Summer 2014 Issue | BIM and the Future of CDs

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Letter from the Editors

By David B Richards, AIA and Donald Simpson, AIA

BIM is changing the way architects think and train. It is changing the way we share our ideas for the scope and intent of a project to the world. It is changing our traditional deliverables. BIM allows an architect and their client to virtually walk the design before the building is built. We can begin to really see the complexities of fitting everything into the building. (A few years ago a consulting plumbing engineer modeled all but one sanitary line in the building. When the pipe was finally modeled it came up out of the ground floor and across every door in a long corridor. It was an opportunity to improve a design that we wished we had had earlier…) and BIM will have an impact on traditional Construction Drawings produced by the architect.

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We are particularly pleased to include excerpts from three books published this year detailing present BIM capabilities and future BIM possibilities for disrupting and improving our practices.

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As the Practice Management Knowledge Community, our mission is to advance the practice of architecture through discovering, generating, organizing, and sharing insights, resources, and tools that enable architects to practice more effectively.

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Book Excerpts

Architecture 3.0: The Disruptive Design Practice Handbook (Routledge - 2014)

By Cliff Moser, AIA, MSQA, LEED AP - This book was written as a result of over 30 years of engagement and observations within the profession of Architecture. I began my career in design and construction as a carpenter building spec houses outside Salt Lake City, Utah during the Carter Administration. Originally I was a music major at the University of Utah, but that was cut short as a result of a nailgun accident.

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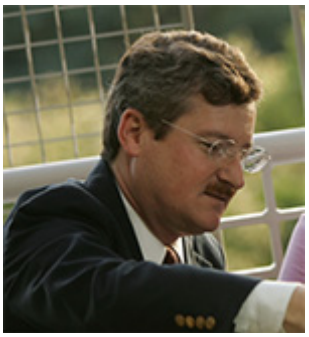
Building Information Modeling: BIM in Current and Future Practice (Wiley-2014)

Chapter 1: Section 1.6 Physics and Materiality



By Karen Kensek, LEED AP BD+C, Assoc. AIA & Douglas Noble; *Chapter Authors: Glenn Goldman and Andrzej Zarzycki; New Jersey Institute of Technology*- What other input will be critical for future BIM models to support the design process? In addition to associative quality of geometry and parametric relationships, the physics-based behaviors, materiality, and more intuitive user interface are among the most pressing needs for an effective computational design platform.

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Building Information Modeling; (Routledge - 2014)

Beyond Basic BIM, p.157-163

By Karen Kensek, LEED AP BD+C, Assoc. AIA- The AEC software industry is not yet at the point where most of the analysis programs work smoothly with BIM. The information in a BIM is only as good as what is put into it, and seamless interoperability is not yet available. Just as design and constructability BIMs differ in how they are made and what they will be used for, an analytical BIM for energy calculations needs different information than one for cost estimation.

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Features

CDs and the Architectural Profession: Past, Present and Future

By Heather Worrell, AIA- Traditional two-dimensional construction documents have been used for decades as the primary communication medium between architect, consultant, contractor and owner. These documents, though able to depict many details about a building's dimensions, layout and composition, present serious deficiencies for today's time crunched, data-driven decision makers.

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BIM or Drawings or Both?

By Jason E. McFadden, E.I.T., LEED AP- I challenge my teams to work more efficiently, to be the best builders possible. Recently, I had a colleague express to me that the building information model (BIM) is not the deliverable to build from; the construction drawings (CDs) are the deliverable. The same colleague later encouraged me to look at the BIM when I had questions.

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BIM and the Future of Construction Documents

By Bill Schmalz, AIA, Construction Contract Administration KC- Technology has changed the architectural profession significantly. Just 30 years ago—spanning no more than two generations of architects—almost all documentation was drawn by hand and printed on paper.

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BIM and the Future of Construction Drawings

By David B. Richards, AIA- BIM is the promise of the computer world from those very early days as CAD entered the field of architecture. I welcome it. I have been totally fascinated by the views of the building that are available in Revit and NavisWorks. I am able to share views of the design with the client that would never have been shown in 3-D in the past.

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Best Practices

One of the PMKC's initiatives is to continuously improve the AIA's Best Practices. AIA Best Practices represent the collective wisdom of AIA members and related professionals. We like to highlight one or two new best practice articles in each issue of the Practice Management Digest. We encourage you to read this edition's pick:

Accounting Basics: The Balance Sheet and KPI
This Best Practice reviews the information in a Balance Sheet and points the way to understanding the relationship between the balance sheet and firm performance.
http://www.aia.org/pdf/?dname=AIAB100975.

Upcoming Events

2014 AIA New York Practice Committee Symposium

In Collaboration with the AIA National Practice Management Knowledge Community

Enjoy a one-day symposium on November 9, 2014, in New York City at the Center for Architecture. Cost is $65.00 and earn 7 AIA LUs. The symposium will feature practice issues relevant to early to mid career architects, both new firm owners and firm employees looking to advance their careers.

The symposium will focus on two main learning tracks:

- What do I need to know to succeed in a start up firm? Entrepreneurship and leadership; business planning; financial management; marketing and business development; being an employer; emerging business practices.
- What skills are needed to advance within my current firm? Ability to bring in work; communication

skill; presentation ability; project management skill; team building skill.

Resources

Survey: Off-Site Construction Technologies & Practices

As you may know, the National Institute of Building Sciences was established by the U.S. Congress to improve the built environment through engagement of the entire building industry. The Institute is interested in advancing the discussion around the role of off-site construction in improving building processes and the achievement of high-performance building goals.

The Institute's Off-Site Construction Council, a knowledge center on issues of off-site construction and productivity in the commercial building sector, is conducting a survey of representatives from across building disciplines to understand the current extent of projects that use off-site construction technologies and practices, their successes or shortcomings, and the opportunity to address industry needs in utilization of these techniques.

Please consider answering and passing along the short survey to help advance our industry and support achievement of high performance buildings. The survey will close on Friday, September 19, 2014.

Complete the Survey

The Architect's Handbook of Professional Practice

For the first time and exclusively for AIA members: Get the chapters of The Architect's Handbook of Professional Practice, 15th ed. Select chapters of your choice are sold individually and accessed electronically, costing only $19.95 while the full tome costs $225.

Authored by The American Institute of Architects (AIA), the chapters are the updated architecture profession's standard on practice issues. These indispensable resources cover all aspects of architectural practice, including legal, financial, marketing, management, and administrative issues. Content is significantly revised to reflect the changing nature of the business of architecture related to the impact of integrated practice.

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The AIA Contract Documents team is excited to announce that the 2014 versions of the Design-Build documents are now available. The significant updates include the flexibility to accommodate various ways in which a design-build project can be delivered, the addition of an Owner's Criteria and updated Insurance and Sustainable Project Exhibits. To learn more about the Design-Build documents and to get **free** samples of them, please visit www.aia.org/design-build.

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1735 New York Avenue, NW
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AIA Knowledge Communities

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- Building Information Modeling; (Routledge - 2014) ***by Karen Kensek, LEED AP BD+C, Assoc. AIA***

In the feature articles for this edition,

Heather Worrell, AIA of RATIO Architects considers the advantages of BIM in clarifying and improving an architect's drawings.

Jason Mc Fadden a Project Manager at Barton Malow sees a future of streamlined collaboration, improved communication and construction ready drawings that meet the demands of our clients.

In collaboration with the Construction Contract Administration KC, Bill Schmalz, AIA of Perkins + Will explores how BIM may change the profession.

David Richards, AIA of ROSSETTI considers how the scope and intent of the project might be communicated without drawings.

Upcoming Issue

The next edition will consider ideas for Managing Projects to Profitability. If you have

Title:
2014 Summer PM Digest - Letter from the Editors

Location:

Contributor:
Isabella Rosse

Published:
3/16/12 12:00 AM

Posted Date:
8/15/14 11:06 AM

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expertise or information in that regard to share with the AIA PMKC, please contact David Richards at drichards@rossetti.com. The deadline will be here before you know it so send me your thoughts this week.

Best Practices

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Upcoming Programs

For more information, please contact Rena M. Klein, FAIA at rena@rmklein.com.

Architecture 3.0; Handbook for the Disruptive Practice – Cliff Moser - 2013

Preface and Introduction

Author's Bio:

Cliff Moser, AIA, MSQA, LEED AP is a Director for Facility Planning and Design, National Facility Services, Kaiser Foundation Health, Kaiser Permanente, Oakland, California. He has over thirty-five years of design and construction experience.

He is a member of the AIA, and from 2006 to 2011 he was an Advisory Group Member of the Practice Management Knowledge Community (the Chair of the group in 2010).

He is also a member of the board of directors, Design and Construction Division, American Society for Quality (ASQ).

As an author, he has contributed the "Practice Quality" chapter to the AIA, Architect's Handbook of Professional Practice 14th Edition 2007 and 15th Edition 2013.

This excerpt is taken from his book, Architecture 3.0; The Disruptive Design Practice Handbook, Routledge; 2014.

