

# A PRACTICAL HANDBOOK FOR SAFE HOUSING EXPANSION

## ACKNOWLEDGEMENTS

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Build Change would also like to thank the individuals who participated in the design, production, and revision of A Practical Handbook for Safe Housing Expansion; their contributions have been invaluable.



MINISTÈRE DES TRAVAUX PUBLICS TRANSPORTS  
ET COMMUNICATIONS  
(MTPTC)



*Lavi miyò nan Katye m*



## PREFACE

This handbook compliments and frequently references the *Code National du Bâtiment d'Haïti* (referred to as CNBH), the *Guide de Bonnes Pratiques pour la Construction de Petits Bâtiments en Maçonnerie Chaînée en Haïti* (referred to as Guide de Bonnes Pratiques), and the *MTPTC Guide de Renforcement Parasismique et Para cyclonique des Bâtiments* (referred to as Guide de Renforcement). It is recommended that any implementing person have a copy of these documents available for consultation during the design and construction phase which can be found on the MTPTC website (<http://www.mtptc.gouv.ht/>).



**Intended Audience**

The Practical Handbook for Safe Housing Expansion has been developed to help guide experienced construction professionals (such as technicians, engineers, and government authorities) through the process of safely designing, planning and supervising the construction of multiple housing expansion types.

The Handbook can also be useful in promoting good construction practices among builders and help homeowners plan and manage expansion projects by helping to identify important points to evaluate and provide clear, illustrated steps for expansion construction.

Although this Handbook has been designed to be easily accesible, homeowners should always implement safe expansion with assistance from a qualified engineering professional.



**Applicability**

The content of this handbook applies to the addition of extra living space to unreinforced or confined masonry houses of one to two stories in height. This Handbook is not applicable to other building types or non-residential buildings.



Confined masonry house



Unreinforced masonry house

Refer to the CNBH to determine the seismicity for each building location and to the Build Change *Seismic Evaluation and Retrofit Manual* for information on how to identify the different building types (unreinforced masonry or confined masonry).

Existing House		Horizontal Expansion		Vertical Expansion	
Number of levels	Construction type	Seismicity		Seismicity	
		Low to moderate Sds ≤1.1g	High Sds ≥ 1.1g	Low to moderate Sds ≤1.1g	High Sds ≥ 1.1g
1 Story	Unreinforced masonry	✓	✓	✓	✗
	Confined Masonry	✓	✓	✓	✓
2 Story	Unreinforced masonry	✓	✗	✗	✗
	Confined Masonry	✓	✓	✓	✓



## **A PRACTICAL HANDBOOK FOR SAFE HOUSING EXPANSION**

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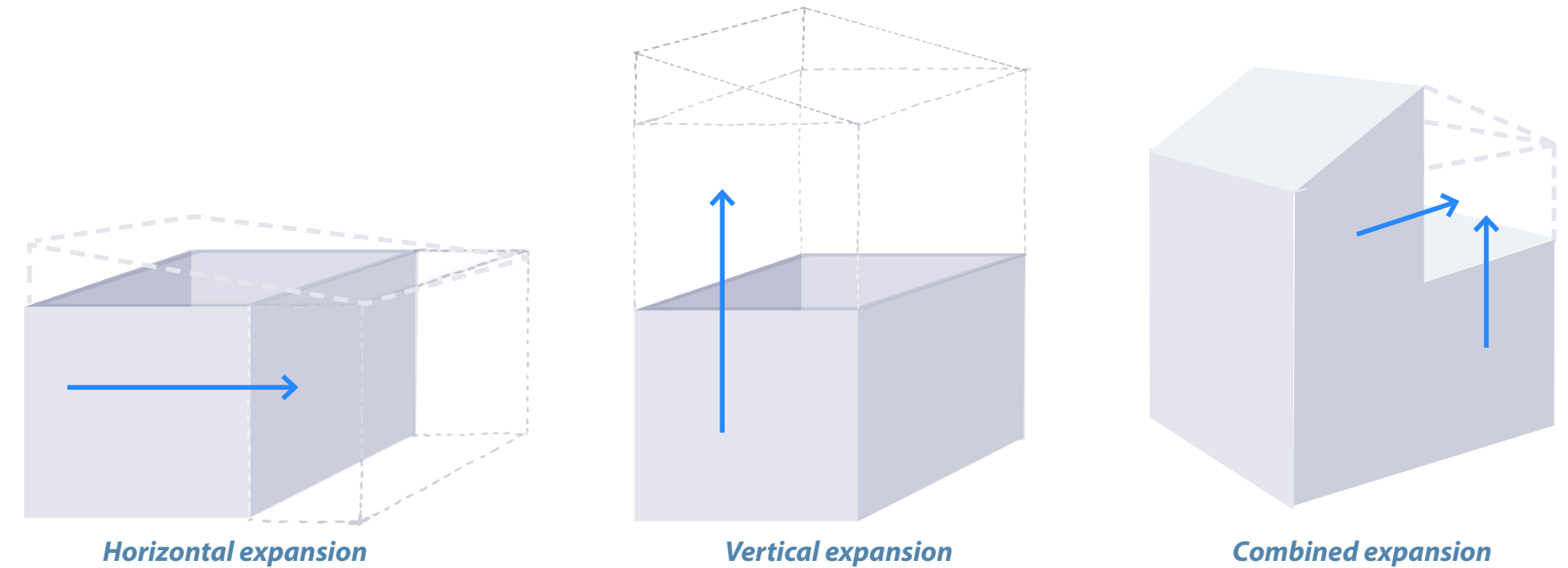
# 1 DEFINITION AND TYPES OF EXPANSION

When a house is built incrementally over time, a basic structure is built first and then added on to. Each habitable addition to the house is considered an expansion.

Expansions that increase the footprint of the house, and grow the house outwards are considered **HORIZONTAL** expansions. A horizontal expansion can take place at the ground floor or at multiple floors.

Expansions that increase the number of levels of the house, and grow the house upwards are considered **VERTICAL** expansions.

When an upper level is expanded horizontally above an existing part of the house, it is considered *both* a horizontal and vertical expansion and called a **COMBINED** expansion.



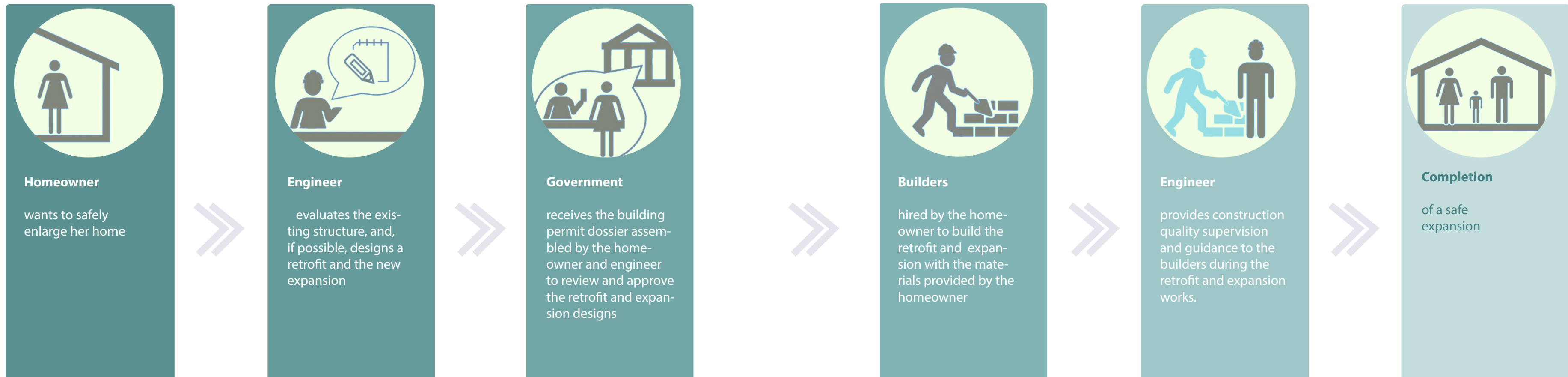
It is very common for houses in Haiti to be expanded. When expansions are not connected well to the existing house or when the effect of the extra weight, shape and size of the expansion are not considered, both the house and the expansion can suffer damage or collapse in an earthquake or hurricane. Both existing houses and new expansions must be designed and built to resist earthquakes and hurricanes. On many occasions an existing house must first be strengthened, or retrofitted, before being expanded.

## 2 BASIC STEPS TO SAFE EXPANSION





**2.1 - ROLES AND RESPONSIBILITIES  
IN THE EXPANSION PROCESS**



## 2.2 - TECHNICAL EVALUATION: SITE AND BUILDING

When a homeowner decides to expand her home, she should first engage a qualified engineer. The two primary questions that the engineer must address are:

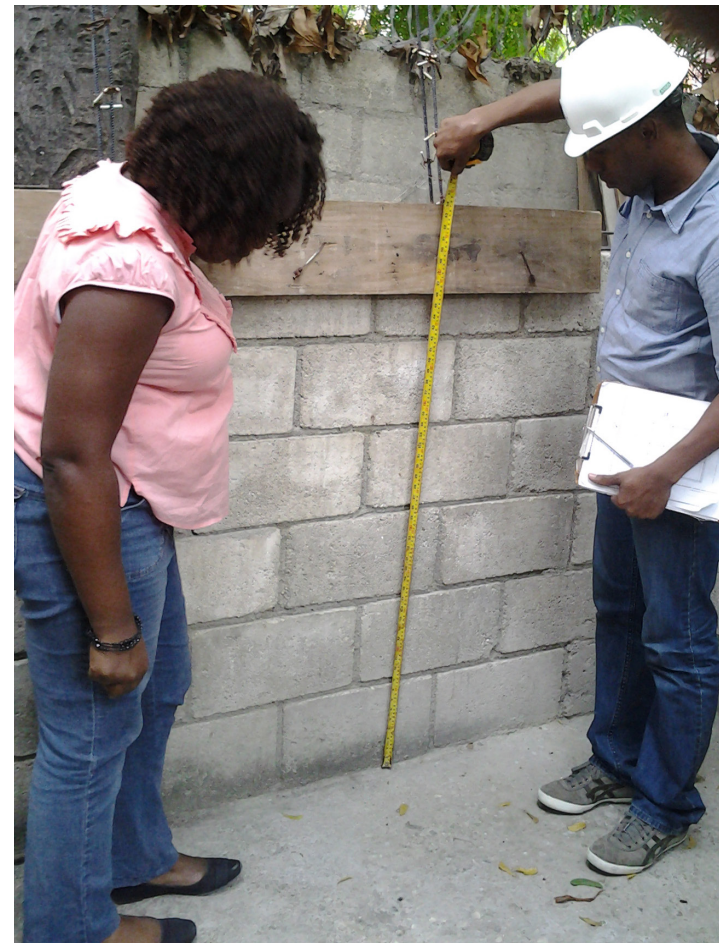
- \* Is an expansion of the house safe and feasible?
- \* If so, what strengthening, or retrofit, of the existing home should be made in order to safely permit the housing expansion to be built?

The engineer will answer these questions by evaluating the existing site and structure.

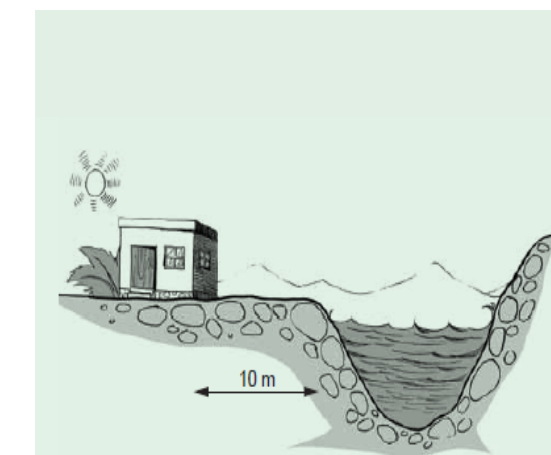
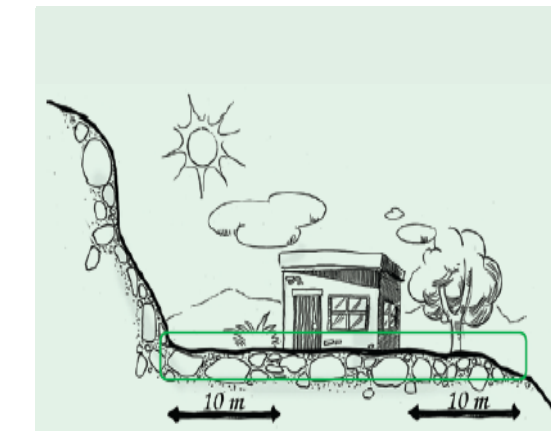
The engineer will also assess the condition of the existing house and its components.

- \* Refer to the MTPTC “Guide de Renforcement” for the evaluation of the structural condition of an existing building.
- \* Refer to the following sections of this handbook for specific considerations to make during the evaluation for both vertical and horizontal expansion.

At the end of the evaluation, the engineer should have a complete picture of the existing house condition and will be able to recommend whether or not an expansion is feasible, and if so, what work must be done to the existing house in order to support it.



### LOCATION OF THE PROPERTY AND SITE HAZARDS



Refer to the CNBH for further details on site condition evaluation.



If the site is not suitable for a new house, then it is not suitable for a new housing expansion (vertical or horizontal).

SLOPE	CONSTRUCTION
≤10%	Authorized <input checked="" type="checkbox"/>
>10% ≤35%	Authorized if stability guaranteed by a specialized research department
>35%	Forbidden <input type="checkbox"/>



**⊘ DON'T DO**



## 2.3 - TECHNICAL DESIGN: RETROFIT AND EXPANSION

### **Retrofit and Expansion Design**

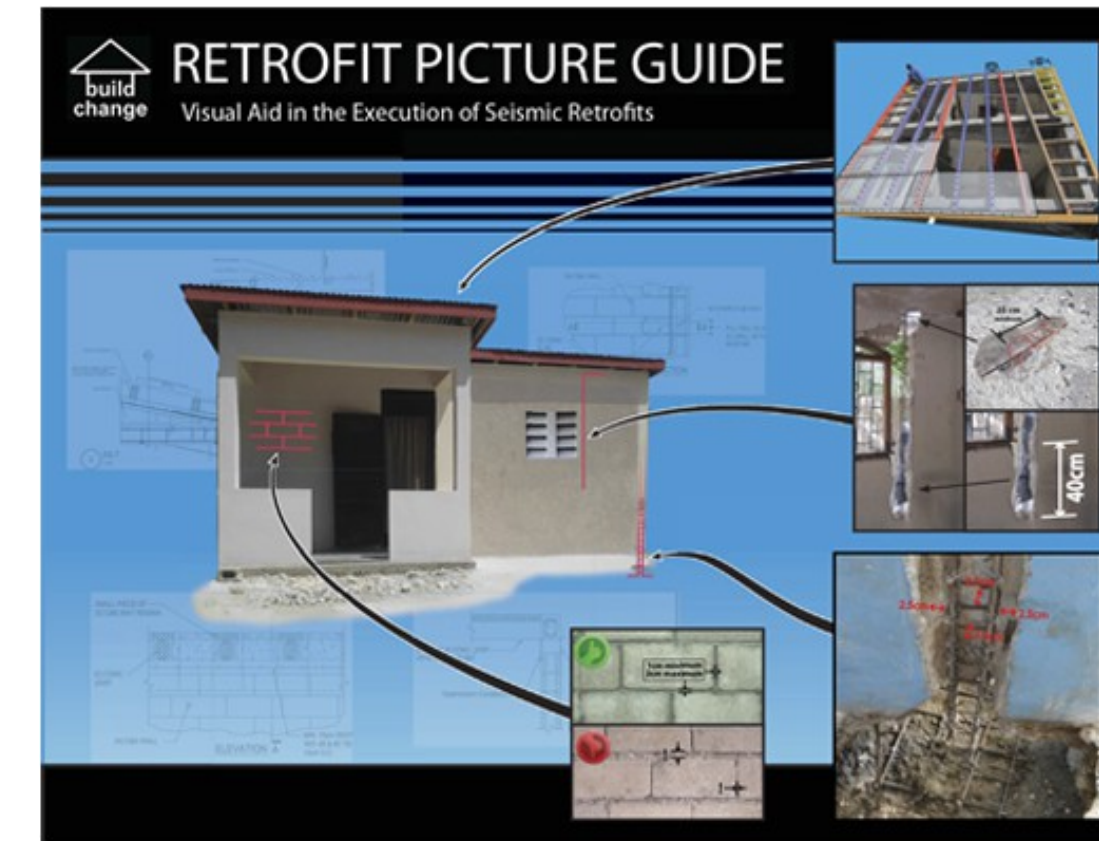
If the engineer determines that a safe expansion of the house is feasible, he will next develop a detailed design for both strengthening the existing house (as required) and building the expansion. The engineer will determine the sequence of the work and in some cases may require the retrofit of the existing home to be performed before the expansion is built.

- \* Refer to the Guide de Renforcement for additional information about designing a house retrofit.
- \* Refer to the following sections of this handbook for specific considerations to make during design for both vertical and horizontal expansion.
- \* Refer to Build Change Retrofit Practical Handbook<sup>1</sup>, which presents step-by-step photos for implementing retrofit techniques identified in the MTPTC Guide de Renforcement.

The retrofit and expansion designs should consist of plans and details with sufficient information in order to determine the extent of work and the quantity of materials and labor that are required to complete the work. This will allow the homeowner to understand the cost of constructing both the retrofit and the expansion and to budget the work accordingly.

### **Homeowner Validation**

At the start of the retrofit and expansion design, the engineer should meet with the homeowner to understand her preferences and needs. They can then incorporate the homeowners' preferences into the retrofit and expansion design, while also ensuring that the desired design will stay within the required codes, guidelines and standards for safety. After the design has been validated for safety by the engineer, the homeowner should review and approve it as well.



