統合設計プロセス
――環境に配慮した持続可能なデザインへの望ましい方法

Integrative Design Process: The Desired Approach to Green and Sustainable Design

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『Construction World』誌「2011年の女性」選定。

統合設計プロセス(IDP)はサステナブル建築の実現に大きく貢献する。IDPは協働により、環境配慮型で経済的でもある、社会に受け入れられる合理的な成果を生む。IDPは設計から運用までの全段階において、協働作業でプロジェクトを改善する理念を持つ。IDPではチームは初期段階で目標性能を設定し、その実現に向けたチームメンバー間での継続的コミュニケーションを要する。目標に向かって、チームは建物に対し包括的なアプローチができる。IDPは複数の専門分野を調整しプロジェクトに貢献する。

従来の方法では建築設計確定後に設備設計がされ、しばしば過剰設計につながっていた。一方、チームによる目標設定から始まるIDPでは、温熱環境、負荷とエネルギーも目標に含まれ、快適性を効果的に達成する。IDPではチームが費用便益も含め検証し、すべての設計要素とシステムの最適化に基づく案を作成できる。IDPの早期からの協働は過剰設計を防ぎ、最適化により高性能でコスト効率の高い建物の実現に貢献する。

LEEDと統合設計:環境性能認証システムであるLEEDはIDPを促進すべく加点の条件を設けている。この加点を得るには、エネルギーと水システムの目標性能と予測を設定する。さらにIDPを促進する追加項目に建材をライフサイクル評価する項目、健康促進のための統合プロセスの項目を設けている。IDPの好例としてLEEDプラチナ認証のYKK80ビルを紹介する。

統合設計を容易にするツールと技術の活用:BIMはIDPを実現するツールで競合を解決し無駄を削減できる。しかし、IDPの本質である人の協働にBIMが代わるのではない。エネルギーや構造の解析を使用したBIMモデリングはIDPの機会を提供し、高い環境性能の設計を促進することができる。(抄訳)

"Less is more" lies at heart of green design. Green buildings are high performing buildings that use energy and water optimally, generate minimal waste, and stimulate human experience and its connection to nature. They contribute to improved air quality, they minimally impact the land, and with proper planning, they are, in every way, the economically smart way to go.

So what constitutes proper planning? Today, it has much to do with an approach known as Integrative Design Process (IDP). IDP is a concept that improves projects at every step: From building design, to project implementation, to the ongoing operations and maintenance. This document examines and explains the Integrative Design Process: What it is and how it works.

The Integrative Design Process begins at the earliest stages of project planning. It is a collaborative process that focuses on a building's design, construction, operations and occupancy over its complete life-cycle. The entire team, from client, to architect, to engineering, to landscaping, and so on - identifies goals and establishes performance objectives for the building and its systems during the earliest design stages.

IDP demands continuous, goal-oriented communications between all team members, including people from design, detailing, construction, and operations. When properly implemented, IDP compels project teams to adopt a systems-oriented approach that achieves exceptional performance goals by using comprehensive optimization techniques, appropriate technologies, and a thorough project life cycle assessment. This systems-oriented, whole-building approach to designing effective solutions orchestrates the multi-disciplinary skills of each team member for the benefit of the project.

The IDP approach stands in stark contrast to the sequential and isolated approach followed in a conventional design process. Let's take the example of an office. In a conventional design process, the architect would develop designs that address the client's functional needs and space requirements. Next, the electrical and mechanical engineers would design the lighting and HVAC systems based largely on applicable codes and standards. Finally, an interior fit out consultant would address work space requirements from within those previously established constraints. Consequently, the positioning of lights and supply diffusers for cooled air may not be synced with seating arrangements. Occupants might experience ongoing visual and thermal discomfort. Predictably, the conventional approach often leads to redundancy and overdesign, both of which run counter to the spirit of true sustainability.