Architecture 3.0; The Disruptive Design Practice Handbook

Cliff Moser 2014

This book was written as a result of over 30 years of engagement and observations within the profession of Architecture. I began my career in design and construction as a carpenter building spec houses outside Salt Lake City, Utah during the Carter Administration. Originally I was a music major at the University of Utah, but that was cut short as a result of a nailgun accident. My first job on the boards was drawing housing for retirement communities for a Utah developer. One of my next jobs was in Denver where I worked on a boutique shopping mall – Beau Monde, which fell victim to the Savings and Loan crisis in the mid-80's and became a poster-child for economic over-reach and over-indulgence. Beau Monde was sold for pennies on the dollar to the parishioners of "The Happy Church" (you can check out the story here- http://jrdelisle.com/JSCR/IndArticles/Brown_N199.pdf).

One of my next jobs found me in Philadelphia, working on Continuing Care Retirement Communities for the Quakers. This led me to a focus on health care architecture. My career has led me to move across the US from West to East and back again, as well as to work in all phases of the industry. For example, I've worked as a construction manager and been involved with the Society of Value Engineers as a candidate for Certified Value Specialists, and I received a Master of Science degree in Quality Assurance.

What I discovered during my peripatetic career was that I found a continuous curiosity in the practice of architecture. Be it in building or working as an owner's rep, or working with elementary school children in teaching the tools of "Idea Sketching," I found that architecture provides the foundation for critical and systems thinking, and that today, with

Title:
2014 Summer PM Digest - Book Excerpt: Architecture 3.0; The Disruptive Design Practice Handbook

Location:

Contributor:
Isabella Rosse

Published:
3/16/12 12:00 AM

Posted Date:
8/14/14 10:29 AM

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the opportunities for connection through social media, we have the ability to be bigger than the sum of our connections through disruption of incumbent systems.

In Architecture 3.0; The Disruptive Design Practice Handbook, I identify that we as architects facilitate design solving opportunities through the use of disruptive tools and relationships. Like my career from musician to housebuilder to hospital designer to outsourcing start up provider, to health care organization facility services director, I've enabled disruption through my relationship with the practice of architecture. You can too.

Preface

Creating a Disruptive Architecture Practice

What is Disruption?

Can you build disruption into your architectural practice?

While a number of organizations today may describe their business model as disruptive, true business disruption is a narrowly defined activity. Described as the disturbance of an incumbent business model, a business disruption is a provision of a lower cost or lower performing service by a new provider within an existing incumbent market.

This disruptive service is generally discovered and delivered by a new provider in the industry because this new activity is generally deemed too risky or unprofitable to be of value within the existing incumbent organizations.

Soon overall business disruption is realized as these new services become more accepted, and being more convenient and assessable, eventually replace the existing incumbent services. This process of creation and replacement was first identified and described by Austrian Economist Joseph Schumpeter in his book ***Capitalism, Socialism and Democracy*** (1942), who defined the process as **Creative Destruction**. Harvard Professor, Clayton Christensen described the process as "Disruptive" in his book ***The Innovator's Dilemma*** (1997). He outlined a more nuanced process of destruction, which, leveraged with innovation within the organization, uses improvement or substitution to create a different product or service in ways that the incumbent market is not expecting or prepared for. Using these new and unexpected methods, the disruptor can eventual overwhelm the incumbent.

In describing disruption, Christensen identified a first gradual and then sudden replacement as a disruption which eventually led to replacement or destruction.

Furthermore, in defining the difference between disruption and innovative improvement, he detailed that innovation within service and deliverables can exist without disruption and occurs as the improvement of existing processes, which Christensen identified as "sustaining innovation". A separate activity from disruption, these innovations can trick a provider into believing that it is practicing disruption when it is just improving existing processes.

Sustaining Innovation

For example, in architecture there have been many sustaining innovations to our business model –in innovating deliverables from hand drafting to CAD, which initially just digitized drawing. Additionally we have continuously innovated our services through new contracts and new definitions of our activities. These innovations are typically made to address changing relationships within the profession, but do not change the core of the practice. For example, most architectural practices now typically use professional consultants as engineering support in lieu of carrying in-house staff.

These revisions are sustaining innovations, which leave the existing value stream and business models intact, undisrupted.

However, innovations may cross-pollinate and disrupt another market without expectation. For example, the emergence of a sustaining innovation in the development and marketing of smart phones, within the existing industry of cellphones, initially delivered the Blackberry and Palm Pilot. However, while most industry leaders thought that the arrival of the iPhone, was a continuation of sustaining innovation, the iPhone (and then Android devices) turned out to be an unexpected disruptor in an adjacent industry – the Personal Computer.

Following the disruptor's identified emergent model was the fact that this smartphone

turned out to replace the computer; albeit in a lower-performing, lower-priced why. While it was unable to do "real" computer tasks, like spreadsheets or word-processing, as an acceptable substitute it came with built-in wireless internet capability and nurtured its own disruptive eco-system through its value stream of free downloadable software (or apps). In classic Christensen disruption diffusion, the smartphone soon became a more useful solution than a PC or a laptop. Once established, the smart phone scaled in size and performance into a tablet (as with the iPad and Android Tablets), and the disruption of the PC became complete, and the broad (creative) destruction of an entire industry and value-chain was set in motion.

True Disruption

The disruption of the PC by the smartphone delineates the role disruption plays as a completely different business approach. This new provision takes a market by surprise. This new solution isn't just a lowering of fees or pursuing a different set of clients, it is the creation of new and different deliverables, solutions, and value stream which disrupts a market and business model.

But what does this have to do with the practice of Architecture?

Disruption in Architecture

Christensen and others look at certain industries and describe them as being "ripe for disruption." This inclination is identified by the existence of a business model in which the incumbents have continually improved or innovated but not replaced or destroyed. Disruption occurs within these industries when there is a singular event that sets in motion the unraveling of the incumbent model. In this book, I argue that in the practice of architecture, the singular event was the Great Recession. As our markets dried up, as our deliverables and services were no longer needed, and as life-long practitioners were let go by the thousands from firms no longer stable enough to sustain them, we as architects faced a disruption that could only be described as destruction.

As work and the profession recovers from the recession of 2008 to 2013, we will want to return to our old business model. However the model has been destroyed.

Creating a Disruptive Architectural Practice (and creating a disruptive profession for those architects that work outside of practice) means accepting the existing disruption and continually building new disruption into the core of your practice.

This handbook is based on the premise that the traditional practice of architecture disappeared in 2008. This shift forces us to reconsider our world. What type of profession and practice will replace the old model? And how will we create that practice?

"Design is the appropriate combination of materials in order to solve a problem" Charles Eames

Introduction

Architecture 3.0

Innovation and Disruption.

Architecture 3.0 and disruption.

The profession of architecture has evolved from the realm of the early master builder (Architecture 1.0), pre-1900, to the specialized solo or corporate practitioner (Architecture 2.0), of the industrial revolution through 2007. The latest evolution in this timeline is Architecture 3.0 (Arch3.0). This paradigm shift is a result of the 2008 financial crash and subsequent recession, as well as other disruptive events within the profession.

In 2013, five years since the crash, the construction industry that provided employment and engagement for architects is still hollowed-out. Registered and non-registered architects are still unemployed or under-employed, scraping together contingent work in ad hoc relationships with former employers or scratching together smaller projects on their own. Young non-registered architects, as well as the new graduate architects of the profession, are barely finding work within the industry. As recovery continues, 2014 and beyond may provide more opportunities for work similar to we recognized as practice before 2008. But something else has changed within the profession. Something that may make it difficult to go back to the halcyon years prior to 2008.

Professional Irrelevance

In his book The Scheme of Things, Thomas Fisher outlines the negative perception of architects and architecture by a public, which is "numbed by an ugly and shoddily constructed built environment and outraged by the cost of high-profile design projects." This public is now "disinterested and contemptuous of architecture as both a profession and an art." We, as architects in our Arch2.0 environment "isolated ourselves from the tastes and needs of mainstream society." We overspecialized, under-delivered and created a profession that, in most of the public's opinion, served no purpose.

Global connectedness and diversity.

Social networks now play an important part of leveraging our expertise. Arch2.0 was a closed profession. Arch3.0 disrupts this sealed and closed system, by enabling us to work and integrate with other professions and professionals from around the globe.

Design for Solutions

The true disruptor in this Arch3.0 world is our ability as architects to Design for Solutions. The recession and death of Arch2.0 has demonstrated that our central professional purpose –to design buildings- has all but disappeared. This book outlines the case for Design for Solutions being the new purpose and model for the profession, and Design for Building becoming a subset of that model.

As Arch3.0 continues to expand, firms which survived the recession will find themselves harnessed to the vestigial constructs of past relationships. The existing and familiar separation of services and activities within the design and construction industry established and nourished by years of 2.0 processes and agreements, will continue to be challenged by the new needs and opportunities for clients and partners. Globalization will continue to shift the landscape of professional services and their deliverables. Cloud-based IT services will enable central storage and drafting/modeling from anywhere in the world, facilitating crowdsourcing of services.

Cloud services will leverage an individual's ability to link remote and distributed designers, modelers and drafters to any client and project in the world, without the need for the infrastructure of a firm. The architect can be completely untethered if necessary, becoming a specialist free agent working through brokered engagements with new and different clients than existed in 2.0.

