GREENFORMS™

A BUILDING SYSTEM FOR SUSTAINABLE DEVELOPMENT
CENTER FOR MAXIMUM POTENTIAL BUILDING SYSTEMS, AUSTIN, TEXAS

SUMMARY

GreenForms™ is a building system particularly suited for tying into regional conditions of labor, materials, environment, and user preference. The building system is an adaptable framework that can be applied to a variety of building techniques and styles. Underscoring its function is the ability of GreenForms™ to simplify the building process. At one level, the system is comprised of what could be considered substitutes for wood building members that are used as posts and beams. But these same components are the basis for an elegantly simple foundation system which attaches to the column and beam system, the basis for scaffolding, for stairs, spatial furniture and for other uses that go beyond what is normally thought of as the "boundary" of what a home building system might be.

There are many reasons for this approach. One: to increase market appeal; two: to bridge the barriers as to where "building a home" starts and stops so that more people can be included at all scales of the building process; and third: to fit into how an urban dweller with little money can literally start saving, in parts terms, evolving from spatial furniture into a country cottage, for example. (Country cottages have been constructed as sophisticated tents using frameworks shaped like houses with well designed canvas covers, windows, and all as very low cost vacation homes). Many other examples of how this system matches the real issues of the evolving family or user are prevalent throughout the GreenForms™ approach.

The GreenForms™ system responds to specific trends in the home building industry. The fact that the home office, the edu-tainment center, the kid's room, and storage systems are fast becoming mini-building systems in themselves is a relevant trend to which GreenForms™ responds. Change within a building's layout as to added space needs and change in interior partitions is often as costly as the original building, yet to our knowledge is not adequately accommodated by any building system on the market. This represents another area of concern and points to a potentially strong market niche. Similarly, the fact that different regions have different material availability is seemingly unaddressed by existing building systems, since they are, for the most part, optimized for factory production and assume only certain material options instead of adapting to a variety of regional manufacturers, thus significantly reducing transportation costs. This material inflexibility is underscored by the fact that many of the most prevalent materials used by the building industry are suspect from a range of environmental criteria. The reality of developing regionalized building systems using a flexible manufacturing paradigm, and tapping into the spectrum of existing manufacturers within a region, who often are accustomed to using regional resources, and coordinating these manufacturers to become players in a regional manufacturing system, becomes the basis for the production of a true building system. The ultimate objective of GreenForms™ is to adopt the approach of flexible manufacturing to the building industry, now used in a number of other industries, while adhering to regionally-appropriate environmental parameters.

This building system is conceived and organized to be part of an integrated management system for sustainable building from the sourcing of materials, to the design and engineering phase, to the final life and death of the building. Each component or set of components is viewed as an object or objects in computer object oriented programming terms, in which each contains performance parameters that function in a specific structure and language relative to other objects that in themselves are performance entities. This means that the whole system can be accountable to the environment in which it exists by matching its metabolic needs part by part (or hierarchical stage by hierarchical stage) with the environment's metabolic capacity. We refer to this procedure as Total Quality Building™ which incorporates an array of life cycle design principles.

GREENFORMS™ BUILDING SYSTEM AS AN ORGANIZATIONAL SYSTEM

GreenForms™ is conceived as a hierarchy of parts within parts from the basic building materials and their constituents through to entire building types and neighborhood clusters. This hierarchy consists of the following and is purposely organized in order to establish operational objectives at each stage: 1) **Materials** (cement, clay, wood type, metal, etc.) 2) **Elements** (manufactured parts such as a wall panel, a CMU, a brick, a shade made of fabric, pipe, a photovoltaic panel, a light shelf) 3) **Components** (a standing closet, piece of furniture, spatial furniture, a commode, photovoltaic panels and stand ready for use, a kitchen appliance, a light shelf combined with fenestration) 4) an **Assembly** a number of components brought together as a functional unit that becomes part of an assemblage (i.e. all wastewater producing appliances both in the kitchen, bathroom, and shop, etc.) 5) A **Module** (seven individual modules including energy, water, wastewater, solid waste, structural, spatial, and communication) 6) **Building** (a set of performance modules that are configured to respond to the requirements of humans and other living things and their activities) examples are homes, businesses, greenhouses, etc. 7) **Clusters** Buildings of asingle or multiple types sharing certain resources and operating as a whole.

