Seismic Evaluation and Retrofit Companion

Examples and Documentation

Build Change
&
Degenkolb Engineers

2011

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Seismic Evaluation and Retrofit Companion – Table of Contents

A. INTRODUCTION

1. Background

The earthquake of January 12th 2010 killed tens of thousands of people and left over one million people homeless with many more finding refuge in unaffected surrounding areas. The location, mechanism, magnitude, and ground motion characteristics of every earthquake are different, as is the response of individual buildings to varying ground motions. Consequently buildings that survived the January 2010 earthquake may still be at risk of collapse in future earthquakes.

The MTPTC has conducted surveys of hundreds of thousands of buildings and has classified the damage state relative to its pre-earthquake condition. Green-tagged buildings have mostly been reoccupied. Repairs of yellow and some red-tagged buildings are ongoing, however, there is uncertainty regarding whether the repaired buildings will meet a recognized engineering standard for life-safety performance in future earthquakes.

2. Objective

This companion manual is designed to accompany the Seismic Evaluation and Retrofit Manual and provide supplementary information and guidance. A complete example is included to provide a step by step illustration of how a model retrofit is performed. Also provided is an example cost estimate spreadsheet, and backup documentation to the procedures in the manual.

3. Applicability

The guideline is appropriate for application to existing, low-rise, typical Haitian masonry construction. Typical Haitian masonry construction is generally described as:

- Foundations - rock/concrete or masonry footings and reinforced or unreinforced concrete slabs-on-grade
- Walls - unreinforced concrete masonry bearing walls for vertical support with or without reinforced concrete columns and other confining reinforcement
- Elevated slabs and roofs - reinforced concrete slabs and joists with masonry void-forms, or roof systems may also be constructed of lightweight metal and wood systems.

B. EXAMPLE RETROFIT

Seismic Evaluation Checklist: Low-Rise Haitian Masonry Construction
Unreinforced, Confined, or Infill Masonry

1.0		GEOLOGIC SITE HAZARDS	NOTES
1.1	(C) NC N/A	LIQUEFACTION: Liquefaction-susceptible, saturated, loose granular soils that could jeopardize the building's seismic performance shall not exist in the foundation soils at depths within 50 feet under the building.	
1.2	(C) NC N/A	SLOPE FAILURE: House siting meets the requirements of the MTPTC Construction Guidelines for Confined Masonry Construction p 8, 9, 12 and 13. Alternatively, in the judgment of the evaluating engineer, the building site shall be sufficiently remote from potential earthquake-induced slope failures or rockfalls to be unaffected by such failures or shall be capable of accommodating any predicted movements without failure.	
1.3	(C) NC N/A	SITE RETAINING WALLS: Unreinforced rock retaining walls which directly support the structure shall be no greater than 2.0m tall without supplemental reinforcement. Weep holes shall be present in solid wall systems for drainage.	
1.4	(C) NC N/A	SURFACE FAULT RUPTURE: Surface fault rupture and surface displacement at the building site is not anticipated.	

2.0		FOUNDATIONS	NOTES
2.1	(C) NC N/A	WALL FOUNDATIONS: Foundations are constructed of rock base or concrete and are continuous under walls and around the perimeter of the building. There is a continuous plinth beam at the base of all walls and the columns are dowelled into the foundation where present. Footings are embedded a minimum of 50cm below grade.	
2.2	(C) NC N/A	FOUNDATION PERFORMANCE: There shall be no evidence of excessive foundation movement such as settlement or lift that would affect the integrity or strength of the structure.	
2.3	(C) NC N/A	OVERTURNING: The total height above the base of the foundation level is no more than three times the narrowest dimension of the lateral system.	
2.4	(C) NC N/A	TIES BETWEEN FOUNDATION ELEMENTS: For all sloped sites (>10% grade) or for soft sites, the foundation elements shall be interconnected by reinforced concrete slab, and footings and reinforced concrete plinth beams shall be continuous underneath all walls.	
2.5	(C) NC N/A	DETERIORATION: There shall not be evidence that foundation elements have deteriorated excessively due to corrosion, sulfate attack, material breakdown, or other reasons in a manner that would affect the integrity or strength of the structure.	

3.0		BUILDING SYSTEM	NOTES
3.1	(C) NC N/A	MATERIALS: Materials used for the gravity and lateral load resisting systems shall consist of reinforced concrete and concrete masonry. A lightweight wood and metal roof system may be present but is not required to resist seismic forces.	
3.2	C (NC) N/A	LOAD PATH: A minimum of two separate lines of wall is required in each direction; an additional line of walls is required for each additional 4.5 m of building dimension over 4.5 m. Walls considered for lateral resistance shall be at least 1.0m long. Parallel walls are located no greater than 4.5 m apart. Walls shall be connected to the diaphragm at the top and bottom by a continuous reinforced concrete floor or plinth beam that is centered on the wall and contiguous with the floor slab.	

3.0		BUILDING SYSTEM	NOTES
3.3	C NC N/A	NUMBER OF STORIES: The maximum number of stories is three, except for URM buildings which are limited to two for Sds < 1.1g, and one for Sds >= 1.1g	
3.4	C NC N/A	STORY HEIGHTS: The maximum story height of the first story is 3.0 m from the ground floor slab and the floor to floor height of the upper levels is no more than 2.75m.	
3.5	C NC N/A	MASS: The average weight (1.0xD) of each level, including the tributary weight of walls and contents shall not exceed 7.2kPa (150 psf).	
3.6	C NC N/A	FLOOR AND ROOF SYSTEM: Elevated floor and roof systems shall be of typical Haitian construction (approximately 15cm thick, with 5cm of reinforced concrete over reinforced concrete joists and masonry void-forms. Roof systems may also be of wood and metal light framed construction.	
3.7	C NC N/A	WALLS: Walls shall consist of at least 15cm thick concrete masonry units with sand cement mortar with no less than 40% net solid area.	
3.8	C NC N/A	CANTILEVER UPPER LEVELS: Perimeter walls at the upper levels shall not be supported on cantilevers or eaves that extend beyond the lower level building envelope greater than 50% of wall thickness. This statement does not apply to single story buildings.	
3.9	C NC N/A	DAMAGE: Structures have no earthquake or excessive weather related damage to the masonry walls or roof system. Damaged buildings are NON-COMPLIANT but may be repaired per the MTPTC guidelines to become COMPLIANT.	

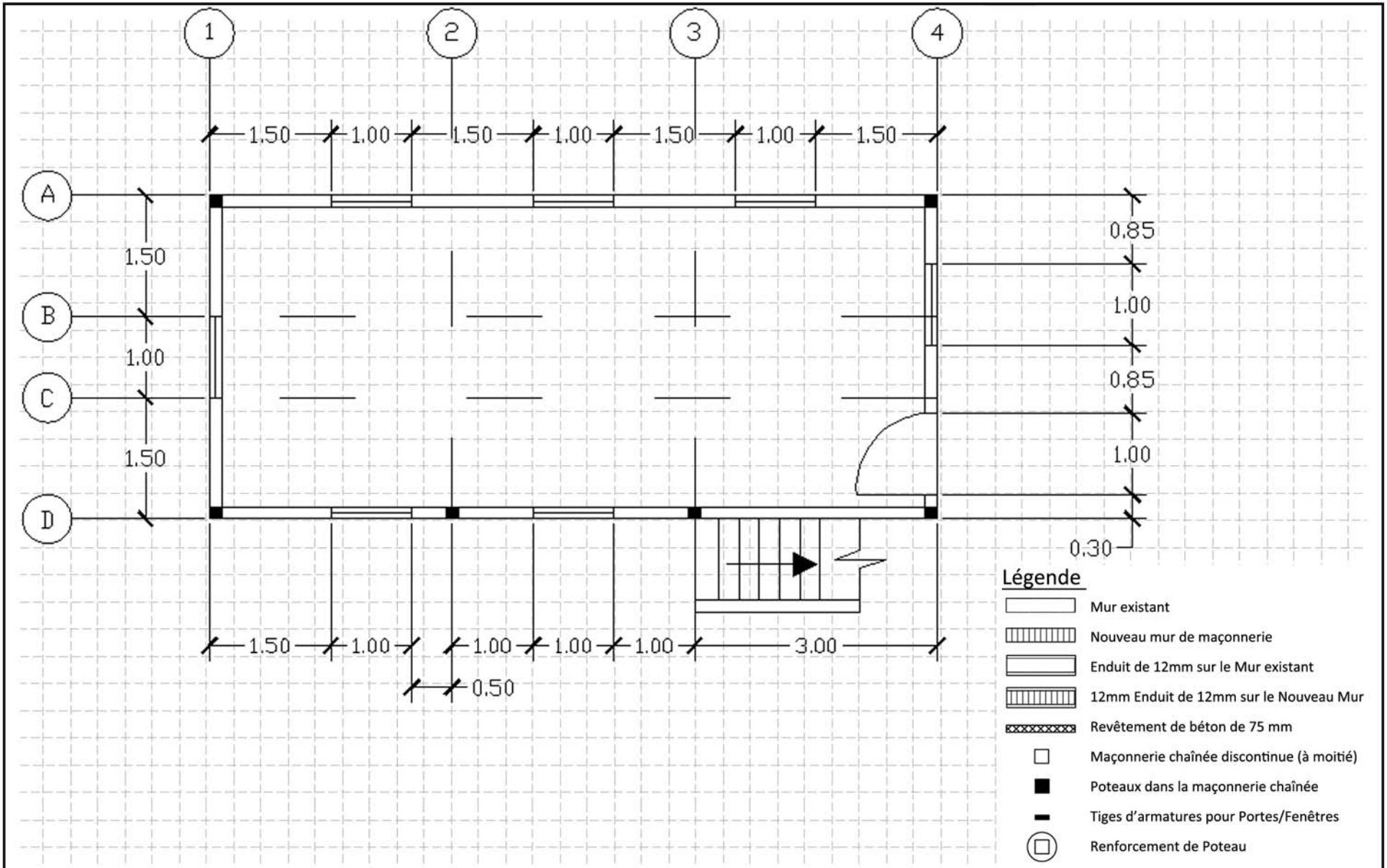
4.0		MASONRY WALLS	NOTES
4.1	C NC N/A	MASONRY CONFINEMENT: Walls shall be tightly installed to the soffits of the ring beam or slab and to the columns where present. Formwork shall not be present between the top of the masonry and underside of the beam/slab.	
4.2	C NC N/A	OPENINGS: Doors, windows and other openings wider than 0.6m shall extend to the beam above, or shall be provided with a reinforced concrete lintel beam. Lintel beams shall extend a minimum of 15cm into the adjacent masonry or shall be connected to an adjacent concrete boundary column or trim reinforcement.	
4.3	C NC N/A	TOP RING BEAM: Buildings constructed with light-weight wood/metal roofs shall have a continuous reinforced concrete ring beam at the top of the walls to transfer out-of-plane forces to cross walls. Ring beams shall span over door openings where present. Roof systems shall be positively anchored to ring beams	

4.0		MASONRY WALLS	NOTES
4.4	**Transverse** **3: C NC N/A** **2** C NC N/A **1: C NC N/A** **Longitudinal** **3: C NC N/A** **2** C NC N/A **1: C NC N/A**	WALL AREA PERCENTAGE: The provided Wall Area Percentage shall be greater than the required Wall Area Percentage at each level and in each direction. Note the Wall Area Percentage provided and required on the right, and C, NC, or N/A in the column to the left. Attach the calculation worksheet to this checklist.	**Transverse** **Story Required / Provided** **3** / **2** 4.9% / 5.0% **1** 7.4% / 1.3% **Longitudinal** **Story Required / Provided** **3** / **2** 4.9% / 5.0% **1** 7.4% / 5.4%

5.0		BUILDING CONFIGURATION	NOTES
5.1	**C NC N/A**	TORSION: Walls are located on all exterior sides of the building, or within 25% of the plan dimension at the wall location, including L-shaped and T-shaped plans. Alternatively the estimated distance between the center of mass and the center of rigidity shall be less than 20% of the maximum building width in either plan dimension.	
5.2	**C NC N/A**	ADJACENT BUILDINGS: If floor and roof slabs of adjacent buildings are not vertically aligned, then the contact distance shall be greater than 3 cm for single story structures, 6 cm for two-story structures, and 9cm for 3-story structures. If floors and roof slabs are aligned the item is compliant.	

5.0		BUILDING CONFIGURATION	NOTES
5.3	C (NC) N/A	VERTICAL DISCONTINUITIES: Second story walls are generally located on top of lower story walls. Second story walls that do not align with lower story walls are supported on both ends by any of the following, and do not span more than 3.0m unsupported: • Complying freestanding columns, see separate checklist item for requirements. • Perpendicular walls that extend at least 60cm each side of the wall above. • Parallel walls with at least ¼ length (30cm minimum) of the upper wall overlapping with the lower wall. This statement does not apply to single story buildings.	

6.0		BUILDING COMPONENTS	NOTES
6.1	C NC (N/A) C NC (N/A) C NC (N/A)	FREESTANDING/DISCONTINUOUS CONCRETE COLUMNS: Free-standing columns supporting concrete floor/roof slabs or discontinuous masonry walls shall meet the following minimum requirements: • Columns shall be reinforced concrete in good condition, with a minimum clear height of 1.5m. • Column bases shall be connected to the remainder of the building by a continuous foundation or reinforced concrete slab. • Columns shall have a minimum dimension of 6" when supporting a concrete roof or patio, 8" when supporting a one-story discontinuous wall, and 12" when supporting a two-story discontinuous wall above.	
6.2	C NC (N/A) C NC (N/A)	SLAB OPENINGS AT SHEAR WALLS: Slab openings adjacent to shear walls shall meet the following requirements: • Openings immediately adjacent to the shear walls shall be less than 25% of the wall length. • Slab openings at exterior masonry walls shall be less than 2.5m in length, and a reinforced concrete beam shall extend the length of the wall adjacent to the opening.	
6.3	(C) NC N/A	PARAPETS: There shall be no laterally unsupported unreinforced masonry parapets or cornices with height-to-thickness ratios greater than 1.5. Masonry parapets must be in good condition with masonry units bonded to each other and to the supporting roof slab.	
6.4	(C) NC N/A (C) NC N/A (C) NC N/A	STAIRS: Stairs shall meet the following requirements: • Stairs shall be connected at each elevated level to the building slab or roof by a continuous reinforced concrete landing. Stairs shall not depend on the building walls for vertical support. • Vertical support for stairs or landings shall be provided by compliant freestanding columns, or by masonry walls at least 0.6m long. • Stair foundation components shall be constructed of rock base or concrete footing that is embedded a minimum of 30cm below grade. On sloped sites (>10%) or soft sites the stair foundation shall be continuous with the remainder of the building.	



build change

Rez de Chaussée

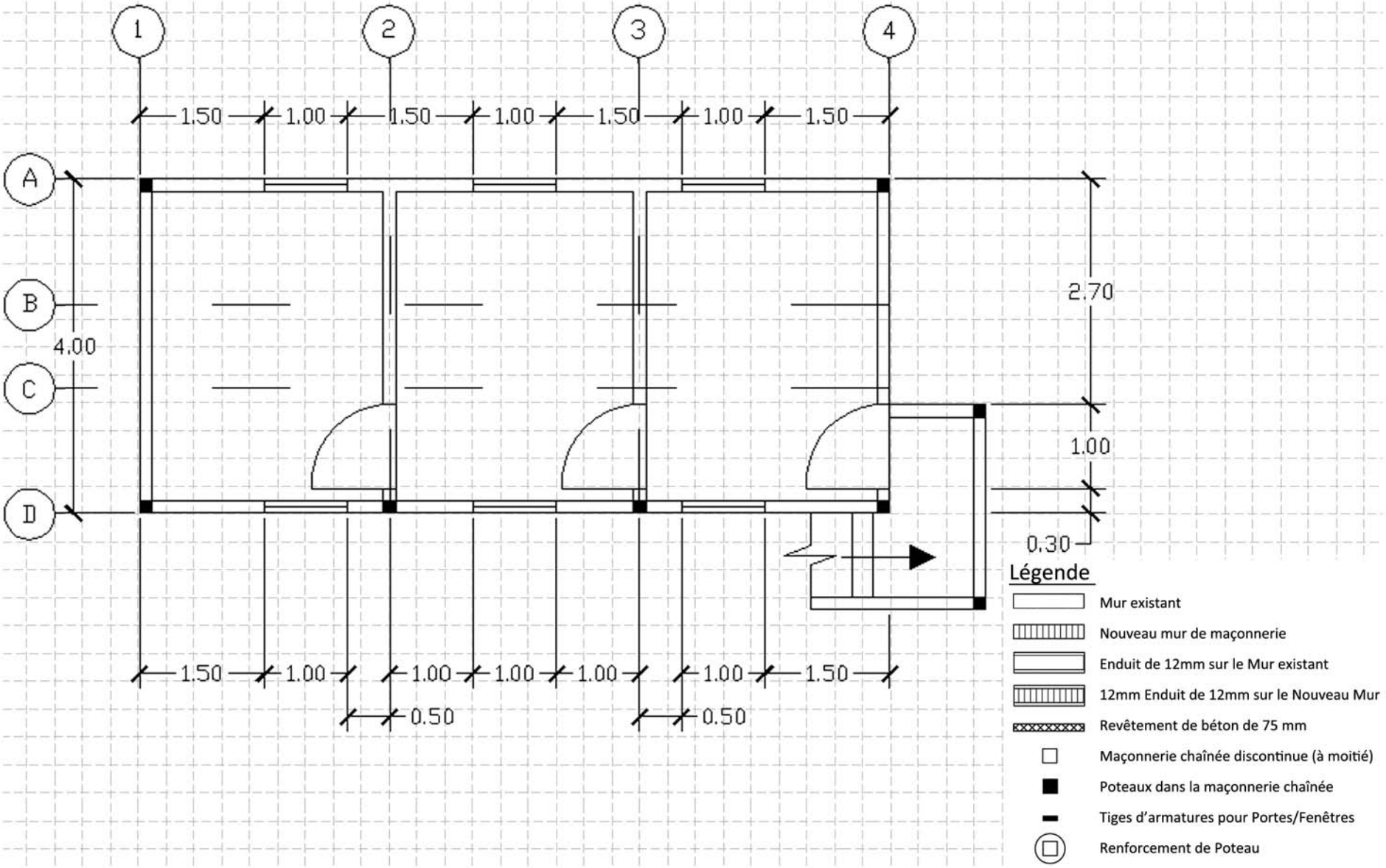
CVM000X

Pierre Jean
(509) 5555-5555

Charis Wu | 9 Aug 2011

18.539345, -72.336414

E



build change

1er Étage

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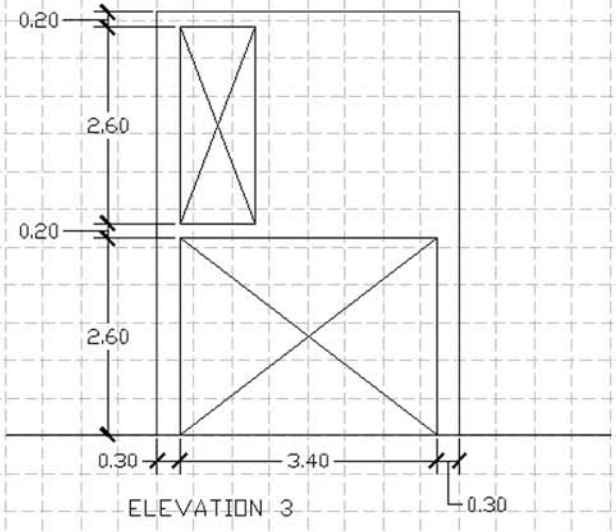
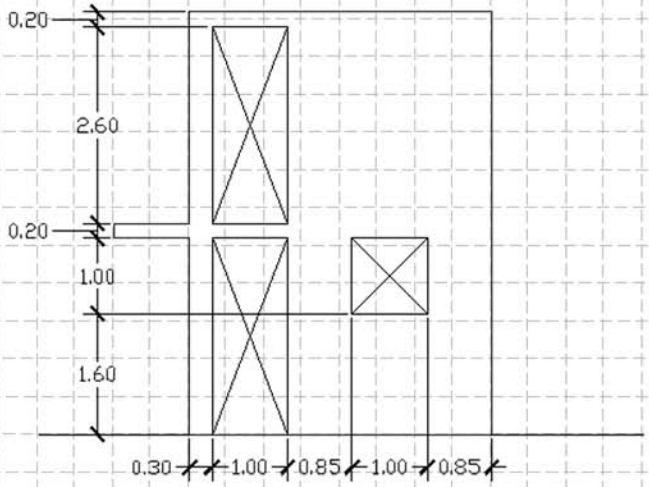
18.539345, -72.336414

