

**DOUGLAS WOOD
& ASSOCIATES, INC.**



STRUCTURAL ENGINEERS

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THE STRUCTURAL ENGINEER AND SUSTAINABLE DESIGN

INTRODUCTION

Recent developments indicate that there is virtually unanimous agreement in the scientific community that global warming is occurring and that human activity (particularly that which contributes to increasing levels of CO₂ and other green house gases in the atmosphere) is a significant contributing factor. Recent scientific studies also indicate that significant climatic effects may occur in some areas in as little as thirty years. At the same time, energy costs are escalating, and there is increasing volatility in the production, transportation and refining of petroleum. For many building owners, developers, regulators, contractors and design professionals, these developments have resulted in a greater interest, even a sense of urgency, in accomplishing the goals of sustainable design.

While there is some variation in the statistics, there appears to be general agreement that the construction, operation and disposal of buildings accounts for approximately 40 to 43% of the world's energy consumption. This compares to 30 to 35% for transportation. Undoubtedly, the effects of building design and construction on the local and global environment can not be ignored.

Changes in the way we design and construct buildings appear to be inevitable, and in fact, are already required in some cases. The federal government's GSA now requires sustainable design. Many other building owners, particularly those who will own and operate them for some time (such as governments, institutions, corporations and homeowners) are studying sustainable design or are already requiring its use. Even developers who are looking to rapidly turn building ownership and operation over to others are realizing that buildings with verifiable sustainable design achievements are far more valuable to prospective buyers than standard buildings. Thorough execution of sustainable design often results in a 35% or greater reduction in energy consumption. This, coupled with lower maintenance costs, lower water usage and increased worker productivity, will prove to be a very

substantial financial impact over the life of the building or over the period of a long term lease.

While one could discuss at considerable length the general and specific issues, goals and implementations of sustainable design, this bulletin focuses on the role of your structural engineer in the process and on the contributions that he/she can make towards the accomplishment of sustainable goals.

ESSENTIAL QUALITIES OF STRUCTURAL ENGINEERS IN SUSTAINABLE DESIGN

Commitment

In order to be most effective, your structural engineer must be as committed as you are to the achievement of the sustainability goals for the project.

Team Player

The sustainable design process is intensely collaborative. Your structural engineer needs to be an integral part of the core design team. He/she must be willing to be an active participant in the decision making process. Particularly, this means sharing ideas in brainstorming sessions and evaluating the structural implications of architectural and mechanical design alternatives.

Creativity

Sustainable buildings sometimes have unusual features, materials and combinations of materials. Commonly, these include skylights, clerestories, overhangs, sunscreens, atria, arrays of solar panels or photovoltaic cells, cisterns and roof gardens. Your structural engineer must be able to support sustainable design decisions with creative structural solutions.

General Knowledge of Sustainable Design

At the beginning of the design process, your structural engineer should at least have a general knowledge of and appreciation for the principles, goals, processes and strategies of sustainable design. He/she should also at least be familiar with the LEED (Leadership in Energy and Environmental Design) Green Building Rating System and its project checklists, by the U.S. Green Building Council. As a project design progresses, your structural engineer should also be willing to expand his/her knowledge, particularly through research into structural materials specifically appropriate to the project.

SUSTAINABLE DESIGN

AT

DOUGLAS WOOD & ASSOCIATES, INC.

The engineers of **Douglas Wood & Associates, Inc.** understand and appreciate the goals of sustainable design and stand ready to assist our clients in achieving those goals.

At the present time, **Douglas Wood & Associates, Inc.** is proud to be participating in the design and construction of three projects which are planned for LEED certifications. The first is the fourteen-story **2020 Ponce** office building now under construction in Coral Gables (Architect: Roux Architects). The second is **Villa Matti**, a six-story, low-cost residential project by the Miami Beach Community Development Corporation (Architect: Arthur Marcus). The third project is the **Bellevue Biltmore Resort** in Bellair (near Clearwater) (Architect: R.J. Heisenbottle Architects, P.A.). This large project includes the restoration of the five-story, multi-winged, 380,000 square foot historic wood-framed hotel (on the National Trust for Historic Preservation's top priority list). The project also includes the construction of significant new meeting facilities, spa, golf club, hotel rooms and parking, for a total floor area of nearly 900,000 square feet.

Please contact us to discuss your next sustainable design project.