Arch3.0

Arch3.0 will create new opportunities while destroying others. That is what disruption does. The rapidly continuing specialization within the profession will continue to create smaller and smaller activities and specialized expertise that will test the ability of design professionals to understand and leverage their project role. It will also create large vertically integrated global firms. Only exceeded by the size of governments, these mega firms like AECOM, Balfour Beatty, and Stantech currently employ thousands of individuals globally in specialty design and construction roles across multiple disciplines. These firms will be the other successful players in Architecture 3.0, leveraging their ability to design and build massive projects, but also to self-fund these projects as well. Acting almost as mini-governmental authorities, these behemoths have paved the way for Public-Private-Partnerships, organizations that can finance, design, build and operate entire cities, leasing the final space as an annuity to cover all of their costs (including profit) for a thirty to sixty year lifecycle.

Mega Large and Micro Small

Both mega large and micro small, Architecture 3.0 also creates a strong market for the "non-architect" architect. In the latter years of 2.0, licensure had been steadily declining, and the marketplace for new licensed architects had become stagnant. Why get registered? More and more graduates were not seeing the benefit behind the costly endeavor (both in money and time), in order to achieve the intangible goal of licensure. Firms were no longer helping to recover the cost nor reward the achievement. Individuals that practiced the non-building parts of architecture without the benefit license were protected from liability issues that came with licensure. And as long as they called themselves "designers" they seemed to enjoy all of the rewards of being an "architect" without many of the risks. These players don't even design buildings, instead they find themselves working on the design-thinking problem-solving side of the equation, and their role as architects exists only as much as their graduate degree informs.

The boundaries of Arch3.0

The boundaries of Architecture 3.0 actually support this new business model. Both self-funded, self-insured mega firms, as well individual non-licensed players available to work on projects anywhere in the world will delineate this new landscape.

A handbook for Arch3.0

This handbook is a guide for navigating the proto-development of Architecture 3.0. It will also help design the boundaries of the new practice as Architecture 3.0 continues to grow after the Great Recession. We stand at the beginning of a new era and the rigid legacy tools of the profession; including the contracts, the defined relationships, and the definition of what an architect does and his role are still being explored. The path this handbook takes is one of investigation. As a registered architect with over thirty years of experience, I have experienced the tumultuous shifts of Architecture 2.0. From hand drawings on vellum that were reproduced in-house as blue-lines for a project that I could drive to, to drawings that were initially delivered by mail and then by overnight delivery; then by fax for projects far away; and finally by Computer Aided Design (CAD) which is delivered by email for a project in another country. The end of Architecture 2.0 is defined by the diffusion of the inherent information, knowledge and expertise of the profession and not the location.

Design for Building versus Design for Solutions

The formation of Arch 3.0 is also formed by the cleaving of the profession at its 2.0 rootstock graft. 2.0's architect is a profession of building designers. However at our core we architects are essentially problem solvers. We design buildings in order to solve problems. Therefore the Arch 3.0 model is shaped by first identifying our fundamental role in one of "Design for Solutions". Therefore this handbook on the disruptive practice's foundation is built on identifying the architect's value as an innovative disruptor as a fundamental shift in the practice as a Design for Solutions professional. This is what we do first and foremost as architects and this handbook will outline how to define value in that role.

Furthermore, the Arch 3.0 profession identifies Design for Building as a separate specialized activity (but not the core activity) that the architect may or may-not choose to practice.

Thus, this handbook will identify tools for you to first and fundamentally create a successful practice as a Designer for Solutions and then how to engage in the specialized role as Designer for Building and its separate requirements.

The bi-directional interoperability is particularly important when considering multiple, often competing, design criteria and the need to solve for the most optimal collective solution, not a single variable. Additionally, clients' priorities change and so do the site and marketplace conditions. Consequently, an effective computational design delivery platform needs to accommodate the volatility and uncertainty of the design process.

1.6 PHYSICS AND MATERIALITY

What other input will be critical for future BIM models to support the design process? In addition to associative quality of geometry and parametric relationships, the physics-based behaviors, materiality, and more intuitive user interface are among the most pressing needs for an effective computational design platform. The lack of materiality considerations hinders the creative process when considering current digital or analog design tools. With the ability to generate complex forms, designers sometimes operate within scaleless and etherlike environs that bear little resemblance to actual built designs. Materiality and physics-based behavior brings a scale and "bite" into otherwise abstracted forms. Emerging design BIM platforms need to consider physicality of the final product and be able to account for it in all design stages. This physical awareness needs to be both quantitatively expressed in units and costs and qualitatively contributing to a designer's intuitive understanding of performance and informing his/her tacit knowledge.

While materiality and physics-based behavior is critical, in understanding design implications, assembly and manufacturing processes as well as a broader impact on material usage and life-cycle analysis are equally important. Current tools allow designers to model more complex designs than those that can be effectively built or solved. When digital fabrication combined with NURBS surface modeling results in fabrication strategies that produce a significant amount of material waste, the issues of material usage optimization and zero-waste designs become critical. The project in Figure 1.5 investigates this condition by analyzing design methodologies for form-making and form-solving. Unfortunately,

FIGURE 1.5 Initial form-finding exercises led to the discussions on material usage in fabrication and zero-waste strategies. Form-finding for pneumatic design with generative/algorithmic tools (right). Unrolled and fragmented surface of the pneumatic form (center). Finding complementary unrolled compo- nents to optimize material usage (left).

(Images by Gayatri Desai, Edward Perez, and Joseph Ribaudo. Designed and modeled with McNeel & Associates Rhino, Grasshopper, and Kangaroo. Graphic layout with Adobe Illustrator and/or Corel Draw. Grayscale conversion and image processing with Adobe Photoshop and/or Corel PaintShop Pro)

in this particular case, the zero-waste part of the project relied significantly on the analog try-and-see method to optimize material layouts. Computer tools provided limited value in addressing this important design consideration.

Future BIM platforms need to account for fabrication and manufacturing processes in order for designers to consider them in their design process. This is a particularly pressing issue since many current designers empowered by fabrication technologies expand the traditional definition of an architect into the maker (master builder) of architecture. This is evident is emerging innovative practices such as SHoP where architects assumed a broader role similar to what was historically considered a master builder. These new practices not only take responsibility for building design but also are aspects of fabrication and oversight of the overall construction delivery. Furthermore, their contribution toward a project goes beyond design intent and often involves industry research and technology/tool development. These practices are the next step in the evolution of the traditional integrated team delivery (ITD) project with much closer collaborations between thinkers and makers. As with the traditional ITD projects, the success of these emerging practices depends on the unified building information platform that guarantees a high level of integration and efficiencies due to the greater level of building delivery control. However, with such highly interconnected and finely tuned design-build pipelines, there is a question of system adaptability, and continuous creative evolution remains to be explored for best possible outcomes.

1.6.1 Solving for Multiple Criteria

Most simulation and optimization approaches such as genetic algorithms allow for a single variable optimization and usually solve for a local optimal solution rather than a global one affecting many variables. This limitation applies to both analog and digital design process where designers address a limited, and often narrow, number of variables without fully investigating all possible scenarios. Architectural design requires solving for multiple criteria based on a particular value judgment. Solving for multiple variables, developing higher-level evaluation mechanism, and going beyond genetic algorithms would provide more effective creative tools. Furthermore, the ability to adaptively reprioritize evaluation criteria during the lifespan of the project would provide a better fit with real-life situations.

1.6.2 Other Data Types

Parametric relationships should go beyond geometric properties and include other data types such as building performance or user behavior. These data types need to feed into form- and space-making while considering constructability, assemblies, and user experience. Whereas solar or lighting analyses are effective tools to inform a designer's thinking and are helpful in justifying a particular course of action, they often do little to quantify design in terms of the actual performance particularly from the multiple criteria perspective.

For example, the following question is not uncommon when designing a curtain wall. What are the benefits and drawbacks of a large glazed façade from the standpoint of solar gains, thermal losses, natural lighting, and possible condensation issues? While it is common for designers to latch on to a single

criterion to justify their preferred design directions, an actual quantification of the competing design objectives would provide designers and clients with a broader understanding of their decisions and ultimately with better performing buildings. While the current state-of-the-practice assumes that all these are part of mental validation processes designers consider when designing a building, these processes are often based on intuitive thinking and unquantified experience rather than on sound and current data. This also limits clients' ability to understand a design decision process and shape it in an informed way.

1.6.3 Soft Constraints

While parametric definitions can be effective design aids in relating multiple assembly components, their binary state functionality (works or does not work) sets a serious limitation for design explorations. Designers experimenting with parametric systems may get overconstraint messages from BIM software when there is a conflict between various competing parameters. However, this does not provide constructive feedback that can help advance the design. What is needed is a soft constraint platform that communicates to the designer the degree to which the design is working. The qualitative message "you are 95 percent there" is more effective from the design process viewpoint than the mechanical response "overconstrained; it does not work."

