



FEDERAL EMERGENCY MANAGEMENT AGENCY



Above the Flood: ELEVATING YOUR FLOODPRONE HOUSE

FEDERAL EMERGENCY MANAGEMENT AGENCY

MITIGATION DIRECTORATE

500 C Street, SW • Washington, DC 20472

www.fema.gov



Table of Contents

Chapter 1	
Introduction	1-1
Chapter 2	
Homeowner Options	2-1
National Flood Insurance Program	2-1
Technical and Regulatory Guidance from FEMA	2-5
Chapter 3	
Overview of the Elevation Techniques	3-1
Technique 1 – Extend the Walls of the House Upward and Raise the Lowest Floor	3-1
Technique 2 – Convert the Existing Lower Area of the House to Non-Habitable Space and Build a New Second Story for Living Space	3-4
Technique 3 – Lift the Entire House, With the Floor Slab Attached, and Build a New Foundation To Elevate the House	3-6
Chapter 4	
Case Studies	4-1
Technique 1 – Extend the Walls of the House Upward and Raise the Lowest Floor	4-1
Case Study 1	4-1
Case Study 2	4-7
Case Study 3	4-10
Technique 2 – Convert the Existing Lower Area of the House to Non-Habitable Space and Build a New Second Story for Living Space	4-13
Case Study 4	4-13
Case Study 5	4-16
Case Study 6	4-21
Combination of Techniques 1 and 2	4-24
Case Study 7	4-24



Technique 3 – Lift the Entire House, With the Floor Slab Attached, and Build a New Foundation To Elevate the House 4-28

 Case Study 8 4-28

Chapter 5

Summary 5-1

Chapter 6

Additional Information 6-1

Acknowledgments A-1

Figures

Figure 1 Hurricane Andrew was a Category 4 hurricane with peak winds of over 140 mph. 1-1

Figure 2 Damage to houses and other buildings was severe. 1-2

Figure 3 Wind damage. 1-2

Figure 4 In low-lying areas, wind and rain damage to interior finishes and furnishings was exacerbated by flood waters. 1-3

Figure 5 A FIRM presents information about flood hazards in a community, including the SFHA (dark-tinted area), 500-year floodplain (light-tinted area), Base Flood Elevations (BFEs) (number in parentheses in dark-tinted area), and flood insurance zones (AE and X in this example). 2-2

Figure 6 In a new, substantially improved, or substantially damaged building in an A zone, the elevation of the lowest floor must be at or above the BFE. 2-4

Figure 7 Technique 1 – Extend the walls of the house upward and raise the lowest floor. 2-6

Figure 8 Technique 2 – Convert the existing lower area of the house to non-habitable space and build a new second story for living space. 2-7

Figure 9 Technique 3 – Lift the entire house, with the floor slab attached, and build a new foundation to elevate the house. 2-8

Figure 10 The first step in Technique 1 is removing the roof. 3-1

Figure 11 The tops of the walls and bottoms of the window openings are raised with concrete blocks. 3-2

Figure 12 Openings are created in the walls near the ground. 3-3

Figure 13 A new wood-frame lowest floor is constructed above the flood level, and the roof, windows, and doors are reinstalled. 3-3

Figure 14 An alternative to building an elevated wood-frame floor is installing a new, elevated concrete slab floor on fill placed over the old slab. 3-4

Figure 15 The new second-story floor and walls are built on top of the existing lower story. 3-5

Figure 16 The new second-story walls are covered with siding or stucco. 3-5

Figure 17 Trenches and tunnels under the slab provide access for the jacks and I-beams that will lift the house. 3-6

Figure 18 With I-beams and jacks in place, the house is ready to be lifted. 3-7

Figure 19 The house is temporarily supported on cribbing. 3-7

Figure 20 New, extended foundation walls are constructed with concrete blocks. 3-8

Figure 21 Elevated house and slab on new, extended foundation walls. 3-8

Figure 22 The front of the house at the beginning of the project. 4-1

Figure 23 View from the back of the house. 4-2

Figure 24 Another view of the extended walls. 4-2



ABOVE THE FLOOD: ELEVATING YOUR FLOODPRONE HOUSE

- Figure 25** This view through the garage door reveals the different levels of the elevated slab floor, in the background, and the unelevated garage floor. 4-3
- Figure 26** The roof has been rebuilt with the salvaged trusses, and most of the new concrete slab has been poured on top of the sand fill. 4-3
- Figure 27** As work progresses, the elevated house begins to take shape. 4-4
- Figure 28** The bottoms of the original window openings are raised with concrete blocks. 4-4
- Figure 29** Windows and doors are added. 4-5
- Figure 30** Interior partition walls and utilities are added. 4-5
- Figure 31** This view from the rear of the house shows that the project is almost complete. 4-6
- Figure 32** The final product: an attractive elevated house that meets local floodplain management requirements and is now much less vulnerable to flood damage. 4-6
- Figure 33** Wood framing for a new concrete staircase that will provide access to the elevated floor. 4-7
- Figure 34** After the new concrete slab is poured, wood framing for interior walls is added. 4-8
- Figure 35** The electrical system is upgraded to meet current code requirements. 4-8
- Figure 36** In this view from the front of the house, the amount of elevation is shown by the rows of concrete block on the tops of the original walls and by the raised window openings. 4-9
- Figure 37** The project nears completion. 4-9
- Figure 38** The elevated house is now complete. 4-10
- Figure 39** The roof of this house was removed as a single piece; the trusses were held together with bracing and portions of the original roof sheathing. 4-10

