4.3.5 - Breakaway Walls

Elevation of a structure on a properly designed foundation reduces the potential for water damage from flooding. When the space below the lowest elevated floor is maintained free of solid obstructions as well, the potential for damage from waves or debris is further reduced. In recognition of the desirability of using the sheltered space beneath elevated structures, NFIP regulations permit certain limited uses of enclosed space below the BFE. Uses such as parking of vehicles, building access, or storage are permitted, as long as the walls of any enclosures are designed as "breakaway". **A breakaway wall is a wall that is not part of the structural support of the building, intended through its design and construction to collapse under specific lateral (wind and water) loading conditions without causing collapse, displacement, or other structural damage to the elevated portion of the building or supporting foundation system.**

To ensure that breakaway walls withstand forces from wind and everyday use, yet collapse under storm conditions, current NFIP regulations require that a breakaway wall shall have a design safe loading resistance of not less than 10 and no more than 20 pounds per square foot. The regulations allow walls with a greater loading resistance under certain conditions, and when the design is certified by a registered professional engineer or architect. The need for greater loading resistance could be a result of design requirements or required by local or state codes. In either case, the designer must certify both of the following:

- Breakaway wall collapse shall result from a water load less than that which would occur during the base flood

- The elevated portion of the building and supporting foundation system shall not be subject to collapse, displacement, or other structural damage due to the effects of wind and water loads acting simultaneously on all building components (structural and nonstructural). maximum wind and water loading values to be used in this determination shall each have a 1% chance of being equaled or exceeded in any given year (100 year mean recurrence interval)

The uses that owners make of the sheltered space beneath elevated homes has historically led to a wide range of enclosure designs, from insect screening to heavy conventional walls.

Screening and lattice work are the best low strength enclosures and when properly constructed can serve their intended function with little effect on the structural loadings on the house. These walls provide partial protection and security for items stored under an elevated structure. Lattice work is often used for architectural purposes as shown by figure 4-60, to visually tie the house to its surroundings.

While screening and lattice provide some protection for vehicles and stored items from salt spray and other environmental conditions, full protection from the elements can only be provided by a solid wall. Walls providing this protection from the elements can be designed to withstand certain wind and water loads and to break away or fail when design loads are exceeded.

Construction of walls stronger than the structural frame of the building was designed to stand will jeopardize the integrity of the structure under storm conditions. This strengthening of the walls (i.e., by using extra fasteners) so that they do not break away before damaging the structure may occur during initial construction or as a result of later

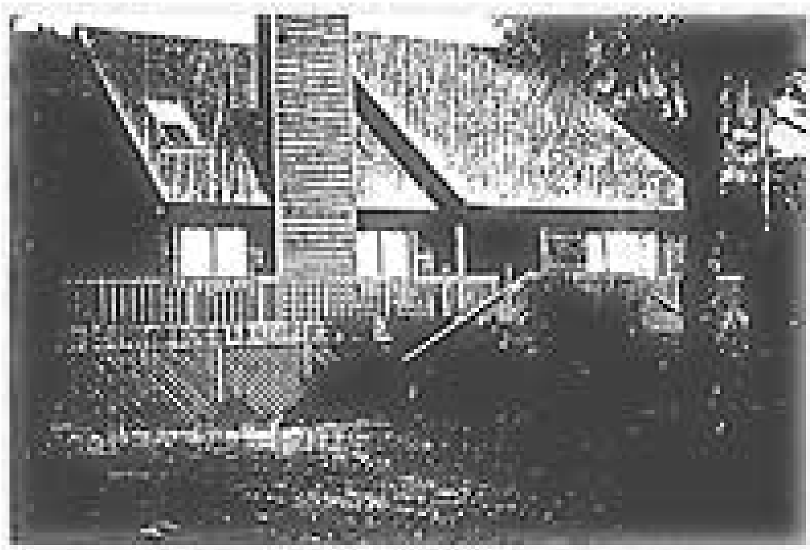

Figure 4-60. Lattice enclosure under elevated structure

modifications by the owner. Strong walls would allow excessive scour and damaging wave runup during severe storms, while weaker walls will break away before these effects become significant.

In accordance with the current NFIP regulations, which provide the specific guidance stated above, this manual recommends that only screening, lattice work, or light breakaway walls be constructed below residential structures, unless specifically designed by a registered professional engineer or architect. As Figure 4-61 (of storm damage during Hurricane Alicia) shows, structures can survive major storms relatively intact when ground level enclosure walls break away.

4.3.5.1 - Breakaway Wall Designs

Screening. One means for partially or fully enclosing the area below the BFE is installation of metal or synthetic screening to provide insect protection and minimal security. Screening is fastened to pilings by nails, staples, or nailed moldings, and will fail under small loads imposed by wind, velocity water, or moving debris. Replacement costs are very low.