The case study shown in Figure 1.6 demonstrates such functionality achieved with chipboard models of kinetic assemblies using scissor mechanisms. In this case, the physical material used for the

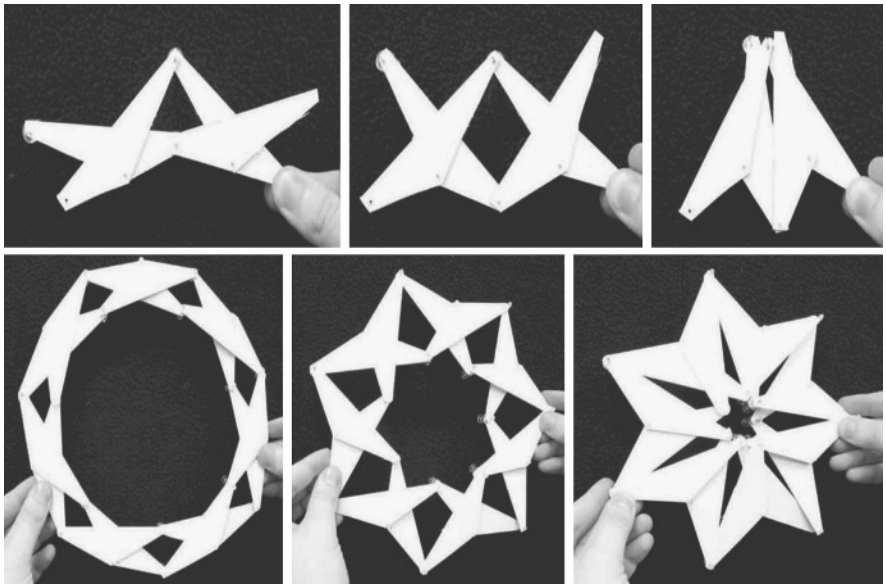


FIGURE 1.6 Materiality (digital and analog) provides valuable design feedback and facilitates problem solving.

(Images by Elvira Hoxha, Michael Middleton, and Travis Stracquadanio. Image composition and grayscale conversion and image processing with Adobe Photoshop and/or Corel PaintShop Pro)

mock-ups provided enough flexibility and strain to allow for the soft constraint functionality. Students were able to use interactions with physical models to understand kinetic movements of their designs and later bring them within a computational platform for further design explorations and resolutions. What was learned from this case study was that while physical interactions were helpful, materiality of a model was critical in providing the desired design feedback. Using acrylic glass or other rigid material would not provide the same results as chipboard models. This suggests that computational materiality employed in a similar manner could also be an effective response for soft constraint system.

1.7 DESIGN AND CONSTRUCTION 2.0

Analogous to Web 2.0 functionalities that utilize context-awareness, track user interactions and preferences, and incorporate crowd-sourcing, the future BIM platform may find it worthwhile to break away from a single data node mindset and become a part of a broad data-sharing network. This raises several questions:

- Can the experience of one designer contribute to the success of another one?
- Can data make the design process and design knowledge modular enough to be quantified, compared, and shared?
- What is required of the BIM platform to facilitate broader collaboration, knowledge transfer, and experience building?

Of course, this may posit a somewhat different business relationship between owner, architect/interior designer, contractor, and facilities management personnel as well as a redistribution of liability. Nevertheless, "turf wars" aside, there are opportunities that could be *technically* feasible that would benefit future designers. It is possible, for example, that the collection and (re)distribution of data (with appropriate identity protections) may create an entirely new area for employment. For example, some architects could specialize in development of fully integrated digital prototypes (virtual prefabs) that can be used as parametrically flexible design modules. These design assets could be reused by others and franchised as long as the digital building models would allow for easy and flexible parametric reconfigurations, thus leading to genetic standardization of architecture and formatting it into universalities that go beyond the traditional one-off designs. Additionally, this could lead toward considering designs as forms of intellectual property, not unlike the situation with tangible objects.

1.7.1 Context-Aware Data

With the exponential growth of datasets and design models, the question of filtering information, just-in-time, and just-in-place functionalities is critical. Having access to relevant information at the appropriate level of abstraction or detail would streamline design process and eliminate unnecessary trial-and-error attempts. While often criticized for the requirement of too-much-data-too-early in the design process, future BIM platforms could adapt its dataset into the level of the design resolution. While this is a representational rather than systematic issue, the initial data required by a BIM model would not have to be input by a

criterion to justify their preferred design directions, an actual quantification of the competing design

- monitoring building performance
- real-time sensors and response

The AEC software industry is not yet at the point where most of the analysis programs work smoothly with BIM. The information in a BIM is only as good as what is put into it, and seamless interoperability is not yet available. Just as design and constructability BIMs differ in how they are made and what they will be used for, an analytical BIM for energy calculations needs different information than one for cost estimation. Because of this, the additional data that is needed is typically added directly in the simulation software program. Thus one opportunity of BIM that is not fully exploited in analysis software is completing the feedback loop. Design is not simply a linear process. A designer should be able to create a conceptual model of a building, bring the file to a simulation program, make changes based on the analysis results, and continue with the updated model to other software programs, and then take results back to the BIM software without losing information along the way. This is currently not usually the case.

At a conference in December 2012, Stephen R. Hagan, FAIA, challenged the audience to consider a dramatic "moon shot" concept for BIM. He implored members of the architecture profession, the construction industry, and building product manufacturers to resolve that "within this decade (by 2020), technology and process innovators will develop a methodology and online tools to model the envelope of buildings, test for thermal, moisture, physical and energy integrity . . . all before construction in the field" (Hagan 2012).

Optimization

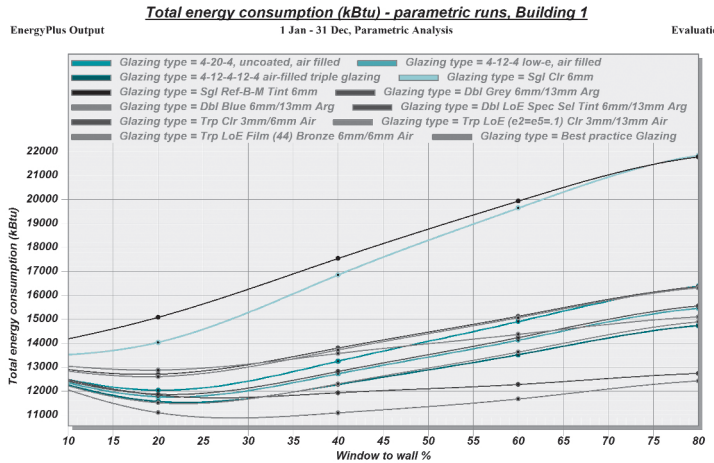
Analysis can help designers achieve more optimal solutions for their buildings. Architects are expected to be master optimizers and excellent at evaluating consequences and trade-offs. For example, in the early stages of design they are balancing a number of issues including client requests, preliminary costs, aesthetics, community concerns, structural requirements, environmental impacts, etc. Other examples can be found throughout the design process; for example, using steel versus concrete for the structure of a building has many ramifications including cost of materials, length of time for construction, code requirements, concerns about expertise, implications about the

5.5 Concrete panel alternatives for reducing heat gain (courtesy of LPA, Inc.).

façade, and others. Designers are using their experience and digital tools such as spreadsheets and simulation software to locally "optimize" or find the best solution for one variable or competing objectives. More recently, multivariable optimization algorithms offer potential solutions for well-defined questions. Although a bit off the mainstream discussion of BIM, optimization features within analytical tools are becoming more common. Even though the technology is not mature, software is already available to assist designers in selecting better solutions.

Solving for an optimal solution for one variable can be as simple as running the software multiple times until an acceptable value is reached. LPA created a process where the design team and mechanical engineers evaluated building envelope concepts using SketchUp, Autodesk Ecotect, and Autodesk Revit. They were seeking to balance design aesthetics, predicted energy performance, and construction cost while in the schematic stage of design. Once an optimal configuration was obtained the resulting design was modeled in Revit for documentation.

Parametric design curves are another method for understanding the variables involved. Instead of just providing numbers, the graphs can show many runs of the software with different variables.



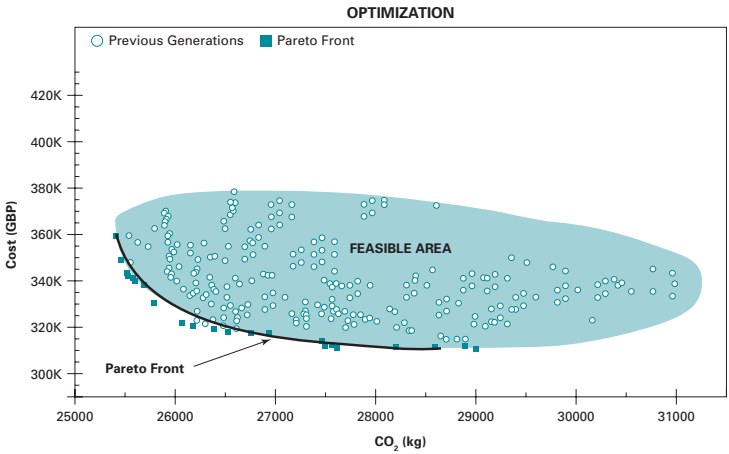
5.6 Parametric design curves illustrating effect of different WWR and glazing combinations on total energy consumption using EnergyPlus (Singh and Kensek 2013) (thanks to Sukreet Singh).

