



# Constructability

## BLUEPRINT



An ACI Center of Excellence  
for Advancing Productivity

[www.concreteproductivity.org](http://www.concreteproductivity.org)

Founding Member:



PRO proudly recognizes

Members:



PRO: An ACI Center of Excellence for Advancing Productivity was established in 2023 by the American Concrete Institute. Its purpose is to be a catalyst for solving the barriers of constructability to advance concrete construction productivity, leveraging ACI's role as a world-leading authority for the development, dissemination, and adoption of consensus-based standards for concrete design, construction, and materials.



## **TABLE OF CONTENTS**

### **SECTION 1: VALUE OF DESIGN COLLABORATION**

- 1.1 What is Constructability?
- 1.2 Improving Productivity via Constructability
- 1.3 Status of Construction Productivity
- 1.4 Constructability Economics
- 1.5 Collaborative Relationships
- 1.6 Design Collaboration is the Key
- 1.7 Timing of Collaboration to Maximize Results
- 1.8 Outcomes of Constructability Focus
- 1.9 Concrete's Design Advantages Versus Constructability
- 1.10 The Path to Concrete Productivity—A Summary
- 1.11 Additional Resources for Those Seeking to Improve Concrete Productivity

## 1.1 WHAT IS CONSTRUCTABILITY?

PRO defines constructability as the effective integration of construction knowledge into the planning and design of a project to optimize its construction cost and schedule and maximize its value to the owner.

Constructability practices should be introduced as early as possible to achieve the best results, potentially providing a 10:1 return on the owner's investment, according to the **Construction Industry Institute (CII) Task Force**. Constructability input during design will improve efficiency once construction begins, reducing requests for information (RFIs), redesigns, and overall construction time.

Concrete constructability is not about sacrificing architectural creativity or owners' goals. On the contrary, it helps achieve desired architectural and ownership outcomes by reducing the complexity, leveraging local labor and materials, maximizing the productivity potential of concrete construction systems, and capitalizing on available technologies. In short, constructability improves construction productivity through effective designer/contractor collaboration.

The CII **Constructability Graph** (Fig. 1.1.1) illustrates stages in the design and construction process and ability to influence final project costs. As can be seen, the greatest potential for cost reduction arises during the conceptual planning and early design stages. At these stages, designer/concrete contractor collaboration can pay big dividends.

A key element of improving concrete constructability is to create fully complete and coordinated structural concrete design documents. A poll of members of the American Society of Concrete Contractors (**ASCC**) showed that 75% of ASCC members believe that poor design documents are the single largest barrier to improving field productivity. Time and labor efficiencies are lost when the design information is inferior, insufficient, and/or inaccurate.

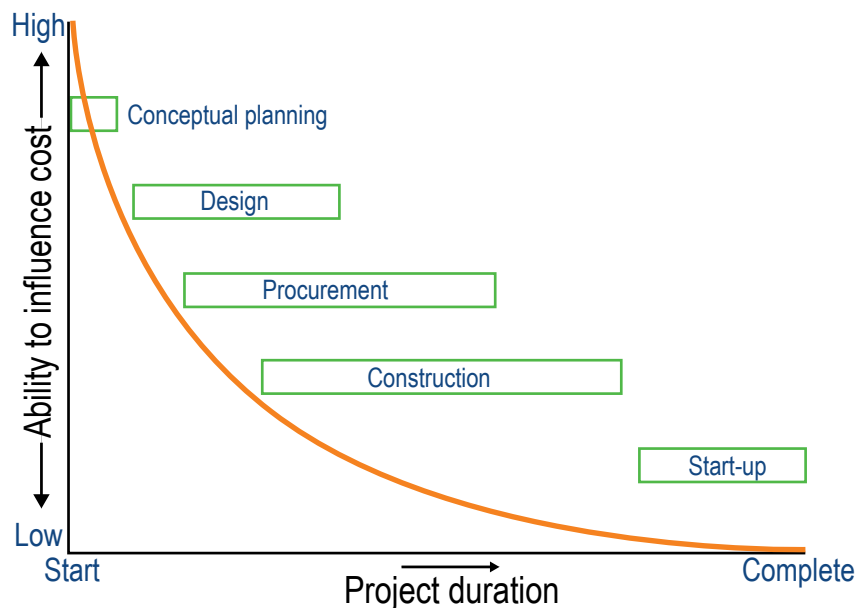


Fig. 1.1.1: The ability to influence the final cost of a project decreases rapidly with each phase of the project (“Constructability: A Primer, Construction Industry Institute,” Austin, TX, 1986, 24 pp.)

