Good Evening.

Well, those of us are here can finally get some work done. I hope you've actually read Chapter 10 and Chapter 16, and I hope you're ready to absorb a bit of data in advance of absorbing all that turkey.

[1] In any case, we're back to where we were last week. I'll repeat what I said before: The chapter on Masonry Loadbearing Wall construction includes some of the most important concepts you'll encounter this semester. The irony is this: You will rarely get a chance to design for a "loadbearing" wall, unless you are working on an existing, historic building. [2] Here are the systems involved in those kinds of buildings, which we've studied to some extent earlier in the semester.

[3] Although there are exceptions in the current construction industry, masonry is seldom used anywhere except as either a veneer or an "enclosure" material, such as fire stair towers or foundation walls for small-scale projects. You'll find masonry partitions, non-bearing, in certain institutional projects such as schools. [4] Wherever the impact of occupancy might provide significant wear and tear, masonry is often the material of choice. But as structure? Hardly ever... Not these days.

And that's a shame, since so much of our architectural sensibility is shaped by the historical importance of masonry. [5] In many of our environments, even the fake the details relate to real details which emerged essentially from the masonry vocabulary. Already this semester, how many times have you heard about Louis Kahn's conversations with bricks? How many times have you heard me "diss" cheaper types of construction while praising the capabilities of stone or brick?

But although you may be sick of hear about these things by now, there's still a reason for paying attention to the detailing of Masonry. That's because of its continuing importance as a finish material and, more significantly, because of the clarity with which we understand its detailing requirements. [6] If, for instance, you want to understand flashing, you need to see how flashing works with masonry. If you're curious about "rain screens" using lightweight panels like Swiss Pearl or Trespa, well, the masonry cavity wall was the original rain screen. [7] If, on the other hand, you want to understand how we detail for expansion, here too, our treatment of masonry pretty much determines how we detail expansion in other materials as well. In almost all technical circumstances, masonry was there *first*!

[8] The book begins its treatment of Masony Bearing Walls by reminding us that "masonry walls must be designed not only to support structural loads, but also to resist water penetration and the transfer of heat between indoors and outdoors." If we add to that "to resist failure due to its own thermal expansion and contraction," then we have completed the suite of requirements of any wall in question.

[9] Let’s start with an inventory of Wall Types:

Reinforced or unreinforced;
Homogenous (a single type of masonry unit) or Composite (two or more types of units);
Solid or Cavity.

It’s safe to say that these days, all masonry walls are reinforced. The reinforcing may be simply to pin one wythe to another or to assure that during thermal expansion, the movement remains homogenous. More significantly, the vertical bond of the masonry may be reinforced with steel rods similar to concrete reinforcing, so the bearing capacity and the lateral force capacity is significantly increased. Reinforced Masonry systems have now become rationalized so that certain economies of scale have reintroduced masonry as a competitive system for certain types of low-rise construction.

Post-tensioned Masonry Walls offer similar advantages to other post-tensioned systems, including a slimmer profile and potential labor savings compared to assemblies of other systems.

Now, why is it so common to introduce a different kind of masonry unit in a wall, even if we are not using a cavity to resist moisture infiltration? Why are Composite Masonry Walls so common?

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That’s right. The book uses the phrase “optimum balance,” and to be sure, there is an obvious economy to create a composite wall where one material is better at being a “finish” while another, cheaper material does the heavy-lifting so to speak. Naturally, to introduce a mix of materials means that attention need be paid to the mutual, physical connection between the different units. Most important, however, is to be sure that the thermal and moisture expansion characteristics are not significant.

And what would be significant? Well, if on a hot day one wythe gets this big, and the other gets this big, well, something’s got to give. And with masonry, you don’t really get a second chance: Any cracks or voids won’t be self-sealing against the elements. If you break it, you bought it.

The most obvious example of differential expansion potential is in walls with brick wythes and CMU wythes. Bricks will tend to expand over time, due to moisture; and concrete products will tend to shrink, due to long-term curing. This dilemma is usually solved by insuring that each wythe can expand independently; that each wythe is given the appropriate control join regimen; and that the ties connecting the wythes accommodate the required differential expansion. And, sure enough, the market has provided practices and products which take all this into account.