There are currently software programs designed for the building industry that use optimization algorithms in the background; users are not required to know how the algorithms operate, but are just asked what it is they wish to optimize. This is fine for "quick and dirty" estimates; however, quantitatively understanding the trade-offs helps designers fine-tune their solutions and support their decisions. Examples include:

- mechanical system optimization for energy efficiency, air flow distribution, and thermal comfort
- cost optimization for site grading
- CO_2 footprint versus building cost optimization

Some designers are using genetic algorithms directly to find more optimal design solutions. Essentially, in order to create a genetic algorithm, five items are required (Besserud n.d.):

1 what is being optimized (fitness function)
2 a starting population or set of designs



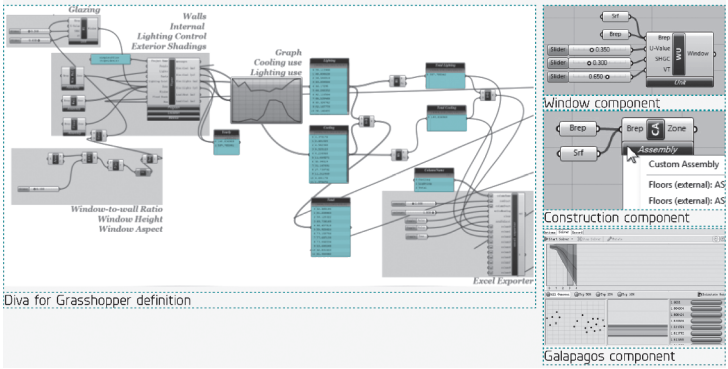
5.7 Multi-objective optimization results fromDesignBuilder generated as a set of solutions for the designer to choose between. The more optimized solutions are along the Pareto Front (Singh and Kensek 2013) (thanks to Sukreet Singh).

3 a method of testing the designs versus the fitness function
4 combinations of the best designs to create the next set for testing
5 a process that repeats the first four steps until a specified end condition is met

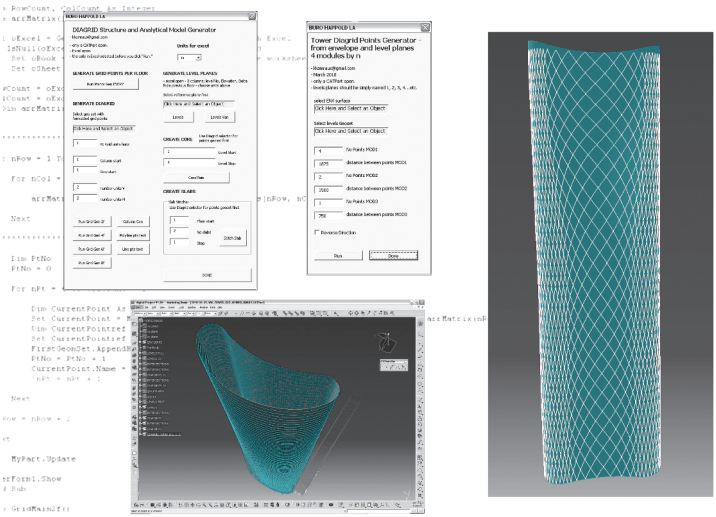
Genetic algorithms and evolutionary systems provide a framework by which locally optimal solutions can be searched for within a nearly infinite generative field of variation. Using these types of tools, the parametric system becomes the genome, the field of alternatives becomes the population, and the architect's design goal becomes the fitness criteria (Miller 2010). It is not guaranteed that the most optimal solution will be found with this technique; a local maximum/minimum might be discovered instead.

How is this actually used to help in making design decisions? One can use evolutionary systems to look for design solutions that meet certain criteria. It is easiest to understand this through a specific example. A designer wanted to know the optimal window-to-wall ratio for a test "office" during the summer. The trade-off was between smaller windows to mitigate heat gain or larger windows for natural daylight. She was also interested in the results for four orientations (north, south, east, and west), two climate zones,

	Company	Features
Diva for Grasshopper (Viper Component)	GSD	-EnergyPlus engine; -More open to users in modeling and input variables; -Limitation: some parameters are not shown in Grasshopper interface, but users can make changes through EnergyPlus basic settings;



5.8 Rhino 3D is the graphic engine. DIVA with Viper in Grasshopper is used to analyze energy and lighting. Galapagos is the optimization component (thanks to Geman Wu).



5.9 Zero E development research project: an automated structural efficiency optimization of diagrid structure in 80-story mixed-use tower (courtesy of Buro Happold and Woods Bagot, thanks to Kurt Komraus).

two illuminance levels, four aspect ratios of the window, two glazing types, and three window overhang conditions. According to the simulation results, she discovered optimal ranges for a window-to-wall ratio (and the rest of her parameters) that save the most cooling and lighting energy for electricity during summer months (Wu et al. 2012).

The designer is not required to choose the most optimal solution according to the tool. Furthermore, the suggested solution is only based on a limited number of constraints. But understanding quantitatively the trade-offs gives more information to the architect for decision-making. In time, these techniques will become increasingly incorporated in the use of BIM.

Some structural engineering programs make use of optimization to decide the size of columns and beams. Custom scripting can be used for unique building shapes and provide automated efficiency optimization.

Optimization and the future of analytical BIM

Architects, consultants, engineers, contractors, facilities managers, and design professionals – they all manage, synthesize, and balance huge amounts of information about a building (BIM in the most expansive use of the term). What happens when the building is also part of the team? Up to this point, "reactive" optimization has been described, the designer is reacting to current information, but then the solution is "fixed." For example, the architect uses a software program to determine that a steel structure rather than concrete structure is an optimal choice given cost, construction time allowances, CO_2 footprint, and other constraints. Or that a moveable shading device is a good resolution that balances cost, glare, daylight, and cooling loads.

Another type of optimization is "cognitive" optimization. Cognitive optimization is what people do – planning based on past experience, current conditions, and future expectations. But people are not especially good at it for large-scale building operations – hence intelligent building systems are being developed. The building can in real-time gather data, compare it with past usage, use other forecasts (like climate and pricing), and choose a strategy to optimize something (for example, energy consumption or interior comfort levels). It could also inform the occupants of its decisions, be able to be overruled, and provide the consequences of other choices that are not "optimal."

The building (more precisely, the building management system) can be "taught" how to do this if it has sensors, access to data, control systems,

and actuators. The building has passive components (i.e. overhangs and light shelves), active systems (i.e. occupant sensors for turning of/off lights), and very active systems that are often overlooked – the occupants in the building. They can also be "trained" to operate the building efficiently, even as simply as opening and closing blinds to increase comfort level. For example, a small business owner knows how much money she needs each month to stay in business. Let's say a heat wave is predicted. If she knew that, she might use less energy at the beginning of the month to save energy (and money) for a bigger problem later on. Preferably both the real and virtual components of the system are working together to predict, monitor, correct, and optimize the performance of the building while reporting back to the facilities managers through organized data in the form of immediate warnings, historical graphs, and building performance dashboards. A BIM would be part of this system.

Cloud computing

Background

Cloud computing can provide the power to fuel more analysis and streamline the workings of an office. Although currently marketed as an innovative practice, cloud computing's roots go back to the 1960s when the concept of timesharing resources on mainframe computers was developed. Computers were considered fast enough that a single machine could be shared among multiple users, and an expensive machine could be kept busy all the time. In its modern incarnation, cloud computing comes in many forms:

- Users remotely access a very high-performance computer or cluster of computers for computationally intensive tasks such as rendering, animation, energy calculations, computational fluid dynamics (CFD), etc.
- Users share software resources rather than hardware resources. A group of people lease software applications on a remote computer and pay just for the time that they are actually using them. However, due to software technology and some current end user licensing agreements, this is not always feasible or legal.
- Users share a set of active model files or other active or archived data located on a remote server.

CDs and the Architectural Profession: Past, Present and Future

By Heather Worrell, AIA

Traditional two-dimensional construction documents have been used for decades as the primary communication medium between architect, consultant, contractor and owner. These documents, though able to depict many details about a building's dimensions, layout and composition, present serious deficiencies for today's time crunched, data-driven decision makers. Today, Building Information Modeling (BIM) allows the project team to communicate designs in a much more effective and efficient manner, with the desire to save clients time, money and frustration.

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Many of the challenges posed by traditional CDs are in regards to speed and efficiency of collaboration between parties during the design and construction process.

BIM is a vehicle that can transform those processes, forcing greater collaboration and reducing the traditional discipline silos. Geographically dispersed project team members can work on a project simultaneously and visualize the impact of design in three dimensions instead of two. The linking of elements (grid lines, levels, structural columns) across the individual discipline models allows for changes to be communicated and executed with greater ease. Virtual file sharing environments allow for a higher level of communication with the project team as the updates are real-time instead of taking place on a weekly or bi-weekly basis. This means better informed and more efficient decision making for all parties during the design process.

Conflict resolution is also greatly improved, as software platforms such as Navisworks detect these conflicts between elements (such as structural beams and mechanical ducts) and generate a report for the project team. Improved visualization of the design within the modeled environment also allows the project team to identify problem areas and quickly generate design solutions.

The greatest yet-to-be-realized potential for BIM is the sheer depth and breadth of information contained within. Leveraging the database behind the modeling, everything from material quantities to the cost impact of specific design decisions can be integrated and tracked with accuracy. R-Values can be evaluated automatically with a change to the size of the air space; exiting calculation totals are modified when the size of a room changes; or the impact of changing a light source type can be seen as quickly as modifying a few numbers within the parameters that drives that light fixture. This allows the design to be developed in 3D and simultaneously documented for bidding and construction.

