Innovative Technology in Home Construction: Impact on Labor and Costs

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2016-2017 | PlaceWorks partnered with The California Endowment to identify design and policy solutions to bring affordable housing to more family households.

Geography: Eastern Coachella Valley with statewide and national implications.
Coachella Valley Tourism/Resort
$4 billion industry

Photo: La Quinta Resort & Spa
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Coachella Valley Agriculture
$1.7 billion industry
Coachella Valley Housing Options

100+ unpermitted mobile home parks (safety/sanitation issues)

Other living options: cars, street, makeshift camps, or even caves
The Desert Housing Report
December 2018

Coachella Valley Median Detached Home Price
December 2002 - December 2018

- CV Detached Median Price
- 4% Growth Curve

Source: California Desert Association of Realtors
Desert Housing Report
Coachella Real Estate Market Overview

- **Median Sales Price**: $242,500
- **Price Per Sqft**: $152
- **Median Rent Per Month**: $1,700

Housing Market Trends

Market trends help you understand the movement of key price indicators. Trends in Coachella show a 3% year-over-year rise in median sales price and a 19% rise in median rent per month.

- **Median Sales Price**: The median sales price for homes in Coachella for Oct 24 to Jan 23 was $242,500 based on 38 home sales.
- **Price Per Square Ft.**: Average price per square foot for Coachella was $152, an increase of 6% compared to the same period last year.
- **Median Rent Per Month**: The median rent per month for apartments in Coachella for Dec 24 to Jan 24 was $1,700.

Source: Trulia real estate market overview January 2019
www.trulia.com/real_estate_Coachella-California
Affordable Housing New Construction Projects:
Cost Components as % of Total Development Costs (Net of Land)

- Construction Costs: 69%
- Demolition/Site Prep: 8%
- Developer Fees: 7%
- Permits/Dev Impact Fees: 6%
- Architect/Engineering/Surveys: 4%
- Acquisition Costs: 1%
- Offsite Improvements: 1%
- Other Costs: 4%

Average calculated by summing (real) cost measures across all 400 affordable projects and dividing by total project costs excluding land.
Can we decrease construction costs?

Materials
Technology
Policy
<table>
<thead>
<tr>
<th>Technology &amp; Material</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Site Built (local code)</strong></td>
<td>89%</td>
</tr>
<tr>
<td>Stick frame</td>
<td>55%</td>
</tr>
<tr>
<td>Concrete masonry</td>
<td>14%</td>
</tr>
<tr>
<td>Panelized</td>
<td>13%</td>
</tr>
<tr>
<td>Insulated Concrete Form (ICF)</td>
<td>4%</td>
</tr>
<tr>
<td>Steel frame</td>
<td>2%</td>
</tr>
<tr>
<td>Structural Insulated Panel (SIP)</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Other</td>
<td>&lt;1%</td>
</tr>
<tr>
<td><strong>Modular Construction (local code)</strong></td>
<td>2%</td>
</tr>
<tr>
<td><strong>Manufactured Home (federal code)</strong></td>
<td>9%</td>
</tr>
</tbody>
</table>

Emerging Technologies

3D printing
Autonomous brick laying
Autonomous construction

THE FUTURE
Robotic construction for the world.

Image: Hadrian X, a fully-automated, end-to-end bricklaying robot by Fastbrick Robotics (FBR)
Construction Material: Traditional Stick Frame

Stick framing is the traditional method of home building in the United States. Typically, homes are assembled on site using lumber to form walls and roof trusses. These frames are then linked together and sheathed with plywood on the exterior and drywall on the interior. The exterior is finished with shingles, clapboard, vinyl siding, adobe or some kind of brick or brick veneer.

Costs based on the low end of the cost per square foot estimate range to build an affordable single family home in Riverside County (per Valon Consulting 2016).
Modular Construction

Modular construction involves factory built construction of rooms (boxes) that are shipped to the site and stitched together to create entire buildings on a permanent foundation. Modular construction can use a wide variety of materials while meeting the same building codes and architectural specifications as conventional construction.

Costs based on figures from Silvercreek, a factory-built housing manufacturer in Perris, California as of 2015.
A manufactured home is factory-built that is assembled on a permanent chassis and intended to be a single-family dwelling on a support chattel or a permanent foundation. Manufactured homes are built to comply with the federal uniform building standards (HUD Code). Manufactured homes are not the same as mobile homes. Mobile homes have not been constructed since June 15, 1976 at which time the federal preemptive HUD Code took effect.
Construction Material: Structural Insulated Panels (SIP)

SIP is a composite building material consisting of an insulating layer of rigid core sandwiched between two layers of structural board. The board can be a sheet of metal, plywood, cement, magnesium oxide board (MgO) or oriented strand board (OSB) and the core of the panel can be either expanded polystyrene foam (EPS), extruded polystyrene foam (XPS), polyisocyanurate foam, polyurethane foam or composite honeycomb (HSC).

Costs assumes $14.9-$17.6 per sq. ft. installed wall, and $5.3-$7.3 per sq. ft. installed roof.
Construction Material: Super Adobe (Cal-Earth)

Long or short sandbags are filled with on-site earth and arranged in layers or long coils (compression) with strands of barbed wire placed between them to act as both mortar and reinforcement (tension). Stabilizers such as cement, lime, or asphalt emulsion may be added.
Construction Material: Rammed Earth

+32%

Rammed Earth is a building method used for constructing walls, foundations, and floors using raw materials such as earth, sand, chalk, lime, gravel or clay. The building process involves compressing a damp mixture of earth with various proportions of sand, gravel and clay into an externally supported frame/mould, thus creating a solid wall surface.
Costs generated in coordination with the BIA and an affordable housing builder to generate baseline proforma. PlaceWorks obtained cost figures from manufacturers for building wall material and substituted new material costs into baseline project. Cost factors also assume the use of prevailing wage.