By way of comparison, the Integrative Design Process begins with thorough goal-and-objective-setting sessions involving all team members. These planning sessions include thermal comfort, energy performance, and HVAC load reduction. The team, for example, discuss how HVAC load reduction can be achieved through better envelop design, adding insulation, using high performance glazing, utilizing adaptive thermal comfort criteria for space design, and achieving lower light power density with efficient lighting design and daylight integration. All of these options are discussed and evaluated, and the resultant schematic design of interiors with work place configuration can more effectively and efficiently achieve thermal and visual comfort for all occupants, while also being aligned with many other critical project objectives.

To avoid overdesign and redundancy resulting from different team members working in isolation, an IDP collaboration must be forged early.

Integrative Design Process	Conventional Design Process
・Collaborative and inclusive. ・Team decisions are based on goals, life cycle assessment, and costs. ・Results in lean and optimized design. ・Value engineering done from design through operations in a holistic manner; each team member is responsible for outcomes. ・Ongoing operations monitored through performance tracking and evaluating measured outcomes.	・Usually driven by individuals: architect or client in most cases. ・Decisions are driven by few individuals mostly based on capital expenditure. ・Increased chance of over-design and redundancy. ・Isolated scope of value engineering. Responsibility for comprehensive outcomes cannot be assigned to individuals. ・Usually ends with completion of construction. Outcomes not measured.

Figure 1: Difference between integrative design and conventional design

Everyone on the team, not just the Mechanical Electrical Plumbing (MEP) consultant, must understand that a lower window wall ratio (WWR) will reduce HVAC loads. This enables related discussions to address the impact not only on the aesthetics of the façade, but also on interior daylighting, which are both traditionally in the domain of the architect. The Integrative Design Process allows the entire team to explore the pros & cons of different scenarios, and to test them with energy modeling. Final decisions can then be developed based on an optimization of all design elements and building systems, including a cost-benefit analysis (initial costs and operational costs). Thus, IDP helps craft an optimized design that is high performance and cost effective.

LEED and integrative design

The newest iteration of LEED - LEED V4 – facilitates the Integrative Design Process with an IDP credit requirement. A project attempting to earn this credit must set goals and expectations involving the performance of energy and water systems.

Energy modeling on preliminary base design is done to evaluate advantages of site conditions, all with an eye on HVAC sizing. The impacts of building orientation, and interior and envelope design elements – such as insulation, high-performance glazing , window-to-wall ratios, shading, optimal lighting levels, indoor design temperatures – are collectively and individually assessed in the energy modeling exercise.

A similar analysis is recommended for water systems. The planned integration of plumbing fixtures, landscaping species, roofing systems, and rain water capture systems can cohesively and efficiently reduce and optimize water use.

Additionally, in the built form there is often a nexus between energy and water systems. For example, a roof garden provides a cooling effect and helps to reduce HVAC loads in hot climates. At the same time, water is required to maintain that roof garden. In the Integrative Design Process, an optimization between energy and water requirements is determined before deciding on final designs for, by way of example, either the roof-garden or the HVAC system.

Another fundamental optimization of energy and water systems involves the decision as to whether to install water-based chillers and evaporative cooling systems – or air based chillers.

Traditionally, water-based chillers have been more energy efficient. But that is no longer a given. New chiller technology often makes the comparison much more competitive – with decisions generally being made based on operating costs. With that in mind, the conventional design process applied in a water restrained geography, might simply call for the use of an air cooled chiller. In an IDP scenario, however, one could also explore factoring the impact of using water that is reclaimed from a sewage treatment plant as a measure that might yield greater efficiencies from a water-based cooling system. A detailed cost benefit analysis covering the life of the building and its systems would give the team the data they need to choose one approach over the other.