E



ELEVATION 3



ELEVATION 4

Légende

- Mur existant
- Nouveau mur de maçonnerie
- Enduit de 12mm sur le Mur existant
- 12mm Enduit de 12mm sur le Nouveau Mur
- Revêtement de béton de 75 mm
- Maçonnerie chaînée discontinue (à moitié)
- Poteaux dans la maçonnerie chaînée
- Tiges d'armatures pour Portes/Fenêtres
- Renforcement de Poteau

build change

Elevations

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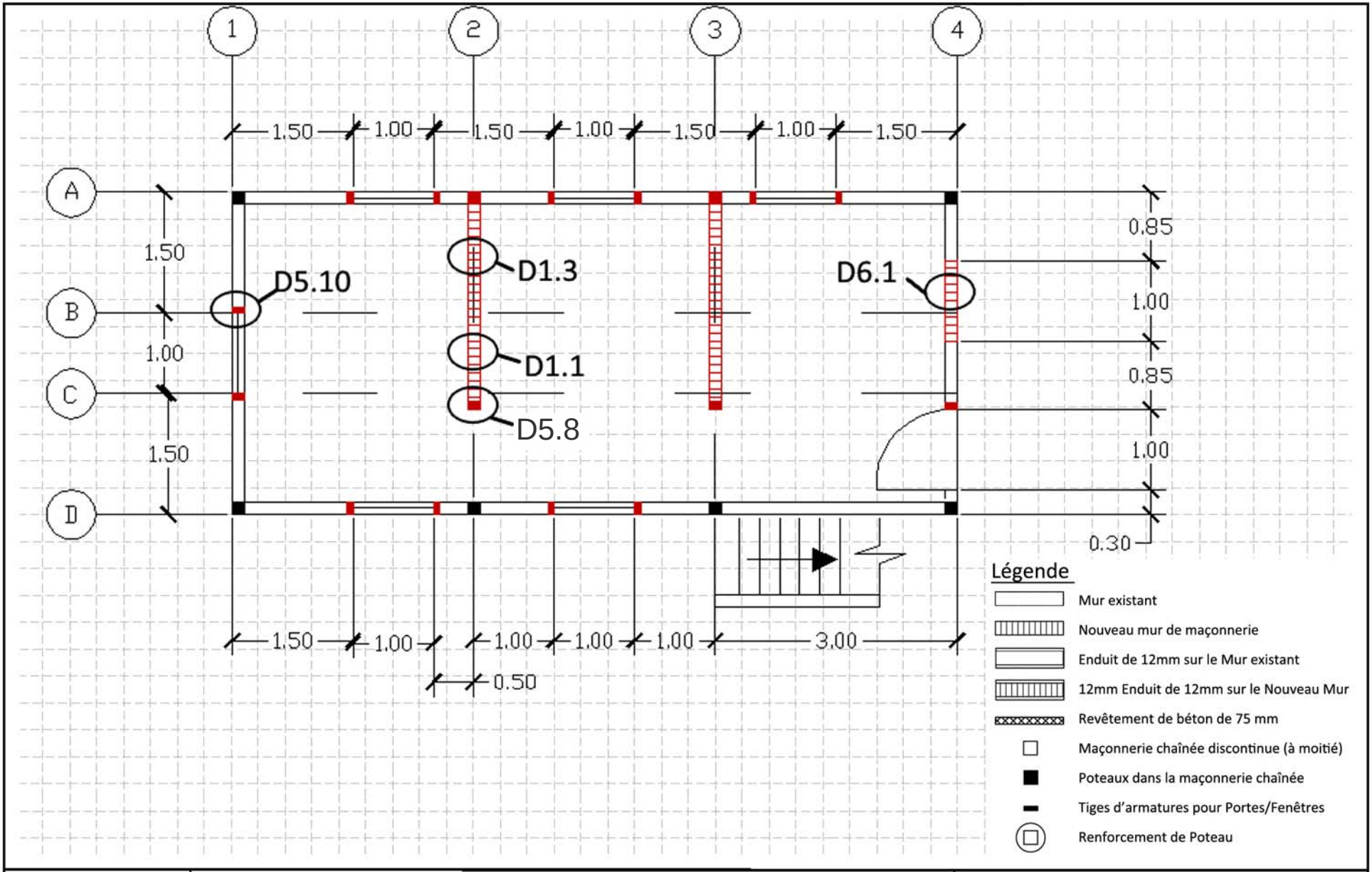
Confined Masonry Conversion



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Rez de Chaussée

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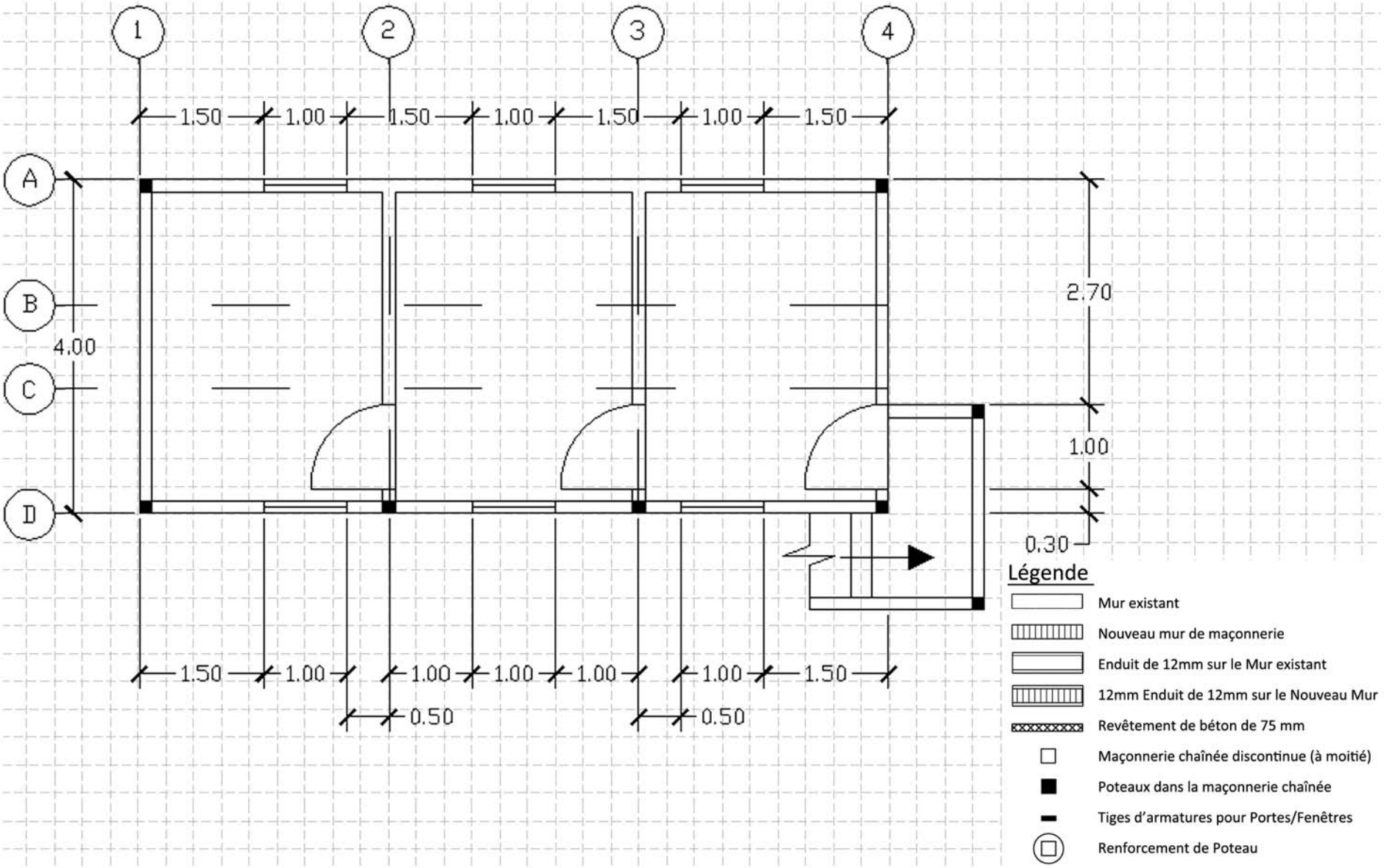

build change

1er Étage

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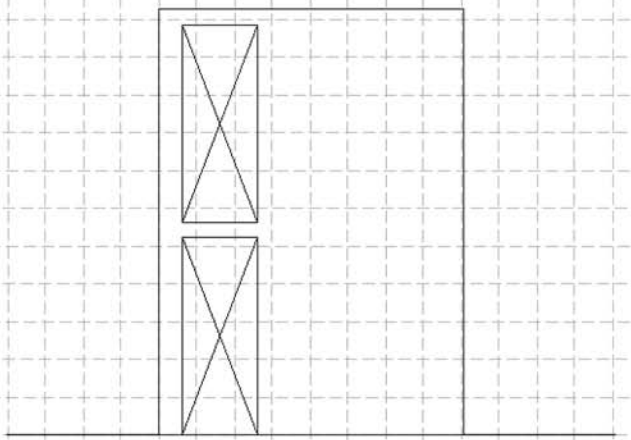
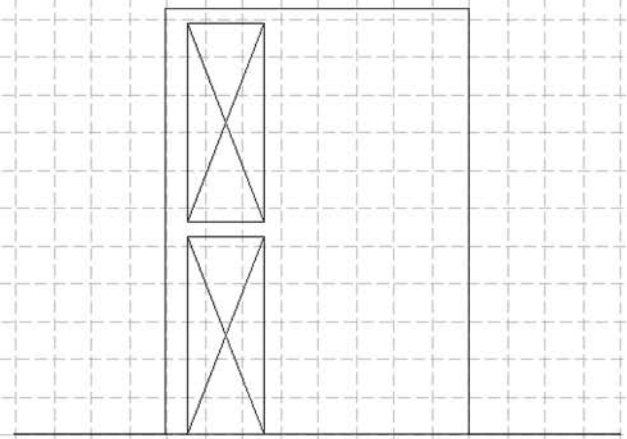


ELEVATION 3



ELEVATION 4

Légende

- Mur existant
- Nouveau mur de maçonnerie
- Enduit de 12mm sur le Mur existant
- 12mm Enduit de 12mm sur le Nouveau Mur
- Revêtement de béton de 75 mm
- Maçonnerie chaînée discontinue (à moitié)
- Poteaux dans la maçonnerie chaînée
- Tiges d'armatures pour Portes/Fenêtres
- Renforcement de Poteau

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Elevations

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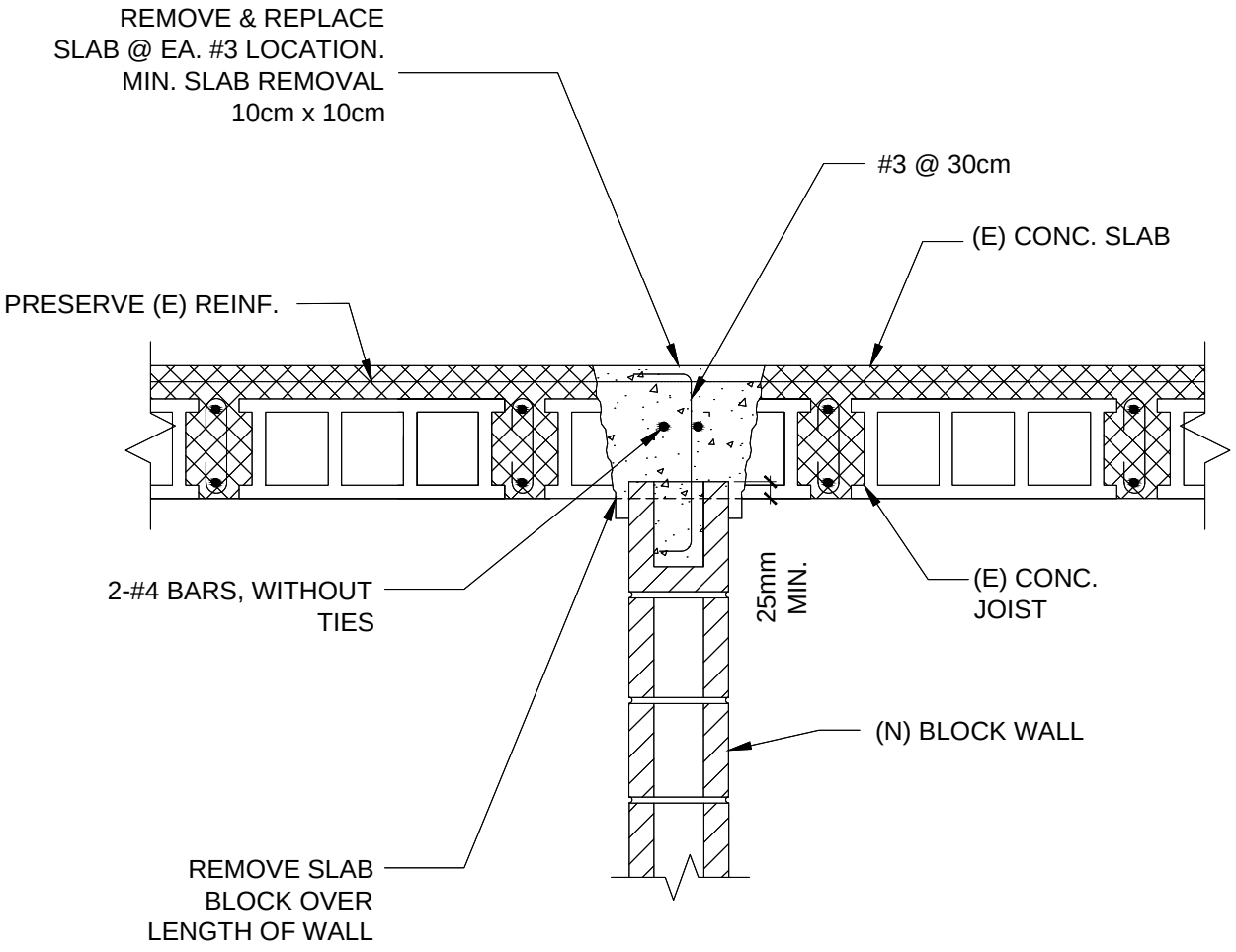

NOTE:
REFER TO DETAIL D1.9 WHEN BUILDING IS CLASSIFIED AS CM/IM.

build change

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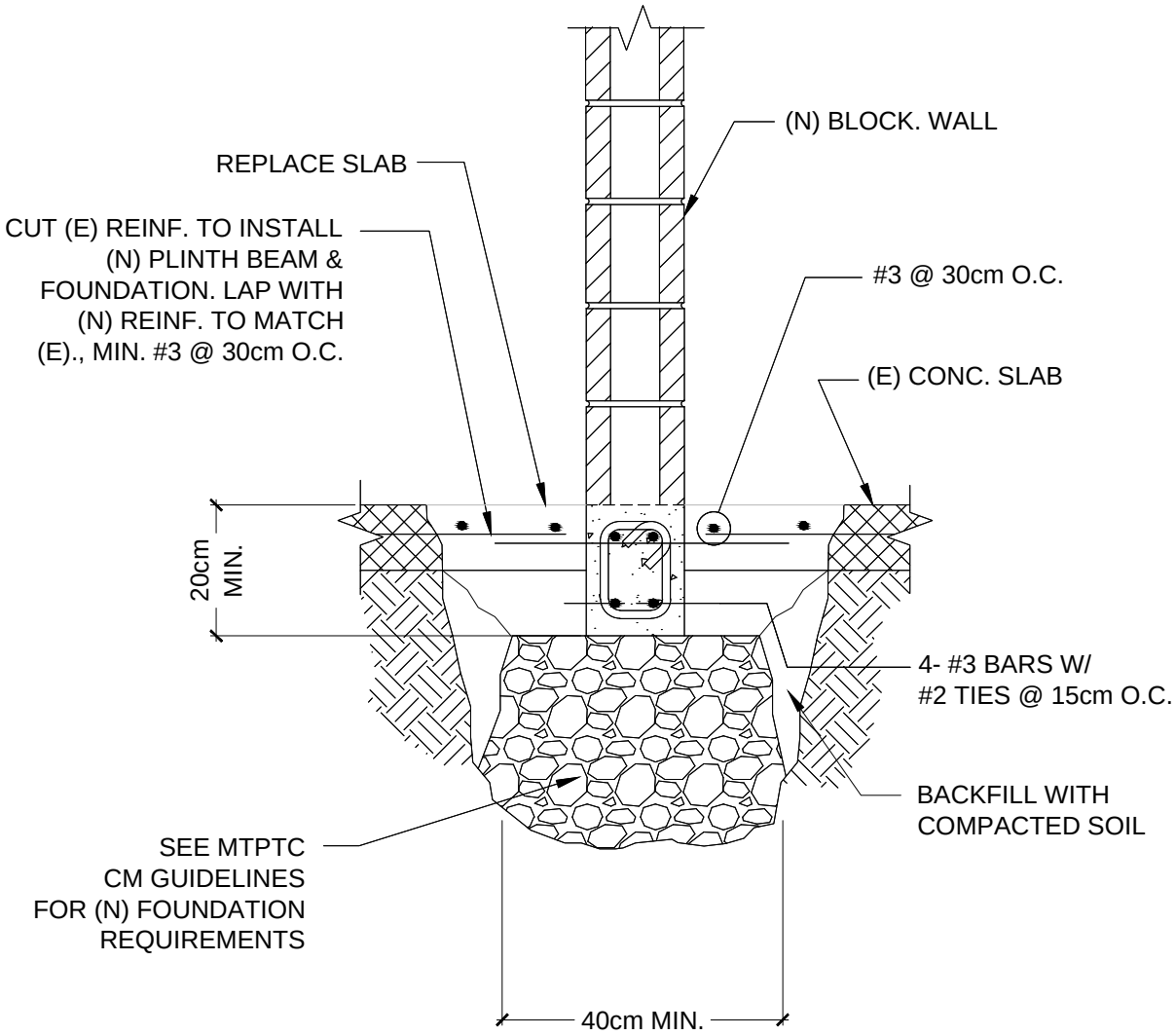
510.272.9526 *Fax*
www.degenkolb.com

(N) WALL PARALLEL W/ JOIST
(2 BAR RING BEAM)

PROJECT	DATE
SCALE	

D1.1



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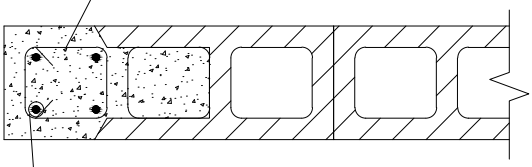
(N) WALL TO (N) FOUNDATION

PROJECT	DATE
SCALE	

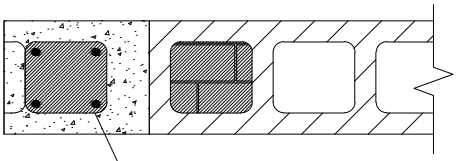
D1.3

#2 TIES @
15 cm O.C.



4- #4 FOR TIE COLUMNS AT
WALL ENDS AND EA. SIDE
OF DOORS

OR



#2 TIES @
15 cm O.C.