Lattice. Lattice work can be used for minimal enclosures beneath an elevated structure. If fabricated using light materials and properly connected to the foundation, lattice will break away under small water loads. No portion of the lattice wall should overlap the piles supporting the elevated structure. The wall could be butt connected to the piles.

Figure 4-61. Storm damage during Hurricane Alicia.

Figure 4-62 shows a lattice wall design using light crisscross lattice that is available premade and sold in 4-by-8 foot sheets. As shown in the figure, a 2-by-4 top plate is permanently nailed in to the floor beam and a 2 by 4 bottom plate is permanently attached to the grade beam. Wall studs (2-by-4's) are toe-nailed into the top and bottom plate using 2 (two) 8d nails. The premade lattice (1/4 by 1 1/2 inches) is nailed to the frame using galvanized nails. **This wall will have a working strength of approximately 10 psf and will fail as a result of material failure in the lattice.**

Lattice walls that use larger (i.e., 1-by-4 to 1-by-8) boards have greater inherent strength than crisscross lattice, even when the open/solid space ratio is the same. While the light lattice wall will fail in the lattice material even if the frame is overbuilt, the stronger lattice wall likely will fail at the connections under a much higher loading. Because of the difficulty in accurately predicting the material strength of heavier lattice walls, it is recommended that the wall be designed to fail at the connections. The wall attachment concept and nailing systems for these heavier lattice walls are the same as described below for wood stud walls.

Wood Stud Walls. Most solid breakaway walls under elevated single-family residences are of wood stud construction. A wood stud breakaway wall design is shown in figure 4-63. Permanent top and bottom plates (2-by-4) are respectively nailed to the floor beam and grade beam with permanent high strength fasteners or nails. A 2-by-4 breakaway frame that consists of studs (toe-nailed with 2 (two) 10d nails) and top and bottom nailer plates is attached to the permanent top and bottom plates with nails sized and spaced to give the required lateral capacity. Care should be taken that the 10d nails do not penetrate into the top and bottom plates. The frame is then covered with plywood or other sheathing

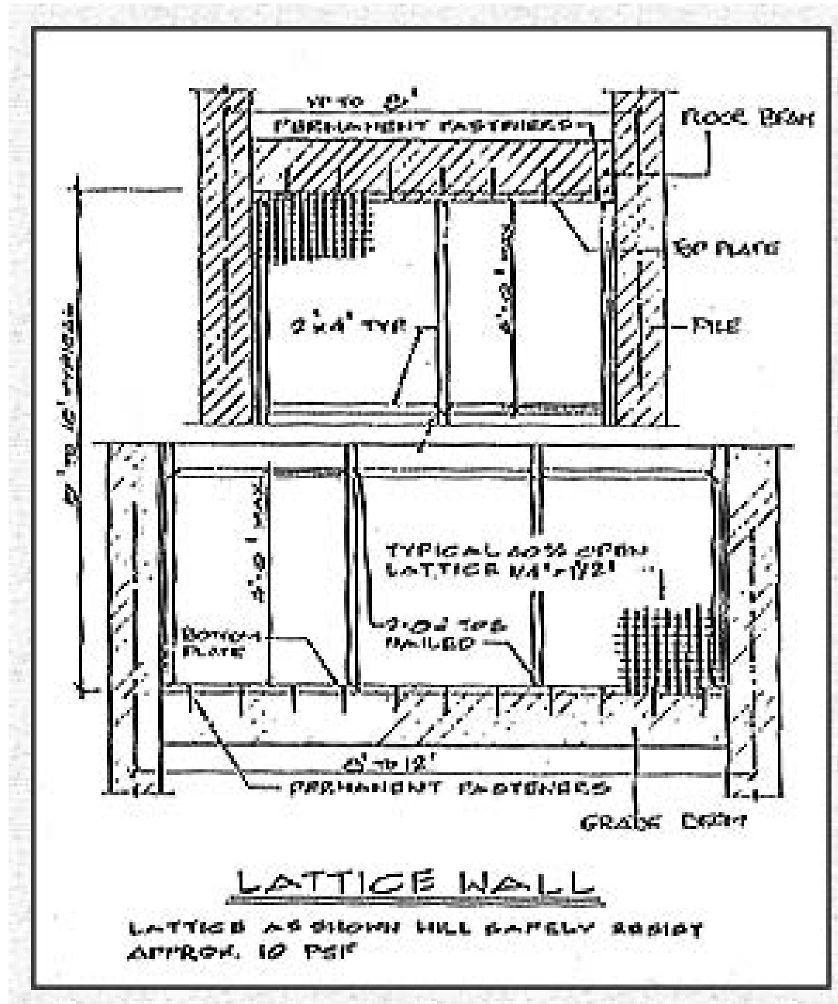

Figure 4-62. Lattice Wall.

