

# ARXX™ HIGH PERFORMANCE WALLSYSTEM

– A Comparison, Under Lateral Earth Pressures, with Plain Concrete and Concrete Masonry Units –

## Summary

A variety of concrete wall configurations were analyzed for their resistance to lateral earth pressures that are typical in residential house construction. The study was undertaken by an independent consulting engineering firm, widely recognized for its expertise in foundation wall design.<sup>(1)</sup> The study focused on 8 foot high walls only, and assumed full height backfill. For purposes of this analysis, three classes of soils were selected as representative of the full range of soil types likely to be encountered in a large majority of cases in North America.

## Principal Conclusion of the Study

Properly reinforced, the 6.25 in. Arxx Wallssystem is demonstrably more resistant to lateral earth pressures than an 8 in. plain or lightly reinforced cast-in-place concrete basement wall. Moreover, neither 8 in. nor even 12 in. concrete masonry wall systems commonly specified and used in many regions of North America, approach the lateral strength capabilities of the Arxx High Performance Wallssystem.

## Scope of the Study

The purpose of the study was to compare the capacities of each of the following sections to resist lateral earth pressures over a broad range of possible loading types:

- › 8 in. plain or nominal reinforced cast-in-place walls (8 in. plain)
- › 8 and 12 in. Concrete Masonry units (8 or 12 in. cmu),
- › 6.25 in. concrete core/reinforced Arxx units (6.25 Arxx).

Each of the subject sections were compared using the most prevalent code limitation, a 30 pcf lateral pressure.

Additionally, the design portion of the study gave consideration to three broadly defined soils typical of the range of materials used to backfill residential foundation walls. This produced a suggested reinforcement schedule to meet the lateral load conditions in the Arxx Wallssystem.

The strength analysis of the selected wall designs applied the recommendations of the American Concrete Institute for both reinforced and plain concrete design (ACI 318 and 318.1), and for the masonry foundation walls, the National Concrete Masonry Association.

To investigate the strength requirements to resist the loads imposed by a range of soil types, soils classifications put forward by the Concrete Reinforcing Steel Institute in its Handbook (1982) were chosen. (See “Soil Properties Used for Design”, Table 14-1). These soil classifications are illustrated in the following two tables:

Table 1: Soils Classifications

CLASS A	includes clean sand, gravel, broken stone, free of fines that might obstruct free drainage
CLASS B	includes granular soils, mixed grain sizes, dense enough to cause low permeability
CLASS C	includes fine silty sands, granular soils with some clay, some glacial tills. Note that the basic horizontal pressure is liquid pressure. Class C backfill designs will also suffice for some combinations of Class A or B soils with partial height water table, thus extending the applicability of these designs

Using these soils classifications, the CRSI puts forward the following horizontal load factors when considering lateral earth pressures:

Table 2: Lateral Force by Soil Type

CLASS OF SOIL	HORIZONTAL FORCE ACTIVE psf/L.F.
A	30h
B	45h
C	62.5h

Where h is the height below the top of the wall

It should be noted that the Council of American Building Officials (CABO) requirement in the 1 & 2 Family Dwelling Code, is that soils exhibiting more than the 30 pcf pressure “shall be designed in accordance with accepted engineering practices”. In addition to the foregoing assumptions with respect to soil types and loadings, two additional conditions were stipulated for prudent design practice:

- › Selection of vertical and horizontal reinforcing in accordance with ACI 318 Section 14.3, Structural Design of Walls
- › Selection of Load Safety Factor to resist lateral earth pressures, in accordance with ACI 318, Section 9.2.4

Under the discipline of the foregoing design procedures, it is concluded that the 6.25 in. Arxx Wallssystem, reinforced with a minimum of #3 bars @ 16 in. o.c. in the vertical, and #4 bars @ 16.75 in. o.c. in the horizontal will adequately resist a free draining soil for an 8 foot height of backfill. The table at the beginning of the following page illustrates the corresponding steel requirements under more severe lateral earth pressures.

Table 3: Reinforcement Requirements

SOIL TYPE/PRESSURE	MINIMUM VERTICAL STEEL REQ'D	MINIMUM HORIZONTAL STEEL REQ'D
Class A/30 pcf	#3 @ 16 in. o.c.	#4 @ 16.75 in. o.c.
Class B/45 pcf	#4 @ 18 in. o.c.	#4 @ 16.75 in. o.c.
Class C/62.5 pcf	#4 @ 13 in. o. c.	#4 @ 16.75 in. o.c.

