



# Pop-Up and Pre-fabricated Architecture

**AIAPDH186**

**3.0 PDH/3 CE Hours/3 AIA LU/HSW**

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# ANSWER SHEET

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## Pop Up Prefab: Pop Up and Pre-Fabricated Architecture : AIAPDH186

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22. (A) (B) (C) (D)

23. (A) (B) (C) (D)

24. (A) (B) (C) (D)

## **FINAL EXAM**

1. **Pop-Up Architecture, a quintessentially 21<sup>st</sup> century form of architecture, is emerging as a powerful force of creative expression and imagination in which of the following:**
  - a. Hospitals
  - b. Festivals and Expos
  - c. Bridges
  - d. Housing
  
2. **Which of the following is NOT an example of Pop-Up Architecture**
  - a. World's Fairs and Expositions
  - b. The Biennale
  - c. The Serpentine Pavilion
  - d. The U.S. Capitol
  
3. **LQC is a term coined by the New York Projects for Public Spaces and stands for**
  - a. Light
  - b. Quick
  - c. Cheap
  - d. All of the above
  
4. **Pop-Up Weddings are a \_\_\_\_\_ to the more traditional wedding, according to Faye Darcy.**
  - a. Slower
  - b. Simple and elegant alternative
  - c. Dramatic change
  - d. Much more complicated alternative
  
5. **Prefabrication in architecture has historical roots in which of the following structures:**
  - a. The Crystal Palace at Britain's Great Exhibition of 1851
  - b. Portable Colonial Cottages of the 1830s
  - c. Ship building and lighthouses
  - d. All of the above.

6. **Features of prefabrication in Britain embraced which of the following advanced concepts**
- Flexibility
  - Standardizations
  - Interchangeability of components
  - ALL of the above
7. **The history of prefabrication is linked to \_\_\_\_\_ during Victoria's reign**
- Climate change
  - British colonialization
  - Warfare
  - Geographic diversity
8. **The FIATECH Capital Projects Technology Roadmap was conceived and published in what year?**
- 1830
  - 1851
  - 1997
  - 2004
9. **Which of the following is NOT a project or publication by Kieran Timberlake**
- The Hirschhorn Gallery in Washington DC
  - Loblolly House
  - Cellophane House
  - Refabricating Architecture
10. **Which of the following “breakthrough improvements” is NOT one listed in The National Academy of Sciences 2008 publication on *Advancing the Competiveness and Efficiency of the U.S. Construction Industry***
- Greater use of prefabrication
  - Widespread use of BIM
  - Art in public places
  - Improved job-site efficiency
11. **Examples of automation in the Prefab marketplace includes all of these projects EXCEPT**
- The FutureHome Project
  - The ManuBuild Project
  - TailorCrete Projects
  - Falling water

12. **Techniques taking prefab from prototype to mainstream include all of the following EXCEPT:**
- 3D Concrete Printing
  - Digital Fabrication of Architectural Structures
  - Robotic Tile Placement
  - Stick built wooden frames.
13. **The FMI 2013 Survey of Prefabrication and Modularization in Construction Listed key industry drivers for the continued development of prefab, including all of the following EXCEPT:**
- Pressure to lower price
  - Need to achieve a competitive edge
  - Impending lack of skilled construction labor
  - Manual processing of paper documents
14. **The Mortenson Prefabrication Research Study Results (May 2014) documented the following benefits of prefabrication**
- Schedule & Cost Certainty
  - On-site Labor Density
  - Fewer Safety Incidents
  - All of the above.
15. **BLOX documents the metrics around prefabrication and hospital patient room modules that include**
- 800 Components
  - Installed by a dozen Trades
  - Over a span of three months
  - All of the above.
16. **“Dismal Land”, a pop-up exhibit in England, has a focus on \_\_\_\_\_ and experience and sculpture, combined in space and time and immediacy.**
- Toys
  - Cars
  - Architecture
  - Food
17. **Many do not realize that expositions and world’s fairs, an example of pop-up architecture, date back to:**
- Greek archaeology.
  - 1791
  - Pre-historic times
  - Roman Architecture

18. **Expos, a form of pop-up architecture, in North America date back to what state and fair?**
- New York City
  - World's Fair of Tunbridge, Vermont
  - San Francisco
  - Austin
19. **World's Fairs are generally constructed with a functioning duration of:**
- Over a decade
  - IA few days
  - 3 to 6 months
  - Forever
20. **Certain venues such as \_\_\_\_\_, according to Harry Swartout, provide a more locally meaningful and durable alternative to World's Fairs**
- Indy 500.
  - Biennale and Serpentine Pavilion
  - Pyramids
  - Stonehenge
21. **An annual event in the Nevada desert, \_\_\_\_\_, has been billed as "the place to find out who you are, then take it a step further."**
- Nascar
  - Burning Man
  - The British Baking Show
  - A Netflix Original Series
22. **One example of a new type of pop-up business is \_\_\_\_\_ which have proven to be imaginative and popular in Las Vegas, Washington DC and New York City is:**
- Stationery Stores
  - Weddings
  - Tech
  - Plumbing
23. **The Pop-up wedding business has proven extremely \_\_\_\_\_ for brides and grooms where a typical cost of \$2,500 has been reduced to \$325.**
- Complex
  - Economical
  - Overly sophisticated
  - Hard to manage

24. **Around Here is a business founded in 2013 with a mission to:**
- a. Create a series of coffee shops.
  - b. Provide low-cost books
  - c. Build a network of the noteworthy retail space
  - d. Compete with WeWork



## Pop-Up Prefab *Pop-Up and Pre-fabricated Architecture*

*By Stephen R Hagan FAIA*

01/28/2020

### *Course Description and Learning Objectives*

#### **Course Description**

*Is Pop-Architecture just a trend or a new way to practice architecture and engage with a rapidly growing segment of the retail, entertainment and housing industries? Is pre-fab the next best thing in design? New techniques in prefabrication and direct-from-design manufacturing promise to dramatically change the practice of architecture.*

*In this course, you will:*

- 1. Explore current trends and their impact on the industry*
- 2. See how these options can help you reduce waste, save time, and access materials that were once cost-prohibitive*
- 3. Engage with experts and understand how you can make the most of these advances*
- 4. The industry is already feeling the impact of pre-fab. This course will help you stay ahead of the sea change.*

#### **Learning Objectives:**

- 1. Course learners will be able to identify key skills needed to influence change by being exposed to several different applications of **pop-up architecture** and how it is changing the way we think about design.*
- 2. Course learners will be able to identify key skills needed to influence change by actively understanding key concepts discovering some of the differences between traditional design / construction processes and **pre-fabrication** enabling them to apply these concepts to their own practices.*
- 3. Course Learners will be able to identify key skills needed to influence change by addressing some of the techniques used in digital fabrication. Learners will be exposed to numerous methods of how digital fabrication tools are being used in pre-fab and modular construction to increase efficiency and improve quality.*
- 4. Course Learners will have a better understanding of the principles of logistics and management and potential for integration with pop-up architecture and prefabrication.*



## Pop-Up Prefab *Pop-Up and Pre-fabricated Architecture*

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### ***I. INTRODUCTION AND OVERVIEW***

This course provides a detailed analysis of the culture and processes of the design and construction industry, new technologies that are providing game changing approaches to solving problems, and the exploration of a series of questions:

- Is Pop-Up Architecture just a trend or a new way to practice architecture and engage with a rapidly growing segment of the retail, entertainment and housing industries?
- Is pre-fab the next best thing in design? New techniques in prefabrication and direct-from-design manufacturing promise to dramatically change the practice of architecture.
- How can Pop-Up Architecture and Pre-Fabrication integrate to transform the industry, save time and money, and dramatically improve customer experience?

So what is Pop-Up Architecture and why does it matter to the design and construction industry and why should I care? By one writer's observation, "America is fast becoming a pop-up nation. From sea to shining sea, her cities have been swept up in the frenzy for temporary architecture" (see <http://forum.skyscraperpage.com/showthread.php?t=199318>).

This is also happening globally as both housing, urban design, and retail marketing are finding the virtues of Pop-Up Architecture. The exploration of the definition of Pop-Up Architecture and what differentiates it from "temporary" architecture, its historical roots, and its potential impact will be explored fully in this course.

Along with Pop-Up Architecture is an equally relevant and timely topic of Pre-Fabrication. The industrialization of the process of design and construction has been going on for over a century but pressures on cost and delivery schedules are increasing the impact and pervasiveness of pre-fabrication. As the economic environment becomes increasingly

global, so does the importance of supply chains. And supply chain management in the built environment is increasingly becoming an important aspect of industry.

The following is an abbreviated outline of items we will cover in detail in this course:

## **COURSE OUTLINE**

- I. *Introduction and Overview*
  - a. *What is “Pop-Up Architecture”, why does it apply to the construction industry, and why should I care?*
  - b. *What is Pre-Fabrication and how does it relate to architecture and the construction industry*
  - c. *What do we mean by “Global Supply Chains” and how does that relate to the design and construction industry, pop-up architecture, and pre-fabrication.*
- II. *Pop Up Architecture*
  - a. *History*
  - b. *Romans and Greeks Buildings and Urbanism*
  - c. *World's Fairs Expos and Burning Man*
  - d. *Millennials take the Stage*
  - e. *Architecture Becomes Marketing Becomes Commerce*
- III. *Prefabrication*
  - a. *What is the History of Prefabrication?*
  - b. *What Problem it is trying to solve?*
  - c. *What is Potential Benefit?*
  - d. *What are Challenges?*
  - e. *Who are Stakeholders?*
- IV. *Cutting Edge Case Studies*
  - a. *Phillipe Starck*
  - b. *Eggrock*
  - c. *Bloxbuilt*
  - d. *Projectfrog*
- V. *Conclusion*
- VI. *Bibliography*
- VII. *Internet Links and Notes*

## ***I. Introduction and Overview***

### **REVIEW QUESTIONS**

#### **1. A key question about Pop-Up Architecture is**

- a. Is it a trend?
- b. Is it a new way to practice?
- c. What is involvement in retail, entertainment, housing industries
- d. All of the above.

#### **2. Pre-Fab (Pre-Fabricated Architecture) involves**

- a. Social Media
- b. New techniques in direct-from-design manufacturing
- c. Legal discussions
- d. Automotive industry

#### **3. Which of the following is NOT an example of Pop-Up Architecture**

- a. World's Fairs and Expositions
- b. The Biennale
- c. The Serpentine Pavilion
- d. Frank Lloyd Wright's Falling Water

#### **4. Pop-Up Architecture can be considered a “frenzy for temporary architecture” in what way?**

- a. It costs too much
- b. It reflects ancient traditions
- c. Examples abound in Brooklyn, Dallas, San Francisco and Washington DC.
- d. It is way too complicated

#### **5. Pop-Up Architecture is changing our Relationship to the Built Environment by \_\_\_\_\_.**

- a. Extolling Vitruvius' virtues of utilitas, firmitas, and venustas (utility, durability and beauty)
- b. Because the permanent is becoming a lot less permanent
- c. Creating monuments in marble and stone.
- d. Building in green field sites.

**6. New York's transportation commissioner implemented an example of pop-up architect that she calls "Jane Jacobs's revenge on Robert Moses" with the following features**

- a. Extensive bridges and highways
- b. Fast-acting interventions favoring pedestrians and cyclists
- c. Urban parks systems
- d. Improvements to schools.

## ***II. Pop-Up Architecture***

From housing, urban revitalization, artistic expression, festivals and expos, and retail market place presences, Pop-Up architecture in the early 21<sup>st</sup> century is truly an emerging and powerful force for creative expression and imagination.

### **America a Pop-Up Nation**

Kelly Chan in May 2012 wrote an article for Blouartinfo.com that stated America was fast becoming a “Pop-Up Nation.” Her assessment is provided in more detail in **Appendix IX.1**, but can be summarized as a surprisingly pervasive movement across the U.S. in many varied locations to embrace the idea of temporary architecture for many purposes. Some of the examples she cites include:

- *Brooklyn vendors sell their wares in artfully arranged shipping containers;*
- *Dallas’s Build a Better Block group champions DIY painted bicycle routes and pop-up small businesses;*
- *architects in San Francisco are repurposing metered parking spaces into miniature parks;*
- *residents in Oakland, California rallied to create an entire pop-up neighborhood*

Ms. Chan’s assessment looks at historical precedents and current cultural phenomena, but the fact is the millennials as a generation are flocking to the concept because it is lively, vibrant and “very cool”. While she quotes “the strains of contemporary living”, the fact is many are trying to do “more with less” and “more immediately” as opposed to long term and complicated. For more specific business models (i.e. weddings, retail) and building types, the following examples add a particularly interesting dimension.

### **History of Pop-Up Architecture**

But Pop-Up Architecture has a history that goes back to Ancient Rome. (A more in depth excerpt is provided in **Appendix IX.2**) There was a time when the roman rulers were opposed to permanent amphitheaters and other structures unless they themselves had ordered them to be built. For common citizens, temporary or Pop-Up architecture, mostly of wood which was easy to build and disassemble, were conceived as venues for community celebrations, local theatrical performances, and various religious and non-religious festivals.

Although temporary, the structures would actually be significant in size and scope. There was a moratorium on permanent theatre structures in the city of Rome that lasted until 55 BC, and therefore the “pop-up” nature of structures prevailed, some even with

significant stories of columns, statuary, and provided a rich expression of architecture and art.

Permanent building began after 55 BC and throughout the Roman Empire, and temporary structures didn't arise again on a significant level until the Renaissance. Pop-up architecture would again be created in both cities and villages and along the routes to cities to celebrate the arrival of royalty. One example during the reign of King Henry II of France when he travelled to cities and festivals sprouted up along the parade route.

So during 1500s and 1600s, the pop-up architectural form provided many ways to experiment with both design innovations as well as construction techniques. Many were, although temporary, as extravagant as more lasting structures. An example was Inigo Jones's temporary arch of 1622.



## England's "Dismal Land"

From urban scale world's fairs, expos, biennales and Burning Mans, Pop-Up Architecture can also be more of a neighborhood festival, fair or art exhibit. Marni Epstein-Mervis writes about a pop-up exhibit in England called "Dismal Land". A more detailed description is in **Appendix IX.3**, but the focus is how architecture and experience and sculpture are combined in space and time and immediacy, to a very compelling effect.

## World's Fairs and Expositions

World's Fairs and Expositions are perhaps the most common and explicit example of Pop-Up Architecture at a mini-urban scale. Although with few exceptions such as

- London’s Great Exhibition of 1851 (with the Crystal Palace)
- Chicago’s World Columbian Exposition in 1893 (with the first Ferris Wheel among other architectural innovations),
- the Paris Exposition of 1889 (with the Eiffel Tower), and
- the New York World’s Fairs of 1939 and 1964 (with the Unisphere),

many of us do not realize that expositions and world’s fairs date back to 1791. That first world’s fair in Prague, Bohemia led to many more, varied in their size, scope, nature and there are numerous examples world –wide.. The list is amazing and is available at: [https://en.wikipedia.org/wiki/List\\_of\\_world's\\_fairs](https://en.wikipedia.org/wiki/List_of_world's_fairs).

In addition, as Wikipedia notes, “The oldest North American expo calling itself a World's Fair is the World's Fair of Tunbridge, Vermont, which is held yearly.” So there are examples that are both local and international in scope and theme.

Generally constructed with a functioning duration of about 3 to 6 months, world’s fairs are a perfect example of Pop-Up architecture and innovative approaches to urbanism. Temporary in nature, they often espouse both patriotic and nationalistic themes (celebrating their host countries or cities), as well as industrial and modern-day innovation.

Harry Swartout, in a *Time Magazine* article on April 29, 2014, gave an overview of the current state of World’s Fairs, asking the question “Have the World of Tomorrow” Become a Thing of the Past?” (see **Appendix IX.4**)

Mr. Swartout was writing on the 75<sup>th</sup> anniversary of the 1939 World’s Fair in Flushing Meadow, NY. Although New York hasn’t had a world’s fair since 1964, North America hasn’t had one since 1986 in Vancouver, British Columbia.

Part of the problem is the world has moved on, and the themes of the 1939, 1964 and even older world’s fairs of 1893 in Chicago and Paris in 1889. Many of the themes of technology breakthroughs and innovation that could only be seen and visited in those periods of history now are available immediately and very accessibly on smart phones and tablets with a click of a button. So events such as the Biennale and the Serpentine Pavilion provide a more locally meaningful and durable alternative, and can build on previous years’ hosting in venues such as Vienna and London.



## The Biennale

Pop-Up art and architecture have been combined in a series of events occurring every 2 years dating back to 1895: The Venice Biennale. The apropos to our course topic, the 15<sup>th</sup> International Architecture Exhibition, titled “Reporting from the Front” was just ran from May 28 2016 to November 27<sup>th</sup> 2016 and was organized by La Biennale di Venezia. The online archive of this exhibition, which can be viewed at:

<https://www.google.com/culturalinstitute/beta/u/0/project/biennale-architettura-2016>

and this archive provides a dramatic representation of the breadth and depth of how Pop-up Architecture can express artistic points of view and perspectives.