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EXAMPLES OF SPECIFIC STRUCTURAL ENGINEERING STRATEGIES IN SUSTAINABLE DESIGN

There are numerous strategies specifically related to structural engineering and structural materials which have proven to be effective in assisting the achievement of sustainability goals. The following are brief discussions of several of these strategies.

Inherent Structural Properties of Materials

The structural engineer is the team member with the most knowledge of the structural properties inherent in building materials. These properties include capacities for compression, tension, shear and flexure. These properties also include elasticity, durability, response to humidity and moisture and thermal expansion and contraction.

In the early stages of design, the structural engineer's knowledge of these properties should be utilized to help determine the structural materials and systems that will assist in achieving the sustainable goals, not the least of which is the determination of which structural materials and systems will achieve the requirements most efficiently. The appropriate use of a material's inherent properties also, no doubt, enhances the building's aesthetics.

Efficiency of Structural Design

Of course, the structural engineer must design within the requirements of the Building Code and its adopted standards and within the parameters of good engineering practice and judgment. In sustainable design, however, the structural engineer should also give extra effort to achieving the most efficient structural design possible. The structure should use no more material than is required.

To accomplish this goal, the engineer should strive to waste no material. He/she must recognize that there is no need to use a #5 bar when a #4 bar is adequate. Going beyond this simple and obvious approach, for all but the simplest of buildings, the structural engineer must use advanced structural analysis and design software, and he/she must use it to its fullest extent. There are many advanced structural analysis software applications available, and they

are frequently being further advanced by their providers. These advances result in more accurate structural modeling, analysis and design. Therefore, the structural engineer should have licenses for the latest versions of the most appropriate software for the proposed structure. We have seen recently where some structural engineers are using advanced structural modeling and analysis software but restricting its use to design only some of the structural systems. While this approach is reasonably valid for determining design stresses for structural members, it ignores the interaction between all of the building's structural systems and components. This approach can result in overly conservative designs.

“The structure should use no more material than is required”

Besides using structural efficiency to reduce the consumption of building materials, efficiency and purposeful reduction in foundation sizes will minimize excavation, thereby minimizing damage to the site and reducing the energy required for excavating and disposing of earth.

Reuse of Existing Building Structures

Reuse of existing building structures can be a very successful strategy in sustainable design. Building reuse can result in a significant savings in material resources and reduction of waste. To reuse existing buildings successfully and most efficiently, your structural engineer should be familiar with older structural materials, systems and construction techniques. Your structural engineer should also be familiar with the types and rates of deterioration of structural materials and the tools and techniques available to investigate and evaluate existing structures. Besides visual observation and review of drawings and other available documentation, these can include “sounding,” concrete compression testing (in the field and/or in the laboratory), chemical analysis, petrographic analysis, x-rays, metal detection, ground-penetrating radar, exposure of reinforcement, visual grading of lumber, laboratory testing of lumber, soils exploration and laboratory testing, moisture testing and load testing.

Reuse of Existing Structural Materials

In some cases, it may not be possible to reuse a building structure, but it may be possible to incorporate previously used building materials into the new

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structure. Such materials may include brick, stone, steel, aluminum and lumber. It is important, however, to verify the properties of these materials using the techniques described above. Careful design of the details of the incorporation of the specific materials and members into the new structure is essential.

Use of Recycled Materials

In addition to the direct reuse of existing building materials, significant amounts of recycled material can be incorporated into the structural systems. The principal of these are:

- Blast furnace slag is a waste product from the smelting of steel, and fly ash is a waste product from coal burning. Both slag and fly ash can be used to replace cement, and the proper use of either in a concrete mix actually improves the concrete quality. Since both of these substances are otherwise waste products and since the production of cement requires a large amount of energy, the use of fly ash or slag to replace cement is an obvious and effective sustainable design approach. These days, concrete mixes routinely include fly ash or slag, generally up to 25% of the total cementitious material (cement and fly ash or slag). In most cases, however, fly ash or slag can be increased to 50% of the cementitious materials, and in some cases, levels as high as 70% can be used.

Since cement is normally 10% to 15% of the total final concrete weight, recycled content in the range of 5% to 10% can be achieved with the use of fly ash or slag.

