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RESEARCH ARTICLE

INFLUENCE OF SUSTAINABLE MATERIAL IN CONCRETE STRUCTURE

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A R T I C L E I N F O

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A B S T R A C T

On a planet with finite natural resources and an ever-growing built environment, engineers of the future must consider the environmental, economic, and social sustainability of structural design. To achieve a more sustainable built environment, engineers must be involved at every stage of the process. So in this paper we are discussing the solution for today and challenges for future. Solutions for today: There are many steps that each structural engineer can take to mitigate the environmental impact of structural design. Furthermore, there is growing demand for engineers who are knowledgeable of environmental issues in construction. This section presents several options that are available today for engineers interested in reducing environmental impacts. Case studies will illustrate examples of more sustainable structural design. Challenges for the future: Although short-term solutions exist to reduce the environmental impact of construction, there are significant long-term challenges that we must address as a profession. By facing these challenges, we can take a leadership role in matters of vital global importance.

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INTRODUCTION

This Modern society is demanding that the use of energy associated with construction and operation of structures be investigated during the planning and design phases. The engineering community has been striving to design more sustainable buildings in an attempt to reduce both raw material requirements and energy use during all phases of design. Structural engineers currently have very limited guidance on how to incorporate sustainability concepts in their designs. Innovative methods are needed to address the environmental impact, energy use, and other sustainability issues faced during planning and design of buildings.[1] The goal of this paper is to describe and address issues associated with the proposed design methodologies to determine which, if any, can produce the most sustainable structural designs. It was determined that no single methodology can address all the issues surrounding sustainable structural design. Also, it was determined that combinations of two or more methodologies may increase the ability of design professionals to produce more sustainable designs.

Solutions for Today

There are many steps that each structural engineer can take to mitigate the environmental impact of structural design. Furthermore, there is a growing demand for engineers who are knowledgeable of environmental issues in construction. In the last ten years, the tremendous growth of the LEED rating system developed by the U.S. Green Building Council has illustrated the growing demand from clients and the general public (USGBC 2004). This section presents several options that are available today for engineers interested in reducing environmental impacts. Improve life cycle performance: Currently most structures are designed to minimize the initial cost, rather than the whole life costs. For example, in the case of bridges, the maintenance and demolition costs often exceed the initial cost of construction, yet engineers rarely consider the whole life design costs.[2] By reducing life cycle costs, engineered structures can become much more sustainable than current practice. This is an obvious goal for engineering design, which can provide measurable improvements in the economic and environmental performance of construction. As an example of a more sustainable structure designed for improved life cycle performance, Joerg Conzett’s Traversina Bridge in Switzerland was designed to be built using small sections of locally available timber (see Figure 1). A key design constraint was the need to replace any single piece of the structure without a need for auxiliary support. In this way, the structure could be maintained indefinitely using locally grown timber.[1] This explicit design goal helped to achieve an elegant structure with low life cycle costs and improved environmental performance.

Fig.1 Traversina Bridge, Switzerland (1997)

Specify salvaged or recycled materials: The traditional approach to construction is to mine natural resources and convert them into useful products.[3] As natural resources are depleted, engineers must begin to look for alternative sources of materials. In particular, we should mine the existing built environment for materials. This is occurring out of necessity for some materials already. For example, it has been estimated that more copper exists currently in the built environment than in the natural environment. Clearly, future generations will salvage and recycle the materials that we are extracting from the earth at present. Growing landfill costs and waste disposal problems will provide new economic incentives for recycling and salvaging.[4] Concrete in the future will be made largely from salvaged materials and waste products. Indeed, this is already occurring today, with recycled aggregates, fly ash, and other waste products replacing natural aggregates and Portland cement. The resulting products can have better environmental performance as well as reduced costs and improved engineering performance (Meyer 2004). In addition, designers should seek to maximize the flexibility of any structural design, to allow for future changes in the use of the building. The long spans provided by the steel modules allow for great interior flexibility and also allow the building to expand and contract as needed in the future.[1] As building use changes over time, the ideal structure would allow the change to occur. Otherwise, an obsolete structure will be dismantled and greater material consumption will be required for additional new construction. Finally, in the event that the Stansted terminal is no longer required, the modules could be disassembled and reused on another building site.[1] Salvaging existing steelwork is far preferable to recycling due to the high energy requirements for recycling steel. Structural engineers should seek opportunities to salvage and reuse existing structures wherever possible.[4]