1- The Retrofit Practical Handbook is referring to Retrofit Picture Guide. It can be found contacting Build Change office in Haiti or downloaded on our webpage: <http://www.buildchange.org/resources/retrofitting-guides/>

### 3 STRUCTURAL CONSIDERATIONS FOR VERTICAL EXPANSIONS



## 3.1 - STRUCTURAL IMPLICATIONS

### **Structural Implications of a Vertical Expansion**

Vertical expansions add more weight to the structure, which increases the gravitational loads on the house in its resting state. The additional weight and size also increases the horizontal loads on the house in an earthquake or hurricane. Therefore the existing building must be evaluated to understand if the existing walls, columns and footings - which make up the vertical load-resisting system - can withstand the additional gravity loads from an expansion.



### **Retrofitting and Vertical Expansion**

It is necessary to evaluate if retrofitting works are required before designing the expansion. Retrofitting at the ground floor might require changes in the floor plan, that would in turn affect the expansion floor plan.

It is also necessary to execute the retrofitting work before starting the expansion construction work.

**1- Retrofit existing building**



**2- Build vertical expansion**



**3- Safely expanded house**



## 3.2 - EVALUATION CONSIDERATIONS

### 1- Foundations

The engineer will check that the foundations exist below all the walls and columns and that they are in good condition, and assess the soil condition to know how wide the footing should be to support additional stories and load from a vertical expansion. If the footing is in poor condition or not wide enough, it may need to be replaced or strengthened.

### 2- Slabs and beams

Slab: The engineer will need to consider that converting an existing roof (which has very little load on it) to a floor in a new level, will increase the load on the slab and supporting beams with more people and furniture resting on it regularly. (Refer to the CNBH Section 0.4 and 1.9 for the different superimposed loads to be considered for residential floors). The engineer will evaluate if strengthening or replacement of the existing slab and beams is required.

### 3- Lightweight roof

If the existing house has a lightweight roof, it will have to be removed and replaced by a new slab which can serve as the floor to the new level added above.

### 4- Columns and walls

The engineer will evaluate columns and walls to make sure that they are continuous to the foundation and that they are in good condition. Thin walls and narrow columns may not be sufficiently strong to support additional vertical loads from an expansion, and may need to be replaced or strengthened.



### 3.3 - DESIGN CONSIDERATIONS

#### Configuration

- \* The geometry of the expansion should be regular and respect the geometry of the lower floor plan.
- \* All columns should be aligned continuously from the foundation up to the roof.
- \* Perimeter and interior walls should align on all stories and reduce impacts on the structure.
- \* Openings (doors, windows, galleries) should be vertically aligned through the entire height of the building
- \* There should be no overhanging floor portions.
- \* The upper story should be no higher than 2.2m: (Cf. Article 1.5.8 of the CNBH)
- \* Toilets should be aligned to simplify the plumbing.
- \* Consider the distance of the expansion to adjacent structures. There might be overhangs at the upper levels of the adjacent structures interfering with the shape of the expansion. The distance between buildings should not be less than 1.5 m. The minimal distance should be  $H/100$  where H is the building height. (Cf. Article 1.5.4 of the CNBH for further detail).



The upper story should be no higher than 2.2m.



All columns should be aligned continuous from the foundation up to the top floor.



The geometry of the expansion should be regular and respect the geometry of the lower floor plan.

## 3.3 - DESIGN CONSIDERATIONS

### Stairs

- \* Stairs to access the upper story should be placed within the perimeter of the plot
- \* Footprint area required for stairs : consider at least 2 m<sup>2</sup> to locate the stairs, with a minimum width of 1m (Cf. Article 1.5.7.4 of the CNBH)
- \* Stairs should lead to a safe covered space that provides access to the rooms at the upper floor
- \* In order to make space for the stairs, the opening in the slab can not be bigger than 3.6m or the 50% of the small dimension of the slab

### Circulation

Define how house inhabitants are going to access the new space (corridor minimum width should be 1 m) (Cf. Article 1.5.7.4 of the CNBH)



Consider the distance of the expansion to the adjacent structure.



There should not be overhanging floor portions.



All openings should be aligned.

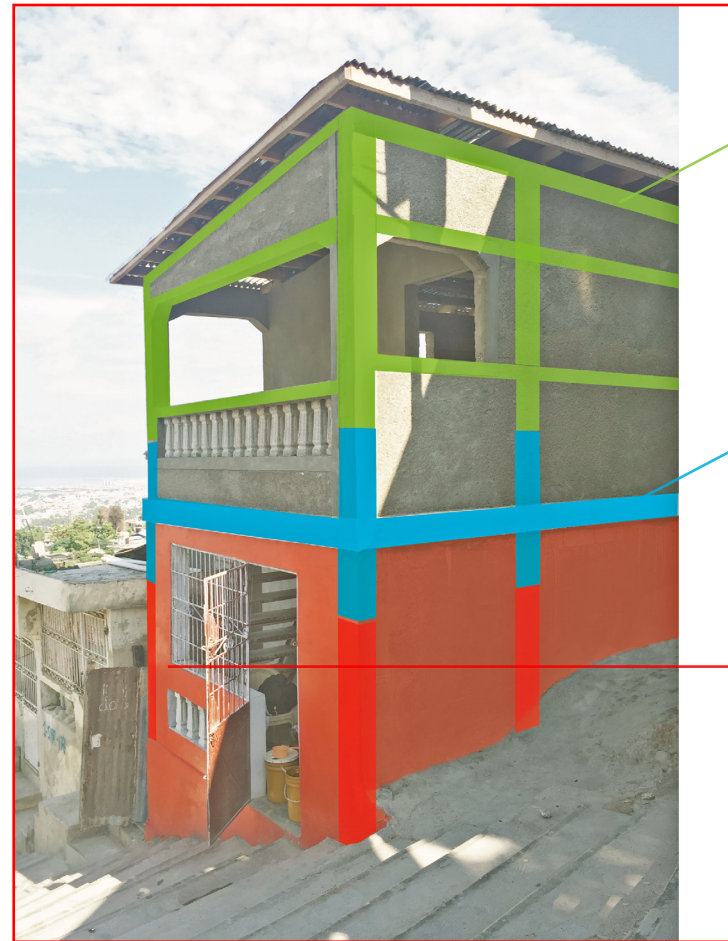


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## VERTICAL EXPANSION DETAILS



4.1 - WHERE TO USE VERTICAL EXPANSION DETAILS



**Expansion is designed and built according to new construction standards.**

Refer to Section 3 on considerations for vertical expansions, CNBH and MTPTC Guide de Bonnes Pratiques for additional information.

**Expansion is safely connected to the existing building.**

Refer to the Vertical Expansion details and step-by-step photos in this section to see how this connection can be made well.

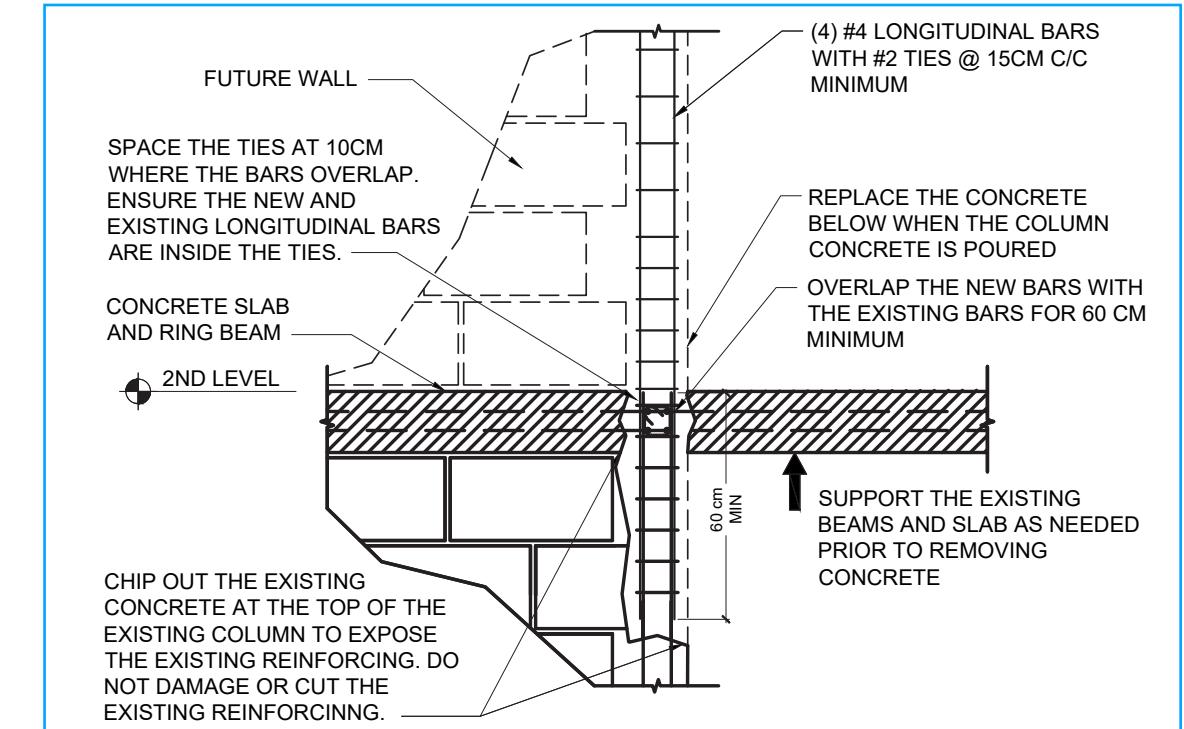
**Existing level is retrofitted and strengthened to support the expansion above.**

Refer to the MTPTC Guide de Renforcement and Build Change Retrofit Practical Handbook for additional information.

4.2 - CONTINUING COLUMNS ABOVE AN EXISTING SLAB

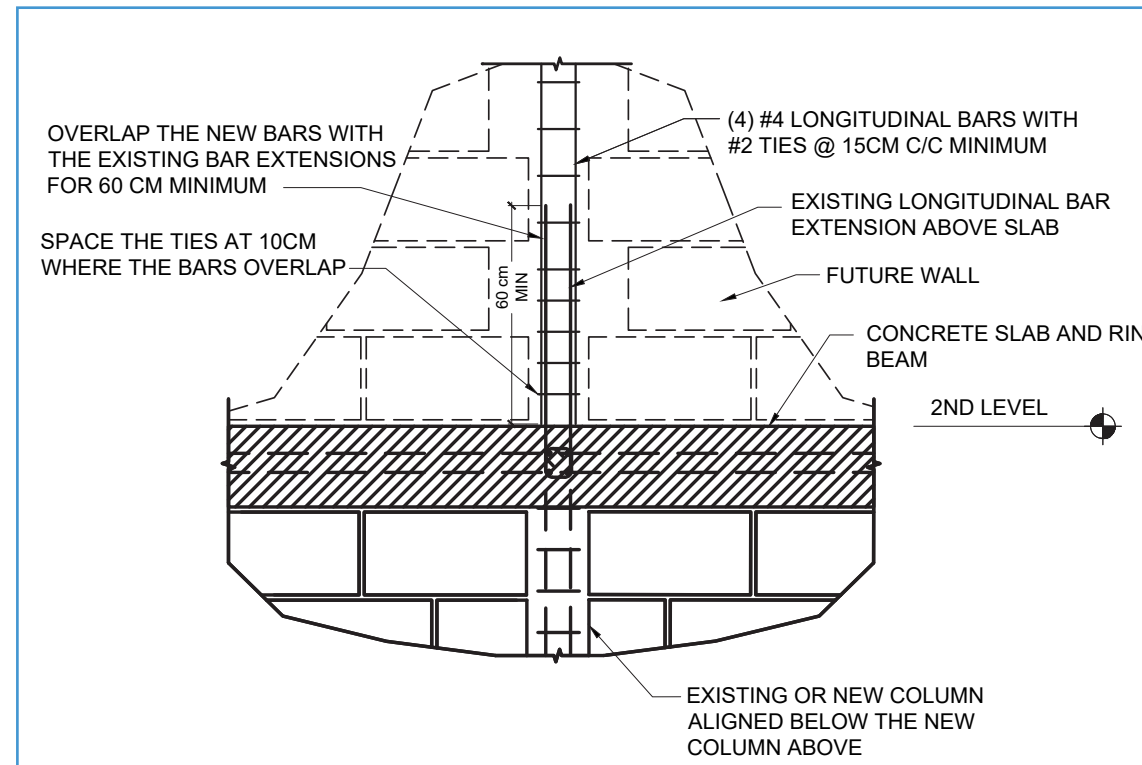
If the engineer determines that the existing slab is adequate to be used as the floor of the new vertical expansion, then the primary concern for expansion work will be to make sure the new columns are continuous, aligned and well-connected to the existing columns below.

The existing columns may or may not have sufficient extensions above the existing slab. The following detailed steps show:



How to lap new column bars when the existing bar extensions are not sufficient or adequate.

4.2 - CONTINUING COLUMNS ABOVE AN EXISTING SLAB



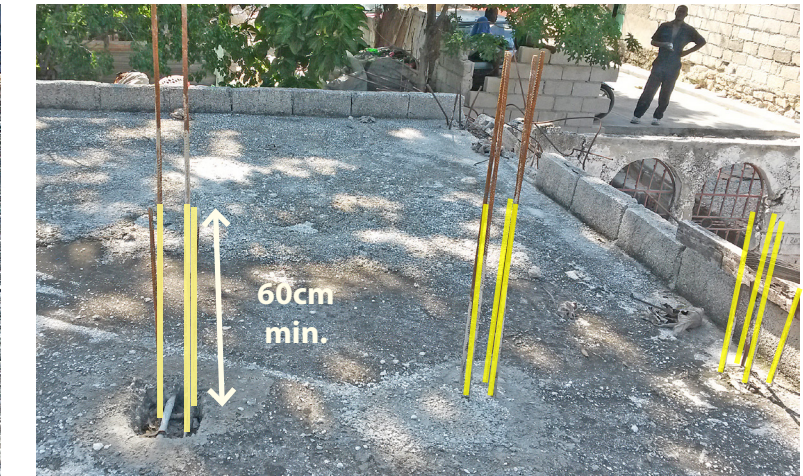
How to lap new column bars with the existing bar extensions above the slab.



1. Identify the condition and locations of the existing column rebar extension



2. Extensions that are significantly bent or corroded or are less than 60cm long should not be used to connect the expansion to the existing building below and will need to be replaced.

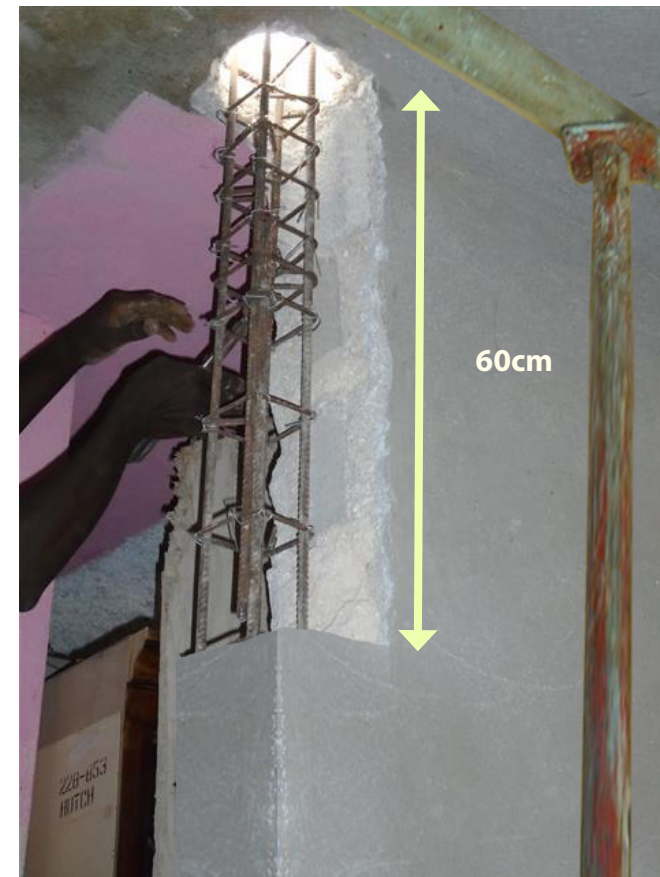


3. During the retrofit of the lower level, install new columns with correct extensions at locations where columns are required in the expansion above and where they do not yet exist or where they require replacement. The extensions shall be 60cm minimum from the top of the concrete slab to the top of the vertical rebar to allow for adequate bar lap. Refer to the Retrofit Practical Handbook<sup>1</sup>, page 39, for detailed steps on installing a “New Tie Column in an Existing Wall”.

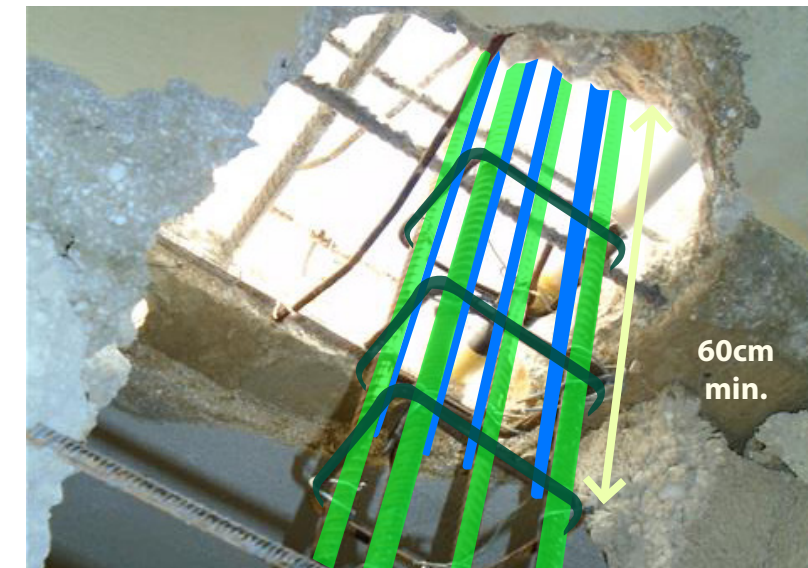
4.2 - CONTINUING COLUMNS ABOVE AN EXISTING SLAB



4. Where the existing column extensions are insufficient (less than 60cm) or inadequate (significantly bent or corroded), the new column rebar can be installed to extend below the existing slab and lap with the existing column rebar below.



5. Ensure that the existing slab and beams are properly shored, then chip out the existing concrete from the column. Be careful to maintain and do not damage the existing column reinforcing. Remove the concrete until at least 60cm of the existing vertical rebar is exposed below the top of slab.

