Technical Features − Fire Construction
Specifying the Most Important
Walls In Your Building

CONSISTENT IN−SERVICE PERFORMANCE KEEPS USG CAVITY SHAFT WALL SYSTEM AHEAD OF THE FIELD

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(Editor’s Note: This article originally appeared in the 1991, Issue 1 of Form Function. Some pictures, graphics or charts may not appear in this version. Printed copies of this article, or information about the products mentioned in it, can be obtained by writing: Editor, FORM FUNCTION, 125 South Franklin Street, Chicago, IL 60606−4678.)

It’s no coincidence that the tallest and most prestigious buildings built in the United States since 1969 have used variations of the drywall shaft−enclosure system that U. S. Gypsum introduced that year. The current generation of the system has more fire−protection and structural features than ever. But you don’t have to be designing the tallest building in the world to use the proprietary features of this system. This system has a performance edge that gives it significant advantages over both concrete block and other drywall systems, whether the building is four or 40 stories tall.

USG Cavity Shaft Wall is the system of choice among architects and contractors because of the intensive testing and detail refinements that have been developed into its design. The most important walls of a building deserve this consideration since they are vital life−lines, facilitating safe movement of people, communications, power and other utilities in case of fire. Here are some of the proven features of this unique system.

The Tested System

The economy, lightweight, ease of erection and one−sided installation characteristic of the system have enabled the USG Cavity Shaft Wall System to dominate the high−rise shaft−enclosure market in most geographic areas. Because it is a drywall system, it offers the low cost of drywall, and its easy installation features make it economical to install. The basic 2−hr. fire−rated system weighs just 9 lb/sq. ft. and is only 3−1/2 in. thick, and the fire rating is applicable with or without acoustical insulation in the stud cavities. The basic system consists of 25−ga., 2−1/2−in, deep USG Steel C−H Studs, 1−in. Sheetrock Brand Gypsum Liner Panels (which engage the flanges of the C−H studs) and two layers of 1/2−in. SHEETROCK brand Gypsum Panels, FIRECODE C Core. IMPERIAL FIRECODE C Gypsum Panels can be used in place of the SHEETROCK brand Panels if a veneer plaster finish is desired. The assembly of the system with the stud−flanges engaging the shaft wall liner panels is progressive and permits the entire assembly to be installed from the floor side of the shaft.

The USG Cavity Shaft Walls are covered by all three model building codes

(BOCA, ICBO and SBCCI) under National Evaluation Report NER−258. The system has been designed and tested using accepted engineering practices with deflection criteria of L/120, L/240 and L/360 clear partition heights. Additionally, limiting height tables for the system account for flexural and shear forces. Variations of the system have been fire tested up to 4 hrs., including four UL design listings up to 2 hrs.

Over twenty years of successful experience with this system on construction projects is proof that it performs up to expectations. However, just doing the job is not good enough. U. S. Gypsum has used this construction experience to incorporate many improvements that make the system lighter, more economical, easier to install and able to perform better. The original system was a solid gypsum wall using a steel H−stud; the next generation had a cavity created by using a steel box "T" stud; the current generation system uses a steel C−H stud which is lighter in weight and permits less heat and sound transmission than the previous type stud did.

This wealth of experience has led U. S. Gypsum to fully understand all the criteria needed for fire−rated shafts, to then develop the elements that best meet these criteria, and to conduct tests to assure that the system satisfies the criteria. Two unique tests of the USG Cavity Shaft Wall System usually ignored by others include fire tests of the system with each of 20 elevator entranceways from nine manufacturers; and fire tests of the wall with penetrations for call buttons and floor indicators. These tests are vitally important because they confirm that the USG Cavity Shaft Wall System provides the fire−protection required with detailing representing actual job conditions.

The elevator entranceway tests were conducted using the standard 2−hr. fire−rated USG Cavity Shaft Wall System in tests at Underwriters’ Laboratories Inc. The interface of the wall with the entry system requires a 20−ga. J−strut with a 3−in. leg at the doorjamb; both the thickness and width of leg are necessary to meet the 1−1/2−hr. "B" rating for the door as demonstrated by the test. Note that ASTM El 52 requires that the door frame be installed in the wall in which it was tested.

In the call−button and floor−indicator penetrations test the system maintained 2−hr. fire endurance when tested with these penetration details per ASTM E119 fire exposure (certified and witnessed by Consulting Engineers Group).