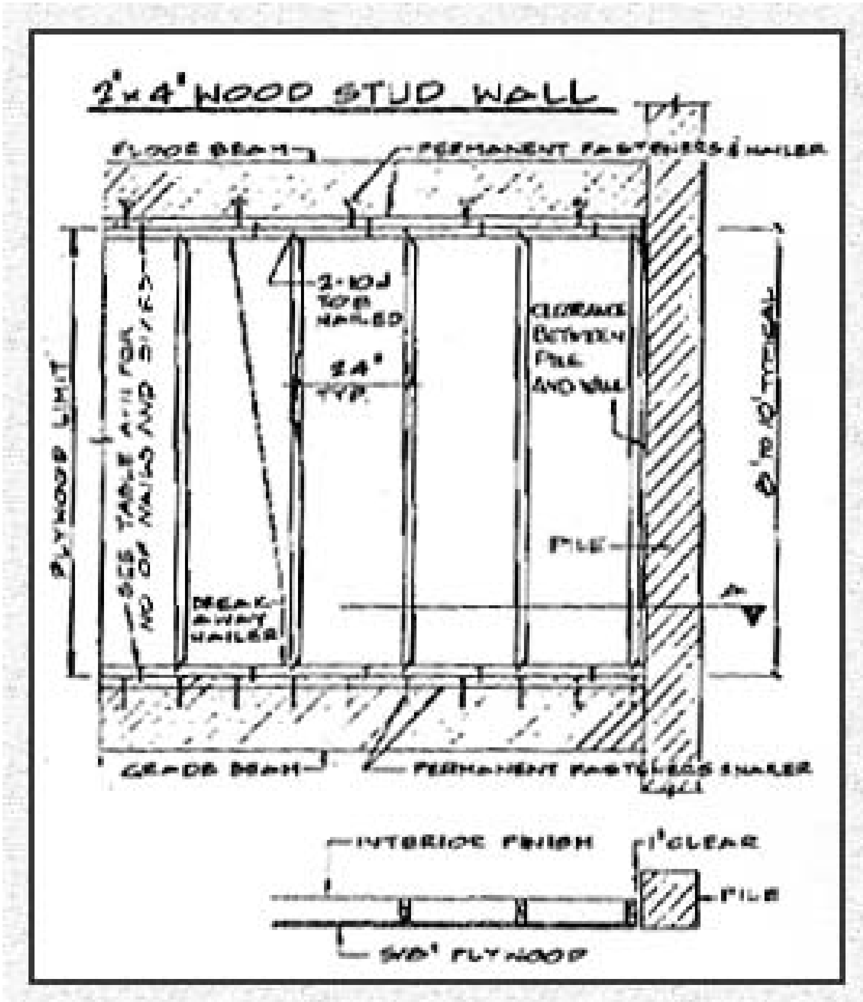

Figure 4-63. Wood stud breakaway wall.

that is either butted to the piles or allows for a small clearance. **The sheathing must not overlap the permanent plates or the piles.**

It is planned that the walls would be placed as a unit and then nailed as prescribed at the top and bottom to permanent nailer plates already securely attached to the floor system and grade beam or slab. The permanent nailer plate is an essential component of the wall system and provides a predictable point of attachment for the wall. The wall is designed to fail at the nailed connections to the permanent nailer plate. Various sizes and spacings of the nails could be used to achieve the desired resistance to lateral load. The capacities of 8d through 16d common nails in shear are shown on table A-11. Table A-11 provides a nailing schedule for normal combinations of breakaway wall height and pile spacing to result in wall with a design safe loading resistance between 10 and 20 psf.

Metal Stud Walls. Metal studs, which have been commonly used on larger structures, are now being used more frequently on low-rise multifamily structures and to a lesser extent on single family residences. Unless properly galvanized, metal studs will corrode rapidly in the coastal environment.

Figure 4-64 shows a light-gauge metal stud wall design. The wall attachment concept and nailing system is the same as the wood stud wall design discussed above. Fastener capacities for the self-tapping screws commonly used to attach the metal stud wall to the more firmly secured wood nailer shown on table A-11. Note that the failure capacity of metal stud wall systems can be more accurately determined than for wood systems and a lower safety factor can be used.