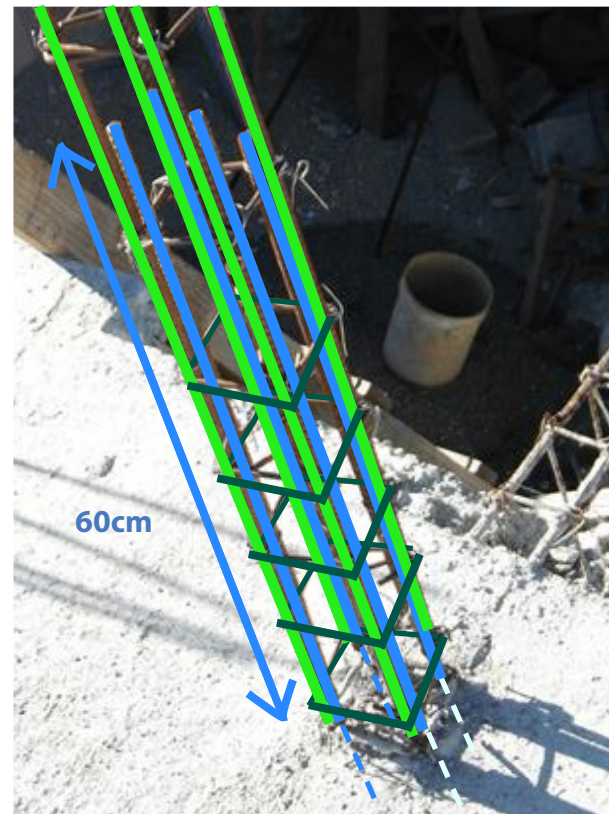


6. Insert the vertical reinforcing for the new column above into the existing column below so that new vertical rebars (4 #4 minimum) lap a minimum of 60cm with the existing vertical rebars and so that the new vertical bars fall inside the existing column ties.



7. After the new reinforcing is placed below the existing slab, the concrete for the column below the top of slab can be replaced. Refer to the information on pouring concrete columns from above the existing slab (steps 15 - 21) in the detailed steps of "New Tie Column in an Existing Wall" outlined in the Retrofit Practical Handbook<sup>1</sup> (page 39). Be sure to adequately support the column cage above the slab so that the vertical bars are installed plumb.

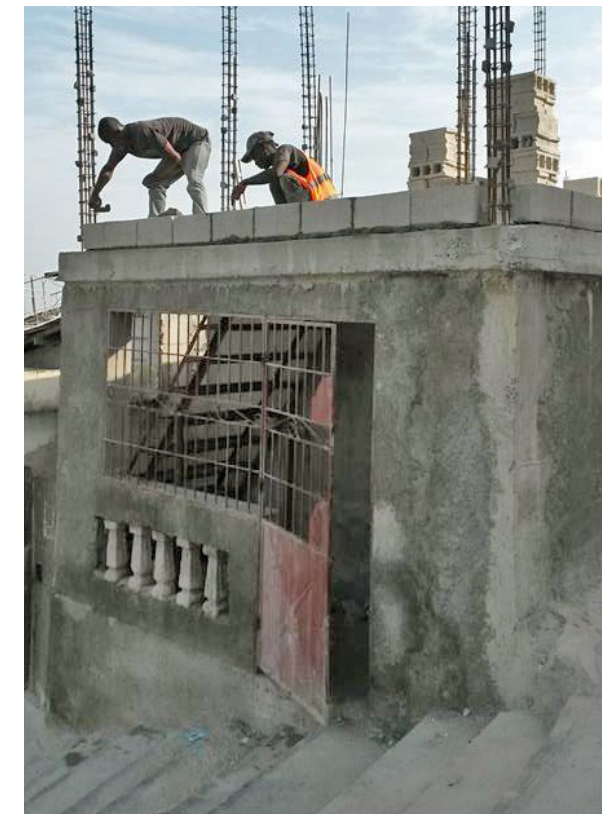
4.2 - CONTINUING COLUMNS ABOVE AN EXISTING SLAB



**8.** Where the existing or new column extensions from the lower level are sufficiently extended above the existing slab, the column reinforcing cage for the upper level can be installed directly on the extensions from below. The new vertical reinforcing bars for the upper level column (4 #4 minimum) should align next to and lap with the corresponding vertical bar extensions from below.



**9.** The ties of the new column shall be placed at a closer spacing where the vertical bars overlap (10cm on the first 50cm; space all other stirrups at 15-20cm). Refer to CNBH Article 1.8.3.6.



**10.** Once the new column rebars are installed at the upper level, the walls of the expansion can now be built. Refer to the Retrofit Practical Handbook<sup>1</sup>, page 16, for detailed steps on masonry “Wall Constructions”.



**11.** Refer to the other identified resources for new construction to continue the process of constructing the expansion.

### 4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

#### Continuing an existing column prior to new slab construction

In some cases, a new slab will be required to serve as the floor for the new vertical expansion above. The engineer may determine this is necessary in two cases :



**1.** The existing roof slab is damaged or inadequate to serve as the new floor

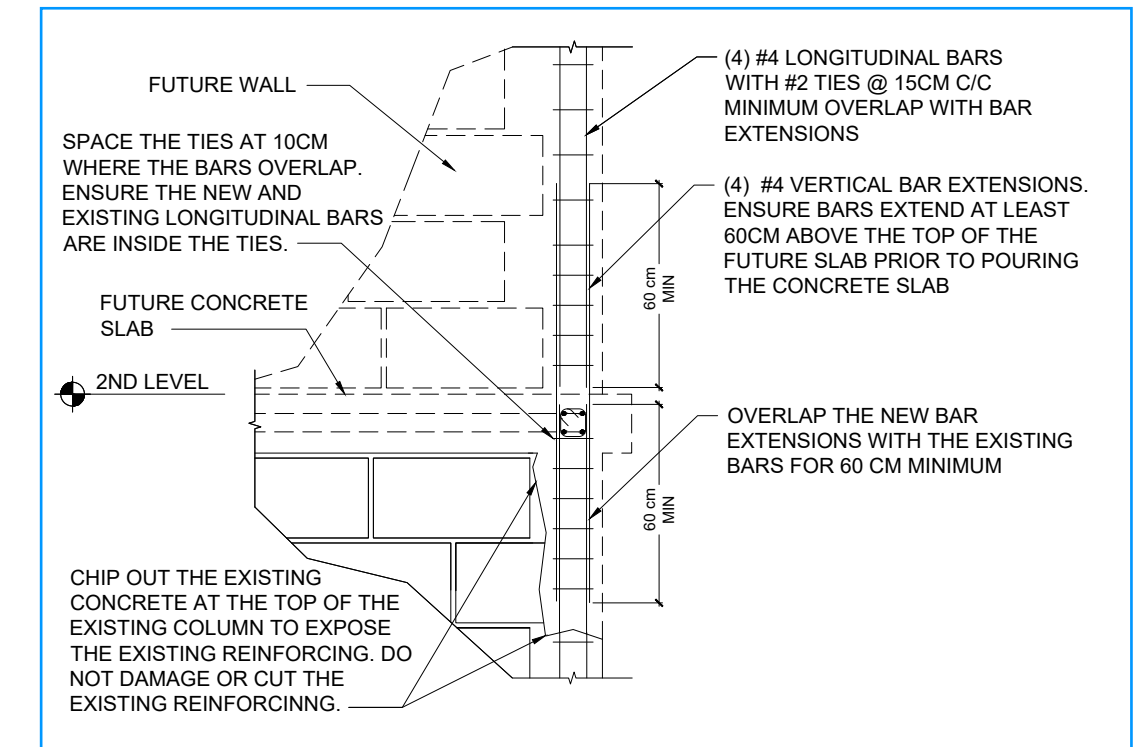


**2.** The existing roof is a light weight roof and therefore can not act as a floor to the upper level

The following detailed steps highlight key aspects of building a new floor slab for a vertical expansion above an existing building.

The most convenient time in construction to ensure that the columns will be continuous between the new expansion and the existing building below is after the existing slab is demolished or the lightweight roof removed but before the new slab is built.

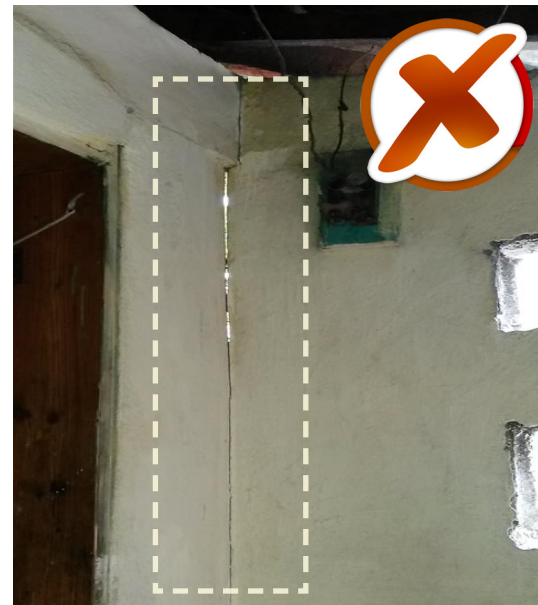
The existing columns may not have sufficient extensions above the future concrete slab. The following detailed steps show how to extend the column bars to the level above.



How to lap a new column before pouring the slab

4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

Continuing an existing column prior to new slab construction



1. Identify the condition and locations of the existing column rebar extensions.



2. Extensions that are significantly bent or corroded or are less than 60cm long should not be used to connect the expansion to the existing building below and will need to be replaced.



3. Demolish the existing slab or lightweight roof, particularly in areas where columns will be extended up to the vertical expansion.



4. Where new columns at the lower level are required, install them with correct extensions above the future slab. The extensions shall be 60cm minimum from the top of the future concrete slab to the top of the vertical rebar to allow for adequate bar lap. Refer to the Retrofit Practical Handbook<sup>1</sup>, page 39, for detailed steps on installing a "New Tie Column in an Existing Wall".

4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

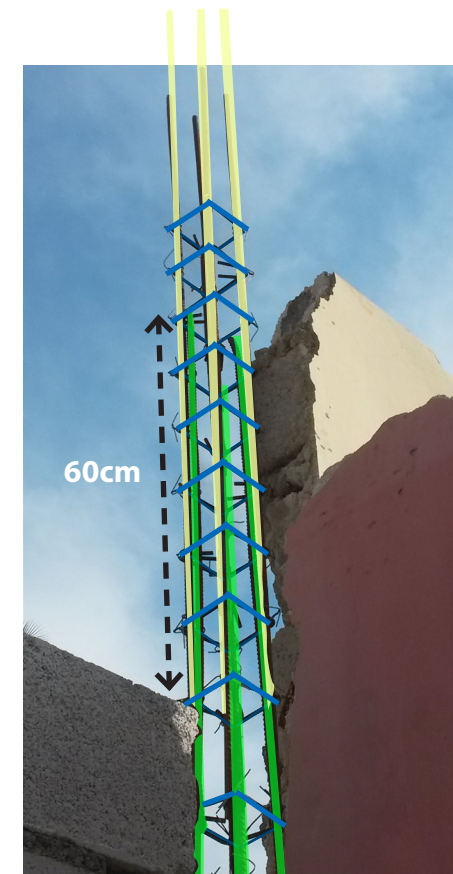
Continuing an existing column prior to new slab construction



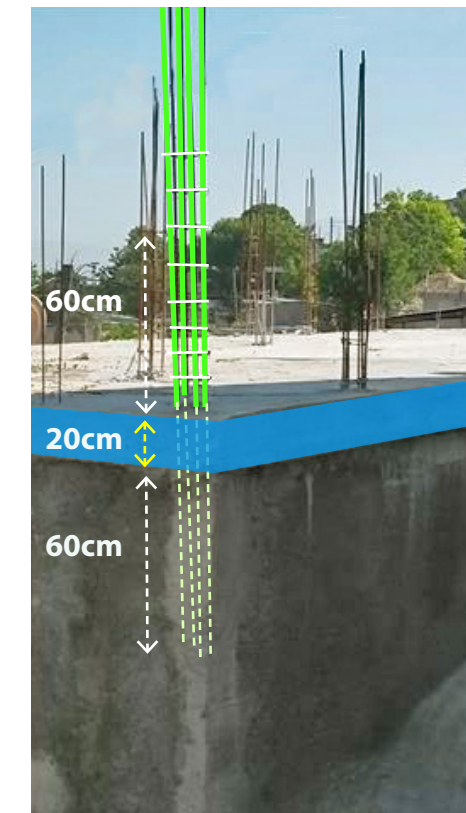
5. Where the existing column extensions are insufficient (less than 60cm) or inadequate (significantly bent or corroded), extensions for the new upper level column rebar should be installed to lap with the existing column rebar.



6. Chip out the existing concrete from the column. Be careful to maintain and do not damage the existing column reinforcing. Remove the concrete until at least 60cm of the existing vertical rebar is exposed.



7. Place the vertical bar extensions inside of the existing column reinforcing (4 #4 bars minimum).



8. The extensions should be long enough to have 60cm overlap with the column bars below, plus the extension through the slab (approximately 20cm) and plus the 60cm extension above the future slab.



### 4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

#### Continuing an existing column prior to new slab construction



**9.** If there is an existing ring beam superior, ensure that the vertical column bar extensions are adequately wrapped by the horizontal bars in the ring beam.

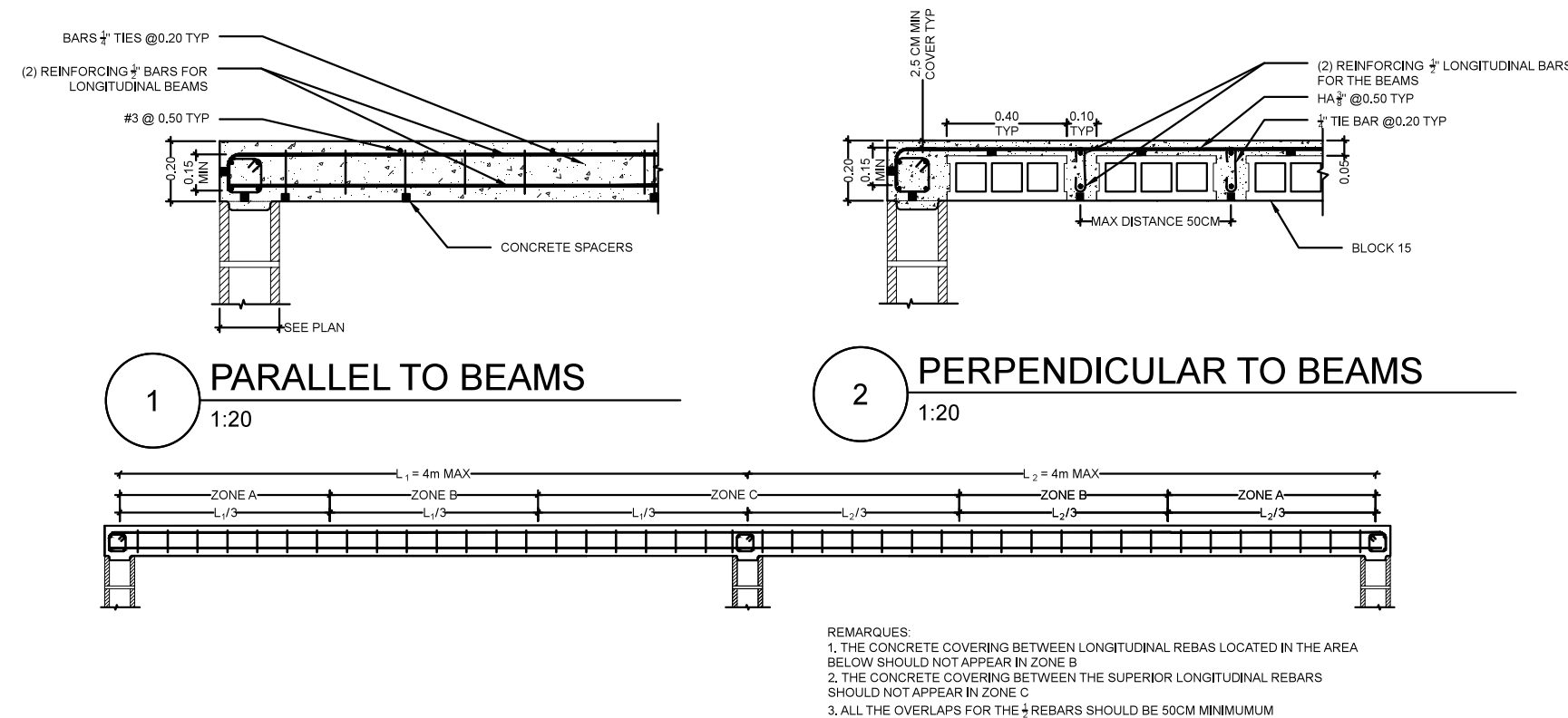


**10.** Once the bar extensions for the new column above are installed properly, the concrete slab for the expansion floor can be built. Refer to the following pages for detailed steps regarding slab construction.

4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

Pouring a new slab

If it is necessary to build a new slab to support the new extension, the engineer has to follow the prescription of the CNBH . This handbook explains the construction of an alveolar slab with beams because it's the most effective way to build a slab for little house.



1. Destroy the lightweight roof or the damaged concrete roof.



2. Prepare a clear level and regular surface on top of the blocks in order to place the new horizontal ring beam.

4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

Pouring a new slab



3. Follow the step above for continuing a column above a new slab where necessary. ( p.44 to 51)

4. Place plywood formwork with props. Refer to CBNH Article 1.9.4.2.



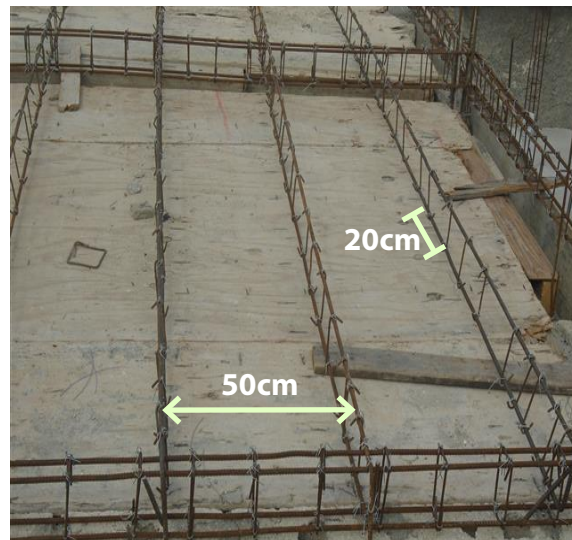
5. Place the superior ring beam above existing walls with 4#4 rebars minimum. Refer to CNBH Article 1.8.3.9.