## 1.2 IMPROVING PRODUCTIVITY VIA CONSTRUCTABILITY

According to the Construction Industry Institute Task Force, effective constructability programs can lower project costs (4.3% reductions on average) and shorten project timelines (7.5% reductions on average) while minimizing rework, improving safety, and advancing environmental sustainability.

Constructable designs capitalize on the available construction personnel and skills, materials, and equipment while accounting for other factors such as local weather and general construction logistics. Constructable designs also have fully complete and coordinated structural design documents that are dimensionally compatible with architectural and other design professionals' plans, and that apply appropriate construction tolerances selected to reduce rework and avoid conflicts with trades that follow the structural work.

Concrete specifications that are performance based rather than prescriptive can set the stage for innovative construction solutions. For example, properly specified performance-based concrete mixture designs will empower the concrete contractor and concrete supplier to achieve desired strength, durability, and embodied carbon goals in efficient and innovative ways.

Standardizing element sizes and concrete mixtures, and reducing reinforcement congestion early in the design process, improves constructability by reducing construction complexity. When constructability is improved, shop and field labor can achieve higher levels of productivity while time of construction is reduced.



*Miami World Tower. Image courtesy of Ceko Concrete Construction.*

## 1.3 STATUS OF CONSTRUCTION PRODUCTIVITY

According to studies conducted by the McKinsey Global Institute (MGI) and others, construction productivity was essentially stagnant from 1947 to 2010 (refer to Fig. 1.3.1). During that same period, however, productivity gains in manufacturing, retail, and agriculture ranged from 800 to 1600%. This trend is unacceptable, as construction contributes 4% of the U.S. gross domestic product (GDP).<sup>1</sup> To ensure society is able to continue to afford efficient and safe infrastructure and buildings, construction productivity must increase.

A recent study published by the National Bureau of Economic Research further shows that construction prices over the past 70+ years have skyrocketed in comparison to the GDP. As demonstrated in Fig. 1.3.2, construction cost increases have been most dramatically affected by poor labor productivity, as the cost of construction intermediates (energy, materials, and purchased services) have tracked with the GDP over the same period.

PRO members have expressed concerns that insufficient collaboration between designers and contractors is the source of this poor performance, as it leads to designs lacking in constructability. As architectural and structural designs have become increasingly complex, time constraints can force constructability considerations to take a back seat. The resulting construction documents may lack adequate coordination, so construction productivity suffers.

The previously cited MGI report observed that acting in seven areas simultaneously could boost construction productivity by 50 to 60%. The cited enablers are:

- Reshaping regulation and raising transparency;
- Rewiring the contractual framework to reshape industry dynamics;
- Rethinking design and engineering processes;
- Improving procurement and supply chain management;

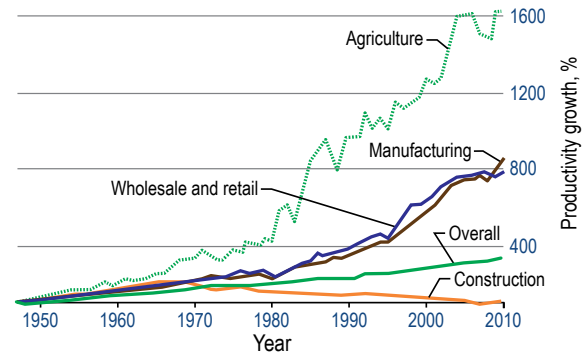


Fig. 1.3.1: For decades, construction productivity has experienced little or no growth, while other sectors have experienced massive gains in productivity. (Barbosa, F. et al., "Reinventing Construction: A Route to Higher Productivity," McKinsey Global Institute, Feb. 2017, 158 pp.)

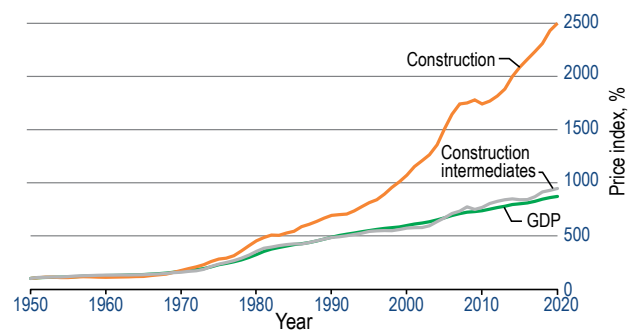


Fig. 1.3.2: Price indexes for construction, construction intermediates, and GDP, from 1950 to 2020. (Goolsbee, A., and Syverson, C., "The Strange and Awful Path of Productivity in the U.S. Construction Sector, Working Paper 30845," National Bureau of Economic Research, Jan. 2023, Revised Feb. 2023, 27 pp., <http://www.nber.org/papers/w30845>)

