walls failed. Two images showing the timber members resting against (and not propping) still standing stone masonry wall. (Corregated Iron structure in background still standing.)

	 
House 3 in the compound: no masonry walls	Other structures in the compound include a water tank which is relatively unscathed and corregated iron chicken coup which is still being used.
Building Coordinates	Lat: N18° 31.179', Long: W72° 20.656'
Building Name:	Rue Pacot Prolongéen, Haut Vieux Kay (Owner/Occupier: Oscar Pierre)
Site	Hillside semi rural community. Sloping ground with rocky outcrops.
Building Description	House 1: Built in 2003 according to the owner/occupier. Single storey 1-2 room house. Built on stone masonry foundations. Basic reinforced concrete columns unreinforced concrete masonry infill panels. Light weight timber frame roof with metal sheeting. House 2: Single storey house partially constructed. Evidence projecting reinforcement indicates possible plan to extend upwards in the future. Built on stone masonry foundations which are, according to the owner, built onto the rock. Reinforced concrete columns and reinforced concrete beams in places. Infill panels are a combination of either stone masonry or block masonry. House 3: Not inspected
Assessment Findings	Both Houses 1 and 2 have suffered critical failures. With collapse of perimeter walls and roof structure. Remaining walls are unstable. Foundations appear to be unaffected. It was evident that the owners have been proactive in building new shelters. With much of the original buildings having been tidied up by completing demolishing or similar. Nevertheless there are still risks associated with the remaining bits we were able to observe. Better hand tools would be of great help to this community who also have the benefit of having open land around their homes to make necessary adjustments
Rating	YELLOW for what we have seen – See recommendations Whilst the buildings might be strictly a RED, given the options these people have, saying to them that they cannot use any parts of their remaining properties is unlikely to be of help and at odds with their realities and desire to make the best out of what they do have. This does however leave them vulnerable to the effects of aftershocks or similar.
Recommendations	For houses 1 and 2 unstable masonry panels should be removed (or stabilised) This may mean the complete demolition of structure, as some concrete ring beams and concrete columns are fully embedded in the masonry panels and/or are too slender to support themselves. An alternative might be to provide temporary shoring to enable the remaining portions of the properties to be better supported against future lateral loads. Clearly, repairing these houses will be hard and it is likely that building new homes will be the best option for this community. However, the need for shelter is forcing them into using as much of the existing buildings they have. The issue is that to build a shelter people either need timber or some other type of structural member all of which are in very short supply. This is forcing people to reuse as much of the remaining poor quality reinforced concrete members as is possible. These houses do clearly demonstrate the difficulties of applying developed world standards to an environment where it is likely that even before the earthquake the houses may have been judged to be unsafe, though this is also hard to tell.

Appendix C

Orphanage and School

To	Rick Bauer (Oxfam GB)	Reference number	212323/KHG
cc	Jo da Silva	File reference	
From	Kathy Gibbs x61030 (Doha) Kubilay Hicyilmaz x 61351 (Dubai)	Date	21 March 2010
Subject	Haiti Damage Assessment of School and Orphanage facilities in Carrefour		

1 Introduction

Oxfam GB commissioned Arup to provide damage assessments for two community facilities, an orphanage and a school in the Carrefour area of Port-au-Prince, Haiti following the 12th January 2010 earthquake and subsequent aftershocks.

Cursory post-earthquake damage assessments were performed on 26th February, 2010 for the following two facilities:

1. Centre d'Acceuil de Carrefour
2. Lycée de Carrefour

This memo summarises the findings from these inspections.

1.1 Overview of Seismic Risk in Haiti

The earthquake evaluations below are based on whether the earthquake of January 12, 2010, or subsequent aftershocks, caused damage to the structure to significantly reduce its safety. **It is not intended to determine that the structure is 'safe'.** With the exception of a few isolated cases, very few of the structures in Haiti were deliberately designed or built to withstand potential earthquake forces.

The chance, however, of a structure experiencing partial or complete collapse in the event of an aftershock (assuming that the aftershock is of lower intensity than the initial earthquake at that location) is small if the structure was not compromised by the initial shock and had been close to the epicentre.

As stated earlier, a vast majority of the buildings in Haiti are not designed to withstand a large earthquake. This likely includes buildings rated 'Green' is this study.

This risk, however, needs to be balanced against other risks (e.g. security, shelter) and other objectives. The aim here is to provide guidance as to the most reasonable options assuming a certain level of base earthquake risk.

2 Assessment Overview

2.1 Items Inspected

In general, the following items were inspected where possible, visible, and applicable:

Overall Hazards:

- Collapse or partial collapse
- Building or story lean

Structural Hazards

- Foundations (where possible and/or visible)
- Roofs, floors (where possible)
- Columns, pilasters, corbels
- Diaphragms, horizontal bracing
- Walls, vertical bracing
- Precast connections

Non-Structural hazards

- Parapets, ornamentation
- Cladding, glazing
- Ceiling, light fixtures
- Interior walls, partitions
- Elevators
- Stairs, exits

Geotechnical Hazards

- Slope failure, debris
- Ground movement, fissures

2.2 Rating System

The inspections are based on an *Applied Technology Council, Post Earthquake Safety Evaluation of Buildings, ATC-20* guideline format. They are structural and non-structural damage evaluations only intended to provide an indication as to the level of damage sustained by the earthquake, not to provide information as to the earthquake safety of the building. They utilize the following rating system, based on ATC-20, and modified for this unique situation:

Green – The vertical and lateral load capacity of the structure does not appear to be significantly decreased by the earthquake or its aftershocks. Its ability to withstand an earthquake is likely similar to that before the January 12 earthquake. However, with reference to the background information above, rating a building 'Green' does not comment on the overall safety of the building. A 'Green' building may still be a collapse hazard in a strong earthquake.

Yellow – This structure has been damaged and its safety is questionable. A strong earthquake (including a strong aftershock) poses a collapse hazard. It is recommended that this building is not used for operation purposes, nor occupied. If a decision is made that based on other priorities (security, operations, general necessity to function etc...) this facility needs to be used, the following recommendations apply: It is recommended that the structure be used on a temporary basis only, as long as the occupants are aware of the risk that they undertake by going into the structure;

Red – The structure has been damaged by the earthquake and is unsafe. It is recommended that the structure be off-limits to everyone, even for short periods of time. The footprint around the building (to a distance equal to the height of the building) should be cordoned ('roped') off.

3 Assessment Summary

"ATC-20 Formulaire d'evaluation rapide de la securite des batiments" as apparently developed by the Government of Haiti have been completed for each of the buildings as shown the Appendices. In addition to this photo sheets have been prepared; the details are shown in Appendix Sections A1 for the orphanage and the school. The summary conclusions are presented in Table 1.

Table 1 Summary ATC 20 assessment for the five local NGO facilities.

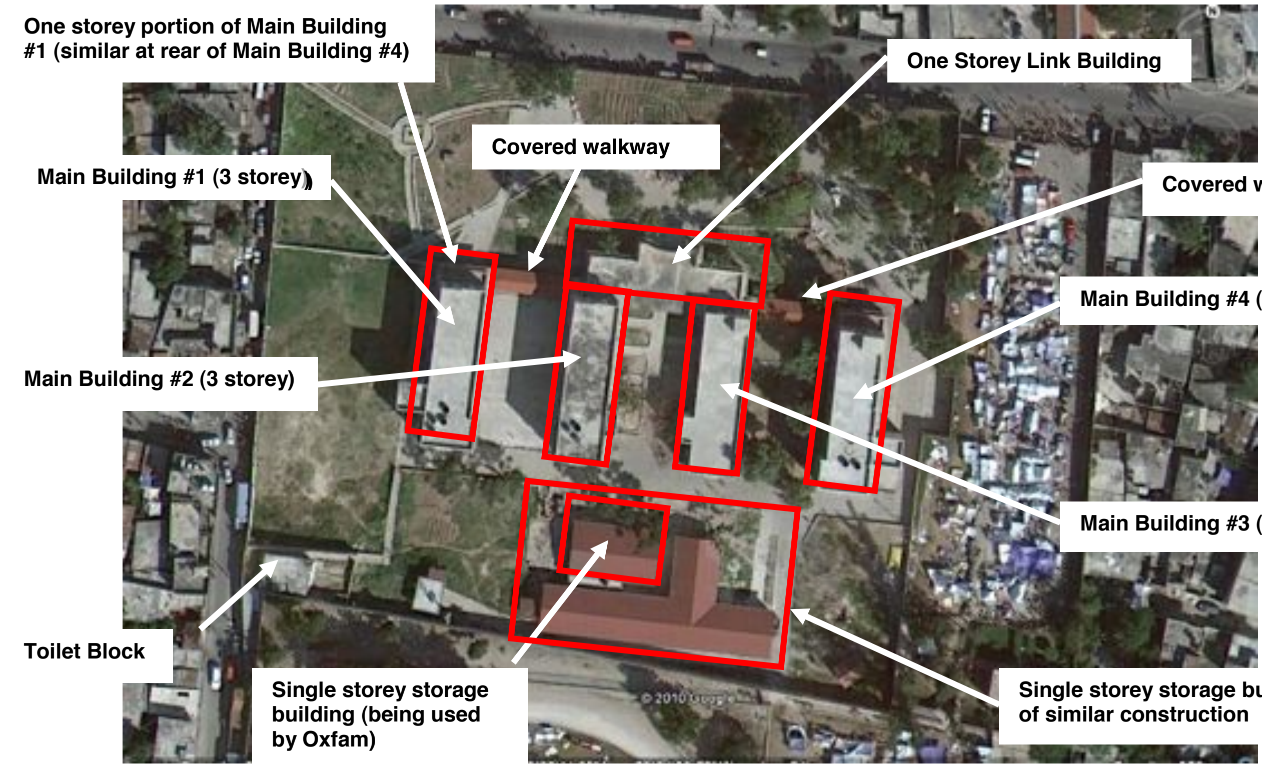
Local NGO Name	ATC-20 Assessment	Notes
Centre d'Acceuil de Carrefour – 4 Main Buildings	Yellow	See Appendix A3
Centre d'Acceuil de Carrefour - Single storey link building	Yellow	See Appendix A3
Centre d'Acceuil de Carrefour - Single storey Storage buildings	Green	See Appendix A3
Lycée de Carrefour	Yellow/Red	See Appendix A3

Note: Refer to Section 2.2 to put the rating system into context.