## Burning Man

Burning Man is an annual event in the Nevada desert billed as “the place to find out who you are, then take it a step further.” The next Burning Man 2017 takes place August 27 – September 4, 2017 in the Black Rock Desert of Nevada. “Participants join in the effort to co-create Black Rock City, a temporary metropolis dedicated to art and community.” See <http://burningman.org/event/brc/>. The description of Burning Man continues:

*Burning Man isn't your usual festival. It's a city wherein almost everything that happens is created entirely by its citizens, who are active participants in the experience.*



## The Serpentine Pavilion in London

London has featured a highly innovative and acclaimed version of the pop-up architecture since 2000 in Kensington Gardens with an annual installation of unique galleries of architecture. The Serpentine Gallery at the Kensington Gardens, London, is considered one of the most important contemporary art centers and exhibition venues in the United Kingdom.

In 2000, Zaha Hadid created a pavilion with sloping roofs that provided a space for many functions. The Serpentine Architecture Programme expanded for 2016, with four Summer Houses joining the Serpentine Pavilion.



The Dutch architect Bjarke Ingels of the firm BIG has an excellent description of his installation in a YouTube presentation at: <https://youtu.be/xkJmer8Hxi4>. The 2016 Serpentine Pavilion structure Ingels designed is a kind of “unzipped” wall that visitors can walk through by way of a dramatic passageway that is a café by day and houses an evening program called “Park Nights” for performing artists, writers and musicians.

## **Pop-Up Weddings Retail and Shelter**

The Pop-Up phenomenon goes beyond the urban and the scale of world’s fairs to smaller and more nimble start-up businesses, many of which are being conceived and executed by millennials. These range from a woman entrepreneur who has launched a pop-up wedding business, to retailers in Europe taking brands globally to Pop-Up wedding chapels in New York City and even temporary shelters for festivals and emergency responses.

Wedding businesses in Las Vegas, Washington DC, New York City and the UK are proving how imaginative and popular the pop-up approach can be.



Victoria Hogan is a 29 year old with a master's degree in fine arts from University of Nevada Las Vegas who had an idea of how to make weddings more intimate, accessible, affordable, and in a dramatic setting. Victoria launched her pop-up wedding business in August 2014 with the name of Flora Pops ( <http://florapop.com/> ).

As reported by Buck Wargo in the Las Vegas Review-Journal (<http://www.reviewjournal.com/business/entrepreneur-launches-pop-wedding-business>), Victoria stated

*"I want to change the way that Vegas weddings are perceived," Hogan said. "The landscapes surrounding the valley are absolutely gorgeous and so close. They can have a typical Vegas experience. I want to highlight the natural landscape and how much beautiful and romantic it can be and it's very serene."*

*Hogan said she gets a lot of business from Europeans and Australians and others who don't mind spending money on their wedding but prefer instead to spend more on their honeymoon. Many Europeans, especially this time of year, can't plan outdoor weddings because of the potential for rain and bad weather, she said.*

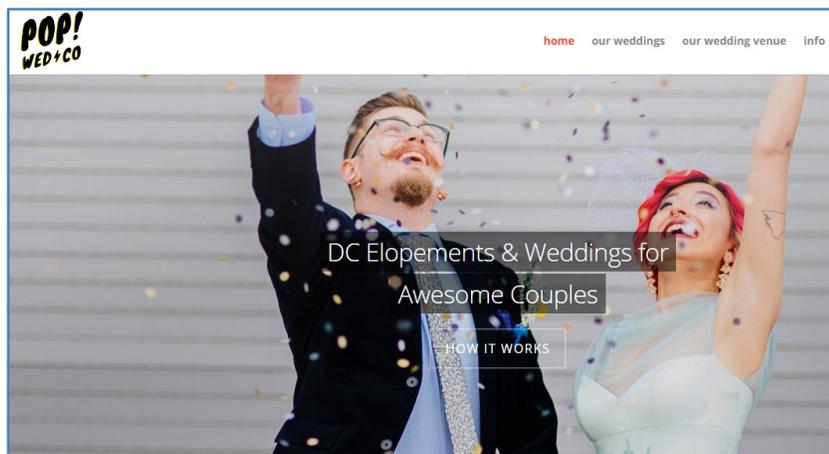
Not only is the business creative, it is also extremely economical for the bride and groom and wedding party:

She said she does at least 10 weddings a month and many times does more than 20.

*The cost varies depending on what people want. A wedding in the desert typically costs \$2,500 and includes permits if needed. If someone wants to get married downtown, it might cost \$1,200, Hogan said. She's done weddings at the homes of Las Vegas residents where she officiates for \$325 but nearly all weddings are done outside and most are planned in advance. She's even done a wedding at a trailer park."*

## Pop! Wed Co. Washington DC

A wedding in Washington DC can be even more expensive, with average amount spent about \$31,000 (and in many cases many multiples of that cost). That is how the pop-up wedding company, Pop! Wed Co. envisioned its market and concept (<http://popwed.co/>) with the tag line on their website: "DC Elopements & Weddings for Awesome Couples."



As Steven and Maggie Gaudaen, the owners of Pop! Wed Co, described it to ABC News (<http://abcnews.go.com/Lifestyle/pop-weddings-tie-knot-ten-minutes/story?id=35895208>) ,

*"[Pop-up weddings] are so simple to do. We talk to the people in the beginning, plan a location, and then they pretty much show up and get married."*

The cost is \$2,900 on weekdays and \$3,200 on weekends, so amazingly affordable. And in Washington DC the venues can be spectacular museum interiors, outdoor gardens, and monuments throughout the capital.

## **Pop-Up Wedding Chapel Contest New York City**

Pop-up wedding chapels have also been the subject of design competitions, in this case to celebrate historic gay wedding legislation in New York City. As reported by Suzanne Labarre on 08.02.11 in Fast Company Magazine,

*The structures — one, a hut of honeycomb cardboard stacked in the shape a tulip; the other, a cube filled with rainbow-colored ribbons — resulted from a design competition launched by Architizer and sponsored by the wedding planning site The Knot. The contest asked architects to design temporary chapels for a day's worth of free, gay nuptials in Manhattan hot on the heels of Gov. Andrew Cuomo signing historic legislation to legalize same-sex marriage in New York.*

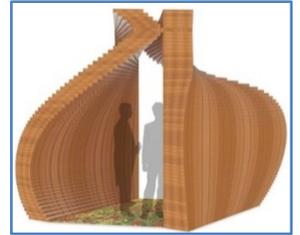


## Architects Design Pop-Up Chapels For NYC's Historic Gay Weddings

Yay gay!



01 / 07 This cheery, rainbow-colored pop-up structure, by Manhattan design studio iCrave, was one of two chapels built for two dozen gay weddings in Central Park on Saturday.





## London Pop-Up Weddings

In London similar businesses are being created mostly due to the increasingly high cost of weddings and the proclivity for millennials to be interested in something new and creative.

<http://www.chroniclelive.co.uk/business/business-news/young-north-tyneside-entrepreneur-launches-11472323>

Twenty four year old Faye Darcy in North Tyneside in North East UK started a company called “Faye Darcy Pop-Up Weddings” and is billed as the first of its kind in the UK. As Ms Darcy has stated:

*“Pop-up weddings are a simple and elegant alternative to the more traditional wedding,” Ms Darcy said.*

*“Couples literally pop into the wedding venue, get married then pop out.*

*“The ethos is to give people a luxury, no-expense-spared wedding but without a huge bill at the end of it, while allowing them to focus on enjoying themselves instead of having to think of every detail and months of stressful planning.”*

Ms Darcy also summarizes the appeal of Pop-Up:

*“I believe that pop-up weddings will be seen as the wedding option in the future, and are perfect for the more adventurous couple who really want to focus on having fun on their special day.”*

## Pop-Up as Global Business

In 2013, A 20 year old named Ross Bailey founded a company called “Appear Here.”

<http://www.retailgazette.co.uk/blog/2016/03/pop-up-opportunities-in-paris-extended-to-retailers>

*Appear Here has been on a mission to build a network of the noteworthy retail spaces, so that merchants can make their ideas travel. Over 15,000 brands use its service, including internationally renowned names such as Apple and Net-a-Porter, luxury fashion houses including LVMH, as well as independent designers and start-ups. In London alone, Appear Here has launched over 2500 pop-ups.*

The unique opportunity that **Appear Here** has capitalized on is empty and/or temporary vacant retail space, often in prime urban locations.

*“Every day, I see amazing retail spaces sitting empty in Paris. When you think it’s one of the top cities for fashion and retail, it doesn’t make sense. I was impressed by how Appear Here is solving the problem in London. Every week they’re helping new ideas launch and it would be great to see more of this happening in Paris.”*

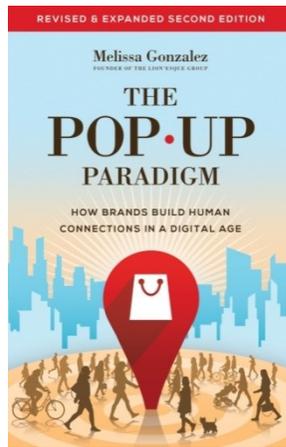
*The company will focus on listing the spaces in the best retail destinations in the city. In London, Appear Here has played a salient role in driving pop-up retail, an industry now valued at £2.3bn. Through partnerships with big landlords including Land Securities and Grosvenor, brands have been given access to over 1500 spaces in key London locations such as Mayfair and Covent Garden.*

So from global business opportunities to individual architectural practices, Pop-Up is making new types of architectural firms. For example, The Lion’Esque Group in New York City calls themselves “pop-up architects” and are focused on the retail industry.

The CEO of the firm, Melissa Gonzales, also has written a book, titled *The Pop-Up Paradigm* with the subtitle, “How Brands Build Human Connections in a Digital Age”

*In her groundbreaking new book, she explains how companies can use temporary retail to generate customer loyalty, understand new markets, test innovative concepts, and much more.*

*Whether you’re a business with an online presence considering a move into physical retail, or an established retail brand looking to create some buzz the *Pop-Up Paradigm* is the definitive guide to the important new role that pop-ups are playing in retail, and the perfect companion when deciding whether or not they make sense for your business.*



PDH Academy  
Pop-Up and Pre-fabricated Architecture

## ***II. Pop-Up Architecture***

### **REVIEW QUESTIONS**

**7. Which of the following is NOT an example of temporary architecture as cited by Kelly Chan in her 2012 “Pop-Up Nation”:**

- a. Brooklyn vendors sell their wares in shipping containers
- b. San Francisco are repurposing metered parking spaces
- c. Typical Suburban developments and playgrounds
- d. Oakland, California rallied to create an entire pop-up neighborhood

**8. Millennials are flocking to Pop-Up Architecture for all of the following reasons EXCEPT:**

- a. It is Lively
- b. Appears to be cheaper
- c. Represents a vibrant idea
- d. It is “very cool”

**9. Ancient citizens of Rome built examples of Pop-Up Architecture such as venues for**

- a. Community celebrations
- b. Local Theatrical Performances
- c. Roman Amphitheaters
- d. Religious and non-religious celebrations

**10. A key reason for the creation of temporary architecture in ancient Rome was:**

- a. There was previous generation precedent
- b. There was a moratorium on permanent theatre structures in the city of Rome that lasted until 55 BC
- c. Sports facilities were scarce
- d. Roman cities needed space

**11. An example of Pop-Up Architecture during Renaissance times was**

- a. Gothic cathedrals
- b. During the reign of King Henry II of France festivals sprouted up along the parade route when he traveled.
- c. Knights in shining armor
- d. Roman Aqueducts

**12. World's Fairs were an example of Pop-Up Architecture at mini-urban scale and were built in which of the following cities EXCEPT:**

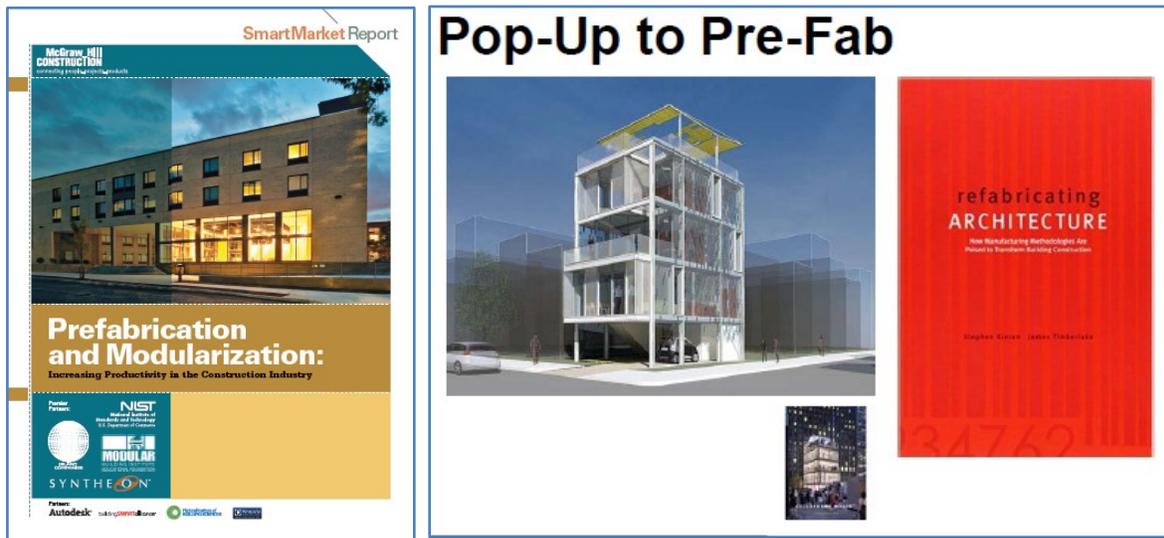
- a. Paris
- b. De Moines Iowa
- c. Chicago
- d. New York

### III. Pre-Fabrication

The transition from Pop-Up to Pre-Fab is a logical one when you consider the work of Kieran | Timberlake Architects of Philadelphia and their ground breaking book: “Refabricating Architecture”, their installation entitled “The Cellophane House” at New York’s Museum of Modern Art (MoMA), and Stephen Kieran’s Loblolly house on the eastern shore of Maryland.

What ties Pre-Fab to Pop-Up is, in fact, the historical roots of prefabrication in Britain’s Great Exhibition of 1851 and the Crystal Palace. As noted in the McGraw-Hill Smart Market Report entitled “Prefabrication Modularization: Increasing Productivity in the Construction Industry.”

*The Crystal Palace was designed in less than two weeks, used light and cheap materials: iron, wood and glass. The construction period lasted only a few months and consisted of assembling the prefabricated components. After the exhibition, the palace was taken apart, piece by piece, and moved to another location.*



There are several other publications that are seminal in the field of prefabrication and construction and will form the basis of our exploration of the topic in this course.

- *Pioneers of Prefabrication*, The British Contribution in the Nineteenth Century, by Gilbert Herbert, 1978
- FIATECH (2004) Capital Projects Technology Roadmap
- *Refabricating Architecture: How Manufacturing Methodologies Are Poised to Transform Building Construction*, Stephen Kieran and James Timberlake, 2004

- Advancing the Competitiveness and Efficiency of the U.S. Construction Industry, (2009), National Research Council of the National Academy of Sciences
- Automation in the Prefab and Modular Construction Industry, National Research Council Canada, 26<sup>th</sup> International Symposium on Automation and Robotics in Construction, 2009
- Survey on automation of the building construction and building products industry, VTT Technical Research Centre of Finland, 2013
- Prefabrication and Modularization in Construction, 2013 Survey Results, FMI
- Prefabrication: Benefits & Drivers for Successful Implementation, Mortenson Prefabrication Research Study Results, May 2014
- Reducing Costs and Increasing Efficiency Through Prefabrication, Todd Sullivan and Don Dye, the Morse Group, 2015
- AIA TAP 13th Annual 2017 Building Connections, January 9, 2017

That is about 40 years of publication and insight into the topic of Prefabrication from perspectives all over the globe.

## **Portable Colonial Cottages**

*Pioneers of Prefabrication* begins with a 19<sup>th</sup> century perspective (see **Appendix IX.5** for a summary). This publication explains that it is setting apart the early innovations of American experience with “mail-order” housing, as well as technical and logistic contributions of Belgium, France and Germany to focus on the self-contained British story.

For colonial settlements such as British settlements on the West Coast of Australia, as well as New South Wales and Tasmania, wooden houses were built in sections in England and packed for shipment in the early 1830s. These were called “portable colonial cottages” and the designer and builder was a London carpenter named John Manning. Prefabrication wasn’t confined to residences, however. In 1787 in New South Wales were examples of timber-framed hospitals that were prefabricated to the extent and (so contrived as not require artificers of any kind to fix them up or take them down—not even a hammer will be necessary.” As mentioned in *Pioneers*,

Samuel Wyatt, the builder of the hospitals, reported to his friend Matthew Boulton “I exhibited the moveable Hospitals to the King...by taking down one of the buildings & putting it up again...in one hour, which gave general satisfaction”

So the emergent needs of colonialism were a driver for prefabrication, whether it was a simple colonial cottage or a large, complex house for a Mr. Busy of New Zealand, which was more than seven times the area of twenty times the cost of the cottages. But with

Manning there were more radical innovations including design, construction and marketing. Ultimately with Manning's drive, prefabrication became an industry.

