EMERGING TECHNOLOGY

BETEC
FALL SYMPOSIUM

DOE CONFERENCE ON
NEW AND IMPROVED MATERIALS FOR
ENVIRONMENTAL AND AFFORDABLE BUILDING SHELLS

NEW MATERIALS, NEW SPECIFICATION SOFTWARE, AND NEW BUILDING SYSTEMS

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INTRODUCTION

The Center for Maximum Potential Building Systems has been researching and applying three related approaches to the life cycle assessment of products and materials as they relate to both the natural and built environments:

1) A specification data base that emphasizes products and materials with the following characteristics:
   - a) high recycled content.
   - b) supplied from regional sources.
   - c) low or negligible environmental impact.
   - d) net carbon sequestering.

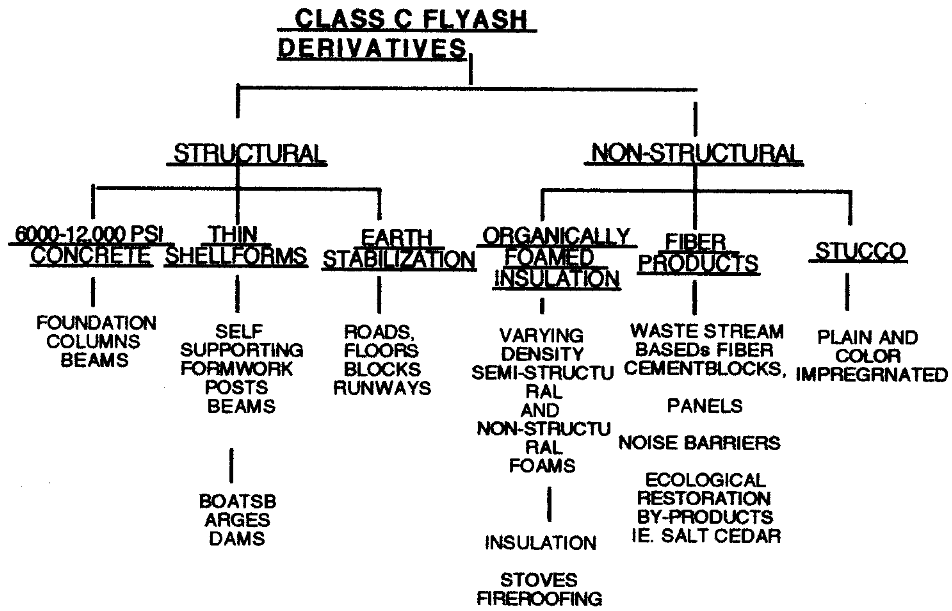
2) A material flow and life cycle analysis procedure encompassing the continental U.S. enabling product and material specifications to respond to a spectrum of significant environmental and employment impacts.

3) The development of open building systems that respond to changing social and environmental needs.[1]

Each of these three approaches is discussed in more detail below.

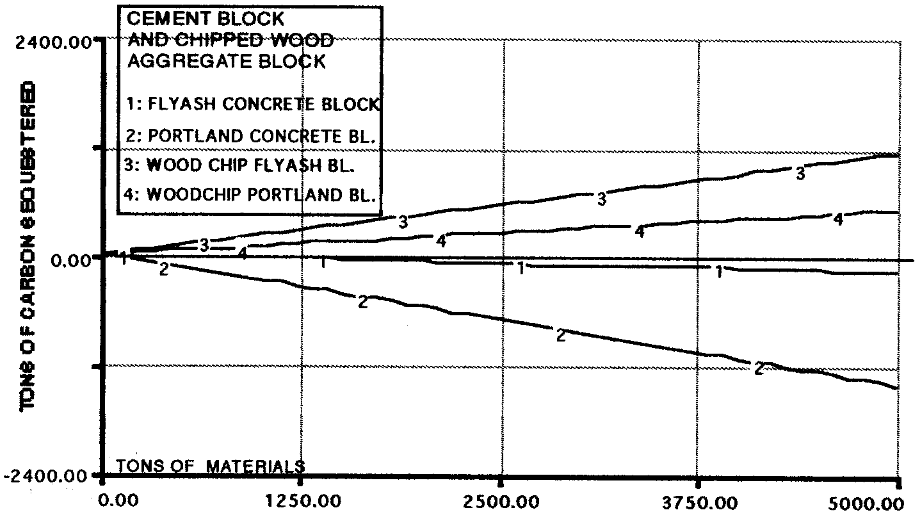
SPECIFYING HIGH RECYCLED CONTENT, REGIONAL, LOW IMPACT, AND NET CARBON SEQUESTERING MATERIAL SYSTEMS

Although CMPBS has incorporated into research projects and demonstration buildings many regional and recycled content materials, this paper concentrates on a family of materials that fit both structural and non-structural applications. These material systems are produced from cements and wood fiber aggregates having a 97% recycled content cement and using <u>no</u> portland cement within the mix. The excellent performance of this family of materials has enabled us to develop mix specifications for large building types that are net carbon sequestering after accounting for carbon impact on the environment from upstream mining, manufacturing and transportation sources compared to the carbon sequestering capacity of materials within the building itself. The cementatious base is derived from coal fired power plants using a class C Flyash and 3% chemical additives to enable more predictability in use. To this is added one or more of a series of aggregates usually of 100% recycled content origin appropriate for both structural and non-structural applications. The taxonomy of the use of 100% flyash concrete appears below (Figure 1) along with the appropriate material outputs.

