

FOR
LOCAL
OFFICIALS/
STAFF



TECHNICAL HANDBOOK ON **Design, Construction and Renovation of Typhoon-Resilient Low-Income Housing**

Typhoon-resilient houses can have different forms depending on the characteristics of the land and socio-economic conditions of each household. The principles for typhoon resilience recommended in this document, however, should be strictly followed in the housing design process.

Issued by the Da Nang Department of Foreign Affairs

Da Nang, 2017

ACKNOWLEDGMENTS

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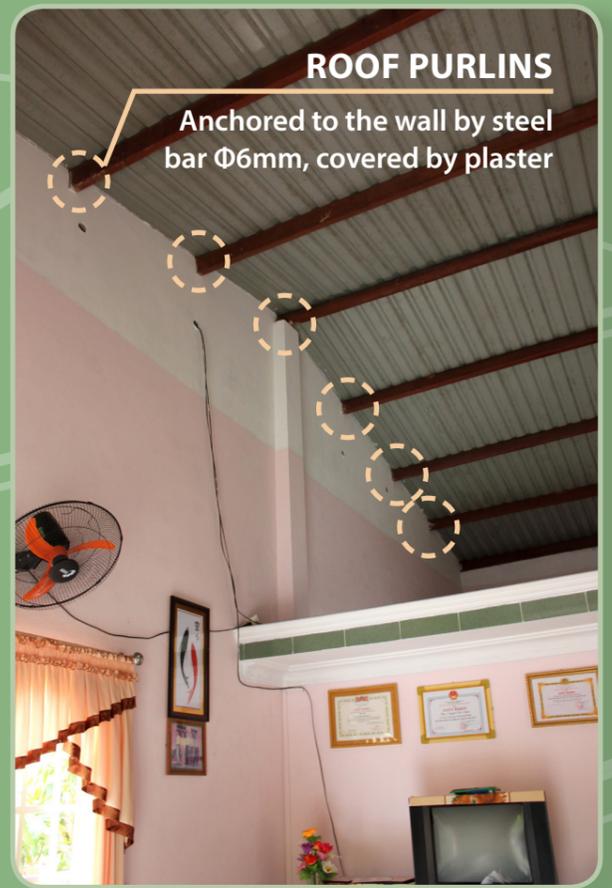
PRODUCED BY

Da Nang Department of Foreign Affairs (DoFA)
Da Nang Department of Construction (DoC)
Institute for Social and Environmental Transition (ISET)

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INTRODUCTION

Located along the coast, Da Nang is vulnerable to climate-related hazards such as typhoons and floods. It is often affected by typhoons that cause extensive damage to housing, especially those of the poor, near-poor, and low-income population. Such damage has been witnessed repeatedly in the recent past during typhoon Xangsane (2006), Ketsana (2009) and Nari (2013). For the poor, near-poor and low-income population of Da Nang, a house is often the single largest asset and, in many cases, provides space for home-based livelihoods, including storage space for stocks and tools. Housing damage caused by disasters results in loss of life and affects the livelihoods of the population, especially the most vulnerable segment.

Damage to the houses of these vulnerable groups can be significantly reduced by factoring typhoon-resilient considerations into the design, construction, and renovation. Such considerations can be simple, cost-effective and easily implemented based on available capacity and resources.

Moreover, recognizing the limited engagement of building professionals—engineers and architects—in the design and construction of low-income housing, to strengthen typhoon-resilience should be the responsibility of all stakeholders, especially household residents, local builders, and local officials.

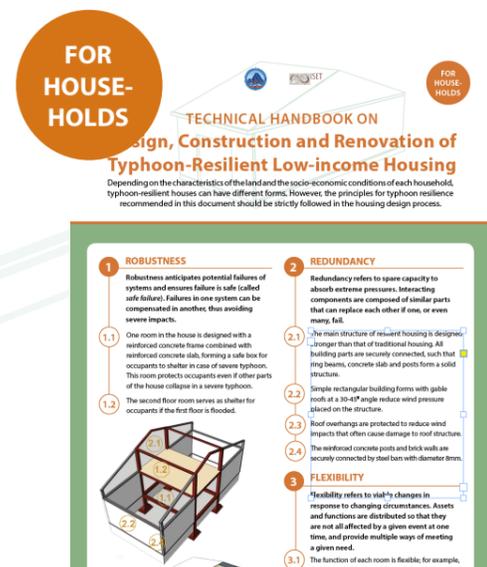
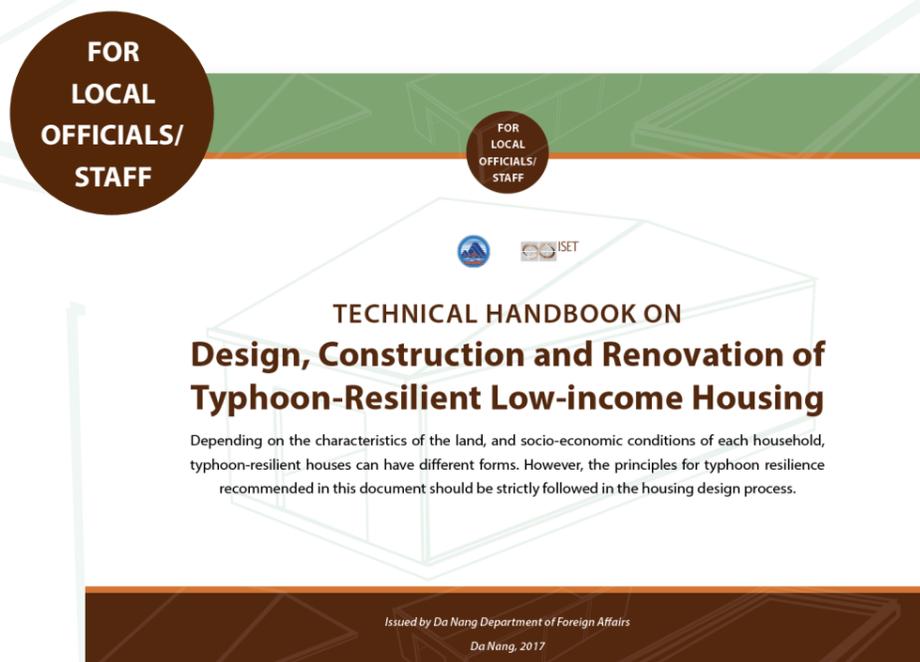
Under Decision 48/2014/QĐ-TTg, the Department of Construction (DoC) has identified four technical standards to be met: (i) the house floor level should be higher than the biggest flood in the past, (ii) the minimum floor area should be at least 10 square meters (m²), (iii) the house structure should be solid, and (iv) the roof should be strong enough for wind resistance. These standards are respected by this document and demonstrated through the proposed construction measures.

This handbook is intended for local officials and staff, and provides guidance for incorporating typhoon-resilient features in the low-income housing development process. The two accompanying handbooks, with the same title provide guidance for local builders and low-income households.

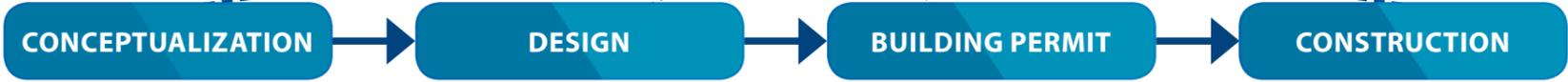
In recognition of the role local officials and staff play in low-income housing design and their limited technical capacity, an attempt has been made to present guidance in a simple manner and focus on practical steps in identifying design options to strengthen typhoon-resilient housing.

THE HANDBOOK SERIES

This series include three handbooks for three different groups:



URBAN HOUSING



HOUSE-HOLDS	NEWLY BUILT HOUSE <ul style="list-style-type: none"> Identify the number and type of rooms required (e.g. living room, bedroom, kitchen, toilet) 	NEWLY BUILT HOUSE <ul style="list-style-type: none"> Prepare the site plan Identify the form of the house Identify the functional layout of the house 	<ul style="list-style-type: none"> Prepare the documents requested by local officials 	<ul style="list-style-type: none"> Check the work of builders against the newly built or renovated house design
	RENOVATED HOUSE <ul style="list-style-type: none"> Identify the building part(s) for renovation 	RENOVATED HOUSE <ul style="list-style-type: none"> Identify the function of the renovated part(s) 		
LOCAL BUILDERS		<ul style="list-style-type: none"> Select methods of construction Estimate construction cost and time 		<ul style="list-style-type: none"> Construct the house according to design and safety-related specifications
LOCAL OFFICIALS		<ul style="list-style-type: none"> Make building drawings for the household 	<ul style="list-style-type: none"> Guide households to prepare documents for building permit application 	

RURAL HOUSING



HOUSE-HOLDS	NEWLY BUILT HOUSE <ul style="list-style-type: none"> Identify the number and type of rooms required (e.g. living room, bedroom, kitchen, toilet) 	NEWLY BUILT HOUSE <ul style="list-style-type: none"> Prepare the site plan Identify the form of the house Identify the functional layout of the house 	<ul style="list-style-type: none"> Check the work of builders against the newly built or renovated house design
	RENOVATED HOUSE <ul style="list-style-type: none"> Identify the building part(s) for renovation 	RENOVATED HOUSE <ul style="list-style-type: none"> Identify the function of the renovated part(s) 	
LOCAL BUILDERS		<ul style="list-style-type: none"> Select methods of construction Estimate construction cost and time 	<ul style="list-style-type: none"> Construct the house according to design and safety-related specifications
LOCAL OFFICIALS		<ul style="list-style-type: none"> Make building drawings for the household 	

HOW TO USE THE HANDBOOK

This handbook introduces a series of steps typically followed in the housing design and construction process, and provides guidance on how local officials can support low-income households to incorporate typhoon-resilient features in design and implementation, even in the absence of professional support from engineers and architects.

In using the guidance provided here, local officials are expected to discuss with the respective households the options provided for each step, and support them in

coming up with the most viable solutions by ticking the appropriate boxes accompanying the 3D drawings.

The orange boxes are optional depending on the site location, needs, and financial capacity of the household. The blue boxes are obligatory and need to be ticked to ensure adherence to typhoon-resilient design principles

STEPS TO USE THE HANDBOOK

STEPS

1

Discuss with the household the three options on **house location** and support them in selecting the most appropriate one: Position A, B or C. (Page 13)

2

Discuss with the household the three options provided for the **location of the storm shelter inside the house** – front, middle and back. Support the household in selecting the appropriate option based on family needs. From the three options, select the most appropriate one. (Page 13)

3

Based on the selections in step 1 and 2, go to the corresponding page describing the **typhoon-resilient design features** with respect to the different positions of houses and location of the storm shelter in the house. (Pages 14-26)

Explain to the household the typhoon-resilient design features provided for each option and support them in selecting the appropriate **blue** and **yellow** boxes.