4 Conclusions and Recommendations

Based on this rapid assessment the following short term actions are recommended for each of the buildings.

Centre d'Acceuil de Carrefour – 4 Main Buildings	The main buildings are still standing and evidence of structural damage is limited. However it is noted that the structures will have been weakened by the event which is manifest in the manner of small cracking of the masonry walls. The embedded reinforced concrete frame appears udamged on the whole. The owner should do further investigations into the integrity of the overall structure of the main school buildings. This should include further assessment of the cracking in infill panels by removing plaster. Owner should consider strengthening to lower stories by reinforcing around openings. Repair/replace damaged internal partitions. Repair damage to column beam connection at link walkway at corner of Main Building #1. Ensure furniture and similar to be braced back to walls and egress corridors kept free. Limit all access to the roofs of buildings.
Centre d'Acceuil de Carrefour – Single Storey Link building	Though the damage to the link building appears to be in the infill masonry panels installed after original construction, the building owner should do further investigations into the integrity of the overall structure of the link building. Repair/replace damaged internal partitions.
Centre d'Acceuil de Carrefour – Single Storey storage buildings	These building appear to have fared well in the earthquake (light roof which appears to be well constructed with generous overhang over ring beams over the top of the masonry block walls. It would be advisable, in the short term, to use these facilities for any activities that can be feasibly carried out in these buildings until further investigations are carried out on the other buildings in the compound.
Lycée de Carrefour – Main Building	The corner classrooms to the eastern side must not be used until repaired. In these locations the corner concrete columns need immediate repair. The following procedure could be adopted: • Propping of roof and floor slabs and providing temporary bracing, • Removal of damaged block work panels, • Increasing the size of foundations for columns • Breaking out damaged concrete and cover concrete providing a new reinforcement cage around the old one (tied into the improved foundation), • Casting new (larger) column around old and de-propping once new column has reached adequate strength. Remove locally damaged masonry and replace with undamaged blocks. Secure block work which is not sufficiently restrained. Cordon off area around east side of building which need urgent attention. Owner should consider detailed structural review of rest of moment frame structure for strength and apply retrofit strengthening. Ensure furniture and similar is braced back to walls and egress corridors kept free.



Airial View of the compound where the Centre d'Acceuil de Carrefour is located. Image taken from Google Earth (image date 25th Jan 2010) with key plan details superimposed.

Rear view of Main Building #1 (3 storey). Stairwell (on right) added after construction of original building. Some minor cracking at junction between two constructions.

View of Main Building #2 (3 storey block) from central courtyard.

View of Main Building #3 (2 storey block) (Main Building #4 in background)

Note the significant horizontal reinforced concrete ring beam / sunshade to all the windows and the horizontal bands

Cracking in plaster of thick masonry wall. Seen typically at the ground floor levels for all Main Buildings.

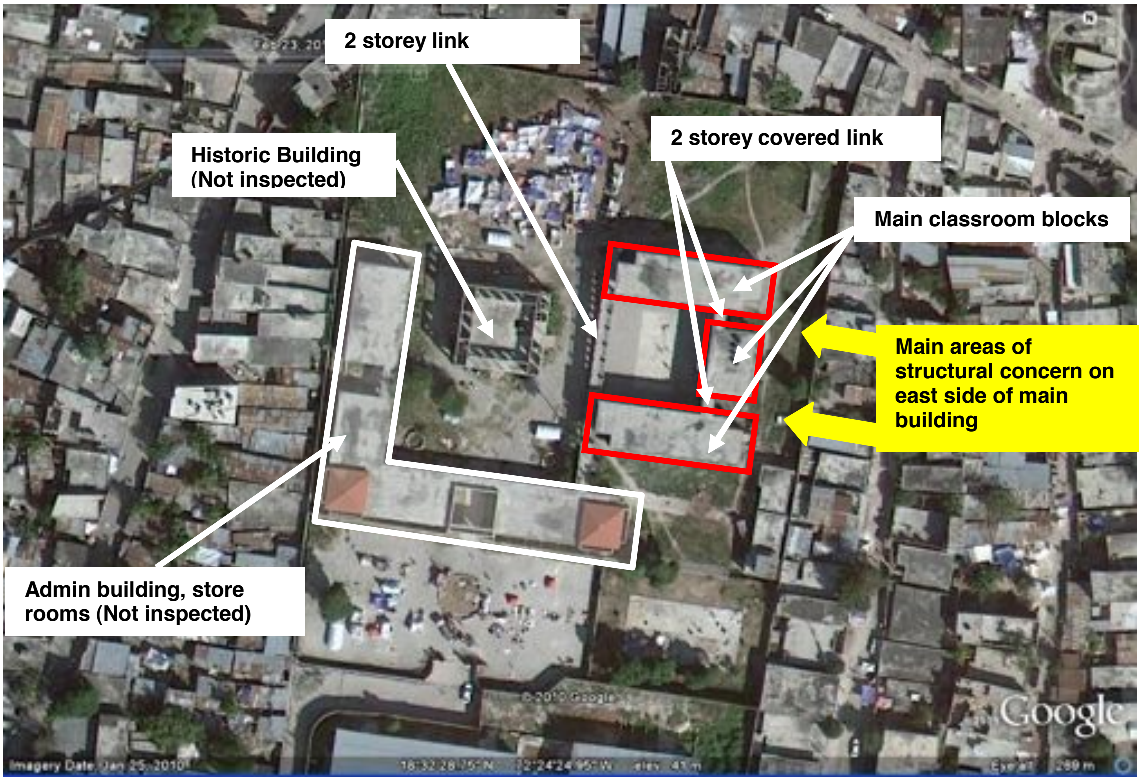
Investigation into composition of thick internal masonry wall (concrete block face dimension 200 mm x 50 mm) – the block/brick appears of solid construction type

Cracking at jucntion between infill masonry pannel (apparently installed after original construction) and original structure. (possible original opening highlighted by red dotted line.)

		
Cracking in masonry inful in stairwell of Main Building #3 (2 storey block). Not sure if this had occurred prior to the earthquake	Typical internal structure in main buidings: concrete floor slab supported by 400 mm square concrete columns. Thick masonry infil walls around the perimeter. No sign of damage to the concrete frame	Inside of hall on top storey of one of the main buildings.
		
View of building number 1 on left and covered link walkway.	Pull out type of damage at connection between column for single storey lean to and beam for covered link walkway due to differential movement between the building and the walkway cover.	No apparent damage to remainder of covered link walkway. Timber trusses are stock and appear well built
		
Roof of single storey link building – no apparent damage.	Cracking at junction between infill block masonry wall and concrete beam in link building. Infill panels put in after original construction for subdivision of rooms	Water tanks on one of the main buildings. The blue one was in same position before the Earthquake, the green one is new.
		
Water tanks at roof level of Main Building #2. Some damage to non structural blockwork around blue tank.	Single storey storage buildings. (Building number 1.)	Single storey storage buildings. (Building number 2.)

		
View of the 2 single storey storage buildings from above. No visible damage.	Another view of single storey storage buildings. No visible damage. Note tall perimeter fence with stone masonry base, reinforced concrete columns and horizontal bandbeams at half and full concrete block wall portion.	Toilet block not inspected as shut because of failure to foul frainage. From distance no apparent structural failure.

Compound Coordinates	Lat: N18°32.234 , Long: W72°24.387
Compound Name:	Centre D'Accueil de Carrefour (School – Orphanage and Oxfam facility for storage and cutting of plastic sheeting)
Site	Level ground in walled compound. 4 main school buildings linked by covered walkway and single storey link building. 2 single storey storage buildings. Outside toilet block and small out structures.
Building Description	Main Buildings (3 No 3 storey and 1 No 2 storey): Foundations (not visible), Reinforced concrete frame building with concrete slab and thick unreinforced solid masonry piers / infill. (the masonry looked of the solid variety) Link Building: Foundations (not visible), Single storey, reinforced concrete frame with concrete roof and unreinforced block work panels. Storage buildings: Single storey concrete frame buildings, block work infill panels with lightweight steelwork roof (Toilet Block: Not inspected in detail -Closed as foul drainage had failed. Other out buildings also not inspected)
Assessment Findings	Minor cracking to majority of masonry piers /panels in the exterior facade at ground floor level of main buildings. Some cracking of internal masonry walls. Damage to connection between one storey column and link walkway beam. Good regular shape, floor slab appears to be of solid concrete. Wide sunshade type ring beam above all lines of openings. Many full height masonry walls between classrooms. Concrete quality appears good
Rating	Main Buildings and Link Building: YELLOW Storage Building: GREEN
Recommendations	Main Buildings: The main buildings are still standing and evidence of structural damage is limited. However it is noted that the structures will have been weakened by the event which is manifest in the manner of cracking of the masonry walls. The owner should do further investigations into the integrity of the overall structure of the main school buildings. This should include further assessment of the cracking in infill panels by removing plaster. Owner should consider strengthening to lower stories by reinforcing around openings by adding a strong frame and cross bracing for example. Repair/replace damaged internal partitions. Repair damage to column beam connection at link walkway at corner of Main Building #1. Ensure tall furniture and similar are anchored / bolted to walls and egress corridors kept free. Limit all access to the roofs of buildings (parapets are not tall) Link Building: Though the damage to the link building appears to be in the infill masonry panels installed after original construction, the building owner should do further investigations into the integrity of the overall structure of the link building. Repair/replace damaged internal partitions. Storage Buildings: These building appear to have fared well in the earthquake. It would be advisable, in the short term, to use these facilities for any activities that can be feasibly carried out in these buildings until further investigations are carried out on the other buildings in the compound.