The Manning Portable Colonial Cottage for Emigrants was a novel approach which included the unique synthesis of several factors:

1. It was conceived, as name connotes, specifically for mobility and ease of transportation.
2. It was designed to pack in a small space for shipping.
3. On arrival, Manning claimed, "as none of the pieces are heavier than a man or a boy could easily carry for several miles, it might be taken even to a distance without the aid of a beast of burden."
4. It was designed for ease of erection. "It was completely fabricated in the carpenter's shop and required little or no site work other than the building of foundations and the assembly of components. The structure required no fashion of joins, no cutting of timber, no nailing—'whoever can use a common bed-wrench can put this cottage up.' The design was tailored to the limited resources of skill and tools available to the emigrant."

So the concept of prefabrication and emigration were directly linked and continued to grow through the early 19<sup>th</sup> century. As noted in *Pioneers*,

*The political and economic basis of Britain's industrial revolution was the colonial empire, at once the provider of raw materials and the consumer of manufactured products. The prefabricated house was an early manifestation of the industrialization of the building process.*

## **Iron Works, Bridge and Ship Building**

But by the mid-19<sup>th</sup> century, the lessons from the prefabricated wooden cottage were well embraced and ready to prepare Britain for a new technology: iron:

*In its best form, the prefabricated wooden cottage embraced advanced concepts of flexibility, ease of erection mobility, standardization, interchangeability of components, and dimensional coordination. However these forward-looking concepts were linked to a traditional material, timber, and derived from the time-honored crafts of the carpenter and the ship-wright.*

But the tools and skills of the carpenter and shipwright were soon to be overtaken by more progressive manufacturing techniques lead by the advanced development of iron construction:

*Iron construction, by its very nature, leads to the concept of pre-fabrication. Iron components of buildings—lintels, windows, balustrading, rainwater goods, columns, beams, arches, trusses—are essentially products of the foundry and the workshop, later incorporated into structures on the actual building site.*

But the products of the foundry taken to the building site, while an innovation and time-saver, ultimately was pre-fabrication in only a partial sense. What would become more important from an innovation standpoint was when these pre-fabricated components would then be incorporated into prefabrication of entire systems.

Instead of prefabricated components being installed in other-wise traditional structures, more integrated and system-wide approaches were coming to the fore. Bridge-building is an example of total pre-fabrication. And the Iron Works involved in Bridge making also began to utilize this prefabricated approach to ship building as well. The Horseley Iron Works, at Tipton Staffordshire, where the Oxford Canal bridges were manufactured, was also the location for the first iron steam vessel to put to sea, the *Aaron Manby*, in 1821.

The techniques of pre-fabrication of steel ships even started to look like the global process of colonial supply started with the wooden cottages. Ships were actually made of prefabricated sections and later riveted together. A ship building firm in Liverpool in fact made several ships in the 1820s in a similar fashion, fabricated so “that the whole may be with facility put together on arrival at the port of their destination, Monte Video, South America.”

Another building type also was constructed utilizing pre-fabricated steel: the lighthouse. *Pioneers* notes that a landmark in Bermuda on Gibb’s Hill was, in fact, a 130-foot-high tower that was fabricated and assembled near London’s Waterloo Bridge in 1844, then dismantled and shipped in sections to its final destination in the West Indies.

Two iron technologies, as noted in *Pioneers*, dominated the 19<sup>th</sup> century: Cast iron and galvanized corrugated iron sheet. Both had a profound effect on pre-fabrication techniques developments and integration in many building types and structures. The detailed history of these two technologies is beyond the scope of this course, but is nevertheless profound in its influence on architect, construction and manufacturing.

*Pioneers* summarizes this pre-fabrication pioneering period through the 19<sup>th</sup> century and into the 20<sup>th</sup> century:

*The history of the British contribution to prefabrication in the nineteenth century reflects the expansionist phase of urbanization at home and colonialism abroad.*

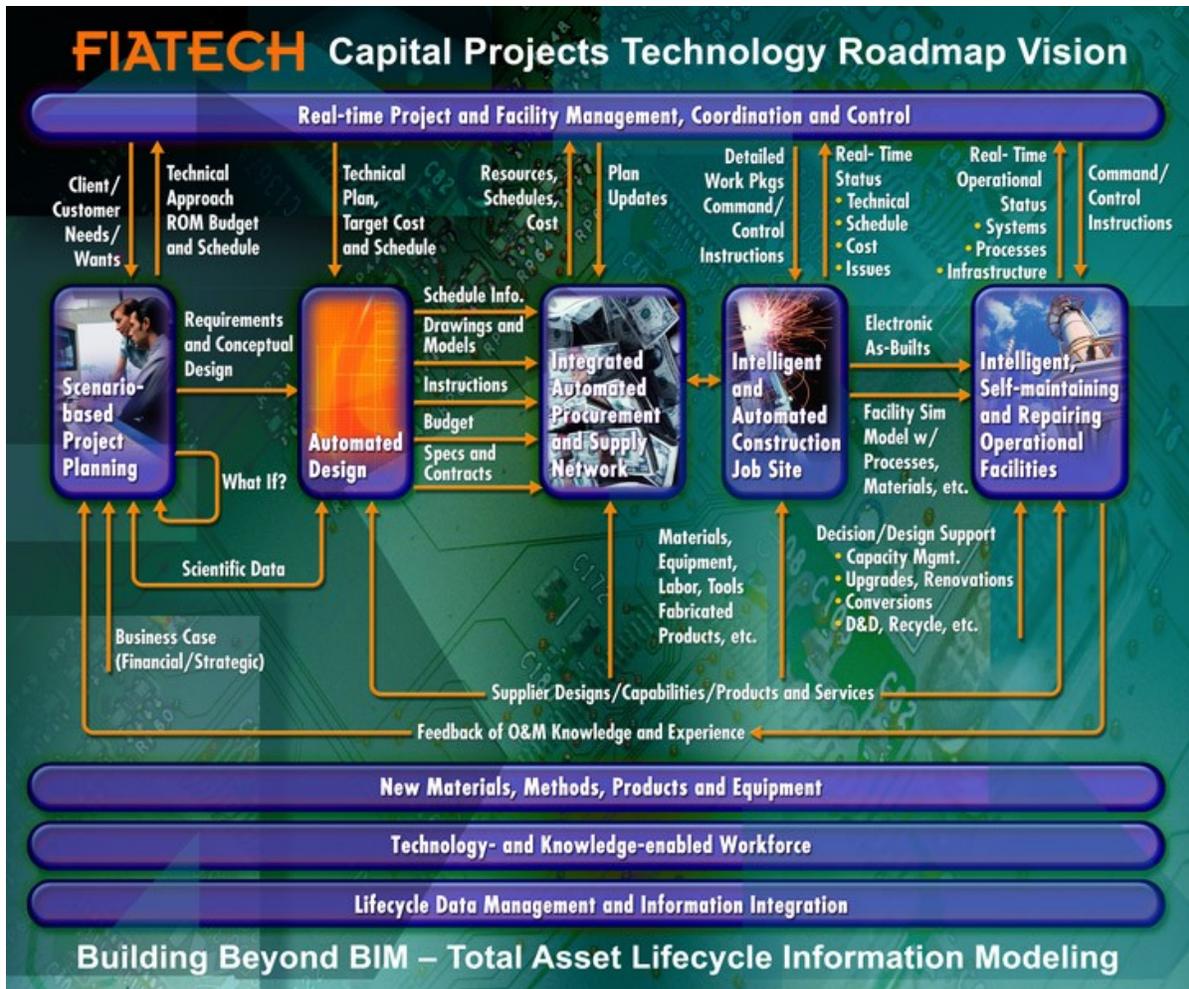
*The vital period of innovation in British pre-fabrication lay in the earlier years of Victoria's reign, but innovation continued significantly until the end of the century—the passing of Victoria, and the end of an era. During this era, and in their modest workshop and in their large factories, British manufacturers of prefabricated buildings established the basic concepts of industrialized building: the concepts of standardization and modular coordination, of large-scale industrial production of repetitive elements of sales promotion and marketing on an international scale, of integrated packaging and distribution systems, of rational site erection procedures, and of the differentiation of open and closed systems. These concepts were propounded and explored and principles established during this pioneer phase. It was a preliminary stage, tentative, and often immature, but it was the essential basis of all future development.*

The 20<sup>th</sup> century brought an enormous amount of innovation and new technologies, built on the foundation of these pioneering efforts. Precast concrete emerged as a new system of building technology with enormous prefabrication potential. Patents were received for prefabricated slabs, walls, and other building systems that had the potential to solve mass housing problems, among others.

### **FIATECH Capital Projects Technology Roadmap (2004)**

In 2004, FIATECH (Fully Integrated and Automated Technologies for Construction) published its roadmap for technology innovation and the construction industry. Prefabrication was definitely one of the key technologies that FIATECH members had in mind when they developed the vision:

*Imagine a highly automated project and facility management environment integrated across all phases of the facility life cycle. This is the vision of FIATECH, its members, and its Roadmap initiative. The future environment is one where information is available on demand, wherever and whenever it is needed to all interested stakeholders. Such an integrated environment could enable all project partners and project functions to interconnect—instantly and securely—all operations and systems. This will drastically reduce the time and cost of planning, design, and construction. Scenario-based planning systems and modeling tools will enable rapid, accurate evaluation of all options, resulting in the best balance of capability and cost-effectiveness. New materials and methods will reduce the time and cost of construction and greatly extend facility performance, functionality, aesthetics, affordability, sustainability, and responsiveness to changing business demands.*



## Refabricating Architecture (2004)

So this innovative effort that continues today at FIATECH.ORG was happening at the same time that a major milestone in prefabrication was taking place at the American Institute of Architects.

Kieran | Timberlake began their firm in Philadelphia in 1984. The book *Refabricating Architecture* was the deliverable from their award by the American Institute of Architects (AIA) of the first Benjamin Latrobe prize in 2001. The book was published in 2004 and immediately set a precedent as a powerful treatise on the future of the profession of architecture, manufacturing, and the broader construction industry. As the book states on its cover: “The new architecture will not be about style, but rather substance—about the very methods and processes that underlie making.”

The key areas that Kieran / Timberlake address in their book cannot be all included here, but are worthy of in depth reading. But they have taken their principles and

applied them in real world projects, with award winning results. Here are the key areas of their book:

- The Process Engineer and the Aesthetics of Architecture
- Role Reminders in the New World
- Enabling Systems as Regulatory Structure
- Processes We Do Not See
- Architecture
- Mass Customization of Architecture
- Evolution, Not Revolution

Through extensive case studies and detailed analysis of processes, the book is a tour de force of how both the profession of architect, the construction industry and even individuals can transform themselves and their practice.

So first in 2007 and then in 2009, Kieran Timberlake won Building Information Model Awards from the AIA with innovative designs that highlight and promoted the concept of prefabrication. The Loblolly House won in 2007 for a residence on the eastern shore of Maryland that was assembled without a single glitch and can easily be unassembled and moved at a later date.



The Cellophane House won the AIA TAP BIM Awards in 2009 for a structure that was designed and installed at the Museum of Modern Art in New York City. But it did provide the ultimate in sustainability and demonstration of true prefabrication:



**DESIGN FOR DISASSEMBLY**

COMPONENT	Frame	Slabs	Ceiling	Wall Panels	Window Frames	Floors
<b>MATERIAL</b>	Boxed Aluminum Framing Steel Connectors	PET Fibers	Aluminum Joist G2	Steel Insulated Shear PP	Aluminum Joist	Aluminum Joist 83.3 Polystyrene Shear
<b>CODE</b>						
<b>WEIGHT</b>	15,000 LBS Aluminum 200 LBS steel	170 LBS	2,000 LBS	1,370 LBS	200 LBS	670 LBS Aluminum 450 LBS polystyrene
<b>RECYCLABLE MASS</b>	28%	0.8%	9%	8%	0.8%	55%
<b>TOTAL RECYCLABLE MASS = 85%</b>						

Because Cellophane House was assembled rather than constructed, it was disassembled rather than demolished. Along with this is the inherent capability to modify or exchange components with ease, without specialized tools or skills. At the end of the exhibition, the connections were removed and the house was un-stacked, from the top down. All interior walls were held in place by removable inserts snapped into the frame and removed without affecting the structure. Throughout this process, the individual materials retained their integrity, for reuse or recycling. Plastic, glass and aluminum being to a well-established waste stream allowing the entire house to be disassembled and come into existing recycling chains, leaving no residual waste.

Removal of chunks

Classification and sorting of aluminum frame for storage and reuse

Materials sorted and packed in dry van for relocation of the house

*Because Cellophane House was assembled rather than constructed, it was disassembled rather than demolished. Along with this is the inherent capability to modify or exchange components with ease, without specialized tools or skills. At the end of the exhibition, the connections were removed and the house was un-stacked, from the top down. All interior walls were held in place by removable inserts snapped into the frame*

*and removed without affecting the structure. Throughout this process, the individual materials retained their integrity, for reuse or recycling. Plastic, glass and aluminum belong to a well-established waste stream allowing the entire house to be disassembled and sorted into existing recycling chains, leaving no residual waste.*

## **Advancing the Competitiveness and Efficiency Of the U.S. Construction Industry**

In 2008, the National Institute of Standards and Technology (NIST) requested the National Research Council (NRC) of the National Academy of Sciences to convene an ad hoc committee of experts to provide advice on increasing the competitiveness and efficiency of the U.S. Construction Industry.

After a 2-day workshop, and 50 papers submitted by experts, the committee developed their report and published it in 2009. There were five “Breakthrough Improvements” summarized as being critical to improving quality, timeliness, cost-effectiveness and sustainability of construction projects and the construction industry:

1. Widespread deployment and use of interoperable technology applications, also called Building Information Modeling (BIM)
2. Improved job-site efficiency through more effective interfacing of people, processes, materials, equipment and information.
- 3. Greater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and processes.**
4. Innovative, widespread use of demonstration installations; and
5. Effective performance measurement to drive efficiency and support innovation.

Item 3 above is emphasized since it is the topic of this course. The report went on to detail specifically the importance of prefabrication:

*Prefabrication, preassembly, modularization, and off-site fabrication involve the fabrication or assembly of systems and components at off-site locations and manufacturing plants. Once completed, the systems or components are shipped to a construction job site for installation at the appropriate time. These techniques*

*offer the promise (if used appropriately) of lower project costs, shorter schedules, improved quality, and more efficient use of labor and materials. Various obstacles stand in the way of the widespread use of such technologies, including building codes that hinder innovation as well as conventional design and construction processes and practices.*

But the obstacles to truly integration prefabrication into mainstream construction were noted as:

*To date, available automated equipment, prefabricated components, and other innovations have been used primarily by large construction companies on industrial and infrastructure projects. Their widespread use by contractors for commercial projects has been hampered by a number of factors, including the costs to own, lease, or operate automated equipment; the limited availability of some automated equipment; and conventional design practices that typically do not consider the use of automated equipment during pre-project planning.*

And the overall recommendation of the report for Prefabrication was:

*Prefabrication and related techniques are commonly used in the construction of industrial projects, but they are also used, if less frequently, for commercial and infrastructure projects. Best practices for the use of these technologies have been developed by CII. The committee believes that greater use and deployment of these techniques (if used appropriately) can result in lower project costs, shorter schedules, improved quality, more efficient use of labor and materials, and improved worker safety*

## **United States Perspective on Modern Prefabrication/Modularization**

McGraw-Hill's SmartMarket Report *Prefabrication and Modularization (2011)* summarizes the 20<sup>th</sup> century perspective on prefabrication in the U.S. (see **Appendix IX.6** for a more detailed excerpt.)

While referring to examples we have provided elsewhere in this course from other sources, the McGraw-Hill survey includes some unique examples such as the Hilton Palacio del Rio Hotel in San Antonio, a 500-room hotel designed for the World's Exposition of 1968 and designed, completed and occupied in an amazing 202 working days. The survey also notes the just refurbished Cunard Line Queen Mary 2 which included prefabricated modular cabins to maintain high standards of quality on an extremely tight schedule under severe cost constraints.

The bottom line conclusion provided by McGraw-Hill is that the construction market place is facing severe shortages of well-trained labor, and prefabrication along with automation and lean techniques will become more widespread in adoption in the early 21<sup>st</sup> century.

## **Automation in the Prefab and Modular Construction Industry**

Automation, including computer aided design and BIM (Building Information Modeling) has a great deal to do with pre-fabrication, can enable it, and can make it much more effective and efficient.

Two studies, in Canada (2009) and Finland (2013) explore this topic in detail and provide extensive background information on this critical topic.

*Automation in the Prefab and Modular Construction Industry* was presented at the 26<sup>th</sup> International Symposium on Automation and Robotics in Construction (ISARC 2009) and included several case studies that illustrate the power of automation and prefabrication:

1. **The FutureHome Project:** A milestone European prefab automation project, this project started in 1998 and was completed in 2002.