4

Support the household in determining the **size, shape and layout of the house** in response to the family's need and capacity. (Page 29-35)

5

Discuss with the households the **key design principles of the storm shelter** and support them in making decisions. (Page 17-25)

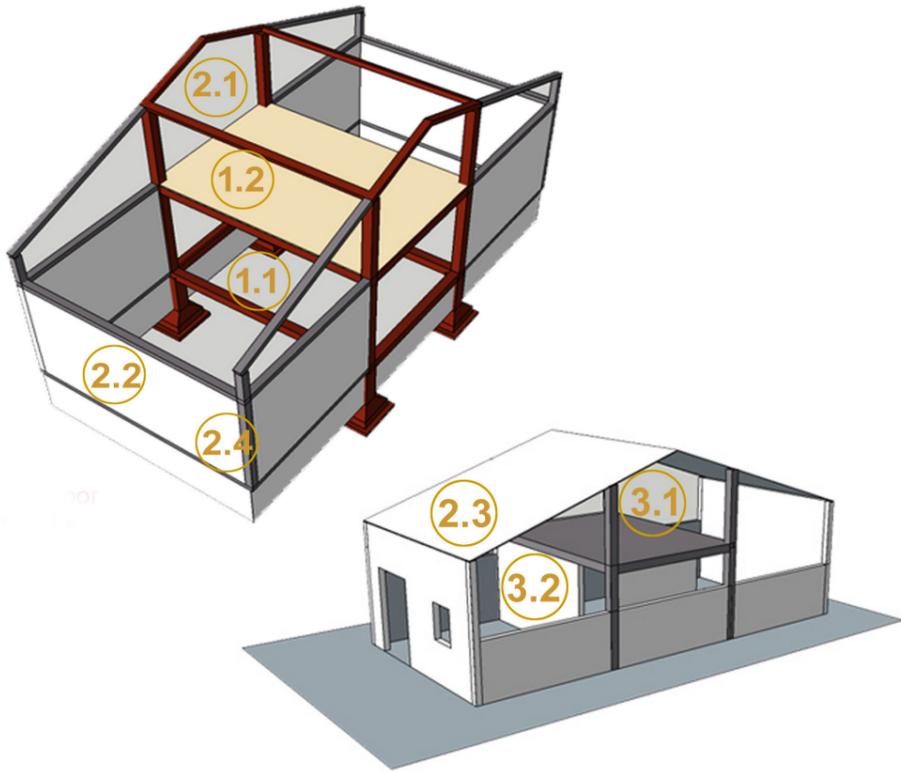
6

Discuss with the household the **principles to be followed for resilient construction** for the 3 main parts of the house – foundation, wall and roof (Page 26-28) and capture the general principles in the construction of the three main parts of the house: foundation, wall, and roof.

1 ROBUSTNESS

Robustness anticipates the potential breakdown of systems and ensures failure is safe (called *safe failure*). Failures in one system can be compensated in another, thus avoiding severe impacts.

- 1.1 One room in the house is designed with a reinforced concrete (RC) frame combined with an RC slab to form a safe box where occupants can find refuge in case of a severe typhoon. This room protects occupants even if other parts of the house collapse.
- 1.2 The room on the second floor serves as shelter for occupants if the first floor is flooded.



2 REDUNDANCY

Redundancy refers to the spare capacity to absorb extreme pressures. Interacting components are composed of similar parts that can replace each other if one or many fail.

- 2.1 The main structure of resilient housing is designed to be stronger than that of traditional housing. All building parts are securely connected such that ring beams, concrete slabs and posts form a solid structure.
- 2.2 Simple rectangular building forms with gable roofs at a 30-45° angle reduce wind pressure placed on the structure.
- 2.3 Roof overhangs are protected to reduce wind impacts that damage the roof's structure.
- 2.4 The reinforced concrete posts and brick walls are securely connected by steel bars with a diameter of 8 millimeters (mm).

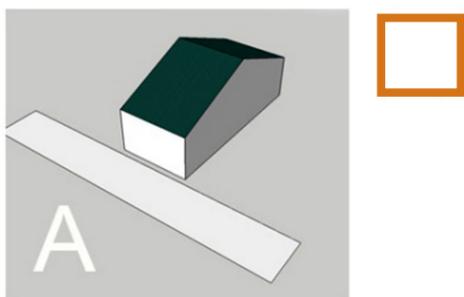
3 FLEXIBILITY

Flexibility refers to viable changes in response to varying circumstances. Assets and functions are distributed so they are not all affected by a given event at once, and provide multiple ways of meeting a need.

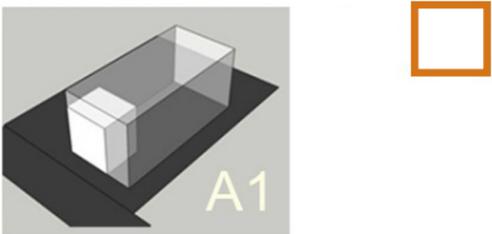
- 3.1 The function of each room is flexible. For example, the room on the second floor of the safe box can be used as a flood shelter, bedroom, study room, altar or storage.
- 3.2 All materials used for housing construction are locally available and technical designs are simple to apply.

POSITION A:

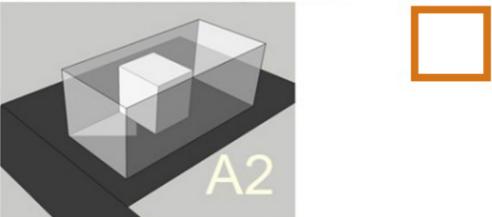
THERE IS NO HOUSE NEXT DOOR



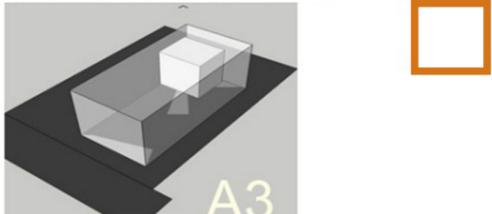
STORM SHELTER in front of the house



STORM SHELTER in the middle of the house

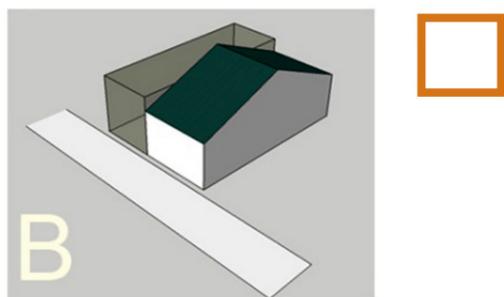


STORM SHELTER at the back of the house

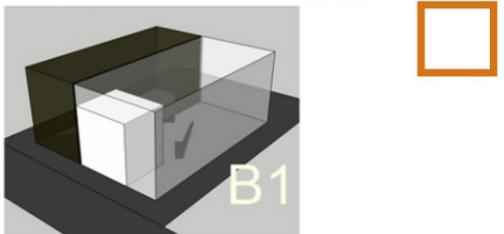


POSITION B:

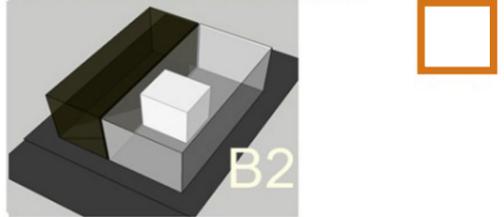
THERE IS ONE HOUSE NEXT DOOR



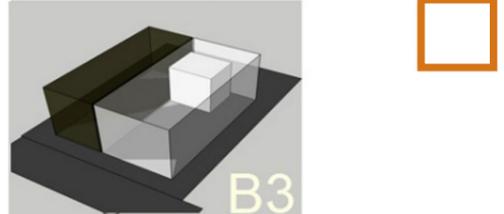
STORM SHELTER in front of the house



STORM SHELTER in the middle of the house

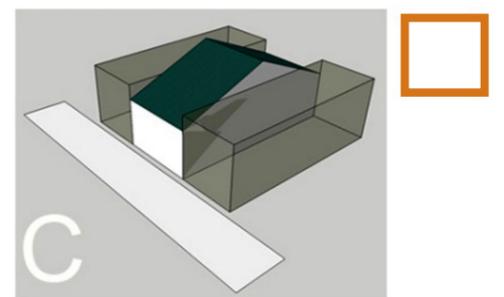


STORM SHELTER at the back of the house

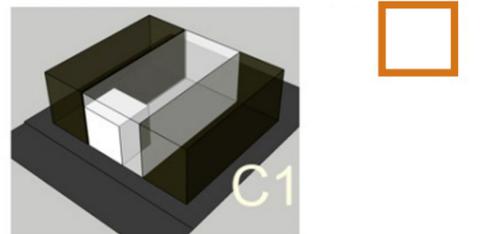


POSITION C:

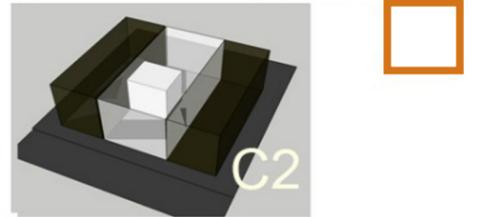
THERE ARE TWO HOUSES NEXT DOOR



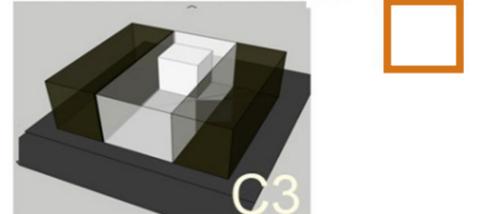
STORM SHELTER in front of the house

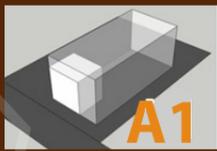


STORM SHELTER in the middle of the house



STORM SHELTER at the back of the house





POSITION A1

There are no built structures on either side of the house. STORM SHELTER will be located in front portion of the house



POSITION B1

There are built structures on one side of the house. STORM SHELTER will be located in front portion of the house

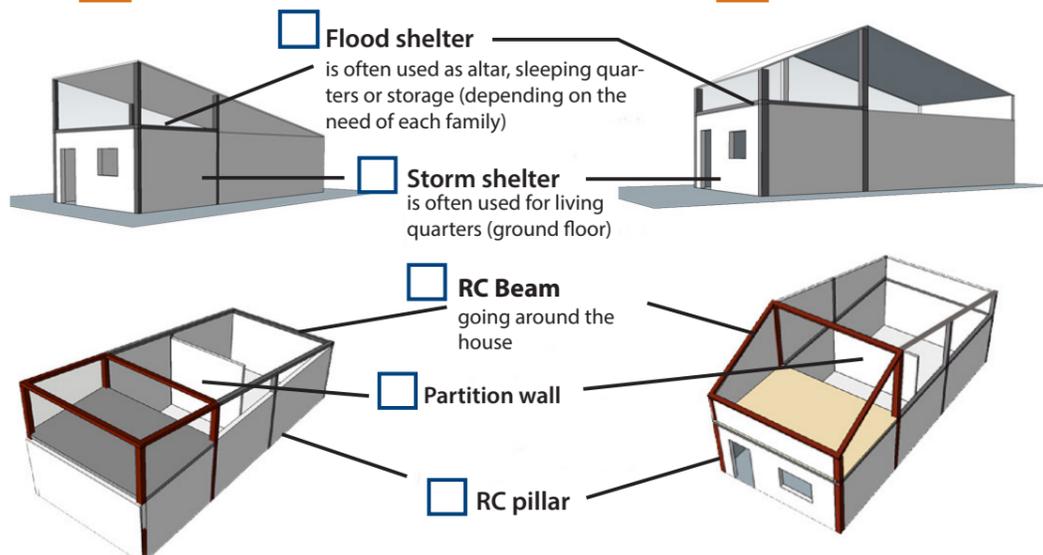


POSITION C1

There are built structures on both sides of the house. STORM SHELTER will be located in front portion of the house

1 SLOPING ROOF

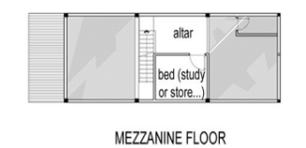
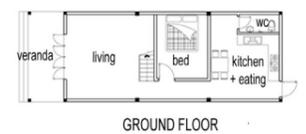
2 SLOPING ROOFS



NOTES

- The cover (envelop) wall should be at least 15 cm thick, and have continuous RC beams at the foundation and wall's top levels going around the house.
- The house should have RC pillars on all corners and along the long gable walls. The distance between two in-wall pillars should not exceed 3 m.
- Roof frames should be strongly connected with walls. Avoid roof extension beyond the wall (if any, the extended part should be shorter than 10 cm and be protected). Veranda roof should be separate and detached from the main house roof.
- Doors and windows should close tightly by bolting or binding.
 - Doors and windows on the uncovered gable wall(s), such as in the case of A1 and B1, should have smaller sizes, and glass panels (if any) should be minimum and reinforced by door/window frames.