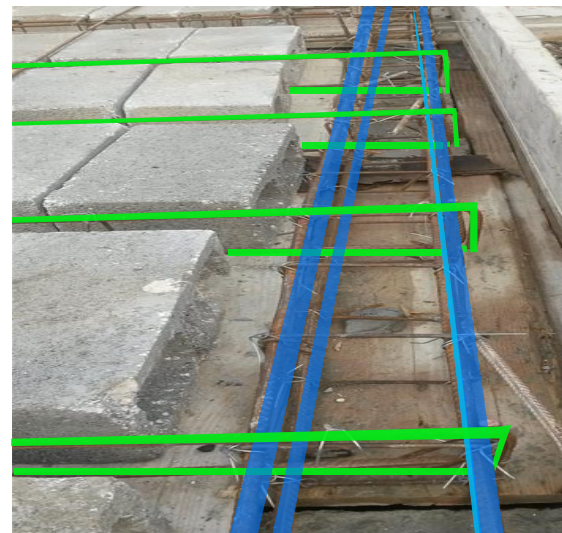
6. Connect the Ring beam to the column, using the T and L connection described in Article 1.8.3.10 of the CNBH. See also the "Connections and Joint Detailing" in the Retrofit Practical Handbook<sup>1</sup> page 7.

4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

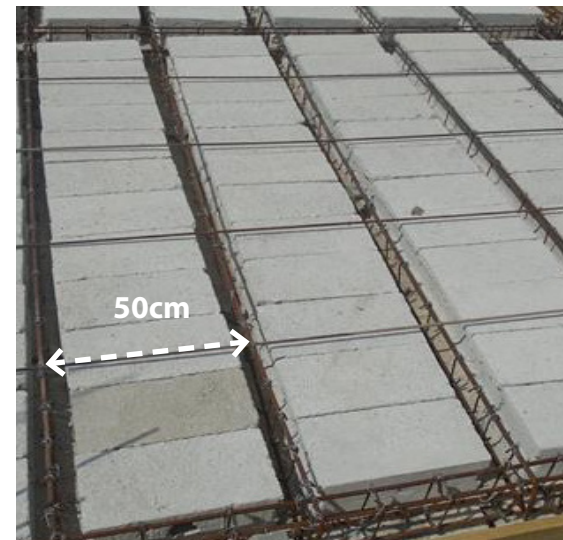
Pouring a new slab



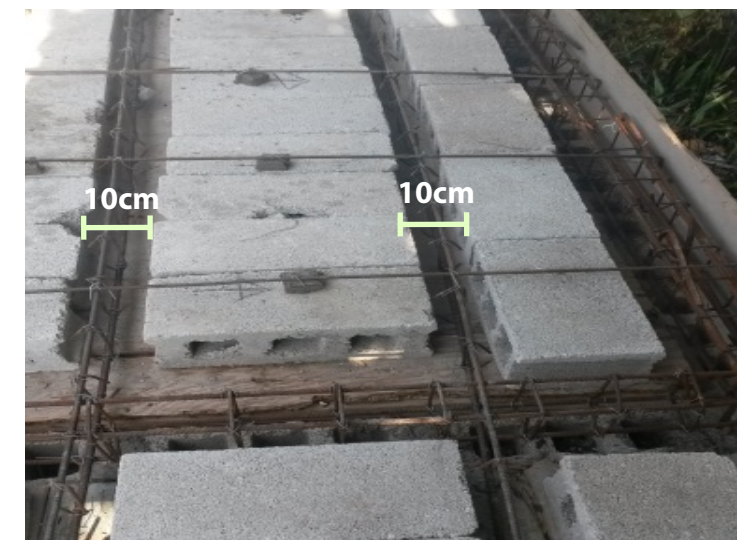
**7.** Place the slab's beams every 50 cm. Place beams in two direction if it is required. Use (2) longitudinal steel #4bars, and steel #2 stirrup at 20cm.



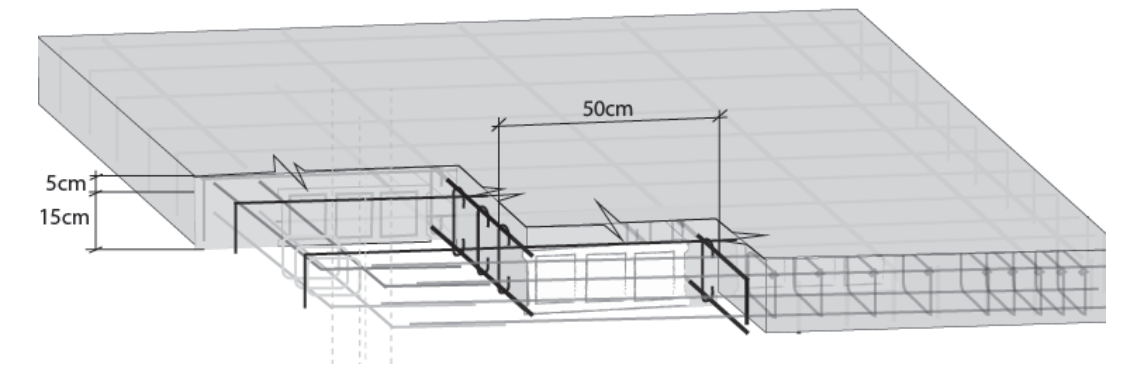
**8.** Anchor the slab beams to the ring beam; see detail above.



**9.** Place the bloks 15 aligned between the slab's beam at 50cm.

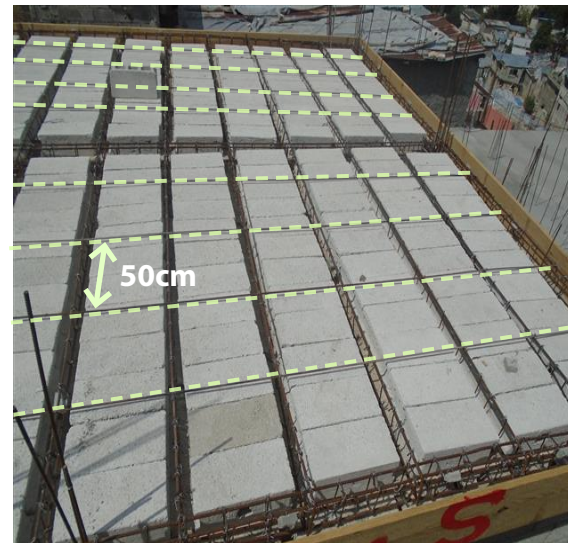


**10.** If the dimension are not regular, you can use half bloc to rectify it, but make sure that all slab beam are parallele and have a thickness of 10cm.

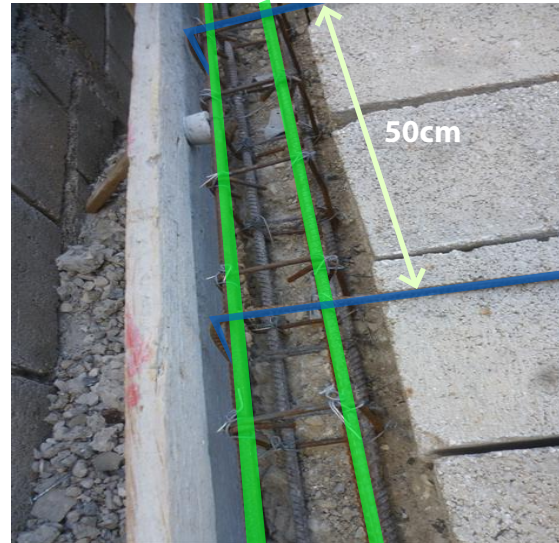


4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

Pouring a new slab



**11.** Place the superior steel bars #3 minimum in the opposite direction of the beams at 50cm.



**12.** Anchor the superior steel bars to the exterior ring beam, with a 90-degree hook; see detail above.



**13.** Use spacers to maintain 2.5cm of covering on the block. (Cf. Retrofit Practical Handbook<sup>1</sup>, "Concrete Spacers" page 5).



**14.** Use string lines to define the thickness of the slab (minimum 20cm, total for a alveol slab, including the 5cm concrete topping).



**15.** Wet the formwork and the blocks to improve the concrete prior to pouring the concrete.

## 4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

## Pouring a new slab



**16.** Make the concrete using a structural mixture as specified by the engineer. Try to pour the slab in just one time; start early in the morning and use a malaxor for a big slab if necessary.



**17.** Use a straight, flat piece of wood to level the surface in alignment with the string line.



**18.** Continue curing of concrete 5 times a day for a minimum of 3 days.

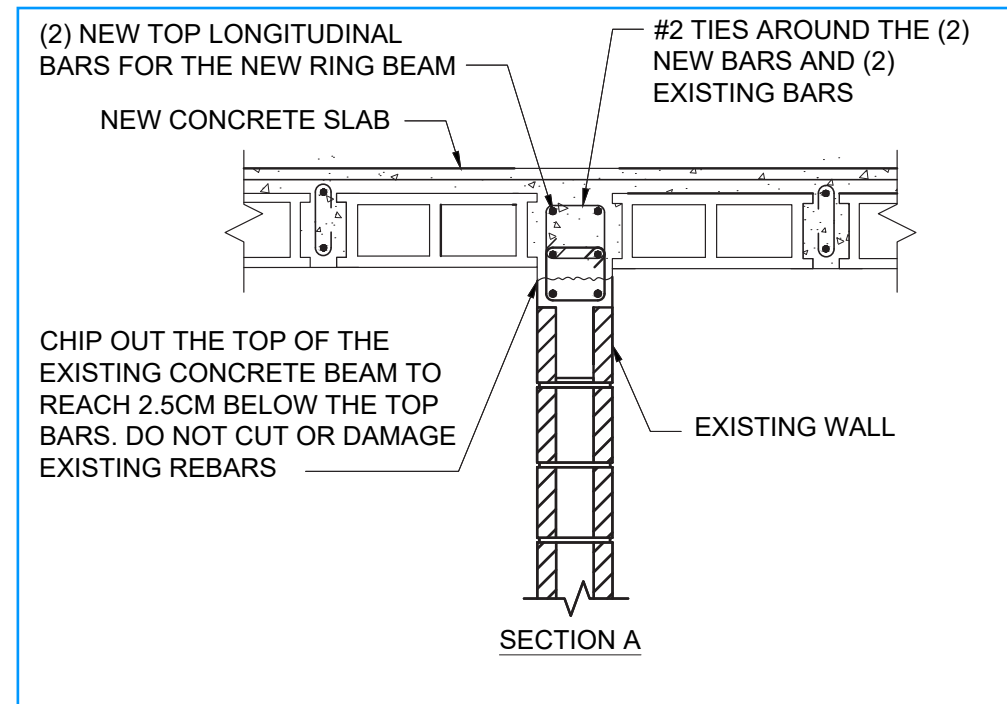
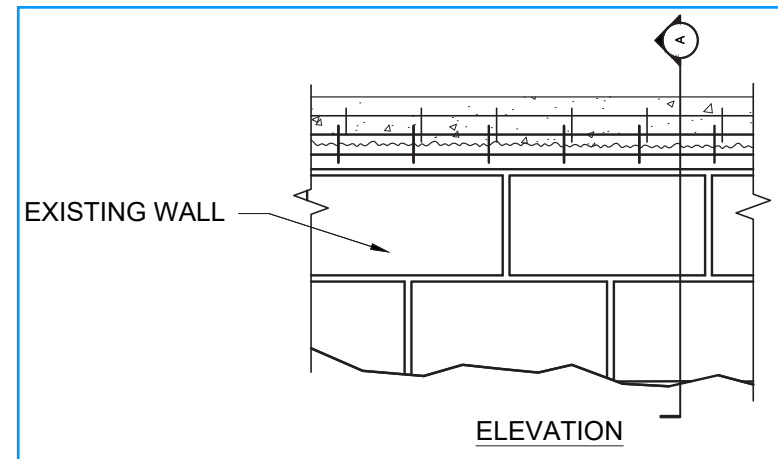


**19.** Protect the slab with a canvas cover and keep the formwork in place below to support the slab for a minimum of 14 days.

### 4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

#### Pouring a new slab using an existing ring beam

If there is an existing ring beam, in good condition, the slab can be connected to it. In this case, add two longitudinal reinforced bars, linked with ties, to the lower part of the existing ring beam in order to create a 6 bar ring beam. The slab beam will be connected to 4 upper rebar that will be used like a new ring beam, to support the slab beams.



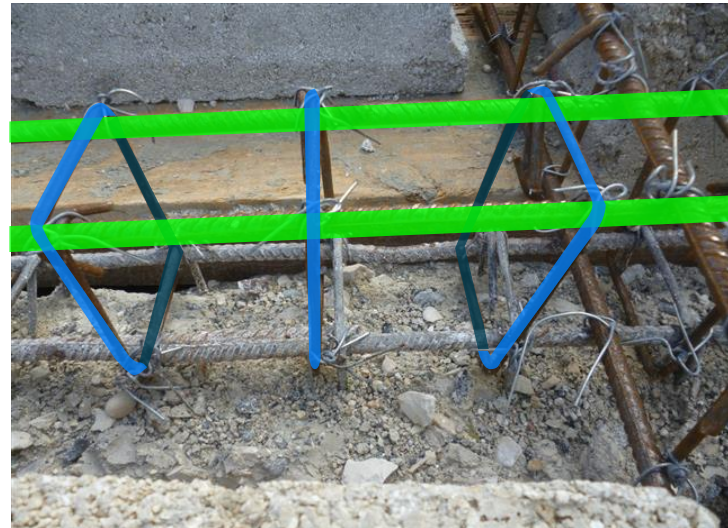
**1.** Follow the 1st, 2nd and 3rd steps of the previous step-by-step explanation, "Construction of a New Slab", page 55. Demolish the light-roof or the damaged slab until the existing ring beam.



**2.** Remove the concrete of the upper part of the existing ring beams, to reach the two upper bars of the existing ring beam. Be careful to maintain and do not damage the existing ring beam reinforcement. If the ring beam is not in good condition, break the entire ring beam, and build a new one (refer to the previous step by step explanation, "Construction of a New Slab", page 57).

4.3 - EXPANDING ABOVE A NEW CONCRETE SLAB

Pouring a new slab using an existing ring beam



3. Add two longitudinal rebars and add ties to enclose new bars at the top of the (2) exposed existing bars.



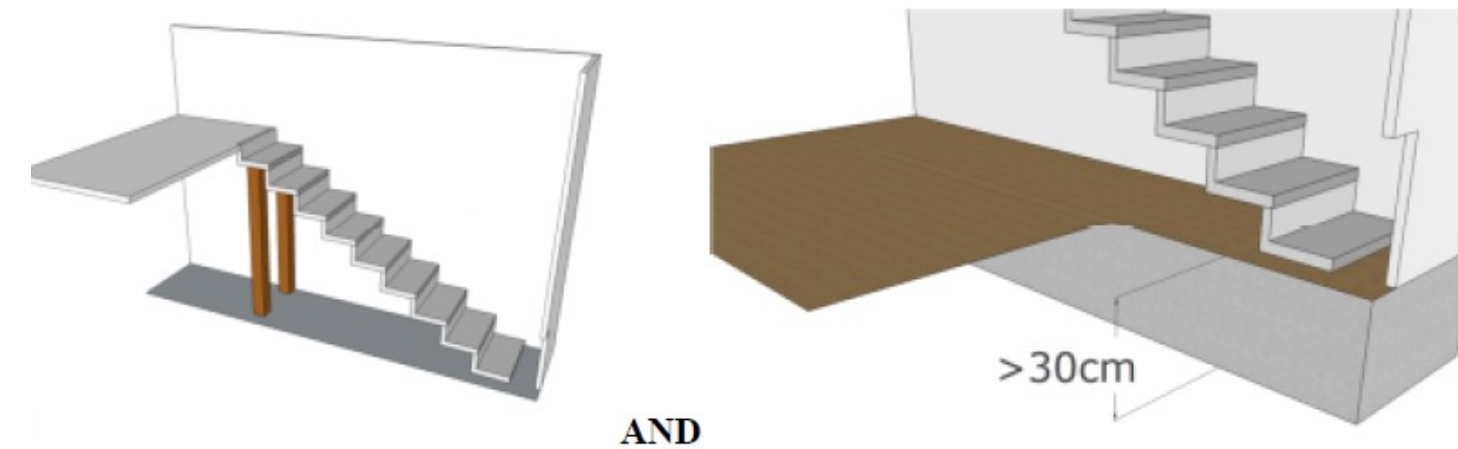
4. Considering the 4 upper rebars like a new ring beam, anchor the slab beams. Refer to the previous step by step explanation, "Construction of a New Slab" for how to finish installing the new slab.

4.4 - INSTALLING STAIRS

Stairs can be installed in reinforced concrete or in metal but must meet all of the following requirements:

- \* Stairs must be connected at each level to the building slab or roof to 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 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 (>7%) or soft sites the stair foundation shall be continuous with the remainder of the building.