Aerial View of Lycée de Carrefour taken from Google Earth (image date 25th Jan 2010) with key plan details superimposed.

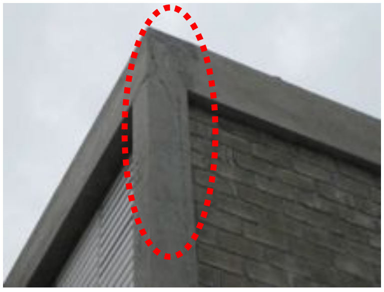
View of central courtyard from south classroom block

View of wester link walkway

Eastern end of the south classroom block with covered link on right of photo.

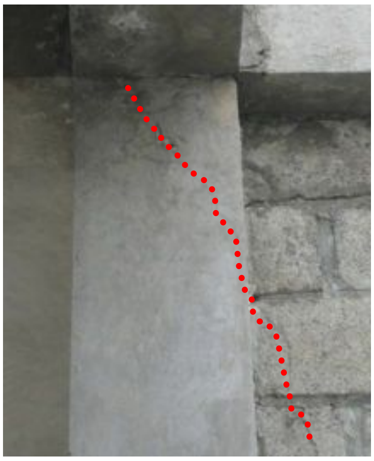
Shearing of top of corner column on east end of south block. Cracking in the infill masonry panel.

View of masonry cracking from inside of classroom



Similar cracking of concrete in corner column of north block

Columns are relatively small in size. Reasonable possibility that the masonry infill wall acted as a strut and was stronger than the column / beams. Observed construction practice means that the beam column joint probably does not have any confinement reinforcement and was particularly vulnerable to the forces imparted by the masonry struts.



Hairline crack propagating through column and block work. (Indicated by red dotted line.)

Cracking in non-structural masonry panels caused by stress concentration at sill level occurring adjacent to most class entrances.

Cracking in concrete slab at junction between covered link and class block

View of “brise soleil” (?) structures on south facade of south classroom block appear undamaged. Unclear if down pipe was damaged during earthquake.

Block cladding to column fell off exposing concrete column.

View of historic building which was being restored and extended before the earthquake.

Building Coordinates	Lat: N18°32.474 , Long: W72°24.422
Building Name	Lycée de Carrefour
Site	Located on relatively level ground.
Building Description	Main School Building: Foundations appear to be stone masonry – founding level not apparent. Superstructure is 2 stories and consists of reinforced concrete slabs and roof supported by reinforced concrete moment frame with infill block masonry wall panels. (Other buildings in compound were not accessed but appeared to be generally of concrete and masonry construction.)
Assessment Findings	Cracking evident in moment frame in top storey, particularly at the eastern corners of the classroom blocks. In these areas evidence of cracking infill masonry panels. Regular cracking in non-structural masonry panels adjacent to entrances to classrooms due to poor detailing and the existence of un anticipated load paths.
Rating	YELLOW (with RED for the corner classrooms on east side)
Recommendations	The corner classrooms to the eastern side must not be used until repaired. In these locations the corner concrete columns need immediate repair. The following procedure could be adopted: • propping of roof and floor slabs and providing temporary bracing, • removal of damaged blockwork panels, • increasing the size of foundations for columns • breaking out damaged concrete and cover concrete providing a new reinforcement cage around the old one (tied into the improved foundation), • casting new (larger) column around old and de-propping once new column has reached adequate strength. Remove locally damaged masonry and replace with undamaged blocks. Secure blockwork which is not sufficiently restrained. Cordon off area around east side of building which need urgent attention. Owner should consider detailed structural review of rest of moment frame structure for strength and apply retrofit strengthening. Ensure furniture and similar is braced back to walls and egress corridors kept free.

Appendix D

NGO Facilities

To	Rick Bauer (Oxfam GB)	Reference number 212323/KMOH	
cc	Jo da Silva	File reference	
From	Kubilay Hicyilmaz x 61351 (Dubai) Kathy Gibbs	Date 1 March 2010	
Subject	Haiti Damage Assessment of Local NGO facilities		

1 Introduction

Oxfam GB commissioned Arup to provide damage assessments to 5 buildings used by local Haitian NGOs in and around the earthquake damage area of Port au Prince, Haiti following the January12 2010 earthquake and subsequent aftershocks.

Cursory post-earthquake damage assessments were performed on 27th February 2, 2010 for the following local NGOs

1. COZPAN – OFFICE
2. COZPAN – School/Office
3. Friendship
4. JEZI Muhamed Bilal
5. OCHAN

A 6th building was inspected for Aprosifa on the 4th March 2010.

This memo summarises the findings from these inspections.

1.1 Overview of Seismic Risk in Haiti

The earthquake evaluations below are based on whether the earthquake of January 12, 2010, or subsequent aftershocks, caused damage to the structure to significantly reduce its safety. **It is not intended to determine that the structure is 'safe'.** With the exception of a few isolated cases, very few of the structures in Haiti were deliberately designed or built to withstand potential earthquake forces.

The chance, however, of a structure experiencing partial or complete collapse in the event of an aftershock (assuming that the aftershock is of lower intensity than the initial earthquake at that location) is small if the structure was not compromised by the initial shock and had been close to the epicentre.

This risk, however, needs to be balanced against other risks (e.g. security) and program objectives. The aim here is to provide guidance as to the most reasonable options assuming a certain level of base earthquake risk.

1.2 Current Predicted Seismological Risk

The United States Geological Survey (USGS) released the website page - *Issues Assessment of Aftershock Hazards in Haiti (Released: 1/21/2010 5:49:20 PM).*

(http://www.usgs.gov/newsroom/article.asp?ID=2385). See Appendix A. In this release they provide the following aftershock predictions:

"The sequence from the Port-au-Prince earthquake continues to be very strong and active. Based on this activity and the statistics of aftershock sequences, our estimate for aftershock activity during a 30-day period beginning January 21, 2010, is as follows:

The probability of one or more earthquakes of magnitude 7 or greater is less that 3 percent.

The probability of one or more earthquakes of magnitude 6 or greater is 25 percent.

The probability of one or more earthquakes of magnitude 5 or greater is about 90 percent.

Approximately 2 to 3 aftershocks of magnitude 5 or greater are expected within this time period.

Precautions: Any aftershock above magnitude 5.0 will be widely felt and has the potential to cause additional damage, particularly to vulnerable, already damaged structures. "USGS 2010"

It is also noted in the same document:

This implies that the Enriquillo fault zone near Port-au-Prince still stores sufficient strain to be released as a large, damaging earthquake during the lifetime of structures built during the reconstruction effort. In historic times, Haiti has experienced multiple large earthquakes, apparently on adjacent faults.

As stated earlier, a vast majority of the buildings in Haiti are not designed to withstand a large earthquake. This likely includes buildings rated 'Green' is this study.

2 Assessment Overview

2.1 Items Inspected

In general, the following items were inspected where possible, visible, and applicable:

Overall Hazards:

- Collapse or partial collapse
- Building or story lean

Structural Hazards

- Foundations (where possible and/or visible)
- Roofs, floors (where possible)
- Columns, pilasters, corbels
- Diaphragms, horizontal bracing
- Walls, vertical bracing
- Precast connections

Non-Structural hazards

- Parapets, ornamentation
- Cladding, glazing
- Ceiling, light fixtures
- Interior walls, partitions
- Elevators
- Stairs, exits

Geotechnical Hazards

- Slope failure, debris
- Ground movement, fissures

2.2 Rating System

The inspections are based on an *Applied Technology Council, Post Earthquake Safety Evaluation of Buildings, ATC-20* guideline format. They are structural and non-structural damage evaluations only intended to provide an indication as to the level of damage sustained by the earthquake, not to provide information as to the earthquake safety of the building. They utilize the following rating system, based on ATC-20, and modified for this unique situation:

Green – The vertical and lateral load capacity of the structure does not appear to be significantly decreased by the earthquake or its aftershocks. Its ability to withstand an earthquake is likely similar to that before the January 12 earthquake. However, with reference to the background information above, rating a building 'Green' does not comment on the overall safety of the building. A 'Green' building may still be a collapse hazard in a strong earthquake.