CONSTRUCTION COST ESTIMATION: **2.2-2.5 million VND/m²** for houses with a floor area of 50-100m² (This estimation is only an average and may be higher or lower depending on the location and physical conditions of each house)



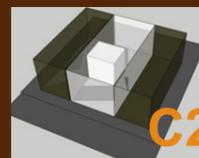
POSITION A2

There are no built structures on either side of the house. STORM SHELTER will be located in the middle portion of the house



POSITION B2

There are built structures on one side of the house. STORM SHELTER will be located in the middle portion of the house



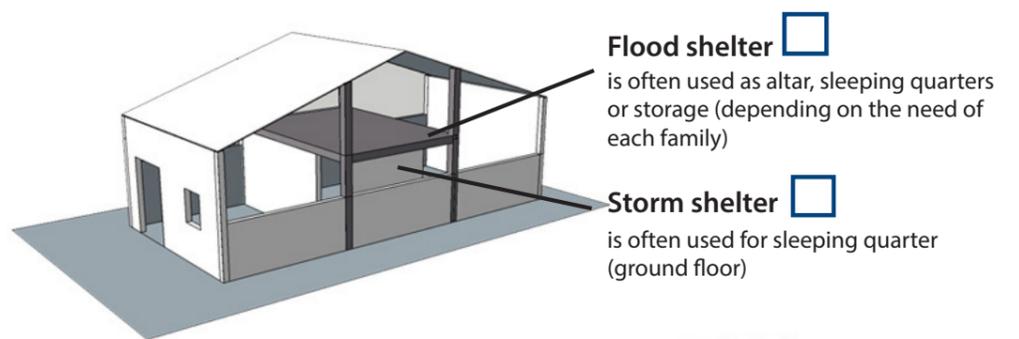
POSITION C2

There are built structures on both sides of the house. STORM SHELTER will be located in the middle portion of the house

NOTES

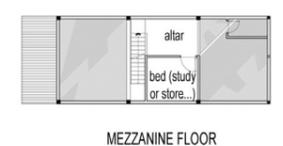
- The cover (envelop) wall should be at least 15 cm thick, and have continuous RC beams at the foundation and wall's top levels going around the house.
- The house should have RC pillars on all corners and along the long gable walls. The distance between two in-wall pillars should not exceed 3 m.
- Roof frames should be strongly connected with walls. Avoid roof extension beyond the wall (if any, the extended part should be shorter than 10 cm and be protected). Veranda roof should be separate and detached from the main house roof.
- Doors and windows should close tightly by bolting or binding.
 - Doors and windows on the uncovered gable wall(s), such as in the case of A2 and B2, should have smaller sizes, and glass panels (if any) should be minimum and reinforced by door/window frames.

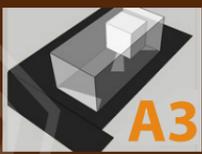
CONSTRUCTION COST ESTIMATION: **2.2-2.5 million VND/m²** for houses with a floor area of 50-100m² (This estimation is only an average and may be higher or lower depending on the location and physical conditions of each house)



RC pillar

RC beam going around the house





There are no built structures on either side of the house. STORM SHELTER will be at the rear portion of the house

POSITION A3



There are built structures on one side of the house. STORM SHELTER will be located at the rear portion of the house

POSITION B3

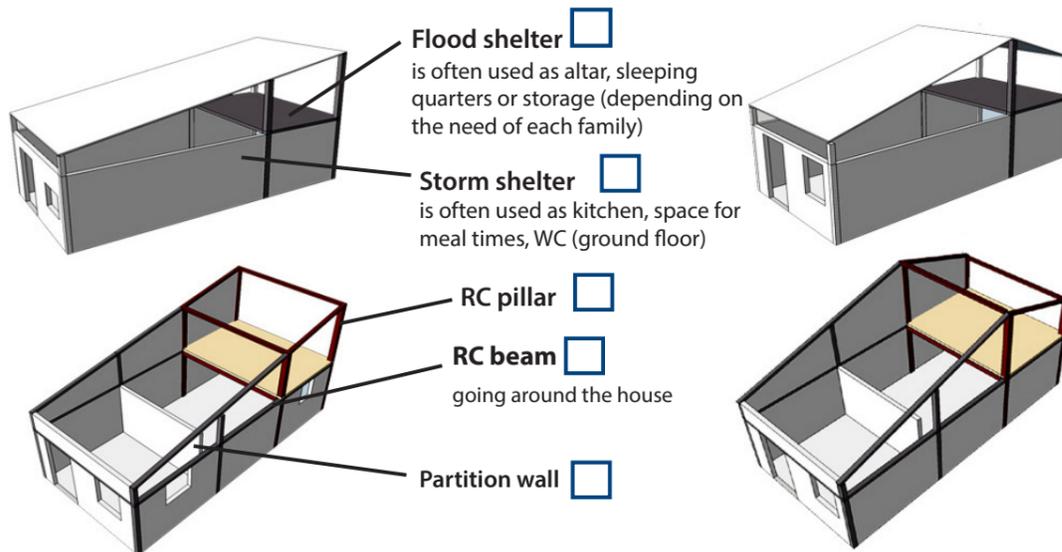


There are built structures on both sides of the house. STORM SHELTER will be located at the rear portion of the house

POSITION C3

1 SLOPING ROOF

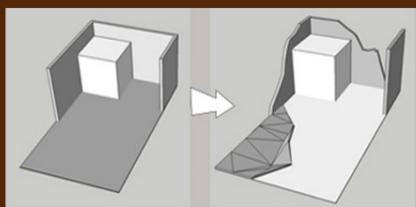
2 SLOPING ROOFS



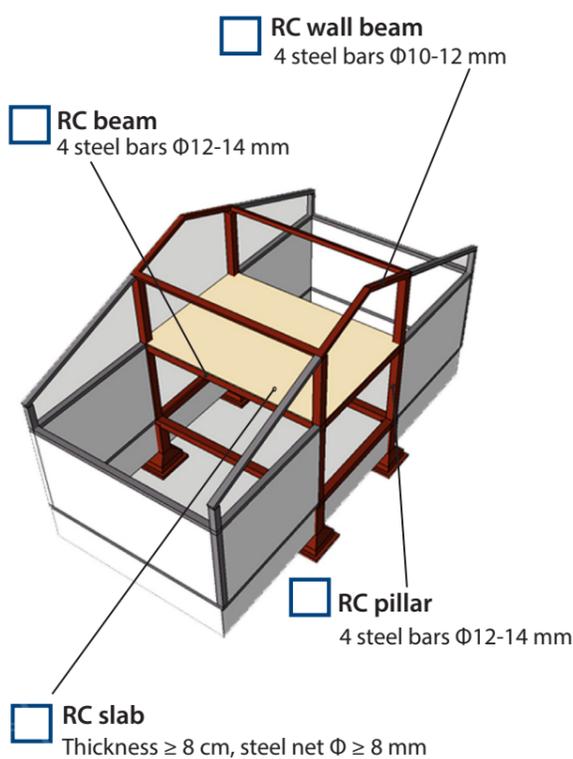
NOTES

- The cover (envelop) wall should be at least 15 cm thick, and have continuous RC beams at the foundation and wall's top levels going around the house.
- The house should have RC pillars on all corners and along the long gable walls. The distance between two in-wall pillars should not exceed 3 m.
- Roof frames should be strongly connected with walls. Avoid roof extension beyond the wall (if any, the extended part should be shorter than 10 cm and be protected). Veranda roof should be separate and detached from the main house roof.
- Doors and windows should close tightly by bolting or binding.
 - Doors and windows on the uncovered gable wall(s), such as in the case of A3 and B3, should have smaller sizes, and glass panels (if any) should be minimum and reinforced by door/window frames.

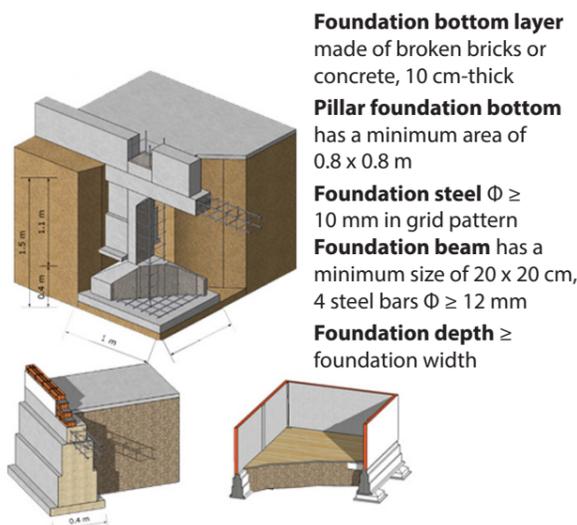
CONSTRUCTION COST ESTIMATION: **2.2-2.5 million VND/m²** for houses with a floor area of 50-100m² (This estimation is only an average and may be higher or lower depending on the location and physical conditions of each house)



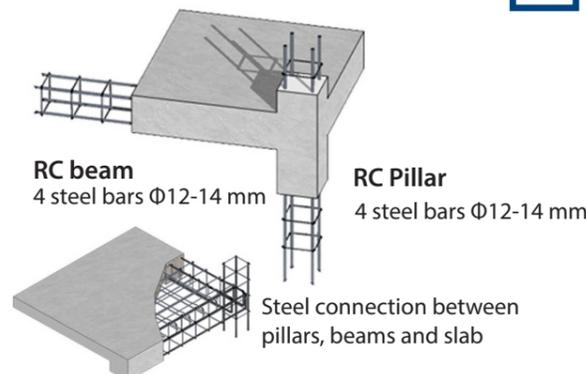
STORM SHELTER: a safe place for storm risk reduction with a foundation, pillars, beams and slabs made of RC