Another important test was that of a shaft wall/beam interface. This test demonstrated that the fire protection of a 2−hr. protected steel beam is not adversely affected when the beam is oriented in the plane of the shaft wall, even though fireproofing must be removed from a portion of it to allow attachment of the shaft wall runner track.

Scores of tests have been conducted with the USG Cavity Shaft Wall System to provide fire−rated systems of 1, 2, 3 and 4 hrs.; sound ratings up to 51−STC; and special applications, such as horizontal applications for ceilings, stair soffits and metal duct enclosures.

U. S. Gypsum has even conducted oscillation tests to check wall performance under full design load cycles representing the buffeting from elevator movement during the life of a building. In the tests, the shaft wall was subjected to one million full oscillation flexing cycles caused by the positive and negative air−pressure loads of high−speed elevators in a shaft. These tests showed that a minimum 24−ga. J−runner is needed at the top and bottom of the shaft wall assembly to ensure system longevity. There is no record of a record of a failure of this system resulting from elevator air pressures in the twenty−plus years the system has been installed.

None of the competitive systems on the market comes close to equaling the performance of the U.S. Gypsum System. The closest competitors rely on a tabbed stud system which supports the liner panel with small tabs bent out from the web of the stud. However, comparing the performance features of the tabbed stud to the USG Steel C−H Stud shows that the continuous edge support provided by the C−H stud gives airtight smoke−tight, rattle−free construction that the tabbed stud systems can’t. Also, the C−H stud has as much as 21% more steel in it than some tabbed studs, making it more costly to produce, but adding to its strength and performance.

Formula Developed To Determine Elevator Shaft Pressures

Building codes address shaft walls in the same manner as standard partitions in terms of design pressure. However, interior walls or partitions are not usually designed to be subjected to substantial differential pressures and normally require only enough strength to withstand people−induced loads (pushing, leaning, bumping).

However, shaft walls are "working walls," subjected to continual flexing caused by positive and negative pressures as elevator cabs rise and descend. Actual measurements of shaft pressure due to elevator movement in high−rise buildings, conducted by U. S. Gypsum, revealed a pressure of 5.15 lb/sq. ft. in a typical case (compared to a residual shaft pressure without elevator movement of 3.64 lb/sq. ft.). Thus elevator shaft enclosures are subjected to live cods and must be designed accordingly. Realistically, "working" shaft walls should be designed to withstand the 5−lb. /sq. ft. pressure of "non−working" interior partitions, plus the load added by the operation of the elevator. For shaft enclosures without elevators, the design load should be 5−lb/sq. ft. plus the residual differential pressure anticipated. From a life−safety standpoint shaft enclosures are the most important walls in a building in the event of a fire because they house channels for the movement of people (occupants exiting and firefighters entering), communication, power, water, fresh air and exhaust. Thus the utmost concern should be given to making sure that they won’t fail.

The fire−resistive requirements for shaft enclosures are adequately covered by the building codes, but the structural requirements for the design of shaft enclosures need upgrading to reflect actual load conditions. The following U. S. Gypsum test data was derived from measurements in three high−rise buildings ranging in height from 17 to 100 stories and may be used as a guide to calculate the needed design elevator shaft pressure.

From these test data, the following formula was derived to reveal anticipated maximum pressure in shafts containing one or two elevators:

$P_s = P_c + (2/3)(V_e/400)$ 1.32.

For shafts containing three or more elevators:

$P_s = P_c + (2/3)(V_e/1000)\ 1.32.$

In the above formulas P_s is design pressure or negative pressure in the shaft in lbs/sq. ft.; P_c is code design pressure or designed static pressure for surrounding wall or partitions without elevators; and V_e is velocity of elevator in ft./min.

From these formulas, the design elevator pressure may be generalized to the values shown in Table 1. It seems apparent from the values in Table 1 that the codes should recognize elevator shaftwalls as being uniquely different from other non−load−bearing partitions. The currently allowed 5−lb/sq. ft. minimum load would rarely be adequate for any elevator hoistway enclosure other than hydraulic ram−lift cab units. U. S. Gypsum would recommend that the design load for elevator shafts be based on the values shown in Table 1; that shaft enclosures without elevator movement be designed for a design load of 5−lb/sq. ft. plus the anticipated pressure differential; that the structural elements of the wall (steel framing) be designed within the stress limitations of the code; and that the maximum deflection of the wall be upgraded to L/240 to minimize the appearance of movement due to buffeting from passing elevators. Occupants should feel equally protected from falling down a shaft as they are from falling out of a building.