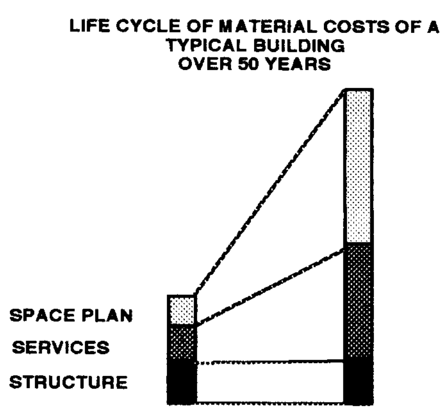
GREENFORMS™ BUILDING ELEMENT DESCRIPTION

The principal ingredient of the system is an open-ended framework made up of a post and beam system that is incorporated as the basis of the foundation, the columns, the beams, and roof and floor joists from which are attached a variety of other elements together making a particular building component. GreenForms™ itself is made up of 90% recycled steel, is square and contains attachment holes on all four sides as well as an attachment at each end. The weight of each element is approximately 35 lbs. for the column and 55 lbs. for a 12 foot beam. All elements can be used, if desired, directly or as reinforcing cage for concrete structures. The concrete is used when permanence or structural integrity of more than one story is required. In a demonstration building in Austin, Texas, the concrete used fit a high recycled content performance specification; therefore 97% 6000 psi flyash cement with no portland cement was used (the proper flyash (by-product from the coal combustion industry) for this mix being readily available in our region). The resulting structure is still a post and beam spatial layout, and can contain non-supporting fill methods between columns and beams. Future growth when wrapped in concrete (so that more GreenForms™ can be added) is accomplished through the use of a high tensile bolting system both horizontally and vertically in conjunction with a Nu-Stick™ extension of the cage so that there is a physical and mechanical connection.

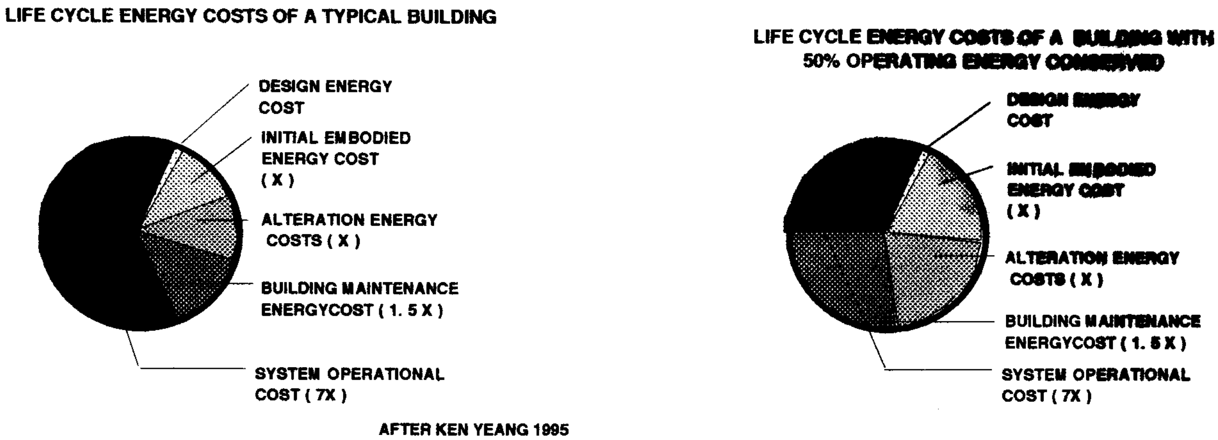
GreenForms™ must therefore be considered only a part of the complete building system. As an element, it must go through the component, assembly and module stages before a whole building can result. Modules themselves contain other assemblies with certain components fitting multi-assembly and multi-module purposes. Including the structural module, there are seven modules overall at one level below the building itself as described earlier. It might be noted that the water and wastewater modules are intimately attached to the building's surrounding landscape; therefore, the landscape is considered a part of both these modules in an integrated fashion. As one goes up through the hierarchy the need for understanding higher and higher levels of integration is important. Each step in the hierarchy is looked at as an operating system in that it contains performance goals, including toxic impacts on humans and the environment resulting from the materials used, as well as the cumulative toxicity of the entire building.

LIFE CYCLE PROCEDURES AS A METHOD OF DESIGN

It is important to understand that each part of the building system, at whatever stage of the hierarchy, is considered a complete system in itself from the viewpoint of life cycle design. The life cycle design method being used is not just life cycle assessment of materials but is the process of "overlaying" the particular stage being addressed in two ways: one, internally at the scale being addressed, thus modeling relative to building performance; and two, externally from the standpoint of environmental impact. At the material stage, for example, a material might be assessed from the standpoint of typical Life Cycle Assessment (LCA) procedures (this would fit under the second category above). Another life cycle issue is the impact that regionalized production has on shortening transportation requirements, which can account for 6% to 30% of a building's embodied energy cost. A material is also assessed from the standpoint of building performance, again using the life cycle structure. In the latter case it could be as a processor of thermal energy or as a source of indoor air quality that is about to be processed by humans. One area that is often overlooked in life cycle design is that of extended use, and the ability of a building to adapt to changing uses over time. As the bar chart below attests, this issue relative to life cycle costs of materials can be significant in the average building.