Yellow – This structure has been damaged and its safety is questionable. A strong earthquake (including a strong aftershock) poses a collapse hazard. It is recommended that this building is not used for operation purposes, nor occupied. If a decision is made that based on other priorities (security, operations, general necessity to function etc...) this facility needs to be used, the following recommendations apply: It is recommended that the structure be used on a temporary basis only, as long as the occupants are aware of the risk that they undertake by going into the structure;

Red – The structure has been damaged by the earthquake and is unsafe. It is recommended that the structure be off-limits to everyone, even for short periods of time. The footprint around the building (to a distance equal to the height of the building) should be cordoned ('roped') off.

3 Assessment Summary

"ATC-20 Formulaire d'evaluation rapide de la securite des batiments" as apparently developed by the Government of Haiti have been completed for each of the buildings as shown the Appendices. In addition to this a one page photo sheet has been prepared; the details are shown in Appendix Sections A1 to A5. The summary conclusions are presented in Table 1.

Table 1 Summary ATC 20 assessment for the five local NGO facilities.

Local NGO Name	ATC-20 Assessment	Notes
COZPAN – OFFICE	Green	See Appendix Section A1
COZPAN – School/Office	Yellow	See Appendix Section A2
Friendship	Red	See Appendix Section A3
JEZI Muhamed Bilal	Red	See Appendix Section A4
OCHAN	Red	See Appendix Section A5
APROSIFA	Green, Green, Yellow	See Appendix Section A6

Note:

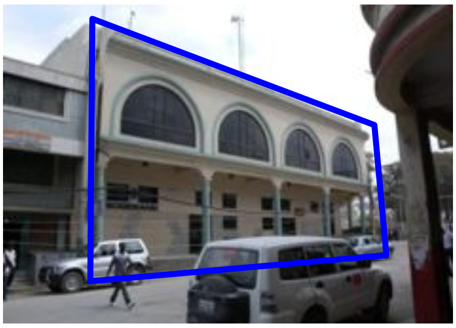
Refer to Section 2.2 to put the rating system into context.

4 Conclusions and Recommendations

Based on this rapid assessment the following short term actions are recommended for each of the buildings.

COZPAN - OFFICE	Recommend that building owner is asked to repair the damaged masonry infill on the first floor Building owner should be in discussions with neighbours about the conditions of the adjacent buildings and any future plans for reparations to and/or demolition of those adjacent buildings Furniture and similar to be braced back to walls and egress corridors kept free Low hanging power and communication cables pose an entry and exit hazard – in normal circumstances this would be reason to post a "Yellow" restricted entry rating.
COZPAN – School/Office	Remove locally damaged masonry and replace with undamaged blocks. Provide ring beam (timber or concrete) to unrestrained masonry blocks to prevent falling hazard. Cordon off area around damaged perimeter walls which needs urgent attention – requires new corner foundation and existing wall portions to be tied in or wall to be demolished and rebuilt. Provide horizontal roof bracing to introduce a diaphragm to enable orthogonal walls to support each other.
FRIENDSHIP (Rue Marcelin)	Reinforced lean too can probably be salvaged assuming demolition of old original building is undertaken carefully. Significant amounts of building material could be salvaged (especially timber). Out house – rebuild with lintel / roof level ring beam.
JEZI MuHAMED BILAL	All activities within this building are to be stopped with immediate effect. Removal of furniture or similar to be done with utmost caution given the circumstances. All tents or similar below the building within the grounds to be moved as there is a real possibility of the building collapsing and falling and rolling towards them.
OCHAN	Demolish remaining structure – salvage material and ensure that a proper foundation is built. (existing columns are poor quality and should not be relied up on)
APROSIFA	It would be sensible to remove the screed on the first floor and apply a thinner but properly made screed to reduce the weight of the building. The cracked tiles are a source of dirt and replacing these would be a prudent measure anyway. Damaged masonry can be readily repaired. Steel rebar on spalled column should be cleaned and patched with high quality sand cement mix. Under no circumstances should any additional floors be added in the future Garage, stub beam next to main building can be cut to create a seismic gap – this will avoid future pounding issues. Small side house, separating walls to be stitched together. Ring beam required at the top of the walls. Prior to attaching the roof structure. Neighbouring, taller building could pose a hazard – discussions should be help with them as their structure, especially the last floor appears of poor quality and is nearly over the inspected building. There may be a benefit on the neighbour removing the most recent top extension on their building.

APPENDIX SECTION A1 – COZPAN OFFICE

		
Small adjacent building posing pounding hazard albeit a lighter structure.	COZPAN offices in the 1st floor	Weakend adjacent bank building – poses a pounding hazard beyond what has already occured.
		
Construction photos made available by the owner showing foundation construction	Beams do not align centrally with the columns introducing additional torsion	Expansion joint with double columns – The gap is only a thermal movement joint and not a seismic Gap joint – but no indication of structural damage at the movement joint location
		
Central staircase with light metal roof in approximately the middle of the building	Cracking in non structural infill over staircase	Foundation construction excavation to competent ground (more than 2m deep excavation)

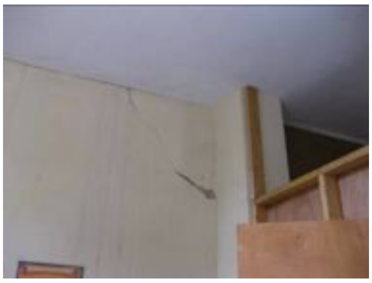
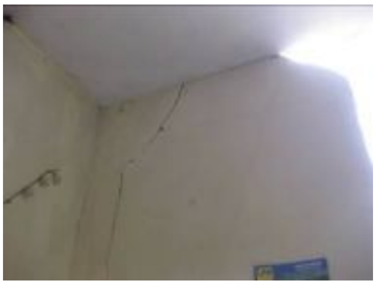
Building Coordinates	Lat: N18°32.804, Long: W72°20.365
Building Name:	COZPAN – OFFICE (inspection date 27 Feb 2010)
Site	Level ground in dense urban setting. Low lying power cables at the building entrance pose a hazard to a safe building entry.
Building Description	Reinforced concrete foundations for a concrete moment frame building with concrete slab and unreinforced block work infill masonry. Flat slab roof with small section of light metal roof with CGI sheets.
Assessment Findings	Some cracking to non-structural infill partitions near the stairs at the front entrance to the building. 1st floor (where COZPAN offices are) had corner cracks to the front masonry wall running parallel to the road next due to the large window. Columns and beams did not show any signs of distress. Urban setting so adjacent building adequacy must be considered - though pounding damage appeared minimal.
Rating	Green (note comment about street cables)
Recommendations	Recommend that building owner is asked to repair the damaged masonry infill on the first floor Building owner should be in discussions with neighbours about the conditions of the adjacent buildings and any future plans for reparations to and/or demolition of those adjacent buildings Furniture and similar to be braced back to walls and egress corridors kept free Low hanging power and communication cables pose an entry and exit hazard – in normal circumstances this would be reason to post a “Yellow” restricted entry rating.

APPENDIX SECTION A2 – COZPAN SCHOOL/OFFICE

		
COZPAN Building location	Original construction of reinfored concrete frame and unreonforced block work infill with concrete roof slab	Lean to extension of unreinforced concrete block masonry with light metal roof
		
Outside Kitchen and Latrines made of unreinforced blocks next to main building	Rear view to the Building	Elevation of lean to extension view from courtyard
		
Damaged perimeter wall – corner column was not anchored to and it failed – remaining masonry wall is vulnerable to falling even by pushing it	Neighbours building facing on to the court yard appearing undamaged from this side	Falling hazard of unrestrained perforated blocks

Building Coordinates	Lat: N18°31.403 ,Long: W72°21.065
Building Name	COZPAN – School/Office (inspection date 27 Feb 2010)
Site	Located on steep slope, built with stone masonry terrace walls
Building Description	Original building constructed on (possibly undressed) stone masonry with reinforced concrete columns, infill block masonry and reinforced concrete roof. Two lean to extensions have been added, the larger one being about 1m lower down, both with light metal roof trusses and CGI sheets. Basic steel trusses appear connected to the blocks with a partial concrete band beam or light steel lative truss
Assessment Findings	RC frame of original part appears undamaged. Lean too structures have small partial diagonal cracks in a few locations over doors.
Rating	YELLOW (but nominal repairs will enable this building to be reintroduced into use.)
Recommendations	Remove locally damaged masonry and replace with undamaged blocks. Provide ring beam (timber or concrete) to unrestrained masonry blocks to prevent falling hazard. Cordon off area around damaged perimeter walls which needs urgent attention – requires new corner foundation and existing wall portions to be tied in or wall to be demolished and rebuilt. Provide horizontal roof bracing to introduce a diaphragm to enable orthogonal walls to support each other.

APPENDIX SECTION A3 - FRIENDSHIP

		
Masonry & timber construction	View of timber framed roof	Rubble stone masonry wall
		
Solid clay brick masonry wall	Lean to extension of reinforced concrete and masonry blocks	Separation of infill and concrete frame with damage to infill
		
Out house with unstable wall	Internal corner cracks in the lean too extension	Internal corner cracks in the lean too extension

Building Coordinates	Lat: N18°32.143, Long: W72°20.075
Building Name	Friendship (Rue Marcelin) (inspection date 27 Feb 2010)
Site	Level ground in predominantly residential area with garden.
Building Description	Original building is unreinforced stone and solid brick masonry with timber trusses. Probably 2 storeys with loft space. Lean too is reinforced concrete frame and unreinforced block masonry – not bonded to original structure. Unreinforced block work with light metal roof, 1 storey
Assessment Findings	Original building is destroyed. Reinforced concrete lean to has infill masonry damage
Rating	RED (Extension is yellow assuming recommendations are done)
Recommendations	RED (Extension is yellow assuming recommendations are done)
	Reinforced lean too can probably be salvaged assuming demolition of old original building is undertaken carefully. Significant amounts of building material could be salvaged (especially timber). Out house – rebuild with lintel / roof level ring beam.