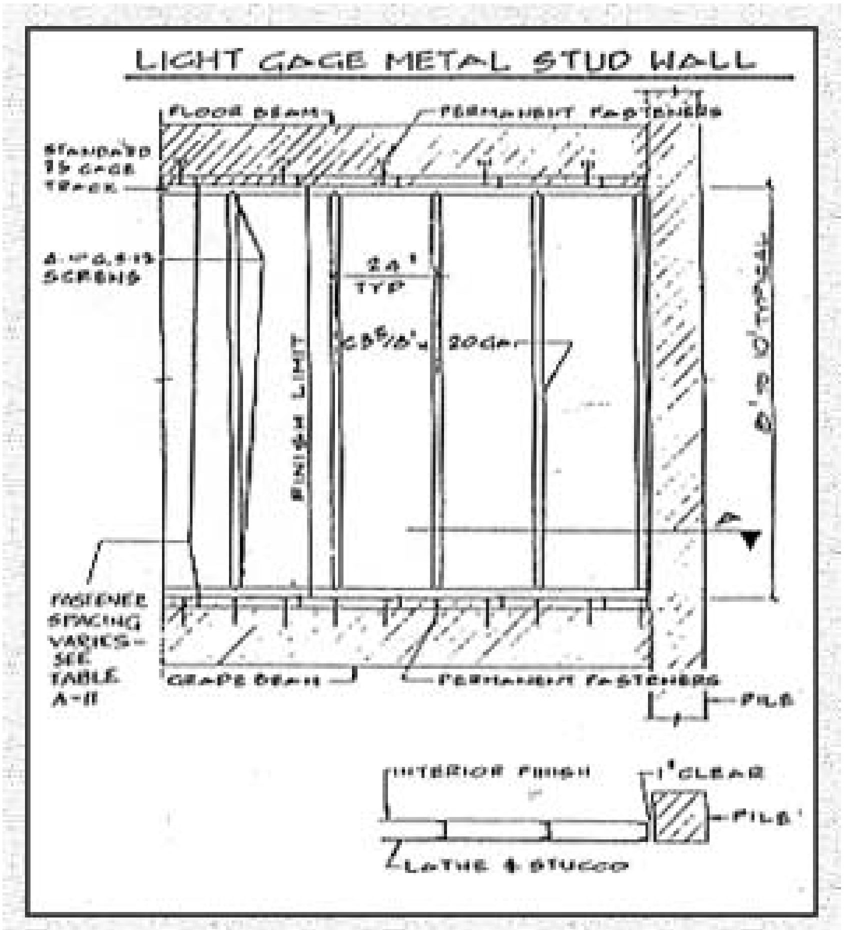

Figure 4-64. Light gauge metal stud breakaway wall.

Masonry Walls. Full masonry walls for enclosures under structures are common in larger buildings, though in south Florida they are used in all types of structures. Masonry walls can be constructed either unreinforced or reinforced.

Figure 4-65 shows a wall that can be constructed with or without reinforcement. The pins at the top of the wall are to maintain the stability of the wall under design wind loadings. The sides and top of the wall must not have bonded contact to the structure. If unreinforced, the wall will likely fail in shear in the mortar prior to shearing the retaining pins. An unreinforced masonry wall with mortared joints, constructed as shown in figure 4-65, will have a design safe loading resistance of about 20 psf (assuming an 8 foot high wall and 1,800 psi Type S mortar), and would meet NFID criteria for breakaway walls.

If reinforced, the wall is restrained by dowel pins at the top and reinforcing bars at the bottom. The placement of dowel pins and reinforcing bars permits a more accurate determination of the strength of the wall before failure occurs. Failure will begin with the pins shot into the main structure rather than with the mortar in the wall. This is due to the reinforcing. Once the pins fail, the wall will cantilever with the reinforcing bars at the bottom of the wall, providing additional resistance to failure until the walls capacity is reached. The lateral capacity of the reinforced masonry wall will vary depending on the size and spacing of the reinforcing bars. Because the loading resistance of a reinforced masonry wall exceeds NFIP criteria, such walls should be used only when designed by a registered professional engineer or architect.

4.3.5.2 - Design Considerations for Breakaway Walls. A number of design considerations are required when a solid enclosure wall, or even a partially open wall, is placed beneath the BFE. Governing the design process are the following primary concerns:

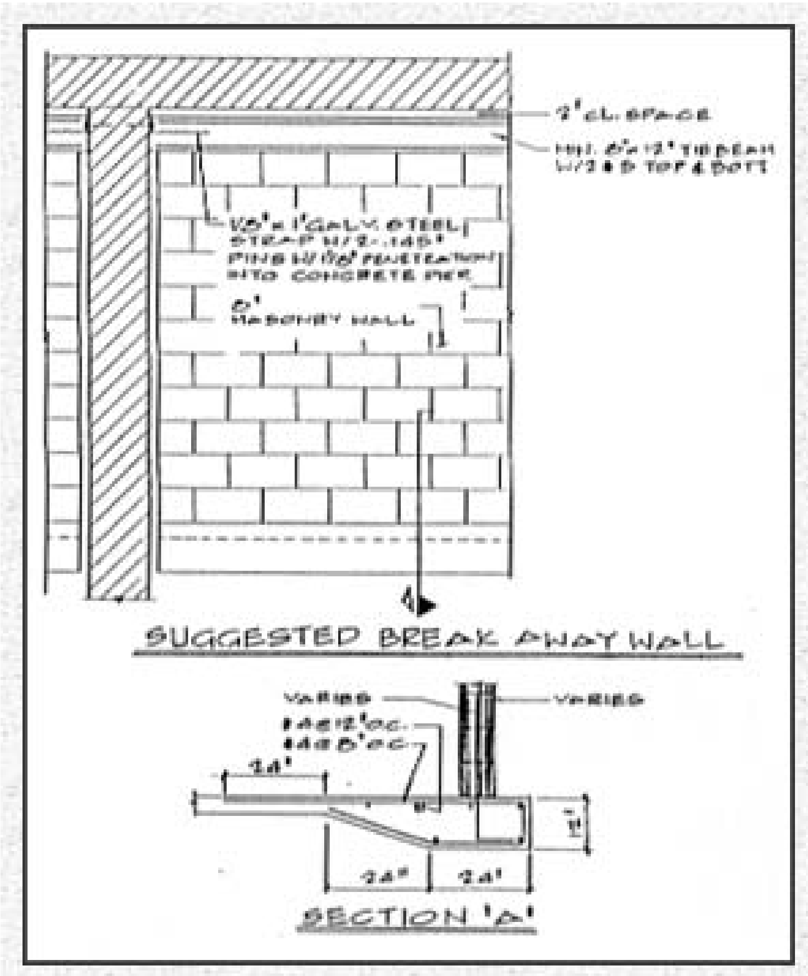

Figure 4-65. Masonry breakaway wall.

- Enclosure walls must be constructed to withstand loading forces from moderately high winds, with a normal factor of safety. At a minimum, this load capacity would be the design wind load required by the local building code. If the code-required design load is greater than the 20 psf allowed by NFIP regulations, the code should prevail.

- At high wind speeds and/or under water loading, the wall must fail without causing damage to the foundation or superstructure, either from lateral loading or wave runup/ramping into the rest of the structure. This is the failure load or ultimate load capacity of the wall.

- For small enclosures or relatively close spacings, it can be assumed that all piles within the enclosed area resist wind and water loads against below the BFE. For larger enclosures or wider pile spacing, only a limited number of piles can be brought into action to resist lateral loading. Additional bracing will be required for front row piles supporting the wall receiving water loading.

- Solid enclosure walls below the BFE increase potential for wave scour and grade beams and piles, particularly for stronger walls.

Wind Forces. Design for breakaway walls must consider wind forces on the house superstructure, which are transmitted to and resisted by the foundation system, as well as wind forces on the breakaway wall, which are also transmitted to the house frame and foundations until the lateral resistance of the wall or its fasteners is exceeded. The wind load on a breakaway wall is considered to be applied as a uniform load per square foot of vertical wall, which can be resolved into a resultant load applied along the fastened edge(s) of the wall.

Wind direction during storm events is often from offshore. However, in design of houses and breakaway walls, the wind should be assumed to blow potentially from any lateral direction relative to the house.

Water Forces. In addition to wind loads on the entire house, water loads on the portions of the structure below the BFE must be considered. These water loads include both simple hydrostatic pressure from a slow rise in stillwater depth and the forces of waves against the structure. The BFE for a given is the maximum height of stillwater plus waves above which a structure must be elevated, as illustrated in Figure 4-66a. When the area below the BFE is obstructed by a wall, wave runup occurs on the wall. In this case, illustrated in Figure 4-66b, water reaches the BFE on the wall when the stillwater plus unobstructed waves remain well below the BFE. **To prevent water damage to floor beams and suspended utilities, breakaway walls should be designed to fail when or before wave runup reaches the BFE.**

Structural Considerations. Designing for ultimate capacity requires that the breakaway wall strength at failure be predetermined, and that sizes and spacings of components be selected to assure failure at the desired location and loading. It is not sufficient for enclosure walls to merely breakaway; they must do so predictably.

The best enclosure wall designs use simple construction techniques, materials, and connections. Recommended breakaway wall concepts that meet these requirements were described in the previous section.