<sup>1</sup>Johnson, A., "Using Construction as an Economic Indicator," *Forbes*, Aug. 6, 2023 (<https://www.forbes.com/sites/forbesbusinesscouncil/2023/08/16/using-construction-as-an-economic-indicator/?sh=63ca20467bfa>)



- Improving on-site execution;
- Infusing digital technology, new materials, and advanced automation; and
- Reskilling the workforce

In response to this industry challenge, the American Concrete Institute (ACI) decided to tackle the issue of productivity in concrete construction. A small group addressed McKinsey’s findings and recommendations at an ACI Foundation Strategic Development Council (SDC) meeting in 2020, and the group’s insights led to the formation of an ACI Board Task Group that developed recommendations for how ACI could use its resources to improve constructability and productivity. One of these recommendations was to form PRO: An ACI Center of Excellence for Advancing Productivity. PRO was subsequently inaugurated in 2023, giving ACI and the concrete industry an effective and unifying new resource for positive change.

On June 27 and 28, 2023, PRO held a strategic planning workshop with broad industry participation, including designers, materials suppliers, and concrete contractors (refer to Fig. 1.3.3). The workshop’s many findings included the need to improve early-phase designer-contractor interactions. This finding complements three of the seven areas identified in the MGI study:

- Rewiring the contractual framework to reshape industry dynamics;
- Rethinking design and engineering processes; and
- Improving on-site execution.



Fig. 1.3.3: PRO’s first-ever Strategic Planning Workshop hosted at ACI Headquarters in Michigan.

## 1.4 CONSTRUCTABILITY ECONOMICS

Constructable designs lead to faster build times by minimizing the need for issuing (and waiting for responses to) RFIs, by eliminating the need for rework, and by accommodating realistic tolerances. Project financing costs are reduced; commercial projects capture revenue sooner; externalities such as traffic delays are reduced; and opportunity costs for designers, suppliers, and others are minimized (design professionals, for example, can focus on the next project rather than respond to RFIs for the last project).

At the 2021 SDC Technology Forum, for example, a case study was presented on the constructability economics of concrete construction in the United States. The study of Ceko Concrete Construction projects determined that materials comprise 27% of the total cost of the projects, and time-dependent expenses (for example, formwork rental, hoisting, supervision, and equipment) comprise another 10% of the total cost. Labor (for example, placement of formwork, reinforcement, and concrete) comprises 63% of the total (refer to Fig. 1.4.1). Clearly, a constructable design will optimize labor and provide significant value to project owners.

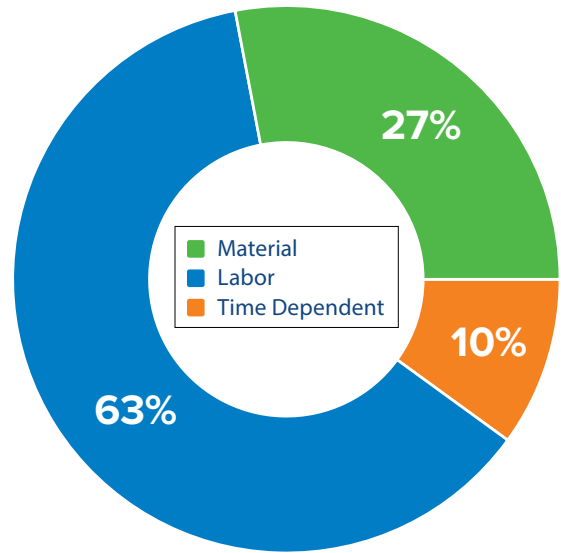


Fig. 1.4.1: The cost of labor comprises more than twice the cost of materials for a concrete construction project.

Improving collaboration between the contractor and designer is critical to producing a constructable design that can improve productivity and eliminate unnecessary cost. Designers find that early concrete contractor collaboration improves design efficiency, with fewer design modifications required during construction compared to the traditional design-bid-build approach. RFIs and costly change orders during construction are greatly reduced.



## 1.5 COLLABORATIVE RELATIONSHIPS

A chart from **The Owner's Dilemma** (refer to Fig. 1.5.1) shows the power and potential of collaboration: While strategic purchasing and proactive problem solving in the Contractor-Designer Collaboration model provide increasing value over the project duration, adversarial change orders in the noncollaborative Design-Bid-Build model result in decreasing value over the project duration. In the former, the parties work together to enhance common project goals. In the latter, each party is focused on their own self-interest. Clearly, trusting and collaborative relationships among the contractors, designers, and project owner offer the greatest value for all parties.