Reinforcement can go some ways towards weaving disparate elements together; but the best solution is to make sure both elements in composite assembly will move in similar fashion. To be sure, avoiding extremely incompatible materials and their placement in extreme environmental conditions is just common sense.

* * *

[10] But the most significant concept in masonry wall construction has surely been the Cavity Wall. A cavity wall is a double-wythe assembly in which the two wythes are separated by a continuous air space, bridged only by corrosion-resistant metal ties and containing only materials to ensure either additional water-resistance, insulation, or continued air flow throughout the cavity.

What a concept!

The theoretical basis of cavity-wall behavior is the movement of fluids under differential pressure. The exterior face of a wall is under severe attack from wind, sun, and driven precipitation. Although there are materials which might be considered impervious to all three, most kinds of masonry -- and especially brick -- will inevitably fail in some way.

It’s no secrete that brick and limestones are porous to a significant extent. Certainly, the mortar joints between the masonry units will undergo deterioration with time, creating at best hairline cracks and fissures in local areas. My point is that moisture, driven by significant pressure, will push through a wall with a certain inevitability.

But something does change as that moisture travels to the inside face of the outer wythe. If the inner air cavity is maintained at an equal pressure to the exterior, the kinetic energy of the driven moisture will easily be dissipated and resisted by the brick wall itself. Bricks are heavy, compared to air -- no contest. So once moisture has gotten through to the inside face of the brick, it really has no where else to go but... down. Down, the inside face of the brick.

So that's the real genius of the cavity wall: Design for Failure. Of *course* the wall is going to leak. But when it does, we have provided a catchment and release system for that moisture. The outside face of the *inner* wythe, the wythe which actually borders our interior spaces, should remain dry.

This is the rain-screen principle, and in fact all modern exterior systems are based on it in one way or another. The air space becomes a "pressure-equalization" chamber, and allows *both* moisture to drop to its release at the wall base *and* air flow to rise to eject excess heat and humidity.

So the key to the cavity wall is that air space. Woe betide the assembly in which that air space is filled in by trash or by mortar. Construction workers are notoriously perverse dudes, and you'll find they take special pleasure in collecting beer bottles, coffee cups -- whatever detrius they brought to work that day -- and leaving them in your nicely-design wall cavity. That's bad news.

So, as a rule of thumb, Architects like always to specify a 2" free air space, big enough to accommodate the tolerances of masonry construction and the encroachment of other bits and pieces. If the Architect chooses to apply board insulation at the face of the interior wythe, the 2” is measured from the face of the board; the masonry wythes themselves are separated by, say, 4 inches. And so on. Leave the air space clear, and your cavity wall might actually function like they teach you in school.

[11] So what other components are necessary in a Masonry Cavity Wall? We’ve talked about metal ties, connecting the inner and the outer wythe, and I’ve alluded before to flashing at the base of the wall.

We’ll speak more carefully about flashings in a minute. Suffice it to say that flashings are sheet-barriers to the movement of water. In a Cavity wall, flashings are introduced at least at every floor to direct to the exterior moisture which has found its way into the cavity. Flashings span the cavity and extend through the outer wythe so moisture can drip out on beyond the face of the building. Weep holes, which are regularly-spaced gaps in the vertical jointing just above the flashing, allow water to move out easily. Spacings range between 16” and 24” on center. The vertical joints are often provided with string wicks or plastic inserts to insure that the weeps are installed free of mortar. Such inserts also prevent the migration of vermin into the cavity once the channels are kept clear.

Another recent innovation to maintain the integrity of the air space is a “mortar control device.” This is a loose-gauge, open mesh placed immediately above the flashings to ensure that mortar and other jetsam does not collect at the base of the cavity, so that water is not retained within the wall.

Back to flashing: What, typically, is flashing? The book describes two kinds of flashings, external and internal.