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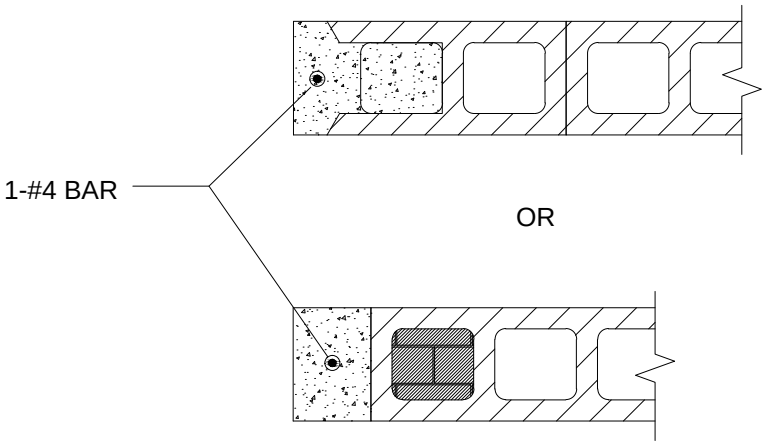
END WALL TIE COLUMN

PROJECT	DATE
SCALE	

D5.8



build change

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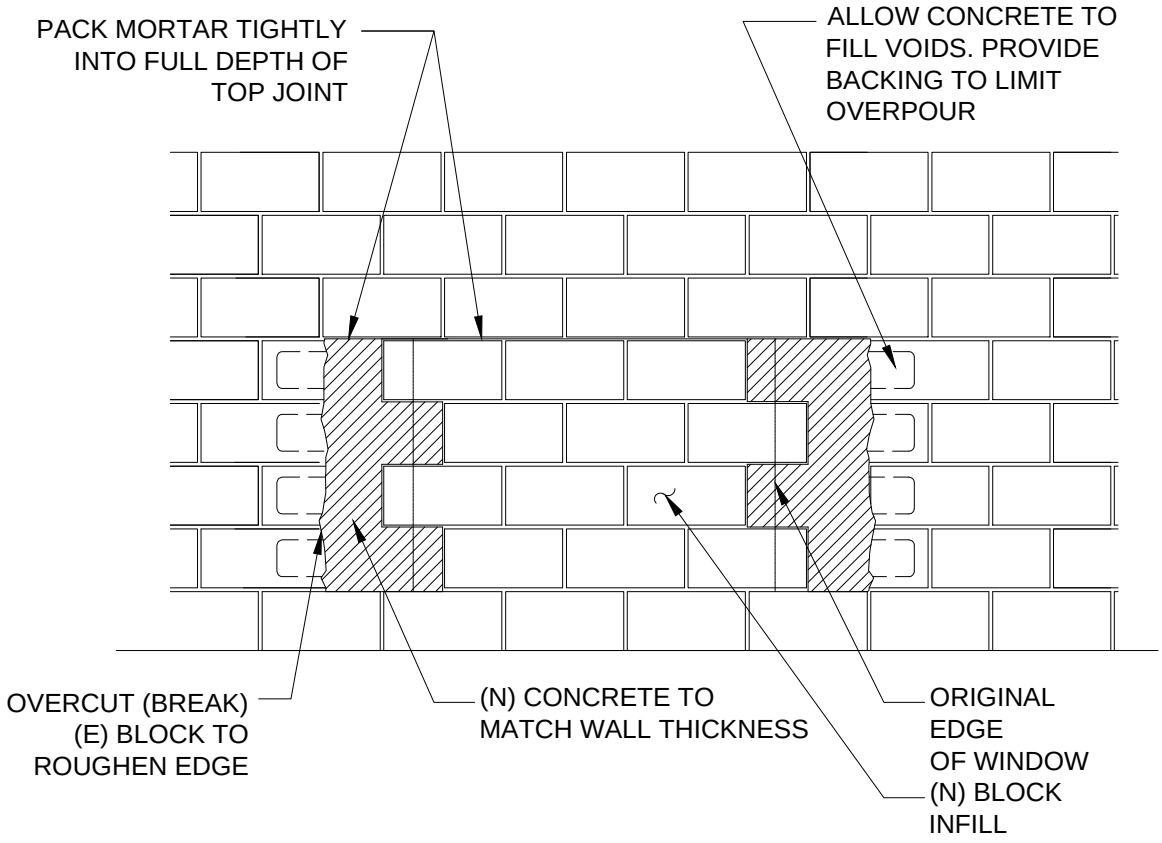
WINDOW TIE COLUMN

PROJECT	DATE
SCALE	

D5.10



build change

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WINDOW INFILL ELEVATION

PROJECT	DATE
SCALE	

D6.1

Guide de Renforcement et d'Evaluation sismique des maisons en maçonnerie en Haiti

Programme d'assistance technique post-seisme en Haiti, Build Change

Adresse de l'immeuble:	**Date:**
Etiquette du MTPTC :	**Ingénieur:**
	Accepté par:

Information sur l'immeuble **Niveau:** 1

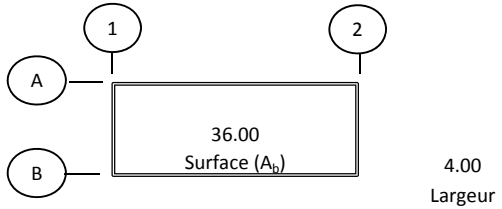
Nombre de niveaux, N: 2 (Limite 3)

Type de Bâtiment : MNA
MC (Maçonnerie chaînée)
MR (Maçonnerie de remplissage)
MNA(Maçonnerie non armée)
Voir Manuel pour description

Lieu: Port-au-Prince

Accélération spectrale du séisme , S_{ds}: 1.05 (1.05 g pour Port-au-Prince)

Dimensions du niveau:



Dimensions des murs transversaux existants (en mètres)

# du mur	Longueur	Epaisseur	Surface du mur
1	3.00	0.15	0.450
		Σ surface de mur, A_{wt} =	0.450
		PSM existant dans la direction transversale(A_{wt}/A_b) =	1.25%

Dimensions des murs longitudinaux existants (en mètres)

# du mur	Longueur	Epaisseur	Surface du mur
A	6.00	0.15	0.900
D	7.00	0.15	1.050
		Σ surface de mur, A_{wl} =	1.950
		PSM existant dans la direction longitudinale(A_{wl}/A_b) =	5.42%

Evaluation du Bâtiment existant **Niveau:** 1

Pourcentage de mur de base, bPSMrequis

6.40%	x	2	x	1.05	=	13.4%
(W_d)		(N)		(S_{ds})		bPSM$_{requis}$

Facteurs du pourcentage de surface de mur requis (voir page 4 pour les valeurs)

	Evaluation du Bâtiment existant	Renforcement (Si nécessaire, s'applique à la page 3)	
Facteur de la Résistance du Bloc, C_B =	1.00	1.00	Dépend de f'm
Facteur de la Qualité de la Construction, C_Q =	1.00	1.00	Qualité mauvaise ou moyenne
Facteur d'Evaluation/Renforcement, C_R =	0.75	1.00	Evaluer le plan de renforcement ou la structure existante?
Facteur de niveau, C_L =	0.86	0.86	Dépend du niveau évalué et de la description de l'immeuble
Facteur de la Surface nette du bloc, C_N =	1.07	1.07	0.55 x Surface brute du Bloc/ Surface solide du bloc
Facteur d'Importance, C_I =	1.00	1.00	Niveau de performance désiré, Sûreté des vies ou occupation immédiate?
Facteur de Réduction de la force sismique, m =	1.25	2.50	Dépend de f'm et du type de bâtiment
Pourcentage de surface de mur requis, PSM$_{requis}$ =	7.39%	4.92%	

$PSM_{requis} = (bPSM_{requis} \times C_B \times C_Q \times C_R \times C_L \times C_N \times C_I/m)$

Pourcentage de surface de mur requis dans la direction transversale, PSM

PSM requis/Existant= 5.91 RETROFIT

Pourcentage de surface de mur requis dans la direction longitudinale, PSM

PSM requis/Existant= 1.36 RETROFIT

Si le rapport PSMrequis/Existant est supérieur à 1.0 au moment de l'Evaluation, alors il est nécessaire de Renforcer

Dimensions du renforcement

Remarques: Matériaux de renforcement = Nouvelle maçonnerie, enduits, revêtement de béton
Surface effective+ Longueur ajoutée x facteur K x Epaisseur, facteur K pris à partir des tableaux de la page 4

Dimensions des murs de renforcement transversaux (en mètres)

Surface de mur existant, A_{wt} = 0.45

# du mur	Matériaux de renforcement	Résistance (Mpa)	Longueur ajoutée (m)	facteur K (0.5 - 1.5)	Epaisseur (m)	Surface effective (m^2)
2	Masonry Wall	6.9	2.7	1.2	0.15	0.486
3	Masonry Wall	6.9	2.7	1.2	0.15	0.486
4	Window infill	6.9	1	1.2	0.15	0.180
4	Existing usable wall	4.8	1.7	1	0.15	0.255
	(due to window infill)					

A_{wt} + Σ de surface effective de mur = 1.857

$PSM_{Renforcement\ transversale}$ (A_{wt} / A_b) x 100= 5.16%

$PSM_{Requis}/PSM_{Renforcement\ transversale}$ = 0.95 **≤ 1.0, OK**

Dimensions des murs de renforcement longitudinaux (en mètres)

Surface de mur existant, A_{wl} = 1.95

# du mur	Matériaux de renforcement	Résistance (Mpa)	Longueur ajoutée (m)	Facteur K (0.5 - 1.5)	Epaisseur (m)	Surface effective (m^2)

A_{wt} + Σ de surface effective de mur = 1.950

$PSM_{Renforcement\ longitudinale}$ (A_{wl} / A_b) x 100 = 5.42%

$PSM_{Requis}/PSM_{Renforcement\ longitudinale}$ = 0.91 **≤ 1.0, OK**

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Adresse de l'immeuble:	**Date:**
Etiquette du MTPTC :	**Ingénieur:**
	Accepté par:

Information sur l'immeuble **Niveau:** 2

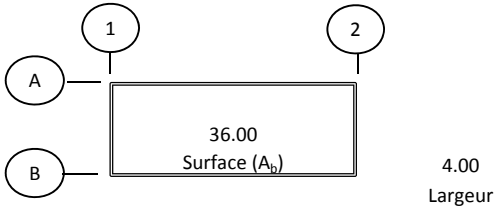
Nombre de niveaux, N: 2 (Limite 3)

Type de Bâtiment : MNA
MC (Maçonnerie chaînée)
MR (Maçonnerie de remplissage)
MNA(Maçonnerie non armée)
Voir Manuel pour description

Lieu: Port-au-Prince

Accélération spectrale du séisme , S_{ds}: 1.05 (1.05 g pour Port-au-Prince)

Dimensions du niveau:



Dimensions des murs transversaux existants (en mètres)

# du mur	Longueur	Epaisseur	Surface du mur
1	4.00	0.15	0.600
2	2.70	0.15	0.405
3	2.70	0.15	0.405
4	2.70	0.15	0.405
		Σ surface de mur, A_{wt} =	1.815
		PSM existant dans la direction transversale(A_{wt}/A_b) =	5.04%

Dimensions des murs longitudinaux existants (en mètres)

# du mur	Longueur	Epaisseur	Surface du mur
A	6.00	0.15	0.900
D	6.00	0.15	0.900
		Σ surface de mur, A_{wl} =	1.800
		PSM existant dans la direction longitudinale(A_{wl}/A_b) =	5.00%

Evaluation du Bâtiment existant **Niveau:** 2

Pourcentage de mur de base, bPSMrequis

6.40%	x	2	x	1.05	=	13.4%
(W_d)		(N)		(S_{ds})		$bPSM_{requis}$

Facteurs du pourcentage de surface de mur requis (voir page 4 pour les valeurs)

	Evaluation du Bâtiment existant		Renforcement (Si nécessaire, s'applique à la page 3)
Facteur de la Résistance du Bloc, C_B =	1.00		Dépend de f'm
Facteur de la Qualité de la Construction, C_Q =	1.00		Qualité mauvaise ou moyenne
Facteur d'Evaluation/Renforcement, C_R =	0.75		Evaluer le plan de renforcement ou la structure existante?
Facteur de niveau, C_L =	0.57		Dépend du niveau évalué et de la description de l'immeuble
Facteur de la Surface nette du bloc, C_N =	1.07		0.55 x Surface brute du Bloc/ Surface solide du bloc
Facteur d'Importance, C_I =	1.00		Niveau de performance désiré, Sûreté des vies ou occupation immédiate?
Facteur de Réduction de la force sismique, m =	1.25		Dépend de f'm et du type de bâtiment

Pourcentage de surface de mur requis, PSM_{requis} = 4.90%

$PSM_{requis} = (bPSM_{requis} \times C_B \times C_Q \times C_R \times C_L \times C_N \times C_I/m)$

Pourcentage de surface de mur requis dans la direction transversale, PSM

PSM requis/Existant= 0.97 OK

Pourcentage de surface de mur requis dans la direction longitudinale, PSM

PSM requis/Existant= 0.98 OK

Si le rapport PSMrequis/Existant est supérieur à 1.0 au moment de l'Evaluation, alors il est nécessaire de Renforcer

Tableaux de Référence

Nouveaux murs de maçonnerie

Facteur d'ajustement de surface, K_m

Nouvelle maçonnerie	Maçonnerie existante f'm MPa (psi)		
f'm	2.8 (400)	4.8 (700)	6.9 (1000)
4.8 (700)	1.3	1.0	1.0
6.9 (1000)	1.5	1.2	1.0
10 (1450)	1.5	1.4	1.2
12 (1740)	1.5	1.5	1.3

Facteur de niveau, C_L

Niveau	# de niveaux qu'a l'immeuble 1-Niveau	2-Niveau	3-Niveau	Remarques
3	-	-	0.39	Pour les immeubles ayant une dalle de toiture ou de plancher lourde en béton, poutres en béton et des hourdis en bloc de béton
2	-	0.57	0.67	
1	1.00	0.86	0.79	
3	-	-	0.14	Pour les immeubles avec toitures légères faites de tôle ou une ossature en bois
2	-	0.20	0.43	
1	0.33	0.67	0.65	

Nouvelle couche d'enduits

Facteur d'ajustement de surface, K_p

K_p = 0.5. t_p max = 2.5 cm (1.25 cm d'enduits sur les deux côtés du mur)

Facteur de Résistance du Bloc, C_B

fm de la maçonnerie MPa (psi)	Facteur C_B
1.7 (250)	1.55
2.8 (400)	1.28
4.8 (700)	1.00
6.9 (1000)	0.85
10 (1450)	0.71
11.7 (1700)	0.66

Facteur d'Evaluation/Renforcement, C_R

1	Evaluation du plan de renforcement
0.75	Evaluation de la structure existante

Nouvelle couche de béton

Facteur d'ajustement de surface, K_c

K_c = 1.5. t_c max = 7.5 cm de béton sur un côté du mur

Facteur de la Qualité de la Construction, C_Q

1	Construction de qualité moyenne

Facteur d'Importance, C_I

1	Sûreté des vies
1.5	Occupation immédiate

Facteur de Réduction de la force sismique, **m**

fm de la maçonnerie MPa (MPa)	Système MNA	MC et MR
< 10	1.25	2.5
≥ 10	1.5	3

Guide de Renforcement et d'Evaluation sismique des maisons en maçonnerie en Haiti

Programme d'assistance technique post-seisme en Haiti, Build Change

Derniére mise á jour: 2 Août 2011

Addresse du Batîment:	CVM000XIw	**A ce jour:**	9-Aug-2011
Etiquette du MTPTC :		**Ingénieur:**	
Niveau:		**Accepted By:**	
Remarques:			

PHASE 1: Réparation mineures, Préparation et Démolition			**No.**	**Unité**		**No.**	**Unité**
Réparation mineures							
MTPTC F1 (p.41)	Remplissage de petites fissures (lorsque seulement l'enduit a craqué)	Longueur de fissure=		m			
Pas encore de détails	Remplacement des murs sévèrement endummagés (lorque les blocs ont craqué)	Surface du mur=		m^2			
D0.1	Réparation de murs dégradés par les intempéries	Surface du mur=		m^2			
D0.2	Remplissage des joints principaux	Longueur =		m	Hauteur du vide=		m
Préparation et Démolition							
Pas encore de détails	Démolition de murs (murs hors d'aplomb, murs ayant des fissures > 1.5mm)	Surface=		m^2			
Pas encore de détails	Toiture légère a être enlevée	Surface=		m^2			

PHASE 2: Construction jusqu'à la toiture			**No.**	**Unité**		**No.**	**Unité**
Fondations et Chaînages inférieurs pour le mur							
D1.3	Nouvelle fondation avec chaînage inférieur	Longueur=	5.4	m			
D1.4	Chaînage inférieur seulement (nouveau mur en maçonnerie chaînée sur l'existante fondation)	Longueur=		m			
D1.6	Nouvelle fondation sans Chaînage inférieur	Longueur=		m			
Nouveaux murs avec Toiture/Plancher en béton							
D1.1	Nouveau Mur avec 4 barres(pour la MC) au dessus du mur, w/ Parallèle aux existantes nervures (cela inclut la connection au dessus du mur et le mur lui-même)	Longueur=	5.4	m	Hauteur=	2.6	m
D1.1*	Nouveau Mur avec 2 barres(pour la MNA) au dessus du mur w/ Parallèle aux existantes nervures (cela inclut la connection au dessus du mur et le mur lui-même)	Longueur=		m	Hauteur=		m
D1.2	Nouveau Mur avec 4 barres(pour la MC) au dessus du mur, w/ Perpendiculaire aux existantes nervures (cela inclut la connection au dessus du mur et le mur lui-même)	Longueur=		m	Hauteur=		m
D1.2*	Nouveau Mur avec 2 barres(pour la MNA) au dessus du mur w/ Perpendiculaire aux existantes nervures (cela inclut la connection au dessus du mur et le mur lui-même)	Longueur=		m	Hauteur=		m
D1.5, D1.7, D1.8	Connection entre le nouveau mur et celui existant(Pour MNA seulement, utiliser D5 en cas de conversion en MC)	No. d'articles=		connexions	Hauteur=		
Nouveaux murs avec Toiture/Plancher en bois							
D9.1 et D9.2	Nouveau mur en MNA avec chaînage supérieur ayant 2 barres (cela inclut attaches anti-cyclone(straps))	Longueur=		m	Hauteur=		m
Pas encore de détails	Nouveau mur en MC avec chaînage supérieur ayant 4 barres (cela inclut attaches anti-cyclone(straps))	Longueur=		m	Hauteur=		m
D1.5	Connection entre le nouveau mur et celui existant(Pour MNA seulement, utiliser D5 en cas de conversion en MC)	No. d'articles=			Hauteur=		m
Mur doublé			**No.**	**Unité**		**No.**	**Unité**

D2.1* et D2.3	Mur doublé ayant 4 barres(Pour la MC) au dessus w/ parallèle aux existantes nervures (cela inclut le mur, connexion, er prolongement de la fondation)	Longueur=		m	Hauteur=		m
D2.1 et D2.3	Mur doublé ayant 2 barres(Pour la MNA) au dessus w/ parallèle aux existantes nervures (cela inclut le mur, connexion, er prolongement de la fondation)	Longueur=		m	Hauteur=		m
D2.2* et D2.3	Mur doublé ayant 4 barres(Pour la MC) au dessus w/ perpendiculaire aux existantes nervures(cela inclut le mur, connexion, er prolongement de la fondation)	Longueur=		m	Hauteur=		m
D2.2 et D2.3	Mur doublé ayant 2 barres(Pour la MNA) au dessus w/perpendiculaire aux existantes nervures(cela inclut le mur, connexion, er prolongement de la fondation)	Longueur=		m	Hauteur=		m

Addresse du Batîment: CVM000XIw

Niveau:

Remarques:

Phase 2(suite)

Revêtement de béton armé							
D4	Revêtement de béton, d'un côté, ayant 75mm d'épaisseur (cela inclut toutes les connexions et le prolongement de la fonfation)	Longueur=		m	Hauteur=		m
Conversion en maçonnerie chaînée							
D5.1 ou D5.2	Colonnes seulement (Utiliser l'existante semelle et base de colonne)	No. d'articles=	2	colonnes	Hauteur=	2.6	m
D5.1 ou D5.2, et D5.7	Colonnes avec semelle	No. d'articles=		colonnes	Hauteur=		m
D5.9	2 barres #4 en guise de renforcement sur chaque côté des portes	No. d'articles=	3	Armatures	Hauteur=	2.6	m
D5.10	1 barre #4 sur chaque côté des fenêtres	No. d'articles=	12	Armatures	Hauteur=	1	m
Pas encore de détails	Chaînage supérieur de 4 barres au-dessus mur existant w/ toiture légère	Longueur=		m			
Pas encore de détails	Chaînage supérieur de 4 barres au-dessus du mur existant dans la dalle de béton(nervures parallèles)	Longueur=		m			
Pas encore de détails	Chaînage supérieur de 4 barres au-dessus du mur existant dans la dalle de béton (nervures perpendiculaires)	Longueur=		m			
Remplissage de fenêtre							
D6.1	Remplissage d'une fenêtre	No. d'articles=	1	fenêtres	Surface total de remplissage=	1	m^2
Chaînage Supérieur Sur les Structures en MNA avec Toiture Légère							
D9.1, D9.2 et D9.3	Chaînage supérieur avec 2 Barres (pour les structures en MNA avec toitures légéres, cela inclut attaches anti-cyclone(straps))	Longueur=		m			
D9.4	Linteau w/ 4 Barres (pour les structures en MNA avec toitures légéres, au-dessus des ouvertures, cela inclut attaches anti-cyclone(straps))	Longueur=		m			
Détails techniques pour 2 niveaux							
D8.1	Renforcement des colonnes aux niveau du porche	No. d'articles=		colonnes	Hauteur=		m
D7	Renforcement du larmier	No. d'articles=			Longueur du larmier=		m

PHASE 3: Replacement de la toiture			**No.**	**Unité**		**No.**	**Unité**
Toitures légères	(Toitures légères uniquement)						
	La grande dimension du Plan de toiture(longueur)	Longueur=		m			
	La petite dimension du plan de toiture(largeur)	Largeur=		m			
	Estimation du pourcentage de bois usagés qui seront utilisés pour la construction de la toitiure			%			
	Estimation du pourcentage de tôles usagées qui seront utilisées pour la construction de la toitiure			%			

PHASE 4: Finition			**No.**	**Unité**		**No.**	**Unité**
Enduit							
D3.1	Enduit de plâtre (I.e. un seul côté, Epaisseur 2cm)	Surface du mur=		m^2			
Peint							
Pas encore de détails	Peint sur l'extérieur (I.e. un seul côté)	Surface du mur=		m^2			

Adrès CVM000XIw **Dat:** 9-Aug-2011

Enjenyè **Aprouve pa:**

				FAZ 1		FAZ 2		FAZ 3		FAZ 4		TOTAL	
No	**Atik**	**Pri inite**	**Inite**	**Total**	**Pri Total**	**Total**	**Pri Total**	**Total**	**Pri Total**	**Total**	**Pri Total**	**Total**	**Pri Total**
1	Siman	$7.50	/sac			20	$150.00					**20**	**$150.00**
2	Sab Rivyè	$25.00	/m^3			1.75	$43.76					**1.75**	**$43.76**
3	Sab Blan	$20.00	/m^3										
4	Gravye	$18.75	/m^3			1.52	$28.52					**1.52**	**$28.52**
5	Wòch	$15.00	/m^3			1.73	$25.92					**1.73**	**$25.92**
6	bafè demi (1/2)	$11.01	chak ba(9m)			8	$88.08					**8**	**$88.08**
7	bafè demi (3/8)	$8.30	chak ba(9m)			11	$91.30					**11**	**$91.30**
8	bafè demi ka (1/4)	$3.21	chak ba(6m)			13	$41.73					**13**	**$41.73**
9	Fil alegati	$1.50	/liv			6	$9.47					**6**	**$9.47**
10	blòk 20cm	$0.80	chak										
11	blòk 15cm	$0.65	chak			180	$117.31					**180**	**$117.31**
12	blòk 12cm	$0.50	chak										
13	blòk 10cm	$0.40	chak										
14	bwa 1x4x16'	$9.00	chak										
15	bwa 1x8x 16'	$12.00	chak										
16	bwa 2x2x16'	$10.00	chak										
17	bwa 2x4x16'	$14.80	chak										
18	féy playwood 1/2"	$40.65	chak										
19	klou varye	$1.20	/liv										
20	klou tòl	$1.40	/liv										
21	tòl 3'x12'	$30.00	chak										
22	tòl 3'x10'	$28.00	chak										
23	tòl 3'x8'	$26.00	chak										
24	fetyè	$20.00	chak										
25	penti	$10.00	/galon										
26	strap	$1.65	/m										
27	konsèvasyon bwa	$10.00	/galon										
	Pri materyo konstriksyon						**$596**						**$596**
	Kofray Ki Lwe						**$40**						**$40**
	Pri Mendèv						**$229.71**						**$229.71**
Soutotal							$865.57						**$865.57**
20% pout transpò ak kou nou pat prevwa							$173.11						**$173.11**
Total							**$1,039**					**Gran Total=**	**$1,039**