The main objective of the FutureHome project represents the development of an integrated construction automation concept and associated technologies for all stages of the house-building construction process, from the architect's desk to site robots. This includes: a) the modular design of buildings with planned robotic erection, b) automatic planning and real-time planning of offsite prefabrication, transportation, and onsite assembly and c) onsite automated transportation, manipulation, and assembly of the prefabricated parts.

*The FutureHome building system derives from a Kit-of-Parts approach, which is a specific implementation of prefabrication. As noted by Wing et al (2002), virtual reality is employed, providing a common virtual environment that can be shared by clients, architects, engineers, constructors, etc. The clients can be led through the virtual design of their house, created on-line using "prefabricated" components.*

*The construction process can be simulated, allowing examination of cost, quality and time aspects. This is an environment within which the user creates a design from its constituent prefabricated components.*

2. **The ManuBuild Project** is another prefab automation project started in 2005 and completed in 2009. The objective of the project is for customers to be able to purchase high quality manufactured buildings that have a high degree of design flexibility at relatively low cost.

*Customers will be actively engaged in the design of their buildings using state of the art interactive tools; incorporates mass customization; and offers customers increased choice and design flexibility.*

Ultimately the impact of this project could lead to significant reductions in:

- *Waste,*
- *Cost,*
- *Time to construct and*
- *The number of construction related accidents.*

*Striving to achieve automation, ManuBuild aims to provide ICT support for distributed building manufacturing. To achieve this, several decision support tools have been developed ranging from catalogues of products via information delivery, design custom configuration and assembly planning.*

The ISARC 2009 study mentioned some key innovations that are becoming critical to concept of prefabrication in the 21<sup>st</sup> century (see **Appendix IX.7.** for detailed descriptions):

- Robotics Automation
- Automated Construction Site
- Virtual Reality and Simulation
- Schedule Automation and Sensor-Based Control
- Prefab Factory Automation
- Prefab Construction Automation

## The Finnish Study

The VTT Finnish study in 2013 followed the Canadian report by four years. The VTT study included emerging technologies excerpted in more detail in **Appendix IX.8**. The study also explored

- the motivations for building construction automation,
- market acceptance, and
- the emerging use of data acquisition technologies for construction operations
- applications for building automation
- Experimental work for automation. Robotics, digital design and manufacturing in architecture
- Construction logistics
- Building construction cost

**Motivations for Building Construction Automation** Motivation for automating building construction comes from the success achieved in the civil engineering sector, where typical robot applications are the automation of road, tunnel and bridge construction and earthworks. There will certainly be resistance by current organizations and workers who have a stake in the status quo. Potential job losses, general inertia and resistance to anything new, and safety fears of robots in close proximity (and dangerous conditions) with fellow workers all contribute to negative adoption.

Cultural will undoubtedly have to change. And the construction industry has been notoriously resistant to change and very reticent about investing in new technologies to gain productivity. This is one of the primary differences in personality and culture between the construction industry and manufacturing, where the people and the environment respond very positively to technological innovation.

### Market Acceptance

The market acceptance issue is one of the keys to success of prefabrication from the user perspective:

*Customers like custom features and unique appearance. Automation works best, when production is standardized. Houses or apartments that are too standardized are neither preferred nor even accepted by customers. Therefore automation should be flexible, and individual modifications should be easy and economical to implement from the point of view of the manufacturer and thus be attractive to the customer.*

*This may be possibly achieved by “digital products which can be manufactured on-demand”. A digital product is a computer model, and if the customer chooses to use it, it can be made automatically without extra costs.*

*Thus, market acceptance can be gained if automation and robotics enable giving the customers the feeling that they can implement individual housing needs without extra costs or at reasonable costs and without delays.*

## **Data acquisition technologies for construction**

*In the construction phase, measurements are typically needed for object locations, asset management, and component installations during assembly, for capturing the existing condition of a construction project and for gathering as-built information essential for the maintenance and redesign of the facility. More accurate data acquisition comes along with the automation of the construction process. BIM provides reference values for dimensioning the prefabricated components, as well as accurate locations of components on the building site. The traditional measurement system used in manual assembly involving tape measures, transits, lev-els, and plummets that were used for decades cannot be used any more. In auto-mated operations, data acquisition has to be digital, fast and accurate enough in order to provide the possibility to control the process according to the reference values given in BIM. Although there are plenty of suitable data acquisition technologies available that are used in other sectors, applications in the construction sector are not very common.*

**Robotics, digital design and manufacturing in architecture** The opportunity to utilize robotics and digital design in prefabrication to enhance the built environment is now just being explored:

*Automation and robotization can be also viewed from the opposite perspective, as an enabler for erecting more unique buildings more economically. Unique architectural designs are more common in public and commercial buildings than, for example, in residential buildings. Residential buildings have to be very cost-effective and this limits the freedom of the designer. With automation, the extra cost of customizing can be reduced to a more affordable level.*

*Using automation, it would be possible to manufacture more customized structures (etc. concrete elements), but the design of the structure should be*

*done digitally and all modifications should be made by altering the digital model of the product. Then the manufacturing of the product can be carried out automatically according to the digital design. The goal is that complex products and product customizations, which can be very laborious and expensive to make with traditional methods, can be done at minimum extra cost. Several research groups are currently studying this kind of technology.*

## **Construction Logistics**

The Finnish study includes some important metrics that inform the discussion of manufacturing and how logistics relates to construction:

*Construction has been slower than other industries in realizing the benefits that good logistics can provide. On construction sites, time is often lost due to unavailable materials, inefficient handling systems and poor timekeeping by haulers and suppliers, leading to congestion at access points. A widespread belief is that potential savings – from 10% up to 30% – can be achieved by improving construction logistics [Improved Logistics 2005]. The same reference provides plenty of non-quantified evidence to demonstrate the inadequacy of logistics in the construction process, whilst in other industry sectors there are increasing examples of how they are addressing logistics. Other industry sectors, especially manufacturing and retail, have made huge advances in improving logistics, whereas the construction industry does not seem to have been able to take advantage of these opportunities.*

**Building construction cost** The VTT Finnish study utilized data from the European Union to look at the issue of prefabrication and automation and its impact on the construction industry.

*Potentially, the emergence of robotics and flexible manufacturing methods will have a great impact on the construction industry, since product and process variety can be accommodated much more easily than with hard automation methods. Apart from technical and commercial success, many people are concerned that there will be substantial industrial or worker resistance to the widespread introduction of robotics and automation in construction, especially on-site robotics. The possible reason for worker resistance is potential job losses through the displacement of labor. The full potential of robotics will unfold as soon as robots do not just copy human work but rather this is enhanced by robot*

*oriented planning, engineering, management and labor training. BIM providing building-related information in a digital form enables better exploitation of automation and robotics during the life-cycle of the facility.*

## **FMI 2013 Survey of Prefabrication and Modularization in Construction**

The FMI Corporation conducts numerous surveys of the design and construction industry and in 2013, Authors Ethan Cowles and Philip Warner outlined their findings which updated a similar 2010 survey. See also **Appendix IX. 9**.

Their bottom line summary:

*“We do expect more use of prefab techniques. BIM is currently making it more possible or feasible to do, but the real driver will be owners seeing examples from elsewhere in the world and starting to demand it for their projects. Contractors will drive this too — by starting to use it more on projects, and working with trades to do more single-trade prefab, it will become more prevalent, even on projects where the GC is not looking at prefab opportunities.”*

At the outset of their summary they also listed the key industry drivers the survey observed:

- *The constant pressure to lower price.*
- *The need to achieve a competitive edge in markets increasingly calling for the use of prefabrication and modularization, i.e., hospitals, hospitality, education.*
- *The lack of, or impending lack of, skilled construction labor.*
- *The use of BIM — allowing greater coordination of design with construction.*
- *The need to increase productivity.*

The challenges the FMI Survey observed get to the core of the construction industry's nature and organizational lack of inertia. To quote from some of the survey respondents:

*One of the largest challenges to overcome before prefabrication and modularization become accepted practices is perception. For too long the words modular and prefab have been associated with cheap, poor quality, temporary, etc. We need to get past this and start to look at prefab items as manufactured products. The analogy I like to use is buying a new car. You wouldn't be too happy if you ordered a new car at a dealership and were told the dealership would order up all the pieces, the mechanics in the shop would put them all together, and if you come back in three to six months, they will have a car ready for you. Yet, this, in essence, is what traditional construction does. We expect manufactured products to be built efficiently, in controlled environments, to high-quality standards. We need to start making our construction sites assembly locations where a series of manufactured products are brought together and assembled into the finished product.”*

## **Mortenson Prefabrication Research Study Results (May 2014)**

Mortenson Construction introduced their research study and explained the reasons for conducting the survey and writing the report. In this study, a value-based cost-benefit analysis was performed on an ongoing 831,000-square-foot hospital consisting of 360 patient beds, in which the above main performance drivers were analyzed to determine actual project performance results. Mortenson is currently under contract to build the new \$380 million Exempla Saint Joseph Heritage Project with a construction schedule of 29.5 months.



# PREFABRICATION

The complexity of the project, combined with an extremely aggressive schedule, required creative solutions to be successful. Prefabrication was used extensively to tackle the problem.

The key research study results were summarized graphically and the highlights are listed below:

- 1.13 Benefit to Cost Ratio
- Schedule & Cost Certainty
- On-site Labor Density
- Fewer Safety Incidents
- Manpower Consistency

# EXECUTIVE SUMMARY: RESEARCH STUDY RESULTS

## 1.13 BENEFIT-TO-COST RATIO

For every dollar spent on prefab, approximately 13% of the investment is expected to be returned as a **quantifiable benefit to the project.**

### EXEMPLA ST. JOSEPH HERITAGE PROJECT

PREFAB ELEMENT	LABOR & SCHEDULE REDUCTION	DIRECT COST SAVINGS	DIRECT COST	REDUCTION IN REQUIRED LABOR	DIVERTED OFF-SITE LABOR	SAFETY INCIDENTS REALIZED	CRISSE PRODUCTIVITY LOSS PREVENTION
Exterior Wall Panels	41 Days	\$2.4 M	3.7% Savings	5,000 Hours	33,000 Hours	2	\$0.5 M
Bathroom Pods	52 Days	\$3.1 M	4.6% Premium	27,700 Hours	78,000 Hours	4	\$1.4 M
Multi-Trade Racks	20 Days	\$1.2 M	21.7% Premium	N/A	24,000 Hours	1	\$0.4 M
Patient Room Headwalls	0 Days	\$0	7.6% Premium	1,300 Hours	16,000 Hours	1	\$0.3 M
<b>TOTAL</b>	<b>72 Days</b>	<b>\$4.3 M</b>	<b>6.0% Premium</b>	<b>29,500 Hours</b>	<b>150,500 Hours</b>	<b>7</b>	<b>\$2.6 M</b>



#### SCHEDULE & COST CERTAINTY

Commit to an aggressive schedule and budget with more confidence.

**18%** SCHEDULE ENABLED **29,500** HOURS OF SAVINGS IN LABOR **6%** DIRECT COST PREMIUM



#### ON-SITE LABOR DENSITY

Improved productivity, flexibility, housekeeping and safety.

**\$2.6M** JOB PRODUCTIVITY LOSS AVOIDED **150,500** LABOR HOURS DIVERTED OFF-SITE



#### FEWER SAFETY INCIDENTS

Reduced congestion and schedule demands, improved positions and spaces.

**7 SAFETY INCIDENTS AVOIDED**



#### MANPOWER CONSISTENCY

Enhanced efficiency reduces training costs and reinforces cost certainty.

**376** HEAD WALLS **346** EXTERIOR WALL PANELS **440** BATHROOM PODS **166** MULTI-TRADE RACKS





### ***III. Pre-Fabrication***

#### **REVIEW QUESTIONS**

**13. Pre-Fabrication examples include all of the following EXCEPT:**

- a. Kieran | Timberlake Architects' "The Cellophane House"
- b. The Lobloolly House
- c. Britain's Great Exhibition of 1851 and the Crystal Palace
- d. The U.S. Capitol

**14. "Mail-Order" housing is an example of pre-fabricated architecture in which following location:**

- a. Africa
- b. West Coast of Australia, as well as New South Wales and Tasmania
- c. Russian Federation
- d. Antarctica

**15. The Manning Portable Colonial Cottage for Emigrants was a unique synthesis of several factors, EXCEPT:**

- a. Designed to pack in a small space for shipping
- b. Conceived for mobility and ease of transportation
- c. Designed for ease of erection
- d. Involved brick masonry elements

**16. Which construction processes were lead by the concept of pre-fabrication:**

- a. Stick built wood
- b. Iron
- c. Concrete foundations
- d. Excavation

**17. Examples of Pre-fabricated architecture include all the following EXCEPT:**

- a. Bridges
- b. Steel Ships
- c. Igloos
- d. Lighthouses

**18. Pre-Fabricated Architecture was cited as a significant way for the United States to advance the competitiveness and efficiency of the construction industry by which organization?**

- a. The 19<sup>th</sup> Century *Pioneers of Prefabrication*
- b. National Research Council of the National Academy of Sciences (2009)
- c. Refabricating Architecture by Kieran Timberlake (2004)
- d. FIATECH Roadmap (2004)

## **IV. Cutting Edge Case Studies**

There are a myriad of cutting edge ideas to conclude our discussion with.

### **AIA TAP 13<sup>th</sup> Annual 2017 Building Connections**

The American Institute of Architects (AIA) Technology in Architectural Practice (TAP) Knowledge Community convened its 13<sup>th</sup> annual Building Connections | Congress on Technology and Interoperability on Monday, January 9<sup>th</sup> at the AIA Headquarters Board Room with significant innovative presentations and case studies on pre-fabrication and new technologies for architecture and construction.

The charter of the Building Connections | Congress has been: *Once a year, AIA TAP's Building Connections Congress invites key players to convene and update each other on the progress and challenges in achieving interoperability. Invited participants, including Owner organizations, Industry associations and Technology providers, engage in frank conversations about the triumphs and shortcomings of interoperability standards, their implementations and applications.*

The three presentations by Nathan Miller of Proving Ground, Christopher O'Hara of Studio NYL, and John Cerone of SHoP Architects, and their subsequent Speaker Q&A Dialogue, insightfully encapsulates the current state of Digital Design and, in particular, the state of the art of prefabrication in the 21<sup>st</sup> century.

Proving Ground (<https://provingground.io/>) is a firm that focuses on and is leveraging a "data-driven building industry". What makes this so important is the need to create very dramatic and complex structures for architects, and the need to creatively use, and even invent, new tools and processes to accomplish that. Whether it is at the level of building spaces and stacking plans for tenants in complex real estate configurations, or a set of buildings in a dynamic urban environment, the architecture, spaces and components ultimately can be expressed as data and can be visualized, contoured and managed to create innovative solutions. And on projects that have increasing pressures for complexity and performance, the need to measure teams and project data becomes critical.



# AIA

## 2017 TAP Building Connections Congress

Retooling Practice  
 January 9  
 AIA National Headquarters  
 Washington, DC

### Module 1: Design

Time	Event	Notes
8am	Sign-in & breakfast	
9am	Introduction	Cory Brugger, 2017 AIA TAP Chair <i>Morphosis Architects</i>
9:10am	Data, Performance, and the Mainstream	Nathan Miller <i>Proving Ground</i>
9:30am	The Future of Making Things: The Balance of Digital Technology and Fabrication Balanced with the Craft of Building	Christopher O'Hara <i>Studio NYL</i>
9:50am	Process in Practice	John Cerone <i>SHoP Architects</i>
10:10am	Speaker Q&A	

So if Proving Ground provides the measurement and collaboration framework for integrating digital design and fabrication into the concept of pre-fabrication, then Studio NYL provides deep knowledge and technical expertise in the making of building envelopes and components.

A key to digital integration is managing the flow of data and form-making.



## Optimization Tools:



**OVIS**  
Englewood, California

Architect: HKS  
Engineer of Record: Walter P Moore  
Façade Consultant: Walter P Moore  
Opaque Façade Contractor: A. Zahner  
Skin Design & Development: Studio NYL | Zahner





These examples illustrate how all the pioneering work of dimensional control, precision fabrication from digital models, and computer-aided management systems is enabling these products, designs, teams and logistics synchronized to reach fruition in these forward thinking firms and project teams.