See the requirements for stair sizing and materials in the CNBH per Article 1.5.7.4, Article 1.5.11.4, and Article 1.6.1.9,



AND

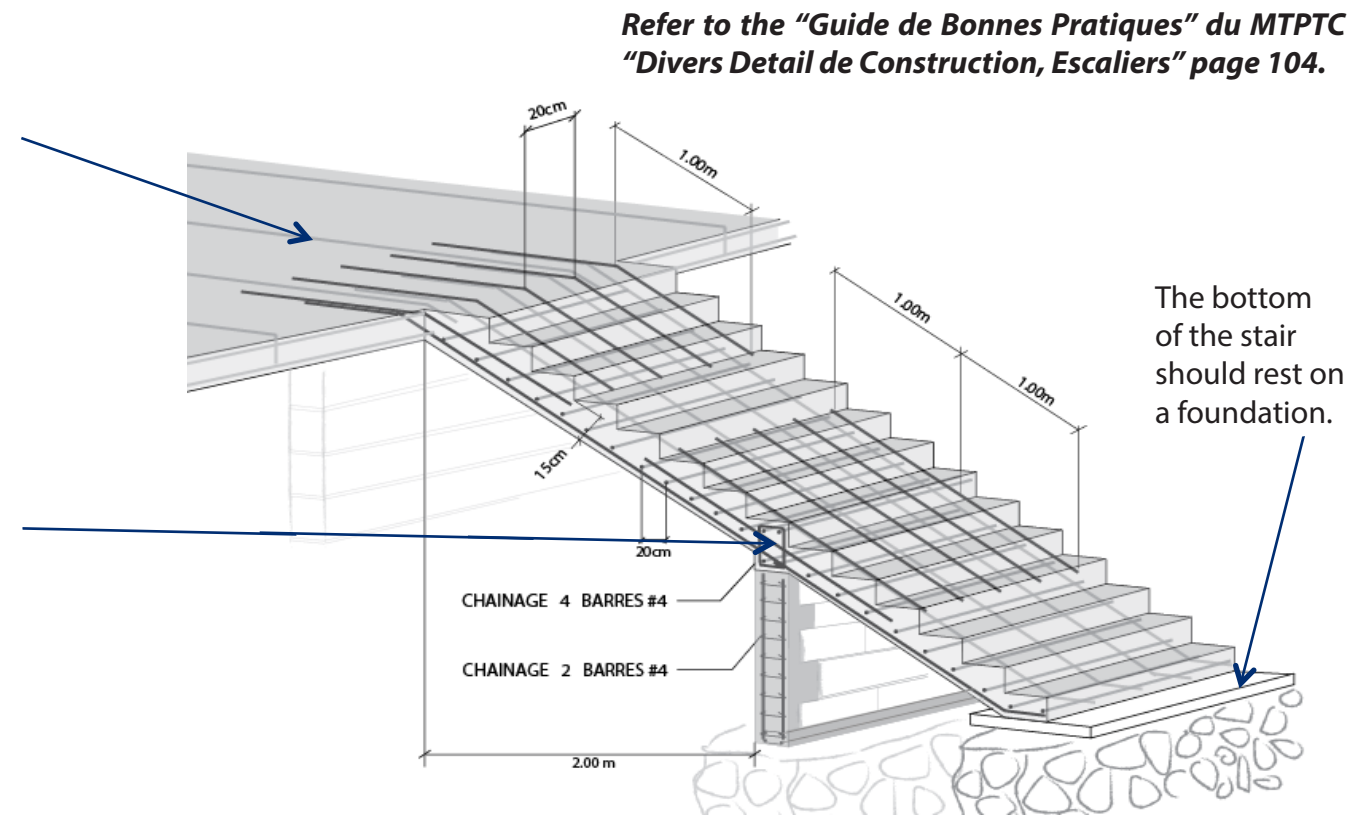


4.4 - STAIRS

Concrete stairs

The stair is anchored in the slab. Add superior longitudinal rebars #3 minimum at 20 cm, lapping 50 cm on the landing and 1m the other side on the stairs. The inferior longitudinal bars are extended into the slab for 50cm.

An intermediate wall is necessary to support a concrete stair. Add superior longitudinal rebars #3 minimum each 20cm, 1 m from both side of the ring beam of the wall. The longitudinal bars of the stairs have to be connected to the ring beam superior of the wall.



Metal stairs



Connect the top of the stair to the slab. Add a metallic extension of the last step of 50cm minimum into the slab.

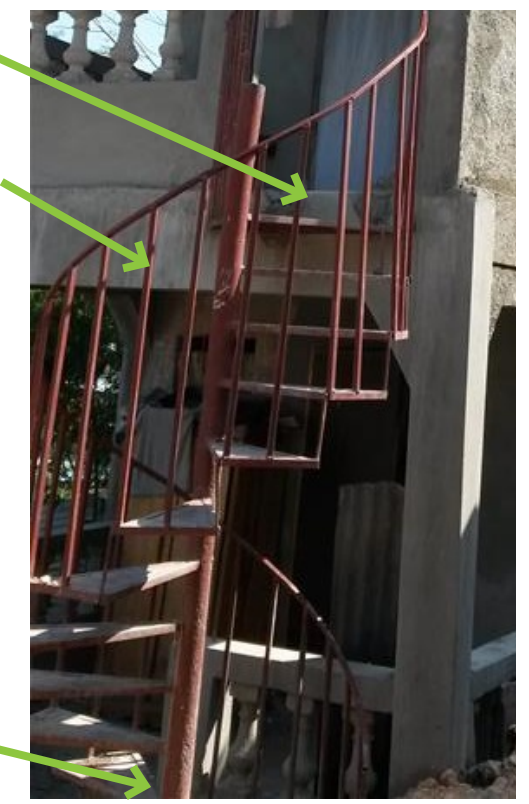
Paint to reduce future corrosion of the steel.

Leave a joint between the stair and the adjacent wall.

If necessary, add intermediate metal supports with new concrete foundations.

Add metal supports for the first step with new concrete foundations

Build a new concrete foundation for the extension of the central metal column.



## 5 STRUCTURAL CONSIDERATIONS FOR HORIZONTAL EXPANSIONS



## 5.1 - EVALUATION CONSIDERATIONS

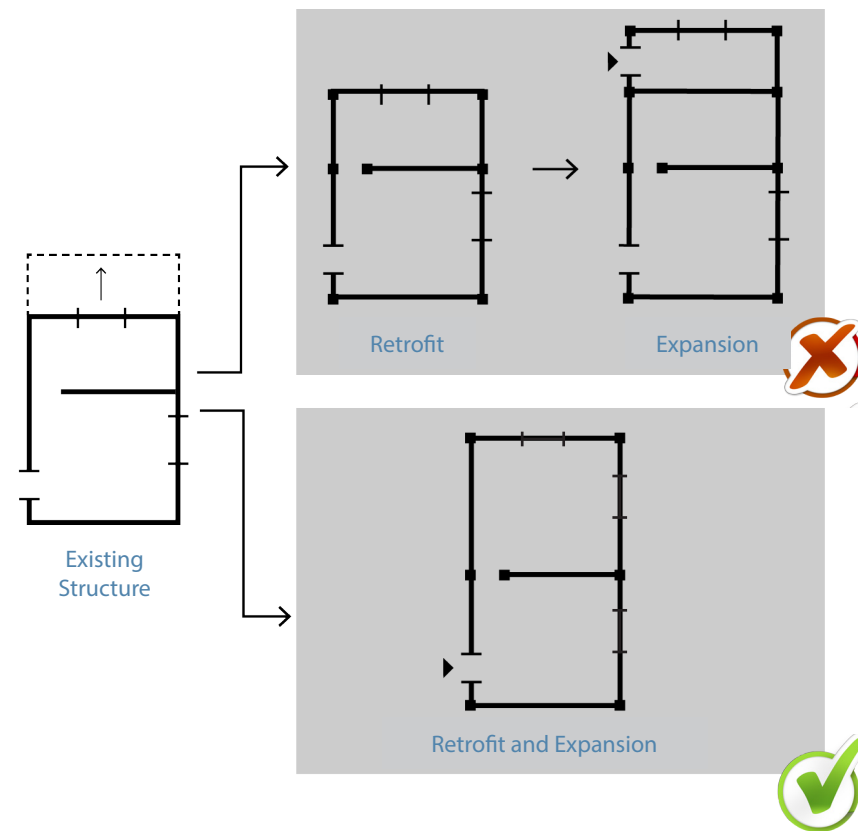
### Structural implications of a horizontal expansion

Horizontal expansions will change a structure's layout. Additions to a structure also modify the proportion of the house and how it behaves in an earthquake. Evaluating the existing building will allow the engineer to understand how to best plan and execute the expansion.

### Retrofitting and horizontal expansion

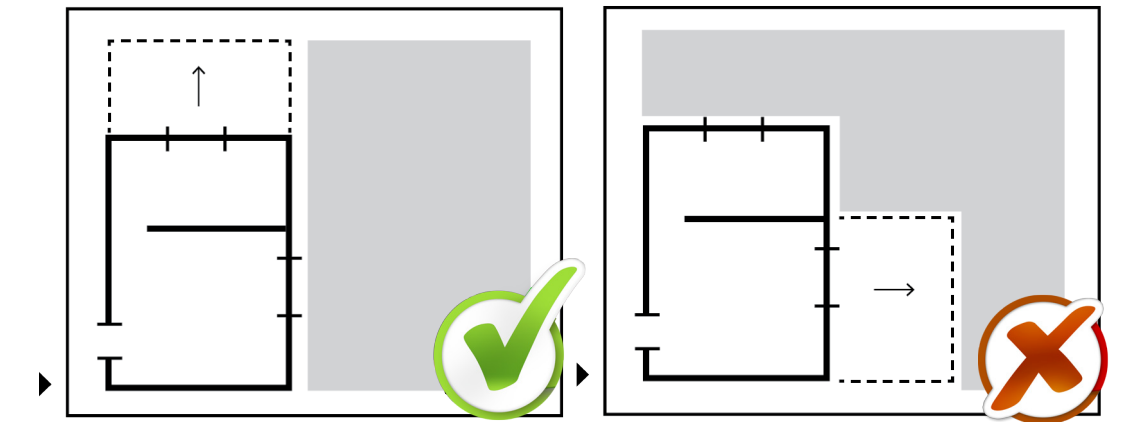
*Design the retrofit (if necessary) and the expansion at the same time.* Without a seismic joint, the existing building and the expansion will work as one structure. It is preferable to design the retrofit and the expansion at the same time in order to optimize the structural grid, the spans, the room spaces and the circulation spaces. See the scheme to the right.

**Coordinate retrofit and expansion works.** In comparison to vertical expansion, where it is necessary to complete the retrofitting before starting the construction of the expansion, in the case of a horizontal expansion it is more convenient to execute the retrofitting and the expansion works in parallel. For example, If a ring beam must be implemented for the retrofit, then it is convenient to build it at the same time as the ring beam of the expansion.



### Plot configuration and layout

- \* Evaluate the available space in the plot. Identify the plot perimeter, and the distance of the existing building from adjacent buildings, from underground tanks or pits, and from protected or unprotected slopes.
- \* Evaluate the slope of the plot. When the plot is sloped, evaluate the possibility to create stepping floor levels or to raise the foundation to make the floor of the existing structure leveled with the expansion's. In both cases, the foundations of the existing structure and of the expansion should be connected vertically to the depth of the lower foundation.
- \* Identify the grid of walls, columns and beams of the existing structure; identify spans and consider how the expansion would complete or modify them.



Evaluate the space on the plot to plan an expansion with a regular geometry and avoid L or T shaped plans.

5.1 - EVALUATION CONSIDERATIONS



**Structure configuration**

A horizontal expansion can take place on the second floor. When the expansion happens at an upper level, this essentially create a vertical expansion for the structure below the new expansion and the engineer must evaluate if the entire structure below needs to be retrofitted prior to receiving the expansion. Refer to the section "Evaluation considerations" for vertical expansion page 30 in this handbook for more information.



**Roof**

- \* Lightweight roof: evaluate the current configuration of the lightweight roof (type and geometry) and plan in advance how the expansion roof is going to integrate with it.
- \* Slab: Evaluate the status of the slab: connecting the new slab of the expansion to an unsafe slab would create a hazard.

## 5.2 - DESIGN CONSIDERATIONS

### Plot configuration/layout

- \* Consider expanding vertically instead of horizontally if there is not enough space for horizontal expansion.
- \* Plan in advance: it might be worth planning for the entire plot/building configuration even if the available budget allows building only a portion of it.
- \* Expanding horizontally might require building site mitigation infrastructure in the plot.



Consider the required minimum distances required by the CNBH, from pits, underground tanks, trees, unprotected slopes.

### Structure Configuration

- \* The configuration of the expansion should be regular. Irregular and L shape buildings are discouraged. If a regular layout is not possible, a seismic joint should be considered. (Cf. CNBH 1.4.8.2)
- \* Perimeter walls should be aligned with the existing walls.
- \* Foundations: when the plot is sloped, avoid creating "poteaux court" (Cf. CNBH 1.4.8.2 ). Raise the foundation above the ground level, while keeping the foundation depth prescribed by the CNBH.
- \* When creating stepping adjacent floors, it is convenient to make elevation levels equals at the upper ring beam. In this case, verify that the H/L proportions of confined masonry panels are compliant to the "MTPTC- Guide des bonnes pratiques".
- \* When the horizontal expansion happens at an upper level, the expansion design must respect the layout of the floor below. The detailing of the connection to the lower structure must consider the indications provided in this handbook in the vertical expansion section..



The length dimension of the complete structure (the existing with the addition of the expansion) should not exceed four times the structure width.

5.2 - DESIGN CONSIDERATIONS



**Structure configuration**

- \* Inferior ring beam: the majority of the existing structures in masonry do not have ring beams.
- \* Consider the height difference due to the new inferior ring beam when calculating masonry wall heights.
- \* Always place an inferior beam on top of the foundation.

**Roof**

- \* Lightweight roof: when the expansion is made perpendicularly to the roof inclination, then the roof can be continued over the expansion. Otherwise, a change in the roof configuration might be needed.
- \* Respect the maximum and the minimum roof inclinations as spans between walls and beams change (Cf. CNBH Art. 1.4.9.9 Forme de la toiture). Lightweight roof horizontal additions like verandas and galleries should be independent from the lightweight roof covering the house.



6

## HORIZONTAL EXPANSION DETAILS



### 6.1 - WHERE TO USE HORIZONTAL EXPANSION DETAILS

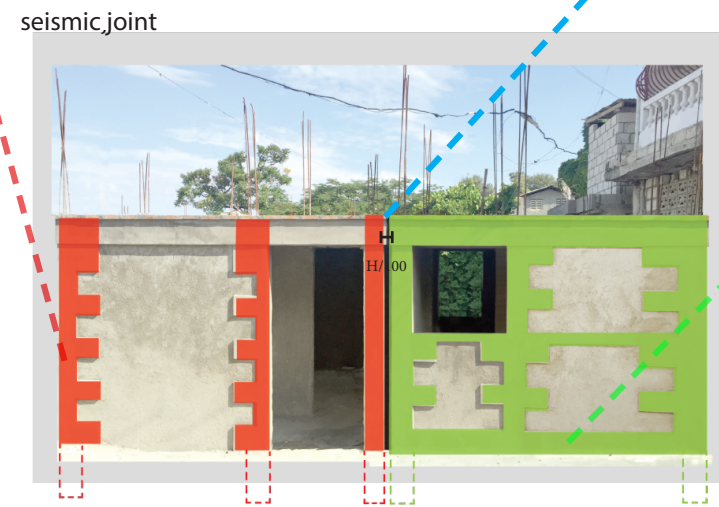
Existing house is retrofitted to ensure safety and security.

Refer to the MTPTC Guide de reinforcement and Build Change Retrofit Practical Handbook\* for further instructions.



Expansion is safely connected to the existing building or built with an adequate seismic joint.

Refer to the details and step-by-step photos in this section to see how this connection can be made well.

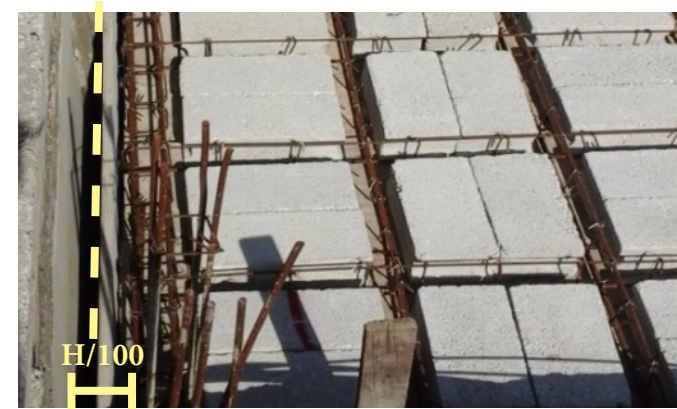


Expansion is designed and built according to new construction standards.

Refer to the following section on consideration for horizontal expansions, CNBH and MTPTC Guide de Construction to see how to proceed.

### 6.2 - NEW CONSTRUCTION WITH A SEISMIC JOINT

It is recommended to create a seismic joint between two buildings with a minimum gap of  $H/100$  (H being the height of the building). This gap goes from the foundation to the roof. (Cf. Guide de Bonnes Pratiques, p23)



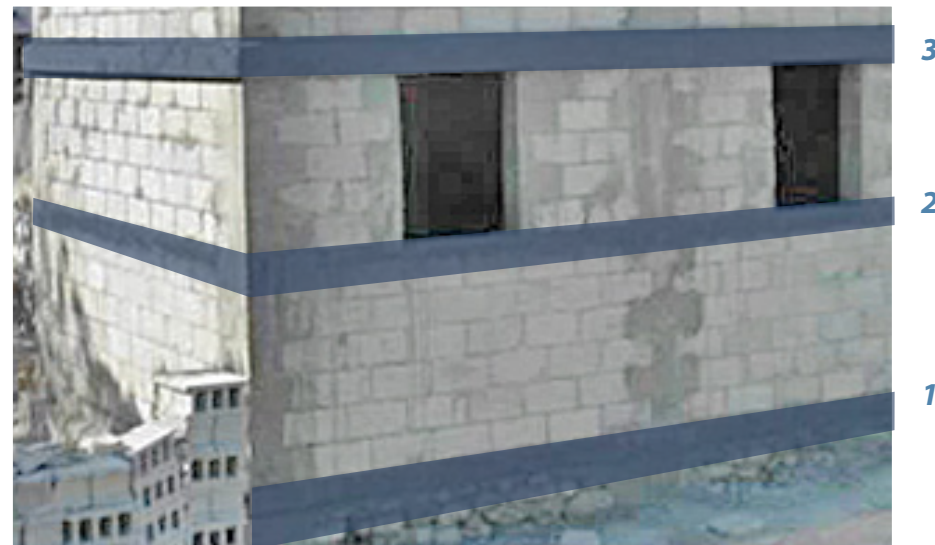


### 6.3 - CONNECTING TO AN EXISTING STRUCTURE

If the engineer determines that a horizontal extension is possible, the primary concern is to connect all new ring beams and new walls to the existing columns. Note that if existing columns are not present where the expansion connects to the existing house, then a new column can be added to link the two portions (existing and new) together. Refer to the *Retrofit Practical Handbook*<sup>1</sup>, page 39 for detailed steps on how to insert a “New Tie Column in an Existing Wall”. Connect the existing and new portions together along the height of the house, starting with the foundation and continuing to the roof.