Remak= Tout pri yo an dola ameriken

build change

9 Aug, 2011

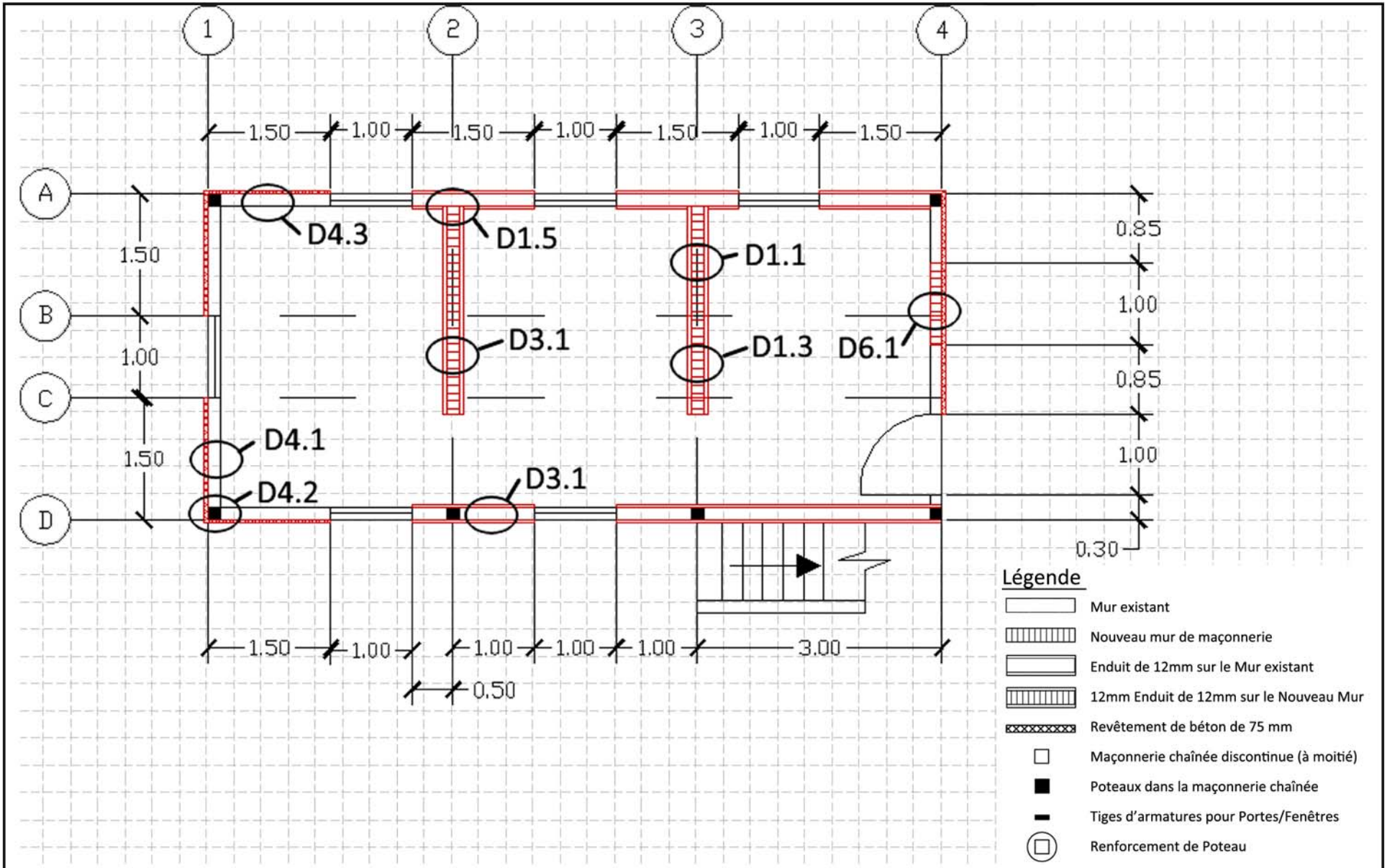
Build Change has evaluated the existing structure of house number CVM000X and has found that seismic retrofit is necessary.

The following work is required:

Structural Intervention

- Fill in window along line 4
- Construct new walls along lines 2 and 3
- Add columns at 2A and 3A
- Add window reinforcement to all windows and door reinforcement to doors as noted

Unreinforced Masonry



build change

Rez de Chaussée

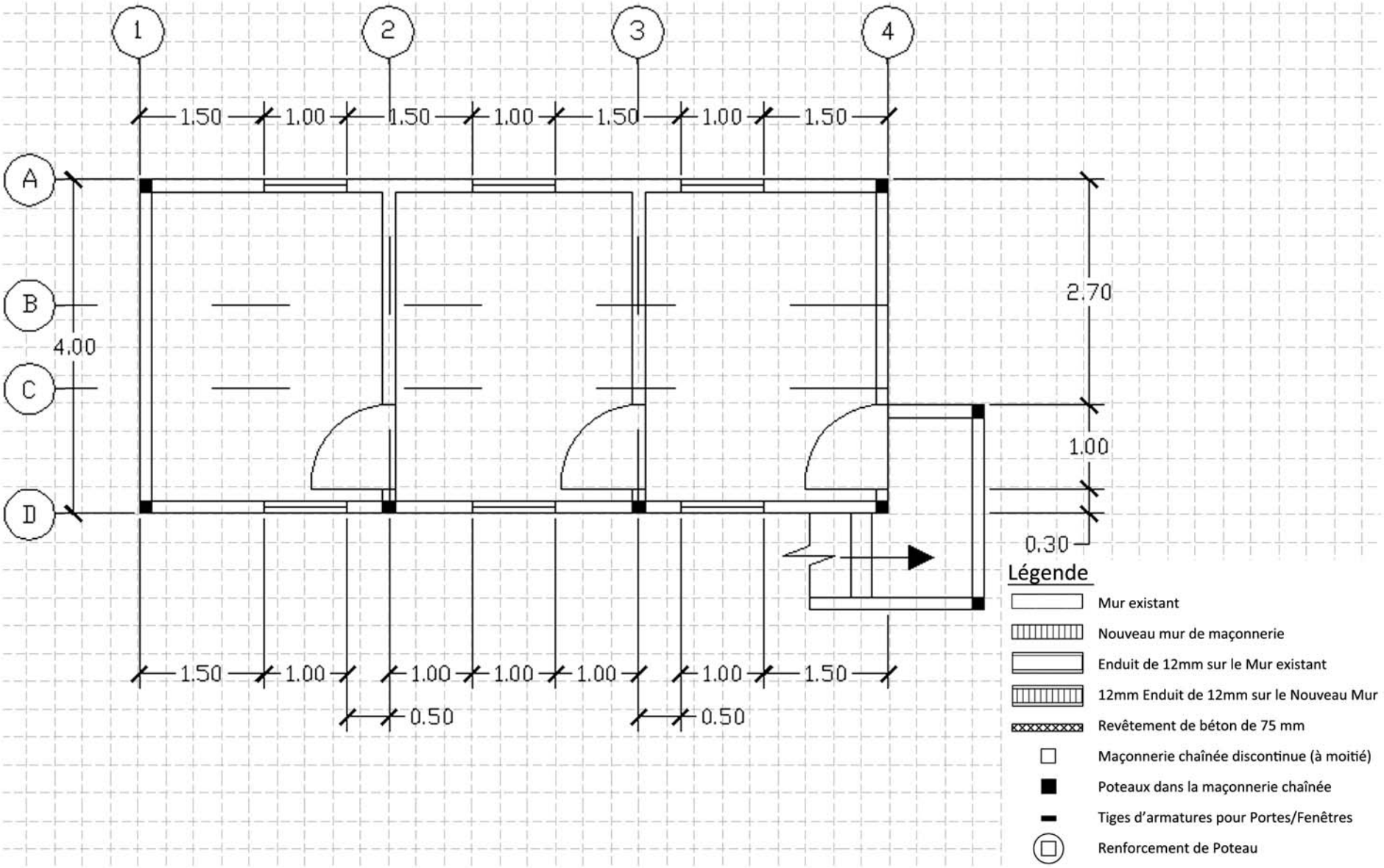
CVM000X

Pierre Jean
(509) 5555-5555

Charis Wu | 9 Aug 2011

18.539345, -72.336414

R



build change

1er Étage

CVM000X

Pierre Jean
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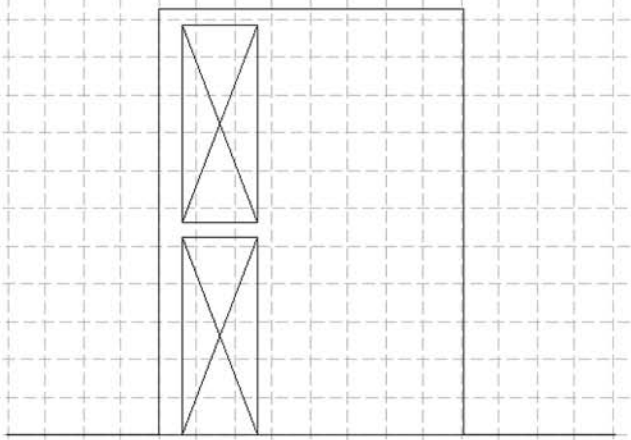
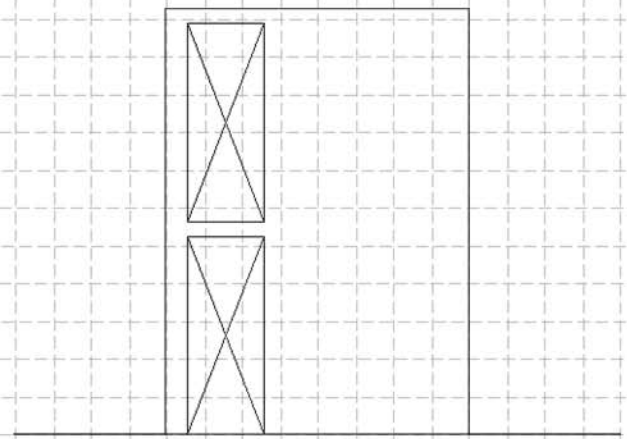
Charis Wu | 9 Aug 2011

18.539345, -72.336414

R



ELEVATION 3



ELEVATION 4

Légende

- Mur existant
- Nouveau mur de maçonnerie
- Enduit de 12mm sur le Mur existant
- 12mm Enduit de 12mm sur le Nouveau Mur
- Revêtement de béton de 75 mm
- Maçonnerie chaînée discontinue (à moitié)
- Poteaux dans la maçonnerie chaînée
- Tiges d'armatures pour Portes/Fenêtres
- Renforcement de Poteau

build change

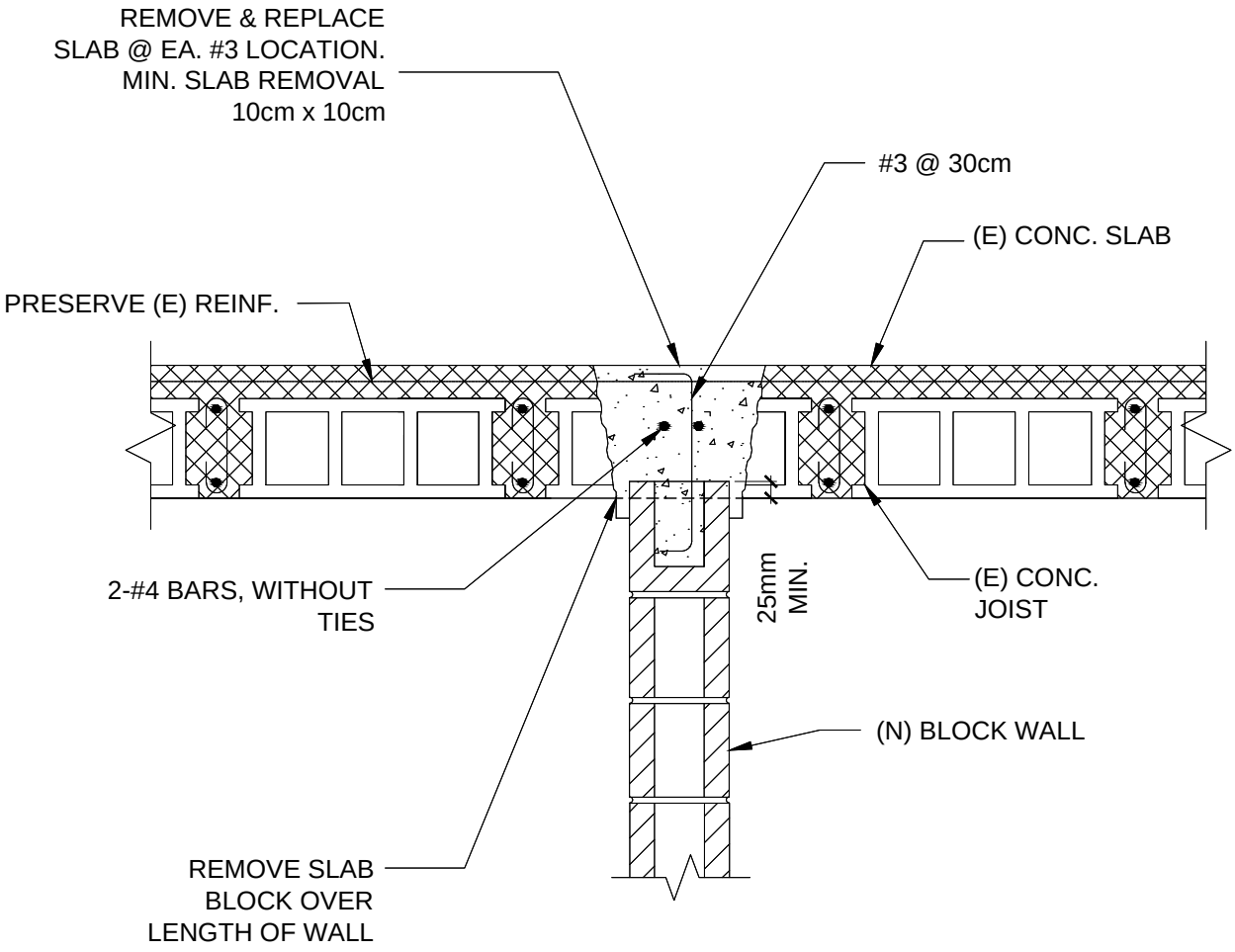
Elevations

CVM000X

Pierre Jean
(509) 5555-5555

R

Charis Wu	9 Aug 2011
18.539345, -72.336414	



NOTE:
REFER TO DETAIL D1.9 WHEN BUILDING IS CLASSIFIED AS CM/IM.

build change

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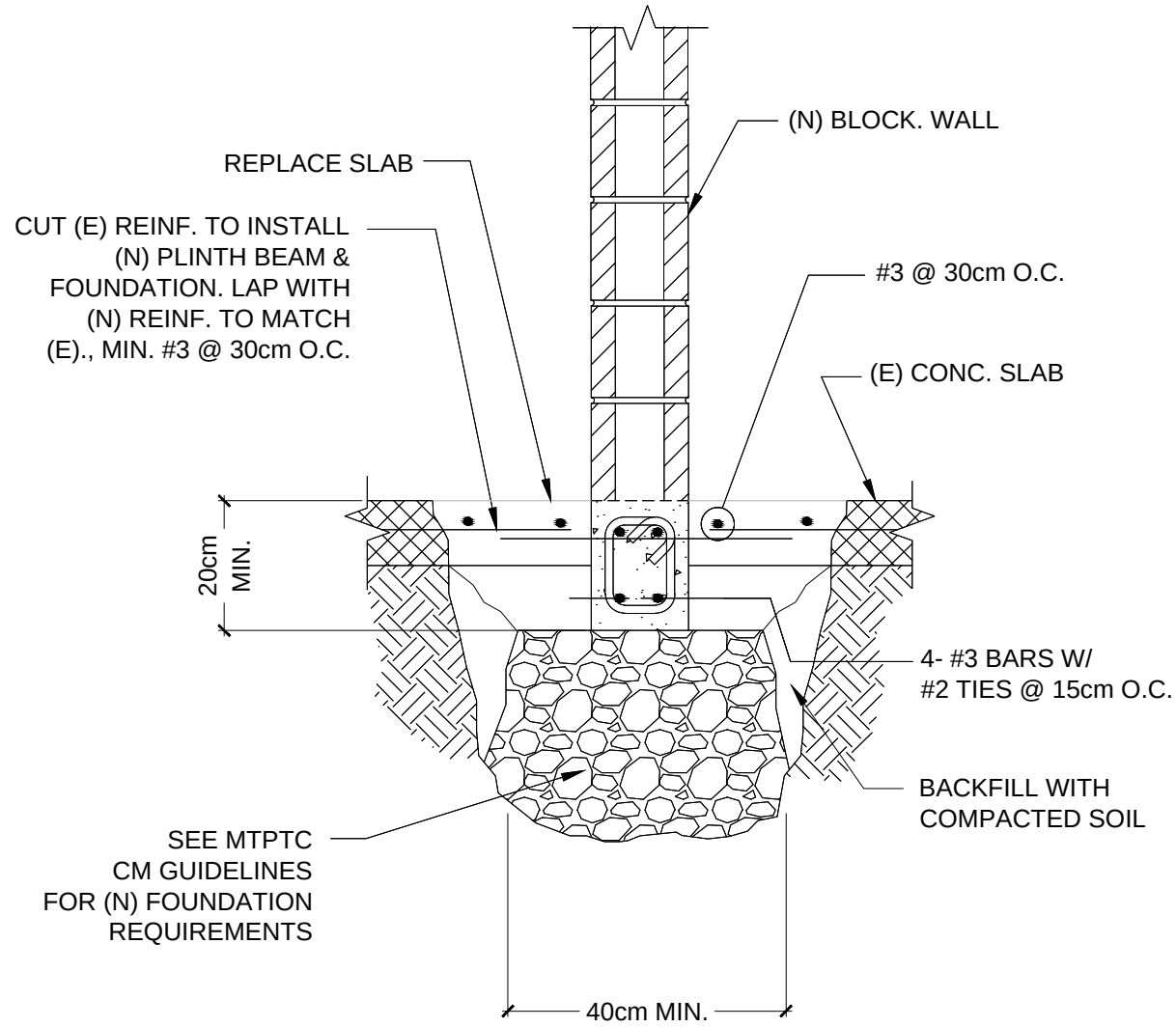
(N) WALL PARALLEL W/ JOIST
(2 BAR RING BEAM)

PROJECT	DATE
SCALE	

D1.1



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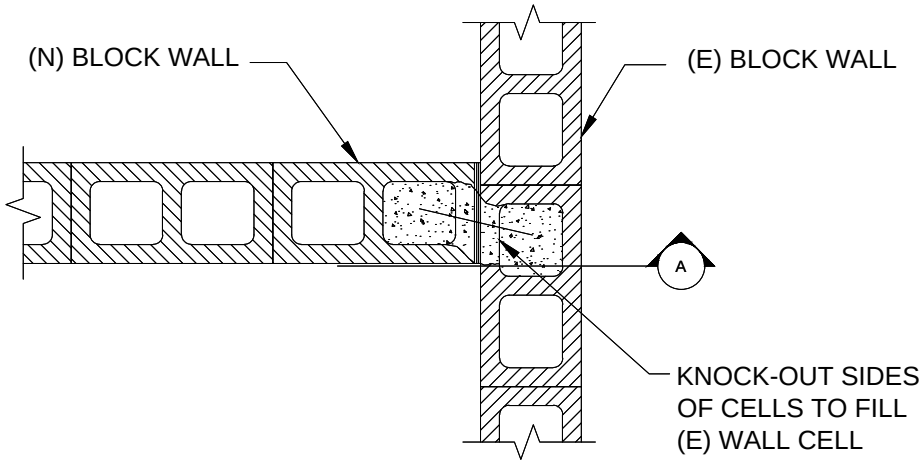
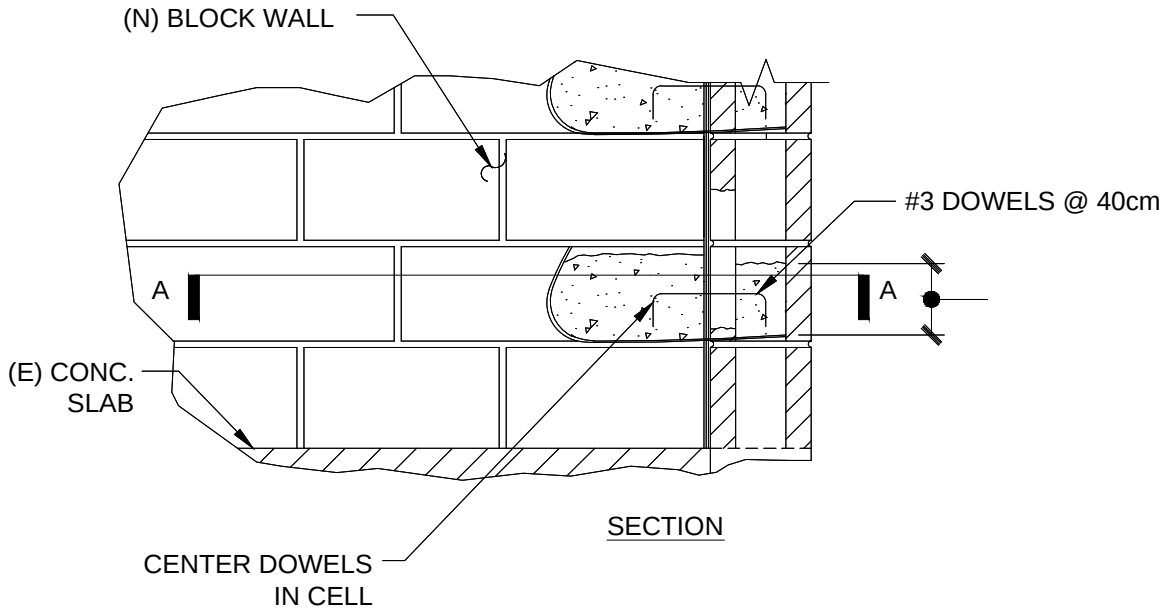
(N) WALL TO (N) FOUNDATION