APPENDIX SECTION A4 – JEZI MUHAMED BILAL

Rear view. Corner soft storey with damage to corner columns. Slight twist to the corner

Staircase damaged and appears to be disconnected from the floor slab

Building has moved away from the external stairs

View of top level from front of house

Internal view of extensive non-structural damage.

Extensive damage to masonry walls

Rear view showing damage to masonry

Serious floor damage with cracks appearing in a number of locations in lines

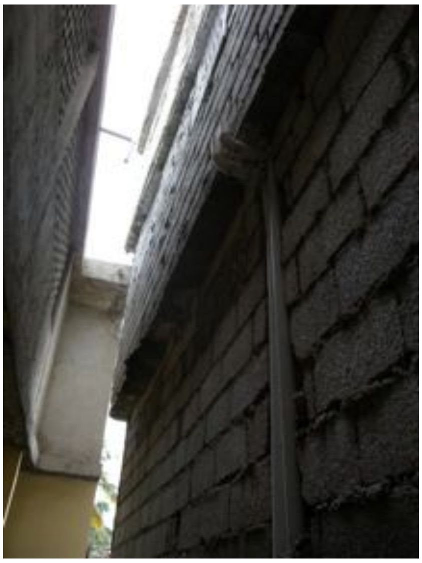
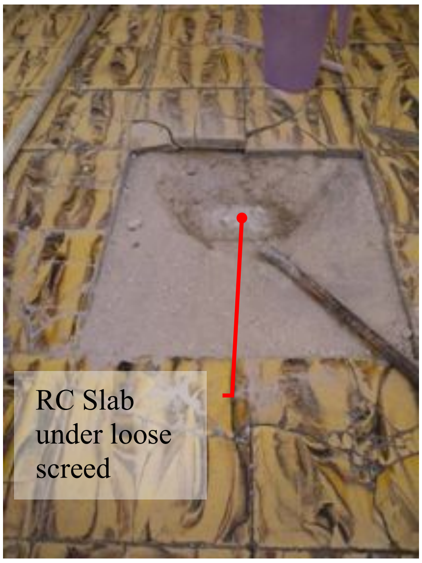
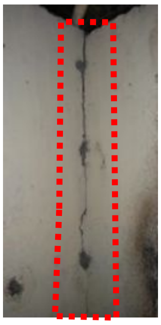
Floor slab material appears to be little more than loose sand and gravel

Building Coordinates	Lat: N18°31.718, Long: W72°20.493
Building Name	JEZI Muhamed Bilal(inspection date 27 Feb 2010)
Site	Predominantly residential area, building on slope in two directions away from the road.
Building Description	Reinforced concrete frame with masonry infill and light metal roof at top level. Building consists of lower ground level, upper ground level, and covered balcony extension on roof
Assessment Findings	Extensive damage, building twist, floor appear to have disintegrated, light metal roof appears reasonable though.
Rating	RED
Recommendations	All activities within this building are to be stopped with immediate effect. Removal of furniture or similar to be done with utmost caution given the circumstances. All tents or similar below the building within the grounds to be moved as there is a real possibility of the building collapsing and falling and rolling towards them.

APPENDIX SECTION A5 - OCHAN

		
Minimal reinforced concrete frame	Roof has been removed, possibly used for baricading the remaining building	Timber ring beam rebar strapping
		
Spindly internal column	Damaged stair cases	Adjacent house – may pose hazard to this site. State of this house has not been assessed

Building Coordinates	Lat: N18°31.553, Long: W72°20.211
Building Name	OCHAN(inspection date 27 Feb 2010)
Site	On top of a ridge with poor quality stone masonry terraces – ridge appears covered in soil and no obvious visible rock to found the buildings on.
Building Description	Simple reinforced concrete frame – infill either fell out or have been removed
Assessment Findings	There is no building to talk of.
Rating	RED
Recommendations	Demolish remaining structure – salvage material and ensure that a proper foundation is built. (existing columns are poor quality and should not be relied up on)

		
General side view	Front view showing independant concrete frame car port structure with infil masonry in one direction only	General view on on the firsy floor indicating walls and columns
		
Proximity of neighbouring house. Which has been built incrementally upwards – although very close in places there was no visual evidence of any pounding between the buildings	Reinforced concrete slab under the screed which is effectively loose sand, gravel and small pebbles.	Spalling of concrete on one column. Reinforcement looks as if it has rusted, indicating possible long term exposure. Bars or links do not appear damaged
		 
Back of the main building with covered space – Soft storey appearance is limited what is shown on the photo	Pounding damage between the garage and the main building structure. Stub end of garage to be cut	Small, two room hollow block masonry structure with light roof– walls have not been bonded and are coming apart – repair possible

Building Coordinates	Readings not taken
Building Name	APROSIFA (inspection date 3 March 2010)
Site	Predominantly residential area, building on slope in one direction.
Building Description	Reinforced concrete frame (mainly in the building long direction) with unreinforced hollow block masonry infill and a concrete floor and roof. Garage is structurally independent from the main building – There is no seismic gap which has led to some nominal pounding damage. Light metal roof over the garage. Potential for short storeys do exist by the perforated construction methodology that has been adopted. However there is no evidence of any shear damage to the columns. Garage is a RC frame in one direction with block work in fill in the same direction as the frame – Lateral system in the cross direction is nominal but this does not seem to have adversely affected the building
Assessment Findings	Some minor cracking to infill walls at the lower level. One column has cover concrete spalled but it should be noticed that this is non representative, corrosion damage is more likely the cause of the cover falling off. There is some cracking across door lintel beams but these appear old and this was confirmed by the present occupants. Damaged masonry infill can be readily repaired, either by patching up or removing the damaged sections and replacing with new blocks. Floor screed is of very poor quality – and floor tiles are loose. Small side house (unreinforced block masonry with light roof) has suffered from separation at orthogonal wall junctions.
Rating	GREEN for the main Building and garage structure. YELLOW for the small side house
Recommendations	It would be sensible to remove the screed on the first floor and apply a thinner but properly made screed to reduce the weight of the building. The cracked tiles are a source of dirt and replacing these would be a prudent measure anyway. Damaged masonry can be readily repaired. Steel rebar on spalled column should be cleaned and patched with high quality sand cement mix. Under no circumstances should any additional floors be added in the future Garage, stub beam next to main building can be cut to create a seismic gap – this will avoid future pounding issues. Small side house, separating walls to be stitched together. Ring beam required at the top of the walls. Prior to attaching the roof structure. Neighbouring, taller building could pose a hazard – discussions should be help with them as their structure, especially the last floor appears of poor quality and is nearly over the inspected building. There may be a benefit on the neighbour removing the most recent top extension on their building.

Appendix E

Warehouses

Oxfam GB

Post Earthquake Damage Inspections

Warehousing

Oxfam GB

Post Earthquake Damage Inspections

Warehousing

March 2010

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Job number 212323

ARUP

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Issue Document Verification with Document ✓

Contents

1 Introduction

Oxfam GB commissioned Arup to provide damage inspection s to two warehouses in and around the earthquake damage area of Port au Prince, Haiti following the 12th January 2010 earthquake and subsequent aftershocks.

Post-earthquake damage assessments was performed for one warehouse units that we have called "Cowley" for the purposes of this report. This warehouse was inspected on the 3rd of March 2010 for the purpose of understanding if from a structural safety perspective the facility could be rented by Oxfam as part of their logistics warehousing requirements.

The location of the facility is shown in Figure 1 and Figure 2.

Latitude: 18°34'3.92"N, Longitude: 72°18'14.47"W

Figure 1 Arial views of where the Cowley warehouse location is

Figure 2 Walk around views of the warehouse exterior

This memo summarizes our findings. Our recommendations are presented at the end of this memo.

1.1 Overview of Seismic Risk in Haiti

The earthquake evaluations below are based on whether the earthquake of January 12, 2010, or subsequent aftershocks, caused damage to the structure to significantly reduce its safety. **It is not intended to determine that the structure is 'safe'.** As stated above, with the exception of a few isolated cases, very few of the structures in Haiti were deliberately designed or built to withstand potential earthquake forces.

The chance, however, of a structure experiencing partial or complete collapse in the event of an aftershock (assuming that the aftershock is of lower intensity than the initial earthquake at that location) is small if the structure was not compromised by the initial shock and had been close to the epicentre.

This risk, however, needs to be balanced against other risks (e.g. security) and program objectives. The aim here is to provide guidance as to the most reasonable options assuming a certain level of base earthquake risk.

1.2 Inspection Methodology

The inspections are based on an *Applied Technology Council, Post Earthquake Safety Evaluation of Buildings, ATC-20* guideline format. They are structural and non-structural damage evaluations only intended to provide an indication as to the level of damage sustained by the earthquake, not to provide information as to the earthquake safety of the building. They utilize the following rating system, based on ATC-20, and modified for this unique situation:

Green – The vertical and lateral load capacity of the structure does not appear to be significantly decreased by the earthquake or its aftershocks. Its ability to withstand an earthquake is likely similar to that before the January 12 earthquake. However, with reference to the background information above, rating a building 'Green' does not comment on the overall safety of the building. A 'Green' building may still be a collapse hazard in a strong earthquake.