Figure 40 After the roof was removed and the storm-damaged interior gutted, the walls of the house were extended upward and a new bond beam added at the top. 4-11

Figure 41 Note the new bond beam at the top of the extended wall, the new concrete tiedown column at the corner, and the raised window opening. 4-11

Figure 42 This view from the back of the house shows the height of the elevated slab floor. 4-12

Figure 43 The owner of this house decided to use light-gauge metal framing for the new interior walls. 4-12

Figure 44 The final product. 4-13

Figure 45 Concrete bond beams similar to those shown earlier were used in this house, but here they were installed on the tops of both the original first-story walls and the new reinforced concrete block second-story walls. 4-13

Figure 46 Concrete tiedown columns, such as the one to the left of the window in this photograph, were also used in this house. 4-14

Figure 47 The tiedown columns extend down from the new second-story walls and into the original first-floor walls. 4-14

Figure 48 Wood 2 by 4 studs were used to frame the interior walls of the second story. 4-15

Figure 49 The house nears completion. 4-15

Figure 50 Not only does the completed house meet the requirements of local codes and the NFIP regulations, it now includes a substantial amount of parking and storage space below the new living level. 4-16

Figure 51 The storm-damaged first story has been gutted in preparation for construction. 4-16

Figure 52 The existing first-story walls have been strengthened by the addition of concrete block. 4-17

Figure 53 As the second story takes shape, its size in relation to the size of the original house becomes apparent. 4-17



ABOVE THE FLOOD: ELEVATING YOUR FLOODPRONE HOUSE

- Figure 54** Metal framing is used for the new second story, including the walls and roof support system. 4-18
- Figure 55** Metal framing also supports the floor of the new second story. 4-18
- Figure 56** One advantage of metal framing is its relatively light weight. 4-19
- Figure 57** The project progresses with wiring and other utility work. 4-19
- Figure 58** The new second story nears completion. 4-20
- Figure 59** The exterior walls consist of prefabricated concrete panels. 4-20
- Figure 60** The completed house has the appearance of a typical two-story residence. 4-21
- Figure 61** The wood-frame second story takes shape. 4-21
- Figure 62** After the wood framing was completed, the roof and exterior wall sheathing were added. 4-22
- Figure 63** The new second-story walls are securely connected to the original first-floor walls with galvanized metal hurricane straps. 4-22
- Figure 64** From the outside, the completed house, with its stucco walls, looks like a conventional masonry house. 4-23
- Figure 65** After the house was gutted, the walls were extended upward with reinforced concrete block. 4-24
- Figure 66** The new second-story walls as seen from inside the garage. 4-25
- Figure 67** The extended first-story walls. 4-25
- Figure 68** Rather than install a new concrete slab on compacted fill, the owner of this house chose to build a new wood-frame floor above the old concrete slab. 4-26
- Figure 69** Wood framing is used for the new second story. 4-26

Figure 70 Metal hurricane straps are used to tie the structural members together and create a continuous load path from the roof to the foundation. 4-27

Figure 71 All plumbing and electrical renovation work must be performed according to state and local code requirements. 4-27

Figure 72 The completed house is compliant with local floodplain management requirements, is more resistant to flood damage, and provides additional living area above the flood level. 4-28

Figure 73 Like the houses shown previously, this one-story house, with its concrete block walls, concrete slab foundation, and attached garage, is typical of the houses in the area affected by Hurricane Andrew. 4-28

Figure 74 In this variation of Technique 3, steel beams are inserted through the walls of the house rather than under the slab. 4-29

Figure 75 Electrical lines and other utilities were disconnected early in the project. 4-29

Figure 76 Inside the house, workers drill holes in the concrete slab 4-30

Figure 77 ... install anchors 4-30

Figure 78 ... and use hangers to attach the anchors to the grid of steel beams. 4-31

Figure 79 The anchors and hangers connect the slab securely to the beams, enabling the beams to raise the slab along with the rest of the house. 4-31

Figure 80 Lifting the house, while simple in theory, is complicated by the need to ensure an equal amount of lift at each jack throughout the process. 4-32

Figure 81 The house and slab were raised one full story. 4-32

Figure 82 While the jacks and beams supported the house, new steel foundation members were installed below. 4-33



ABOVE THE FLOOD: ELEVATING YOUR FLOODPRONE HOUSE

- Figure 83** Concrete blocks were brought to the site ... 4-33
- Figure 84** ... and used to build the lower-level walls. 4-34
- Figure 85** The completed house, with lower-level space for parking and storage and upper-level living space, looks as if it were originally designed and built as a two-story structure. 4-34