A collaborative effort initiated by the Construction Users Roundtable (CURT) along with the American Institute of Architects (AIA) and the Associated General Contractors of America (AGC) has led to the introduction of contract documents supporting project teams. Integrated, value-based contractual agreements designate risks and rewards for trusting collaborative processes. These agreements should include performance-based incentives and disincentives. Collaborative teams must believe in true, fault-free collaboration. Collaboration allows stakeholders to manage risks together, effectively dismantling silos that have been previously constructed to deflect risk.

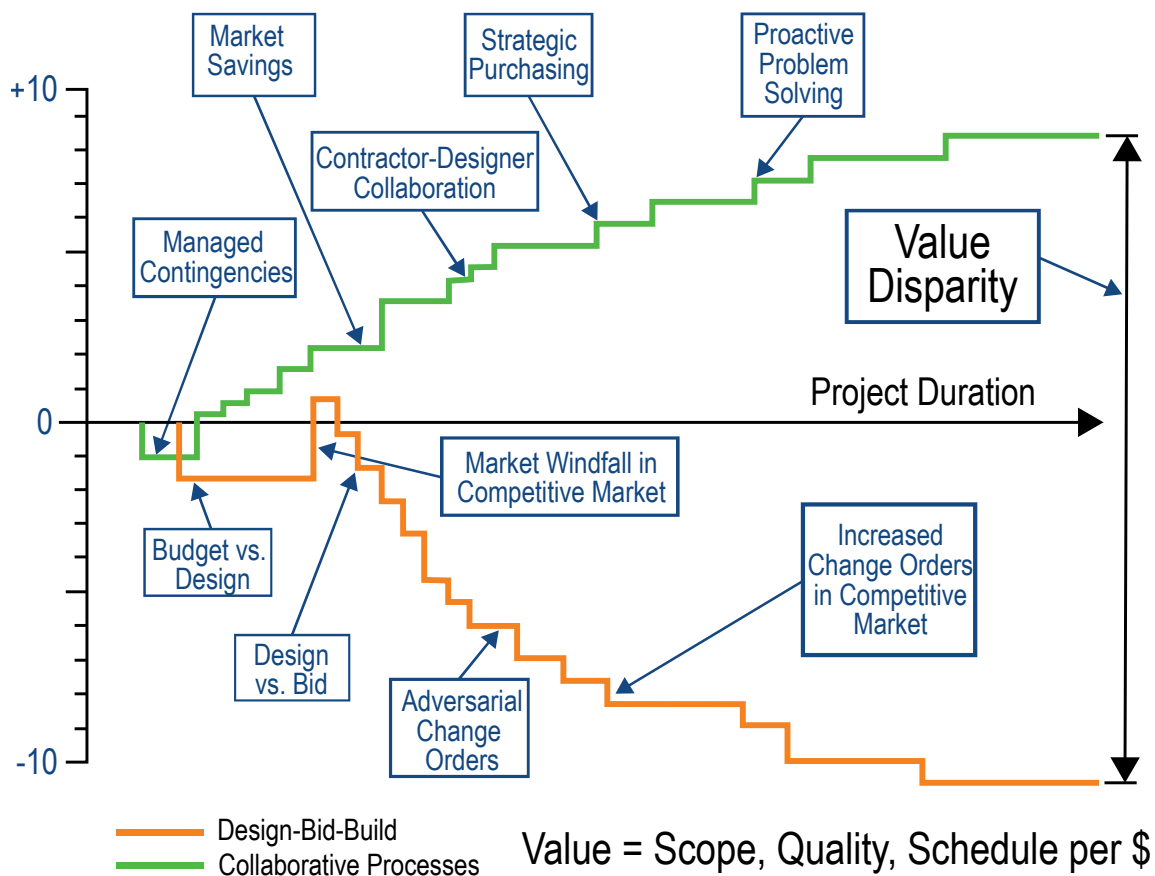


Fig. 1.5.1: Value (scope, quality, and schedule enhancements per dollar spent) can be lost within an adversarial bid environment—even in a competitive market, where significant windfalls at ‘bid-time’ are sometimes captured. (Bryson, B.W., and Yetmen, C., *The Owner's Dilemma: Driving Success and Innovation in the Design and Construction Industry*, Ypsilon & Co., July 1, 2010, 245 pp.)



Author Clive Thomas Cain<sup>2</sup> has stated that trust-based collaboration can deliver up to 30% savings in construction costs.

Integrated project delivery (IPD) with lean construction and design is a construction project delivery method and philosophy by which key parties involved in the design, fabrication, and construction aspects of a project are joined together under a single agreement. IPD can be achieved through various relationship arrangements (refer to Fig. 1.5.2), with associated degrees of collaboration and benefits. While a contractual agreement has benefits for an IPD (refer to Levels Two and Three), it is not required (refer to Level One). The key element for effective relationship arrangements is trust.