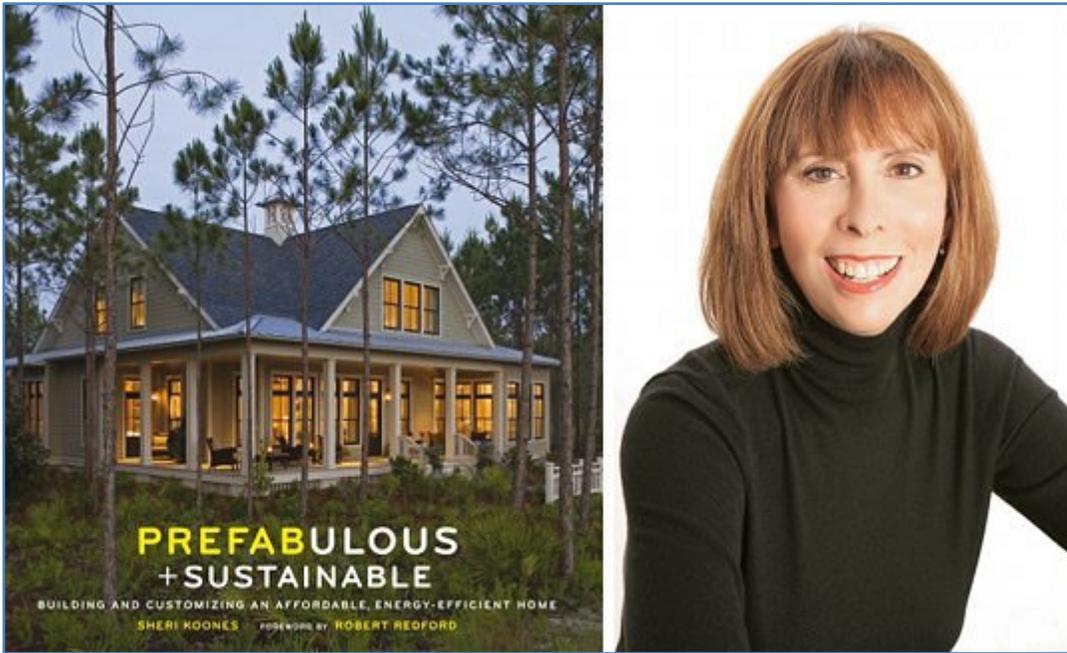
## Phillipe Starck and P.A.T.H

The architect and interior designer Phillippe Starck in 2013 began working with a European wooden prefab builder Riko and unveiled a series of plans for high end, carefully crafted yet prefabricated homes. The technology was named P.A.T.H which stood for Prefabricated Accessible Technology Homes and demonstrates how prefabrication is not just relegated to utilitarian or “ugly” looking buildings.



### Prefabulous

In 2014 Author Sheri Koones wrote a book called “Prefabulous+Sustainable” which combined the two concepts of prefabrication and sustainable design in homes that were beautifully designed and, actually, epitomize “dream” homes.

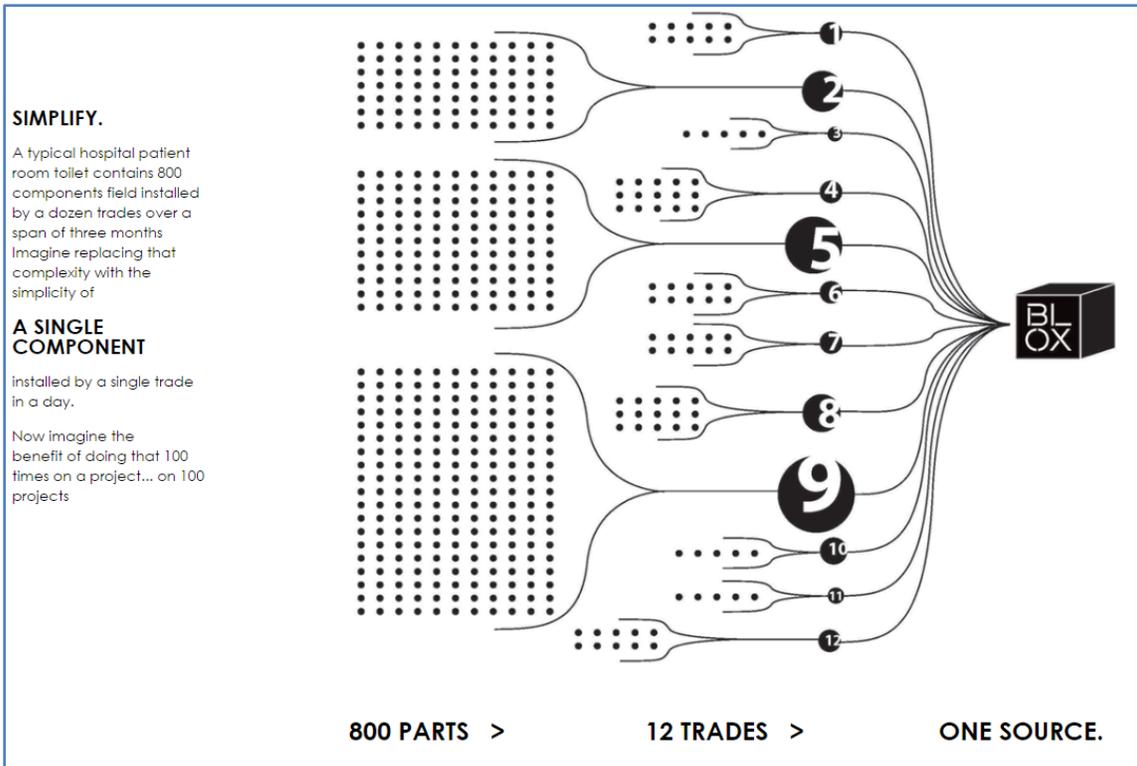


This book helps evangelize the concept of prefabrication and provides extensive resources on the current housing market and information for all stakeholders including architects to builders to prospective homeowners.

Other building types are benefitting from prefabrication and entrepreneurial businesses focused on that technology, particularly health care facilities. One such company is BLOX (<http://www.bloxbuilt.com/>). Their technology provides solutions for spaces in hospitals including the patient room, headwalls that include extensive utility outlets, bathrooms and entire exam rooms.

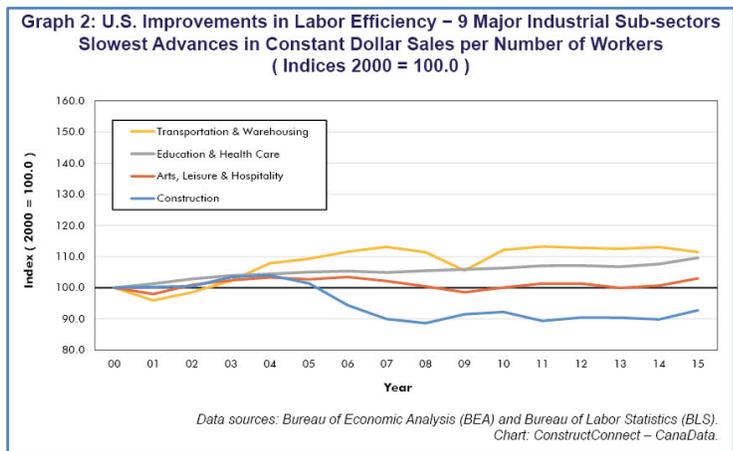
What is the value proposition behind a company like BLOX? To summarize, it is to simplify. As they describe:

- A typical hospital patient room toilet contains 800 components field installed by a dozen trades over a span of three months
- Imagine replacing that complexity with the simplicity of
- Installed by a single trade in a day.
- Now imagine the
- benefit of doing that 100 times on a project... on 100 projects



techniques to produce custom, ready-to-install bathrooms for hotels, hospitals, military barracks and multi-unit residential projects. After building a significant brand and market following, they were acquired by OldCastle and renamed “Surepods” (<https://oldcastlesurepods.com/>). Their clientele is mostly hotels and other hospitality firms and one of the problems they are focused on is increasing efficiency for their clienteles. Construction in general has lagged all the other industries and this prefabricated approach to bathroom “pods” is their focus.

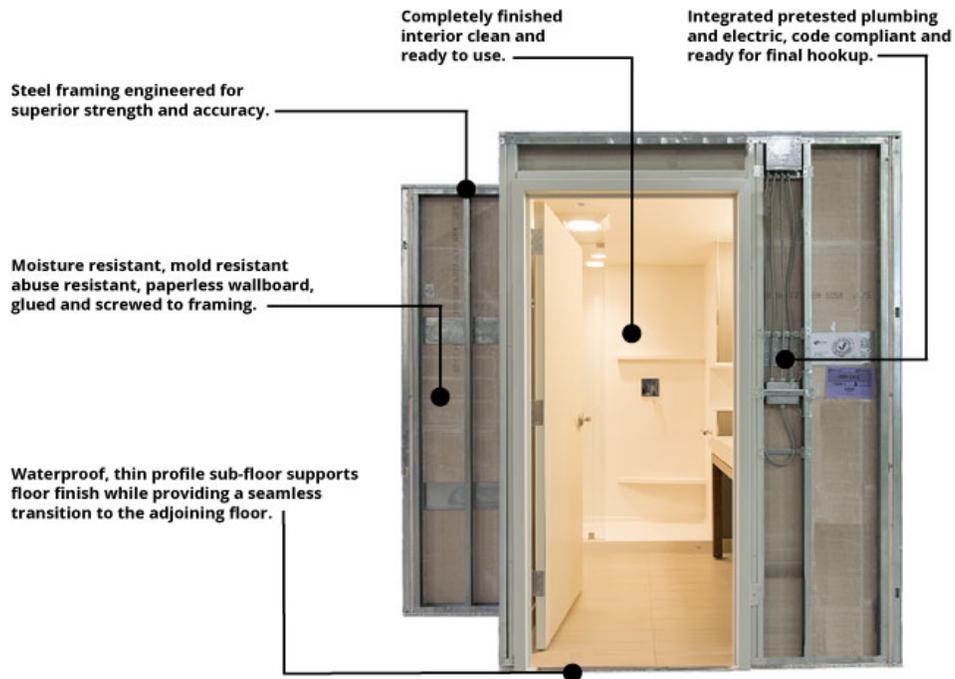
But in addition to clients such as Hilton Garden Inn, Residences Inn, and Embassy Suites, also been end as the Hotel in Springs, campuses Atlantic military as Fort The proposition BLOX in



Surepods have installed in high properties such Broadmoore Colorado colleges such as Florida University, and barracks such Carson, CO. primary value is similar to that quality

control and cost effectiveness are key elements:

**OLDCASTLE SUREPODS™ ARE SIZED, DESIGNED AND ACCESSORIZED  
PRECISELY ACCORDING TO ARCHITECTURAL PLANS, THEN BUILT UNDER  
CONTROLLED FACTORY CONDITIONS.**



## **Modular Building Institute and SOMA Studios**

SOMA Studios in San Francisco is a case study of taking prefabrication beyond the bathroom module to an entire building, in an urban context, and making it extraordinarily sustainable.

The Modular Building Institute has highlighted the transforming qualities of the project located in San Francisco's South of Market district. From both an aesthetic and construction logistics and prefabrication standpoint, the entire project is an amazing example of how extremely sustainable buildings (LEED Platinum) are attainable on a complex and tight urban site. See **Appendix IX.10** for a complete detailed description and explanation of prefabrication techniques and urban logistics.



## Granddaddy of Modernist Prefabs

And In a unique twist of contemporaneous news, in February 2017 one of the most famous of prefabricated structures, the Aluminaire House, has been preserved and being moved to its new home. In a report in Dezeen:

*Designed by architects Albert Frey and A. Lawrence Kocher, the roughly 1,200-square-foot cubic abode spread five rooms over three levels. Made of steel and aluminum, the spare structure embodies the modernist ethos of affordable materials and simple construction.*



## ***IV. Cutting Edge Case Studies***

### **REVIEW QUESTIONS**

**19. Prefabricated Architecture Case Studies include all of the following examples EXCEPT:**

- a. Proving Ground ([proving.ground.io](http://proving.ground.io))
- b. AIA TAP Building Connections (2003 to 2020)
- c. Prefabricated Accessible Technology Homes by Phillipe Starck
- d. Poured in Place Concrete Projects

**20. BLOX illustrates examples of pre-fabrication techniques which include the following building types:**

- a. Data Centers
- b. Hospitals
- c. Playgrounds
- d. U.S. Embassies

**21. SOMA Studios in San Francisco suggests pre-fabricated architecture can go “beyond the bathroom module” to:**

- a. Nature centers
- b. An entire building, in an urban context
- c. Museums
- d. Aquariums

**22. One example of a firm or organization making use of 3D modeling and lean construction techniques in pre-fabricated architecture is:**

- a. CMAA
- b. AGC: Associated General Contractors of America
- c. EggRock ([www.eggrock.com](http://www.eggrock.com))
- d. Army Corps of Engineers

**23. Pre-Fabricated Architecture does not have to be boring or utilitarian, as illustrated by whose publication?**

- a. Travel Guides
- b. Sheri Koones “Prefabulous+Sustainable”
- c. Construction Handbooks
- d. The U.S. Constitution

**24. Oldcastle “Surepods” are an example of illustrating the value proposition for pre-fabricated architectural components in all of the following EXCEPT:**

- a. Hilton Garden Inn
- b. The Broadmoor Hotel
- c. The HUD building in Washington DC
- d. Military Barracks at Fort Carson, CO

## VII. Conclusion

We began this course with a look at Pop-Up Architecture and its roots even back to ancient Roman times. The millennial generation has taken this form of building to heart and even have created companies focused entirely on servicing the pop-up culture.

But as we explored the history of Prefabrication, we soon discovered how similar the two concepts were! For example, Samuel Wyatt in the 1780s had demonstrated to the king that a prefabricated hospital could be taken down and put back up again in an hour. How close is that to the concept of Pop-up?

There continue to be many naysayers in the design and construction industry who suggest that prefabrication has as many disadvantages as advantages. Arch Daily published an article entitled “The Downfalls of Prefab Design” in 2013, and made some significant negative points about prefabrication:

*With [prefabricated](#) towers and skyscrapers now in the works (and, in some cases, going up in as little as [six days](#)), pre-fab begs the question: is it really safe? Does quick production time lead to instability, making [prefabricated](#) buildings more likely to collapse?*

*There can be more risk with the prefabrication technique than in traditional construction: since the majority of the large building components are constructed off-site, there is a great amount of trust given to the manufacturer to produce precisely what is needed. One single error can eventually put the entire building in danger.*

*Moreover, every site is unique and has its own individual characteristics and challenges; a prototype building for all sites does not exist. Prefabricated buildings, designed for efficiency, may appear ideal in theory, but they lack personalization and detail. By creating pieces off-site instead of on-site there exists a disconnect between the architect and the land itself.*

*As pre-fabrication continues to boom, we must take the utmost care to ensure its quality – just as we do with traditional construction – or else all the time and money gained will result in a very real, human cost.*

Although that article, actually more like an editorial, laid out some major points, the evidence from the many case studies presented in this course suggest that prefabrication is far safer and more productive than current practice.

In fact, at the panel discussion at the AIA TAP Building Connections | Congress on January 9 in Washington DC at AIA Headquarters, the speakers were far more positive about prefabrication and the quality and positive benefits that accrue. Admittedly many of the projects presented at that event were quite complex, but process control was the same whether it is a simple building type or complex geometric building such as a sports stadium. The speakers emphasized that in their process of designing, fabricating and installing connections, details, data, geometry and interfaces with overall building elements, there was constant checking for internal integrity. They emphasized that there was much more checking than in a normal analog building project.

In conclusion, Pop up and Prefabrication have enormous potential to change the nature and practice of architecture, construction and the built environment.