- For low strength concretes, it may be possible to recycle previously used materials for concrete aggregates. Such materials may include stone, brick and waste concrete. The inclusion of these materials can greatly increase the recycled content of concrete. Their use, however, is most appropriate for non-structural concretes, such as for pavements and other slabs-on-ground. The use of recycled aggregates for structural concrete is generally limited to low strength concretes and requires prior testing.
- Steels used in construction (including structural steels and steel reinforcing bars for concrete) commonly contain high percentages

of recycled content, and this information is generally available from the producing mill. It is quite common for structural steels to contain up to 90% recycled steel. If desired, steels with virtually 100% recycled content can be obtained.

- As with steel, it is common for most aluminum alloys in construction to contain high levels of recycled content.
- While considering recycled materials, the design team may also consider the potential for recycling of the new building's material when the building's useful life is done. Of the typical structural materials, steel is generally the most readily recycled.

“If desired, steels with virtually 100% recycled content can be obtained.”

Use Local Materials

The use of building materials from local origins reduces the structure's embodied energy by reducing the energy used in transporting heavy, bulky material. “Local” is usually considered to mean within 500 miles.

For South Florida, most of a concrete's material (large aggregate, sand and water) are available here in South Florida. Cements (and slag and fly ash) are, however, generally imported. Concrete masonry is similar to concrete. Other usual structural materials, such as steel and timber generally come from greater distances.

Use Renewable Resources

In the case of building structures, this means wood, specifically wood from renewable forests. Such forests can be certified by an FSC-accredited body to be in compliance with FSC 1.2, “Principles and Criteria for Forest Stewardship.” A building project's specifications can require certification that the lumber has been obtained from such a forest.

Lower VOC's

Yes, even some structural systems can contribute to poor indoor air quality. Primarily, these contributors are wood preservatives, wood glues (plywood and glulams), concrete sealers and other field-applied finishes (such as paints). It is important for the engineer to know and to limit VOC levels in these products.

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Longevity of Building

The last, but not least, of our strategies to be discussed is building longevity. Obviously, the longer a building can be used, the lower its environmental impact. For the structural engineer, the two most important qualities are durability and adaptability. Planning for the adaptation of a building to future uses is mostly within the architect's realm. The structural engineer can assist, however, by accommodating the architect's designs for longer spans, shallower members and simpler structural solutions.

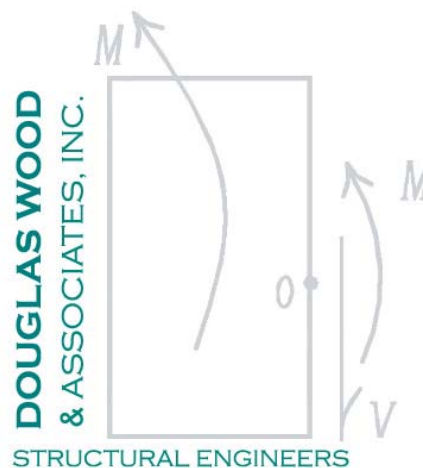
After good building design (by the architect), good construction (by the contractor) and good maintenance particularly of the weatherproofing systems (by the owner), the durability of the structural systems can be significantly improved by the structural engineer's effort. Primarily, the engineer must provide well detailed construction documents and thorough construction inspection. Good design includes thorough mathematical modeling and analysis, and must include not only the primary gravity, wind and seismic loads, but also the secondary effects such as shrinkage of cementitious materials, concrete creep, moisture

response, thermal expansion and contraction and differential settlements. With the powerful computer programs available today, these often significant secondary effects can actually be included in many mathematical models.

Good design also, of course, includes the careful selection and specification of appropriate materials, appropriate concrete coverages for reinforcement and appropriate coatings. Also, it should be noted that since sustainable buildings are more likely to leave structural members exposed to view, the structural engineer must understand and execute the aesthetic considerations required by the architect. For steel construction, the engineer must work closely with the architect relative to layout, sizes, structural steel shapes, connection design and fireproofing. For concrete design, there are the added considerations of formwork (materials, form inserts, form ties), concrete materials, admixtures, concrete finishing and coatings.

CONCLUSION

With the right knowledge and skill, along with the appropriate commitment, the structural engineer can and should be a key member of the core team in sustainable design.



FEEDBACK

We welcome your comments, questions and suggestions relative to this bulletin and relative to our office Environmental Plan. Please e-mail us at greenstructures@douglaswood.biz

Suggestions of a topic for a future technical bulletin can be e-mailed to us at techbulletins@douglaswood.biz

October, 2007

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