<sup>2</sup>Cain, C. T., "Profitable Partnering for Lean Construction," Oxford: Blackwell, 2004, 241 pp.



Mat pour. Image courtesy of The Conco Companies.

### Degrees of Collaboration from the AGC webinar by IPD

	“Classic” Collaboration	“Non-Multi-Party”	IPD
Level of Collaboration:	Lower ←————→ Higher		
Delivery Approaches:	CM At-Risk or Design-Build	CM At-Risk or Design-Build	IPD
Typical Selection Process:	Qualifications-Based Selection of all team members or Best Value Proposal	Qualifications-Based Selection of all team members	Qualifications-Based Selection of all team members
Nature of Agreement:	Transactional	?	Relational
Key Characteristics:	<ul style="list-style-type: none"> <li>No contract language requiring collaboration</li> <li>Limited team risk sharing</li> <li>CM or DB share in savings</li> <li>Open book trust between parties</li> <li>Early project commitment to designer-contractor by owner</li> </ul>	<ul style="list-style-type: none"> <li>Contract language requiring collaboration</li> <li>Some team risk sharing</li> <li>All parties’ compensation tied to project success</li> <li>Co-location of team</li> </ul>	<ul style="list-style-type: none"> <li>Owner-Designer-Contractor (and possibly other key team members) all sign one contract that contracts collaboration</li> <li>Team risk sharing</li> <li>Team decision-making</li> <li>Optimizing the project</li> <li>Pain/gain sharing</li> <li>Limits on litigation</li> <li>Co-location of team</li> </ul>
Typical Basis of Reimbursement:	GMP	GMP	No GMP or GMP (some costs guaranteed)

Fig. 1.5.2: Levels of collaboration for Integrated Project Delivery

## 1.6 DESIGN COLLABORATION IS THE KEY

The design-bid-build (DBB) method creates silos (refer to Fig. 1.6.1). While DBB can ostensibly provide owners with low costs at bid time, it rarely brings the owner the lowest possible final cost. In *The Commercial Real Estate Revolution*,<sup>3</sup> Scott Simpson of KlingStubbins explains the illusionary allure of DBB: “The idea that a project will cost less if you don’t bid is counterintuitive. Owners use bidding as a cost management tool, but inevitably end up higher than managing the cost on the front end.

Improved constructability must start with foundational change to relationships between all parties. These changes must garner new practices of trust, collaboration, and sustainability to yield the best results. Designers and subcontractors should base their team selections on tried-and-true professional relationships.

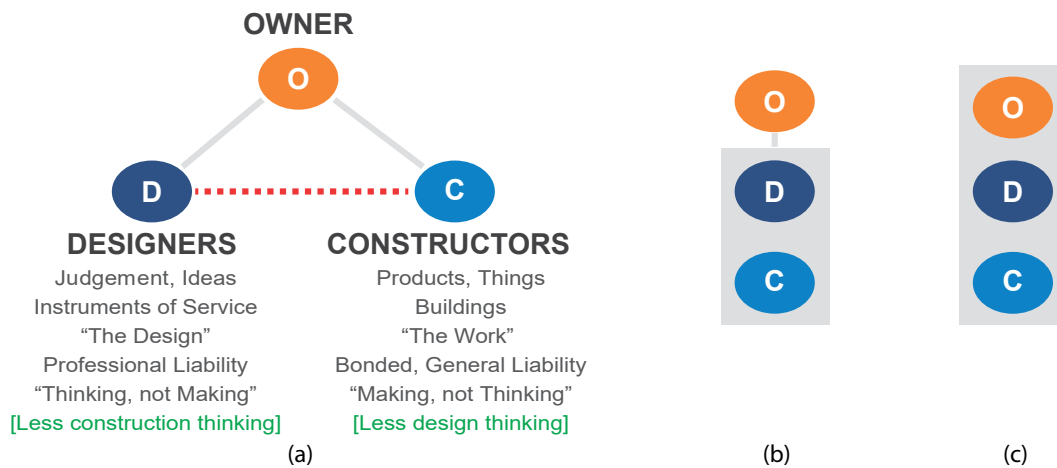


Fig. 1.6.1: The owner must work with design and constructor teams, each with its unique goals, responsibilities, purpose, and mindset: (a) Traditional Design-Bid-Build delivery creates silos and results in inefficient communication; (b) Design-Build delivery improves communication between designers and constructors; and (c) Integrated Project Delivery creates a total team mindset (Image Credit: Bernstein, P., “Integrated Project Delivery [IPD]: Why Owners Choose Multi-Party,” AGC, Presentation on Oct. 29, 2009).