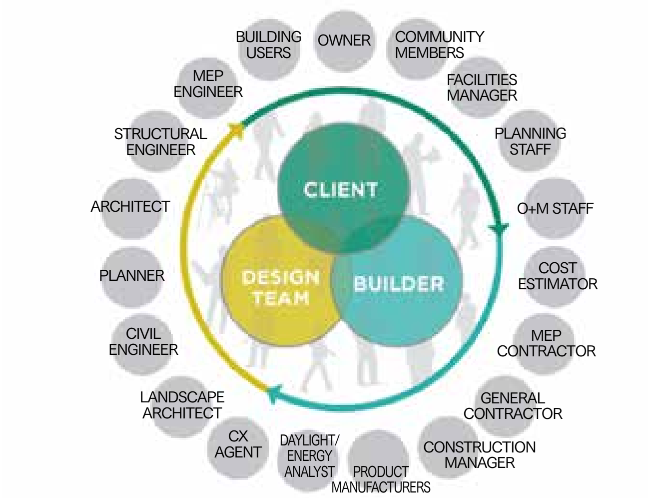

Figure 2: Team members in integrative design © 2013 U.S. Green Building Council

LEED V4 has two additional pilot credits that have been designed to promote integrative design at the sub-system or sub-component levels. One credit promotes the Integrative Analysis of Building Materials by encouraging use of products and materials for which life cycle information is available. Preference is given to those materials that have environmentally, economically, and socially preferable life-cycle impacts. The other pilot credit, Integrative Process for Health Promotion, supports high-performance, cost-effective and health-promoting project outcomes through an early analysis of the interrelationships among building systems. It also facilitates the systematic consideration of the impacts that project design and construction have on physical, mental and societal health and well-being.

An IDP case study

The YKK building, situated in the thick urban setting of Chiyoda-ku Tokyo, is a LEED Platinum Core and Shell building. The façade is very interesting and aesthetically pleasing. However a deep dive into the façade reveals a multi-dimensional design philosophy that addresses many issues.

A sun screen provides sun protection but allows daylight to penetrate through clear double glazing. Specially designed “bottom up” blinds can be pulled down in case of glare, while also allowing daylighting to filter. Located in a dense urban setting, the double façade filters exterior noise. The gap between the double façade houses pipes and ductwork for easy maintenance. This design exemplifies the seamless coordination between façade consultant, energy consultant, architect, and services consultant.

Additionally, the façade also features an outdoor, ground-level misting system that mitigates heat island effect. The transparent façade design provided scope for HVAC optimization. Further HVAC load reduction was realized through radiant cooling, treated outdoor air, and a higher set point for indoor temperature (26-28℃). These measures, combined with an efficient lighting system, resulted in a 36% energy-cost reduction over the ASHRAE baseline.

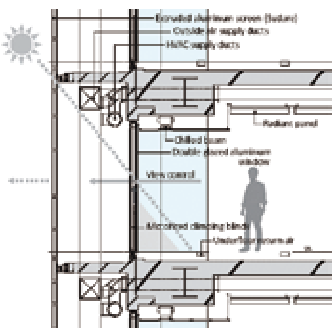

Figure 3: Integrative design in YKK80 building Tokyo
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Use of tools & techniques to facilitate integrative design

While team collaboration and system-oriented life cycle analysis form the foundation of IDP, there are technological tools available to facilitate the process and add qualitative and quantitative value. Building Information Modeling (BIM) is perceived to be technological tool to achieve integrative design. However, BIM should not be taken as a tool that can replace human collaboration, which is the essence of IDP.

BIM is a virtual approach to representing a building. While CAD requires one to put spatial information in a two dimensional format, BIM enables the development of a three-dimensional virtual building construct in which information related to each component is embedded. It is a powerful tool for solving service and design conflicts, thereby contributing to minimizing wastage and streamlining time of execution. A BIM model can determine if the structure, duct work, piping, and so on conflict with one other, which saves considerable time and money.

Many BIM models are available with LEED outputs. BIM modeling protocols with embedded tools for energy analysis and structural analysis offer opportunities for IDP, and if used by designers can greatly facilitate green designs.

Conclusion

The Integrative Design Process offers endless options for achieving green and sustainable designs. It fosters partnerships and yields results that are environmentally benign, economically viable and socially acceptable.