SPEIGHT MARSHALL & FRANCIS
A Professional Corporation

# Technical Bulletin

FROM SPEIGHT, MARSHALL & FRANCIS, P.C.

Structural Engineering - Special Inspections
September 2009
Bulletin No. XXXVI

# Horizontal Force Resisting Elements

## Introduction

Our previous "Lateral Loads" Technical Bulletin discussed sources of lateral loads induced on a structure associated with wind, seismic, and blast. The Lateral Force Resisting System (LFRS) is the structural assembly that resists lateral loads and transfers them to the foundation and underlying soils. The LFRS can be separated into two sets of force resisting elements, horizontal and vertical. This Technical Bulletin will concentrate on horizontal force resisting elements, most commonly referred to as diaphragms.

## Horizontal Force Resisting Elements

The primary function of a Horizontal Force Resisting Element (HFRE) is to collect the lateral loads applied to a building and transfer them to the vertical force resisting elements. The most common types of HFREs are floor and roof diaphragms. In addition, HFREs typically brace various structural members such as joists, beams, columns and wall elements. The diaphragm is the horizontal structural element that transmits lateral forces to the vertical-resisting elements. The strength of a diaphragm increases with its depth, since the horizontal forces distribute along its depth. For instance, a 20 ft deep diaphragm will have approximately twice the capacity as a 10 ft deep diaphragm.

Examples of HFREs:

- Concrete slabs
- Steel Deck
- Wood Sheathing (OSB, Plywood, etc.)
- Horizontal Trusses
- Drag Struts

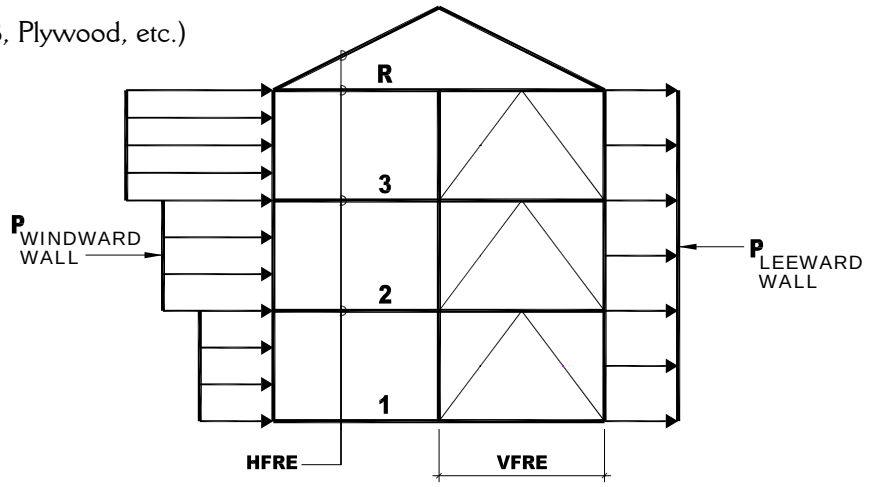
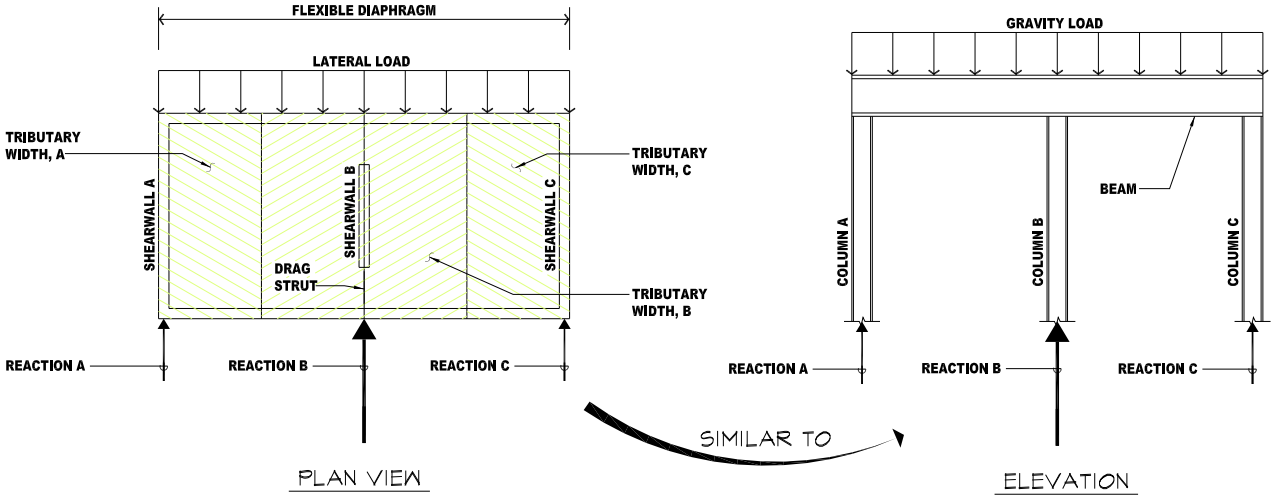



**FIG. 1**

**(SHOWS INTERACTION OF WIND PRESSURE, HFREs AND VFRE)**

Diaphragms can be classified as flexible or rigid. This primarily depends on the stiffness of the diaphragm versus that of the Vertical Force Resisting Elements (VFRE). A wood floor nailed to floor joists is an example of a flexible diaphragm. A concrete slab is an example of a rigid diaphragm. Flexible diaphragms distribute loads to VFREs based on tributary width, whereas rigid diaphragms distribute loads based on the stiffness and location of the vertical resisting element. For example, the manner in which a flexible wood floor diaphragm spans to a wood shearwall is similar to the manner in which a beam spans to its support columns as shown in Figure 2. Alternatively, a rigid concrete slab spanning to a 16" wide concrete shearwall will be approximately twice as stiff as an 8" wide concrete shearwall and will receive approximately twice the lateral load. Another horizontal element is the drag strut. A drag strut, or collector, is a structural member parallel to the applied load that distributes the load directly to the Vertical Force Resisting Elements (VFRE). In situations where a diaphragm is shortened due to a building opening, the vertical force resisting element is detached from the diaphragm, or the diaphragm chord is too weak, a drag strut can be used.




**LATERAL LOADS ON DIAPHRAGMS (HFRE)** **GRAVITY LOADS ON BEAMS**

**FIG. 2**

**(SHOWS DIAPHRAGM LOADING COMPARED TO GRAVITY BEAM LOADING)**

There are many items that can affect the HFREs when laying out a structure. Floor plans with discontinuities and irregular layouts often require the quantity and size of the diaphragm connections to increase. Another factor affecting the strength of a diaphragm is the spacing of the floor or roof members. For instance, a typically fastened 1½" x 22 gage steel roof deck diaphragm supported at 4 ft on center has a shear resistance nearly double that of one supported at 8 ft on center. If the optimum layout is chosen, HFRE labor costs and materials can be greatly reduced.

## Conclusion

Understanding how HFREs work is a critical part of building design. The selection of construction materials, building geometry, opening locations, seismic design categories, etc., all contribute to the efficiency and types of HFRE that are chosen. Proper consideration for these factors could lead to a more economical structural system.

Be on the lookout for our next Technical Bulletin discussing Vertical Force Resisting Elements.

SPEIGHT, MARSHALL & FRANCIS, P.C.
2125 McComas Way, Suite 103
Virginia Beach, Virginia 23456
www.smandf.com
(757) 427-1020
(757) 427-5919