BIM also allows for Performance Based Design, with data analyses from energy, structural, sustainability, programmatic, cost and collision detection driving solutions that can reduce cost over the lifecycle of the project.

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Title:
2014 Summer PM Digest- CDs and the Architectural Profession: Past, Present and Future

Location:

Contributor:
Isabella Rosse

Published:
3/16/12 12:00 AM

Posted Date:
8/1/14 10:10 AM

Last Viewed:

The many advantages of the BIM process have changed the dynamics of the client/architect/contractor relationship. The use of BIM does require greater effort earlier in the project; however, this is precisely at the point it makes the most sense, and the reduction in effort later in the project is more significant, resulting in a building that is much closer to design. All parties can recognize gains in speed and quality control, as potential design issues can be identified and analyzed before they become construction problems requiring change orders.

A data-rich BIM deliverable can also provide a tremendous value as a lifecycle tool for facilities management, maintenance, and future project integration.

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Certainly, much of the change spurred by BIM has been internal as well. Since serving as a Revit Beta Test Site in 2002, RATIO's practice has been broadly impacted in numerous ways.

Our design process has changed; before, more time was spent during the construction document phase, as many of the details and discipline coordination hadn't been resolved until that point. Now the process is more heavily weighted toward schematic and design development, which has led to a change in how we contract for payment during the project and changing our fee structure.

From an industry perspective the architectural profession has been impacted as well; in our office, we no longer have any dedicated draftspeople, and we certainly see where this type of position will become obsolete as the industry moves towards BIM as an industry standard. Architects must be versatile and work towards an understanding of designing in a 3D, data-rich environment. Interns coming into the profession will need to understand how a building gets put together earlier, as they are putting it together virtually. This requires a great deal of professional development and training initiatives, and therefore knowledgeable buy-in on the part of firm management.

That said, the opportunity for specialization has grown exponentially. Many firms have dedicated BIM managers and specialists on staff, and those that don't can hire consultants devoted solely to BIM.

The ongoing challenge is maintaining an understanding and an investment in BIM as the technology expands into other tools besides Revit, such as Navisworks (clash detection), Civil3D (landscape design), Ecotect (day lighting and LEED quantification), and e-Specs (specification integration).

As for the future of CDs in relation to BIM, we will eventually see architects ceasing to deliver two-dimensional printed drawings, in favor of Building Information Models and electronic documents. This is already happening today: a large airport project team calculated that it would cost more to print and maintain the traditional paper construction documents than it would to provide the entire construction staff with properly equipped iPads. Even now, when RATIO's construction administrators are out in the field they use iPads to document deficiencies and communicate with the contractors and clients.

The future holds changes for our client relationships, as well. During the initial design stages, we'll be able to provide project data about an amazingly diverse set of factors, from energy use to materials costs. Imagine being able to show a client that rotating a building on the site could save them thousands of dollars in heating and cooling costs, or changing a bulb could result in drastic changes in energy use for the lifecycle of the building. Those are both possible with current technology and this platform will be utilized in an increasingly sophisticated way as we move forward.

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With any new technology comes new concerns, of course, and BIM is no different.

One challenge we see is in regards to liability: architects have always been tasked with producing "design intent" drawings, and with traditional paper CDs there has always been some necessity for interpretation on the part of contractors. Now that BIM allows us to pass along these incredibly detailed files to a contractor wholesale, where does the liability lie with issues that arise during construction that have traditionally been the responsibility of the contractor or sub-contractor?.

Other questions that have started to come up over the past few years: with BIM quickly becoming industry standard, is there liability for architects who are not using this

technology because they are not able to provide adequate clash information? Where does liability lie if the data behind an object indicates one thing but the 2D documentation states another? These are areas we must work out as an industry as the use of BIM becomes more prevalent.

As we move toward providing a Building Information Model to the contractor, that contractor has to be skilled enough to use it and also be able to have buy-in from subcontractors on the project. As the model moves from design to construction, additional models get produced and additional “I”nformation gets added. Where is the line between Architect and Builder in the virtual world, and how does the team continue to delineate that line during the construction process?

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Generally, the advantages of BIM far outweigh any disadvantages, and an extremely limited number of significant projects are being completed today without a serious application of the technology. Enhanced visualization, coordination, quantification and reduced schedule are all things that can be improved for all phases of design and construction. The key for greater success is broad acceptance and positive motivation by all team members (architect, consultant and contractor) to carefully plan for and make use of this technology. Relatively speaking, the evolution of design deliverables from 2D drafted drawings to Computer Aided Drafted Drawings and now to BIM has been fairly quick. Who can guess what the next big leap will be to delivering a design and constructing it? From my software and model in the cloud to the 3D printer working on the construction site? Whatever it may be, it will likely come faster than we expect.

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RATIO Architects, Inc. (www.RATIOarchitects.com) is an award winning design and planning firm with studios in Indianapolis, IN, Champaign, IL, Raleigh, NC and Chicago, IL. As RATIO’s BIM Specialist, Heather Worrell, AIA coordinates BIM technology, standards, and training throughout all of the RATIO studios.

Early BIM adopters, RATIO was asked to serve as a Revit Beta Test Site. Since that time, more than 9.6 million square feet and $1.9 billion of construction has been generated with Revit for a variety of project types and sizes.

BIM or Drawings or Both?
By Jason E. McFadden, E.I.T., LEED AP

I challenge my teams to work more efficiently, to be the best builders possible. Recently, I had a colleague express to me that the building information model (BIM) is not the deliverable to build from; the construction drawings (CDs) are the deliverable. The same colleague later encouraged me to look at the BIM when I had questions. Confusing? Yes. Uncommon? No. The way our industry communicates is evolving. It has been clear for some time now that taking a pick and choose approach to determining project information is not efficient or sustainable. As a builder, the BIM or drawings or both conversation raises two questions:

> ***How close are we to issuing Building Information Models as the construction drawings?***
>
> ***How long will it be before traditional drawings are obsolete?***

It is clear that drawings, specifications and Building Information Models are all valuable. That said, we must challenge the construction drawing status quo. The industry will ultimately produce BIM-centric deliverables from which all project information is derived, including drawings.

Industry Demands Improvement.

Today's construction business demands ever-increasing efficiency. This pressure is felt throughout the construction supply chain. Owners want better projects for less money in less time. Often, this results in incomplete drawings and requires more construction administration resources to answer questions and clarify design intent due to unclear documentation. Together, designers and builders are under pressure to streamline their project delivery processes. They are constantly searching for ways to improve productivity, lower costs and deliver better quality while reducing their own risk.

A Cultural and Contractual Divide.

Every day, agreements are executed that require construction drawings in a variety of forms. For many, the construction drawings are a combination of information from the BIM and details from our library of experience. The production of construction drawings is a very time consuming and tedious process. In spite of this tedium, much of the information needed to efficiently build still won't make it into the final deliverable. Some Owners and Builders have expectations that construction drawings contain no mistakes. However, there are no perfect construction drawings. Fundamentally, the goal of CDs must be to provide constructible information. At times, traditional construction drawings do not meet this standard. They are not the best communication tool and leave many questions to be asked by owners and builders. As a result, traditional construction drawings tend to have a dampening effect on team spirit and foster a lack of trust in construction documentation.

Paper-based tracing was the ultimate in interoperability. See the paper, trace the paper. There was nothing preventing architects from placing a drawing on a light board or a new

Title:
2014 Summer PM Digest - BIM or Drawings or Both?

Location:

Contributor:
Isabella Rosse

Published:
3/16/12 12:00 AM

Posted Date:
8/7/14 11:07 AM

Last Viewed:

sheet of vellum over a drawing and tracing to your heart's content. This is not the case with 2D CAD. File formats and CAD standards must be carefully managed. While drafting productivity was raised, some would argue communication was harmed. 2D CAD brought copy protection, hold harmless agreements, CD-ROM fees and the promise of increased drafting productivity. It also brought new communication challenges.

As Building Information Models supplants two-dimensional text based processes, the construction industry has an opportunity to not only regain but improve our ability to communicate with each other. What will happen if we don't take up this challenge? BIM will be another hurdle (and often a roadblock) to overcome when providing a deliverable to builders. BIMs will be provided to the owner to convey design intent with some level of coordination of systems but will have little construction value. Focusing the purpose of the BIM on a deliverable that provides constructible information aligns with the design team's responsibility to provide construction drawings. Whether a project is successful or not is largely dependent on the thoroughness and completion of the CDs. Too many times we continue to develop the design during the product submittal review period which highlights a flaw with our process and the need for change!

The real value of BIM is a constructible level detail that can be shared with all project stakeholders.

Improve the Process with the Model.

With or without BIM, process improvements are needed with how we plan and deliver projects. Using the BIM as the centerpiece of our process and deliverable has the following inherent benefits:

- Better decision-making by project stakeholders.
- More accurate systems understanding and coordination.
- Production of accurate documentation.
- More realistic cost-estimating and reconciliation.
- Alignment of construction sequencing and building techniques resulting from an understanding of what is to be built.
- Inclusion of actual product data and operations information.

