Sustainable Structures

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Green design = Good design

Sustainable design attempts to reduce the collective environmental impacts during the production of building components, during the construction process, as well as during the lifecycle of the building.

Required and incentivized by:

- US General Services Administration
- Cities and towns
- Progressive developers
- Businesses
- Homeowners
Motivating factors

- $$$$$
- Health
- Ethics
- Beauty
- Self Expression
- Philosophy
- Environmental Ethic
- Lifestyle
- Security
- Functionality
- Innovation
- Responsibility
Elements of a good team

The *integrated* whole is greater than the sum of its parts.

- Share design philosophy
- Speak the same language
- Open communication
- Reliability
- Experience
- Learning attitude
Project types

- Custom homes
- Adaptive re-use
- Office
- Retail
- Education
- Entertainment
- Breweries
- Restaurants
- Nature Centers
- Medical Clinics
Sampling of Sustainable Structural Methods

- Straw bale (vs. hay bale)
- ICF (Insulated Concrete Form)
- SIP (Structural Insulated Panel)
- Stacked stone
- Canvas
- Insulated pre-cast panels
- Shipping Container
- Building re-use
Moab Straw Bale
Bundled cellulose

- An excellent reference for structural design guidelines is the California Health & Safety Code #18944.

- Load bearing capacity is recommended to not exceed 800pflf based on multiple destructive tests, plastered & unplastered.

- Testing by the Ecological Building Network demonstrated that plastered walls having having adequate out-of-plane capacity.

- Testing shows walls yielding in shear at 1250pflf, making 425pflf a reasonable allowable capacity.

- It is essential to pound bales into place to reduce settling.

- Recent development indicates that pining bale walls to the fndn with rods is not necessary to achieve reliable performance.
Insulating concrete

- Two types of systems – forms and molded blocks
- Forms are straightforward and offer different than conventionally designed concrete walls and beams. The forms are not meant for individual columns
- Blocks are structurally interesting since the block, which has no structural capacity, provides for a post and beam grid of reinforced concrete cells
- The system is well suited for single level basements and 3-4 stories above grade. Individual columns require conventional forms.
- Designing for EQ forces can be tricky, especially for bldgs of 2 stories or more because the system usually incorporates light flexible diaphragms and SWs need to be long enough to avoid the need for special confinement zones
- Block width is 8”-14”. 8” blocks are only for non structural partitions
OSB and expanded foam sandwich

- Used along side conventional wood framing and incorporating principals of such, but fundamentally a product with rated capacities based on destructive testing.

- The thickness of the foam is chosen to match the sizes of dimensional lumber since 2x’s, at a minimum, are needed at the sill and cap plates.

- Panel to panel CONXs, or splines, start with OSB and graduate to TJIs, single and double 2x’s, then LVLs, with increasing transverse loading capacity.

- Rated allowable OSB spline assemblies afford a designer up to 955plf of in-plane SW shear capacity with 4” O/C nailing.
Stacked Stone, Bras Gauche (Haiti)
Structural innovation

- Challenges: remote site, low skilled labor force, limited funds, high seismic
- Import as few materials as possible and keep them light
- Available building materials at site? Stones
- NO PROBLEM -> just ask a structural engineer
- Dry stacked square hewn stone walls confined by steel plate reinforced and cross tied galvanized fencing mesh with CFS bracing and trusses
- Advantage 1: relatively low mass roof simplifies diaphragm design whereby the primary EQ force the walls need to resist comes from their own mass
- Advantage 2: small one room bldg
Canvas – worldwide, for all applications
Designing with aluminum + PTFE

- Proprietary wide flange shapes made of 6351-T6 aluminum (Fy= 21,7 ksi)
- Sheds snow (8 psf max pre-shed load, field testing shows release at 3psf)
- Sustains high EQ loads and hurricane force winds
- High tensile PTFE laminated fabric
- Deploys and dismantles rapidly
- Up to 160ft span without interior columns
Avian exhibit
Insulated precast
Sandwich precast panels

- JR-500 – State of the Art Precast/Prestressed Concrete Sandwich Wall Panels, 2nd edition, by PCI
- Noncomposite: analyzed and detailed so that the 2 concrete wythes act independently. The structural wythe is generally thicker.
- Composite: analyzed and detailed so that the 2 concrete wythes act together to resist applied load, with the entire panel acting as a single element. This is accomplished by introducing regularly placed mechanical shear transfer connectors linking the concrete wythes across the insulation layer.
- Structural concrete wythes are prestressed
- Panels are typically encased on all sides, but open panels are common
MARKING ARRANGEMENT

ROOF PANEL BASE ASSEMBLY
SIDE WALL ASSEMBLY
REAR END ASSEMBLY

DESCRIPTION

5
43
2
1

ITE

DWG NO.

REMARC QT

TITLE:

20' x 8' x 9'-6"

HC

OWNED BY:

DESIGNED BY:

CHECKED BY:

APPROVED BY:

SHEET OF SHEETS

SCALE: 1 : 25

WEIGHT:

DWG No.:

ISSUE:

KG. QTY.:

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Standard ISO containers are rated for a
stacking load of 400kip
Boxy steel

- Basic steel design principles per AISC manual
- Deep beam theory
- Confine openings
- Containers are made to be supported at their corners. Openings in the walls shift bearing to the openings, requiring new supports.
- One disadvantage for using containers, mainly in underdeveloped countries or at remote sites, is that trucking and craning the containers requires passable roads and heavy machinery.
Adaptive Re-use – Double T
Ronald McDonald House Seismic Upgrades
Structural solution

- There are many ways to seismically upgrade unreinforced double-wythe masonry bldgs. We have worked with moment frames, braced frames, wrapping the walls in fiberglass and resin, shotcrete, and replacing the brick with wood SWs.

- For 1 and 2 story homes, wood SWs are by far the least expensive, least impactful, and easiest approach we have implemented. I tested the system in my home before suggesting it to our clients.

- There are a lot of these all-brick homes in Utah. These homes are typically small and by today’s standard and/or have closed floor plans. Many owners want to expand them, or, less frequently, simply want to make them safer.

- When owners are looking for a safer home, we approach the project in terms of performance design since the code is not requiring the upgrade.
Conclusion:

- Collaborative team approach
- Open to change
- Research
- Creativity
- Responsibility

"Every time I learn something new it pushes some old stuff out of my brain."

-Homer Simpson
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