[1] Good Evening.

A few logistical arrangements first:

[2] Remember that tomorrow is another BIM event, at 5:30pm, in the Shaeffer building's auditorium. Since the starting time is 5:30, you may have to make arrangements at work, whatever. But please be there.

[3] About next week: I'd promised you a field trip. But I hadn't anticipated properly the challenge posed by the change in daylight hours. I just don't see how we can do this in the dark.

[4] So what we'll do instead is to move our wall-section development project ahead by a week. We'll talk first about some of the issues of masonry walls which we didn't get to last month, and we'll go ahead to begin our wall sections. To this end, please bring with you designs from a previous studio session for which you would like to develop a wall section. I'd prefer seeing something on paper, and bring sketch paper and pencils to draw. Next week, we can begin to work freehand-on-paper to put together the technical "menu" from which we'll draw our solutions.

* * *

[5] Tonight's topic is precast concrete and precast concrete framing systems. It's a topic as sexy as it sounds...

And it is.

Precast systems are so obviously efficient and so obviously powerful and so obviously logical and...

[6] They're so OBVIOUS.

In fact, I had a bit of a block when I sat down with today's syllabus and tried to think of something to write. What can one say about building systems which resemble nothing more than one's childhood LEGO and Meccano Set toys? [7] What important data can one emphasize when, in fact, our architectural profession has NOTHING to do with the design and detailing of these systems? Not only that, your Structural Engineers don't really touch these systems -- they are most typically manufacture-design systems. Almost everything about the "architecture" of these systems is out of our hands.

Almost, but not quite.

Just think about what buildings are typically built with precast: [8] Parking Garages, And more Parking Garages. OK, and Parking Garages.

Now, that's not to say that there aren't other building types which can use precast concrete to good effect. [9] The Richards Medical Laboratories, by Louis Kahn, is the earliest example I know of an architect-conceived use of Precast Structure.

[10] In locations where concrete, not steel, is the typical structural material, you'll find that the use of concrete planks are commonly used where plans are very regular and the spans are not too outrageous -- say, 20 to 30 feet. Essentially, precast plank is a surrogate for poured slabs, especially when the depth of a bearing member, like a beam, is acceptable.

You also see a lot of precast in buildings in which a cellular character requires a rational approach to repetition. [11] Housing and hotels are a good example of this: The necessarily small span between walls can afford economies when both walls and floors can be repeated again and again and again.

As you can tell, the key concept is repetition. Any building element which is repeated a million times affords an economy for the fabrication of that element. So, often times, it's not structure but *finish* elements which make use of precast technology. [12] Entire facade panels, spanning several floors, complete with window openings, finishes, and appurtenances, are fabricated to be hung from any kind of structure. [13] In these circumstances, you're only really limited by your imagination...

[14]... And the rules of the road.

For me, that's the great irony of Precast Technology: It gets stuck in Traffic. As the book points out, the limiting factor on the size of precast elements is the transportation of those elements. And you can't get anything on the road wider than a Hummer, or longer than a double-long tractor-trailer. Except for the odd job when you can helicopter your building elements in, your precast elements need to get to your site on the same roads that we use to get to work.

[15] The implication is that precast elements must be, at their limits, relatively long and narrow (no more than, say, 12' wide).

There's one more general application of Pre-cast structure, but it's in the realm of Civil Engineering: Bridges. [16]

Some of the most dramatic construction narratives of recent times involve Precast box girders, a huge span, and a ravine too deep to provide economical shoring. [17] In these cases, precast elements combine with post-tension technology to allow builders to assemble their structural spans reaching out from side to side, often to absurdly long cantelevers. Even when the sides meet, the spans are so long and the proportions so elegant that one can appreciate, finally, the spatial potential of a new, 20th-century material.

* * *

So before we begin our survey of the technical data , I'd like to put before you several concepts which govern the Architect's work in relation to Precast Systems:

1) Know Your Finished Product [18]

In this I mean to imply that as Architects, we control both the plan concept and the envelope concept. We determine layout and finishes, and in even the most rudimentary, function-driven precast structures, the Architect must clearly indicate both. Naturally, layout will be controlled by the precaster's module; and the method of finishing will be determined in part by the ease of attaching any finish to the precast system. But, in general, the project team will look to the architect to determine the layout and finishes *before* the other side of the ball -- the manufacturer -- begins to play.

2) All systems are different in the details. [19]

In this I'm asking you to acknowledge that since precast building systems are often proprietary, the nitty-gritty of fasteners, attachments, bearing conditions, etc., will vary widely from manufacturer to manufacturer. What that means for us, as Architects, is that our own designs are limited to the very schematic in precast structures.

Do *not* over-design precast structures. Don't work out every little detail, as we are supposed to do with traditional construction. Section details, bearing details, jointing... these all depend on whichever Precast gets the job. I've had at least two projects in which I had to design parking decks, and so to anticipate technical problems I worked closely with one Manufacturer who was nice enough to talk to me over the phone. In the end, another guy got the job, and all my carefully thought-through details were rendered moot. Hey, with a Precast Structure, just don't sweat it!