## ***VIII. Bibliography***

*Pioneers of Prefabrication, the British Contribution in the Nineteenth Century*, by Gilbert Herbert, 1978

FIATECH (2004) Capital Projects Technology Roadmap

*Refabricating Architecture: How Manufacturing Methodologies Are Poised to Transform Building Construction*, Stephen Kieran and James Timberlake, 2004

*Advancing the Competitiveness and Efficiency of the U.S. Construction Industry*, (2009), National Research Council of the National Academy of Sciences

*Automation in the Prefab and Modular Construction Industry*, National Research Council Canada, 26<sup>th</sup> International Symposium on Automation and Robotics in Construction, 2009

*Survey on automation of the building construction and building products industry*, VTT Technical Research Centre of Finland, 2013

*Prefabrication and Modularization in Construction, 2013 Survey Results*, FMI

*Prefabrication: Benefits & Drivers for Successful Implementation*, Mortenson Prefabrication Research Study Results, May 2014

*Reducing Costs and Increasing Efficiency through Prefabrication*, Todd Sullivan and Don Dye, the Morse Group, 2015

AIA TAP 13th Annual 2017 Building Connections, January 9, 2017

## **IX. Internet Links, References and Notes**

1. Pop-Up Architecture: <http://www.blouinartinfo.com/news/story/802841/pop-up-populism-how-the-temporary-architecture-craze-is>

*Kelly Chan, in May 2012 writes: America is fast becoming a pop-up nation. From sea to shining sea, her cities have been swept up in the frenzy for temporary architecture: Brooklyn vendors sell their wares in artfully arranged shipping containers; Dallas's Build a Better Block group champions DIY painted bicycle routes and pop-up small businesses; architects in San Francisco are repurposing metered parking spaces into miniature parks; residents in Oakland, California rallied to create an entire pop-up neighborhood.*

*The phenomenon has even climbed its way from grassroots origins to the agendas of local authorities: D.C.'s office of planning sprouted a Temporary Urbanism Initiative, while New York's transportation commissioner Janette Sadik-Khan is implementing what she calls "Jane Jacobs's revenge on Robert Moses" with her fast-acting interventions favoring pedestrians and cyclists. The temporary, so it seems, is overtaking the permanent. But how permanent is our current fascination for the temporary?*

*There is a natural tension within the term "temporary architecture" that makes the notion seem vaguely unstable. To understand the significance of this fact, it helps to go back to the lessons of Vitruvius. The prolific architect and scribe of antiquity imparted three principal virtues, among other things, unto the Western architects that would fall under his influence: utilitas, firmitas, and venustas.*

*The meaning of these terms is subject to much debate, but semantics aside, Vitruvius's virtues roughly translate to "utility," "durability," and "beauty." With these virtues firmly in place, Vitruvius equated the Roman empire's commanding marble cities with built perfection. The monuments that he extolled in the 1st century BC are an unmistakable tribute to the import of permanence.*

*But for centuries now, this association of great architecture with fixed and timeless permanence, along with the entire Vitruvian triad, has been losing traction. Our environment has been built, altered, and rebuilt in overlapping waves. While some buildings stand the test of time, most seem to expire in relevance. Grand architectural and planning schemes are increasingly rare. In fact, we fast-forward to today, and it seems that we are collectively swinging*

*towards a polar opposite of Vitruvian values. We are moving towards an architecture in which the permanent is becoming a lot less permanent.*

### **Temporary is the New Permanent**

*Lydia DePillis, architecture and urban issues critic for the Washington City Paper, recently penned an article entitled "Temporary is the New Permanent." Her piece centers around a recent urban intervention in D.C., in which, for one weekend, a typically lifeless neighborhood in D.C. became the site of a bustling marketplace. People (white people, as DePillis emphasizes) flocked to the remote district by bicycle to sample food truck fare, listen to live music, and admire the work of local artists and artisans.*

*The next Saturday, the streets were empty, as if it were all a dream. But when night fell, an entourage of D.C. youth came flooding into the area on chartered school buses to kick off a three-month-long arts event series called LUMEN8Anacostia.*

### **Lighter Quicker Cheaper**

*This pop-up urban revival is but one example of an approach informally called "lighter, quicker, cheaper" (LQC) by members of New York's Projects for Public Spaces (PPS). The organization pitches the phenomenon as a response to the strains of contemporary urban living: "As cities struggle to do more with less... we have to find fast, creative, profitable ways to capitalize on local ingenuity and turn public spaces into treasured community places." Enter the new triad of virtues: the light, the quick, and the cheap.*

*The LQC approach favors low-cost projects, incremental steps, and high levels of community engagement. Its implementation is widespread, ranging from pop-up marketplaces and pavilions to seemingly cosmetic but effective city planning reforms. Small budgets meet less resistance and allow for faster execution, which means the effects of these interventions can be felt more immediately. As a result, the schemes can be adapted as needed, responding quickly to the successes or failures of their forms. Moreover, these projects are often initiated by locals, diverse groups of individuals who can see the demands and aspirations of their respective communities firsthand. The results often become a more direct and intimate response to their sites.*

*Because of its low cost, modest appearance, and community-driven spirit, LQC architecture is often seen as a reflection of our times: this sudden infatuation for*

*the temporary can be read as a pragmatic response to economic downturn as well as a material expression of the slow democratization of our cities.*

*But if and when current circumstances change, will cities abandon the temporary for more traditional solutions? That is a difficult question to answer, as our conceptions of architecture are becoming increasingly unfixed. It seems that today's architects, planners, and city dwellers are actively redefining the binary that distinguishes the temporary and the permanent.*

*As we are seeing more and more, temporary architecture can be surprisingly permanent; Brooklyn's DeKalb Market and Oakland's Popuphood are two examples of essentially permanent interventions cloaked in the illusion of impermanence. Both projects are seen as "temporary" not because they are disposable, but because they are susceptible to instantaneous change at multiple points in time.*

*Conversely, temporary architecture that is objectively short-term but nonetheless strives for an illusion of permanence can be a thoroughly wasteful endeavor. Temporary, in this throwaway sense, risks enabling architects to disregard the specifics of their sites and build freely and thoughtlessly. The flippant pavilions and overwrought month-long constructions that result are not responsive to our times. Instead, they perpetuate the older, static notion of permanence, which has its place elsewhere.*

*At their worst, these short-lived projects cling to an architect or patron's self-serving delusions of grandeur, and the public is left with only a burn image of a monument, a two-dimensional idea that can occasionally inspire but often merely conceals a serious drain on efforts and resources. With all this in mind, we can return to our initial question: Is the pop-up here to stay? That depends on whether the pop-up truly means to stay.*

2. History of Pop-Up Architecture: <http://www.archdaily.com/784007/from-ancient-rome-to-the-coachella-festival-a-brief-history-of-pop-up-architecture>

Marni Epstein-Mervis in Arch Daily dispels the myth that pop-up architecture is “a quintessentially 21st century form of architecture”.

*Examples of temporary architecture appear as early as 58 BCE in ancient Rome, where they functioned as a form of revolution. Ancient Romans circumvented government opposition to permanent amphitheaters and other structures by building temporary ones. The Metropolitan Museum of Art notes that ancient Romans built spectacular wooden structures with intended life spans of just a few*

*weeks in which to stage plays and celebrate their most important community festivals, or ludi. Despite their impermanent nature, these structures could be large and ornate, including one Roman Theater that was comprised of three stories of columns and was embellished with 3,000 bronze statues. Temporary architecture in ancient Rome was a rich celebration and an expression of anti-establishment ideals.*

From early Roman days to the Renaissance, Pop-Up Architecture continued to evolve:

*The Renaissance saw a resurgence of temporary architecture together with other classical forms, says author and University of Toronto Professor of Art History Christy Anderson. Civic groups would welcome King Henry II of France to their cities with festivals showcasing the best and most elaborate in temporary design of the time. Archways made of painted canvas would denote important points along the festival's parade route. Sculptor Jean Goujan and architect Pierre Lescot's collaboration on France's original Fountain de Innocents (1550) was commissioned specifically for the festival; the fountain, which featured panels of delicately carved embellishments of nymphs and tritons, was an addition to an existing building and was meant to serve as a viewing platform for notables during Henry II's procession.*

For architects and designers of the Renaissance

*...temporary architecture allowed the creation of structures for special occasions and afforded the opportunity for experimentation. The ephemeral nature of the installations lent themselves to design innovations believed to be too unconventional or extravagant for lasting architecture. One other such example was British architect Inigo Jones' [Design for a Temporary Arch Ornamented with](#)*

*[Btti and Allegorical Figures of Music and War](#), done around 1622. Once again, temporary architecture was the realm of ideas and designs thought too forward-thinking or progressive.*

### 3. History of Temporary Architecture :

<http://www.curbed.com/2016/3/9/11180920/architecture-history-temporary-banksy>

*Pop-ups like Dismal Land are everywhere. The impermanent, unexpected, and even slightly irreverent have become community staples. We can visit pop-up amusement parks, shop at pop-up stores, eat at pop-up restaurants, and stay at pop-up hotels. "Architecture has transitioned into an experience. An experience where, purposefully, it is difficult to tell the difference between the design and the art installation," says Melanie Ryan, Design Principal at the Los Angeles-based experiential and mobile design house Open For Humans.*

*Pop-up architecture offers something rare: design that is undiluted. Traditional, permanent architecture often needs to serve multiple purposes—it's an office building and transit hub, it's a hotel and retail space—and changing surroundings. Architects must incorporate the demands of building owners, financial backers, and users. By contrast, pop-up architecture can advance a singular purpose and concentrate its impact. Pop-ups can also precipitate economic development and community engagement, sometimes in underserved or undeveloped areas. Temporary themselves, pop-up structures can be a catalyst for lasting change.*

4. Time Magazine, April 29, 2014, "Have the World of Tomorrow' Become a Thing of the Past?", by Harry Swartout

*What happened to the World's Fair? On April 30th, which marks the 75th anniversary of the 1939 World's Fair in Flushing Meadows, the question becomes especially poignant. How did the global cultural events that inaugurated broadcast television (New York 1939), built the Eiffel Tower (Paris 1889), and introduced the world to the Ferris Wheel (Chicago 1893) disappear?*

*Actually, they haven't: World's Fairs haven't gone anywhere, it's just America that has moved on.*

*The next World's Fair is scheduled for Spring 2015 in Milan Italy, but expo-goers who are looking to catch the latest glimpse at the "world of tomorrow," will be disappointed. "A lot of Americans imagine World's Fairs as they were in the 1930s and the 1960s, but the medium has changed," says World's Fair consultant Urso Chappell. "Whereas the focus was on progress or the space age and things like that at one time, the themes tend to be more environmental now," he adds.*

*With smaller scope and a concentration on solving problems rather than trumpeting triumphs, World's Fairs just don't capture the imagination like they used to. Milan's theme — Feeding the planet, energy for life — focuses on ending hunger and developing food sustainability. By contrast, the 1939 World's Fair's Dawn of a New Day slogan exuded aspirational wonder and 1964's (which had its 50th anniversary last week), centered on Peace Through Understanding.*

*Then there's the problem of proximity. There hasn't been a World's Fair in North America since 1986 in Vancouver. During the Fairs' heydays, wealthy and middle class families would make pilgrimages across the seas to meccas of modernization to see the wonders firsthand, but the internet put an end to that. "I don't know today how a World's Fair can be viable, because everybody has a camera in their pocket," says Louise Weinberg, World's Fair Archive Manager at the Queens Museum. A quick search on your phone has replaced an expensive trip to a foreign country.*

*Cost plays a significant role too. Unlike the Olympics, which occasionally have made money for their host cities, there's no profit from hosting a Fair. "Running a Fair is a losing proposition, you don't do it to make money" says Weinberg.*

*Prestige was the prime motivator for hosting World's Fairs. Some of New York's most prominent political figures like Robert Moses, Fiorello LaGuardia and Grover Whalen performed Herculean feats (and spent gobs of money) in order to bring the two Fairs to New York. Now the U.S. leaves the bidding to developing or resurgent countries looking to impress the rest of the world.*

*But while the U.S hasn't hosted a Fair in decades, it's still participating in them. Barack Obama announced more than a year in advance that America will participate in Milan's Expo in 2015, and U.S. cities are already bidding to host ones much further out. "There's groups in Minneapolis looking to [host the World's Fair in] 2023, there's groups in San Francisco and Houston looking at 2025, so hopefully we will see a World's Fair in North America sometime soon," says World's Fair consultant Chappell. To avoid slipping from "the world of tomorrow" to "the world of the past," the new U.S. Fairs will have to harken back to the old New York Fairs' sense of wonder and aspiration.*

5. The prefabrication pioneering period through the 19<sup>th</sup> century and into the 20<sup>th</sup> century, is outlined in: *Pioneers of Prefabrication, The British Contribution in the Nineteenth Century*

*The history of the British contribution to prefabrication in the nineteenth century reflects the expansionist phase of urbanization at home and colonialism abroad. The vital period of innovation in*

*British pre-fabrication lay in the earlier years of Victoria's reign, but innovation continued significantly until the end of the century—the passing of Victoria, and the end of an era. During this era, and in their modest workshop and in their large factories, British manufacturers of prefabricated buildings established the basic concepts of industrialized building: the concepts of standardization and modular coordination, of large-scale industrial production of repetitive elements of sales promotion and marketing on an international scale, of integrated on an international scale, of integrated packaging and distribution systems, of rational site erection procedures, and of the differentiation of open and closed systems. These concepts were propounded and explored and principles established during this pioneer phase. It was a preliminary stage, tentative, and often immature, but it was the essential basis of all future development.*

6. McGraw-Hill's SmartMarket Report Prefabrication and Modularization (2011) summarizes the 20th century perspective on prefabrication in the U.S.

*For the U.S., modern prefabrication/modularization is said to have started in the early 1900s. Housing started being developed using prescheduled procedures based on modern mass production. Aladdin and Sears Roebuck Company sold prefabricated houses that were delivered to customers as mail-order homes.*

*Prefabrication/modularization was increasingly used during World War II due to the need for mass accommodation for military personnel. The United States used Quonset huts as military buildings. These all-purpose, lightweight buildings could be shipped anywhere and assembled without skilled labor.*

*Following World War II, both Japan and Europe had massive rebuilding needs and turned to prefabrication and off-site construction to fill the demand. It is because of this early adoption and acceptance that European and Japanese companies are still considered some of the most advanced in terms of modular construction techniques. In the U.S., commercial applications of modular construction like hotels, offices, hospitals and schools began to emerge throughout the '70s, '80s, '90s, and into the 2000s as demand exceeded the supply of existing structures.*

*Recent innovations over the past few decades have allowed the prefabrication and modular construction industry to make significant advances in developing processes and materials to build and deliver more sophisticated and complex facility types.*

*An example of this is the Hilton Palacio del Rio Hotel in San Antonio. Built by Zachry Construction Corporation for the Texas World's Exposition of 1968, the 500-room deluxe hotel was designed, completed and occupied in an unprecedented period of 202 working days. All the rooms were placed by crane in 46 days. Still in use, the hotel is believed to be the tallest modularly constructed facility in the United States. The project is a testament to the durability of modular construction.*

*A current example of just how well accepted modular units have become is their use in the construction of the new cruise liner Queen Mary 2, which is one of the largest and most expensive cruise liners in the world. The ship owners chose to use modular passenger cabins to ensure all cabins were built to the higher standards that are available in a factory environment; even their VIP suites utilized the modular building process.*

*Prefabrication/modularization has not had a steady increase in use over time; instead, it has fluctuated based on the level of drastic need during war and economic booms. However, technological advancements over the past 20 years have increased what prefabrication/modularization can achieve in the construction industry. BIM, quality modern materials and sophisticated manufacturing facilities now offer significant productivity gains on projects not possible before.*

*Recently a committee of experts appointed by the National Research Council identified "greater use of pre-fabrication/modularization" as a key breakthrough opportunity that could significantly improve the efficiency and competitiveness of the U.S. construction industry going forward.*

*With a construction market facing acute shortages in onsite skilled labor and also where players are trying to be leaner, many believe the time is right now, more than ever, for widespread adoption of*

*off-site prefabrication/modularization solutions on a major scale in the construction industry.*

7. *The Automation in the Prefab and Modular Construction Industry (ISARC 2009) paper included some critical components of automation and prefabrication to enable significant movement forward in the 21<sup>st</sup> century:*
- ***Robotics Automation*** *is an important and emerging innovation in the Prefab Industry. Robots found its way to construction first in components making and the production of modular housing. Later, mobile robots were developed for special on-site construction tasks. As reported by Bock (2004), robots played active roles at the production line of Sekisui Chemical Sekisui Heim in Japan, where more than 85 percent of the houses are prefabricated. Bock (2007) elaborates a robotic precast concrete panel factory that uses a multipurpose unit which allows flexible production of the concrete floor, wall and roof panels.*
  - ***The Automated Construction Site*** *is also critical to the success of the prefabrication process as materials and products are delivered to the site and installed. An automated construction site may use robotics for logistics and assembly, but can face many barriers that are technological or economical. The technological barriers are that a robot must cope with the complexity of the construction process involving a dynamic and evolving site, together with the need for performing multiple tasks with differing characteristics. Robotics research in construction has moved to address technological barriers via: a) development of mobile platforms and manipulators, b) development of control systems and sensory systems integration, c) re-engineering of processes to suit robotic systems, d) software development related to support the above, and use of advanced IT systems to enhance the whole system performance.*
  - ***Virtual Reality and Simulation in the Prefab Industry*** *is becoming a cutting edge opportunity for dramatic improvements in productivity and “game changing” efficiency. Virtual reality (VR) enables real-time viewing of, and interaction with, spatial information. The visualization can simulate performing such tasks as production, transportation, handling and assembly of components. It can also evaluate which pieces of the building are to*

*be assembled in what sequence, as well as reuse the model at different stages of construction. Team members can visualize their specific tasks and the relationships between the works of various other sub-contractors. Li et al (2008) described an integrated framework and process for general contractors to apply the virtual prototyping technology. In this framework, an expert (process modeler) accepts the BIM model from the designer, and decomposes it into formats required by contractors and consultants. At the same time, the process modeler integrates information provided by a team member into the BIM model to create a virtual prototyping of the construction processes. Through an iterative process, the process modeler enables the construction team to conduct 'what-if' analyses of different construction methods in the virtual prototyping environment until a satisfactory method is achieved.*

- ***Schedule Automation and Sensor-Based Control*** is also an emerging innovation. An efficient production schedule drives automation in the actual creation of prefab components. Several scheduling prototypes have been reported, which addresses this issue. For example, a decision support system for coordinated prefabrication scheduling has been described by Chan and Zeng (2003). It supports key elements of production (re)scheduling, namely, conflict detection, determination of the priority for conflict resolution, generation and evaluation of alternatives for conflict resolution, and ranking of outcomes for negotiation. It combines the use of an explicit constraints-based scheduling model, and genetic algorithms (GA) to determine scheduling parameters and conflict resolution priorities. A GA based searching technique is also adopted in a mixed precast flow-shop scheduling system proposed by Leu and Hwang (2002), providing near-optimal combination of production sequences, resource utilization, and minimum make-span while complying with resource constraints and mixed production. Take notice that prior to construction, the components delivered to the site need to be inspected, stored and then tracked, while the details related to installation require adequate documentation. Prefab components locations need to be known, and transported to the site with minimum time loss. Gajamani and Varghese (2007) have presented a RFID- based location tracking real time scheduling and monitoring system that make use of prefab/ precast components. Data is collected in real time and is

*converted using a software system, not only for the control but also for field material management and future use.*