Assuming operating energy can be reduced by 50% through instructional manuals for building placement, performance based material selection and energy-efficient equipment, the remainder of the building's energy cost is directly involved in change as illustrated by the pie charts below. Therefore, both initiatives--that of material costs and energy costs over a building's life--influence how buildings should be designed. Both of these costs are absorbed by GreenForms™ approach, and are central themes from an energy standpoint in the Build America Initiative.



ADDITIONAL USES OF THE GREENFORMS™ BUILDING ELEMENT

Due to its multi-position attachment technique, GreenForms™ can be employed in a broad range of uses, from scaffolding to shade trellis, spatial furniture to outbuildings and play equipment, as well as display systems, outdoor markets or roaming urban walkway definers. When placed together in this fashion, the building element, GreenForms™, becomes a building component under the structural assemblage category. GreenForms™ therefore responds to a broad set of client needs and use conditions, not only to the singular activity of homebuilding. At the smaller assemblage scale, certain furniture types are possible in the ready-to assemble (RTA) industry using basic system elements combined with other elements such as precious regional woods inlaid in such items as the framework for canopy beds, home office nooks, edu-tainment centers. The system partially responds to the need for add-on building flexibility in what now has become a $123 billion remodeling industry. According to NAHB, the highest monetary output in the remodeling industry, based on recent national surveys, is in the area of wall moving, replacing and expansion (see chart below from the Remodelers Association).

BRIEF DESCRIPTION OF OTHER ASSEMBLIES AND THEIR COMPONENTS WITHIN THE GREENFORMS™ BUILDING APPROACH

Flexibility to fit user needs and at the same time adapt to environmental parameters has significance in how we look at time and space use. This, in turn, influences how we configure an assembly at the transport distribution part of the life cycle. Our kitchen assembly is a case in point, which enables all facets of the kitchen to be completely mobile, as has been designed by industry innovators Boffi and Ikea, two well known furniture designers which have brought onto the market mobile kitchens and mobile furniture. The importance to the user from the point of view of space adaption is nearly unheard of in the industry, in which kitchens have not fundamentally changed in the last 100 years. In our demonstration building in Texas, due to its mobility and up-beat design, the mobility of stoves, sink cabinets, serving carts, and rollar cabinets enables the user to take the kitchen outside in a breezeway during a significant portion of the year, thus drastically reducing the heat gain effects of appliances on indoor space. Somewhat similar scenarios have been developed in this demonstration for sleeping areas, echoing the old sleeping porch in a new motif, and similarly with movable storage areas, spatial furniture, and bathroom adaptability.

USER FEEDBACK CONTROL AS A RESOURCE USE REDUCTION MEASURE

A part of the GreenForms™ concept is to stress integration between resource use modules instead of the usual conservation approach. This method optimizes nearly all processes in multiple use fashions and reduces complexity, increases monitoring potential and become a non-linear approach to establishing multi-system economics. The latter will be discussed in a following paragraph.

Building adaptation to people's personal needs is expressed in multiple ways from longer term building changes such as rooms to much shorter term day to day and even hour to hour requirements. This approach is taken to the point interfacing between the spatial/mechanical module and the communication module, in which information is transferred on a constant feedback basis so the user is conscious of resource use. The Communication module tracks water use (with the operating limit being that which is available on the site itself). Similarly, electric use is monitored on a constant feedback basis to show whether consumption exceeds the electricity supplied by the photovoltaic roof panels. Photovoltaic panels are elements within the energy assemblage which are carefully optimized so that electricity is minimized for functions such as lighting, and never directly used for functions such as heating or cooling other than for operating a heat pump which uses the cistern tank water and the wastewater landscape as a heat sink. The human interface with all systems is stressed in their design and their electronic feedback control. It has been demonstrated that significant reductions can be made by knowing how much of a resource that user is draining, and what is left of this resource within the boundary of the system (in this case the building site).

THE GREENFORMS™ BUILDING SYSTEM AS AN INFORMATION SYSTEM

This building system is as much an information management system as it is a building system made up of physical parts. In a sense the core to this information system is the GreenForms™ approach to building due to its ability to organize regionally based production methods. Each component or set of components is viewed as an objects and relationships contained within a system of information management. This information management enables the building system to become critiqued at all levels from a performance viewpoint (of a part and the whole) and from an operating standpoint. This object oriented technique for design not only aids in the efficiency of application of building system principles through the incorporation of a hierarchy of built form relationships, but also introduces performance memory (inheritance - change in one part effects changes in other parts from a performance standpoint) into the system so that any decision can "ricochet" throughout. The ability of the entire building system as a cluster of sub-system integrated performance levels enables it to be a measurable part of a region's resource availability under sustainable resource use. Since each level as well as the whole has regional performance objectives such as water use, liquid waste disposal needs, and embodied energy performance, the building system as a whole becomes a part of a region's standards performance. Each metabolic scale in the building has a metabolic corollary in the environment.