Yellow – This structure has been damaged and its safety is questionable. A strong earthquake (including a strong aftershock) poses a collapse hazard. It is recommended that this building is not used for operation purposes, nor occupied. If a decision is made that based on other priorities (security, operations, general necessity to function etc...) this facility needs to be used, the following recommendations apply: It is recommended that the structure be used on a temporary basis only, as long as the occupants are aware of the risk that they undertake by going into the structure;

Red – The structure has been damaged by the earthquake and is unsafe. It is recommended that the structure be off-limits to everyone, even for short periods of time. The footprint around the building (to a distance equal to the height of the building) should be cordoned ('roped') off.

The site inspection to the warehouses was performed on the 28th February 2010.

1.3 Available Information

The only information available was a 30minute visual inspection and some limited discussions with the building owner.

It is understood that earthquake engineering was undertaking a detailed structural assessment of the facility; however, this information was not available at the time of the site visit.

It is not believed that the facility was originally designed for earthquake loads.

1.4 Building Characteristics

The warehouse is on reasonable level ground.

The ware house is made up of 5 structural components.

Part 1 – Reinforced concrete frame with an intermediate RC mezzanine level with a light metal roof consisting of two roof trusses

Part 2 – Reinforced concrete columns with light steel roof trusses and a partially connected one storey office

Part 3 – Reinforced concrete columns with light steel roof trusses and a partially connected one storey office

Part 4 – Single storey reinforced concrete frame building with unreinforced masonry infill walls.

Part 5 – Single storey unreinforced masonry building that is structurally independent of the warehouse building.

The warehouse components of Parts 1 to 3 do have movement joints in them but are structurally connected by the roof. In other words, there is no seismic gap between the building components as would be expected between structurally independent building components.

The warehouse structure consists of perimeter reinforced concrete columns on to which steel trusses are connected at the top. There was no obvious lateral load resisting system in the building apart from the cantilever capacity of the columns. Perimeter infill masonry walls will have provided some degree of lateral resistance but it is not thought that this would have been a deliberate design feature. It is likely that unreinforced hollow concrete blocks were used to provide the perimeter walling between the columns.

Figure 3 Building parts of the ware house.

Movement Joint locations

2 Assessment Overview

2.1 Items Inspected

In general, the following items were inspected where possible, visible, and applicable:

Overall Hazards:

- Collapse or partial collapse
- Building or story lean

Structural Hazards

- Foundations (where possible and/or visible)
- Roofs, floors (where possible)
- Columns, pilasters, corbels
- Diaphragms, horizontal bracing
- Walls, vertical bracing
- Precast connections

Non-Structural hazards

- Parapets, ornamentation
- Cladding, glazing
- Ceiling, light fixtures
- Interior walls, partitions
- Elevators
- Stairs, exits

Geotechnical Hazards

- Slope failure, debris
- Ground movement, fissures

3 Inspection Findings

Short column effects have severly damaged the vertical load carying capacity of the building.

Figure 4 Near total collapse Part 1 of the warehouse, Assessment = RED

The roof is continuous across Parts 1 to 3 of the warehouse.

Figure 5 Part 2 of the warehouses with significant damage to columns due to partial collapse of Part 1, Assessment = RED

<table>
<tr><td>
</td><td>Loading dock on the left hand image with light metal canopy with no obvious signs of earthquake damage.

Middle images showing the perimeter reinforced concrete frame with no obvious signs of earthquake damage</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td>Vertical bracing between roof trusses

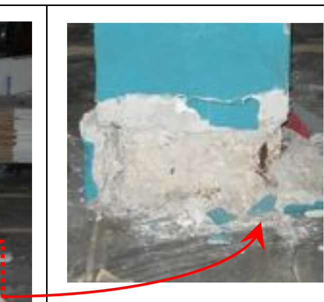
Tiny tension only roof cross bracing that is loose and it will be ineffective under wind or earthquake loads.</td></tr>
<tr><td></td><td> 
Slightly buckled main column reinforcement</td></tr>
<tr><td colspan="2">Figure 6 Part 3 of the warehouse with damage to the top and bottom of the central columns in the direction of the gutter beam, Assessment = YELLOW</td></tr>
</table>

Figure 7 Part 4, single storey reinforced concrete frame with unreinforced masonry infill.
The concrete frame appears undamaged. However, there are significant cracks in the infill.

It is not known if the single storey office part is attached to the warehouse perimeter columns.

Assessment = YELLOW

Exterior view of the utility rooms (generators and similar) on the side of the warehouse building.

Figure 8 Part 5, single storey unreinforced masonry construction with light timber roof with metal roof sheeting.
Separation has occurred between the warehouse and the masonry part along the movement joint (which had been plastered over) however, there did not appear to be any other significant damage.

Pounding damage to the warehouse columns does not appear to have been done due to the light weight roof of the single storey side building.

Assessment = GREEN but nobody from Oxfam needs to use this space.

Figure 9 Perimeter wall being repaired to secure the warehouse site.

4 Conclusion and Suggestions

The warehouse building has suffered damage due to the earthquake and it has been weekend. Part 1 of the warehouse has suffered extensive damage and is probably best demolished. A summary of the assessments are shown in the Table 1.

Table 1 ATC-20 Assessment results

Building Part	Assessment Rating
Part 1	RED
Part 2	RED
Part 3	YELLOW
Part 4	YELLOW
Part 5	GREEN

However, given the circumstances, and the difficulty in finding good quality, structurally safe warehousing for Oxfam's operations the following suggestions are made to manage the risk of potentially using this warehouse.

Whilst not ideal Part 3 of the warehouse has the greatest potential to be utilised. Actions that one would expect the building owner to do for this to be considered are outlined below:

- Detach the roof after the double column line from Part 2 so that the Part 3 portion of the warehouse if fully independent from the rest of the warehouse.
- Detach the central large gutter beam between Parts 2 and 3 so that Part 3 can be independent.
- Build a new perimeter wall at the double column line so that Part 3 is fully enclosed. These walls to be adequately restrained by band beams and columns so that they can safely resist wind and earthquake loads. This perimeter wall will need to work structurally in its plane so as to create a closed loop of walls around the warehouse to resist earthquake loads.

- Strap the double columns at the joint between parts 2 and 3 to take benefit of the two columns.
- Roof bracing to be tightened/ strengthened.
- All false ceiling straps, hangers to be removed to reduce the mass acting on the roof trusses.
- Central columns to be repaired around the base and at the connection with the gutter beam by an appropriate method. This may include the installation of epoxy grouted reinforcement into the ground slab and the gutter beam or similar. As a minimum it is suggested that partial jacketing is installed to improve the ductility of the column to a future earthquake event.
- Oxfam staff should not go into the formal office spaces as long as the infill masonry walls are damaged.

Under no circumstances should any Oxfam employees spend any time in Part 1 of the warehouse.

These suggestions have been outlined with the understanding of the difficulty of the post earthquake situation in Port au Prince. Under more normal circumstances the recommendation would be for this facility not to be used by Oxfam post earthquake.

Recognising the difficulty of the post earthquake situation it is felt that the above approach is practical for Oxfam as a way to manage the potential future earthquake risk and it is assumed that Oxfam will be using this report as part of a wider assessment of their warehousing needs before reaching a decision.

The above suggestions are well within the means of the warehouse owner to implement. Clearly a more detailed engineering assessment (including a review of structural engineering drawings, calculations and performing independent engineering calculations) is needed to support the above suggestions.

It is assumed that the owner will employ a suitably qualified earthquake engineer to design a proper seismic retrofit for this facility in due course. However a detailed seismic repair and retrofit will take many months to execute.

Should Oxfam, decide to use this warehouse, this should be undertaken on the basis that the suggestions mentioned here are implemented by the warehouse owner prior to Oxfam making any use of the facility.

Should Oxfam make use of the warehouse it is recommended that Oxfam will continue to look for warehousing facilities that have been designed to a sufficiently high level to withstand likely seismic loads.

Sketches, to help illustrate some of the suggestions are shown in **Figure 10** and **Figure 11**.