The list could go on and on but the fundamental point is to have one source of truth, the BIM. All project information in one location is a needed deliverable for project teams to plan and build projects.

Looking To The Future.

The future is now. Producing constructible BIMs, or BIMs that lead to refinements that can be used in construction must be the focus going forward. By focusing our efforts on improving the quality of the BIM and providing a constructible model, the model will be the deliverable of the future. Embedding key project information within the model including, adding attribute information from the responsible companies, will change the way we work. The BIM will become the hub of all construction and design coordination processes. Model objects will begin to include:

- Necessary submittal and supplier information. **Revamped submittal process!**
- Product / Equipment information including driving data for facility management. **Revamped handover process!**
- Supply chain tracking states for information and physical status. **Revamped material tracking process!**
- GPS / location based information within BIM for easy navigation at jobsite. **Revamped field management process!**

The ultimate deliverable will be the BIM in a collaborative space for all project stakeholders to log-in and drive data queuing while continuing to enhance the BIM with additional data. Gone will be the days of producing sheets and sheets of 2D PDFs. Providing a BIM collaborative workspace will drastically change how we interact amongst teams and will help to force necessary improvements to our inefficient request for information, submittal,

material tracking, and change management processes that are crying for a drastic overhaul.

About the Author: Jason McFadden is a project manager for Barton Malow Company, a leading North American general contractor. Through his innovative approach while leveraging technology for constant process improvement, Jason is leading the design-build team on the $400M redevelopment of Daytona International Speedway also known as "Daytona Rising". He can be reached at: jason.mcfadden@bartonmalow.com.

BIM and the Future of Construction Documents

By Bill Schmalz, AIA, Construction Contract Administration KC

Technology has changed the architectural profession significantly. Just 30 years ago—spanning no more than two generations of architects—almost all documentation was drawn by hand and printed on paper. Even during the CAD "revolution," most architects used the new electronic tools to prepare two-dimensional drawings, which were almost always distributed to contractors as paper documents. But we are now in the early years of a true revolution, in which Building Information Modeling (BIM) is making even the concept of "drawing" obsolete. Or is it? What is the future of Construction Documents in the BIM era?

Looked at in one way, it could be said that the future of Construction Documents is already here. Given the right team of collaborators, including architects, contractors, owners, consultants, and subcontractors; given a highly integrated project delivery method that encourages teamwork; and given the sophisticated use of current technology at all levels of the project delivery, there is nothing stopping teams from designing and constructing buildings without ever using a piece of paper. That is, as long as we are talking about ***Construction Documents***. The obstacles preventing that vision from being a reality arise because most projects need Permit Documents, Bid Documents, and Contract Documents.

It's hard to imagine a time in the near, or even not-so-near, future when building authorities will be comfortable issuing building permits on the basis of three-dimensional virtual models. They rightfully understand the importance of their responsibilities, and most experienced plan reviewers learned their trade in pre-BIM or even pre-CAD days. Some of the more progressive building authorities now review PDFs or other electronic versions of paper, but we may have to wait until today's generation of BIM-trained young architects moves into positions of authority on building departments before seeing permit submissions consisting only of virtual models.

Despite the proliferation of collaborative delivery methods, such as Integrated Project Delivery, Design-Build, and some forms of CM-at-risk (sometimes called IPDish or IPD-lite), a large number of projects, especially publicly funded ones, rely on the most traditional and least collaborative method, Design-Bid-Build, and therefore require Bidding Documents. While Bidding Documents ***could*** be virtual models, there are problems with this. Even architects who are BIM experts understand that virtual models can be unreliable; changes in a model can occur without anyone seeming to have caused them, or knowing they happened. Such occurrences might be acceptable in an integrated team, but in a competitive bidding environment, it's essential that all the documentation be "frozen" into a two-dimensional format—either paper or PDF—that everyone can rely on.

Similarly, the need to make drawings part of the Contract Documents requires that the documents be frozen, and that every change be meticulously tracked. The litigious nature of our society, and particularly of the construction industry, demands this level of reliability.

Title:
2014 Summer PM Digest- BIM and the Future of Construction Documents

Location:

Contributor:
Isabella Rosse

Published:
3/16/12 12:00 AM

Posted Date:
8/1/14 10:23 AM

Last Viewed:

This is not to say that virtual models are not shared between architects and contractors today, even in Design-Bid-Build projects. As more contractors are becoming more familiar with BIM, they are realizing that using the architect's design models can significantly improve their coordination efforts. However, typically these models are not Contract Documents, or even Construction Documents, and should not be confused as such. It is also becoming more common for owners to require BIM deliverables from architects, and for the Owner-Architect Agreement to define the level of development for the models. Knowledgeable owners understand that the models prepared by architects are not sufficiently developed to be used for construction. Most architects, when giving their models to contractors, are careful to make clear that the models were built for the purpose of developing the design and documenting the design intent. Contractors are often required to sign statements confirming their understanding of this before they can receive the models. This is far from ideal in promoting a collaborative design and construction team, and it prevents BIM from achieving its full potential. But architects, often at the insistence of their insurance carriers, need to protect themselves from the risk of their models being misused.

For the near future (ten years? twenty years?), it is likely that most design and construction projects will use some hybrid form of documentation. Architects are becoming much less dependent on paper documents, and even on two-dimensional visualization. Today, architects are using BIM during their school years for design and documentation; this will undoubtedly lead to their exploring ways of pushing its use during construction in the future. Some contractors, especially larger and more sophisticated ones, are even further advanced in their use of BIM. In the world of large projects designed and constructed by integrated teams, two-dimensional documents may be needed only to comply with the requirements of the building authorities. All other "documents" will be virtual models, viewed with handheld tablets, or possibly now-in-development methods of true 3D visualization. As the benefits of using BIM become apparent, its use will become more prevalent at all levels of the construction industry, but this will take time. BIM itself may be revolutionary, but its adaptation will more likely be evolutionary.

Bill Schmalz, AIA, is a Principal with Perkins+Will in Los Angeles. He was the 2011 Chair and is an Advisory Group member of the AIA CCA Knowledge Community. His book, The Architect's Guide to Writing, has recently been published, and he is a contributing author for The Architect's Handbook of Professional Practice, 15th Edition.

BIM and the Future of Construction Drawings

By David B Richards, AIA

BIM is the promise of the computer world from those very early days as CAD entered the field of architecture. I welcome it. I have been totally fascinated by the views of the building that are available in Revit and NavisWorks. I am able to share views of the design with the client that would never have been shown in 3-D in the past. I was especially thankful for the diligent teamwork between the design team and the subcontractors on a recent project that resolved a multitude of utilities that passed through a particularly tight ceiling cavity from several directions - all without lowering the ceiling. From the perspective of someone that drew on linen well before pin-bar was a thing, BIM is pretty cool. I envy those that get to think this way about their architecture.

I see a future today in BIM where, based on existing technology, the full scope and intent of a project is expressed on an iPad (or similar device.) I'm not suggesting that we simply have PDFs of the drawings available; I am envisioning a highly interactive environment that would allow the user to move quickly from overall scoping plans to enlarged plans to plan details to model without flipping through drawings.

It would work like Google Maps. Plans, sections and elevations; the overall scoping drawings, would be easily accessed with a tap of an icon along the top of the screen. Once a general type of drawing has been selected, let's say a floor plan, a swipe of the fingers would change floor levels. A spread of the fingers would take the viewer deeper into the detail of the drawings. In elevation swipe to rotate around the building or room. Tap the plan next to a wall – inside or out, and switch from plan to elevation, at the same level of detail; another tap takes you back, or if you choose, into the model. Just tap the model icon and be put into the model in that location. Tap a material call out and see the specifications, complete with links to manufacturers, schedules and model quantities.

Like Google Maps, each level would reveal more detailed information. Plans might start as an overall plan that includes the full building. As the image is expanded, with a spread of the fingers, the next level of detail would come into view. It would be as if I started viewing a 1/16"=1'-0 overall plan and with a spread of the fingers I would be viewing a 1/8"=1'-0 plan with wall locations and types and exterior dimensions. Another spread of the fingers and I would be looking at enlarged plans that would indicate the location of things on the walls. A tap of an element on the wall would reveal the spec and a view of mounting height information. Tap a door in plan or elevation and get full door and hardware information another tap and full door schedule information appears.

Also like Google Maps the viewer could easily toggle between orthographic projection and the model view. The viewer could choose to "walk" through the model then toggle back to the plan or elevation view in their new location.

With a tap of the icons along the side of the screen, users could toggle between the focused information of the various trades; structural, mechanical, plumbing, electrical... all while in the same location in the building and at the same level of detail. Specification information would be linked to every material call-out. On site, the internal GPS would put

Title:
2014 Summer PM Digest - BIM and the Future of Construction Drawings

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you directly into your location in the model and drawings, while standing there.

So, with technology available today, all of the drawings and the specifications could be on a single device in a highly interactive environment. Traditional drawings might exist electronically, but the interactive “drawings” would be incredibly useful.