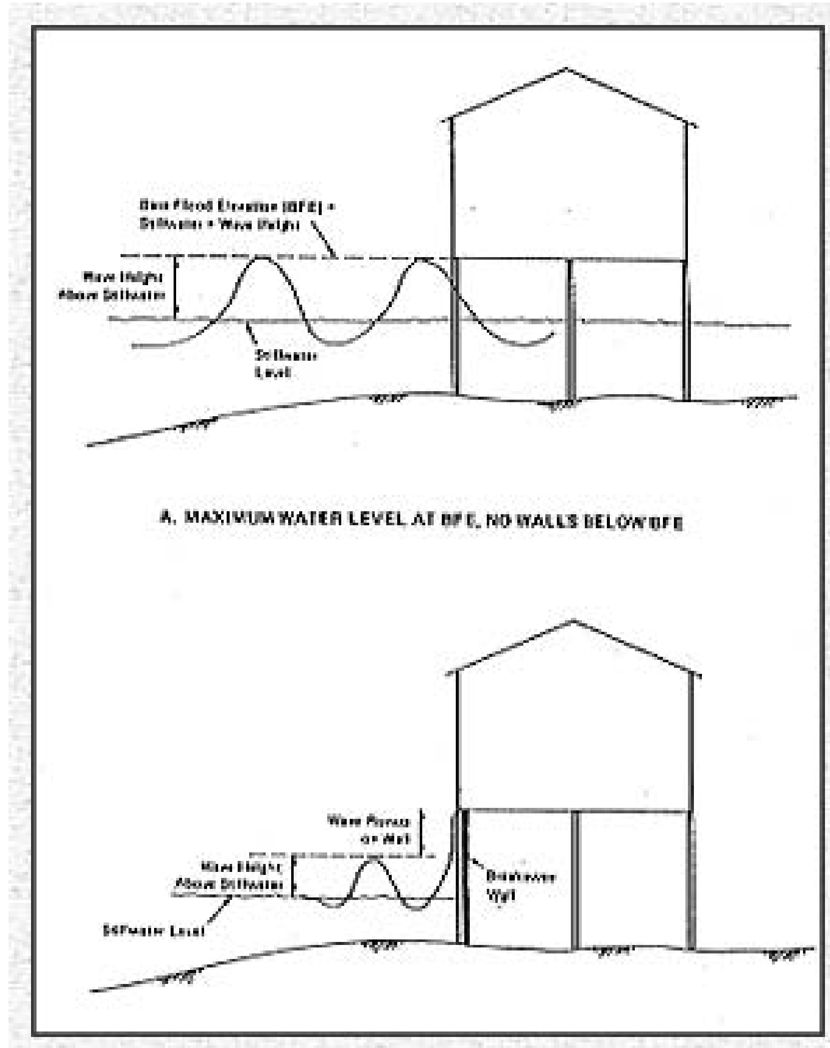

Figure 4-66 a&b. Effect of enclosure walls on waves.

Connections. Breakaway walls should be constructed such that they are fastened to the structural frame on two (2) opposite ends only, either top-and-bottom fastening or fastening on each side. Under lateral loading they will then bend from one plane only, stressing the connections approximately equally. Top-and-bottom connections are preferred and are recommended in this report for three reasons. First, while wind forces are essentially uniform over a flat wall, water forces will be concentrated at the bottom of the wall as the water rises. It is appropriate structurally to have the lower edge remain firmly connected at lower water levels and its connections reach their ultimate capacity uniformly across the bottom as the water rises. Second, stud walls are generally installed with the studs vertical, and should be flexed along the length of the studs. Third, and most importantly, loads on the breakaway walls need to be directed into the floor system of the first elevated floor, in order to assure distribution of the loads to adjacent piles. Side fastening would direct too great a portion of the total load into the piles on the loaded wall.

Included in the above considerations is the basic premise that, unless designed by a registered professional, breakaway walls should be proportioned such that wall strength is governed by the wall's connections to the pile foundation/grade beam system and to the bottom of the elevated floor system. Experience has shown that it is more reliable -- and much easier -- to design connections to fail at a specified level of force rather than have the wall material fail internally.

Working/Ultimate Strength of Fasteners. The safety factor that is used in design depends on the materials used and the accuracy with which one knows the design loads and material properties. To compensate for these uncertainties, working (or safe) load capacities of materials and connections are generally taken conservatively. The "design safe loading resistance" referred to in the NFIP regulations corresponds to a working capacity. The collapse or ultimate resistance of a wall would be higher, corresponding to the factor of safety appropriate to the wall material and fasteners used. Table A-10 provides working and ultimate strength values for fasteners that could be used for breakaway wall connections.

It is important to note the effect of the different factors of safety on the overall safe and ultimate capacities of breakaway walls. That is, walls of different construction, designed to the same standard for safe capacity, will have different ultimate capacities because of their differing factors for safety.

Distribution of Wall Loads. For breakaway walls, wind and water loads cannot be distributed equally among the piles under a structure. Compared to the upper superstructure, the floor beams and joists are an insufficiently stiff system for transfer of lateral loads over any distance. It is therefore reasonable to limit load distribution to among those piles in the enclosed area, and to further limit distribution if piles are widely spaced. A breakaway wall connected to a well-constructed floor system can transfer water or wind loads on the wall laterally for about 8 feet maximum. Therefore, only piles that are within an enclosed area, and within 8 feet of the outside walls of such enclosed space, may share the lateral loads equally with other piles within the enclosed space.