PROJECT	DATE
SCALE	

D1.3



PLAN A-A



SECTION

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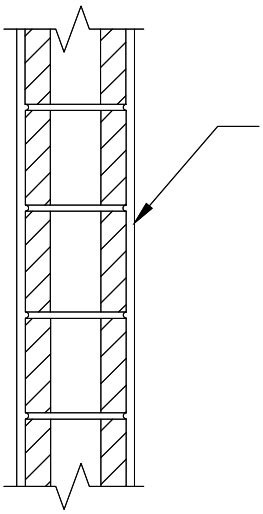
(N) URM WALL TO (E) WALL CONN. DETAILS

PROJECT	DATE	D1.5
SCALE		



SMOOTH, EVEN LAYER
OF CEMENT PLASTER EACH
SIDE OF WALL. MIN. COMP.
STRENGTH = 14 MPa

NOTE:
SEE MTPTC GUIDLINES FOR MIX PROPORTION
AND APPLICATION OF CEMENT PLASTER

build change

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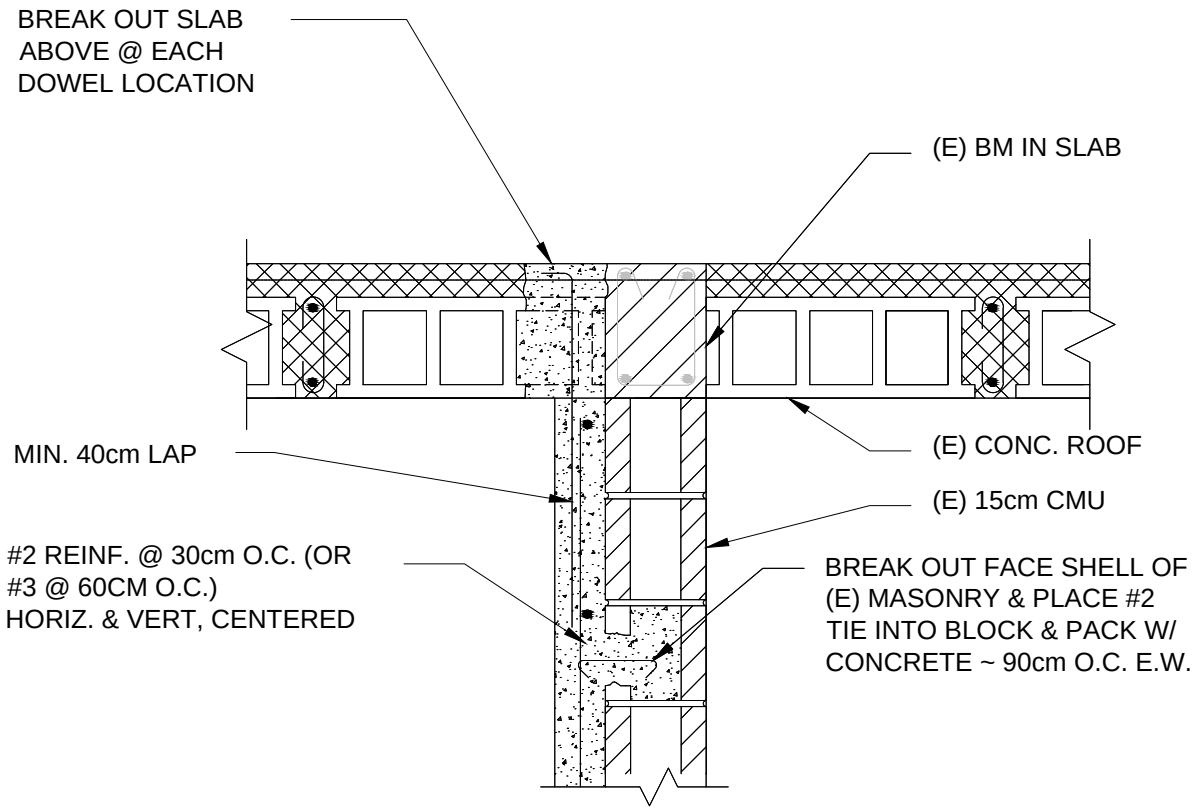
PLASTER OVERLAY ON BOTH SIDES

PROJECT	DATE
SCALE	

D3.1



build change

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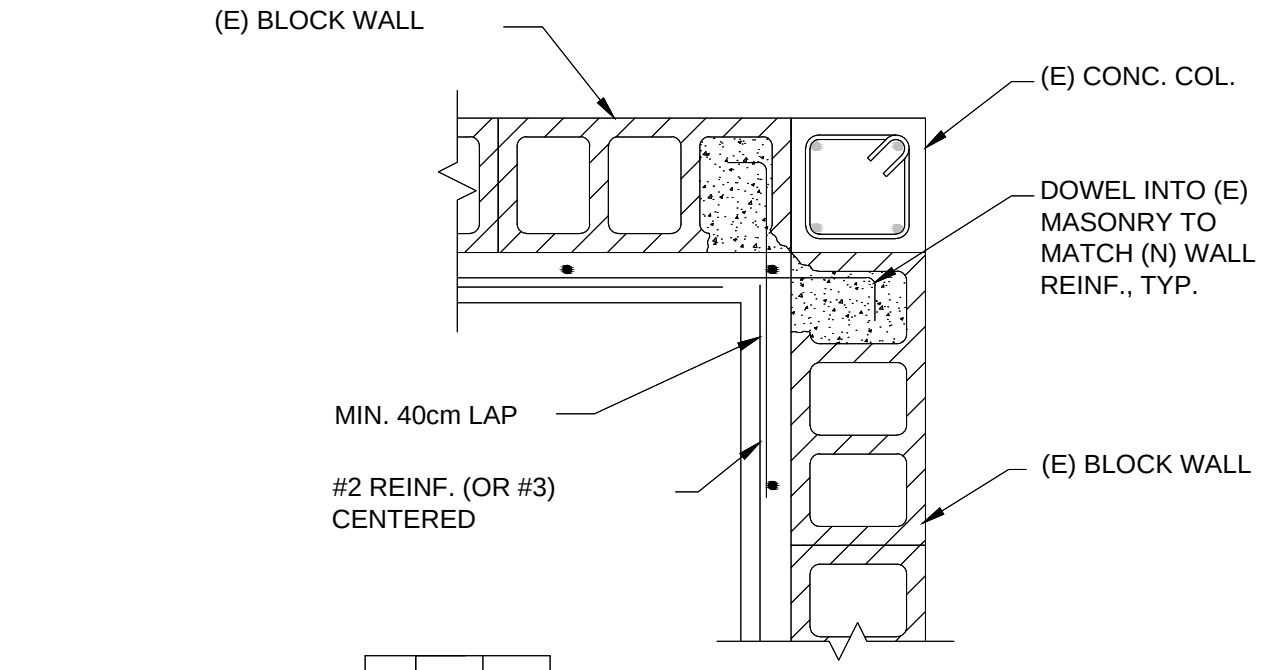
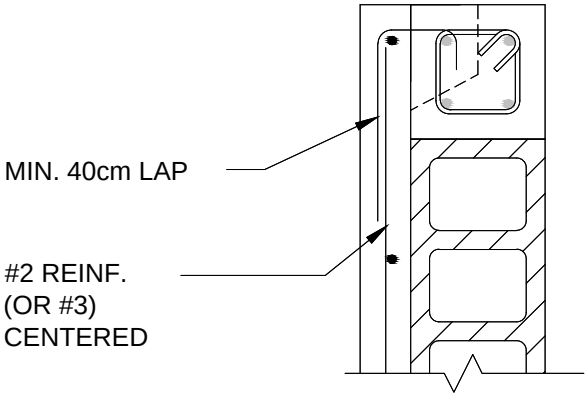
SHEAR WALL CONNECTION TO ROOF

PROJECT	DATE
SCALE	

D4.1



TWO SIDES



ONE SIDE

build change

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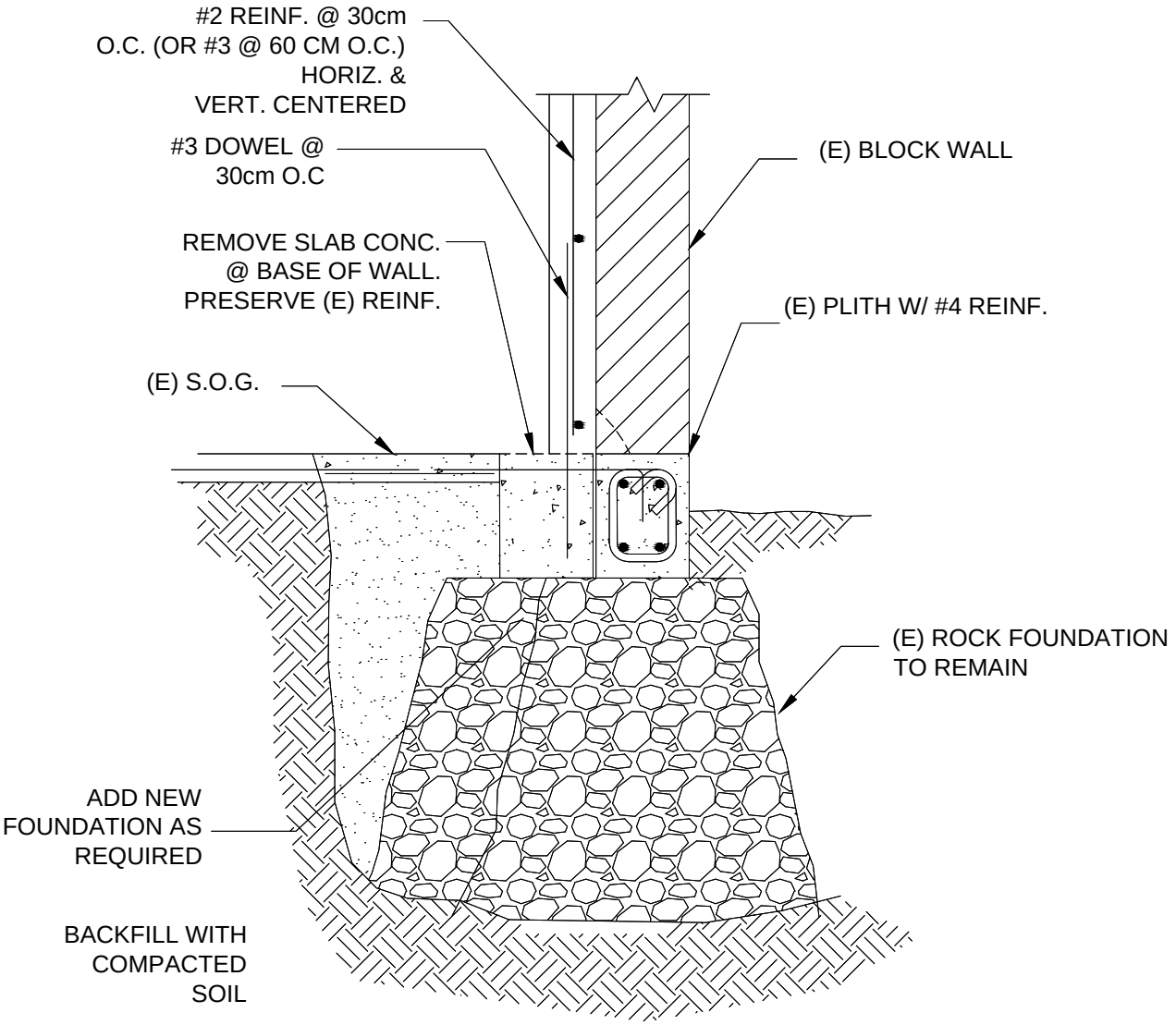
SHEAR WALL CONNECTION TO COLUMN

PROJECT	DATE
SCALE	

D4.2



build change

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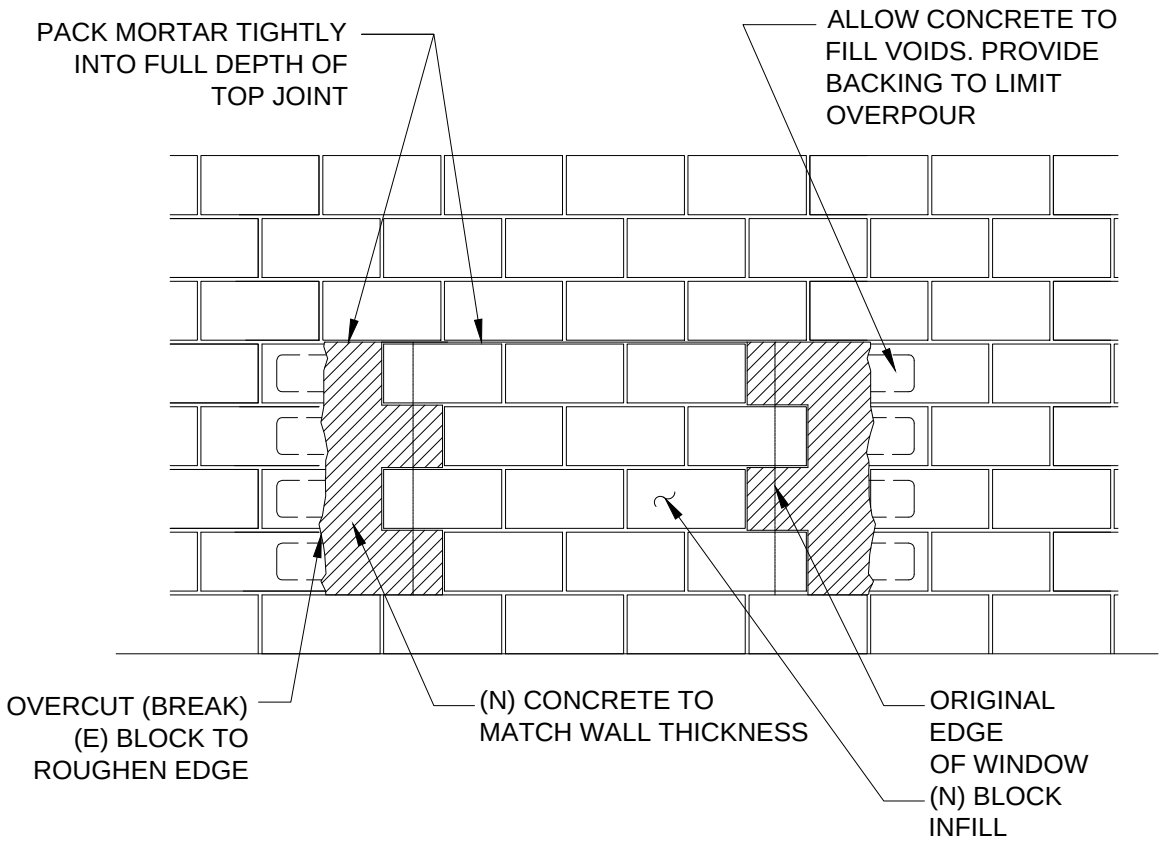
www.degenkolb.com

SHEAR WALL CONNECTION TO COLUMN

PROJECT	DATE
SCALE	

D4.3



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WINDOW INFILL ELEVATION

PROJECT	DATE
SCALE	

D6.1

Guide de Renforcement et d'Evaluation sismique des maisons en maçonnerie en Haiti

Programme d'assistance technique post-seisme en Haiti, Build Change

Adresse de l'immeuble:	**Date:**
Etiquette du MTPTC :	**Ingénieur:**
	Accepté par:

Information sur l'immeuble **Niveau:** 1

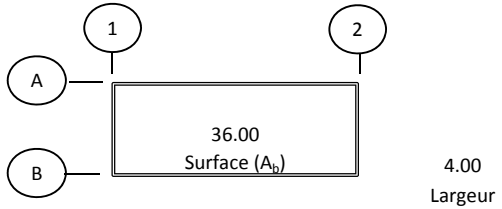
Nombre de niveaux, N: 2 (Limite 3)

Type de Bâtiment : MNA
MC (Maçonnerie chaînée)
MR (Maçonnerie de remplissage)
MNA(Maçonnerie non armée)
Voir Manuel pour description

Lieu: Port-au-Prince

Accélération spectrale du séisme , S_{ds}: 1.05 (1.05 g pour Port-au-Prince)

Dimensions du niveau:



Dimensions des murs transversaux existants (en mètres)

# du mur	Longueur	Epaisseur	Surface du mur
1	3.00	0.15	0.450
		Σ surface de mur, A_{wt} =	0.450
		PSM existant dans la direction transversale(A_{wt}/A_b) =	1.25%

Dimensions des murs longitudinaux existants (en mètres)

# du mur	Longueur	Epaisseur	Surface du mur
A	6.00	0.15	0.900
D	7.00	0.15	1.050
		Σ surface de mur, A_{wl} =	1.950
		PSM existant dans la direction longitudinale(A_{wl}/A_b) =	5.42%

Evaluation du Bâtiment existant **Niveau:** 1

Pourcentage de mur de base, bPSMrequis

6.40%	x	2	x	1.05	=	13.4%
(W_d)		(N)		(S_{ds})		bPSM$_{requis}$

Facteurs du pourcentage de surface de mur requis (voir page 4 pour les valeurs)

	Evaluation du Bâtiment existant	Renforcement (Si nécessaire, s'applique à la page 3)	
Facteur de la Résistance du Bloc, C_B =	1.00	1.00	Dépend de f'm
Facteur de la Qualité de la Construction, C_Q =	1.00	1.00	Qualité mauvaise ou moyenne
Facteur d'Evaluation/Renforcement, C_R =	0.75	1.00	Evaluer le plan de renforcement ou la structure existante?
Facteur de niveau, C_L =	0.86	0.86	Dépend du niveau évalué et de la description de l'immeuble
Facteur de la Surface nette du bloc, C_N =	1.07	1.07	0.55 x Surface brute du Bloc/ Surface solide du bloc
Facteur d'Importance, C_I =	1.00	1.00	Niveau de performance désiré, Sûreté des vies ou occupation immédiate?
Facteur de Réduction de la force sismique, m =	1.25	1.25	Dépend de f'm et du type de bâtiment
Pourcentage de surface de mur requis, PSM$_{requis}$ =	7.39%	9.85%	

PSMrequis = (bPSM$_{requis}$ x C_B x C_Q x C_R x C_L x C_N x C_I/m)

Pourcentage de surface de mur requis dans la direction transversale, PSM

PSM requis/Existant= 5.91 RETROFIT

Pourcentage de surface de mur requis dans la direction longitudinale, PSM

PSM requis/Existant= 1.36 RETROFIT

Si le rapport PSMrequis/Existant est supérieur à 1.0 au moment de l'Evaluation, alors il est nécessaire de Renforcer

Dimensions du renforcement

Remarques: Matériaux de renforcement = Nouvelle maçonnerie, enduits, revêtement de béton
Surface effective+ Longueur ajoutée x facteur K x Epaisseur, facteur K pris à partir des tableaux de la page 4

Dimensions des murs de renforcement transversaux (en mètres)

Surface de mur existant, A_{wt} = 0.45

# du mur	Matériaux de renforcement	Résistance (Mpa)	Longueur ajoutée (m)	facteur K (0.5 - 1.5)	Epaisseur (m)	Surface effective (m^2)
2	Masonry Wall	6.9	2.7	1.2	0.15	0.486
3	Masonry Wall	6.9	2.7	1.2	0.15	0.486
1	Overlay		3	1.5	0.15	0.675
4	Overlay		2.7	1.5	0.15	0.608
2	Plaster		2.7	0.5	0.15	0.203
3	Plaster		2.7	0.5	0.15	0.203
4	Window infill	6.9	1	1.2	0.15	0.180
4	Existing usable wall	4.8	1.7	1	0.15	0.255

A_{wt} + Σ de surface effective de mur = 3.545

$PSM_{Renforcement\ transversale}$ (A_{wt} / A_b) x 100= 9.85%

$PSM_{Requis}/PSM_{Renforcement\ transversale}$ = 1.0 **≤ 1.0, OK**

Dimensions des murs de renforcement longitudinaux (en mètres)