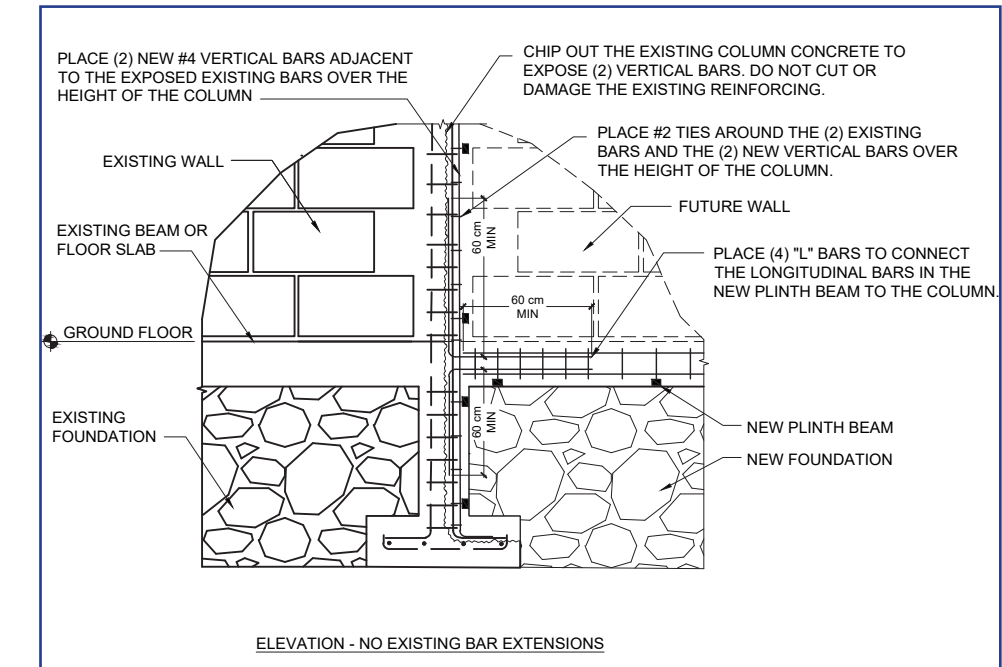
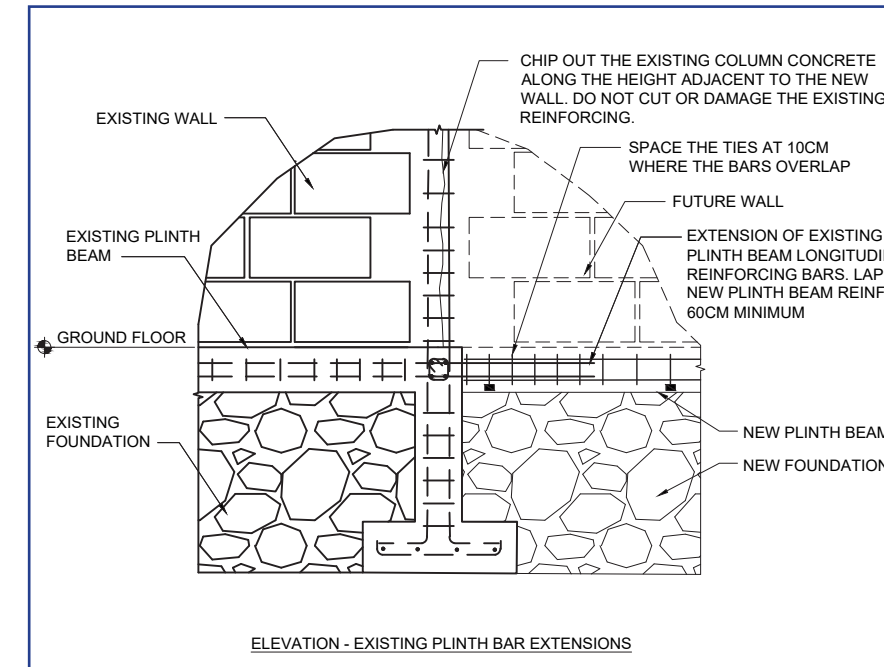
The following detailed steps show :

- 1- How to connect the foundation and the inferior ring beam to the existing column
- 2- How to connect the new wall and its intermediate ring beam to the existing column
- 3- How to connect the new superior ring beam to the existing ring beam superior



3  
2  
1

#### Connecting a new foundation to the inferior ring beam

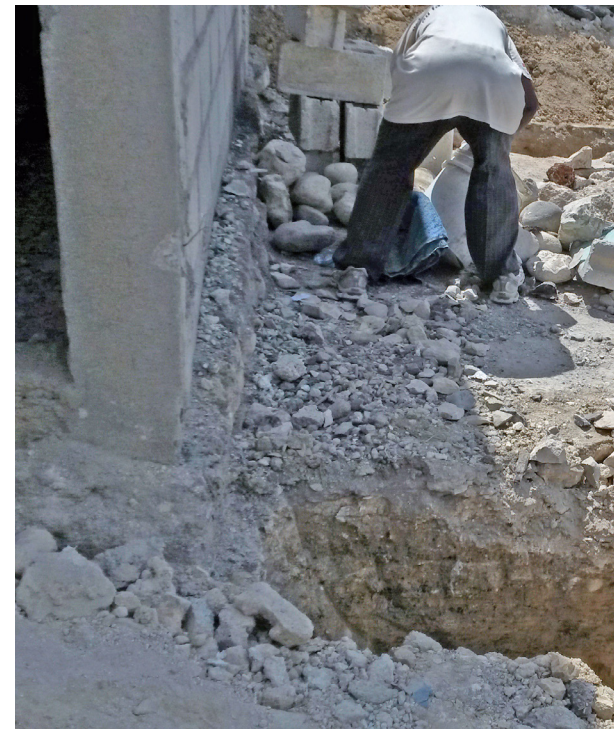


## 6.3 - CONTINUING AN EXISTING STRUCTURE

## Connecting a new foundation to the inferior ring beam



**1** – If there is a slab, ensure that the existing slab and beams are properly shored next to the wall that link to the expansion. Refer to the Retrofit Practical Handbook<sup>1</sup> page 1 “Shoring a Concrete Slabs”. The prop has to stay in position until the superior ring beam is finished.



**2** - Excavate the foundation adjacent to the existing column. Refer to CNBH section 1.7 “Foundation” for more informations. Make sure that the foundation is aligned with the existing wall.



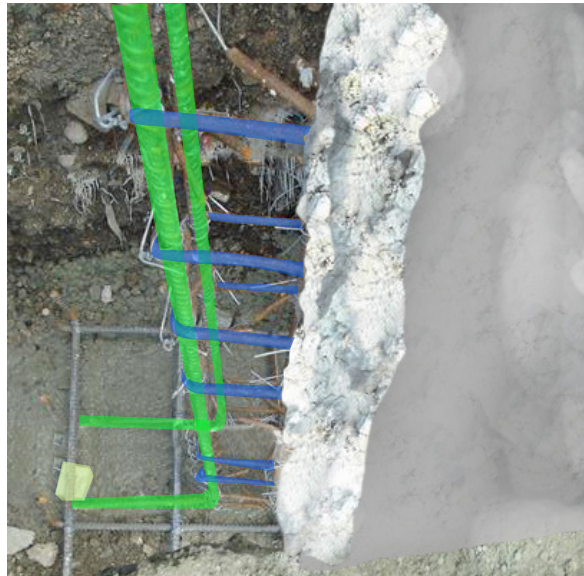
**3** – Chip out the concrete of the existing column on its entire length. Be careful to maintain and do not damage the existing column reinforcing. Remove concrete to expose the two longitudinal rebars with at least 2.5cm gap behind the bars.



**4** – Place minimum two longitudinal vertical rebars (min #4) along the height of the exposed existing column rebar and use ties to connect them with the two existing rebar.

## 6.3 - CONTINUING AN EXISTING STRUCTURE

## Connecting a new foundation to the inferior ring beam



**5** – The two longitudinal bars have to be tied to the existing column, extending into the foundation, and should hook into the existing foundation basket for 25cm.



**6** – Build a new foundation up to the top of the adjacent level of existing foundation. Refer to CNBH Section 1.7 “Fondations” for requirements of constructing new foundations.



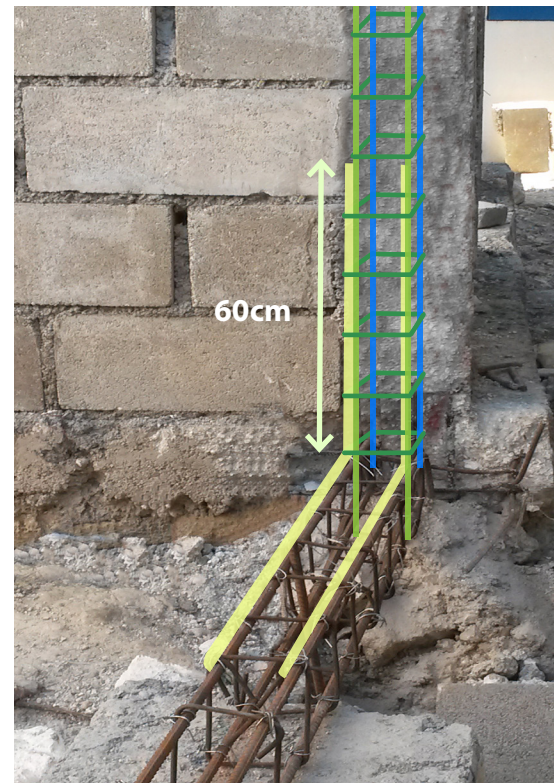
**7** – Pour the structural concrete for the column foundation to the level of the bottom of the inferior ring beam.



**8** – Place the inferior ring beam with (4) longitudinal #4 bars minimum. Refer to the CNBH Article 1.8.3.8 “Chaînage horizontal inférieur”.

## 6.3 - CONTINUING AN EXISTING STRUCTURE

## Connecting a new foundation to the inferior ring beam



**9** – Connect the inferior ring beam to the existing column using the the added “L” bars extending from the foundation. Bend the inferior ring beam rebar into the column, or provide additional “L” bars, to achieve a 60cm minimum lap.



**10** – Place the formwork for the inferior ring beam and place concrete spacers. Refer to Retrofit Practical Handbook<sup>1</sup>, page 14 “New Plinth Beam on Existing Foundation”.



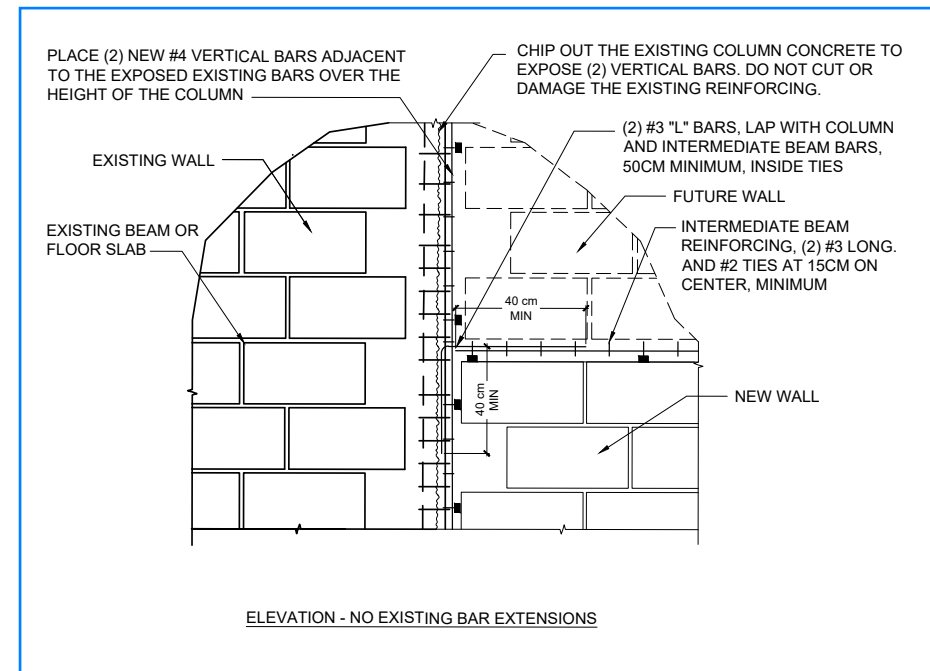
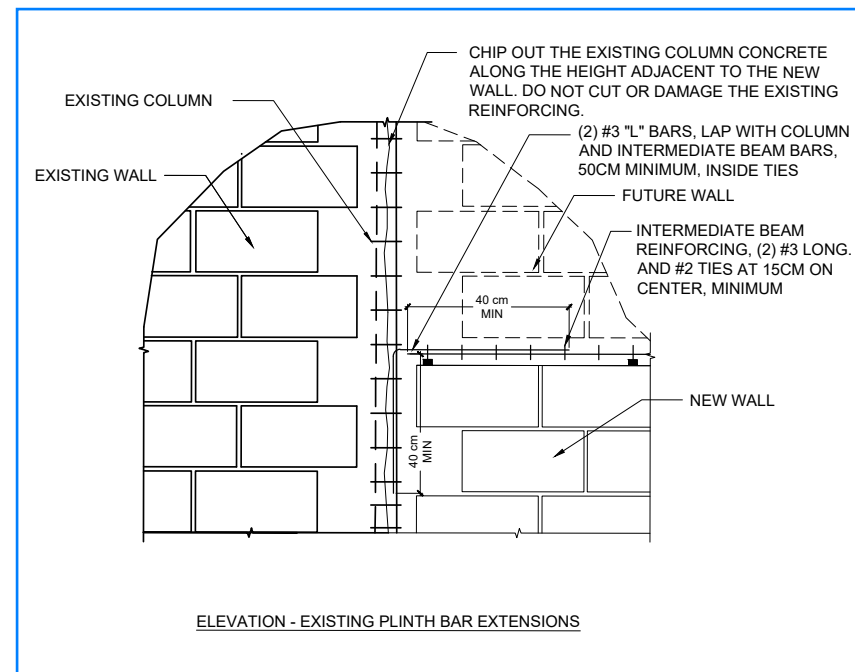
**11** – Place the formwork for the inferior ring beam and place concrete spacers. Refer to Retrofit Practical Handbook<sup>1</sup>, page 14 “New Plinth Beam on Existing Foundation”.



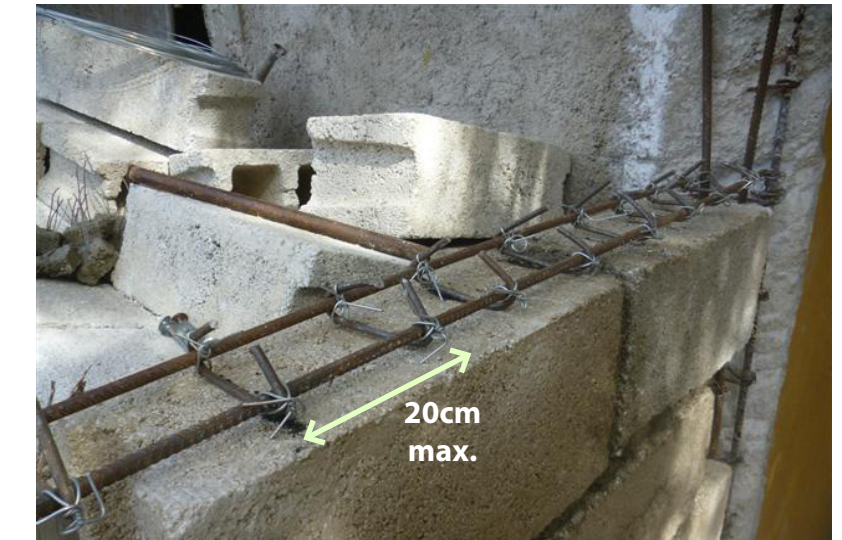
**12** – Leave the formwork and cure the concrete for 3 days before beginning the construction of the wall

6.3 - CONTINUING AN EXISTING STRUCTURE

Connecting walls to the intermediate ring beam



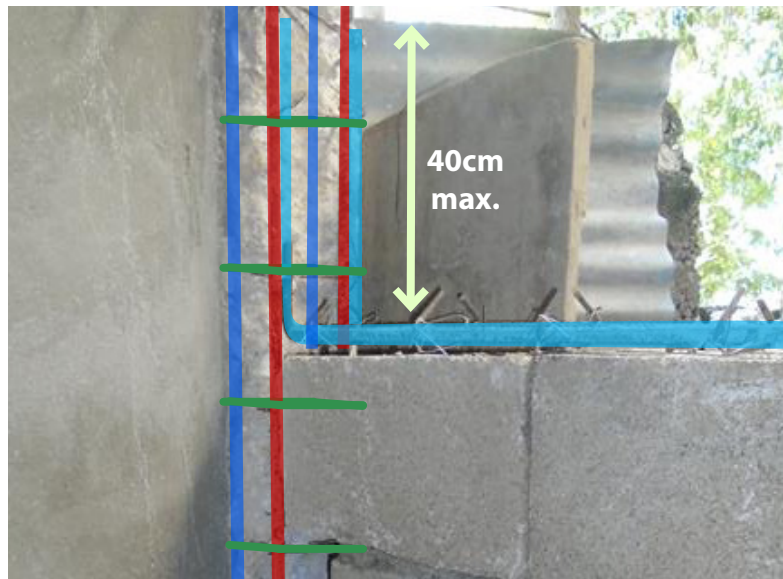
1 – Build the wall up to the level of the existing intermediate ring beam, or up to 1m20 if there is not an intermediate ring beam in the adjacent existing wall. Refer to the Retrofit Practical Handbook<sup>1</sup> page 16 “Wall Construction” for more details.