*“The old design-bid-build paradigm had its day, but it has outlived its usefulness and is getting in the way of the kind of real change that can transform the way we build buildings.”*

### The Commercial Real Estate Revolution

Owners who bring about the most productive projects require design consultants and contractors who are prepared to both collaborate and innovate.

Communication among trusting teams is vital to successful collaboration and increased productivity on projects. Those who are not interested in improving productivity are having increasing issues securing business opportunities, as more owners see productivity and constructability as the way to go.

<sup>3</sup>Miller, R.; Strombom, D.; Iammarino, M.; and Black, B., *The Commercial Real Estate Revolution*, John Wiley & Sons, Inc., New York, 2009, 352 pp.

# 1.7 TIMING OF COLLABORATION TO MAXIMIZE RESULTS

Figure 1.7.1 illustrates how collaboration from conceptual design through concrete construction saves a significant amount of time. Contractors benefit, as collaboration maximizes constructability gain. Designers benefit, as time required for redesign and design clarifications is reduced or eliminated. Lastly, owners benefit, as early project design collaboration results in better quality and reduced financing cost.

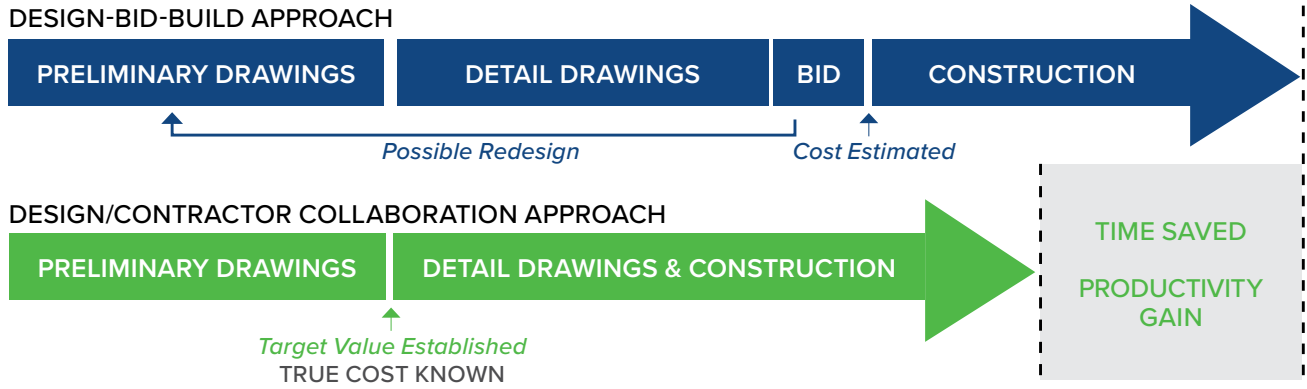


Fig. 1.7.1: IPD adds value through collaboration.

In contrast, the traditional DBB delivery system results in delayed collaboration and/or contentious interactions between designers and constructors, demanding more time and cost expenditures than are needed for projects with early design collaboration. In brief, late-stage design changes can significantly impact the construction of a project (Fig. 1.7.2).