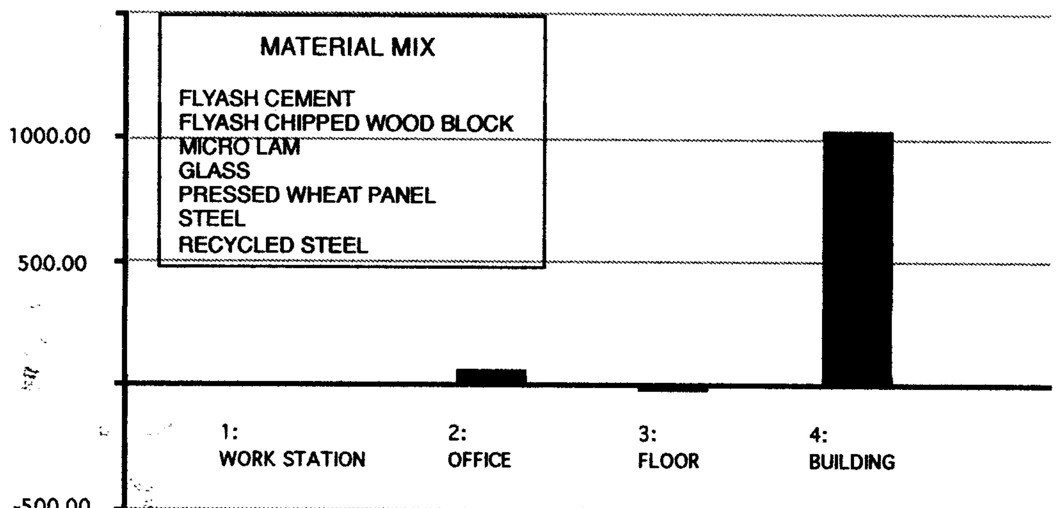


Included in this taxonomy is an important new hybrid material responding to the environmental need to balance C02 in the built environment life cycle process. As mentioned above, these are the wood-cement combinations. The line graph below (Figure 2) illustrates the necessity of mixing flyash cement with wood aggregates vs. using portland cement. The latter does not provide a net sequester of C02 according to this preliminary study. The comparison was made taking into account all life cycle upstream C02 impacts (cement sourcing and manufacturing and wood chip sourcing and manufacturing) compared to the ability of wood to trap the carbon bound within the chips- and within the cement.

A sampling of a variety of materials within a building specified for permanent C02 balancing appears in the bar chart below (Figure 3). It is organized in a hierarchical fashion, starting with the smallest scale, the workstation, and progressing to larger scales - office, building floor, and the entire building. This procedure is followed so that one can track the scale at which the problem of C02 imbalance (or any other environmental impact) might exist so that corrective measures can be more easily identified and undertaken.



COMPARISON IN CARBON BALANCE BETWEEN FLYASH CHIPPED WOOD BLOCK AND PORTLAND CMENT CHIPPED WOOD BLOCK



SCALED SPACE CARBON SEQUESTERING IN TONS

SPECIFICATION SOFTWARE INCORPORATING A LIFE CYCLE ASSESSMENT OF REGIONAL ENVIRONMENTAL AND ECONOMIC IMPACTS

CMPBS developed a procedure for assessing building materials that account for the entire life cycle chain of contributors through the use of a national input/output analysis of the economy.[2] By attaching a series of environmental impacts into 500 major industrial sectors representing 12-14 million businesses and then breaking these 500 into a progressive clustered hierarchy of 1000 industries representing 7000 typical products, a Life Cycle Impact Base lining procedure was developed. The result is a multi-step process that can baseline different building subsystems and their materials so that specification procedures compatible with Masterformat and Uniformat incorporate environmental impacts relative to air quality, water quality, energy use, and land use.

This life cycle impact baseline is presently being coupled with a another procedure referred to as Life Cycle Balancing (using findings from #1 above) so that major baseline impacts found can be counteracted through the development of sub-system alternatives that can potentially create a net balance across the entire life cycle of the facility. Three projects are presently being assessed through these procedures: 1) the EpiCenter at Montana State University, 2) the Nursing and Biomedical Sciences Building at the U.T. Health Sciences Center in Houston and 3) the assessment of two building systems for the Department of Energy's Build America program. Particular attributes of the procedure are outlined below.