FOUNDATION ON THE GOOD-CONDITION GROUND

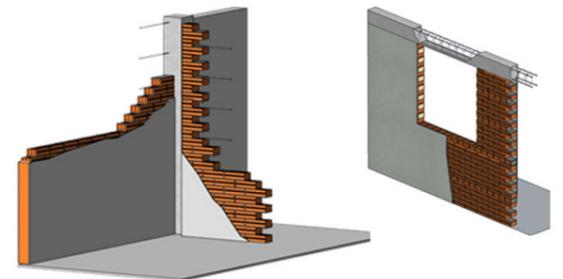


RC PILLAR & BEAM



WALL

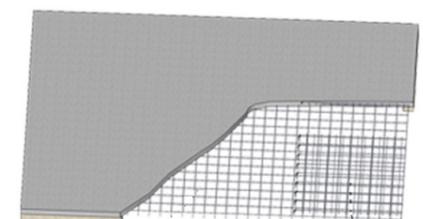
Steel wire Φ 6 mm to connect RC pillars with walls, distance between wires \leq 0.5 m



Six-hole brick wall with minimum thickness of 15cm for envelop walls (outside the house), 10cm thickness for partition walls (inside the house)

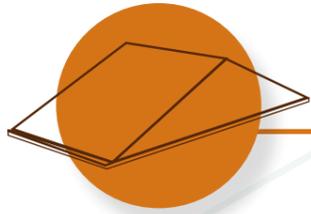
RC SLAB

RC Slab
Thickness \geq 8 cm, steel $\Phi \geq$ 8 mm, net spacing \leq 20 cm

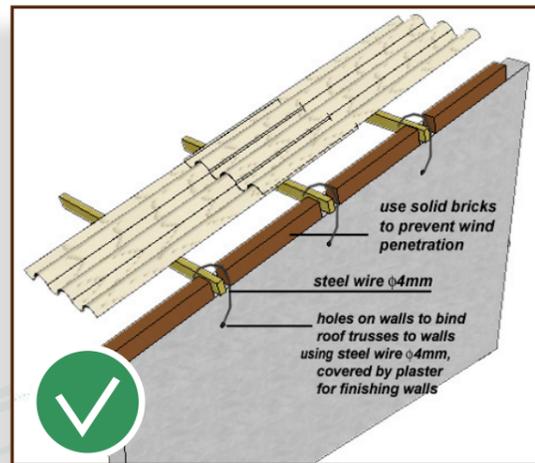
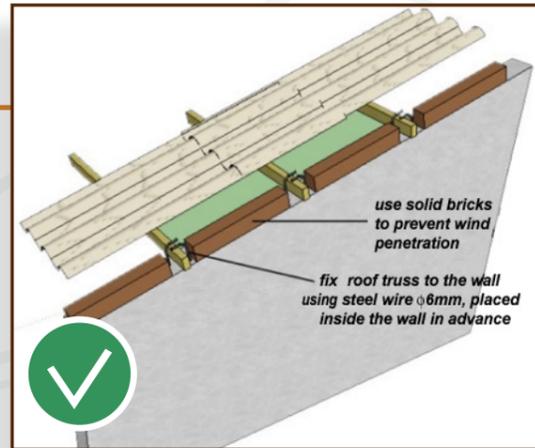
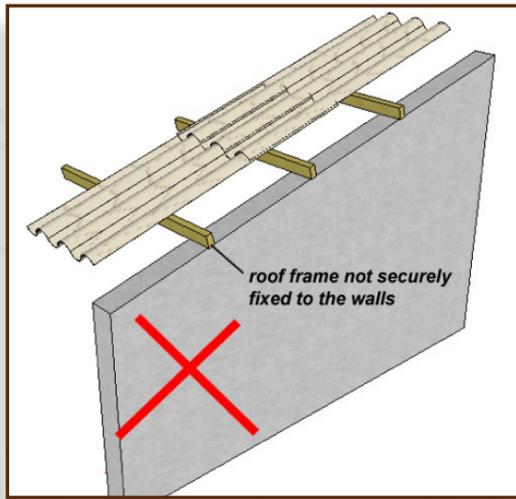


TECHNICAL DETAILS FOR CONSOLIDATING ROOF, WALL AND FOUNDATION

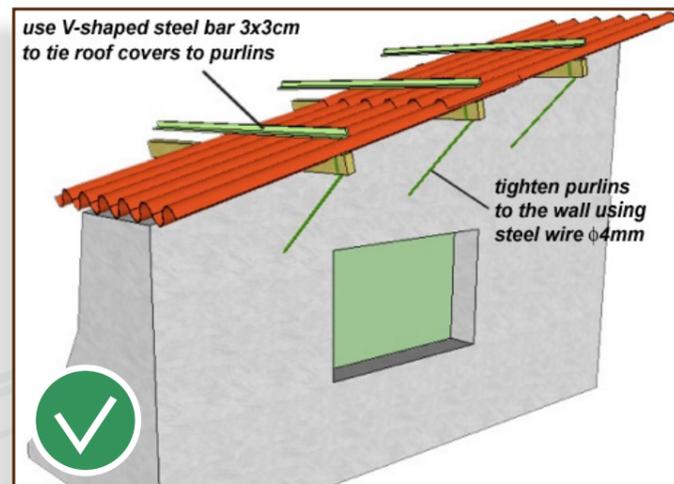
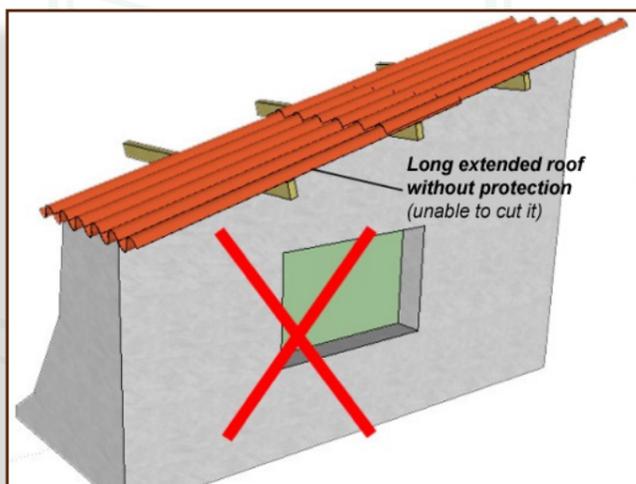
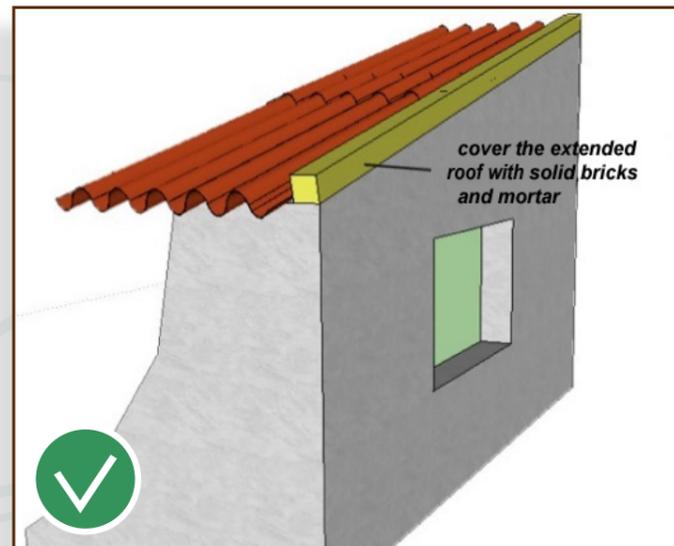
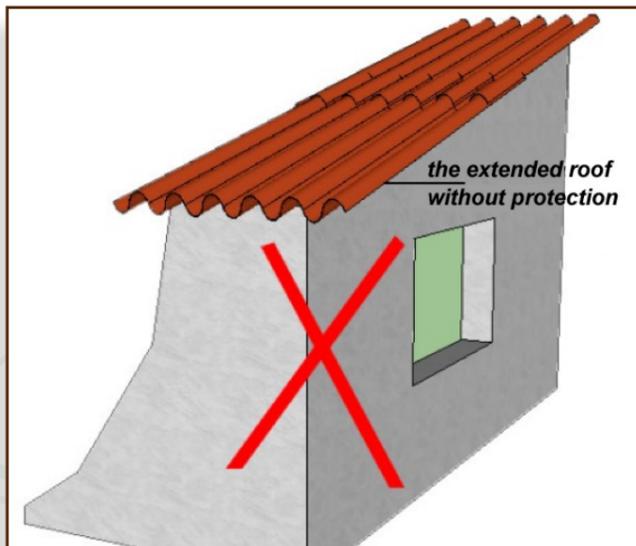
Typhoon-resilient housing is only achieved once all three parts of the house - roof, wall, and foundation - are solid and consolidated in accordance with the technical details of this section.



