HD BIM

&

The Future of the AEC Industry

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“Insanity is doing the same thing over and over again and expecting different results”

Albert Einstein,
German born American Physicist
1879-1955

Corollary 1: If you want the same results, do the same thing.

Corollary 2: If you want something better do something different.
Questions about the Design/Construct Process

Does anyone believe that we are doing as good as we can?

What would make the process better?

How can we make the process more predictable, reliable, and profitable for everyone on the team while making our buildings better, more sustainable, more durable, and more economical?

What stands in the way of making it better?
Proposition

IF
Designers understood construction means, methods, sequences, and details as well as they understand finite element analyses and codes, and;

IF
they had the means and wherewithal to incorporate those constraints into their design and communicate that design at a level of detail that required no interpretation

THEN
It would enable vastly improved planning leading to constructing buildings faster, better, more reliably, at less cost - thereby leveraging the perceived value of the designer’s services resulting in a virtuous cycle of ever-increasing returns for owners, contractors, designers, and society at large
Definition – HD BIM

HD BIM is a process utilizing a Building Information Model containing the high level of detail and precision necessary to visualize, design, detail, fabricate, and install all elements of a building with sufficient reliability that the interaction of elements, the sequence of construction, and the labor activities can be defined and planned to a level of granularity similar to manufacturing.

An HD BIM incorporates multiple HD System Information Models (HD SIMs). System information models must be developed concurrently and together in an integrated environment in order to perform coordination during the design that is currently done in construction.
Once you’ve seen HD BIM, it's hard to go back to regular BIM.
The Future - Where We Are Headed

• Design/Construction Industry
  – HD BIM
  – Functional IPD
  – Virtual Design and Construction (VDC) – utilize HD BIM to visualize, analyze, coordinate, and evaluate different design and construction alternatives

• Structural Engineering (other disciplines similar)
  – Performance-Based Design (PBD) of all building systems
  – Performance Based Earthquake Engineering beyond life safety to eliminate sacrificial structures and control losses
  – Design to target labor savings and construction efficiency
BIM: Building Information Model

BIM

- Graphical Representation
  - Graphics
  - Renderings
- Approximate/Design Intent
- Concept to Design
- Clash-Checking

HD BIM

- Database of Information
  - Knowledge
  - Heuristics
- Shop Drawing Level Detail
- Concept to Facilities
- Virtual Design & Construction

------ GIGO Effect ------
HD BIM

- High Definition BIM (HD BIM) incorporates shop drawing level detail into the design model.

- There is only one HD BIM model, and it is used for all life cycle processes. During one short interval in the life cycle – design-construction – the model is used to produce shop drawings and support both design and construction processes.

- This requires explicit consideration of and provision for, means, methods, and sequences during the design phase.

- This is done today in some design disciplines, i.e., structural engineering and MEP systems engineering.
HD BIM . . .

. . . is a disruptive technology

• The design/construction processes must change to get maximum benefit from the technology.

• Scope shifts from construction to design

• Construction knowledge must be deployed to support design – we pull the knowledge forward in the process

   But that isn’t enough, means, methods, and sequences must also change
Functional IPD – Integrated Project Delivery

- IPD: Incorporating detailed construction knowledge and planning into the design
  - Means, methods, and sequencing
  - Enabling details
  - Prefabrication
  - Precision
The other IPD – Integrated Process Design . . .  

. . . a new process must be designed. It starts with questions:

- “Where are the labor hours being spent?”
- “What percentage of the labor hours are productive?”
- “How can the percentage of productive hours be maximized?”
- “How can the productivity of each hour be maximized?”
- “How can design be changed to optimize construction?”

. . . . . . . . . . It’s a manufacturing process applied to construction
Food for thought . . .

All numbers are estimated:

- % of project cost from labor: 60%
- % of labor hours that are productive “tool time”: < 50%
- % of productive hours that are spent removing previous work: 10%
- % of construction cost spent tracking changes & RFI’s: 5%
- % increase in construction cost due to change orders: 10%
- % of material wasted: 15%

. . . suppose you eliminated the inefficiencies in this process.
Food for thought . . .

All numbers are estimated:

• Potential reduction in field hours through prefab: 75%
• Potential reduction in lost time accidents from prefab: 75%
• Potential reduction in materials through prefabrication: 10%

. . . How much labor could we save if we actually focused our design on that as an objective?
A knowledgeable and Involved Owner is the key... 