3) NO CORE DRILLING! [20]

You may have already gotten a sense about how complex the suite of building systems are, even for a simple building. Besides structure, we have HVAC, lighting, power, and plumbing -- itself a combination of supply, sewage, rainwater, sprinklers, compressed air, and others. All these elements have to thread together through an often limited space. So I've always felt that one of our obligations as designers is to anticipate the interaction of all these systems so that one doesn't crash into the other.

[21] Our analytical tool for studying all these systems is "Superposition," in which we overlay all the systems in plan and in section to check and revise their layouts.

Why am I telling you this? Because we need holes for these systems to go through. And with precast systems, you need to know where the holes are BEFORE you fabricate the elements -- because the one thing you really can't do with Precast (or post-tensioned) concrete is go back and drill a hole where you made a mistake.

Now, that's not necessarily true with cast in place concrete. With most reinforced concrete, you have a sort of redundancy created by the homogeneity and regularity of the rebar spacing. With wood construction, of course, you have plenty of spaces between members; same for steel.

You can thread all sorts of systems in the voids left by the structural members and, in fact, that is their flexibility. But with precast members you have neither the redundancy nor the appropriate manpower on-site to start digging into the structural members. It’s the same for hollow-core slabs, double-Ts, or precast beams: Cut into a strand, and your warrantee’s toast.

And it’s worse with post-tensioned concrete, whether it’s cast in place or applied to precast elements: If you have the slighted chance of cutting into a strand, you don’t cut.

What that means is that the design of precast structures demands a lot of homework and coordination *before* the structure itself is designed. Keep that in mind in your own work, because in the US Architects have tended to delegate the review of system superposition to others, primarily the contractor. That’s a tacit admission that we, as designers, have abdicated not only our role in the spatial layout of the most important capital investment in our buildings, but also our technical expertise in the implementation of those systems. We’re just decorators, so to speak; but with Precast buildings, we need to be decorators with a firm understanding of Mechanical Engineering. [22]

4) The last overall concept that I’d like you to keep in mind about Precast Concrete is that it doesn’t really work like other structural systems: It’s bulky and it has bulges and bends where other systems don’t.

The issue of camber is especially significant in this regard, but I mean it to cover also the enormous bearing elements which begin to encroach upon architectural spaces if you're not aware of these things. [23] Most beam and slab bearing requires cantilevered haunches, which themselves may descend to bump-your-head level where headroom is tight. Even hollow-core slab elements are most often supported by bump-outs which are about as attractive as they sound. Many's the time that these protrusions extend below finished ceilings, since one manufacturer's standards may be different from the original design handbook. The camber of a deck in a parking garage may be so high that even if you are tilting the deck to drain, a crest might come about which prevents the free flow of water. Oops!

So just beware. The manufacturers themselves have all the tricks up their sleeves; but you have either to get them to tell you about them or else to take sole responsibility for their implementation...

* * *

Nevertheless, as your book describes, there are plenty of similarities among Precast systems, not least in their Manufacture. The kit of parts, too, is arranged into the same overall categories no matter where you go:

- Precast and Prestressed Structural Elements
  - Precast Concrete Slabs [24]
    - Solid Slabs
    - Hollow-Core Slabs

[25] Double Ts and Single Ts

[Topping]

Precast Concrete Beams, Girders, and Columns [26]
- Rectangular Beam
- L-Shaped Beam / Spandrels [27]
- Inverted T Beam
- AASHTO Girders (American Associateion of State Highway and Transportation Officials)

Precast Concrete Wall Panels
- Pre-finished Panels
- Insulated Panels

Rules of Thumb for Spans and Depths: [28]

Precast Solid Slab: Depth 1/40 Span
3.5 inches to 8”

Precast Hollow-core Slab: 8”d --> 25’
10”d --> 32’
12” d --> 40’ (1/40)

Precast Double T: depth 1/28 span, depths of
12”, 14”, 16”, 18”, 24”, 32”... 48”

Precast Single T: 36” d --> 85’; 48” d --> 105’

Precast Concrete Column: 10X10” --> 2000sf
12X12” --> 2600sf
16X16” --> 4000sf
24X24” --> 8000 sf

(I’ve only seen 24”X24” columns. Remember, coverage for fire proofing is a consideration in addition to structural

design.)

Assembly Concepts for Precast Concrete Buildings [29]

No Mystery: One thing sits on another.

Columns sit on Foundations (cast in place); upper floor columns sit on lower floor columns, and beams and spandrels sit on both; decks of all kinds sit on the beams and spandrels; and topping is applied to create homogenous services. In pure frame structures, shear walls need to be introduced to provide support for lateral and seismic loads.

Manufacture of Precast Structural Elements [30]

Casting Beds -- No mystery here. The book outlines all the different aspects of the casting beds, including the introduction of reinforcing and prestressed members. If you ever get a chance to visit a precasting plan, it's a fun way to spend a sunny day, but there are no surprises. What's more interesting is the management of the fabrication line and the scheduling which rationalizes even further the modes of production, the delivery of both materials and product, and the handling of waste and byproducts. None of these really impacts our use of the architectural product in design, but it's interesting in itself.

Prestressing and Reinforcing Steel

Hollow-core slab production

Column Production.

Joining Precast Concrete Elements: The Metal Bits!

- Bolted Connections
- Welded Connections
- Poste-tensioned connections.

The Construction Process

Precast Concrete and the Buildings Codes

Uniqueness of Precast Concrete

Field Trip to a Precast Building... Now!