For wider pile spacing perpendicular to the direction of loading, only those piles supporting the loaded breakaway wall, plus those piles attached to the breakaway walls parallel to the direction of flow, carry the lateral forces. This provides some extra margin of safety if the floor system does resist the pile deflection and distributes the forces to other piles, which are not directly subjected to the water loads. The application of

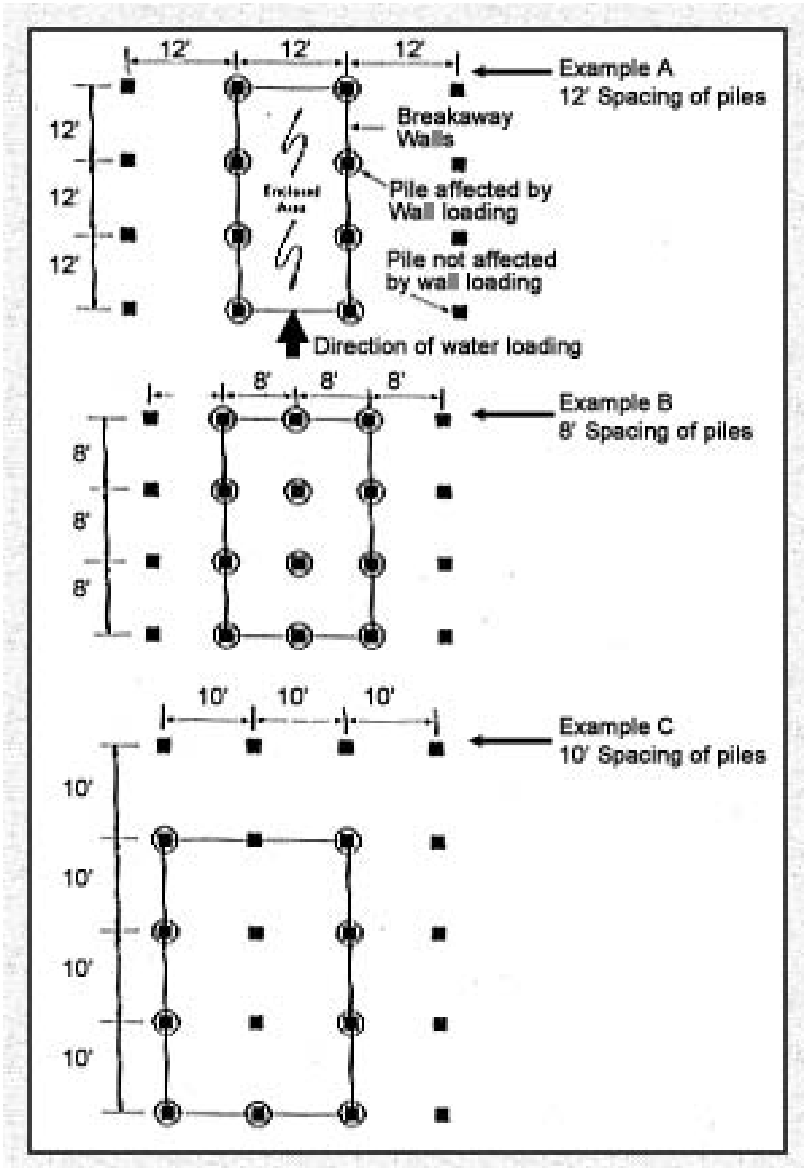

Figure 4-67.

these recommendations to three (3) example pile configurations is shown in Figure 4-67.

It must further be noted that, in general, water loadings can be assumed to act in a direction perpendicular to the shoreline, but considerable variation can occur. Wind can occur from any direction. Therefore, the determination of the number of piles that would resist lateral loads from wind or waves should include consideration of loading both perpendicular and parallel to the shoreline. This would be true particularly for structures that are not aligned normal to the general orientation of the shoreline.

Bracing Considerations for Breakaway Walls. For any house with enclosure walls below BFE, there is an advantage of having floor beams span in the direction of the water flow. This is because the floor beams can assist the front most piles, laterally loaded by water against a wall, to transfer the load back to the tops of piles several rows back from the breakaway wall. If the floor beams run transverse to the direction of water flow, as shown in Figure 4-68, a compression strut (an 8 by 8 or three (3) 2 by 12's, for example) should be placed between the tops of all piles assumed to carry the water loads.

A similar approach should be taken for grade beams. Typical practice is to construct grade beams around the building perimeter only. Grade beams should also be installed on the interior of a building in both directions for all piles considered to carry the breakaway wall load. For the example structure shown in Figure 4-68, this recommendation would require installation of four interior grade beams. These beams will also serve to provide proper support for attachment of the interior breakaway walls.

Knee braces have the desirable characteristic of strengthening both the individual piles to which they are attached and the structure in general. the overall need for knee braces or other bracing is determined using table A-4. The strengthening effect of knee braces on individual piles would be especially important for front row piles supporting breakaway walls subject to water loading, and would assist the piles in resisting shear forces. The front row piles should be considered separately from the overall structure's need for bracing, and knee braces in the direction parallel to expected water forces are a minimum requirement for front row piles that support breakaway walls. Where knee braces or other bracing is used in the same plane with breakaway walls, care should be taken that the bracing does not impede the breakaway capability of the walls.