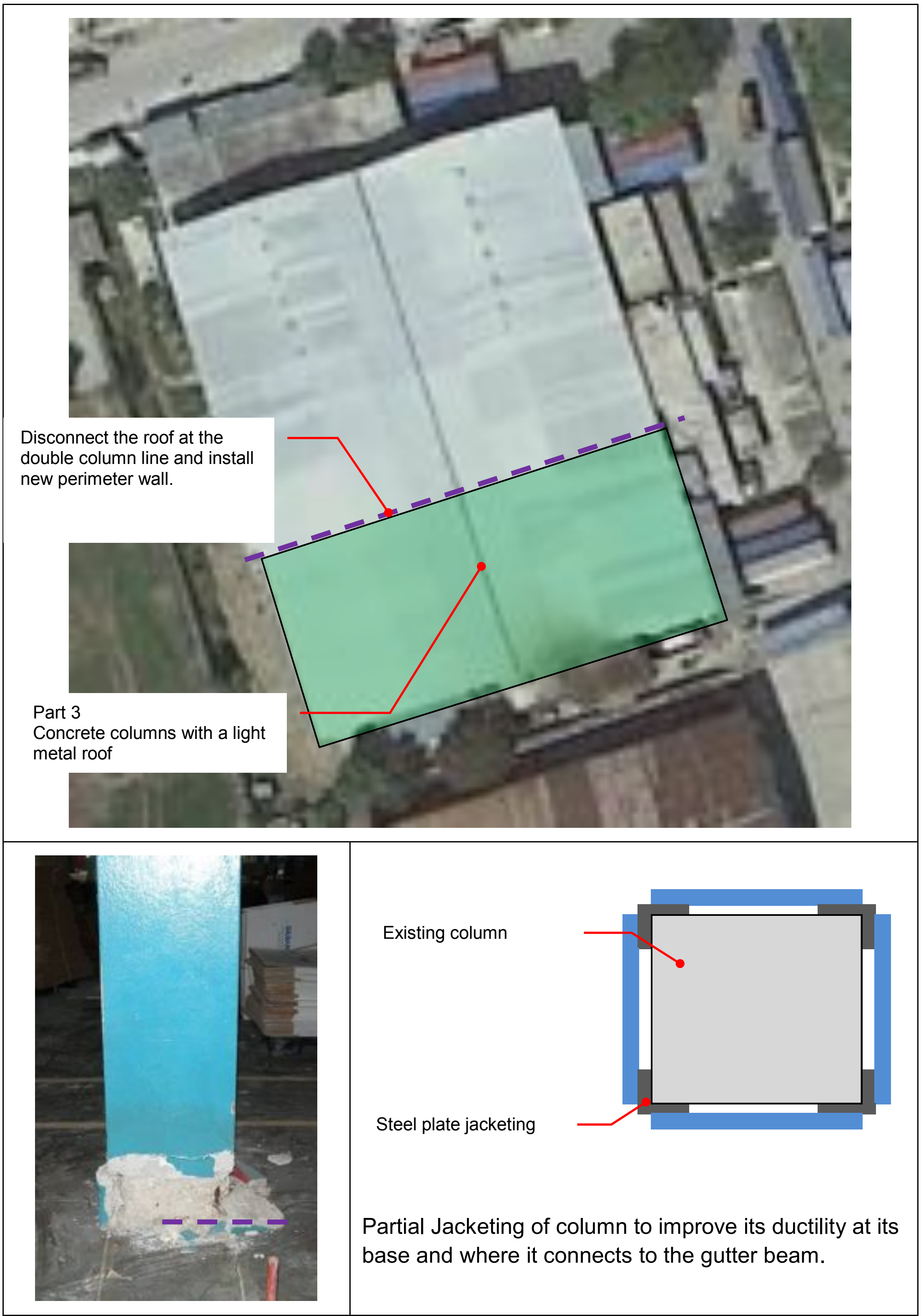


Figure 10 Sketch of possible repairs / modifications to improve the structure of Part 3 of the warehouse.

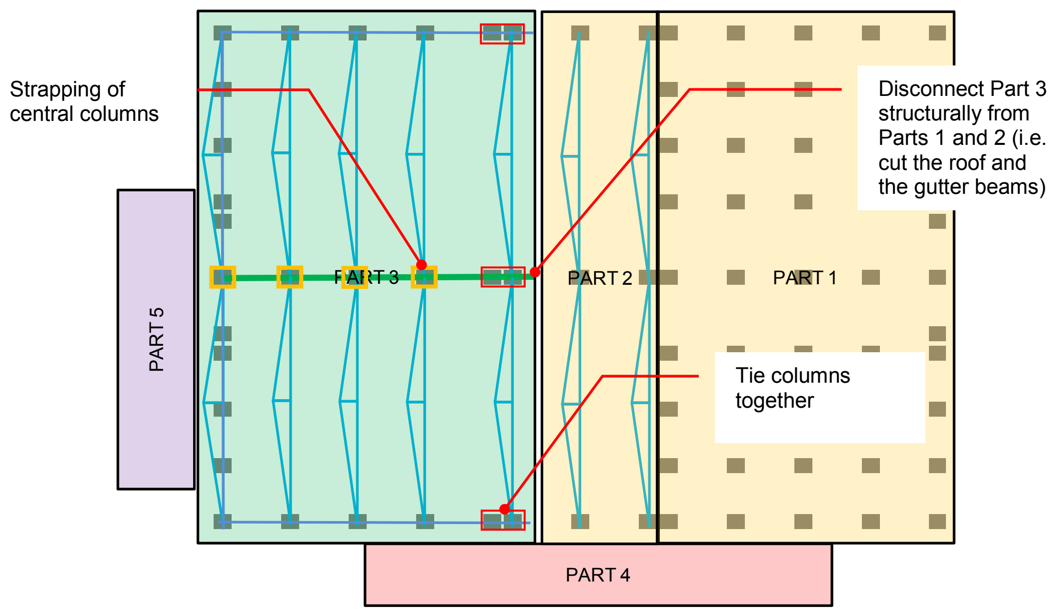


Figure 11 Sketch of possible repairs / modifications to improve the structure of Part 3 of the warehouse.

Oxfam GB

Earthquake Damage Inspections

Warehouse Inspection

Oxfam GB

Earthquake Damage Inspections

Warehouse Inspection

March 2010

This report takes into account the particular instructions and requirements of our client.
It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party

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Contents

1 Introduction

Oxfam GB commissioned Arup to provide damage inspection for two warehouses in and around the earthquake damage area of Port au Prince, Haiti following the 12th January 2010 earthquake and subsequent aftershocks.

A post-earthquake damage assessment was performed for two warehouses within a larger warehousing complex at Shodecosa which is near the main the airport. These warehouses were inspected on the 28th February 2010 for the purpose of understanding if from a structural safety perspective the facility could be utilised by Oxfam as part of their warehousing requirements.

The locations of the two buildings are shown in Figure 1 to Figure 3

Figure 1 Arial views of the two warehouse units are that Oxfam is currently utilising.

Warehouse B4 is Oxfam's main warehouse. Warehouse H2 appeared to be less utilised by Oxfam.

Front views of warehouse B4

Near complete collapse of the back portion of warehouse B4

Near complete collapse of the back portion of warehouse B4

Figure 2 Walk around exterior views for warehouse B4 and the adjoining structures.

Front views of warehouse H2

Figure 3 Walk around views of the warehouse H2 and the adjoining structures.

This memo summarizes our findings. Our recommendations are presented at the end of this memo.

1.1 Overview of Seismic Risk in Haiti

The earthquake evaluations below are based on whether the earthquake of January 12, 2010, or subsequent aftershocks, caused damage to the structure to significantly reduce its safety. **It is not intended to determine that the structure is 'safe'.** As stated above, with the exception of a few isolated cases, very few of the structures in Haiti were deliberately designed or built to withstand potential earthquake forces.

The chance, however, of a structure experiencing partial or complete collapse in the event of an aftershock (assuming that the aftershock is of lower intensity than the initial earthquake at that location) is small if the structure was not compromised by the initial shock and had been close to the epicentre.

This risk, however, needs to be balanced against other risks (e.g. security) and program objectives. The aim here is to provide guidance as to the most reasonable options assuming a certain level of base earthquake risk.

1.2 Inspection Methodology

The inspections are based on an *Applied Technology Council, Post Earthquake Safety Evaluation of Buildings, ATC-20* guideline format. They are structural and non-structural damage evaluations only intended to provide an indication as to the level of damage sustained by the earthquake, not to provide information as to the earthquake safety of the building. They utilize the following rating system, based on ATC-20, and modified for this unique situation:

Green – The vertical and lateral load capacity of the structure does not appear to be significantly decreased by the earthquake or its aftershocks. Its ability to withstand an earthquake is likely similar to that before the January 12 earthquake. However, with reference to the background information above, rating a building 'Green' does not comment on the overall safety of the building. A 'Green' building may still be a collapse hazard in a strong earthquake.

Yellow – This structure has been damaged and its safety is questionable. A strong earthquake (including a strong aftershock) poses a collapse hazard. It is recommended that this building is not used for operation purposes, nor occupied. If a decision is made that based on other priorities (security, operations, general necessity to function etc...) this facility needs to be used, the following recommendations apply: It is recommended that the structure be used on a temporary basis only, as long as the occupants are aware of the risk that they undertake by going into the structure; a list of basic actions that could be reasonably implemented by the owner of the warehouse are also suggested in this report.

Red – The structure has been damaged by the earthquake and is unsafe. It is recommended that the structure be off-limits to everyone, even for short periods of time. The footprint around the building (to a distance equal to the height of the building) should be cordoned ('roped') off.

The site inspection to the warehouses was performed on the 28th February 2010.

1.3 Available Information

The only information available was a 30minute visual inspection and some limited discussions were held with Mr. Padberg who was not the building owner but who had been leasing the warehousing space for a long time.

From discussions with Mr. Padberg, it was understood that he had applied for funds to repair the facility from the Dutch government. The time frame, likelihood of being approved and scope for this was not clear. Should funding be available a proper seismic engineering assessment should be undertaken, including retrofitting concepts for repairing and improving the current conditions of the warehouses.

1.4 Building Description

1.4.1 Warehouse B4

Warehouse B4 is structurally connected to warehouses B1 to B5 as well as the rear reinforced concrete frame portion which looks like it provided office type space.

Vertical Load Path Description

The warehouses consist of a light steel truss roof with corrugated iron sheeting supported on reinforced concrete column. Unreinforced hollow masonry bock has been utilised as infill material between the concrete frames. Deep U-shaped concrete gutter beams run in the longitudinal direction of the warehouse spanning between the reinforced concrete columns.

The warehouse is on a slope and it is thought that the foundations for creating level ground will likely have been achieved by the extensive use of stone masonry. It is not knows if the concrete frame structure extends into the foundations.