2 – Place the new ring beam with minimum (2) #3 and #2 ties at 20cm. Refer to CNBH article 1.8.3.11 “Bande parasismiques”.

## 6.3 - CONTINUING AN EXISTING STRUCTURE

## Connecting walls to the intermediate ring beam



**3** – Connect the intermediate ring beam with the adjacent existing columns. Lap the rebar inside the column reinforcing for 40cm minimum.



**4** – Place the concrete spacers, and pour the concrete following the new construction guidelines. The connections with the column can be poured with the concrete for the column.



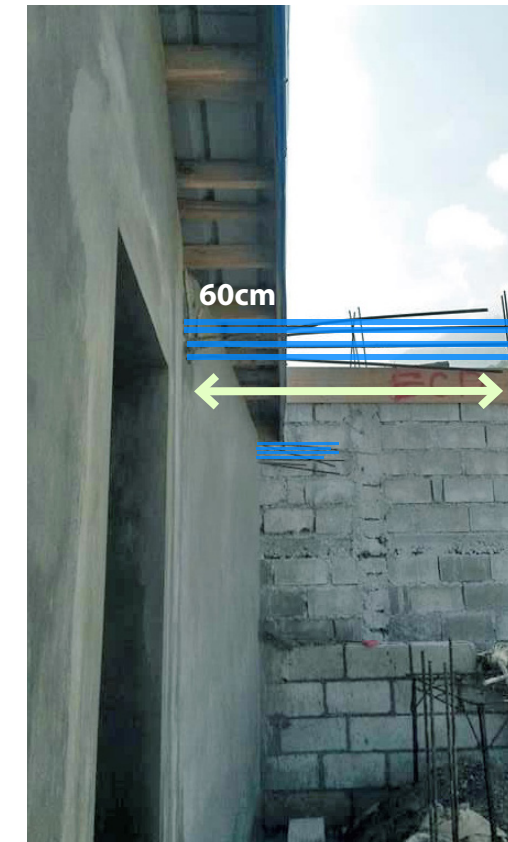
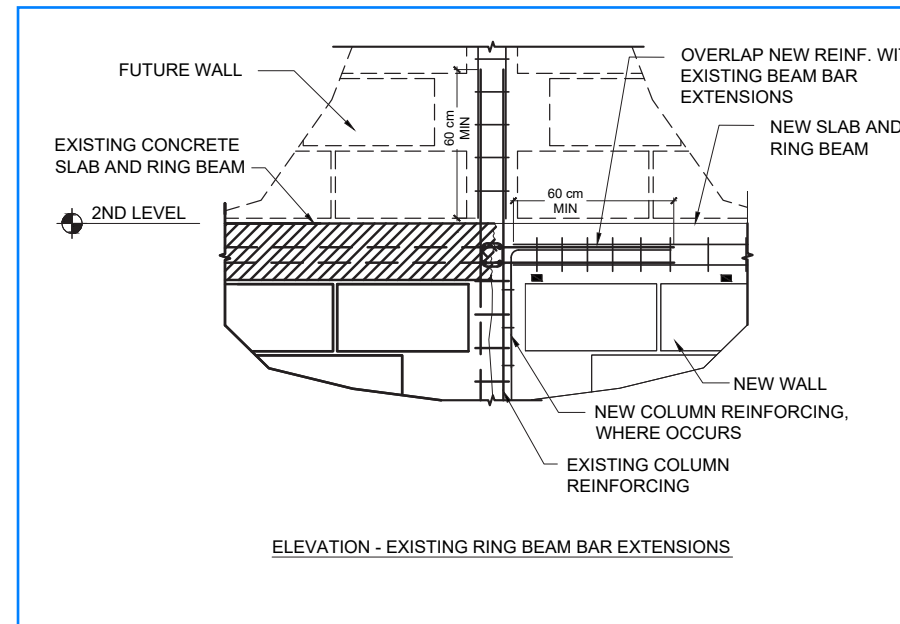
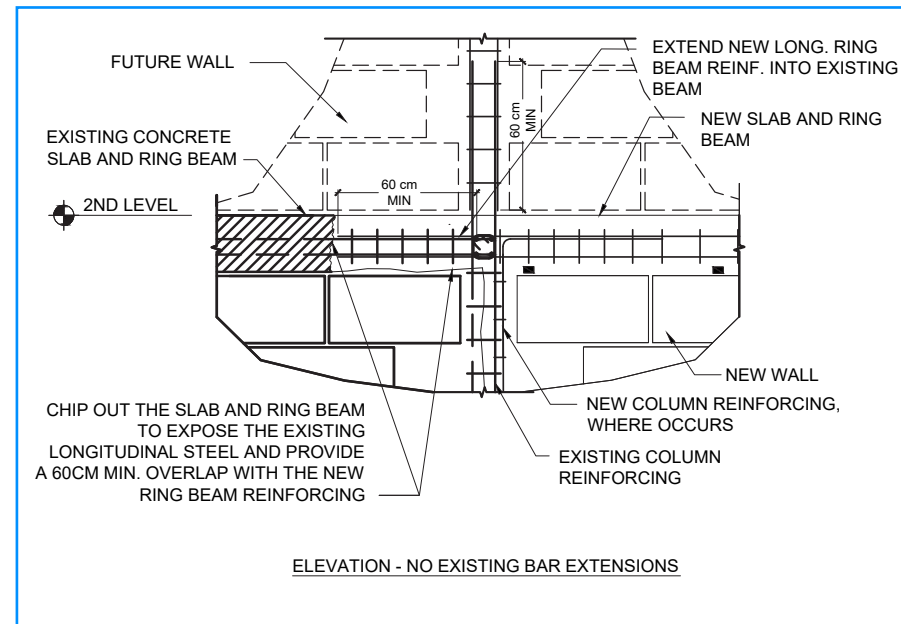
**5** – Continue building the wall up to the superior ring beam. Refer to the Retrofit Practical Handbook<sup>1</sup> page 16 “Wall Construction” for more details.



**6** – Place the concrete spacers and pour the concrete column. It can be poured in two stages, from the base to the intermediate ring beam and then from the intermediate ring beam to the top of the wall.

6.3 - CONTINUING AN EXISTING STRUCTURE

Connecting superior ring beams



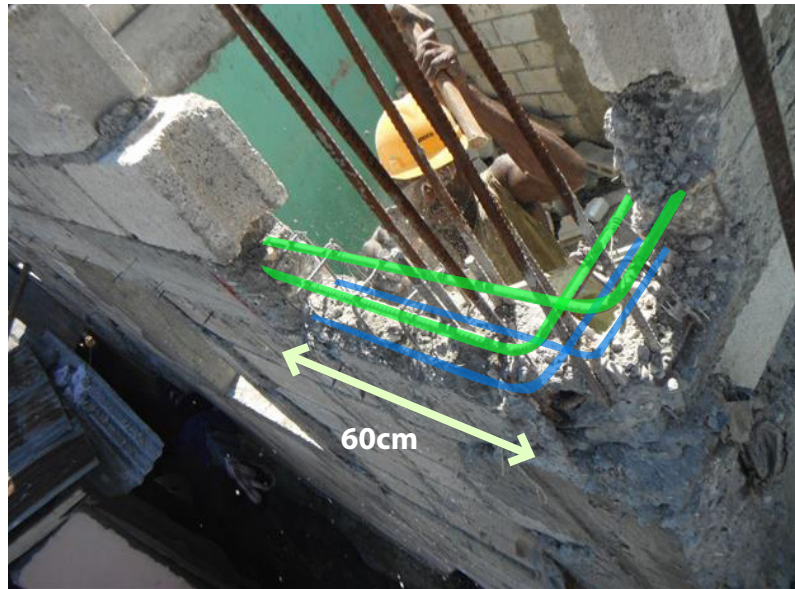
1 – Identify the condition and locations of the existing superior ring beam rebar extensions.



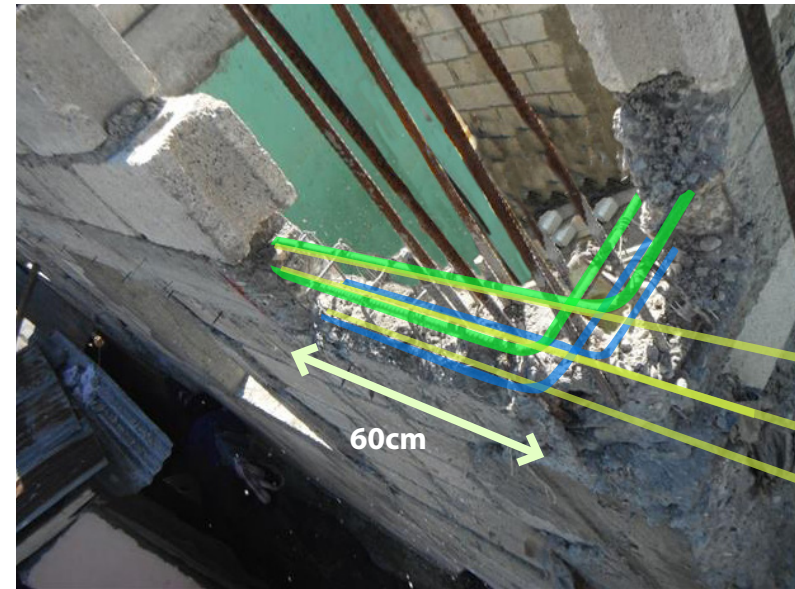
2 – Extensions that are significantly bent or corroded or are less than 60cm long should not be used to connect the expansion to the existing building below and will need to be replaced.

## 6.3 - CONTINUING AN EXISTING STRUCTURE

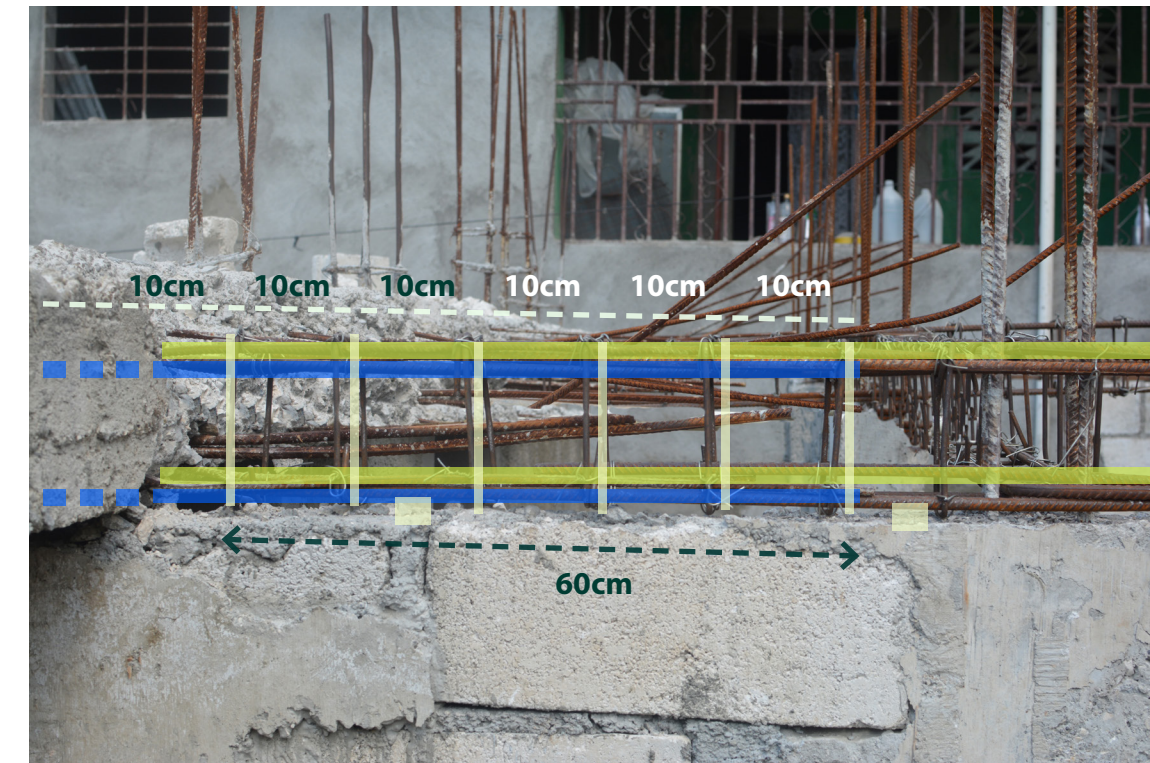
## Connecting superior ring beams



**3** – Where the existing ring beam extensions are insufficient (less than 60cm), or inadequate (significantly bent or corroded), chip out the existing concrete from existing ring beam for 60cm. Be careful to maintain and do not damage the existing ring beam or slab reinforcing. Remove the concrete until at least 60cm of the existing superior ring beam rebar is exposed.



**4** – Insert the horizontal reinforcing for the new ring beam into the existing ring beam so that new horizontal rebars (4 #4 minimum) lap a minimum of 60cm with the existing ring beam rebars and so that the new bars fall inside the existing ring beam ties.



**5** – The ties of the new ring beam rebar shall be placed at a closer spacing where the horizontal bars overlap (10cm maximum for 60cm).



## 6.3 - CONTINUING AN EXISTING STRUCTURE

### Connecting superior ring beams



6 – Once the superior ring beam is well connected, use one of the following details, depending on if it is a slab extension, a lightweight roof expansion, or a mixed roof to complete the roof of the new expansion.

## 6.4 - CONNECTING ROOFS

Once the new superior ring beam is connected to the existing structure, the next step is the connection of the roofing

- \* How to extend a slab (with the slab beams either perpendicular or parallel to the edge of the existing slab)
- \* How to extend a lightweight roof
- \* How to connect a lightweight roof with a slab or second story wall.



Lightweight roof with a second story wall

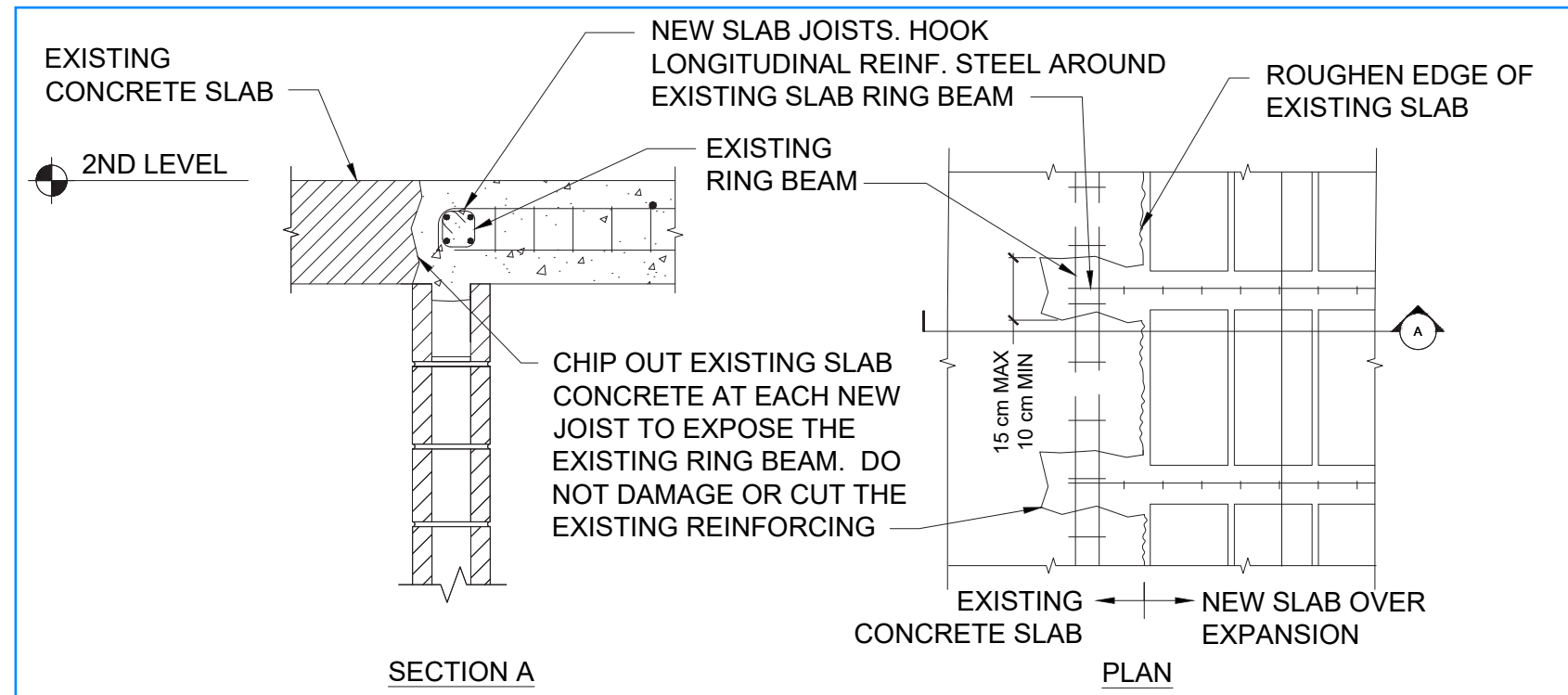


Slab extension

When the existing building has a concrete slab roof or floor and the horizontal expansion adjacent to it will also have a concrete slab roof or floor, the new slab should be well-connected to the existing slab. This will ensure the existing part of the house and the new part of the house will act together to resist the earthquake load.

Depending of the size and layout of the horizontal expansion, the engineer has to determinate the direction of the slab beams. It is a good practice for the slab beams to span on the shorter length. If it is necessary, the engineer can choose a two ways slab.