- ***Prefab Factory Automation.*** *Embracing the technologies that revolutionized manufacturing industry, prefab builders may radically improve the efficiency with which it produces end products - buildings. The future builders will evaluate ways to improve productivity through the application of lean production, information and automation technologies. It will include efficient methods for warehousing, develop strategies to reduce construction waste, and adopt techniques for recycling. It will develop and deploy technologies for defect-free transportation of the prefab components. It will develop and test transportation system features that are high performance, low cost and more fully integrated into the building's structural system. Support processes will include optimization, simulation, visualization and project management tools to evaluate and control alternatives. Materials will arrive in the factory just in time to support production, and stored close to the point of use. Components will be identified and tracked in real time to monitor the exact location and status of all items. Material handling and manufacturing processes will be automated to eliminate injuries, minimize physical exertion, assure capacity and boost productivity. Production documentation will be accurate and timely, and can be accessed from remote locations.*
- ***Prefab Construction Automation*** *Technological advances to improve the quality of a product in terms of its function, is critical. Forward thinking on how the prefab product of the future will look and behave gives good insight. Prefab modules and buildings will adopt a systems integration approach to design, engineering and construction. The building envelope systems (roof, wall, floor, etc.) will maximize integrated performance. Builders will incorporate fully integrated structural systems that can resist the forces applied during component/module transport and site installation. It will develop new assemblies and sub-assemblies that improve performance that could be applied with ease in a factory setting. It will integrate plumbing and mechanical systems within the whole module, and will include new wiring and cabling systems that optimize whole-building performance. It will also incorporate functions that wired and wireless technologies and systems can offer. It will identify the reasons for material failures and/or systems*

*linking to manufacturing and/or installation problems. It will develop new production, installation and joining (ie: fasteners, joints, etc.) techniques, and new designs to minimize failures. A virtual and simulation environment that supports the design of prefab components and their assembly, and simulating the construction to suit schedule will become the standard practice. The simulation environment likely will utilize a library of 3-D models of the prefab modules that can be used to interactively design the whole building. The design and operation of the building will promote and contribute to the health of its occupants. Buildings will have deployed methods for controlling sources of contamination, techniques for improving ventilation, and systems & procedures for controlling moisture. It will develop and deploy new and existing energy conservation and renewable energy technologies and strategies. The built environments will be the most energy efficient, and annual energy costs of these units will be low, or perhaps even lower than comparable site-built structures.*

8. The VTT Technical Research Centre of Finland's 2013 Survey on automation of the building construction and building products industry explored and delineated the emerging technologies now being taken from eprototype to mainstream:

- **3D Concrete Printing.**

*In the last few years 3D printing has become a very common method for rapid prototyping in many industrial fields, for example manufacturing plastic parts. The evolution of this technology has also been an inspiration to test the same method on a bigger scale by using concrete as a material.*

- **Flexible molds in manufacturing freeform concrete elements**

*Digital concrete manufacturing has been studied in Denmark in the TailorCrete and Unique Concrete Structures (UnikaBeton) projects lead by the Danish Technological Institute. Manufacturing custom molds for concrete elements is done using an industrial robot. In this approach, the mould is carved according to a 3D CAD model of the object. Custom-manufactured moulds can be made from foam materials that are cheap, fast and easy to mill [Raun et al. 2010]. Another approach is to use flexible moulds, Figures 20 and 21. In this method, the shape of the mould can be altered under computer control. The surface of the mould is made from a membrane, and under that membrane there are several actuators (pistons) that are*

*used for changing the shape of the mould. With this method, curvatures and the level of details are limited, so flexible moulds are best suited for relatively large double curved surfaces like facades or walls*

- **Contour Crafting**

*Contour crafting is a layered fabrication technology developed by Dr. Khoshnevis at the University of Southern California. In construction, this method is based on the distribution of concrete using a portal type robot with the aim of building the whole frame of a house automatically. This method has been under development for over 10 years. First, a miniature device capable of building small structures was developed for demonstrating the idea. Later, a bigger robot capable of building concrete walls was developed. According to the developers using contour crafting technology, a small house could be built in 24 hours. A potential application for this method is to build low cost houses e.g. for victims of natural disasters such as earthquakes.*

- **D-Shape**

*D-shape is a robotic building system based on the principle of 3D printing. The method was developed by Monolite UK Ltd. In this method, sand is used as a building material. A large-scale robot is used for moving the printing head. During the printing process a nozzle is used to deposit binder onto a layer of sand. The printing starts from the bottom of the structure and rises up in 5–10 mm sections. The solidification process takes 24 hours to complete. According to the developer, the appearance of the material is marble-like, and this artificial sandstone material has very good strength properties. The dimensional tolerances of the d-shape structures are 5–10 mm. Parts that fit inside a 6 x 6 x 6 m cube can be printed with this method based on the 3D design of the structure, Figures 22 and 23. In building construction, this method could be used for manufacturing elements such as stairs, arches, columns etc. An interesting feature of the d-shape method is that the complexity of the shape of the object does not increase the manufacturing costs of the object*

- **Digital Fabrication of Architectural Structures**

*TH Zurich (Faculty of Architecture, Institute of Technology in Architecture, Archi-ecture and Digital Fabrication, Prof. Framazio*

*and Prof. Kohler) in Switzerland has studied robotics and digital manufacturing from the viewpoint of architecture. Several experimental applications are presented, where a digital model of the product is used as a basis for robotic manufacturing. For example, 3D forms are manufactured by assembling bricks or wood cubes very accurately by using an industrial robot. In one experiment, a 22 m long wall consisting of over 7,000 bricks was built in New York, using an industrial robot and digital 3D model of the structure. Robots have been used also for manufacturing moulds from the clay for manufacturing free form concrete parts. Also, wood carvings are manufactured using robots. In one experiment, small flying helicopter type robots were used for building a 6 m high 3D structure from 1,500 polyurethane bricks, Figure 24. These experiments show that robotics and automation can be an enabler for realization of ambiguous architectural designs in the future*

- **Robotic Tile Placement**

*The Design Robotics Group (DRG, Harvard University, Graduate school of design) has studied the use of automation and robotics in manufacturing unique building structures economically. One example presented is a robotic tile placement on facade or floor elements of the building [King et al. 2012]. The research is focused on tile patterns that are very complex and extremely laborious and expensive to install manually. Examples of such patterns are computer generated random patterns consisting of different sized tiles or patterns based on digital images. An example of a digital workflow is that a digital image can be converted into a tile pattern, and movements for the robot are automatically generated according to the tile pattern, Figure 25. This digital workflow and robotic tile placement were tested. According to the tests, the expenses of the robotic tile placement are comparable to a manual tile placement, but the complexity of the tile pattern can be much higher in robotic tile placement. DRG has also studied manufacturing of customized ceramic tiles using robots*

- **Graphic Concrete**

*For centuries, even thousands of years, buildings have been decorated using mosaics, carvings and frescoes applied to the walls and ceilings. These kinds of techniques are extremely laborious, and are currently used only in special cases.*

*Digitalization, robotics and automation can change this, and the decorative effects mentioned above might be applied in modern architecture. One example is graphic concrete developed by interior architecture Samuli Naamanka in 1997. The idea is to produce prefabricated patterned concrete elements. The digital image is printed on a special membrane. During the manufacturing, the printed membrane is added on the top of the concrete element, and a surface retarder is applied to the surface of the membrane. On the surface of the finished elements, the surface is rough in the spots where the retarder is applied. The contrast between rough and smooth surface makes a picture visible, Figures 26 and 27. Also, colored concrete can be used in the surface of concrete elements*

- **Robotic mosaic manufacturing**

*Manufacturing mosaic is a very laborious work demanding great skill. Robotic mosaics manufacturing is one example of digital production. Mosaic4u is a company in Israel that has developed robotized solution for manufacturing mosaics based on digital image. Robot pastes 10 x 10 mm tiles on a 300 x 300 mm sheets with 0.1 mm accuracy. [<http://www.mosaic4u.biz/>]*

9. The FMI 2013 Survey of Prefabrication and Modularization in Construction provided some trends that are worth noting:

*When compared with the numbers from our 2010 survey, it doesn't appear that the use of prefabrication is growing at the rate we expected. While there is growth on the low end and the high end, the growth in usage of prefabricated assemblies seems to have stalled for most respondents. We do not think this signifies that we will not see more growth in the next few years; however, it might show that some are getting better at finding work that can be accomplished in the shop than others are.*

*This apparent trend not to rush into adding prefabrication facilities may be a good idea, especially for those who haven't considered prefabrication and modularization as part of their strategic plans. In other words, it is important to "do the math" before leaping into prefabrication. There are risks involved in such large investment decisions, and some will be able to take on that risk and obtain a competitive advantage, while others will do best to avoid it and subcontract as needed.*

10. The *Modular Building Institute* (<http://www.modular.org/>) provides an excellent summary of the details and benefits of this project, entitled “LEED Platinum SoMa Studios On the Cutting Edge of Urban Prefab:”

*The SoMa Studios, a 23-unit apartment building in San Francisco’s trendy South of Market district, is believed to be the first modular-built urban infill apartment complex in the nation. The stylish four-story LEED Platinum building was deposited, module by module, on a 3,700-square-foot lot between a parking garage and an apartment complex, after being trucked over the Bay Bridge from a Sacramento factory. The entire building process took three months – a fraction of the estimated 13 months for the same project using traditional construction – and the four stories went up onsite in just four days.*

*Seeking to move the project forward quickly, the developer, Panoramic Interests of Berkeley, Ca. decided that modular was the way to go. Modular offered “no change orders, better quality, shorter construction, better scheduling and a more predictable outcome,” according to Panoramic’s Patrick Kennedy. Because modules are built in a controlled environment, modular construction is inherently greener. “There is 50-90 percent less construction waste because of the process but also procurement,” said Sankaran. “Because we buy materials almost exactly to what we need for the project – e.g. pre-cut lumber – we have less waste. Also, we can reuse materials and not put them in a dumpster since we aren’t out on a construction site.”*

*In addition, the modular method can lead to greater energy efficiency. “The offsite process enables a certain level of quality and energy efficiency,” according to Sankaran. “Some of the Energy Star 4.0 components can only be installed in a controlled environment. Also, the buildings are very well sealed.”*

*While the tightness of the SoMa studios produced incredible sound proofing – “better than any high rise in the city,” according to Kennedy – a well-sealed building often comes with the concern for a higher risk of poor indoor air quality. But when using modular, a builder doesn’t encounter the same issues as with stick-built construction.*

*"With modular, you can address these issues," Sankaran said. "For example, you can use kiln-dried lumber – which never gets exposed to elements – so you don't have mold and mildew issues."*



**Pop-Up Prefab**  
*Pop-Up and Pre-fabricated Architecture*

**FINAL EXAM**

1. **Pop-Up Architecture, a quintessentially 21<sup>st</sup> century form of architecture, is emerging as a powerful force of creative expression and imagination in which of the following:**
  - a. Hospitals
  - b. Festivals and Expos
  - c. Bridges
  - d. Housing
  
2. **Which of the following is NOT an example of Pop-Up Architecture**
  - a. World's Fairs and Expositions
  - b. The Biennale
  - c. The Serpentine Pavilion
  - d. The U.S. Capitol
  
3. **LQC is a term coined by the New York Projects for Public Spaces and stands for**
  - a. Light
  - b. Quick
  - c. Cheap
  - d. All of the above
  
4. **Pop-Up Weddings are a \_\_\_\_\_ to the more traditional wedding, according to Faye Darcy.**
  - a. Slower
  - b. Simple and elegant alternative
  - c. Dramatic change
  - d. Much more complicated alternative

5. **Prefabrication in architecture has historical roots in which of the following structures:**
- a. The Crystal Palace at Britain's Great Exhibition of 1851
  - b. Portable Colonial Cottages of the 1830s
  - c. Ship building and lighthouses
  - d. All of the above.
6. **Features of prefabrication in Britain embraced which of the following advanced concepts**
- a. Flexibility
  - b. Standardizations
  - c. Interchangeability of components
  - d. ALL of the above
7. **The history of prefabrication is linked to \_\_\_\_\_ during Victoria's reign**
- a. Climate change
  - b. British colonialization
  - c. Warfare
  - d. Geographic diversity
8. **The FIATECH Capital Projects Technology Roadmap was conceived and published in what year?**
- a. 1830
  - b. 1851
  - c. 1997
  - d. 2004
9. **Which of the following is NOT a project or publication by Kieran | Timberlake**
- a. The Hirschhorn Gallery in Washington DC
  - b. Loblolly House
  - c. Cellophane House
  - d. Refabricating Architecture

- 10. Which of the following “breakthrough improvements” is NOT one listed in The National Academy of Sciences 2008 publication on *Advancing the Competiveness and Efficiency of the U.S. Construction Industry***
- a. Greater use of prefabrication
  - b. Widespread use of BIM
  - c. Art in public places
  - d. Improved job-site efficiency
- 11. Examples of automation in the Prefab marketplace includes all of these projects EXCEPT**
- a. The FutureHome Project
  - b. The ManuBuild Project
  - c. TailorCrete Projects
  - d. Falling water
- 12. Techniques taking prefab from prototype to mainstream include all of the following EXCEPT:**
- a. 3D Concrete Printing
  - b. Digital Fabrication of Architectural Structures
  - c. Robotic Tile Placement
  - d. Stick built wooden frames.
- 13. The FMI 2013 Survey of Prefabrication and Modularization in Construction Listed key industry drivers for the continued development of prefab, including all of the following EXCEPT:**
- a. Pressure to lower price
  - b. Need to achieve a competitive edge
  - c. Impending lack of skilled construction labor
  - d. Manual processing of paper documents.

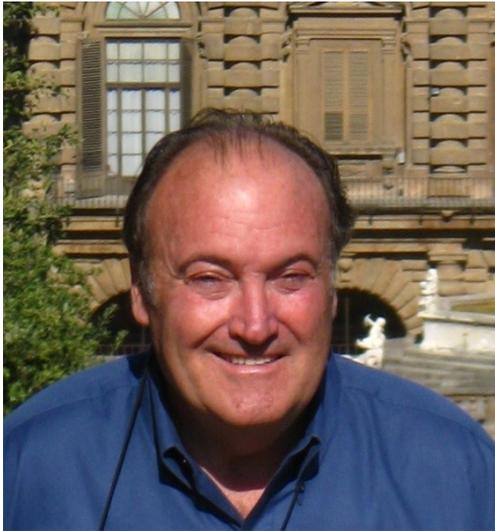
14. **The Mortenson Prefabrication Research Study Results (May 2014) documented the following benefits of prefabrication**
- Schedule & Cost Certainty
  - On-site Labor Density
  - Fewer Safety Incidents
  - All of the above.
15. **BLOX documents the metrics around prefabrication and hospital patient room modules that include**  
800 Components
- Installed by a dozen Trades
  - Over a span of three months
  - All of the above.
16. **“Dismal Land”, a pop-up exhibit in England, has a focus on \_\_\_\_\_ and experience and sculpture, combined in space and time and immediacy.**
- Toys
  - Cars
  - Architecture
  - Food
17. **Many do not realize that expositions and world’s fairs, an example of pop-up architecture, date back to:**
- Greek archaeology.
  - 1791
  - Pre-historic times
  - Roman Architecture
18. **Expos, a form of pop-up architecture, in North America date back to what state and fair?**
- New York City
  - World's Fair of Tunbridge, Vermont
  - San Francisco
  - Austin

19. **World's Fairs are generally constructed with a functioning duration of:**
- a. Over a decade
  - b. A few days
  - c. 3 to 6 months
  - d. Forever
20. **Certain venues such as \_\_\_\_\_, according to Harry Swartout, provide a more locally meaningful and durable alternative to World's Fairs**
- a. Indy 500.
  - b. Biennale and Serpentine Pavilion
  - c. Pyramids
  - d. Stonehenge
21. **An annual event in the Nevada desert, \_\_\_\_\_, has been billed as "the place to find out who you are, then take it a step further."**
- a. Nascar
  - b. Burning Man
  - c. The British Baking Show
  - d. A Netflix Original Series
22. **One example of a new type of pop-up business is \_\_\_\_\_ which have proven to be imaginative and popular in Las Vegas, Washington DC and New York City is:**
- a. Stationery Stores
  - b. Weddings
  - c. Tech
  - d. Plumbing
23. **The Pop-up wedding business has proven extremely \_\_\_\_\_ for brides and grooms where a typical cost of \$2,500 has been reduced to \$325.**
- a. Complex
  - b. Economical
  - c. Overly sophisticated
  - d. Hard to manage

**24. Around Here is a business founded in 2013 with a mission to:**

- a. Create a series of coffee shops.
- b. Provide low-cost books
- c. Build a network of the noteworthy retail spaces
- d. Compete with WeWork

## BIOGRAPHY



Stephen R Hagan FAIA

**Stephen R Hagan FAIA CCM** is recognized as an industry expert on technology | innovation, real estate, and the construction marketplace.

In August 2012, Stephen retired from the federal government after 37 years and is now consulting about BIM, Innovation and Online Technologies. Steve is President | CEO of Hagan Technologies in Reston, VA. Stephen is currently a member of the AIA Documents Committee.