... It starts with assembling a high performance team that:

- Designs to minimize the number of labor hours required
- Designs to maximize the productivity of each hour
- Plans the work down to the smallest detail
- Documents in a comprehensive HD BIM model
- Uses the design model for communicating, coordinating, and controlling the work during construction

... no one has done this yet
Key changes in an HD BIM process

• Design for construction sequence
• Design for prefabrication
• Design level of detail (SEOR shop drawings)
• Communicating design intent (SEOR shop drawings)
• Estimating and bidding procedures (SEOR shop drawings)
• Interdisciplinary design coordination
• Design/Construction coordination
• Change management (SEOR shop drawings)
Construction Sequence, Prefabrication, and Level of Detail

Conventional Practice
Contract documents reflect a concept design that is based on no particular construction sequence or means and methods

IPD with HiDef BIM
The SEOR produces a complete design predicated on the most efficient construction sequence with structure topography and details tailored to optimize construction efficiency, economy, and quality.

USC SCHOOL OF CINEMA I
Design Intent

Conventional Practice
The rebar detailers have to interpret the SEOR’s intent in preparing complete shop drawings. Any questions are resolved using the RFI process. The process takes months.

IPD with HiDef BIM
The SEOR produces a detailed model that IS the design intent. The shop drawings can be furnished to the supplier at the time the contract is awarded or the model can be turned over to the fabricator to produce shop drawings.

Navy Lodge Coronado Island Rebar Field
Rebar Model at Column Drop
Estimating and Bidding

Conventional Practice

Fixed price is an estimate based on incomplete details. Subcontractors have to cover risk in price. Final quantities aren’t known until after shop drawings. Final price is adjusted through change order process based on revised estimates of concept drawings.

IPD with HiDef BIM

Unit price is based on exact quantities in the model and adjusted based on actual quantities delivered. This saves all of the overhead of the RFI and change order process. The advantage goes to the subcontractor with the most efficient and cost effective way to fabricate and deliver...

Denver Health Center Rebar 375/365/372

Denver Health Center Curtain Wall Studs
Change Management

Conventional Practice
Changes are suggested by the owner or contractor, redesign is performed by the design team, sketches may be issued, a new shop drawing and RFI process is begun.

IPD with HiDef BIM
The process is set up around the need to efficiently manage change while maintaining a productive construction operation. The SEOR flags potential changes that will conflict with planned construction activities. Changes are made to both the documents and the shop drawings at the same time. Revised shop drawings are issued to the contractor for construction minimizing or eliminating any delay. Change orders are based on delivered quantities.

Casino Hollywood, Toledo, Ohio
Casino Hollywood, Toledo, Ohio

“This project has elevated our BIM experience to a new level. Our superintendent was referring to the latest model on a daily basis. He was able to use an IPAD to bring the web accessed model out to the field and share it with the crew. When the field crew starts asking to view the model, it gets the attention of everyone. Even subcontractors that have never used it before were on board.”

– Ryan Bannister, Rudolph-Libbe, BIM Manager

“Ordinarily, the rebar shop drawings are detailed from documents that are a month old and frequently changing. Keeping the field updated with information is a challenge. On this project, the web model updates were available immediately, so we looked at it every morning before we started work. The shop drawings, coming directly from the EOR, were even better than the model – the best information on the job.”

– Mike Keane, Rudolph-Libbe, General Superintendent
Case Studies
## USC School of Cinematic Arts Phases I, II, & III

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<td>SEOR Contract</td>
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USC School of Cinema Structural Firsts (2006 – 2012)

- PBEE repairable rocking concrete walls for EQ resistance
- Design HD BIM design model for structural steel shops
- Design HD BIM rebar model for fabrication shop drawings
- Design HD BIM rebar model for shop fabricated assemblies
- Design HD BIM light gage model for architectural walls
- Design HD BIM light gage model for shop drawings for complex shop prefabricated light gage assemblies
- Integrated design/construction AEC BIM model
- Integrated design/construction AEC BIM model for FM
USC School of Cinematic Arts – Phase I  
2006 - 2008

• PBD: Repairable Structure
  – Slit shear plates act as fuses
  – Pivoting captive concrete walls
• HD BIM:
  – CAD drawings plus Tekla model to be able to support construction activities
  – Tekla model turned over to fabricator for detailing
  – Rebar modeled and used to coordinate with fabricator’s detailer
• IPD
  – Optimized construction sequence with temporary bracing
PBEE
USC seismic damage control system:
- Concrete substrate for facade
- Ductile linked shear walls
- Pivoting shear panels
- Replaceable steel fuse
USC School of Cinema – Phase I