Surface de mur existant, A_{wl} = 1.95

# du mur	Matériaux de renforcement	Résistance (Mpa)	Longueur ajoutée (m)	Facteur K (0.5 - 1.5)	Epaisseur (m)	Surface effective (m^2)
A	Overlay		1.5	1.5	0.15	0.338
D	Overlay		1.5	1.5	0.15	0.338
A	Plaster		4.5	0.5	0.15	0.338
D	Plaster		5.5	0.5	0.15	0.413

A_{wt} + Σ de surface effective de mur = 3.375

$PSM_{Renforcement\ longitudinale}$ (A_{wl} / A_b) x 100 = 9.38%

$PSM_{Requis}/PSM_{Renforcement\ longitudinale}$ = 1.0 **≤ 1.0, OK**

Guide de Renforcement et d'Evaluation sismique des maisons en maçonnerie en Haiti

Programme d'assistance technique post-seisme en Haiti, Build Change

Adresse de l'immeuble:	**Date:**
Etiquette du MTPTC :	**Ingénieur:**
	Accepté par:

Information sur l'immeuble **Niveau:** 2

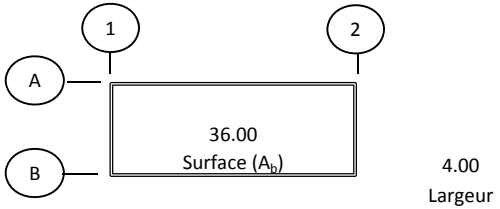
Nombre de niveaux, N: 2 (Limite 3)

Type de Bâtiment : MNA
MC (Maçonnerie chaînée)
MR (Maçonnerie de remplissage)
MNA(Maçonnerie non armée)
Voir Manuel pour description

Lieu: Port-au-Prince

Accélération spectrale du séisme , S_{ds}: 1.05 (1.05 g pour Port-au-Prince)

Dimensions du niveau:



Dimensions des murs transversaux existants (en mètres)

# du mur	Longueur	Epaisseur	Surface du mur
1	4.00	0.15	0.600
2	2.70	0.15	0.405
3	2.70	0.15	0.405
4	2.70	0.15	0.405
		Σ surface de mur, A_{wt} =	1.815
		PSM existant dans la direction transversale(A_{wt}/A_b) =	5.04%

Dimensions des murs longitudinaux existants (en mètres)

# du mur	Longueur	Epaisseur	Surface du mur
A	6.00	0.15	0.900
D	6.00	0.15	0.900
		Σ surface de mur, A_{wl} =	1.800
		PSM existant dans la direction longitudinale(A_{wl}/A_b) =	5.00%

Evaluation du Bâtiment existant **Niveau:** 2

Pourcentage de mur de base, bPSMrequis

6.40%	x	2	x	1.05	=	13.4%
(W_d)		(N)		(S_{ds})		$bPSM_{requis}$

Facteurs du pourcentage de surface de mur requis (voir page 4 pour les valeurs)

	Evaluation du Bâtiment existant		Renforcement (Si nécessaire, s'applique à la page 3)
Facteur de la Résistance du Bloc, C_B =	1.00		Dépend de f'm
Facteur de la Qualité de la Construction, C_Q =	1.00		Qualité mauvaise ou moyenne
Facteur d'Evaluation/Renforcement, C_R =	0.75		Evaluer le plan de renforcement ou la structure existante?
Facteur de niveau, C_L =	0.57		Dépend du niveau évalué et de la description de l'immeuble
Facteur de la Surface nette du bloc, C_N =	1.07		0.55 x Surface brute du Bloc/ Surface solide du bloc
Facteur d'Importance, C_I =	1.00		Niveau de performance désiré, Sûreté des vies ou occupation immédiate?
Facteur de Réduction de la force sismique, m =	1.25		Dépend de f'm et du type de bâtiment

Pourcentage de surface de mur requis, PSM_{requis} = 4.90%

$PSM_{requis} = (bPSM_{requis} \times C_B \times C_Q \times C_R \times C_L \times C_N \times C_I/m)$

Pourcentage de surface de mur requis dans la direction transversale, PSM

PSM requis/Existant= 0.97 OK

Pourcentage de surface de mur requis dans la direction longitudinale, PSM

PSM requis/Existant= 0.98 OK

Si le rapport PSMrequis/Existant est supérieur à 1.0 au moment de l'Evaluation, alors il est nécessaire de Renforcer

Tableaux de Référence

Nouveaux murs de maçonnerie

Facteur d'ajustement de surface, K_m

Nouvelle maçonnerie	Maçonnerie existante f'm MPa (psi)		
f'm	2.8 (400)	4.8 (700)	6.9 (1000)
4.8 (700)	1.3	1.0	1.0
6.9 (1000)	1.5	1.2	1.0
10 (1450)	1.5	1.4	1.2
12 (1740)	1.5	1.5	1.3

Facteur de niveau, C_L

Niveau	# de niveaux qu'a l'immeuble 1-Niveau	2-Niveau	3-Niveau	Remarques
3	-	-	0.39	Pour les immeubles ayant une dalle de toiture ou de plancher lourde en béton, poutres en béton et des hourdis en bloc de béton
2	-	0.57	0.67	
1	1.00	0.86	0.79	
3	-	-	0.14	Pour les immeubles avec toitures légères faites de tôle ou une ossature en bois
2	-	0.20	0.43	
1	0.33	0.67	0.65	

Nouvelle couche d'enduits

Facteur d'ajustement de surface, K_p

K_p = 0.5. t_p max = 2.5 cm (1.25 cm d'enduits sur les deux côtés du mur)

Facteur de Résistance du Bloc, C_B

fm de la maçonnerie MPa (psi)	Facteur C_B
1.7 (250)	1.55
2.8 (400)	1.28
4.8 (700)	1.00
6.9 (1000)	0.85
10 (1450)	0.71
11.7 (1700)	0.66

Facteur d'Evaluation/Renforcement, C_R

1	Evaluation du plan de renforcement
0.75	Evaluation de la structure existante

Facteur de la Qualité de la Construction, C_Q

1	Construction de qualité moyenne

Nouvelle couche de béton

Facteur d'ajustement de surface, K_c

K_c = 1.5. t_c max = 7.5 cm de béton sur un côté du mur

Facteur d'Importance, C_I

1	Sûreté des vies
1.5	Occupation immédiate

Facteur de Réduction de la force sismique, **m**

fm de la maçonnerie MPa (MPa)	Système MNA	MC et MR
< 10	1.25	2.5
≥ 10	1.5	3

Guide de Renforcement et d'Evaluation sismique des maisons en maçonnerie en Haiti

Programme d'assistance technique post-seisme en Haiti, Build Change

Derniére mise á jour: 2 Août 2011

Addresse du Batîment: CVM000X **A ce jour:** 9-Aug-2011

Etiquette du MTPTC : **Ingénieur:** Charis Wu

Niveau: **Accepted By:**

Remarques:

PHASE 1: Réparation mineures, Préparation et Démolition			**No.**	**Unité**		**No.**	**Unité**
Réparation mineures							
MTPTC F1 (p.41)	Remplissage de petites fissures (lorsque seulement l'enduit a craqué)	Longueur de fissure=		m			
Pas encore de détails	Remplacement des murs sévèrement endummagés (lorque les blocs ont craqué)	Surface du mur=		m^2			
D0.1	Réparation de murs dégradés par les intempéries	Surface du mur=		m^2			
D0.2	Remplissage des joints principaux	Longueur =		m	Hauteur du vide=		m
Préparation et Démolition							
Pas encore de détails	Démolition de murs (murs hors d'aplomb, murs ayant des fissures > 1.5mm)	Surface=		m^2			
Pas encore de détails	Toiture légère a être enlevée	Surface=		m^2			

PHASE 2: Construction jusqu'à la toiture			**No.**	**Unité**		**No.**	**Unité**
Fondations et Chaînages inférieurs pour le mur							
D1.3	Nouvelle fondation avec chaînage inférieur	Longueur=	5.4	m			
D1.4	Chaînage inférieur seulement (nouveau mur en maçonnerie chaînée sur l'existante fondation)	Longueur=		m			
D1.6	Nouvelle fondation sans Chaînage inférieur	Longueur=		m			
Nouveaux murs avec Toiture/Plancher en béton							
D1.1	Nouveau Mur avec 4 barres(pour la MC) au dessus du mur, w/ Parallèle aux existantes nervures (cela inclut la connection au dessus du mur et le mur lui-même)	Longueur=	5.4	m	Hauteur=	2.6	m
D1.1*	Nouveau Mur avec 2 barres(pour la MNA) au dessus du mur w/ Parallèle aux existantes nervures (cela inclut la connection au dessus du mur et le mur lui-même)	Longueur=		m	Hauteur=		m
D1.2	Nouveau Mur avec 4 barres(pour la MC) au dessus du mur, w/ Perpendiculaire aux existantes nervures (cela inclut la connection au dessus du mur et le mur lui-même)	Longueur=		m	Hauteur=		m
D1.2*	Nouveau Mur avec 2 barres(pour la MNA) au dessus du mur w/ Perpendiculaire aux existantes nervures (cela inclut la connection au dessus du mur et le mur lui-même)	Longueur=		m	Hauteur=		m
D1.5, D1.7, D1.8	Connection entre le nouveau mur et celui existant(Pour MNA seulement, utiliser D5 en cas de conversion en MC)	No. d'articles=		connexions	Hauteur=		
Nouveaux murs avec Toiture/Plancher en bois							
D9.1 et D9.2	Nouveau mur en MNA avec chaînage supérieur ayant 2 barres (cela inclut attaches anti-cyclone(straps))	Longueur=		m	Hauteur=		m
Pas encore de détails	Nouveau mur en MC avec chaînage supérieur ayant 4 barres (cela inclut attaches anti-cyclone(straps))	Longueur=		m	Hauteur=		m
D1.5	Connection entre le nouveau mur et celui existant(Pour MNA seulement, utiliser D5 en cas de conversion en MC)	No. d'articles=			Hauteur=		m
Mur doublé			**No.**	**Unité**		**No.**	**Unité**

D2.1* et D2.3	Mur doublé ayant 4 barres(Pour la MC) au dessus w/ parallèle aux existantes nervures (cela inclut le mur, connexion, er prolongement de la fondation)	Longueur=		m	Hauteur=		m
D2.1 et D2.3	Mur doublé ayant 2 barres(Pour la MNA) au dessus w/ parallèle aux existantes nervures (cela inclut le mur, connexion, er prolongement de la fondation)	Longueur=		m	Hauteur=		m
D2.2* et D2.3	Mur doublé ayant 4 barres(Pour la MC) au dessus w/ perpendiculaire aux existantes nervures(cela inclut le mur, connexion, er prolongement de la fondation)	Longueur=		m	Hauteur=		m
D2.2 et D2.3	Mur doublé ayant 2 barres(Pour la MNA) au dessus w/perpendiculaire aux existantes nervures(cela inclut le mur, connexion, er prolongement de la fondation)	Longueur=		m	Hauteur=		m

Addresse du Batîment: CVM000X

Niveau:

Remarques:

Phase 2(suite)

Revêtement de béton armé							
D4	Revêtement de béton, d'un côté, ayant 75mm d'épaisseur (cela inclut toutes les connexions et le prolongement de la fonfation)	Longueur=	8.7	m	Hauteur=	2.6	m
Conversion en maçonnerie chaînée							
D5.1 ou D5.2	Colonnes seulement (Utiliser l'existante semelle et base de colonne)	No. d'articles=		colonnes	Hauteur=		m
D5.1 ou D5.2, et D5.7	Colonnes avec semelle	No. d'articles=		colonnes	Hauteur=		m
D5.9	2 barres #4 en guise de renforcement sur chaque côté des portes	No. d'articles=		Armatures	Hauteur=		m
D5.10	1 barre #4 sur chaque côté des fenêtres	No. d'articles=		Armatures	Hauteur=		m
Pas encore de détails	Chaînage supérieur de 4 barres au-dessus mur existant w/ toiture légère	Longueur=		m			
Pas encore de détails	Chaînage supérieur de 4 barres au-dessus du mur existant dans la dalle de béton(nervures parallèles)	Longueur=		m			
Pas encore de détails	Chaînage supérieur de 4 barres au-dessus du mur existant dans la dalle de béton (nervures perpendiculaires)	Longueur=		m			
Remplissage de fenêtre							
D6.1	Remplissage d'une fenêtre	No. d'articles=	1	fenêtres	Surface total de remplissage=	1	m^2
Chaînage Supérieur Sur les Structures en MNA avec Toiture Légère							
D9.1, D9.2 et D9.3	Chaînage supérieur avec 2 Barres (pour les structures en MNA avec toitures légéres, cela inclut attaches anti-cyclone(straps))	Longueur=		m			
D9.4	Linteau w/ 4 Barres (pour les structures en MNA avec toitures légéres, au-dessus des ouvertures, cela inclut attaches anti-cyclone(straps))	Longueur=		m			
Détails techniques pour 2 niveaux							
D8.1	Renforcement des colonnes aux niveau du porche	No. d'articles=		colonnes	Hauteur=		m
D7	Renforcement du larmier	No. d'articles=			Longueur du larmier=		m

PHASE 3: Replacement de la toiture			**No.**	**Unité**		**No.**	**Unité**
Toitures légères	(Toitures légères uniquement)						
	La grande dimension du Plan de toiture(longueur)	Longueur=		m			
	La petite dimension du plan de toiture(largeur)	Largeur=		m			
	Estimation du pourcentage de bois usagés qui seront utilisés pour la construction de la toitiure			%			
	Estimation du pourcentage de tôles usagées qui seront utilisées pour la construction de la toitiure			%			

PHASE 4: Finition			**No.**	**Unité**		**No.**	**Unité**
Enduit							
D3.1	Enduit de plâtre (I.e. un seul côté, Epaisseur 2cm)	Surface du mur=	80.08	m^2			
Peint							
Pas encore de détails	Peint sur l'extérieur (I.e. un seul côté)	Surface du mur=		m^2			

Adrès CVM000X **Dat:** 9-Aug-2011

Enjenyè Charis Wu **Aprouve pa:**

				FAZ 1		FAZ 2		FAZ 3		FAZ 4		TOTAL	
No	**Atik**	**Pri inite**	**Inite**	**Total**	**Pri Total**	**Total**	**Pri Total**	**Total**	**Pri Total**	**Total**	**Pri Total**	**Total**	**Pri Total**
1	Siman	$7.50	/sac			32	$240.00			14	$105.00	**46**	**$345.00**
2	Sab Rivyè	$25.00	/m^3			2.80	$70.01			1.67	$41.64	**4.47**	**$111.65**
3	Sab Blan	$20.00	/m^3										
4	Gravye	$18.75	/m^3			2.62	$49.21					**2.62**	**$49.21**
5	Wòch	$15.00	/m^3			2.99	$44.92					**2.99**	**$44.92**
6	bafè demi (1/2)	$11.01	chak ba(9m)										
7	bafè demi (3/8)	$8.30	chak ba(9m)			14	$116.20					**14**	**$116.20**
8	bafè demi ka (1/4)	$3.21	chak ba(6m)			40	$128.40					**40**	**$128.40**
9	Fil alegati	$1.50	/liv			6	$8.30					**6**	**$8.30**
10	blòk 20cm	$0.80	chak										
11	blòk 15cm	$0.65	chak			180	$117.31					**180**	**$117.31**
12	blòk 12cm	$0.50	chak										
13	blòk 10cm	$0.40	chak										
14	bwa 1x4x16'	$9.00	chak										
15	bwa 1x8x 16'	$12.00	chak										
16	bwa 2x2x16'	$10.00	chak										
17	bwa 2x4x16'	$14.80	chak										
18	féy playwood 1/2"	$40.65	chak										
19	klou varye	$1.20	/liv										
20	klou tòl	$1.40	/liv										
21	tòl 3'x12'	$30.00	chak										
22	tòl 3'x10'	$28.00	chak										
23	tòl 3'x8'	$26.00	chak										
24	fetyè	$20.00	chak										
25	penti	$10.00	/galon										
26	strap	$1.65	/m										
27	konsèvasyon bwa	$10.00	/galon										
	Pri materyo konstriksyon						**$774**				**$147**		**$921**
	Kofray Ki Lwe						**$45**						**$45**
	Pri Mendèv						**$301.67**				**$57.98**		**$359.65**
Soutotal							$1,121.38				$204.62		**$1,326.00**
20% pout transpò ak kou nou pat prevwa							$224.28				$40.92		**$265.20**
Total							**$1,346**				**$246**	**Gran Total=**	**$1,591**

Remak= Tout pri yo an dola ameriken

build change

9 Aug, 2011

Build Change has evaluated the existing structure of house number CVM000X and has found that seismic retrofit is necessary.

The following work is required:

Structural Intervention:

- Fill in window along line 4
- Construct new walls along lines 2 and 3
- Add concrete overlay to walls A, D, 1, and 4 as noted on plan
- Plaster the remaining areas of walls A and D as well as walls 2 and 3

C. COST SCHEDULE

Seismic Evaluation and Retrofit Guide for Masonry Structures in Haiti

Build Change Post-Earthquake Technical Assistance Program, Haiti

Last Updated: 16-Aug-11

Address:		**Date**	16-Aug-2011
MTPTC Tag:		**Engineer:**	
Level:		**Accepted By:**	
Notes:			

PHASE 1: Minor Repairs, Preparation and Demolition			**No.**	**Unit**		**No.**	**Unit**
Minor Repairs							
MTPTC F1 (p.41)	Filling of minor cracks (when only the plaster has cracked)	Total length of cracks=		m			
-	Replacement of severly damaged wall (when the block has cracked)	Wall Area=		m^2			
D0.1	Repair of weathered masonry	Wall Area=		m^2			
D0.2	Stuffing of head joints with gaps	Length=		m	Height of gap=		m
Preparation and Demolition							
-	Demolition of walls (for out of plumb walls or walls with cracks greater than 1.5mm)	Wall Area=		m^2			
-	Removal of lightweight roof	Plan Area=		m^2			

PHASE 2: Construction up to Roof			**No.**	**Unit**		**No.**	**Unit**
Foundations and Plinth Beams							
D1.3	New foundation with plinth beam	Length=		m			
D1.4	Plinth beam only (new CM wall on existing foundation)	Length=		m			
D1.6	New foundation without plinth beam	Length=		m			
New Walls under Concrete Roof/Floor Slabs							
D1.1	New wall with 4 bars (for CM) at top of wall, joists parallel (includes connection at top of wall and wall itself)	Length=		m	Height=		m
D1.1*	New wall with 2 bars (for CM) at top of wall, joists parallel (includes connection at top of wall and wall itself)	Length=		m	Height=		m
D1.2	New wall with 4 bars (for CM) at top of wall, joists peredicular (includes connection at top of wall and wall itself)	Length=		m	Height=		m
D1.2*	New wall with 2 bars (for CM) at top of wall, joists perpendicular (includes connection at top of wall and wall itself)	Length=		m	Height=		m
D1.5, D1.7, D1.8	Connection bewteen new wall and exiting wall (for URM only; use D5 column details for CM)	No. of Items=		connections	Height=		
New Walls under Lightweight Roofs							
D9.1 et D9.2	New wall in URM w/ 2 bar ring beam (includes hurricane straps)	Length=		m	Height=		m
-	New wall in CM w/ 4 bar ring beam (includes hurricane straps)	Length=		m	Height=		m
D1.5	Connection bewteen new wall and exiting wall (for URM only; use D5 column details for CM)	No. of Items=		connections	Height=		m
Doubled Walls			**No.**	**Unit**		**No.**	**Unit**

D2.1* et D2.3	Doubled wall with 4 bars (for CM) at top of wall, joists parallel (includes wall, connections and foundation extension)	Length=		m	Height=		m
D2.1 et D2.3	Doubled wall with 2 bars (for CM) at top of wall, joists parallel (includes wall, connections and foundation extension)	Length=		m	Height=		m
D2.2* et D2.3	Doubled wall with 4 bars (for CM) at top of wall, joists perpendicular (includes wall, connections and foundation extension)	Length=		m	Height=		m
D2.2 et D2.3	Doubled wall with 2 bars (for CM) at top of wall, joists perpedicular (includes wall, connections and foundation extension)	Length=		m	Height=		m

Address:		**Date** 16-Aug-2011	
MTPTC Tag:		**Engineer:**	
Level:		**Accepted By:**	

Phase 2(continued)

Reinforced Concrete Overlay							
D4	Reinforced concrete overlay, one side, 75mm thick (includes all connections and foundation extention)	Length=		m	Height=		m
Conversion to Confined Masonry							
D5.1 ou D5.2	Column only (use existing footing at column base)	No. of Items=		columns	Height=		m
D5.1 ou D5.2, et D5.7	Column with Footing	No. of Items=		columns	Height=		m
D5.9	Door reinforcement- (2) #4 bars on either side of door opening	No. of Items=			Height=		m
D5.10	Window reinforcement- (1) #4 bar on either side of window opening	No. of Items=			Height=		m
-	4 bar ring beam above existing wall with lightweight roof	Length=		m			
-	4 bar ring beam above existing wall in concrete slab, joists parallel	Length=		m			
-	4 bar ring beam above existing wall in concrete slab, joists perpendicular	Length=		m			
Window Infill							
D6.1	Window Infill	No. of Items=		windows	Total area of all infills=		m^2
Ring Beam on URM Structures with Lightweight Roofs							
D9.1, D9.2 et D9.3	2 bar ring beam (for URM structures with lightweight roofs, includes hurricane straps)	Length=		m			
D9.4	4 bar lintel (for URM structures with lightweight roofs above openings, includes hurricane straps)	Length=		m			
Details for 2-Story Structures							
D8.1	Stregnthing of existing porch columns	No. of Items=		columns	Height=		m
D7	Overhang retrofit	No. of Items=			Length of overhang=		m

PHASE 3: Replacement of Lightweight Roof			**No.**	**Unit**		**No.**	**Unit**
-	Long dimension of roof plan (length)	Length=		m			
-	Short dimension of roof plan (width)	Width=		m			
-	Estimation of percentage of old timber making up new roof			%			
-	Estimation of percentage of old metal sheets making up new roof			%			

PHASE 4: Finishes			**No.**	**Unit**		**No.**	**Unit**
Plaster							
D3.1	Plaster (includes plaster on only one side of wall, 2cm thick)	Wall area=		m^2			
Paint							
-	Paint (includes one coat)	Wall area=		m^2			

Address:								**Date**	16-Aug-2011				
MTPTC Tag:								**Engineer:**					
Level:								**Accepted By:**					
				PHASE 1		**PHASE 2**		**PHASE 3**		**PHASE 4**		**TOTAL FOR ALL PHASES**	
No	**Item**	**Unit Price**	**Unit**	**# of Units**	**Total Price**	**# of Units**	**Total Price**	**# of Units**	**Total Price**	**# of Units**	**Total Price**	**# of Units**	**Total Price**
1	Cement	$7.50	/Bags										
2	River Sand	$25.00	/m^3										
3	Limestone sand	$20.00	/m^3										
4	Gravel	$18.75	/m^3										
5	Rubble stone	$15.00	/m^3										
6	#4 bars	$11.01	Each(9m)										
7	#3 bars	$8.30	Each(9m)										
8	#2 bars	$3.21	Each(6m)										
9	Binding wire	$1.50	/lbs										
10	Concrete blocks 20cm	$0.80	Each										
11	Concrete blocks 15cm	$0.65	Each										
12	Concrete blocks 12cm	$0.50	Each										
13	Concrete blocks 10cm	$0.40	Each										
14	Blocs Klostra	$0.60	Each										
15	1x4x16' Lumber	$9.00	Each										
16	1x8x16' Lumber	$12.00	Each										
17	2x2x16' Lumber	$10.00	Each										
18	2x4x16' Lumber	$14.80	Each										
19	Plywood sheet 1/2"	$40.65	each										
20	Assorted nails	$1.20	/lbs										
21	Roofing Nails	$1.40	/lbs										
22	Roofing Sheets 3'x12'	$30.00	each										
23	Roofing Sheets 3'x10'	$28.00	each										
24	Roofing Sheets 3'x8'	$26.00	each										
25	Ridge caps	$20.00	each										
26	Paint	$10.00	/gallon										
27	Hurricane straps	$1.65	/m										
28	Wood preservative	$10.00	/gallon										
	Total Cost of Materials												
	Rented Formwork												
	Total for Labor												
Subtotal													
20% Contingency for Transportation and Unforseen Costs													
Totals												**Grand Total**	

Note: All prices in US dollars

SECTION D: REQUIRED WALL AREA PERCENTAGE

Three methods are provided for calculating the required wall area. Method 1 is the detailed procedure. Methods 2 is the tabulated method. Method 3 uses tables generated for the most common cases, but can by extrapolated to other cases by a number of factors.