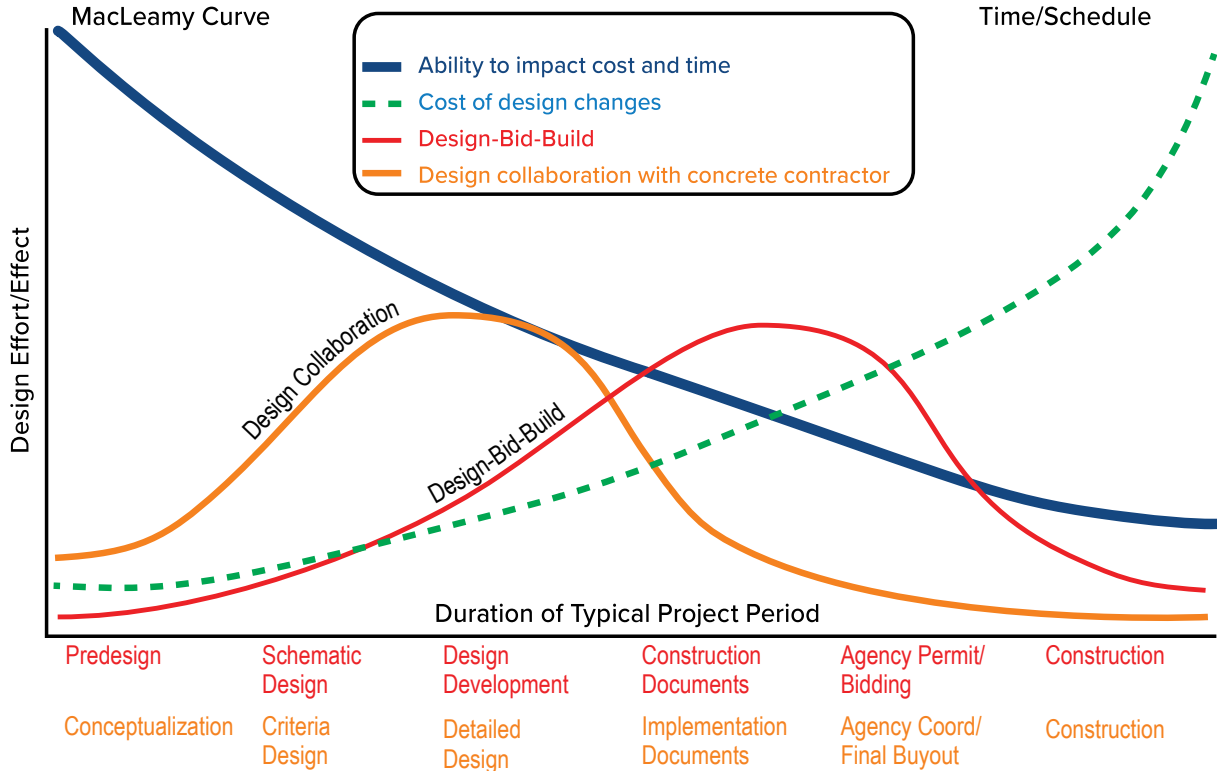


Fig. 1.7.2: The MacLeamy Curve demonstrates the benefits of early collaboration on decisions (after The Owner's Dilemma).

In the DBB approach, as illustrated in Fig. 1.7.3, the contractor is selected later in the preconstruction phase. Unfortunately, because many key design decisions has already been made, the benefits offered by the contractor’s knowledge of constructability and productivity improvements are lost.

Fig. 1.7.3: When the major trade subcontractors are hired in a traditional DBB delivery approach, significant intelligence is added to a project. Because these subcontractors are brought in well after preconstruction design and planning is nearly complete, however, major opportunities to improve constructability are lost.

To achieve collaboration, all major members of project teams should be identified and hired during the predesign phase, including the concrete subcontractor. Major subcontractors should be included in the creative sessions to leverage cost-saving strategies early in the project. The key point is to engage the constructability team in the early planning and design phases.

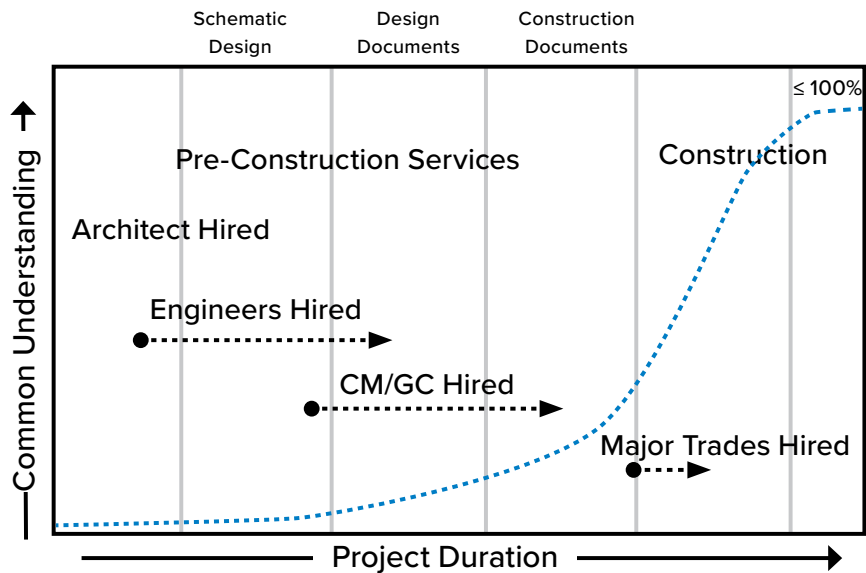


Fig. 1.7.3: Illustration of the significant intelligence that is added to a project when the major trades are hired, often after preconstruction design and planning is nearly complete. The late addition of the major trades reflects a missed opportunity to improve constructability during design.