ROOF

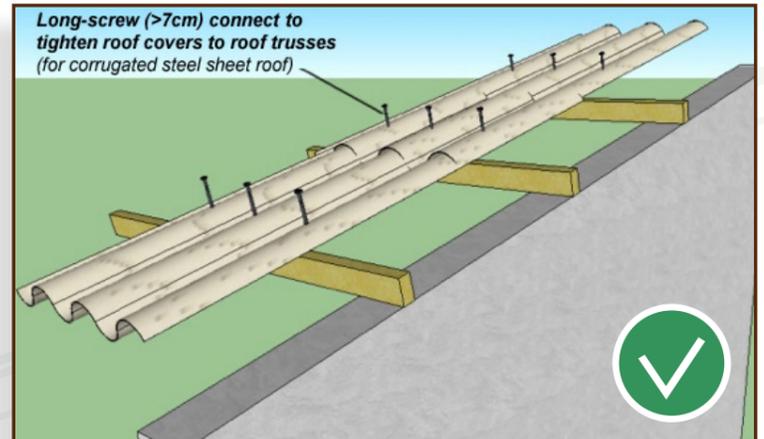
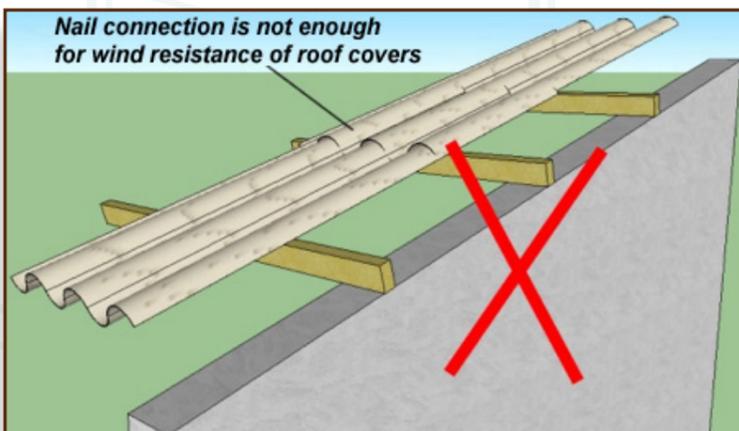
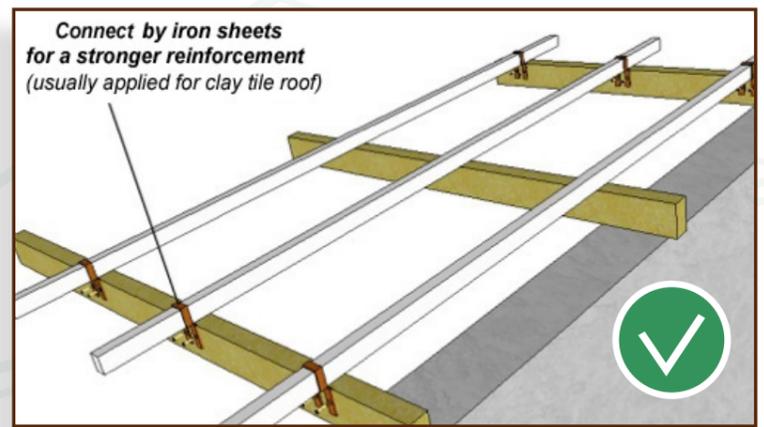
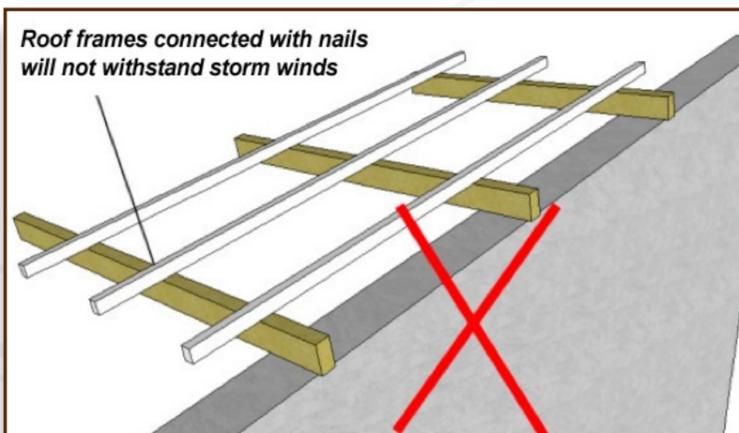
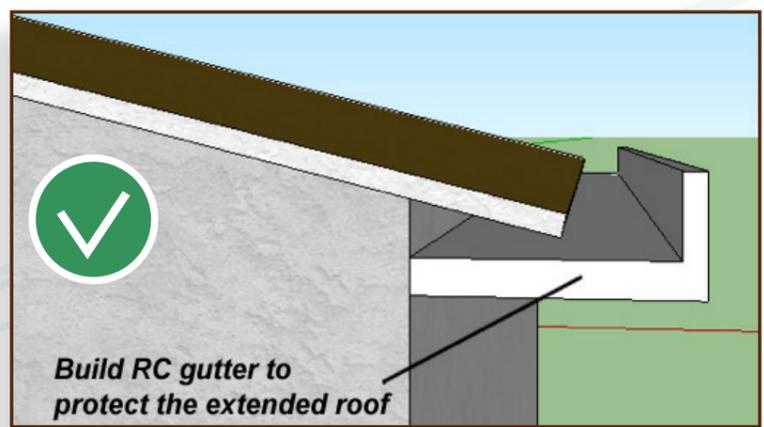
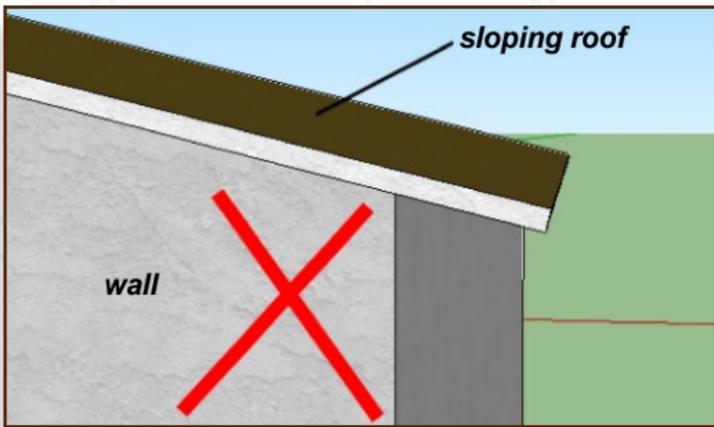
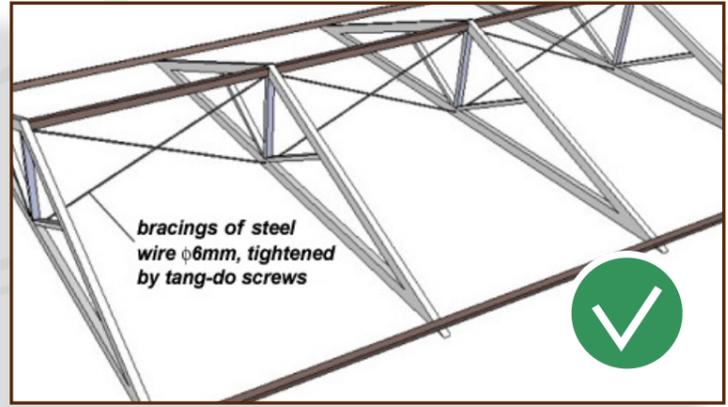
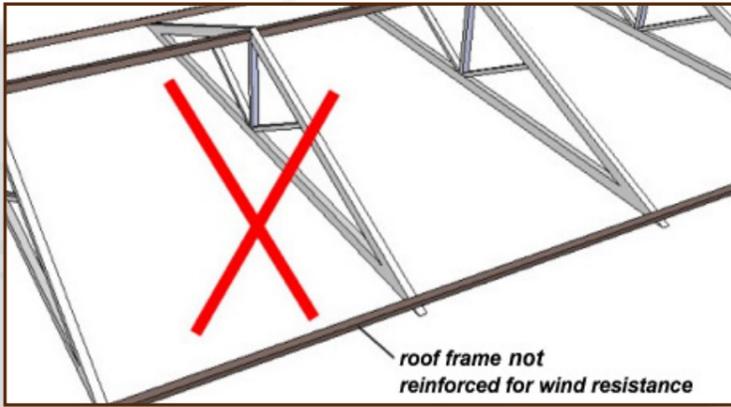


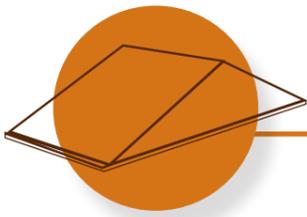
— 18 —



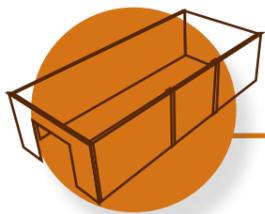
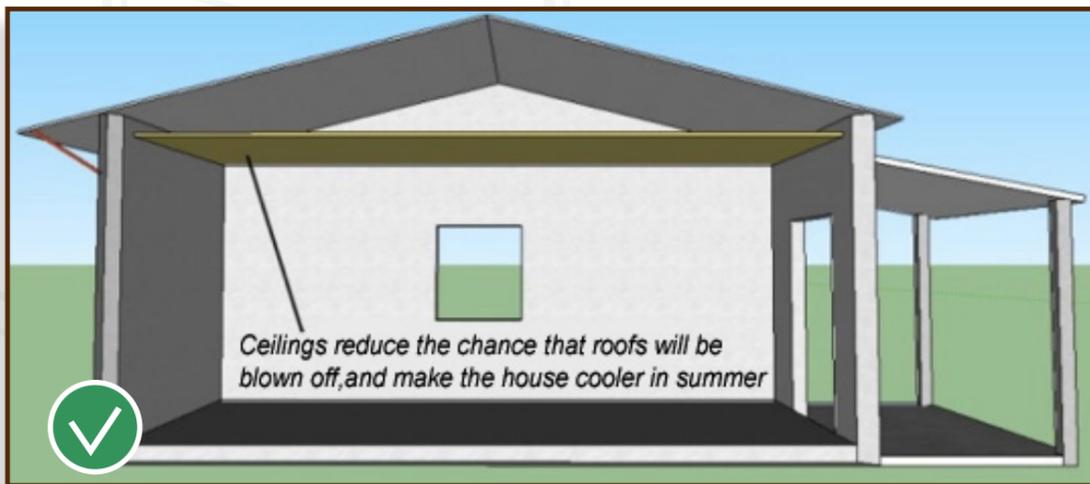
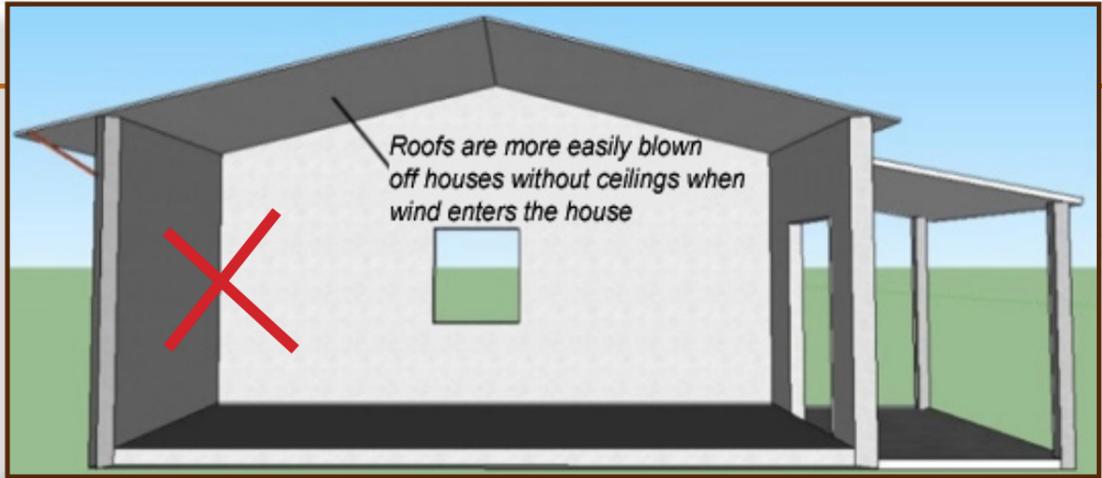
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ROOF