> 1) The procedure takes the full life cycle of materials into account due to the nature of how the model is constructed. This due to the fact that the input/output engine behind the model cross relates all business sectors within the commodity flow index to every other business. These revenues must exceed 1 million dollars annually and they are the only businesses reported to the SIC/BEA. This means all materials placed into services, energy systems, as well as manufacturing machinery and roads for transport.
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> 2) Relative to the construction industry the procedure can query 39 major building type sectors such as single family residential, academic buildings and can report also on 14 categories of building related maintenance and repair. These sectors can then be broken down further into a more refined set of industries at the 100 level category and then into products at the 7000 level.
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> 3) The life cycle impact sectors of the economy relative to building can be matched, particularly at the 1000 industry level and the 7000 product level with the subsystems and product categorization procedures within Masterformat and Uniformat specification procedures. This enables the specifier to earmark major environmental impact areas and to seek out alternatives that can be life cycle tested themselves so that direct one to one caparisons can be made.
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> 4) The procedure can place into an environmental impact hierarchy all the major building subsystems such as shell, structure, HVAC, communications, energy system water and wastewater, relative to one another according to their environmental impact. It is important to note that in certain areas of impact such as TRI (toxic release inventory) that upstream impacts (source to use life cycle phases) can be substantially greater than operational costs.
>
> 5) Economic impact can be linked to environmental impact since the model inherently possesses an economic basis of linkage between all businesses and all life cycle phases. Once one separates all economic activities into the six generic life cycle phases used by this software, economic impact according to life cycle phase (e.g. mining phase of steel production) can be determined when all steps are divided by activity type into corresponding life cycle flow phases. For example, mining of steel is the source phase, prodution of steel the manufacturing phase, etc. This helps to solve environmental impact problems by narrowing the problem down to the phase in which the impact originated.
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> 6) Results for air land and water impacts given an industrial sector or the products that that sector produces can also be displayed spatially within a GIS (geographic information system) format. This has important advantages because the coincidence of other environmental issues can also be displayed and conditions shown (for example specification of certain materials could be adding to non-attainment).

There are numerous issues that still have to be resolved in order of this environmental cost accounting procedure to be complete, some of these are the following:

1) It could be argued that the proportion of the economy is not represented below $1 million is substantial activity especially in the building industry which makes up many small trades. Until there is more detailed business data available this issue will remain unresolved except where it can be afforded to do a more detailed regional levels.

2) There are only 600 out of 60,000 chemicals reported by industry relative to toxic release. This leaves a substantial proportion of the chemical problems still out there unaccounted for. This is true but for the moment at least the 600 are getting into a useful modeling procedure that could force more detailed reporting in the future if the tool becomes a real guide to specification writing and that the architecture and engineering professions become more rigorous in this area.

GREENFORMS™ OPEN BUILDING SYSTEM

The implication of flexible open building systems for large buildings has been indispensable in building todays urban infra and supra structure. Now that we are coming to grips with the its vast potential, housing can equally benefit from using open systems from aspects of disassembly for reuse, reduction of waste generated in the 123 billion remodeling industry, adaptation to the change that our structures go through. Open building has the following distinct advantages and each of these has significant implications for how we think about materials.

1) The financial community should be interested in the safer financing approaches so that home building serve more space use changes over time (e.g. second buyers are able to adapt structures to there future needs) and to the fact that a family need not obtain large loans but be able to pay as you go with small loan increments that are paid off in a grow home type approach to building.

2) By specifying the structure and the shell as separate systems, numerous regional methods of infill are possible that can support local industry, crafts, and suppliers.

3) Due to the vast amount of waste emanating from the building industry, the potential for disassembly or reuse is an obvious advantage verses the demolish and disposal type of housing currently being built. Examples from other manufacturing industries in this category abound from the auto to the computer industry.

4) Utility systems of all kinds are becoming "plug and play" approach to highly flexible connections. This is true not of only in communications but in areas such as drainage systems, quick disconnect gas fittings, hot and cold water etc.

5) A wide range of infill systems particulary panels both structural for flooring and non-structural for walls are becoming more available on the market. Some of these panels are using very high recycled content materials including waste wheat straw, waste paper, 90% recycled EPS and others.

6) The miniaturization of heat pumps and fuel cells is enabling efficiency to come to a room by room or floor by floor approach to modular heating and cooling.

7) There is an increased interest in total building system base component strategy where a building system is applicable to many different community functions as well as to on site adaptability. GreenForms™ for example is purposely engineered so that a truss can be a on site ladder, the post and beam structure can become scaffolding, sheds for building materials, shade structures, to name a few, so that the quick connect multi-use aspect of a building system reaches another level of integration previously not thought of in what a building system might contain.

NOTES

1. Funding for this project was provided by U.S. DOE Build America Program, numerous local and state government agencies, and 29 state and national business/industry partners.
2. Funding provided by U.S. EPA.
3. Funding provided by U.S. DOE Build America Program.