Choice Of Criteria For Limiting Height Determination

The testing and research that have gone into the USG Cavity Shaft Wall System also provide more useful data for designing shaft enclosures subjected to unusual circumstances. Limiting heights tables in the U. S. Gypsum literature provide data based on the factors that can cause failures as well as four intermittent air−pressure loads and three deflection criteria.

Instead of providing limiting heights based only on the deflection failure point as many suppliers do, the U. S. Gypsum tables include limitations based on bending stress and end reaction shear so that all governing factors can be considered. Deflection is the degree of actual bending or displacement under load that a particular wall undergoes while performing its function. Bending stress is the unit force that will break or distort a stud (lighter−gauge studs generally will fail with less stress than heavier−gauge studs). End reaction shear is determined by the amount of force applied to the stud that will bend or shear the J−runner or cripple the web of the stud. Limiting heights are established with an allowable bending stress and shear and an ample safety factor to prevent failure by that mode.

In addition, the tables provide data for four intermittent air pressure loads (5, 7.5, 10 and 15 lbs/sq. ft.), a variety of stud sizes (2−1/2, 4 and 6 in.) and gauges (25, 22 and 20−ga.) and three maximum deflection criteria (L/120, L/240 and L/360). The L/240 deflection criteria is recommended by U.S. Gypsum for most situations and the L/360 may be used to upgrade quality and performance of the structure, as well as to accommodate marble, ceramic tile, plaster and other such finishes.

Long−Term Performance Factors

Recognition of the risks from potential failures has caused design professionals to give greater thought to the long−term performance of shaft wall systems. Lower−cost "economy" systems with no established track record have recently been introduced to the market. It takes a good understanding of the factors governing the performance of shaft wall systems to determine whether these systems will provide long−term life−safety, given the continual flexing that these important walls must endure.

For instance, the structural integrity of the USG Steel C−H Stud is the result of extensive testing and more years of installation experience than have other shaft wall studs, such as the lightweight studs with tabs designed to engage gypsum panels. Other components used in the USG Cavity Shaft Wall System, such as the 24−ga. J−runners and entranceway 20−ga. (with 3−in, leg length) J−struts, represent system requirements based on testing that other manufacturers have not addressed.

Furthermore, the USG Cavity Shaft Wall System has been developed and tested for other useful applications. One such application is using the system in a horizontal plane, such as for enclosing ducts or corridor plenums requiring a 2−hr. fire rating. The one−sided application feature also makes the system ideal for 2−hr. furring applications and enclosures around air−handling systems.

It is critical to the building designer that these vital walls be considered more carefully than most other walls in a building. Failure to consider the factors that affect performance of these walls can result in tragic failure in both high−rise and low−rise buildings. The use of the USG Cavity Shaft Wall System with its years of experience and proven reliability allows architects and engineers the reassurance that the most important walls in their buildings will perform safely.

Twelve Reasons to Choose USG Cavity Shaft Wall

1. The basic system is UL classified (UL Designs U438, U459, U467, U469).

2. National Evaluation Report (NER−258) assures acceptance by all three model code bodies (BOCA, ICBO, SBCCI).

3. All major elevator door manufacturers have tested their doors at UL in USG Cavity Shaft Wall (successfully using the U.S. Gypsum 3−in, leg, 20−ga. jamb strut detail).

4. ASTM El52 standard test for door frames doesn’t allow substitution—the door frame must be installed in the wall in which it was tested.

5. Fire−tested penetration details for call boxes and position indicators.

6. USG Steel C−H Stud offers continuous edge support of liner panel for airtight, smoke−tight rattle−free performance.

7. USG Steel C−H Stud has no tabs to bend, break, cut installers hands or delay the job.

8. USG Steel C−H Stud blank width is wider and contains 21% more steel than some competitive tabbed stud blanks, making it stronger and more resistant to fatigue.

9. Most comprehensive limiting height information allows for safer design practices.

10. Pressure tested to one million cycles proves system longevity.

11. Only wall for which a UL smoke and fire damper test is available.

12. More than 20 years of proven performance.