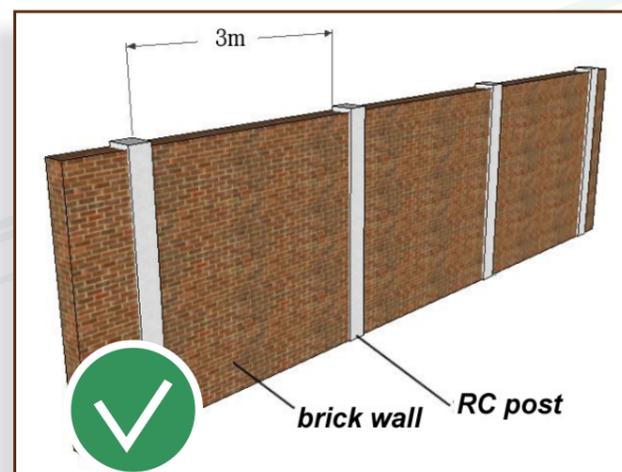
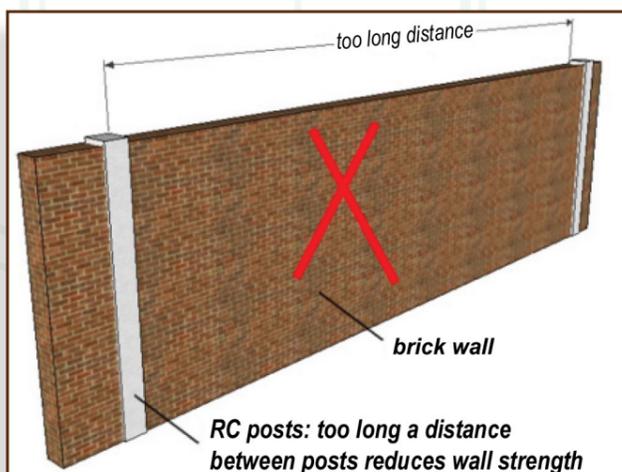
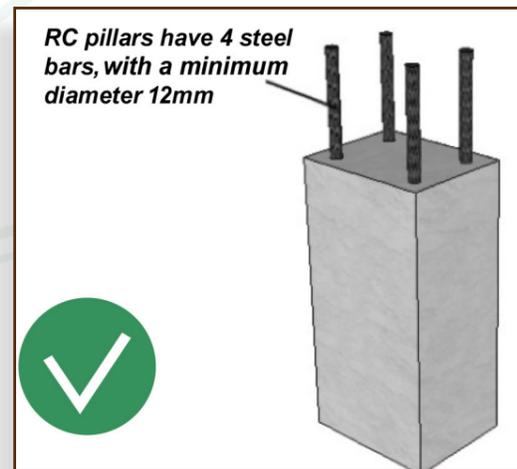
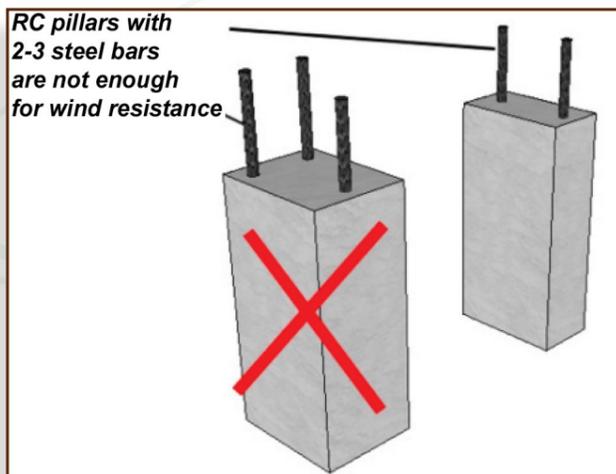


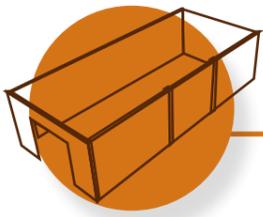


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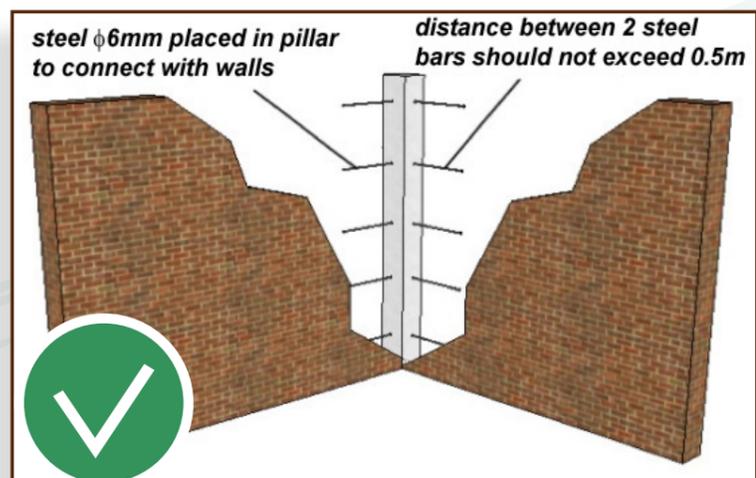
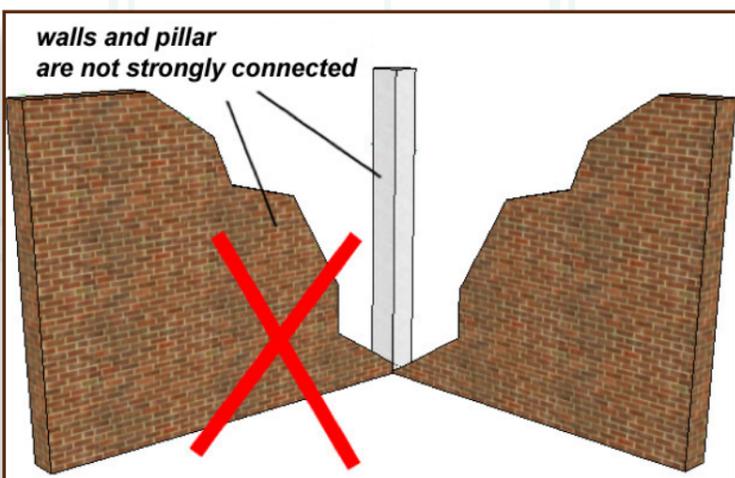
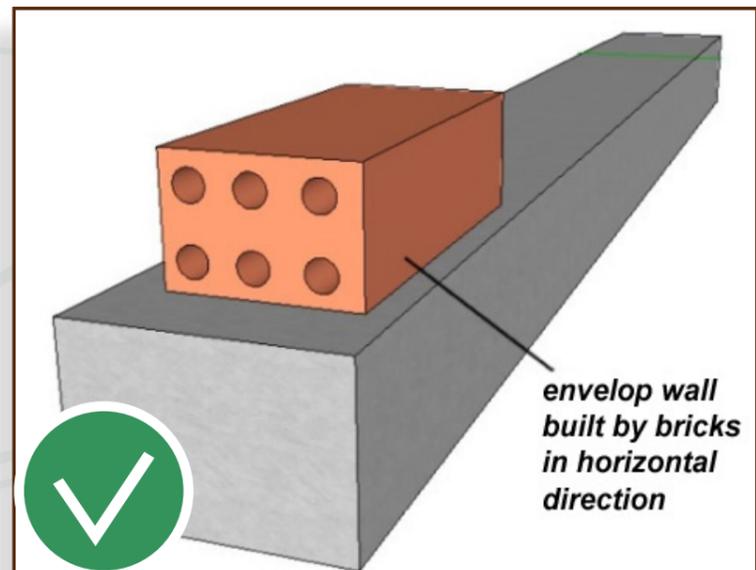
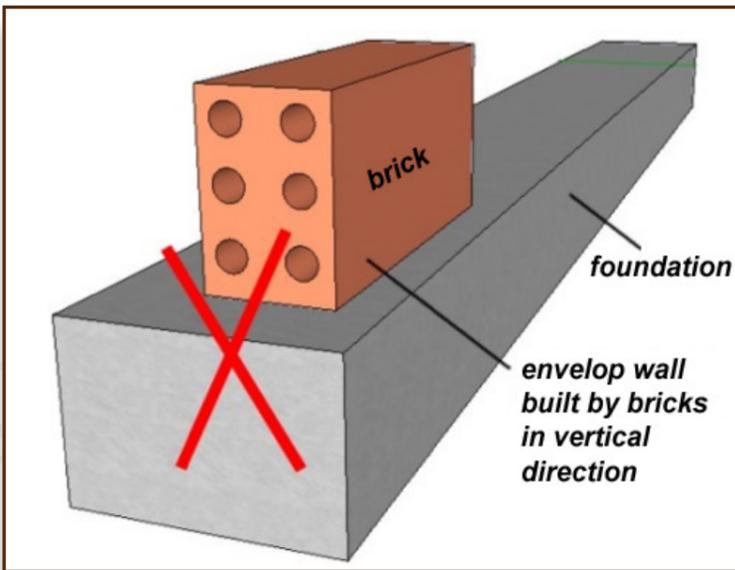
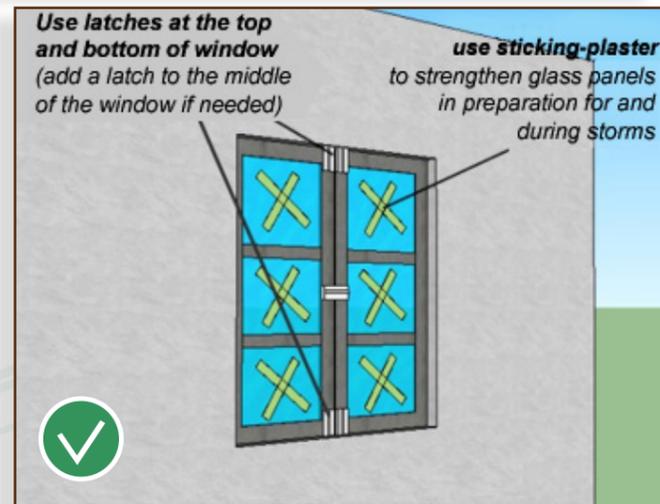
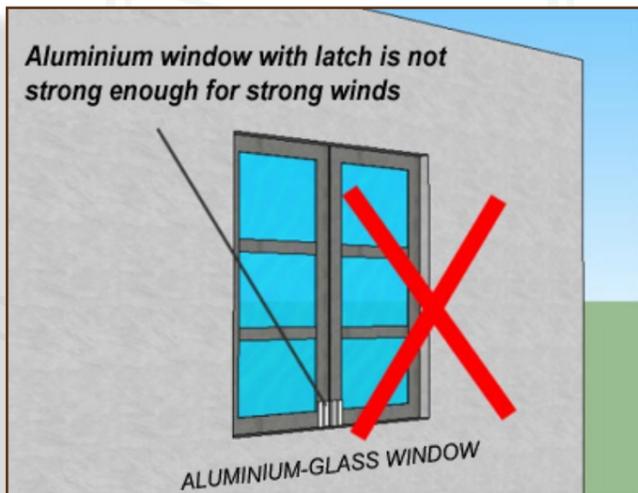
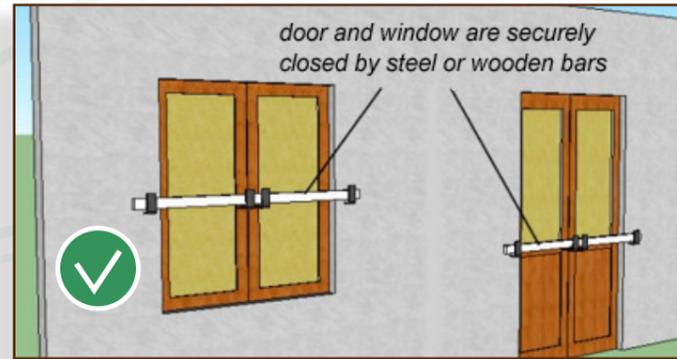


WALLS, DOORS AND WINDOWS





WALLS, DOORS AND WINDOWS



CONSTRUCTION WORK: IMPORTANT NOTES

1. SITE PREPARATION

- Dismantle old building(s), if any, and reuse materials as much as possible.
- Clean up the site for construction
- Set the location of the house on the land:
 - Determine distance between the house and land boundaries. Mark the position of the house on the ground by setting stakes in the ground (e.g. concrete piles, wood or bamboo stakes).