Butterfly Slits Shear and Bending Yield at 10% distortion
USC School of Cinema Phase I

Butterfly Slits Ears vs No Ears
Rebar layouts were standardized with minimum 4#8 ea. side to facilitate panelizing. Cages were assembled without window openings for stiffness and tolerances. Boundary elements allowed for tolerance in opening. Openings were cut and trimmed after installing panels.
HiDEF BIM facilitates the incorporation of the enabling details for PBEE within the context of an aggressive fast-tracked schedule.
Shear is transferred to the foundation wall by a 2”x5” bar that bears on (2) 1 ½” plates separated by 1” of EPS to allow rotation anchored to the concrete on each side of the joint by welded dowels.
USC School of Cinematic Arts – Phase II
2009 - 2010

- PBD: Repairable Structure
  - Slit shear plates act as fuses
  - Pivoting captive concrete walls

- HD BIM:
  - Tekla model turned over to fabricator for detailing
  - Rebar shop drawings created from model as additional service paid by owner

- IPD
  - Optimized construction sequence with temporary bracing
  - Steel roof assemblies for fast erection
  - Light gage panelization and details developed collaboratively with supplier
USC II

With design HD BIM vs construction HD BIM, you get all the pieces in the same model for coordination during design

Anchor Bolts

- 5 – 1” Anchor Bolts Embedded 40”
- Transfers Overturning Tension to Foundation Walls
- Steel and concrete in the same model for coordination
Panelized Light Gage Roof

- Decreases Schedule
- Less Off Ground Work
- Acoustical Details Included
- Plywood, LG Studs 12” OC, Insulation, 2 Layers of ceiling Gyp Board

Savings:

- roof finished in 3 days
- 3 weeks exterior
- 3 weeks interior
- eliminated scaffolding
Comparison of planned and actual schedules for structural frame on USC School of Cinema Phase II, Building B:

- Planned: Start 11/24/08 Finish 12/25/09 – Duration 391 days
- Actual: Start 11/24/08 Finish 8/31/09 – Duration 275 days

The use of detailed construction model, produced by the design team, for design coordination, shop drawings, and field coordination saved 116 days, or 30% of the schedule
USC School of Cinematic Arts – Phase III

- **PBD: Repairable Structure**
  - Slit shear plates act as fuses
  - Pivoting captive concrete walls

- **HD BIM:**
  - Tekla model turned over to fabricator for detailing
  - Rebar shop drawings created from model as part of base scope
  - Shop drawings for panelized light gage roof produced by SEOR from Tekla model

- **IPD**
  - “Temporary” bracing put in stair towers
  - Construction kickoff meeting with rebar fabricator, rebar foreman, formwork, GC and architect
Phase III -
Multiple-Purpose
Cinema Building:

3 stories plus
basement

Pivoting concrete
shear walls

Repairable
structure

Accelerated
construction
sequence
designed into
structure
USC School of Cinema Phase II Building Components

- Panelized light gauge roof with steel support structure
- Metal deck on steel trusses
- Rotating concrete wall exterior
- Soldier piles
- Rebar (not shown)
- Stairs
- Temporary bracing within stair & elevator walls
- Acoustically isolated light gauge rooms
These are screen shots of the structural design model which is being used for steel shop drawings, rebar shop drawings (by EOR), and light gage stud framing shop drawings.

Note that the architectural and MEP models are overlaid on the structural model so that coordination between systems occurs continually to design clashes out of the project. This is immeasurably more effective than doing clash detection after the design is complete.
USC III Wall rebar panel shop drawings from Tekla
Roof panel 3D model from Tekla
Roof panel 3D panels from Tekla
Roof panel shop drawings from Tekla

Gregory P. Luth & Associates
Structural Engineers and Builders

November 16, 2012
Stick built framing shop drawings from Tekla
Stick built framing shop drawings from Tekla
Movie
Lessons Learned
USC III
Status as of 05/29/2012

Interior work partitions and MEP has been ongoing for about a month since slabs were poured. Exterior rebar in. Scaffolding for shotcrete is complete. Shotcrete on the north wing is complete.
Rebar Modeling and Detailing

What is the cost?

Modeling – 0.2 to 0.8 hours per ton
Creating drawings – 0.4 to 1.6 hours per ton

Total with engineers - $70 to $300 per ton

What are the savings?
Thank You!