At the back of B4 there was a reinforced concrete frame building with unreinforced hollow masonry block work.

Horizontal Load Path Description

There is no obvious deliberate horizontal earthquake force resisting system for warehouses B4. At best the reinforced concrete columns are cantilevering from their foundations (likely to be independent pad footings) in the warehouse transverse direction. In the longitudinal direction the columns will be acting with the gutter beams as a moment frame.

The unreinforced hollow block masonry blocks will have contributed to the lateral resisting capacity of the warehouse within the plane of the walls.

The light metal roof is nominally connected at the top of the columns and not able to provide portal frame behaviour in the transverse direction. The roof does not have any in plane bracing to enable the roof to act as a diaphragm.

1.4.2 Warehouse H2

Warehouse H2 forms part of a cluster of interconnected warehouses H1 to H5. Broadly the vertical and horizontal load resisting system of warehouse B2 is similar to that of B4.

2 Assessment Overview

2.1 Items Inspected

In general, the following items were inspected where possible, visible, and applicable:

Overall Hazards:

- Collapse or partial collapse
- Building or story lean

Structural Hazards

- Foundations (where possible and/or visible)
- Roofs, floors (where possible)
- Columns, pilasters, corbels
- Diaphragms, horizontal bracing
- Walls, vertical bracing
- Precast connections

Non-Structural hazards

- Parapets, ornamentation
- Cladding, glazing
- Ceiling, light fixtures
- Interior walls, partitions
- Elevators
- Stairs, exits

Geotechnical Hazards

- Slope failure, debris
- Ground movement, fissures

3 Inspection Findings

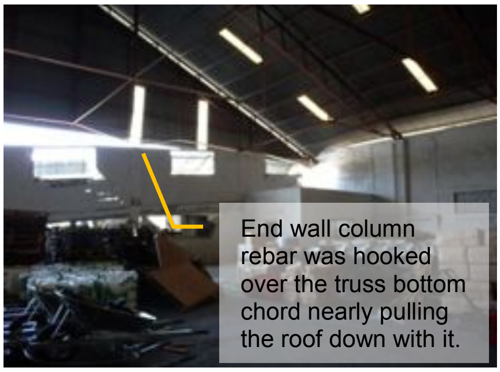
Our findings are illustrated through a series of photos with a short summary text of our findings at the end of each building. Conclusions and Recommendations are made in Section 4.

3.1 Warehouse B4

V-Shaped concrete piers running along the side of the warehouse with B3. Note the collapse at the rear of the warehouse.

Orthogonal reinforced concrete frame between B4 and B5 warehouses. Large columns are thought to contain concrete columns that have been clad with block work. Note the apparent concrete band beams and intermediate vertical concrete columns within the framing. Note that the large columns do not align with the roof trusses. Openings are nicely framed.

Figure 4 Observations on the perimeter concrete frames to warehouse B4



Rear view of collapsed back portion of the warehouse which looked to be structurally independent apart from the connection to the warehouse roof trusses

Collapsed rear portion of warehouse B4. End concrete frame column reinforcement bars are hooked over the steel truss bottom chord nearly pulling part of the whole roof down with it.

Figure 5 Collapse of the rear portion to warehouse B4.

View looking up at the roof trusses. Note the small tension only bracing within the plane of the corrugated galvanised iron roof sheets. The small rods are loose and will not be affective.

There is no vertical bracing between truss lines.

There is no horizontal roof bracing to create a roof diaphragm at the level of the truss bottom chord.

Note that the roof trusses don't align with the main reinforced concrete frame.

Figure 6 Roof truss views

Reinforced concrete frame and hollow block masonry infill end wall at the warehouse loading level.

Columns are most likely cantilevering for which they are unlikely to have been designed.

From having seen the collapsed transverse warehouse wall at the opposite side the columns are likely to be connected to the roof trusses creating an unintended load path. There is no horizontal roof bracing to help prop the end walls.

Figure 7 Wall at the warehouse loading entrance

Figure 8 In plane cracking of masonry walls to the sides of the main warehouse loading entrance.

Column rebar have been tack welded to angles which in turn have been tack welded to steel base plate connecting to the steel roof trusses. Poor quality detailing and workmanship

View along the length of the gutter beam showing concrete props between gutter beam vertical faces

Figure 9 Gutter beam details and typical roof truss to concrete connection (taken from either warehouse B2 or B3 due to easier access at those locations.

Near total failure of the steel roof truss to top of concrete U-Shaped gutter beam connection.

Confinement reinforcement is missing or has failed.

Column bars have been pulled out and severely buckled.

THIS NEEDS URGENT REPAIRING / RETROFITTING

Figure 10 Steel to concrete connection

3.2 Warehouse H2

Warehouse H2 is similar to B4. As with B4 our main observations are documented through a series of figures. Conclusions and Recommendations are made in Section 4.

	
General front view showing in plane crackling of the masonry infill walls	Rear warehouse view showing partially collapsed back wall.

Figure 11 General views of warehouse H2

	
	General view from inside H2. No horizontal roof bracing present. No vertical bracing between trusses is present.

Figure 12 General warehouse H2 views

 Near total failure of the steel roof truss to top of concrete U-Shaped gutter beam connection. Confinement reinforcement is missing or has failed. Column bars have been pulled out and severely buckled. **THIS NEEDS URGENT REPAIRING / RETROFITTING**	 Near total failure of the steel roof truss to top of concrete U-Shaped gutter beam connection. Confinement reinforcement is missing or has failed. Column bars have been pulled out and severely buckled. **THIS NEEDS URGENT REPAIRING / RETROFITTING**
 Modest levels of damage to the masonry infill.	 Damage to gutter beams due to the awkward detailing of this beam.

Figure 13 Damage to longitudinally running gutter beams, infill masonry and the steel roof truss to reinforced concrete connections.

Figure 14 Damage to concrete columns appears to be limited to the cover. Damage to column head / around interface to gutter beam is apparent too.

Figure 15 Partially collapsed rear warehouse portion – note that the warehouse is still being used extensively.

Tiny tension bracing in the roof plane. Some signs of buckling along the roof purlins. No in plane roof bracing is present

	**Figure 16 Close up view of nearly collapsed rear warehouse portion. Note how the wall column reinforcement bars have been crudely hooked over the truss bottom chord, nearly pulling the roof down.** **Severely damaged unreinforced masonry is very dangerous and poses significant threat of collapse to people.**

4 Conclusion and Recommendations

The integrity of both warehouses B4 and H2 has been severely compromised by the earthquake. In a western environment both buildings would receive a clear RED rating and should not be used.

However, the ground realities in Haiti are very challenging and we understand that Oxfam has to balance many risks, with structural integrity of the warehousing facility being only one of the many risks.

Therefore, the advice given here is thought to be achievable and assumes that Oxfam will proactively look for alternative warehousing facilities that are structurally adequate to resist a future significant earthquake.

4.1.1 Conclusions

- Steel roof truss to concrete connections are severely compromised and need urgent attention. In their current condition they pose a significant risk of collapsing under a further earthquake.
- Rear portion of warehouse has in effect collapsed.
- There are real significant risks of using the warehouse in its current condition.

4.1.2 Recommendations

These recommendations are based on the assumption that Oxfam will be continuing to use these warehouses in the short to medium term until a structurally safer warehousing is found. However, there are a number of things that can be done to help minimise the structural risks ands these are noted below.

URGENT ACTION NEEDED

- Extend roof truss ends by welding on angles and brackets so as to create a “hook” for the roof trusses to prevent them from being pulled off their support points.
- Provide confinement to the gutter beam stub columns that are supporting the roof trusses so that the roof trusses can’t just pull out leading to their collapse.
- Disconnected collapsed portions of the warehouses from the roof trusses to stop pulling the trusses down. Demolish the remaining portion safely so that it no longer poses a falling hazard.
- Do not allow any use of the facility within the height of the front and back walls.
- Tighten existing loose tension only bracing within the roof.
- It is expected that these steps can be undertaken within 30 to 45 days by the current building owner.

It must be noted that these are common sense suggestions and have not been substantiated by detailed engineering analysis which would clearly be desirable.

Should the current owner of the warehouses be unwilling to undertake these basic safety measures then Oxfam should as a matter of reasonable urgency look to find more suitable warehousing.

MEDIUM TO LONG TERM

In the medium to long term, this warehouse should only be utilised by Oxfam if the client undertakes a proper structural assessment and seismic retrofit of the warehouses. Simply repairing back the warehouses to their pre-earthquake condition will still leave these building vulnerable to future earthquakes.

Typically a seismic retrofit may involve some or all of the following:

- Creating of “As built” drawings.
- Engineering analysis and assessment of existing facility.
- Design the seismic retrofit:
    - Provide in-plane roof bracing.
    - Repair damaged end walls so that they can provide a lateral system to the warehouse structures in the building transverse (i.e. short) direction.
    - Strengthen the existing steel roof truss to concrete connections.
    - Repair damaged masonry.
    - May need RC wall (or cross bracing) in the longitudinal direction.
    - Check that the terrace end to the warehouse is stable under likely seismic loads.

Should the current warehouse owner undertake the suggestions made in “Urgent Action Needed”, then it is likely that a retrofit could be organised around the continued use of the facility however careful attention to health and safety will be required to ensure the safe execution of the works.

Should the current warehouse owner be unprepared to undertake the required seismic retrofitting works, Oxfam should look to move into safer facilities at the earliest opportunity.

http://www.arup.com/Services/International_Development.aspx