Stephen was program and project management lead for the U.S. General Services Administration PBS Project Information Portal (PIP) and a founding member of the GSA 3D / 4D Building Information Model (BIM) team.

The AIA TAP Innovation awards program, which Steve founded (as TAP BIM Awards) in 2003, in 2014 celebrated its 10th year and includes partnerships with COAA, IFMA, and the AGC BIM Forum. In 2015, this program celebrated 11 years as a leading example of innovation and technology foresight for the Institute.

In 2012-13, Hagan Technologies partnered with Onuma Inc. on development of a Strategic Plan and 5 Year Road Map for the Space and Equipment Planning System (SEPS) and the world-wide facility management system (DMLSS-FM) for the Department of Defense (DoD) and Veterans Administration (VA).

In 2014, Hagan Technologies continues to support Onuma Inc with a new FED iFM initiative for the DoD Defense Health-care Administration (DHA) that will broadly support the entire FM community in the public sector and can broaden to the entire Design, Construction, Facilities Management / Operations communities.

In 2015, Hagan Technologies branched out to include strategy and support for online, social media and collaborative technologies for the global travel industry.

In 2016, through engagement with Geo-Buiz, the Open Geospatial Consortium (OGC), and NIST's Smart Cities program, Hagan Technologies now is focused on emerging and innovative technologies supporting Smart | Connected | Sustainable | Resilient Cities and Urban Eco-Districts.

In 2017, Hagan convened and keynoted a Full Day Pre-convention workshop entitled: **Game Changing Innovation--Designing the Future of Architecture, Construction and The Built Environment** at the 2017 AIA National Convention in Orlando on April 26, 2017. In 2018 to 2020, Game Changing Innovation, Cybersecurity for Architects, and start-up initiatives in the global construction industry and the built environment continue apace.

# ***Review Questions and Evaluative Feedback***

## ***I. Introduction and Overview***

### **1. A key question about Pop-Up Architecture is**

- a. Is it a trend?
- b. Is it a new way to practice?
- c. What is involvement in retail, entertainment, housing industries
- d. All of the above.**

#### ***Answer***

- a. Is it a trend? **Answers are that a, b and c are correct.**
- b. Is it a new way to practice? **Answers are that a, b and c are correct.**
- c. What is involvement in retail, entertainment, housing industries. **Answers are that a, b and c are correct.**
- d. Correct. All of the above. Pop-up Architecture is a trend, a new way of practice, and involves retail, entertainment and housing industries**

### **2. Pre-Fab (Pre-Fabricated Architecture) involves**

- a. Social Media
- b. New techniques in direct-from-design manufacturing**
- c. Legal discussions
- d. Automotive industry

#### ***Answer***

- a. Incorrect: Social Media is a wholly different discipline to pre-fab
- b. Correct. New techniques in direct-from-design manufacturing are involved and critical to pre-fabricated architecture**
- c. Incorrect. Legal discussions. Pre-fab involves design and construction and seldom involves legal discussions
- d. Incorrect. Automotive industry. The automotive industry would call it assembly line, not pre-fabrication.

**3. Which of the following is NOT an example of Pop-Up Architecture**

- a. World's Fairs and Expositions
- b. The Biennale
- c. The Serpentine Pavilion
- d. Frank Lloyd Wright's Falling Water**

**Answer**

- a. Incorrect. World's Fairs and Expositions. This IS an example of Pop-UP
- b. Incorrect . The Biennale. This IS an example of Pop-UP
- c. Incorrect. The Serpentine Pavilion. This IS an example of Pop-UP
- d. Correct. Frank Lloyd Wright's Falling Water is not an example of pop-up architecture**

**4. Pop-Up Architecture can be considered “frenzy for temporary architecture” in what way?**

- a. It costs too much.
- b. It reflects ancient traditions.
- c. Examples abound in Brooklyn, Dallas, San Francisco and Washington DC.**
- d. It is way too complicated

**Answer**

- a. Incorrect It costs too much. In fact, pop-architecture can be very affordable
- b. Incorrect. It reflects ancient traditions. Ancient traditions emphasized firmness, commodity and delight.
- c. Correct: Examples abound in Brooklyn, Dallas, San Francisco and Washington DC and many other venues**
- d. Incorrect.It is way too complicated is not true and can often simplify construction and installaiton

**5. Pop-Up Architecture is changing our Relationship to the Built Environment \_\_\_\_\_.**

- a. Extolling Vitruvius' virtues of utilitas, firmitas, and venustas (utility, durability and beauty)
- b. Because the permanent is becoming a lot less permanent**
- c. Creating monuments in marble and stone.
- d. Building in green field sites.

**Answer**

- a. Incorrect. Extolling Vitruvius' virtues of utilitas, firmitas, and venustas (utility, durability and beauty)
- b. Correct. Because the permanent is becoming a lot less permanent as is evident by many examples from the course.**
- c. Incorrect. Creating monuments in marble and stone is not correct because pop-up often is made of wood and more temporary materials
- d. Incorrect. Building in green field sites is not correct because it is usually in urban and transportation venues.

**6. New York's transportation commissioner implemented an example of pop-up architect that she calls "Jane Jacobs's revenge on Robert Moses" with the following features**

- a. Extensive bridges and highways
- b. Fast-acting interventions favoring pedestrians and cyclists**
- c. Urban parks systems
- d. Improvements to schools.

**Answer**

- a. Incorrect. Extensive bridges and highways were actually an example of the work of Robert Moses throughout New York City
- b. Correct. Fast-acting interventions favoring pedestrians and cyclists including pedestrian safety programs and cyclist safety programs around larger construction projects.**
- c. Incorrect. Urban parks systems also were a key item of Robert Moses
- d. Incorrect. Improvements to schools.

## ***II. Pop-Up Architecture***

**7. Which of the following is NOT an example of temporary architecture as cited by Kelly Chan in her 2012 "Pop-Up Nation":**

- a. Brooklyn vendors sell their wares in shipping containers. A, B, and C. answers ARE examples cited by Kelly Chan
- b. San Francisco are repurposing metered parking spaces
- c. Typical Suburban developments and playgrounds**
- d. Oakland, California rallied to create an entire pop-up neighborhood

**Answer**

- a. Incorrect. Brooklyn vendors sell their wares in shipping containers. A, B, and C. answers ARE examples cited by Kelly Chan
- b. Incorrect. San Francisco are repurposing metered parking spaces
- c. Correct. Typical Suburban developments and playgrounds**
- d. Incorrect. Oakland, California rallied to create an entire pop-up neighborhood

**8. Millennials are flocking to Pop-Up Architecture for all of the following reasons EXCEPT:**

- a. It is Lively
- b. Appears to be cheaper**
- c. Represents a vibrant idea
- d. It is “very cool”

**Answer**

- a. Incorrect. It is Lively. Answers a,b,c and ARE reasons.
- b. CORRECT. Appears to be cheaper, this is NOT a reason for millennials to be excited about pop-up architecture.**
- c. Incorrect. Represents a vibrant idea
- d. Incorrect. It is “very cool”

**9. Ancient citizens of Rome built examples of Pop-Up Architecture such as venues for**

- a. Community celebrations
- b. Local Theatrical Performances
- c. Roman Amphitheaters**
- d. Religious and non-religious celebrations

**Answer**

- a. Incorrect. Community celebrations . Answers a,b,c WERE venues often utilizing pop-up architecture.
- b. Incorrect. Local Theatrical Performances
- c. CORRECT. Roman Amphitheaters were very permanent structures**
- d. Incorrect. Religious and non-religious celebrations were not typically venues for pop-up architecture.

**10. A key reason for the creation of temporary architecture in ancient Rome was:**

- a. There was previous generation precedent
- b. There was a moratorium on permanent theatre structures in the city of Rome that lasted until 55 BC**
- c. Sports facilities were scarce
- d. Roman cities needed space

***Answer***

- a. Incorrect. There was previous generation precedent is not true.
- b. Correct. There was a moratorium on permanent theatre structures in the city of Rome that lasted until 55 BC. Some Roman theatres, constructed of wood, were torn down after the festival for which they were erected concluded because of the law.**
- c. Incorrect. Sports facilities were scarce is not true
- d. Incorrect. Roman cities needed space is not true

**11. An example of Pop-Up Architecture during Renaissance times was**

- a. Gothic cathedrals
- b. During the reign of King Henry II of France festivals sprouted up along the parade route when he traveled.**
- c. Knights in shining armor
- d. Roman Aqueducts

***Answer***

- a. Incorrect. Gothic cathedrals were very permanent, not pop-up
- b. Correct. During the reign of King Henry II of France festivals sprouted up along the parade route when he traveled.**
- c. Incorrect. Knights in shining armor is obviously not a reference to architecture but to medieval protective clothing.
- d. Incorrect. Roman Aqueducts were long extensive and meant to be permanent.

**12. World's Fairs were an example of Pop-Up Architecture at mini-urban scale and were built in which of the following cities EXCEPT:**

- a. Paris
- b. De Moines Iowa**
- c. Chicago
- d. New York

***Answer***

- a. Incorrect Paris. Answers a, b, and c WERE cities where world's fairs were built.
- b. Correct. De Moines Iowa**
- c. Incorrect. Chicago. This WAS an example of a world's fair.
- d. Incorrect. New York. Two worlds fairs were held in New York.

### ***III. Pre-Fabrication***

**13. Pre-Fabrication examples include all of the following EXCEPT:**

- a. Kieran | Timberlake Architects' "The Cellophane House"
- b. The Lobloolly House
- c. Britain's Great Exhibition of 1851 and the Crystal Palace
- d. The U.S. Capitol**

***Answer***

- a. Incorrect. Kieran | Timberlake Architects' "The Cellophane House". Answers a,b, and c are all examples of pre-fabrication projects.
- b. Incorrect. The Lobloolly House IS an example of pre-fab.
- c. Incorrect. Britain's Great Exhibition of 1851 and the Crystal Palace are BOTH examples of pre-fab.
- d. Correct. The U.S. Capitol was not pre-fabricated but built from the ground up over many years.**

**14. “Mail-Order” housing is an example of pre-fabricated architecture in which following location:**

- a. Africa
- b. West Coast of Australia, as well as New South Wales and Tasmania**
- c. Russian Federation
- d. Antarctica

***Answer***

- a. Incorrect. Africa did not have pre-fabricated architecture to any major extent.
- b. Correct. West Coast of Australia, as well as New South Wales and Tasmania.** For colonial settlements such as British settlements on the West Coast of Australia, as well as New South Wales and Tasmania, wooden houses were built in sections in England and packed for shipment in the early 1830s. These were called “portable colonial cottages”
- c. Incorrect. Russian Federation was not a location for pre-fab
- d. Incorrect. Antarctica was not a location for pre-fab.

**15. The Manning Portable Colonial Cottage for Emigrants was a unique synthesis of several factors, EXCEPT:**

- a. Designed to pack in a small space for shipping
- b. Conceived for mobility and ease of transportation
- c. Designed for ease of erection
- d. Involved brick masonry elements**

***Answer***

- a. Incorrect. Designed to pack in a small space for shipping. Answers a,b, and c were ALL unique factors.
- b. Incorrect. Conceived for mobility and ease of transportation This WAS a major factor
- c. Incorrect. Designed for ease of erection. This WAS a characteristic.
- d. Correct. Involved brick masonry elements. Brick would be too heavy and did not lend itself to pre-fab, at least in those colonial days.**

**16. Which construction processes were led by the concept of pre-fabrication:**

- a. Stick built wood
- b. Iron**
- c. Concrete foundations
- d. Excavation

**Answer**

- a. Incorrect. Stick built wood preceded pre-fab and wasn't a characteristic.
- b. Correct. Iron.** the tools and skills of the carpenter and shipwright were soon to be overtaken by more progressive manufacturing techniques lead by the advanced development of iron construction:
- c. Incorrect. Concrete foundations are poured in place and not a characteristic of pre-fab.
- d. Incorrect. Excavation is not an example of pre-fab but in fact very site specific and labor and equipment intensive.

**17. Examples of Pre-fabricated architecture include all the following EXCEPT:**

- a. Bridges
- b. Steel Ships
- c. Igloos**
- d. Lighthouses

**Answer**

- a. Incorrect. Bridges. Answers a, b and c are all examples of pre-fabrication.
- b. Incorrect. Steel Ships. Answers a, b and c are all examples of pre-fabrication.
- c. CORRECT. Igloos**
- d. Incorrect Lighthouses. Answers a, b and c are all examples of pre-fabrication.

**18. Pre-Fabricated Architecture was cited as a significant way for the United States to advance the competitiveness and efficiency of the construction industry by which organization?**

- a. The 19<sup>th</sup> Century *Pioneers of Prefabrication*
- b. National Research Council of the National Academy of Sciences (2009)**
- c. Refabricating Architecture by Kieran Timberlake (2004)
- d. FIATECH Roadmap (2004)

**Answer**

- a. Incorrect. The 19<sup>th</sup> Century *Pioneers of Prefabrication*. This was a much earlier publication, pre-dating the book.
- b. Correct. National Research Council of the National Academy of Sciences (2009). Of the five “breakthrough” improvements cited as being critical, number 3 was “Greater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and processes.”**
- c. Incorrect. Refabricating Architecture by Kieran Timberlake (2004). The exact citation was as noted in answer b.
- d. Incorrect. FIATECH Roadmap (2004). The exact citation was as noted in answer b.

## **IV. Cutting Edge Case Studies**

**19. Prefabricated Architecture Case Studies include all of the following examples EXCEPT:**

- a. Proving Ground (proving.ground.io)
- b. AIA TAP Building Connections (2003 to 2020)
- c. Prefabricated Accessible Technology Homes by Phillipe Starck
- d. Poured in Place Concrete Projects**

**Answer**

- a. Proving Ground (proving.ground.io). Answers a, b and c ARE examples of pre-fabricated architecture case studies.
- b. AIA TAP Building Connections (2003 to 2020). Answers a, b and c ARE examples of pre-fabricated architecture case studies.
- c. Prefabricated Accessible Technology Homes by Phillipe Starck answers a, b and c ARE examples of pre-fabricated architecture case studies.
- d. Correct. Poured in Place Concrete Projects**

**20. BLOX illustrates examples of pre-fabrication techniques which include the following building types:**

- a. Data Centers
- b. Hospitals**
- c. Playgrounds
- d. U.S. Embassies

**Answer**

- a. Incorrect. Data Centers are not an example of BLOX
- b. Correct. Hospitals. Their technology provides solutions for spaces in hospitals including the patient room, headwalls that include extensive utility outlets, bathrooms and entire exam rooms.**
- c. Incorrect. Playgrounds are not an example of BLOX
- d. Incorrect. U.S. Embassies are not an example of BLOX

**21. SOMA Studios in San Francisco suggests pre-fabricated architecture can go “beyond the bathroom module” to:**

- a. Nature centers
- b. An entire building, in an urban context**
- c. Museums
- d. Aquariums

**Answer**

- a. Incorrect. Nature centers are not examples of pre-fab.
- b. Correct. An entire building, in an urban context -- the entire project is an amazing example of how extremely sustainable buildings (LEED Platinum) are attainable on a complex and tight urban site**
- c. Incorrect. Museums are not an example of pre-fab
- d. Incorrect. Aquariums are not an example of pre-fab.

**22. One example of a firm or organization making use of 3D modeling and lean construction techniques in pre-fabricated architecture is:**

- a. CMAA
- b. AGC: Associated General Contractors of America
- c. EggRock ([www.eggrock.com](http://www.eggrock.com))**
- d. Army Corps of Engineers

**Answer**

- a. Incorrect. CMAA is not an example of pre-fab.
- b. Incorrect. AGC: Associated General Contractors of America is not an example of pre-fab.
- c. Correct. EggRock ([www.eggrock.com](http://www.eggrock.com))**
- d. Incorrect. Army Corps of Engineers is not an example of pre-fab.

**23. Pre-Fabricated Architecture does not have to be boring or utilitarian, as illustrated by whose publication?**

- a. Travel Guides
- b. Sheri Koones “Prefabulous+Sustainable”**
- c. Construction Handbooks
- d. The U.S. Constitution

**Answer**

- a. Incorrect. Travel Guides were not the correct publication
- b. CORRECT. Sheri Koones “Prefabulous+Sustainable” She combined the two concepts of prefabrication and sustainable design in homes that were beautifully designed and, actually, epitomize “dream” homes.**
- c. Incorrect. Construction Handbooks were not the correct publication
- d. Incorrect. The U.S. Constitution is not the correct publication

**24. Oldcastle “Surepods” are an example of illustrating the value proposition for pre-fabricated architectural components in all of the following EXCEPT:**

- a. Hilton Garden Inn
- b. The Broadmoor Hotel
- c. The HUD building in Washington DC**
- d. Military Barracks at Fort Carson, CO

***Answer***

- a. Incorrect. Hilton Garden Inn. Answers a, b and c are all examples of the use of “Surepods”
- b. The Broadmoor Hotel. Yes the hotel did use “Surepods”
- c. Correct. The HUD building in Washington DC did not use “Surepods”**
- d. Military Barracks at Fort Carson, CO. Yes the barracks did use “Surepods”