## 1.8 OUTCOMES OF CONSTRUCTABILITY FOCUS

The positive effects of a constructability focus are realized by all stakeholders. The collaborative team of designers, general contractors, and key subcontractors will more fully develop design solutions with less coordination and risk of costly redesign, plus a reduced risk of innovation. Stakeholders can focus on work satisfaction in lieu of confrontational stress, leading to owner satisfaction with innovative structural concrete solutions.

### *PRO Recommendations:*

- *Hire trusted designers, general contractors, and key subcontractors in the early design process and pay for preconstruction services; seek construction firms that have proven design-assist skills.*
- *Assuming contractors provide value, capture the preconstruction input of the contractor and key subcontractors by proceeding to construction with them.*



*Image courtesy of Ceco Concrete Construction.*



## 1.9 CONCRETE'S DESIGN ADVANTAGES VERSUS CONSTRUCTABILITY

Concrete gives architects and engineers creative design freedom, and its locally available materials reduce supply chain challenges and enable faster construction starts. However, concrete's design flexibility can compromise constructability if designs are not carefully evaluated.

Contemporary designs, for example, can challenge designer/contractor teams with significant obstacles to maintaining efficiency. On such projects, the traditional design-bid-build process often results in an unproductive and unconstructable design, accompanied by expensive delays and change orders. Thus, the design freedom offered by concrete construction also increases the value of designer/contractor collaboration.



*Multi-story high-rise undulated slab edge completed through constructable design practice. Image courtesy of Ceko Concrete Construction.*

## 1.10 THE PATH TO CONCRETE PRODUCTIVITY—A SUMMARY

Improving concrete construction productivity requires change. PRO suggests the following as a first step for owners, designers, contractors, and other project stakeholders interested in better constructability, which will lead to improved construction productivity:

- Overcome the false sense of security obtained with the traditional design-bid-build (DBB) delivery method. The traditional method precludes early design collaboration, which is the greatest opportunity for developing significant project value and project cost savings.
- Identify and select designers, contractors, and subcontractors who have proven collaboration skills, business ethics, and industry relationships.
- Establish the designer/contractor/material supplier team at the conceptual design stage.
- Establish a contract framework to define expectations.
- Take proactive steps to maximize stakeholder communication and trust while minimizing stakeholder risk.
- Reward innovative concepts, investigations, and analysis of “game-changing” solutions.
- Pay premium design fees and contractor markups that reflect the knowledge, skills, and creativity the team contributes to project success.
- Avoid design changes late in the process, as they will have a “domino effect” that can have major impacts on productivity and disrupt an optimized construction plan.
- Finish the project as a collaborative team, in the same spirit of cooperation as at the start of the project.



## 1.11 ADDITIONAL RESOURCES FOR THOSE SEEKING TO IMPROVE CONCRETE PRODUCTIVITY

PRO: An ACI Center of Excellence for Advancing Productivity will continually update and expand the Constructability Blueprint by incorporating design and construction concepts, case studies, and much more. PRO is also developing additional resources, and other organizations offer complementary programs and documents. For more information, visit [www.concreteproductivity.org](http://www.concreteproductivity.org). Additional information is available through the following resources:

- ACI University offers many webinars, on-demand courses, and certificate programs relevant to designers and constructors, including its Constructability Certificate Program covering planning, layout, project delivery, project site drivers, structural system concept design, and more. Visit [www.concrete.org/education/aciuniversity.aspx](http://www.concrete.org/education/aciuniversity.aspx).
- The Lean Construction Institute (LCI) provides many resources on Integrated Project Delivery. Visit [www.leanconstruction.org](http://www.leanconstruction.org).
- The Design-Build Institute of America is dedicated to helping members achieve collaboration-driven success, and it helps connect owners and industry looking for qualified team members. Visit [www.dbia.org](http://www.dbia.org).
- The American Society of Concrete Contractors is committed to helping concrete contractors improve their businesses and their roles as contractors by providing the tools to grow business and provide the highest quality product. Visit [www.asconline.org](http://www.asconline.org).



## An ACI Center of Excellence for Advancing Productivity

Launched in 2023, **PRO: An ACI Center of Excellence for Advancing Productivity** will work as a catalyst for solving the barriers to constructability to advance concrete construction productivity. PRO will collaborate with designers, materials suppliers, and contractors to identify and resolve issues that negatively impact productivity in concrete construction.

38800 Country Club Drive  
Farmington Hills, MI  
48331-3439 USA

+1.248.516.1590

[www.concreteproductivity.org](http://www.concreteproductivity.org)

Phil Diekemper, Executive Director  
+1.248.479.4451

[phil.diekemper@concreteproductivity.org](mailto:phil.diekemper@concreteproductivity.org)



American Concrete Institute

Founded in 2023 by the American Concrete Institute