2. FOUNDATION CONSTRUCTION WORK

- To avoid the impacts of rain or underground water on foundation holes, it is essential to have a water pump on site for drainage purposes, if needed.
- After digging foundation holes, pour water into them and ram the holes carefully.

- Pour a concrete layer, 10 cm thick, at the bottom of the foundation holes, mixed with stone 4 x 6 cm, mortar M100. Ram the concrete layer carefully and identify the foundation axes.
- Steel work for the foundation is done outside and put within the foundation holes after they are finished on the foundation axes.
- Pour concrete into the hole to make the foundation, ram carefully, and let the concrete set about 1 day after pouring. After that, the formwork can be removed.
- The steel work for the foundation beam is done outside. Keep the steel frame within the foundation hole, and ensure the thickness of the concrete layer covering steel bars is ≥ 2 cm.
- Pour concrete to make the foundation beam, ram carefully, and allow to set for 1 day. After that, the formwork can be removed.

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3. WALL CONSTRUCTION WORK

- Bricks must be soaked in water before constructing the walls to increase adhesion between brick and mortar.
- After construction, it is vital to let them dry slowly by covering and keep them wet watering them on warm days.
- Mortar lines need to cover the whole brick, not just the edges.

General Principles

The formwork for pouring concrete items (foundation, pillar, beam, slab) must be:

- watertight, with no opening whatsoever
- flat, with no cracks or warp
- strong enough and not moveable during construction process

Steel work

- Use good quality steel, make sure there is no rust
- Ensure the distance between the steel elements are according to design
- Welding/Wiring connections must be strong
- Use shims when pouring concrete into steel framework

NORM FOR MORTAR

Type of mortar	Mortar strength	Norms for 1 cubic meter (m ³) mortar (≈ 20 turtle-formed cart)		
		Cement (kg)	Sand (turtle-formed cart)	Water (liter)
Mortar between bricks	50	213	22 cart	260
	75	296	21 cart	260
Plaster	50	30	21 cart	260
	75	320	21 cart	260
	100	410	20 cart	260

NORM FOR CONCRETE

Type of concrete	Concrete strength	Norms for 1 cubic meter (m ³) mortar (≈ 20 turtle-formed cart)			
		Cement (kg)	Sand (m ³)	Stone (m ³)	Water (liter)
Stone 1x2	200	360	9 cart	17 cart	195
Stone 4x6	100	210	10 cart	18 cart	175

Conversion: 1 turtle-formed cart = 0,05m³

CONSTRUCTION WORK: IMPORTANT NOTES

4. ROOF CONSTRUCTION WORK

Clay tile roof

- Insert mortar and sand at a ratio of 1:3 to fix clay tiles (3-4 lines) around the roof.
- Build roof edges: ensure mortar and sand have a ratio of 1:3.
- Build roof ridges: one double-brick line, one single-brick line, and mortar and sand with ratio of 1:3.
- Use steel wire to attach clay tiles to the roof frames below.

Corrugated steel sheet roof

- Place corrugated iron sheets onto roof frames using strong nails or roof-cover screws (plaster cover, iron core), use iron wires to tie roof covers to roof frames every 0.5-0.7 m.
- Put consolidation bars (can be made of steel, wood or bamboo) on the roof every 1.5-2.0 m, as two roofs overlap.
- The splint bar can be made of the following: steel that is > 14mm in diameter, a V-shaped steel bar, or wooden or bamboo bars.

5. DOOR AND WINDOW INSTALLATION

- Tightly connect doors and windows with bolts and latches and strengthen with bars during windstorms.
- Stick adhesive tape on glass window panels to strengthen wind resistance.
- Close openings between walls and the roof, ventilation holes on gable sides, and on tops of doors/windows to avoid wind penetration.

DESIGN OPTIONS FOR TYPHOON-RESILIENT HOUSING

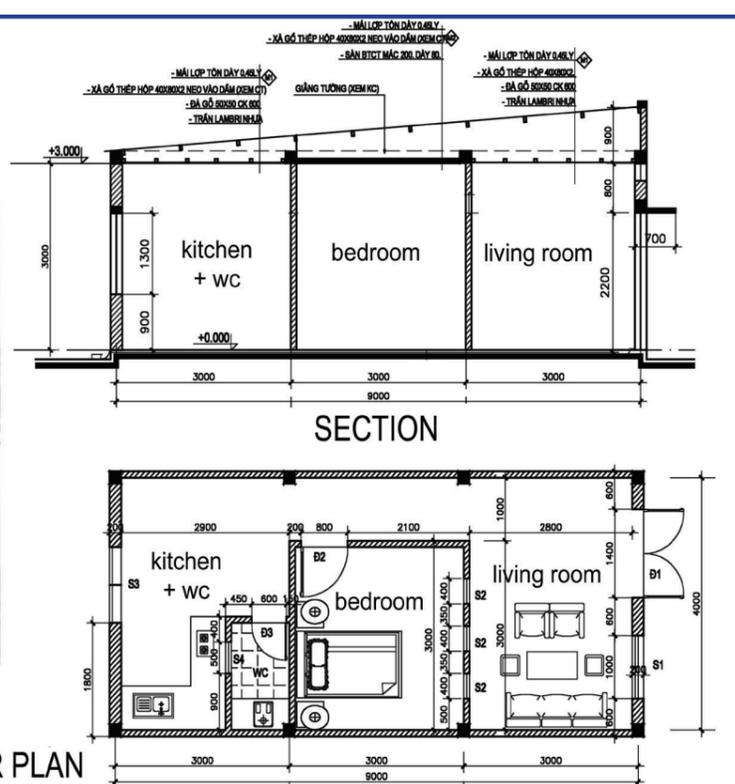
NOTE:

People can choose one of these options if it suits the shape of the land, as well as the needs and economic conditions of the family. The typhoon-resilient guidelines provided in the previous sections of the document, however, should be followed to the letter in order to have a safe home.

1A



PERSPECTIVE



FLOOR PLAN

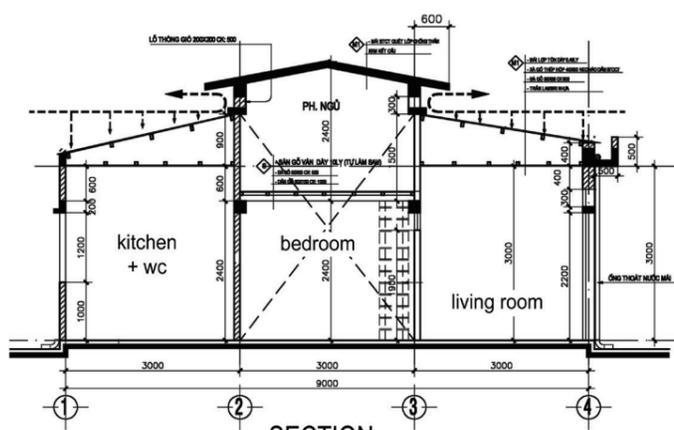
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Source:
Da Nang Department of Construction
(DoC)

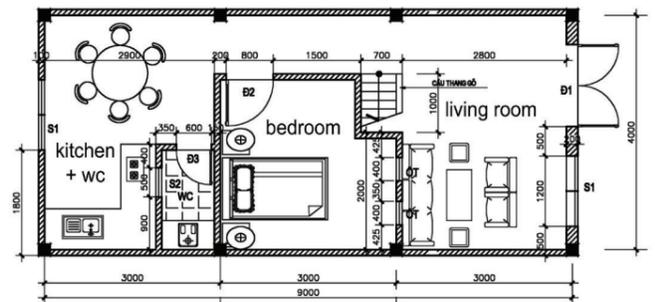
1B



PERSPECTIVE



SECTION



FLOOR PLAN

1

Source:
Da Nang Department of
Construction (DoC)

2A



PERSPECTIVE



SECTION



FLOOR PLAN

2

Source:
Development Workshop France (DWF),
2015. ATLAS: House Design Collection.
Decision No.48/2014/QĐ-TTg: Support
the Poor in Having Typhoon- and Flood-
Resistant Homes in Central Vietnam.

2B



PERSPECTIVE



SECTION



FLOOR PLAN

2C



PERSPECTIVE



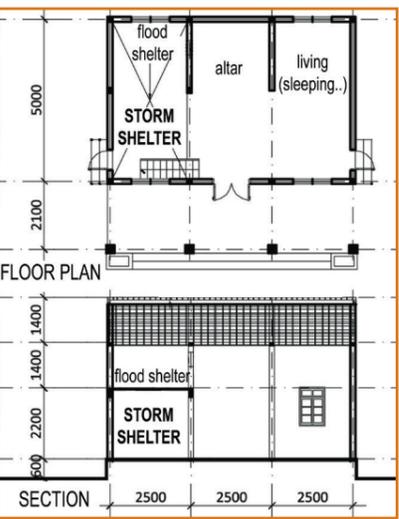
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Source:
Development Workshop France (DWF), 2015. ATLAS: House Design Collection. Decision No.48/2014/QĐ-TTg: Support the Poor in Having Typhoon- and Flood-Resistant Homes in Central Vietnam.