Eventually paper drawings will be a thing of the past. I think that paper drawings will go away soon, like vinyl records. Even I carry PDF drawings on my iPad – they’re much lighter that way. But it won’t be long before traditional orthographic projections are no longer needed or even understood. In the not too distant future, the BIM will be displayed from a device in holographic projection. It might be a table for large models or a cell phone or a wrist watch for smaller projects or field use. It might be glasses that put you into a full size model, on the site that looks and seems real. You will no longer need to be able to understand a flat 3-D image, you will be able to experience the architecture and all of the systems displayed in front of you; you’ll really be able to walk the building. Simple hand movements will allow the viewer to move in and out of detail levels, image qualities, systems focus, quantity tables, and all project information.

In the future, BIM will allow architects to provide better information that is more easily accessed. We have the potential to improve our services and increase our value in the process.

_____

David B. Richards, AIA, LEED AP, PMP is the Chief Operating Officer and a Principal of ROSSETTI, an international leader in sports architecture design. David is the Chairman of the AIA Best Practices Committee, a member of the Practice Management Knowledge Community Advisory Group and a contributing author to the Architect’s Handbook of Professional Practice, 15th Edition.

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Off-Site Construction Industry Survey

The purpose of this survey is to identify the opportunities and challenges associated with the use of off-site construction processes and technologies and how the National Institute of Building Sciences can foster the utilization of off-site construction to support high-performance buildings. This survey is anonymous. Your answers will be included in the aggregate only. There is an option to leave contact information at the end of the questions to allow follow-up, but this is voluntary.

1. I have incorporated the following off-site elements in one or more projects in the last 12 months. (check all that apply)

- ☐ Precast concrete structure
- ☐ Cross laminated timber structure
- ☐ Prefabricated exterior wall assemblies
- ☐ Curtainwall assemblies
- ☐ Permanent building modules (i.e. volumetric construction)
- ☐ Prefabricated interior wall or soffit panels
- ☐ Service pods (bathrooms, utility rooms, etc.)
- ☐ HVAC, Plumbing and Electrical racks, risers and other assemblies (single trade or multi-trade)
- ☐ Headwall assemblies
- ☐ Equipment skids
- ☐ Steel Assemblies
- ☐ None

Other (please specify)

2. Rate the barriers to implementing off-site construction?

	No Barrier	Small Barrier	Moderate Barrier	Significant Barrier
Industry Knowledge	○	○	○	○
Cost vs. Value	○	○	○	○

Design + Construction Culture	○	○	○	○
Program of the Building	○	○	○	○
Lack of Skills	○	○	○	○
Concern for Quality	○	○	○	○
Supply Chain + Procurement	○	○	○	○
Regulations + Codes	○	○	○	○
Site Operations	○	○	○	○
Health + Safety Risks	○	○	○	○
Transportation	○	○	○	○
Financing + Insurance	○	○	○	○
Manufacturing Technology	○	○	○	○
Urban Site	○	○	○	○
Rural Site	○	○	○	○
Distance from factory to site	○	○	○	○

Other (please specify)

3. Considering the most successful project that utilized off-site construction, what was the distance from the factory to the site?

4. During project planning phase for this project, who was responsible for the decision to use off-site? (select all that apply)

- ☐ Client Request
- ☐ Architect Specified
- ☐ Engineer specified
- ☐ Construction Manager or GC requested or required
- ☐ Other (please specify)

5. Considering your most successful experience with off-site construction, what were the pre-construction expected benefits of using off-site? (select all that apply)

- ☐ Schedule advantage/speed to market
- ☐ Quality
- ☐ Cost-effectiveness
- ☐ Weather concerns
- ☐ Cost
- ☐ Safety
- ☐ Sustainability goals (such as LEED)
- ☐ Site operations
- ☐ Schedule

other

6. For this project, what were the actual benefits realized by using off-site construction? (select all that apply)

- ☐ Schedule advantage/speed to market
- ☐ Quality
- ☐ Cost-effectiveness
- ☐ Weather concerns
- ☐ Cost
- ☐ Safety
- ☐ Site Operations
- ☐ Client Satisfaction
- ☐ Other (please specify)

7. For the considered project, when did you collaborate with the contractor performing the off-site work and based on your experience, when do you recommend engaging the offsite contractor?

	Project Engagement	Recommended Engagement
Concept	☐	☐
50% Schematic Design	☐	☐
100% Schematic Design	☐	☐
50% Design		

Development	☐	☐
100% Design Development	☐	☐
50% Construction Documents	☐	☐
100% Construction Documents	☐	☐
Post Bid	☐	☐

8. What level of stakeholder collaboration is required to implement off-site construction in comparison to traditional construction methods?

- ○ Significantly higher level of collaboration
- ○ Moderately higher level of collaboration
- ○ Similar level of collaboration
- ○ Lower level of collaboration

Please explain

9. In the next 12 months, how often do you anticipate using off-site construction?

- ○ More
- ○ The same
- ○ Less
- ○ Not at all

Why is this?

10. What types of support could the National Institute of Building Sciences Off-Site Construction Council offer that would benefit your company's utilization of off-site construction? (select all that apply)

- ☐ Case Studies
- ☐ Industry Data (Construction Performance)
- ☐ Design Standards, Details, Specifications
- ☐ Glossary
- ☐ Networking
- ☐ Academic/Research Partnerships

- [ ] Other

11. What aspects of off-site design and construction information and data are you interested in? (select all that apply)

- [ ] Design, Engineering, Specification
- [ ] Lean Manufacturing
- [ ] Automation (CNC and CAD/CAM)
- [ ] Emerging materials, products and systems
- [ ] Transportation logistics
- [ ] Installation logistics
- [ ] Regulatory/Codes
- [ ] Sustainability, LCA
- [ ] Project management and project delivery
- [ ] Maintenance and durability
- [ ] Accelerated construction and schedule methods
- [ ] High-rise off-site construction
- [ ] Labor skills/training
- [ ] Residential construction
- [ ] Commercial construction
- [ ] Other

12. The company I represent primarily provides the following services. (check all that apply)

- [ ] Construction Manager/GC
- [ ] Architecture
- [ ] Engineering
- [ ] Owner/Developer
- [ ] Trade Contractor
- [ ] Please specify the company type (i.e. HVAC contractor)

13. What is your company's annual revenue?

14. The project types where my company has utilized off-site construction include: (check all that apply)

- ☐ Healthcare
- ☐ Hospitality
- ☐ Housing - single family
- ☐ Housing - multi-family
- ☐ Education
- ☐ Commercial
- ☐ Industrial
- ☐ Data Center/Mission Critical
- ☐ Other

15. In which state(s) was/were the project(s) that utilized off-site construction located?

16. Which organizations does your company belong to? (select all that apply)

- ☐ Air Conditioning Contractors of America (ACCA)
- ☐ American Concrete Institute (ACI)
- ☐ American Institute of Architects (AIA)
- ☐ American Institute of Constructors (AIC)
- ☐ American Institute of Constructors (AIC)
- ☐ American Institute of Steel Construction (AISC)
- ☐ American Society of Civil Engineers (ASCE)
- ☐ American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
- ☐ American Society of Professional Estimators (ASPE)
- ☐ American Wood Council (AWC)
- ☐ Associated Buildings and Contractors Inc. (ABC)
- ☐ Association of Wall and Ceiling Industries (AWCI)
- ☐ Building Owners and Managers Association (BOMA)

- [ ] Building Trades Association (BTA)
- [ ] Construction Industry Institute (CII)
- [ ] Construction Management Association of America (CMMA)
- [ ] Construction Owners Association of America (COAA)
- [ ] Construction Specifications Institute (CSI)
- [ ] Construction Users' Roundtable (CURT)
- [ ] Design Build Institute of America (DBIA)
- [ ] International Code Council (ICC)
- [ ] International Facility Management Association (IFMA)
- [ ] Lean Construction Institute (LCI)
- [ ] Mechanical Contractors Association of America (MCAA)
- [ ] Modular Building Institute (MBI)
- [ ] National Association of Home Builders (NAHB)
- [ ] National Electrical Contractors Association (NECA)
- [ ] National Fire Protection Association (NFPA)
- [ ] National Institute of Building Sciences (NIBS)
- [ ] Precast Concrete Institute (PCI)
- [ ] Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
- [ ] The Associated General Contractors of America (AGC)
- [ ] U.S. Green Building Council (USGBC)

Other (please specify)

17. If you would like a follow-up concerning The Institute's Off-site Construction Council activity, please identify yourself with name and email address in the box below (voluntary).

The National Institute of Building Sciences, Off-Site Construction Council will be conducting periodic surveys to support the AEC industry in implementing off-site construction. We invite you to join the National Institute of Building Sciences Off-Site Construction Council and participate in this discussion. It is open to professionals from across the building industry. Visit The Institute's website and register as a member at: http://www.nibs.org.

Done

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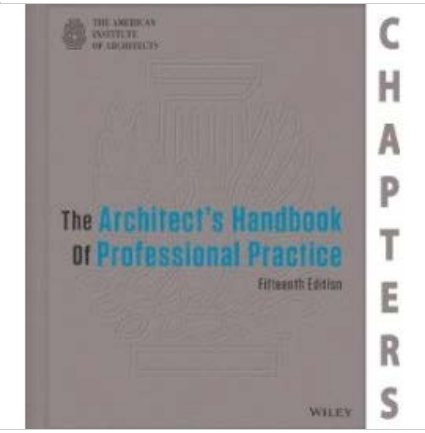

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