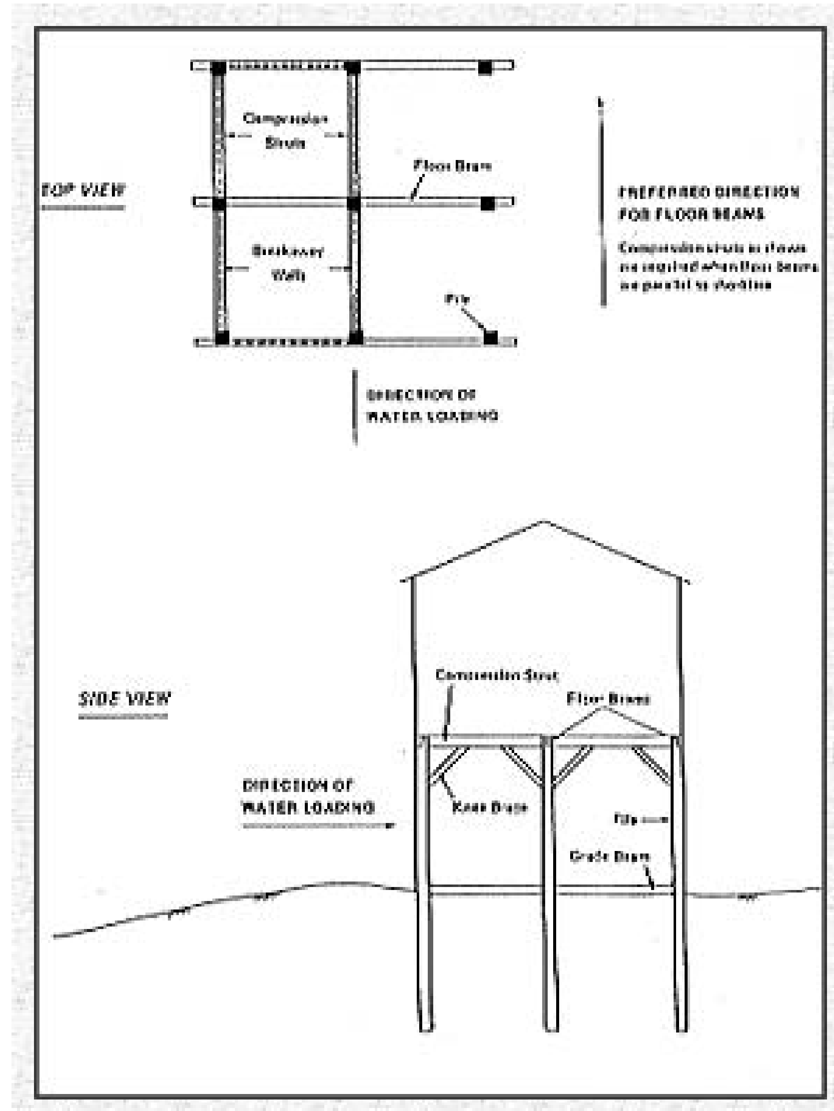

Figure 4-68.

TABLE A-11
FASTENER SCHEDULE FOR BREAKAWAY WALLS

Nails (Wood Stud Wall)

	Breakaway Wall Height (feet)															
	6				7				8				9			
Nail Size	**8d**	**10d**	**12d**	**16d**	**8d**	**10d**	**12d**	**16d**	**8d**	**10d**	**12d**	**16d**	**8d**	**10d**	**12d**	**16d**
Pile Spacing (feet)																
8	8/15	6/10	5/9	-	9/17	6/12	6/10	5/9	-	7/13	7/12	6/10	-	8/15	7/14	7/12
10	10/19	7/13	6/12	6/10	-	8/15	7/13	6/12	-	9/17	8/15	7/14	-	10/19	9/17	8/15
12	-	8/16	8/14	7/12	-	10/18	9/16	8/14	-	-	10/19	9/17	-	-	-	10/19

Notes:
1) Table indicates the range of total (top and bottom) nails that will result in a wall design safe loading resistance between 10 and 20 psf
2) Where an odd number of nails is shown, put the extra nail at the bottom
3) Values for other wall heights or pile spacings can be interpolated

Examples: A 7 foot-high breakaway wall installed between piles spaced 10 feet apart should be fastened with no less than 8 (4 top, 4 bottom) and no more than 15 (7 top, 8 bottom) 10d nails

Screws (Metal Stud Wall)

	Breakaway Wall Height (feet)			
	6	**7**	**8**	**9**
Pile Spacing (feet)				
8	4/5	4/6	4/7	5/8
10	4/6	5/8	5/9	6/11
12	4/8	6/10	6/11	7/13

Notes:
1) Table is used in same manner as nail table above
2) Based on No.6, S-12 screws