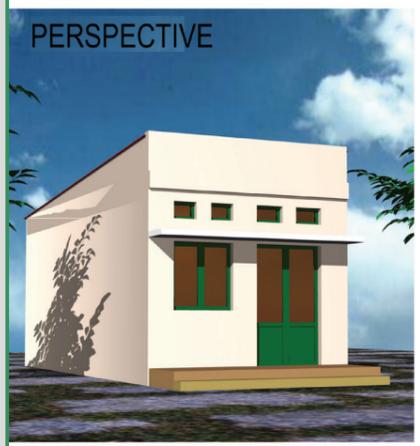
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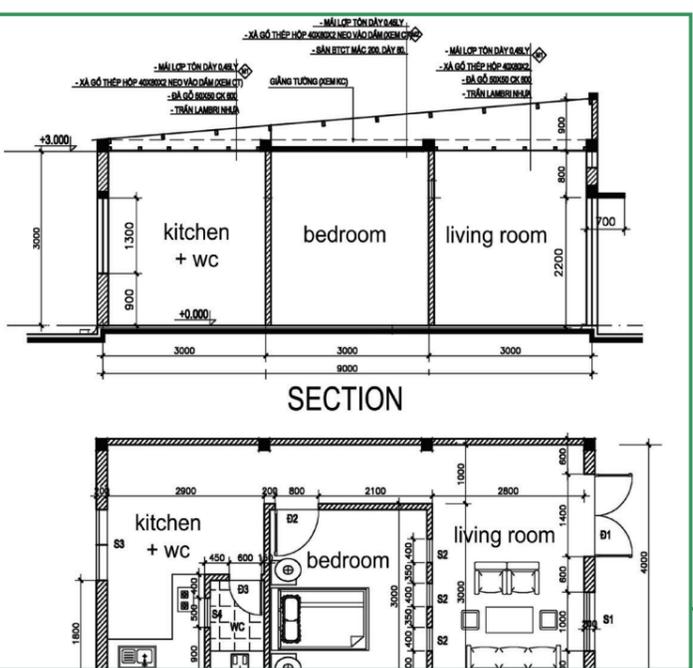
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3A



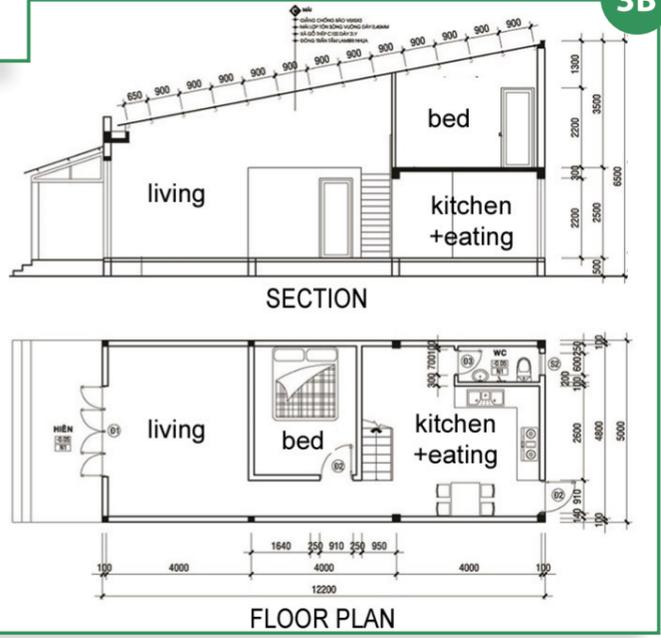
PERSPECTIVE



3B



PERSPECTIVE



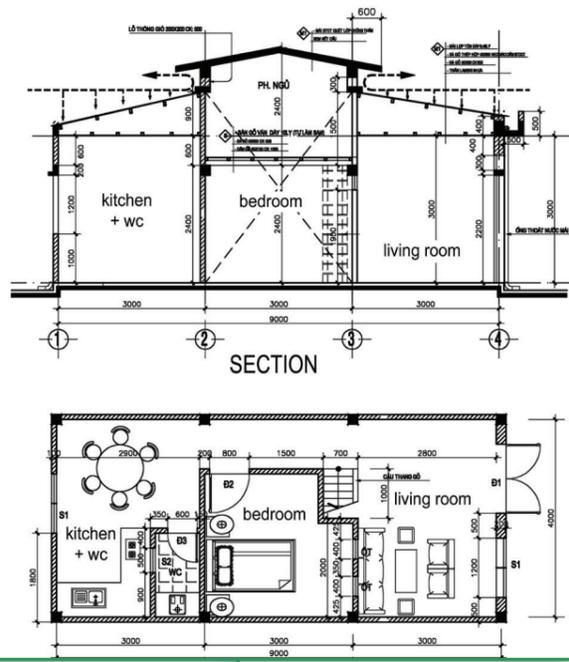
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Developed by the project research team based on field work and stakeholder consultation.

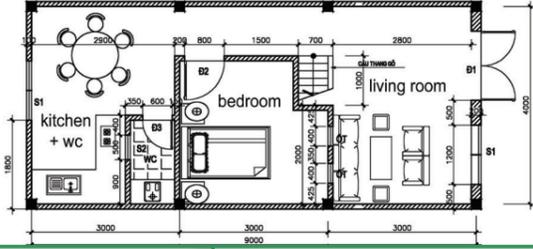
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PERSPECTIVE



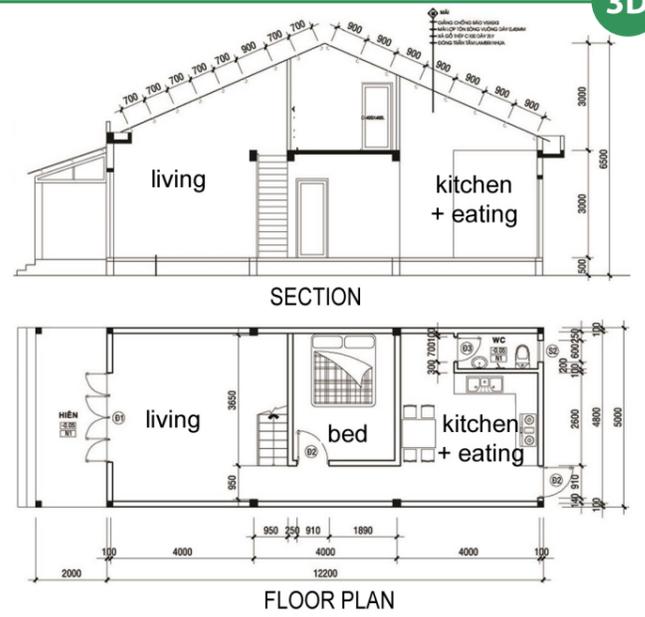
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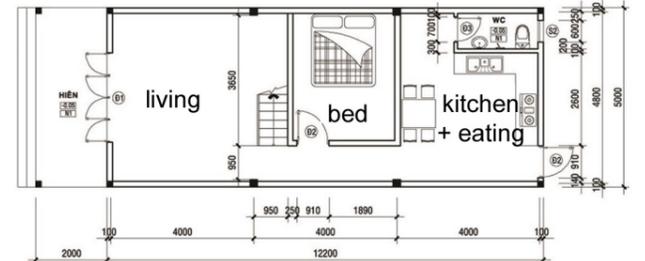
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PERSPECTIVE



SECTION



FLOOR PLAN

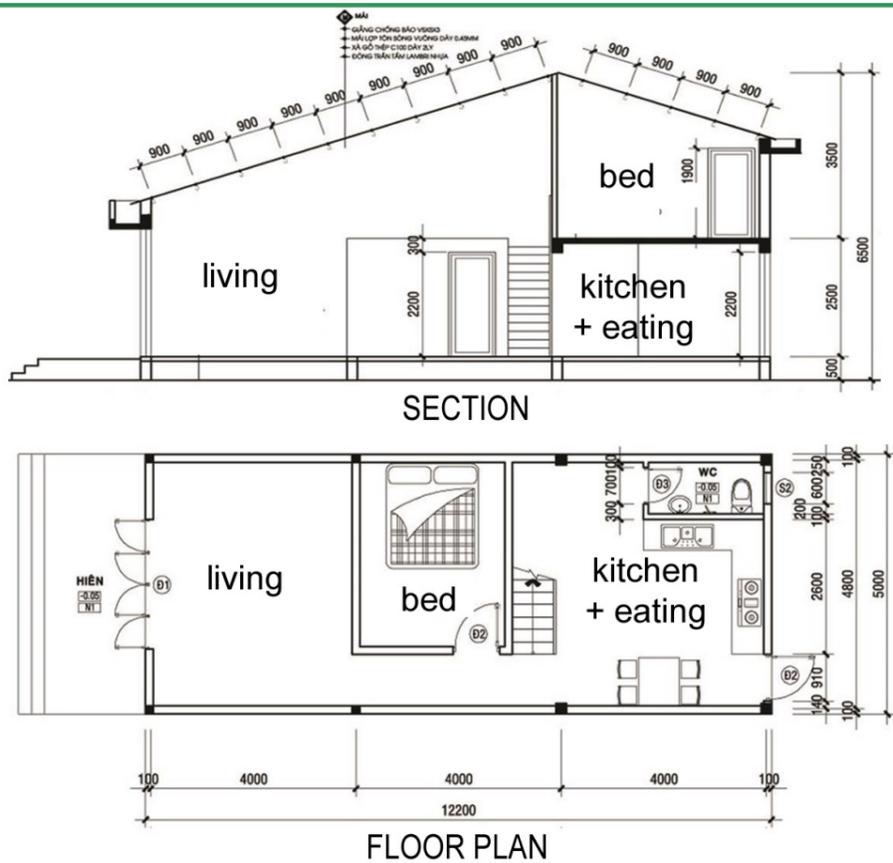
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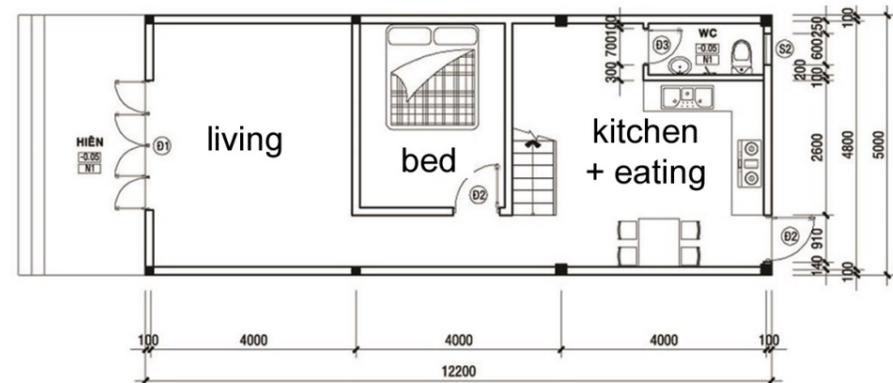
3E



PERSPECTIVE



SECTION



FLOOR PLAN

**FOR LOCAL
OFFICIALS/
STAFF**



TECHNICAL HANDBOOK ON
**Design, Construction and Renovation of
Typhoon-Resilient Low-income Housing**

This technical handbook provides guidance for officials of the Department of Construction, ward/commune People's Committee staff, members of organizations such as the Women's Union and Fatherland Front, and local design and construction professionals.

It is recognized that depending on the characteristics of the land, as well as the socio-economic conditions of each household, storm-resilient houses for low-income families can have different forms. The principles for typhoon resilience recommended in this handbook, however, should be strictly followed in the housing design and construction process.

Guidance for officials of the Department of Construction, ward/commune People's Committee staff, mass organization staff (e.g. Women's Union or Fatherland Front), and local design professionals

Partners:



Canada



Contact Information

DA NANG DEPARTMENT OF FOREIGN AFFAIRS

Ms. Đỗ Phương Thảo (Deputy Head of International Cooperation Unit): thaodp7@danang.gov.vn

Ms. Ngô Việt Hoài Thương (Specialist): thuongnvh@danang.gov.vn

INSTITUTE FOR SOCIAL AND ENVIRONMENTAL TRANSITION- INTERNATIONAL (ISET-INTERNATIONAL)

Mr. Trần Văn Giải Phóng (Technical Lead): phongtran@i-s-e-t.org

Mr. Trần Tuấn Anh (Technical Staff): tuan.anh@i-s-e-t.org