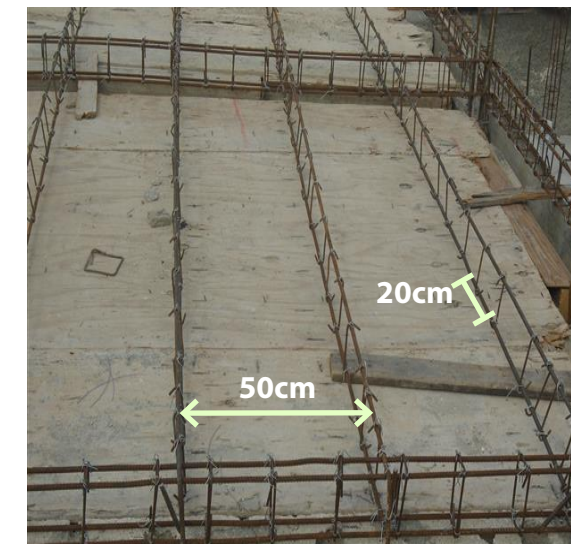
6.4 - CONNECTING ROOFS



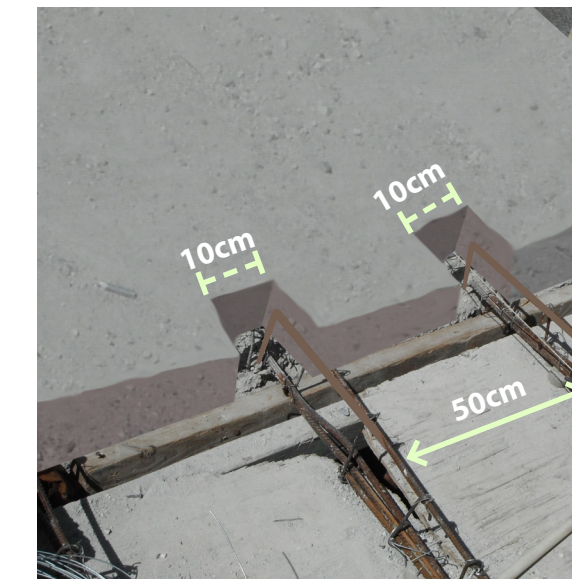
If the new slab beams are perpendicular to the existing ring beam edge of existing slab, it is necessary to chip out the concrete of the existing ring beam to anchor each slab beam into the existing ring beam and slab. The superior reinforcing bars are anchored in the new ring beam created.

Expanding a slab

New slab beams perpendicular to an existing slab edge



1 – Place the slab formwork and slab beam reinforcing. Refer to the “Construction of a New Slab” chapter above, page 60.

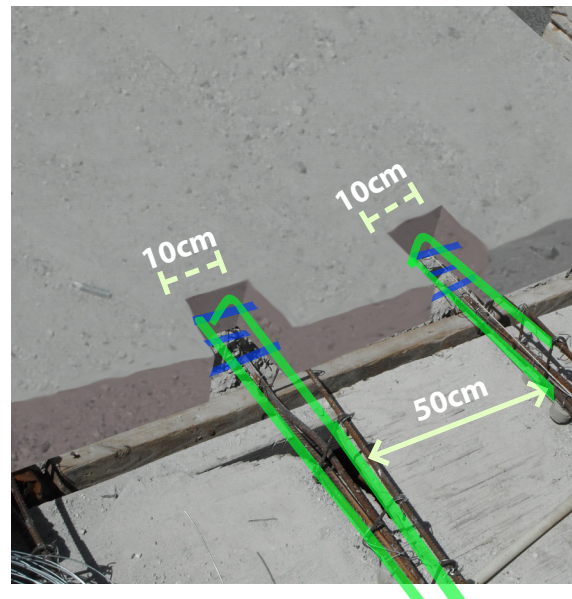


2 – Where the slab beam reinforcing connects to the existing edge of slab, chip out the concrete at each slab beam location, so that the new slab beam reinforcing can hook into the existing slab ring beam. Be careful to maintain, and do not damage, for a 10cm width at each slab beam and chip out to width of the existing ring beam.

6.4 - CONNECTING ROOFS

Expanding a slab

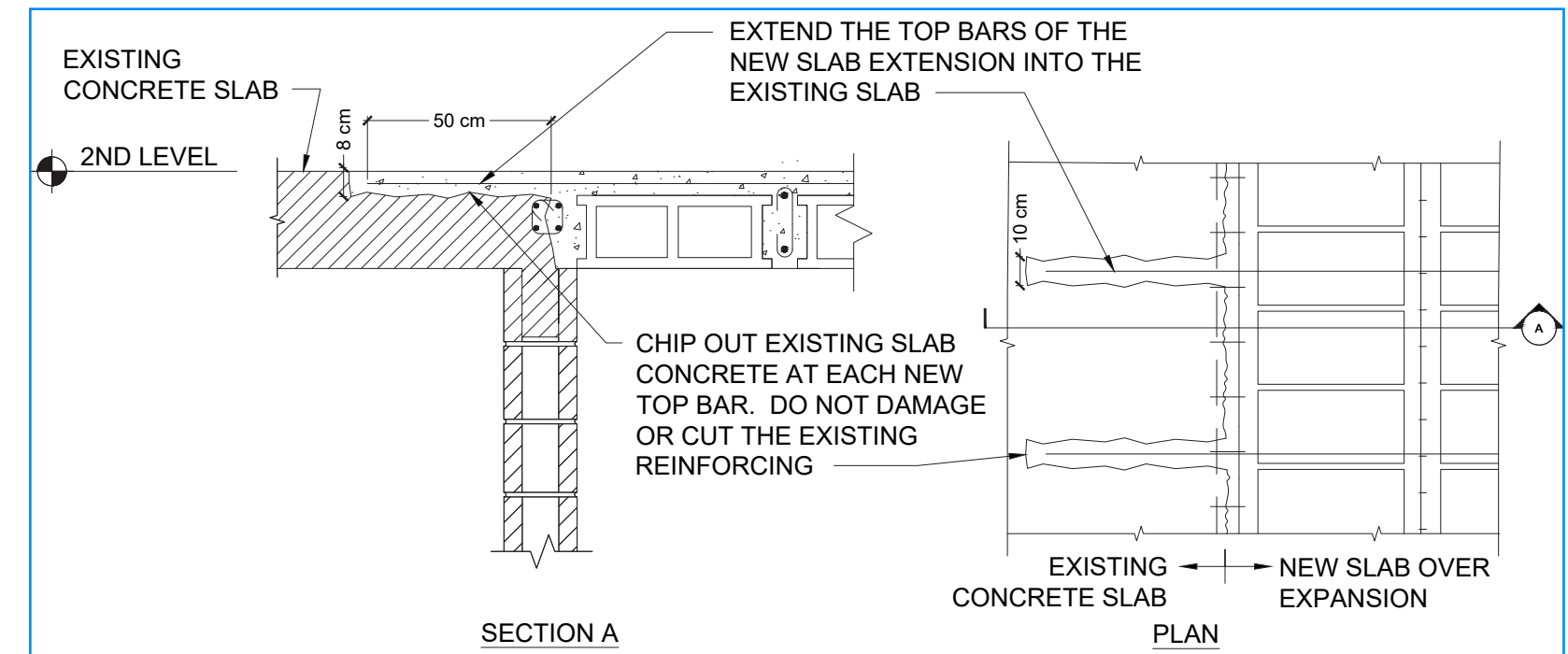
New slab beams perpendicular to an existing slab edge



3 – Hook the new slab beam reinforcing in to the ring beam, with the top bar hooking around the top of ring beam and the bottom bar extending into the ring beam and above the existing bottom reinforcing.



4 – Once the slab beams are well anchored to the existing ring beam, refer to the “Construction of a New Slab” chapter above pages 60-65, for finishing the construction of the new slab over the expansion.



If the slab beams are parallel to the existing ring beam, they will be anchored to the new ring beam created. Just the superior reinforcing bars have to be anchored to the existing slab

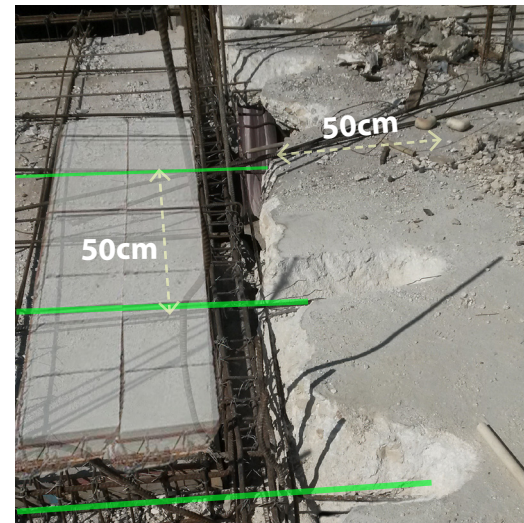
## 6.4 - CONNECTING ROOFS

### Expanding a slab

#### New slab beams parallel to an existing slab edge



**1** – Place the slab formwork and slab beam reinforcing. Refer to the previous step by step “Construction of a New Slab” page 60. Place the blocks and top reinforcing bars.



**2** – Where the top reinforcing connects to the existing edge of slab, chip out the concrete of the existing slab in order to place the superior rebars every 50cm. Remove the concrete on 5cm and extend the space 50cm into the existing slab. Be careful to maintain and do not damage the existing slab reinforcing



**3** – Once the top reinforcing bars are well anchored to the existing slab, refer to the “Construction of a New Slab” chapter above pages 60-65, for finishing the construction of the new slab over the expansion.

## 6.4 - CONNECTING ROOFS

## Connecting lightweight roofs



If the slope of the lightweight roof expansion is the opposite direction than the existing lightweight roof, it is necessary to add a ridge to make the connection .



**1** – Remove the existing metal sheets from the roof adjacent to the expansion.



**2** – Remove the perimetral latte, and cut the existing rafter up to the wall in common.

## 6.4 - CONNECTING ROOFS

## Connecting lightweight roofs



**3** – Put the new rafter adjacent to the old rafters, and link them together with the existing metallic strap embedded in the existing ring beam



**4** – If the existing straps are too short, chip out the concrete of the existing ring beam concrete up to the reinforced rebar and install a new strap.



**5** – Continue to install the roof over the expansion and replace the removed sheets from the existing roof. Refer to Retrofit Practical Handbook<sup>1</sup> page 56 “Lightweight Roof Reconstruction”.

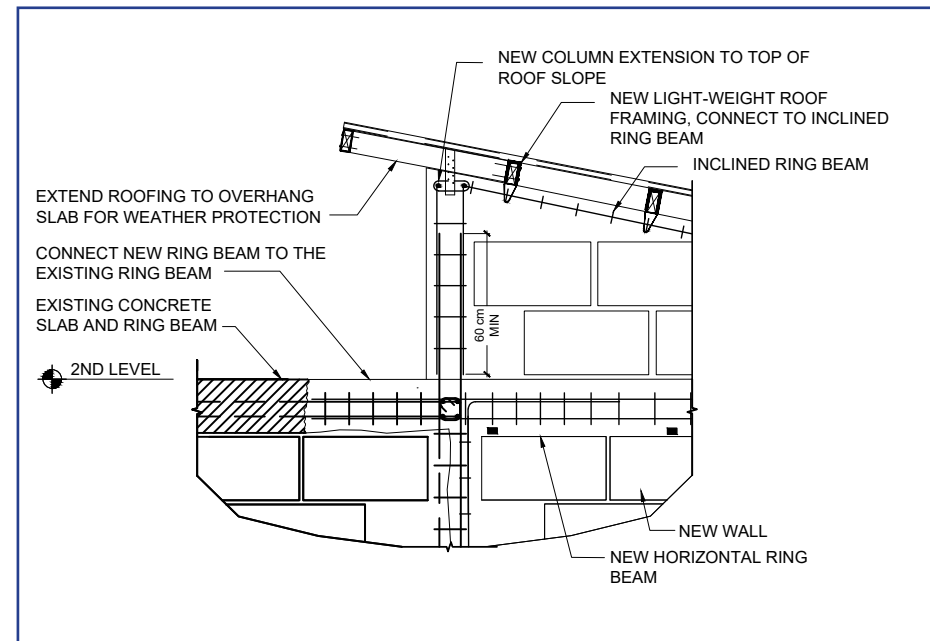


**6** – Place a metal ridge and fix it on both parts of the roof .

6.4 - CONNECTING ROOFS

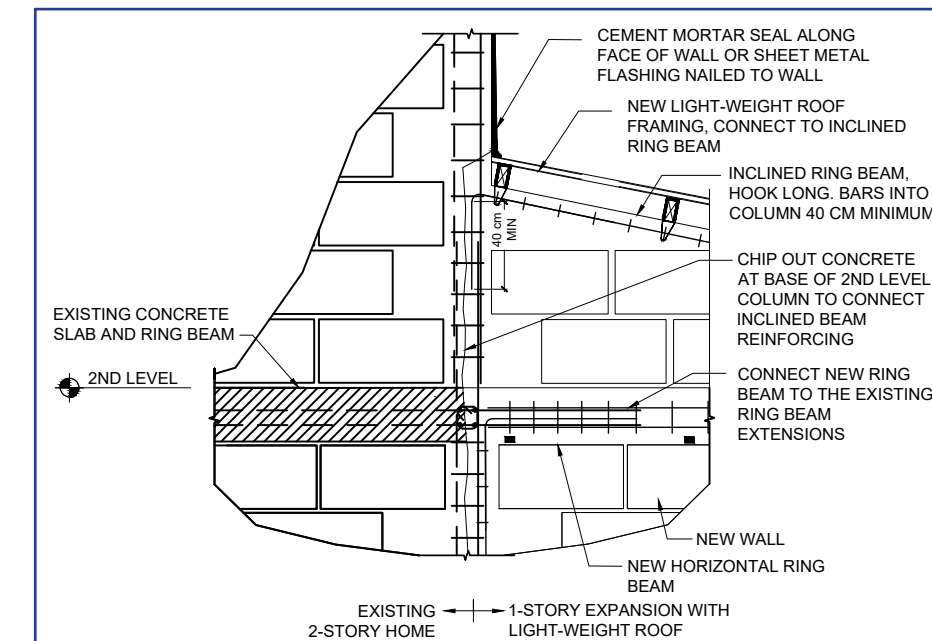
Connecting a lightweight roof to an existing slab

If a single story house is being expanded, and the expansion and the existing house have different roof types, only the superior ring beam between the two requires connection. Refer on section "Construction of a New Slab using an Existing Ring Beam" pages 66-68 of this handbook for more information on connecting the superior ring beam.



Connection of a New Lightweight Roof to an Existing Slab Roof

Connecting a one-story lightweight roof to a two-story house



Connection of a New Lightweight Roof to an Existing Slab Roof

When an existing two story building will have a one-story horizontal expansion, and that expansion has a lightweight roof, the inclined ring beam of the new lightweight roof should be connected to the adjacent existing column. Where the peak of the new sloped roof meets the existing building wall, a treatment for waterproofing has to be done to avoid future damage, such as using a plaster cover. This is a weak point of the waterproofing so it should be checked every year after construction.

6.4 - CONNECTING ROOFS

Connecting a new light weight roof to an existing two-story house



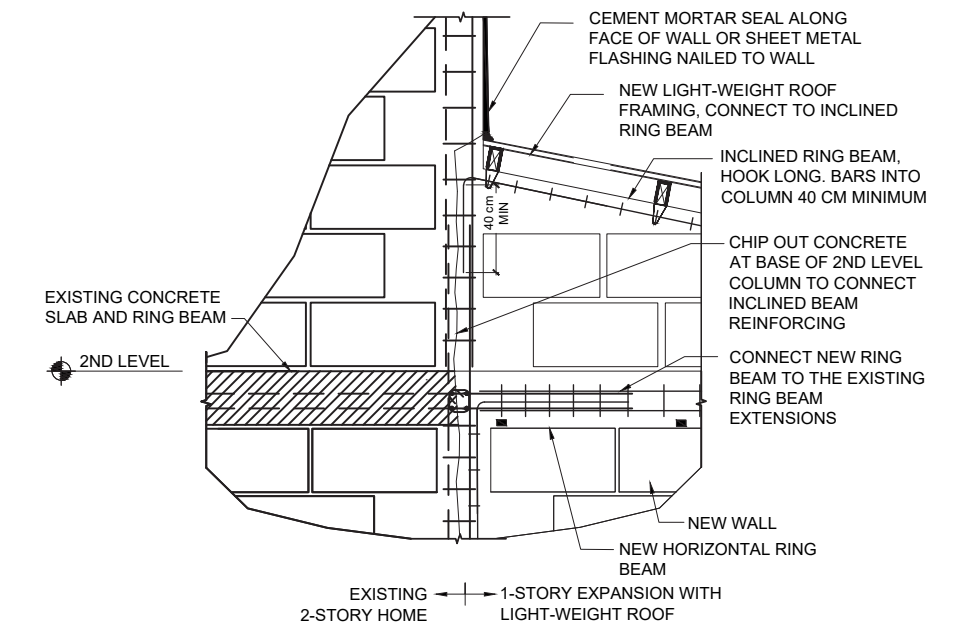
**1** – While preparing the column to connect to the new wall, continue to chip out the concrete of the existing column above the ground floor level to expose the two exterior reinforced bars of the column, up to the level where the inclined ring beam of the new lightweight roof will meet the existing column. Be careful to maintain and do not damage the existing reinforcing in the column. Remove the concrete to expose the 2 rebars of the column, leaving 2.5cm gap behind.



**2** – After connecting the superior ring beam (refer to the previous step by step) Place the form-work, concrete spacers and then pour the superior ring beam .



**3** – Place the blocks between the superior ring beam and the inclined ring beam . Refer to the Retrofit Practical Handbook<sup>1</sup> page 53 “Add a Superior Ring Beam to a Lightweight Roof House”.



**4** – Place the inclined ring beam with two #3 rebar and ties. Place the metallic straps (Refer to the Retrofit Practical Handbook<sup>1</sup> page 53 « Ring Beam Addition to a House with a Lightweight Roof) for the roof framing connection. Connect to the existing column by passing the longitudinal rebars of the inclined ring beam inside the column, and overlap for 40cm minimum.



## 6.4 - CONNECTING ROOFS

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Refer to the  
**RETROFIT PRACTICAL HANDBOOK**<sup>1</sup> "Lightweight Roof Reconstruction".  
p53



**5** – Once the intermediate ring beam is connected, continue the roofing. Refer to the Retrofit Practical Handbook<sup>1</sup> page 56 "Lightweight Roof Reconstruction".

**6** – Once the roof is finished, fill the joint along the top of the lightweight roof where it meets the adjacent wall with a plaster cover from the wall to the sheet.

## 7 ANNEX: CONSTRUCTION QUALITY CHECKLISTS