Use alternative materials: Structural engineering in the United States depends on two primary materials: steel and concrete. Unfortunately, both of these materials require tremendous amounts of energy to produce and are responsible for very high carbon emissions. These materials will continue to be dominant structural materials, for all of their inherent advantages. However, engineers can and should explore alternative materials. In particular, materials with lower environmental impact should be investigated. Particularly for buildings with a short life span, engineers should explore alternative materials which achieve the engineering objectives of efficiency and economics, while reducing the environmental impact of construction.[1]

Challenges for the Future although many solutions exist today to reduce the environmental impact of construction, there are significant long-term challenges that we must address as a profession. By facing these challenges, we can take a leadership role in matters of vital global importance. In order to do so, the profession of structural engineering must consider the challenges in three key areas: practice, research and education. Practice: The practice of structural engineering faces significant challenges in the effort to improve the sustainability of construction.[5] The primary challenges are economic, and new policies will be required to help promote the economic incentives for sustainability. Firstly, the construction industry currently rewards engineers on the basis of initial cost, rather than life cycle costs.[1] This leads to buildings and bridges with higher life cycle costs and higher environmental impact.[4] For example, government spending on bridges as well as private sector spending on buildings could be drastically reduced through consideration of life cycle costs in construction. To allow for efficient whole life design in structural engineering, there is a need for policies which encourage accounting for the maintenance and disposal costs, as well as the initial costs, in structural design. Furthermore, there is a need to develop incentives to reduce material consumption in construction. In many sectors of the construction industry, payment is often proportional to the amount of material used, which encourages greater material consumption. Above all, the economics of construction should reflect the true costs, including the environmental impact of non-renewable resource depletion and the contribution of the construction industry to global environmental concerns. Though significant challenges exist in the sector of sustainable design, practitioners who can innovate in sustainable design will be poised to lead in the next century. Research: Structural engineering is a mature field in comparison to nanotechnology and other emerging areas of research. As a result, research in structural engineering is increasingly focused on the assessment and maintenance of existing structures, as evidenced by the rise of non-destructive testing (NDT) methods and other new research areas in recent decades. A large portion of structural engineering work in the United States is focused on existing structures, rather than new construction, as owners try to keep up with maintenance requirements. The structural engineering community is already improving the sustainability of the built environment by increasing the life of existing structures rather than constructing new structures. However, in order to drastically improve the sustainability of the built environment, research in structural engineering must produce new options for practice. Above all, there is a need for new materials which can utilize waste products to build new structures with lower environmental and economic costs. Ideally, the built environment would help to absorb CO_2 and would utilize waste products from other sectors of society.[2] In addition, the goal of a more sustainable built environment will require new cooperation between government, practice, and universities, as well as a broader outlook. Structural engineering research must engage with policy, design, economics, and social impacts, in addition to conventional research in mechanics and engineering science. Education: To produce the future leaders of structural engineering, educators must be visionary. As with other academic fields, engineering education should promote critical thinking, where assumptions are questioned and students must solve open-ended problems with many possible solutions. We must go well beyond conventional structural analysis and we must teach design, as well as the broader thinking required to address the challenges of sustainable design, including the social and environmental impacts of structural design. Professional engineering associations are now requiring sustainable development principles in education.[1] In the United Kingdom, the Royal Academy of Engineering has appointed visiting professors of sustainable development at 21 engineering departments in the last decade. The needs of sustainable development should become embedded in the thought processes and methodologies of all practicing engineers and engineering designers. [1] Engineering education can improve the perception of engineering while creating leaders in the realization of a more sustainable built environment in the next century.[1]

CONCLUSIONS

As engineers, we have a responsibility to society to offer the best possible solutions. It is becoming increasingly apparent that existing engineering design does not minimize life cycle costs in terms of economics and environmental impact. To improve this situation, future engineers must develop a more holistic view of engineering design, which is commonly referred to as sustainable design.

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