[12] External flashings are sort of a no-brainer, but they have to be detailed “by the rules” like everything else. These elements include copings at the tops of walls or termination strips at the edges of roofs. The think to consider with external flashings is that they have to lap sufficiently over other exterior materials and they have to be fastened appropriately to withstand uplift, traffic, and expansion stresses. Exterior flashings often have to interface with related items like expansion joint covers and finishes, so in many cases their connection to the building becomes a complicated assembly of counter-flashings, reglets, and fascias. The book gives the example of base flashing at a flat roof, something we’ll talk about next week.

Internal flashings are more directly relevant to our discussions. In addition to their location at the base of cavity walls, flashings are also present at every wall opening, including windows, doors, and vents. Flashings also have a role at interruptions in the wall such as shelf-angles and supporting slabs. If you don’t want it to get wet, you need to flash it.

[13] Window flashing is the most significant general case of wall penetration protection. The dilemma faced by flashing windows in a cavity masonry wall is that the window itself

has to span the cavity!

What a joke!

You spend all this effort separating your wythes and keeping them separate; but you then plop in a product whose very nature is to compromise the thermal and moisture behavior of the assembly! Windows! I hate them.

Well, not really, since one begins to take pleasure in the perverse challenges of each new window assembly, which is always a little bit different than the last one. Windows in masonry walls have to be studied at their sills, at their heads, and at their jambs. [14] Flashings for heads and sills need to consider the jambs, too, so that an awareness of the 3rd dimension is a significant part of the success or failure of detailing flashing. [15] You can see here typical details of moisture protection at windows, and how these schematics designs terminate at the jambs is always a challenge. Entire institutes exist whose purpose is to study the prescribed folds and terminations of metal flashing for masonry walls and other systems.

So what is Flashing made of? [16]

Flashing is a sheet-formed material made from sheet metal, plastic, elastomeric compounds, or composite materials such as rubberized fabric. Metals, such as copper and stainless steel, are the best and most durable; they are also relatively expensive. Cheaper metal products like galvanized steel can deteriorate over time, and otherwise rust-resistant metals like Aluminum and lead can react chemically with the mortar. Plastic flashings, at the other end of the cost spectrum, usually don’t last long enough to be useful. The happy medium seems to be composites like copper-foil-faced fiberglass mesh, or a bitumen-coated fabric. But certain of these may deteriorate fast if exposed to sunlight.

A common detail in commercial construction integrates a composite, through-wall flashing with a stainless steel drip-edge which acts as the “exposed” end of the flashing. This protects the flashing membrane itself from the worst of exposure and provides a clean, finished look along the facade of the masonry walls.

The book points out that flashings within a wall are nearly impossible to replace. Once they’re in, they stay in. So you really should get them right the first time, and the investment in good materials is almost always warranted.

* * *

Another component of all exterior walls is the thermal insulation, but it’s hard to see how masonry can help us out here. Masonry is at once a good conductor of heat and a good retainer of thermal energy. Introducing a cavity acts both as a thermal bridge and a “chimney” for the active relief of thermal energy due to solar gain. But that’s not sufficient to keep heat *in* during the winter.

[17] The book mentions three ways in which we can insulate masonry walls: On the outside face, within the wall, and on the inside face.

Placing insulation on the outside of the wall implies that the water barrier migrates to the outside plane of the insulation itself. Therefore, it makes a cavity assembly moot; and, in fact, most walls which receive exterior insulation systems like EIFS are, in fact, single-wythe systems -- or, at least, not cavity walls. The thermal advantage of such a system is that the good thermal behavior of masonry structure -- ie, its thermal inertia -- is retained to stabilize the interior environment. The disadvantage is that one comes to depend almost exclusively on the insulation finish system for weather resistance. And, of course, that finish is no longer masonry, either -- the benefits of masonry for durability and looks are made moot.

Placing rigid board insulation within the cavity is the most effective means of insulating a masonry wall. Typically made from extruded polystyrene, these boards are fastened to the exterior face of the interior wythe; brick ties between wythes reach between gaps in these boards. To propose cavity insulation requires an increase in the effective width of the wall, since the 2” free cavity must be maintained.