Method 1:

Calculate required Wall Area Percentage ($WAP_{Required}$)

$$WAP_{\text{Required}} = bWAP_{\text{Required}} \times \frac{C_B C_Q C_R C_L C_N C_I}{m}$$

Minimum WAP = 2% for CM and IM, and 4% for URM

Where:

$bWAP_{Required}$ = Basic Required Wall Area Percentage as defined below

$$bWAP_{\text{Required}} = S_{DS} \times N \times W_D$$

S_{DS} = Short Period Spectral Acceleration Response Parameter from map.

N = Number of stories (1, 2, or 3)

W_D = Baseline area percentage of 6.4% for 4.8 MPa (700 psi) Block

Short Period (0.2 s) Acceleration Design Values for Different Cities in Haiti from the *Rules for Calculating Interim Buildings in Haiti*

City	S_{ms}	F_a	S_{ds}
Cap-Haitien	1.51	1.00	1.01
Gonaives	0.81	1.18	0.64
Hinche	0.88	1.15	0.67
Jacmel	0.81	1.18	0.64
Jeremiah	0.62	1.30	0.54
Leogane	1.42	1.00	0.95
The Cayes	0.99	1.10	0.73
Mirebalais	2.05	1.00	1.37
Petionville	1.79	1.00	1.19
Port-au-Prince	1.57	1.00	1.05
Port de Paix	1.54	1.00	1.03
St. Mark	1.44	1.00	0.96
St. Raphael	0.8	1.18	0.63

Tabulated Basic Wall Area Percentage

Number of Stories including Roof (N)	*bWAP* (%) S_{DS} 0.50	1.05	1.67
3	9.6%	20.1%	32.1%
2	6.4%	13.4%	21.4%
1	3.2%	6.7%	10.7%

Shaded areas are not permitted for URM construction, and will be significantly reduced from tabulated values when applying the m-factor for CM or IM construction.

***C_B* = Block Strength Factor.** Block strength may quantified through testing or appropriate field tests calibrated to tests. A value of 2.8 MPa (400 psi) may be assumed if no information is available. $C_B = 1.0$ for $f'_m = 4.8$ MPa (700 psi)

$C_B = \sqrt{(555 / (51.2 + 0.724\ f_m))}$ for other block strengths, f_m in psi

Masonry f_m MPa (psi)	C_B Factor
1.7 (250)	1.55
2.8 (400)	1.28
4.8 (700)	1.00
6.9 (1000)	0.85
10 (1450)	0.71
11.7 (1700)	0.66

Factor may be modified by conducting testing of existing block

C_Q = **Construction Quality Factor**, intended to capture poor construction details in URM, IM, or CM construction. Not intended to capture weak masonry (See C_B factor)

C_Q = 1.0 for average quality

C_Q = 1.5 for poor quality

Intermediate values may be used based on extent and severity of construction quality problems. Selective demolition may be required to confirm reinforcement detailing in some cases. Rebar "trees" or other visible exposed conditions can be used as guidance as to the probable detailing and reinforcement present elsewhere in the building.

Photo examples of poor quality are shown :

Factor may be reduced by applying similar techniques to those included in the MPTPC Repair Manual.

Examples of Poor Quality:

Incomplete mortar infill or no mortar in head joists, loose window infill.

Top row of masonry not in full contact with slab or ring beam

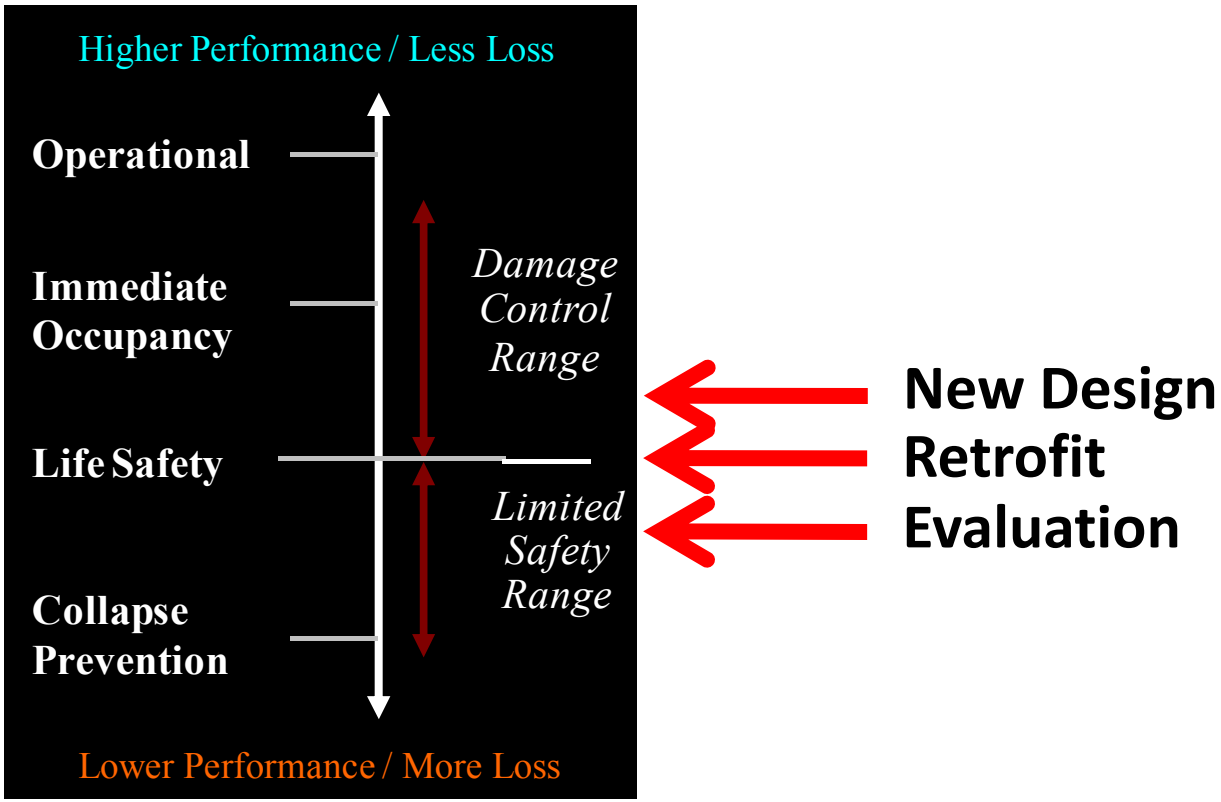
Visible rebar tree is very short

Ongoing construction reveals poor detailing

C_R = Evaluation/Retrofit Factor

C_R = 0.75 when evaluating an existing structure

C_R = 1.0 when evaluating a proposed retrofit scheme.



***C_N* = Net Area Factor.** C_N =1.0 for 15 cm block with 50% to 60% net solid area, including both webs and flanges.

C_N= 0.55 x Gross Area / Solid Area

Example: If block was solid, then C_N = 0.55, therefore less wall is required.

C_L = **Level Factor** required to account for different seismic demands at different levels. A separate evaluation is required for each level of the building. Cantilevered upper stories that extend beyond the walls of lower stories must be retrofit per checklist requirements.

For buildings with heavy floors and roofs having concrete slabs, concrete joists, and masonry void forms.

Level	# Stories in Building		
	1-Story	2-Story	3-Story
3	-	-	0.39
2	-	0.57	0.67
1	1.00	0.86	0.79

For buildings with light roofs made of sheet metal or wood framing.

Level	# Stories in Building		
	1-Story	2-Story	3-Story
3	-	-	0.14
2	-	0.20	0.43
1	0.33	0.67	0.65

Note: Factors are derived from a combination of ASCE-31 story shear forces (3.5.2.2) and Modification Factor C (Table 3-4) for multistory URMA shear wall buildings. Factors are normalized to 1.0 for 1-Story heavy roof buildings by including 1.4 factor in the derivation of the baseline wall area, W_D.

C_I = **Importance Factor**

C_I =1.0 for the Life-Safety Performance Level. Typical for most buildings.
C_I =1.5 for the Immediate Occupancy Performance Level. May be desirable for schools, hospitals, and critical facilities.

Immediate Occupancy performance may require evaluation of the bracing of the building contents. URM is usually not permitted in seismically active areas. Recommend using CM or IM when evaluating for Immediate Occupancy Performance

Method 2:

The required wall area percentage for each story in the building, and in each horizontal direction (transverse and longitudinal) can be found in the table below, and should be adjusted according to the following assumptions:

Level				Notes
	1-Story	2-Story	3-Story	
3	-	-	4.7	For buildings with heavy floors and roofs having concrete slabs, concrete joists, and masonry void forms.
2	-	4.6	8.1	
1	4.0	6.9	9.6	
3	-	-	3.0	For buildings with light roofs made of sheet metal and wood framing.
2	-	3.0	5.2	
1	4.0	5.4	7.9	

Assumptions and Adjustments:

- Table applies for S_{DS} = 1.05g, for other design ground motion values ratio accordingly.
- Tabulated values are for URM construction. For compliant CM or IM construction use 50% of these value, 2% minimum.
- Tabulated values are for "Average" quality construction. For poor quality construction increase by 50%. See photo guide in Appendix A.
- The assumed concrete block strength is 4.8MPa. See Appendix A for adjustment to other strengths if required.
- These values are for Building Evaluation, increase by one third for evaluation of a proposed Retrofit Design.
- The block is assumed to be typical 15cm, about 55% solid, and not plastered. For other thicknesses and sections ratio accordingly, see Appendix A.

The following table can be used to determine the length of 15cm wall needed for a target Wall Area Percentage (%) for a given Building Area (m^2):

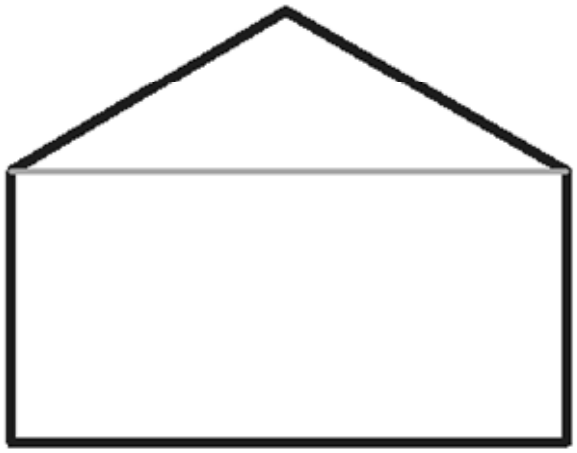
Area	Length of Wall (m) Required for Wall Area Percentage (%)					
m2	2%	3%	4%	6%	8%	10%
10	1.3	2.0	2.7	4.0	5.3	6.7
20	2.7	4.0	5.3	8.0	11	13
30	4.0	6.0	8.0	12	16	20
40	5.3	8.0	11	16	21	27
60	8.0	12	16	24	32	40
80	11	16	21	32	43	53
100	13	20	27	40	53	67

Method 3:

The required length of wall can be read off of the following tables for a given construction type and building area. Values are subject to the following limitations:

- Block strength is average. For blocks with poor strength, multiply values in table by 1.28.
- Construction quality is average. For poor construction quality, multiply values in table by 1.5.
- Block is 50-60% solid. If not, multiply values in table by 0.55*Gross Block Area / Solid Block Area.
- Wall is constructed of typical 15cm block. For wider walls, multiply table values by (width of wall/15cm)

TABLE 1 – ONE STORY HOUSE WITH A LIGHTWEIGHT ROOF



Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	1.33	1.33	1.33	1.33
15	2.00	2.00	2.00	2.00
20	2.67	2.67	2.67	2.67
25	3.33	3.33	3.33	3.33
30	4.00	4.00	4.00	4.00
35	4.67	4.67	4.67	4.67
40	5.33	5.33	5.33	5.33
45	6.00	6.00	6.00	6.00
50	6.67	6.67	6.67	6.67
60	8.00	8.00	8.00	8.00
70	9.33	9.33	9.33	9.33
80	10.67	10.67	10.67	10.67
90	12.00	12.00	12.00	12.00
100	13.33	13.33	13.33	13.33

TABLE 2 – ONE STORY HOUSE WITH A CONCRETE ROOF

Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	2.69	3.59	1.35	1.79
15	4.03	5.38	2.02	2.69
20	5.37	7.17	2.69	3.59
25	6.72	8.97	3.37	4.48
30	8.06	10.76	4.04	5.38
35	9.40	12.55	4.71	6.28
40	10.75	14.35	5.39	7.17
45	12.09	16.14	6.06	8.07
50	13.43	17.93	6.73	8.97
60	16.12	21.52	8.08	10.76
70	18.81	25.11	9.43	12.55
80	21.49	28.69	10.77	14.35
90	24.18	32.28	12.12	16.14
100	26.87	35.87	13.47	17.93

TABLE 3 –TWO STORY HOUSE WITH LIGHTWEIGHT ROOF

Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	3.60	4.80	1.80	2.40
15	5.40	7.20	2.70	3.60
20	7.20	9.60	3.60	4.80
25	9.00	12.00	4.50	6.00
30	10.80	14.40	5.40	7.20
35	12.60	16.80	6.30	8.40
40	14.40	19.20	7.20	9.60
45	16.20	21.60	8.10	10.80
50	18.00	24.00	9.00	12.00
60	21.60	28.80	10.80	14.40
70	25.20	33.60	12.60	16.80
80	28.80	38.40	14.40	19.20
90	32.40	43.20	16.20	21.60
100	36.00	48.00	18.00	24.00

Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	1.33	1.43	1.00	1.00
15	2.00	2.15	1.50	1.50
20	2.67	2.87	2.00	2.00
25	3.33	3.58	2.50	2.50
30	4.00	4.30	3.00	3.00
35	4.67	5.02	3.50	3.50
40	5.33	5.73	4.00	4.00
45	6.00	6.45	4.50	4.50
50	6.67	7.17	5.00	5.00
60	8.00	8.60	6.00	6.00
70	9.33	10.03	7.00	7.00
80	10.67	11.47	8.00	8.00
90	12.00	12.90	9.00	9.00
100	13.33	14.33	10.00	10.00

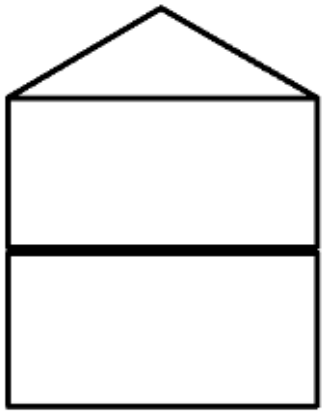
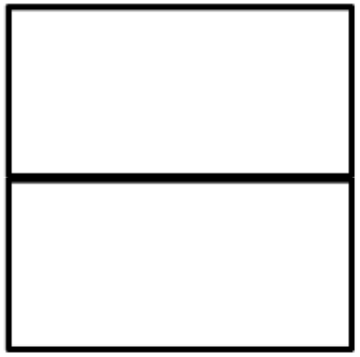


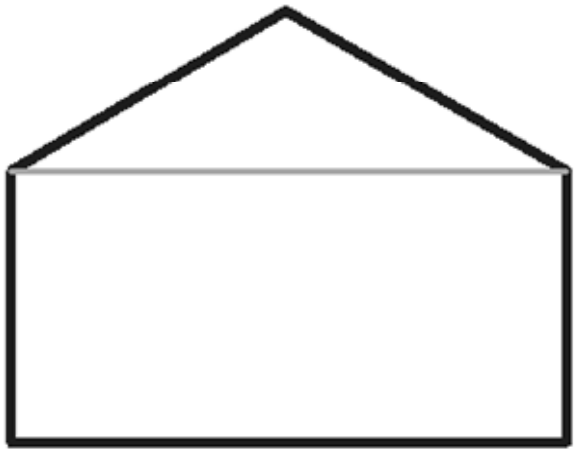
TABLE 4 –TWO STORY HOUSE WITH CONCRETE ROOF, SDS = 1.05G

Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	4.63	6.17	2.31	3.08
15	6.94	9.25	3.47	4.62
20	9.25	12.33	4.63	6.16
25	11.57	15.42	5.78	7.70
30	13.88	18.50	6.94	9.24
35	16.19	21.58	8.10	10.78
40	18.51	24.67	9.25	12.32
45	20.82	27.75	10.41	13.86
50	23.13	30.83	11.57	15.40
60	27.76	37.00	13.88	18.48
70	32.39	43.17	16.19	21.56
80	37.01	49.33	18.51	24.64
90	41.64	55.50	20.82	27.72
100	46.27	61.67	23.13	30.80



Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	3.07	4.09	1.53	2.04
15	4.60	6.13	2.30	3.06
20	6.13	8.17	3.07	4.08
25	7.67	10.22	3.83	5.10
30	9.20	12.26	4.60	6.12
35	10.73	14.30	5.37	7.14
40	12.27	16.35	6.13	8.16
45	13.80	18.39	6.90	9.18
50	15.33	20.43	7.67	10.20
60	18.40	24.52	9.20	12.24
70	21.47	28.61	10.73	14.28
80	24.53	32.69	12.27	16.32
90	27.60	36.78	13.80	18.36
100	30.67	40.87	15.33	20.40

TABLE 5 – ONE STORY HOUSE WITH A LIGHTWEIGHT ROOF, S_{DS} = 1.67G



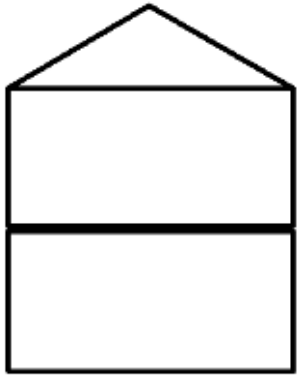
Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	1.42	1.89	1.00	1.00
15	2.13	2.83	1.50	1.50
20	2.84	3.78	2.00	2.00
25	3.55	4.72	2.50	2.50
30	4.26	5.66	3.00	3.00
35	4.97	6.61	3.50	3.50
40	5.67	7.55	4.00	4.00
45	6.38	8.50	4.50	4.50
50	7.09	9.44	5.00	5.00
60	8.51	11.33	6.00	6.00
70	9.93	13.22	7.00	7.00
80	11.35	15.10	8.00	8.00
90	12.77	16.99	9.00	9.00
100	14.19	18.88	10.00	10.00

