SEI STRUCTURAL ENGINEERING INSTITUTE | SE2050 COMMITTING TO NET ZERO January 5, 2024

CASE STUDY:

Bush School

This project is a new, deep green classroom and commons building for a private K-12 school. The building includes ten classrooms, casual break-out areas, 400-seat multipurpose room with pre-function spaces, student lounge, student/faculty collaboration center, administrative offices and faculty work room.

Image credit Lara Swimmer

Project Data

Location	Seattle, Washington, United States
Primary Building Use Type	Education
New building or Renovation project:	New Construction
Construction Year (or Anticipated):	2022
Gross Square Footage (sq ft):	20000
Mean Roof Height (ft):	29.5
Number of Stories Above Grade:	2
Number of Stories Below Grade:	1
Expected Building Life (years):	60

Project Team	Developer: The Bush School Architect: Mithun Engineer: DCI Engineers Builder: Exxel Pacific
Suppliers	Stoneway Concrete, PJ's Rebar, Blue Star Welding, Cascade Joinery, Freres Lumber

Structural System Data

Primary Horizontal Gravity System	Wood: Engineered Panels
Primary Vertical Gravity System	Wood: Mass Timber
Primary Lateral System	Light Frame Shear Panels
Foundation Type	Shallow Foundations
Structural System Description	The Bush School superstructure consists of mass plywood panels with normal weight concrete topping supported by stick-frame shear walls, glulam columns and glulam beams. The substructure consists of a perimeter basement wall, concrete columns and concrete shear walls supporting the post-tensioned slab at grade.

Case Study Narratives

Project Sustainability Goals	The client had a goal of achieving Net Zero Energy, Passive House US Certification and Salmon Safe Certification. Mass timber also provided an embodied carbon reduction that aligned with the school's high sustainability goals.

Embodied Carbon Calculation Methodology and Material Assumptions	The LCA was performed on schematic-level drawings when steel and mass timber framing was considered for the two classroom levels above grade. DCI performed an embodied carbon assessment using a combination of industry-average and product-specific EPDs. The LCA was cradle to gate, so stages included A1-A3. Total calculated GWP is 330572 kg CO2e and total biogenic GWP is -133160 kg CO2e. The infill stud wall framing and mechanical mezzanine was not included in this analysis. Industry-average EPDs were used for all structural elements except for Mass Plywood Panel. Freres' product-specific EPD was used to identify the MPP embodied carbon impacts. The embodied carbon impact of the post-tensioning tendons was conservatively assumed as being twice that of fabricated reinforcing steel. We also assumed a 5% increase of overall steel tonnage to account for connections.
GWP Intensity, including biogenic carbon [kgCO2e/sm]	106
GWP Intensity, excluding biogenic carbon [kgCO2e/sm]	178
LCA Stages Included, for GWP intensity values above	A1-A3
LCA Tool Used	Environmental Product Declarations (EPDs)

Design & Procurement Embodied Carbon Reduction Strategies	During the schematic phase, the design team considered the option of concrete over metal deck supported by structural steel framing in lieu of mass plywood panel supported by glue laminated timber framing. The wood option demonstrated a 13% decrease in embodied carbon and 52% when considered biogenic carbon from cradle-to-gate. The design team optimized wood fiber by determining the minimum beam width that didn't impact head clearance. In addition, the beam spacing was chosen to maximize the utilization of the 2" thick mass plywood panels spanning across. Both of these structural design efficiencies promote material optimization and therefore embodied carbon reduction. Concrete specification language included prescriptive supplementary cementitious requirements. The specifications required 50% fly ash for foundations, shotcrete walls, columns and shear walls and 20% fly ash for interior floor slabs. The supplier informed the design team they use slag in lieu of fly ash for all performance mixes. The supplier was able to offer 50% slag for the foundations, columns and retaining walls and 15% slag for the interior slab on grade, exterior slab on grade, sidewalks, PT slabs & beams, and topping slabs. The submitted flatwork mixes utilized 15% slag instead of 20% slag due to the early age strength and finishing requirements. The shotcrete mixes did not utilize 50% fly ash or slag due to the concern that the concrete would not hang in place while shooting. Freres' Mass Plywood Panel products are American Tree Farm System certified. The concrete materials were procured locally by Ash Grove Cement, Lefarge Cement and Glacier Northwest Aggregates.

Key Findings, Recommendations, and Lessons Learned	This project required the use of a concrete subgrade level to accommodate the sloping site, but the design team chose to utilize lower impact materials for the superstructure to promote embodied carbon reduction and project sustainability goals. Wood products generally have a lower embodied carbon footprint than steel and concrete, plus its lighter weight reduces material necessary at the foundations to support structural demands. The design team met some challenges utilizing the mass plywood panel system, notably at the roof. The MPP was too thin to support the point loads of the roof screen, so the posts and kickers were intentionally placed to align with the glulam beam framing, however, additional solid blocking was required at non-beam locations. Additionally, the elevator hoistway on the roof required a jog in girder framing which greatly complicated the associated connections. Maintaining a regular grid, even around the elevator, is recommended to promote straightforward connections and installation.