[18] Another consideration in this situation is introduction of a vapor retarder. Since the dewpoint of the total wall assembly is now beyond the exterior face of the interior wall, any condensation which occurs is effectively outside

the envelope of the interior; but this condensation must not be allowed to re-enter the building. Consequently, products on the market exist for application on the exterior face of the interior wythe -- but within the plane of the insulation. The attachment of ties to the exterior still must penetrate this membrane, but improvements in “sticky stuff” may have solved most of the challenges here.

[19] Another way of improving, slightly, the thermal behavior of masonry walls is to fill the air cavities of hollow CMU with a better insulative material. Foam inserts, or loose-fill vermiculite, are on the market to do this; but the webs of the masonry still create a large cross section for the transmission of heat.

[20] Perhaps a slightly better approach is to insulate the *interior* face of the interior wythe, so that an almost-continuous plane of insulative material can be maintained. In most cases, we specify additional finish materials at the interiors anyway, and so we can place batt or board insulation between the furring strips holding the interior finish. Doing so also provides space for electrical and plumbing systems to be mounted and accessed without cutting the masonry; but the final effectiveness of this approach is compromised by this very advantage. Insulation in this interior location must be protected in cold climates by vapor barrier at the warm side; so, every penetration for outlets, fixtures, and even fasteners is another hole in the effectiveness of that vapor barrier. If batt insulation is used in these locations, the batts may be easily compromised by condensation; even if EPS board is used, well, you end up

with mold.

So a lot depends on the relative humidity of a space; but since you find this particular approach in many residential basement conditions, well, there you go.

* * *

[21] Movement Joints in Buildings

Our book presents a nice scheme for understanding the categorization of joints in our contemporary buildings:

- Building Joints
  - Non-movement Joints... Examples?
  - Movement Joints
    - Working Construction Joints
    - Structure/Enclosure Joints
    - Surface Divider Joints
      - Abutment Joints
      - Control Joints
      - Expansion Joints

The last category given is the “Building Separation Joint.”

- Building Separa tion Joints
  - Volume Change Joints
  - Settlement Joints
  - Seismic Separation Joints

Some of the important considerations for these joints are as follows:

Structural materials across a movement joint should be discontinuous. Reinforcing, lath, or anchorages should not span the joint. As you can expect, the transition of flashings and sealants across such joints are especially problematic. A good practices is to fasten the typical flashing on either side of a joint to a specially-designed joint cover, which itself is both water tight and flexible. In cavity walls, this principle is particularly hard to understand, since one has to distinguish between two separate planes of movement. Although Architects are good about remembering joint covers in locations where we see (and draw!) them, the critical location for joint detailing is almost always at the inner wythe. Keeping vertical continuity at the inner face of a cavity is a far more difficult endeavor than doing so at the exterior one.

[22] Before finishing up this chapter, the book does discuss floor structure options for bearing masonry wall construction. Although we've covered many of these systems already this semester, we should at least consider how these systems interface with the bearing masonry units.

The wall Sections in the book, pages 353 to 355, are very good examples of typical conditions for these systems.

*Ordinary, Joisted Constructio*n is essentially a balloon frame system in which the outer walls are replaced by a continuous masony wall. Two important details relevant to contemporary practice is the firecut ends of the joists and the metal anchors which add additional stability to the structural action of both floor and wall.

Heavy Timber Construction is not really conceptually different, but for the specific connection details themselves.

Steel Joist/Decking is similar to the above, but instead of wood joists, metal joists are used. Here, too, the details of the joist bearing differs, and here includes metal plates, anchored within the masonry wall, to assure level bearing.

Concrete Decking with Masonry Bearing Walls is a slightly different animal, since the ends of the concrete planking, the topping, and the core of the wall inevitably become connected and reinforced. In this case, the inner wythe actually bears on the deck, which monolithically transfers this load to the block wythe below.

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To conclude, we should review the five special problems of Masonry Construction:

Expansion/Contraction
Efflorescence
Mortar Joint Deterioration
Moisture Resistance
Cold and Hot Water Construction

[23] What else is there to say? Here are some examples of contemporary construction incorporating genuine masonry. Inevitably, an aura of integrity is quite visible both to architects and laypersons. Naturally, the costs of such a labor-intensive material must be weighed against their extensive benefits.