<table>
<thead>
<tr>
<th>Technology &amp; Material</th>
<th>2016 Cost</th>
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<tbody>
<tr>
<td>Site Built</td>
<td>varies</td>
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<tr>
<td><strong>Stick Frame</strong></td>
<td>Baseline</td>
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<tr>
<td>Structural Insulated Panels</td>
<td>+3%</td>
</tr>
<tr>
<td>Ziegel Block</td>
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<tr>
<td>Structural Concrete Insulated Panels</td>
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<tr>
<td>Insulated Concrete Form</td>
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<tr>
<td>Super Adobe</td>
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<tr>
<td>Straw-Bale</td>
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<tr>
<td>Rammed Earth</td>
<td>+32%</td>
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<tr>
<td><strong>Modular Construction</strong></td>
<td>+21%</td>
</tr>
<tr>
<td>Manufactured Home</td>
<td>-25%</td>
</tr>
</tbody>
</table>
Observations on Current Technologies

- As of 2018, stick built construction was still the least expense
- Other technologies may catch up or even become more cost effective in places like California (e.g., 2020 ZNE requirements)
- Select technology based on location and desired benefits
  - Construction cost
  - Life cycle value (owner’s cost to maintain/heat/cool)
  - Regulatory compliance with new building codes
  - Allow owner participation in construction
Changes in Policy & Research

- **Reduce emphasis on energy efficiency**
  Energy efficiency gains lowered ongoing utility costs, but did not reduce construction costs or make it more affordable to buy or rent a home.

- **Protect affordable housing from delays and uncertainty**
  With such a dire need for affordable housing, consider foregoing environmental clearance requirements (e.g., CEQA) and avoid associated delays, NIMBYs, and lawsuits.

- **Tax incentives or public subsidies are increasingly inefficient**
  As housing costs rise faster than incomes, using taxpayer money to subsidize affordable housing becomes less and less efficient and does not fundamentally reduce housing costs.

- **Bring back focus on reducing construction costs**
  Make this a priority at the federal and state level; e.g., refund and refocus the public-private Partnership for Advancing Technology in Housing (PATH) program.
Technology in Construction
Advanced Technology

1. Generative Design
2. Model Based Estimating
3. VR/AR
4. UAV
5. Data Visualization
Emerging Technology

**Additive Manufacturing**
How will new materials change how we work in the future and what are we doing about it today?

**Robotics & Automation**
AEC Industry lessons learned from the automotive industry: automate dangerous work on our projects.

**Internet of Things / Wearables**
It’s about People: Improve Safety of worker. Create the Knowledge Worker of the Future.

**Generative Design / Optimization**
Advancements in computing power is utilized to study an infinite number of design and construction options and arrive at the optimal solution.

**Reality Capture + Computer Vision**
Photogrammetry/Videogrammetry technologies in reality capture are leveraged learn and analyze the built environment.

**Modulization / Prefabrication**
Earlier decisions = increased planning to reduced time, increased quality and safer jobsites through prefabrication and modularization. Control Risk / Enhanced Agility, Reliable Decision Making, Improved Quality.
What is Modular?

• Typically factory built construction of rooms (boxes) that are shipped to the site and stitched together to create entire buildings

• Meets same building codes and architectural specifications as conventional construction
Modular Codes

- HCD Released Guidelines
- Meets same building codes and architectural specifications as conventional construction

“Modular construction…is faster, less expensive, allows for high levels of quality control and significantly reduces waste and truck traffic. It’s also safer for workers as construction is done inside in controlled environments,”

– Michael Bloomberg
Mayor
New York City
Differences from Panelized Construction

- Panelization: The use of interlocking wall, floor and roof assemblies fabricated on tables (on or off-site) and assembled on building pads.
- Greatest efficiencies come from repetitive component members used in highly repetitive plan solutions.
Benefits of Modular

- Potential savings in high wage environment.
- Compressed project schedules
- Sustainability
- More controlled conditions
- Fewer job-site environmental impacts
- Fewer conflicts in work crew scheduling
- Reduced requirements for on-site materials storage
- Increased workers safety
Challenges of Modular

- Limited experience
- Unfamiliarity /Limited Interest/ Learning Curve, Scope Gaps
- Limited factory production capacity
- Risks associated with sole source supply from one factory
- More upfront design and preconstruction effort
- Approval Process / Code Challenges
- Transportation
- Market prejudice
- Major parts of development may need to be field-built
  - ie. Garages, Foundations, Common areas
- Labor Union Pressure
- Potential Height Impact
What does Modular look like?

Exterior designs can embrace modularity

Or can be more like a traditional building
Together, we transform lives and communities.
Local Government Partners

- Getting local government partner comfortable with modular
  - Get the city on board early
  - Overcoming preconceived notions: “It’s not a mobile home”
  - Loss of local control: perception or reality?
- Balancing State law and Local Ordinances
- Getting Political and Staff support
Pre-Development and Design Management

• Code issues are complicated by the difference between how the factory constructs vs. site built
  • Fire ratings
  • Seismic design
  • Utility routing
  • Mating of factory and site utility connections
  • As examples
Pre-Development and Design Management

• The most cost effective money a developer spends is during design
  • Every dollar spent in design can save thousands once under construction
• Compressed Project Schedules
  • Components Manufactured Off-Site while:
    • Foundation Poured
    • Site Work Completed