TABLE 6 – ONE STORY HOUSE WITH A CONCRETE ROOF, S_{DS} = 1.67G

Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	4.30	5.74	2.15	2.87
15	6.45	8.61	3.23	4.30
20	8.60	11.48	4.31	5.74
25	10.75	14.35	5.39	7.17
30	12.90	17.22	6.46	8.61
35	15.05	20.09	7.54	10.04
40	17.19	22.95	8.62	11.48
45	19.34	25.82	9.70	12.91
50	21.49	28.69	10.77	14.35
60	25.79	34.43	12.93	17.22
70	30.09	40.17	15.08	20.09
80	34.39	45.91	17.24	22.95
90	38.69	51.65	19.39	25.82
100	42.99	57.39	21.55	28.69

TABLE 7 –TWO STORY HOUSE WITH A LIGHTWEIGHT ROOF, S_{DS} = 1.67G

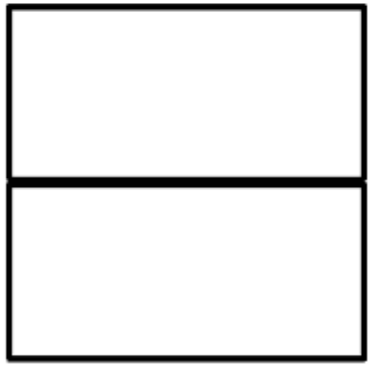
Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	5.73	7.63	2.86	3.82
15	8.59	11.45	4.29	5.73
20	11.45	15.27	5.73	7.63
25	14.31	19.09	7.16	9.54
30	17.18	22.90	8.59	11.45
35	20.04	26.72	10.02	13.36
40	22.90	30.54	11.45	15.27
45	25.77	34.35	12.88	17.18
50	28.63	38.17	14.31	19.09
60	34.35	45.81	17.18	22.90
70	40.08	53.44	20.04	26.72
80	45.81	61.07	22.90	30.54
90	51.53	68.71	25.77	34.35
100	57.26	76.34	28.63	38.17



Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	2.75	3.67	2.13	2.13
15	4.12	5.50	3.20	3.20
20	5.50	7.34	4.27	4.27
25	6.87	9.17	5.33	5.33
30	8.24	11.01	6.40	6.40
35	9.62	12.84	7.47	7.47
40	10.99	14.68	8.53	8.53
45	12.36	16.51	9.60	9.60
50	13.74	18.35	10.67	10.67
60	16.49	22.02	12.80	12.80
70	19.23	25.69	14.93	14.93
80	21.98	29.35	17.07	17.07
90	24.73	33.02	19.20	19.20
100	27.48	36.69	21.33	21.33

TABLE 8 –TWO STORY HOUSE WITH A CONCRETE ROOF, S_{DS} = 1.67G

Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	7.40	9.87	3.70	4.93
15	11.10	14.80	5.55	7.39
20	14.81	19.73	7.40	9.86
25	18.51	24.67	9.25	12.32
30	22.21	29.60	11.10	14.78
35	25.91	34.53	12.95	17.25
40	29.61	39.47	14.81	19.71
45	33.31	44.40	16.66	22.18
50	37.01	49.33	18.51	24.64
60	44.42	59.20	22.21	29.57
70	51.82	69.07	25.91	34.50
80	59.22	78.93	29.61	39.42
90	66.62	88.80	33.31	44.35
100	74.03	98.67	37.01	49.28



Area (m^2)	Required Equivalent Length of Wall (m) in Each Principal Direction			
	URM		CM/IM	
	Existing	Retrofit	Existing	Retrofit
10	1.72	2.29	1.00	1.15
15	2.58	3.44	1.50	1.73
20	3.43	4.59	2.00	2.30
25	4.29	5.73	2.50	2.88
30	5.15	6.88	3.00	3.46
35	6.01	8.03	3.50	4.03
40	6.87	9.17	4.00	4.61
45	7.73	10.32	4.50	5.18
50	8.59	11.47	5.00	5.76
60	10.30	13.76	6.00	6.91
70	12.02	16.05	7.00	8.06
80	13.74	18.35	8.00	9.22
90	15.46	20.64	9.00	10.37
100	17.17	22.93	10.00	11.52

SECTION E: ASCE-31 / ASCE-41 BASIS FOR PROCEDURE AND EXCEPTIONS

This Appendix summarizes the technical approach. The evaluation basis is the ASCE-31 Tier 1 procedures. The information below indicates that this document is conservative relative to the ASCE-31 requirements.

ASCE-31 Tier 1 Basis:

Tier 1 checks for URM use 70psi on the net area of masonry wall. There is no amplification of torsional demands in the Tier 1 quickcheck. We retain the same checklist item that the COM is supposed to be within 20% of the COR. The alternative requirement that is also acceptable for this item is to have a wall close to each exterior side. This combined with the need for regularly spaced walls is likely to result in center-of-mass and center-of-rigidity locations that satisfy the 20% requirement, but this has not been investigated in detail.

Using the ASCE-31 Tier 1 requirements the required starting required wall area percentage can be derived as:
Aw / Ab = (1.4*(150psf / 12^2) *1g) / (70psi * 0.55)
Where the 1.4 factor is for a 1-story building. The different values for taller buildings are accounted for in the C_L factor.
Aw / Ab = 3.8%
This procedure is conservative relative to ASCE-31 because it includes a torsional factor of 1.5, which would make the starting WAP 5.7%.
It is also conservative relative to ASCE-31 because the URM m-factor used here is 1.25, not 1.5. Accounting for this difference is comparable to making the starting WAP value 6.8%, very close to our 6.4%.

Given that the starting WAP values here are conservative relative to the ASCE-31 Tier 1 procedure indicates that the current methodology is appropriate. It has also been approximately calibrated against observed performance of masonry in the January 2010 earthquake. Ideally, full scale testing of URM and confined masonry walls will confirm actual walls strengths relative to masonry and mortar compressive strengths.

Backup Calculations for Retrofit Techniques (K-factors)

New Masonry Wall Area Adjustment Factor, K_m

$$K_m = \sqrt{\frac{f'_m\ NEW}{f'_m\ EXISTING}} \textbf{ (psi)}$$

New Masonry	Existing Masonry f'm MPa (psi)	
f'm	2.8 (400)	4.8 (700)
4.8 (700)	1.3	1.0
6.9 (1000)	1.5	1.2
10 (1450)	1.5	1.4
12 (1740)	1.5	1.5

New Plaster Area Adjustment Factor, K_p

$$K_p \approx \frac{2\sqrt{f'_c}\,t_p}{0.55\times 2.5\sqrt{f'_m}\,t_w}$$ ≤ 0.5 in order to ensure shear demand is adequately spread between existing masonry and new concrete overlay

Where:
$t_p = 2.5\ cm$
$t_w = 15\ cm$

$K_p = 0.5$ when adding 2.5 cm of plaster to a 15 cm wall (1.25 cm each side).

$K_p = 0.25$ when adding 2.5 cm of plaster to a 30 cm wall (1.25 cm each side).

New Reinforced Concrete Overlay Area Adjustment Factor, K_c

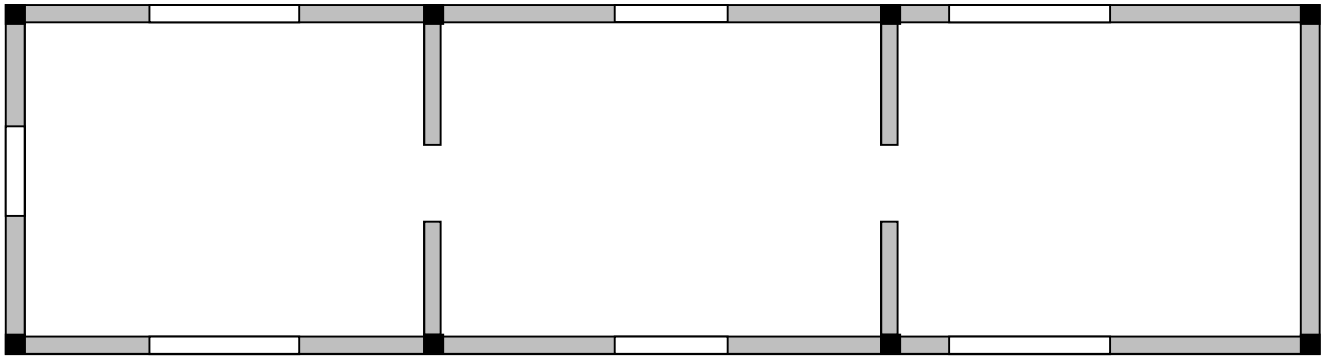
$$K_c \approx \frac{2\sqrt{f'_c}t_c + A_s f_y}{0.55 \times 2.5\sqrt{f'_m}t_w} \leq 1.5$$ in order to ensure shear demand is adequately spread between existing masonry and new concrete overlay

Where:

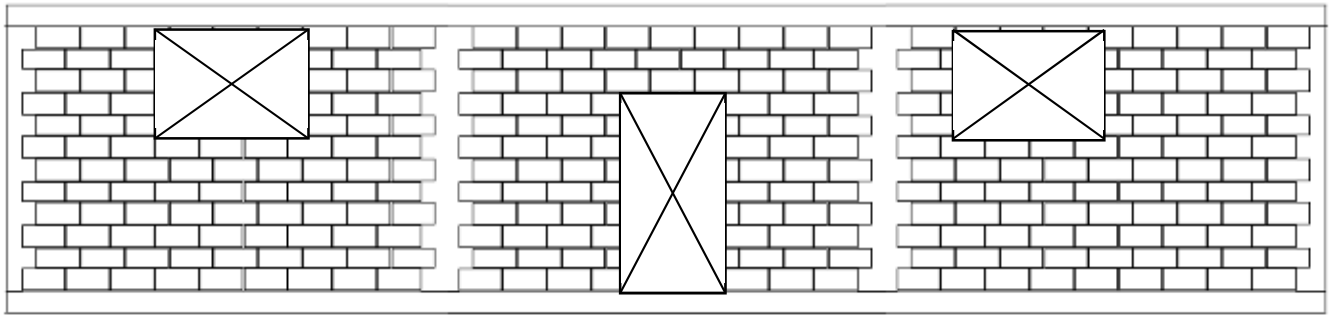
$t_c = 7.5\ cm$
$t_w = 15\ cm$

$K_p = 1.5$ when adding 7.5 cm of plaster to a 15 cm wall (one side only).

SECTION F: WALL IDENTIFICATION EXAMPLE



EXAMPLE BUILDING PLAN

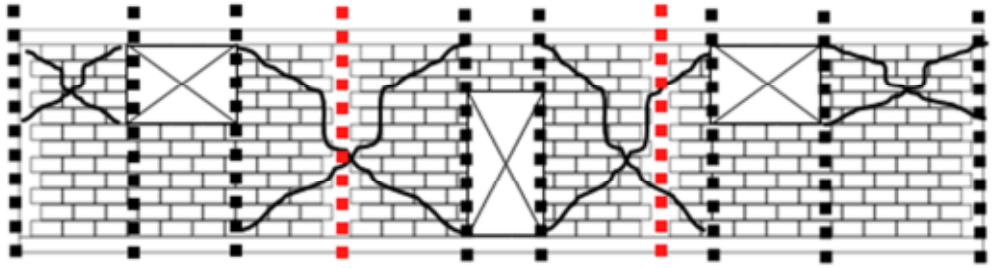


EXAMPLE BUILDING ELEVATION

In this example we are examining the walls in the longitudinal direction, which are assumed to be identical. Our example has reinforced concrete columns in the corners and wall intersections. By careful inspection we also confirm that there, but no reinforcement around the doors or windows. This is a very common condition. Note also that there is no lintel above the door, which is another separate checklist item

.

(1) Define Wall Edges



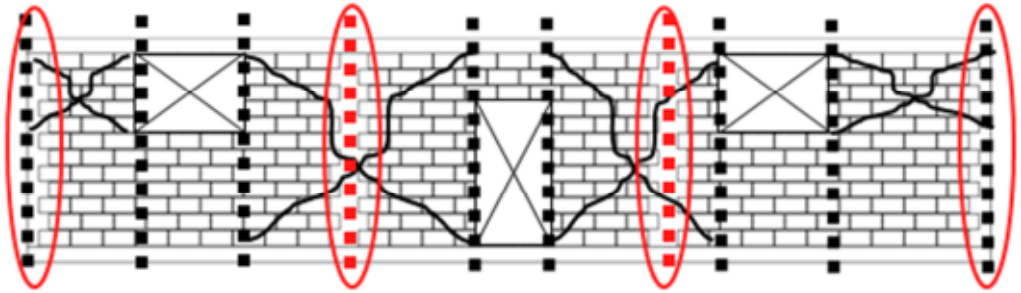
- At the exterior of building - the two ends in this case
- Around all corridors, doors and openings wider than 1.0m – either side of the door and the two windows in this case
- Wall intersections – the two red lines indicating the location of intersection walls from the transverse direction.

(2) Identify Reinforcement Present

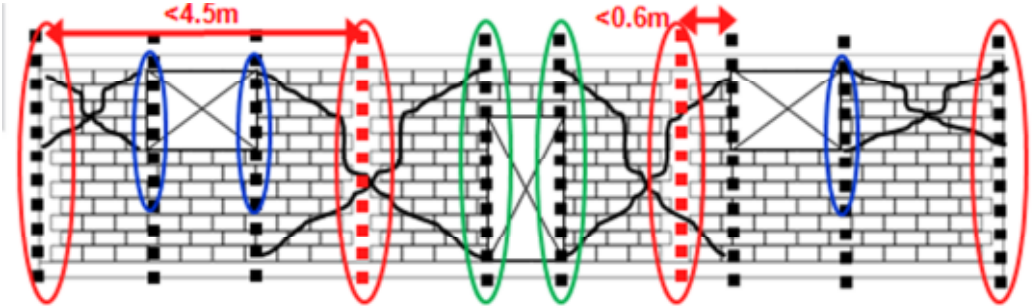
Summarizing the requirements for confined masonry walls:

<u>Confined Masonry Walls</u>

- Have reinforcement within 0.6m of all edges
  - 4- bars at building edges and wall intersections
  - 1-or-2 bars at doors and windows
- Maximum 4.5m spacing between 4-bar columns
- Reinforcement must be developed
  - Into beam or masonry wall above
  - Below window opening or into foundation



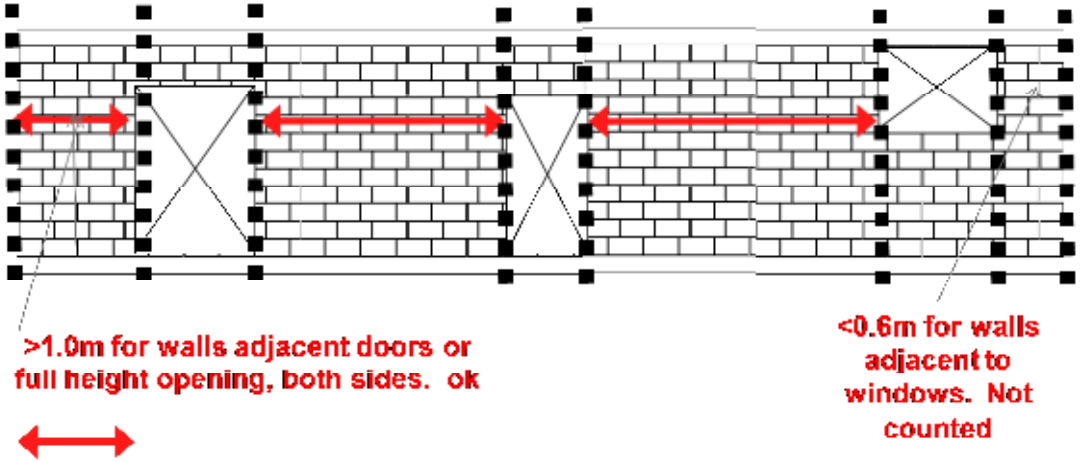
First locate column reinforcement present in wall - here we identify the boundary columns (4-bars) indicated with the red circles.



Now we check for the required trim reinforcement, at the blue and green circle locations, and find that it is not present. We note that reinforcement of the left side of the right window is not required because there is a column within 0.6m of the opening. This will reduce the length of the wall that may contribute to lateral resistance.

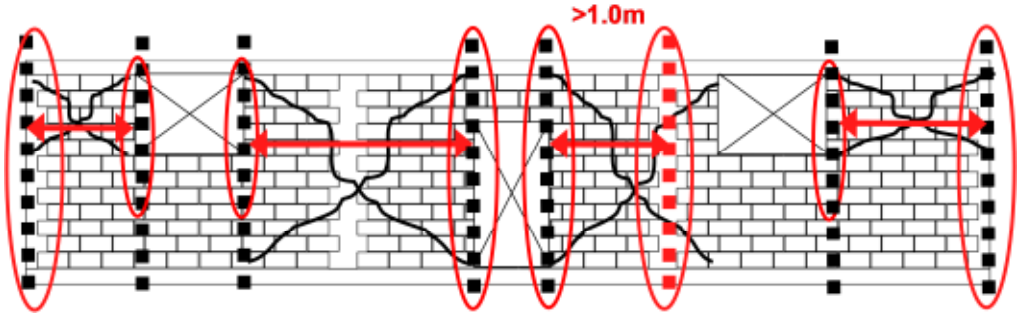
- **At this level/direction the building is therefore not CM/IM and is classified as URM**

(3) Default is to treat as URM



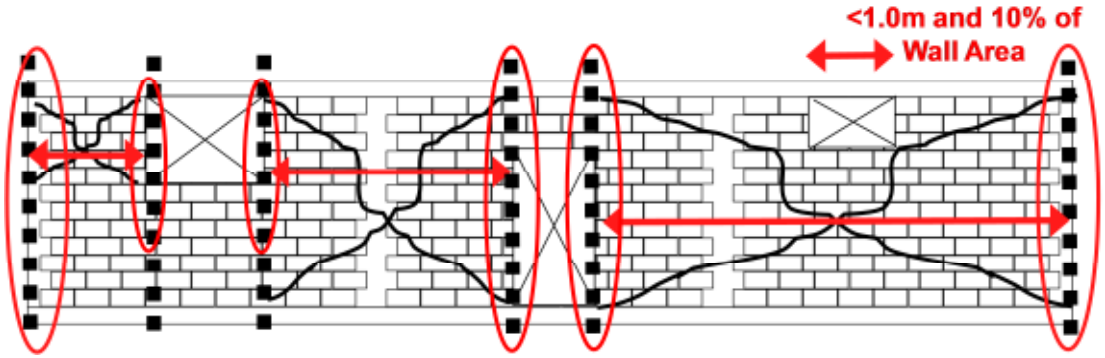
URM walls are also required to be at least 1.0m in length so we can now identify the walls that may be used for lateral resistance for this level/direction. If the right window was located as shown, then the wall segment at the right end of the building is too short.

(4) Confirm Wall Lengths for CM/IM



If we had the required door and window trim reinforcement had been present, or if we elect to add it as part of a retrofit scheme we can determine the lengths of wall that may be used for lateral resistance above.

(5) Ignore Small Openings



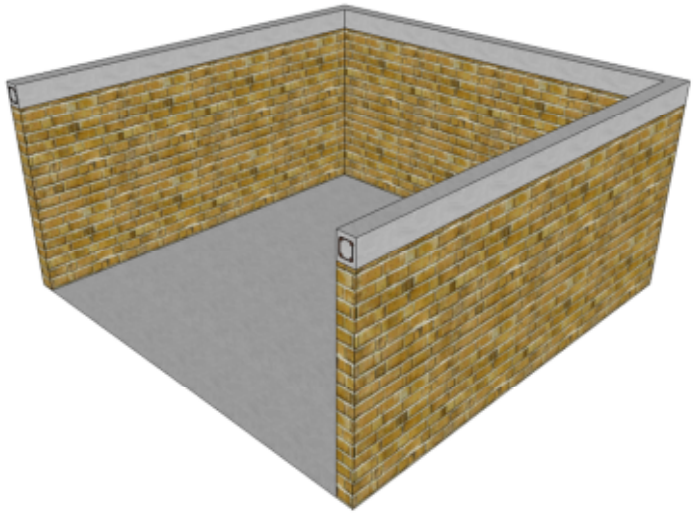
If the right window had been smaller (maximum vertical or horizontal dimension < 0.6m) we could have omitted the trim reinforcement around the right window entirely since the maximum wall length is still less than 4.5m.

(6) Other Wall Requirements

The checklist has some additional requirements for walls.

Walls: Shall meet the following additional requirements:

- Walls shall be tightly installed to the soffits of the ring beam or slab and to the columns where present. Formwork shall not be present between the top of the masonry and underside of the beam/slab.
- Openings larger than 0.6m long or 0.6 high shall be designated a Wall Edge.
- Doors, windows and other openings wider than 0.6m shall extend to the beam above, or shall be provided with a reinforced concrete lintel beam. Lintel beams shall extend a minimum of 15cm into the adjacent masonry or shall be connected to an adjacent concrete boundary column or trim reinforcement.



- Buildings constructed with light-weight wood/metal roofs shall have a continuous reinforced concrete ring beam at the top of the walls to transfer out-of-plane forces to cross walls. Ring beams shall span over door openings where present. Roof systems shall be positively anchored to ring beams. Note that evaluation of wind demands is beyond the scope of this guideline.

Cutaway section of an unreinforced masonry building showing the continuous reinforced concrete ring beam at the top of the wall.

In our example, we would note that there was no lintel beam above the door, so this item is NC (Non-Compliant). There is no light-weight roof and so this item is N/A (Not Applicable).

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