It is important to note, for walls designed under the requirements of ACI 318, it is permissible to use wall thicknesses less than the 7 1/2 inches by using the option to the empirical design procedures.

### 6.25 in. Arxx versus 8 in. Plain Concrete and versus 12 in. Concrete Masonry Units

It is widely believed that 8 inch thick plain concrete and 12 in. wide concrete masonry walls and the 6.25 in. concrete core Arxx Wallsystem will each provide adequate lateral strength to meet the lateral load pressures of the 30 pcf Class soil for walls of 8 foot height or even greater. However, there is some satisfaction in knowing which of these wall systems offers the best moment resistance against lateral earth pressures.

For the 8 in. concrete section, the comparison was made using ACI 318.1 for plain concrete, and specifically, the section dealing with extreme fiber stress in tension. Thus we were able to compute the Ultimate Moment Capacity of each of the sections. The results of these calculations are tabulated below.

Table 4: Moment Capacity of Concrete Sections by Type

6.25 in. Arxx	6.25 in. Arxx	8 in. Nom'l (7.5 actual) Plain Conc.	8 in. Actual Plain Conc.
#3 bars vert. @ 16"	#4 bars vert. @ 16"	#4 bars vert. @ 48"	#4 bars vert. @ 48"
Moment Capacity of Section* Foot Kips			
1.67	2.92	1.67	1.90

\* for 8 ft. wall height and 3000 psi compressive strength @ 28 days

The foregoing shows that the Arxx wall can be configured through reinforcement to strengths 54 to 75 percent above plain or lightly reinforced concrete walls.

Similarly, using the design guides of the National Concrete Masonry Association, the load capacity for lateral loading can be taken from their tables for both reinforced and unreinforced concrete masonry. With axial loadings of no less than 500 pounds of axial load per running foot of wall, the Moment Capacity comparison is derived as follows:

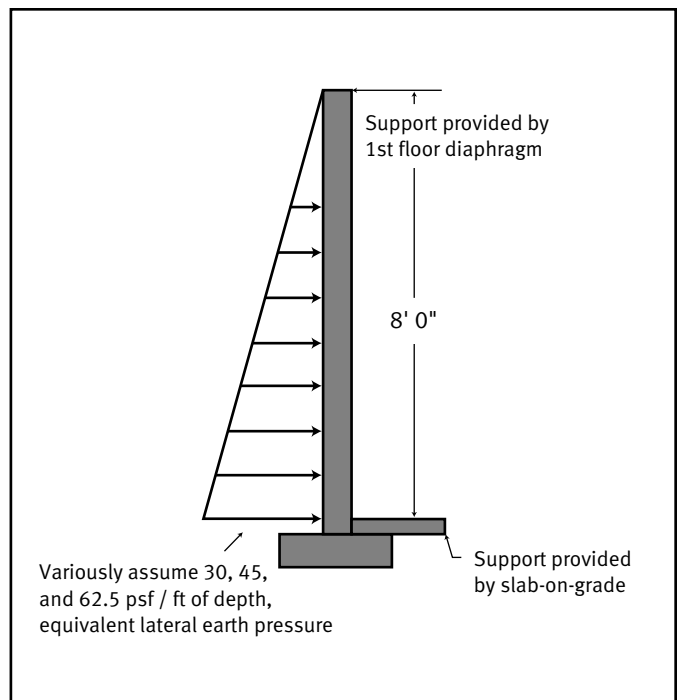
Table 5: Moment Capacities, Arxx Wallsystem and Hollow Concrete Masonry Units:

(assumed 500 plf. axial load)

Arxx 6.25 in. #3 bars vert. @ 16"	8 in. CMU		12 in. CMU	
	unreinf.	reinf. #4 bars @ 48"	unreinf.	reinf. #4 bars @ 48"
Moment Capacity of Section* Foot Kips				
1.67	0.30	0.61	0.61	0.95

### Conclusion:

Clearly, the 6.25 in. Arxx Wallsystem is far superior to concrete masonry as a system to withstand the lateral forces of earth pressures for residential foundation walls.



Schematic: Lateral Loading of a Foundation Wall

<sup>①</sup>The design and analysis work that forms the basis of the foregoing discussion was prepared by Mr. Edward P. Hutson Jr., P. Eng. Mr. Hutson, a graduate of Purdue University (master of science in structural engineering), is a partner in the firm of Norton & Schmidt Consulting Engineers LLP, 1100 Main Street, Ste 419, Kansas City MO, 64105.

Arxx Building Products would like to thank Norton & Schmidt and Ed Hutson, in particular, for his thoughtful approach to this engineering analysis.