

ENERGY EFFICIENCY SOLUTIONS
for Relocatable Classrooms

SCE HIGH PERFORMANCE RELOCATABLE CLASSROOMS



"The design strategies used in this project can be easily applied to any relocatable classroom."

Gregg D. Ander, FAIA
Chief Architect,
Southern California Edison

DESIGN & ENGINEERING SERVICES

HIGH PERFORMANCE RELOCATABLE CLASSROOMS ARE IN A CLASS BY THEMSELVES

Relocatable classrooms can be highly effective learning environments that exemplify energy and cost efficiency.

Nearly two million California students attend class in one of the state's 80,000 relocatable classrooms (RC). They are popular because of their flexibility, low initial cost, and speed of delivery.

Southern California Edison (SCE) teamed with the Pomona Unified School District (PUSD), the Collaborative for High Performance Schools (CHPS), and nationally known design experts to develop an environmentally sound, energy-efficient, relocatable classroom solution.

The resulting high-performance, relocatable classroom at Pueblo Elementary School demonstrates advanced daylighting, electric lighting, space conditioning, thermal envelope, building materials, and finishes. Recent studies show the benefits of daylighting and improved indoor air quality (IAQ). The integrated design contributes to the health and productivity of students and teachers.

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AIR DISTRIBUTION SYSTEM IMPROVES COMFORT AND AIR QUALITY

The wall-mounted HVAC packaged unit, commonly used in most RCs, can contribute to poor indoor air quality, thermal discomfort, and high classroom noise levels.

A solution to these issues is a displacement ventilation (DV) system, which delivers improved occupant comfort, better indoor air quality, and lower HVAC system noise levels.

The displacement ventilation system distributes air near the floor level at a lower velocity and lower flow rate than required for a conventional, mixed-air system, like a wall-mounted unit. As the supply “spills” across the classroom, picking up heat from occupants and other heat loads in the occupied zone, it rises and creates a warmer, stratified air layer above the occupied zone, improving IAQ. This warm air is purged from the building through an exhaust air louver.

In the DV system’s cooling mode, supply air temperatures are higher (65°F instead of 55°F) than that delivered by the packaged unit.

Displacement ventilation components:

- 5 ton chiller heat pump
- (6) 24” x 30” displacement ventilation air diffusers

Displacement ventilation benefits:

- Superior IAQ and improved occupant comfort
 - High efficiency air filtration
 - Capable of delivering 100% outside air
 - Pre-occupancy ventilation purge cycle
 - Maintenance of ventilation rate during all occupied periods

- Lower energy requirements
 - In hot, dry climates, reducing outdoor air percentage will lower energy requirements.
- Lower noise levels:
 - Provides 35 dB-45dB, A scale baseline noise level in classroom
 - Quiet, vibration-isolated fan-coil unit and heat pump/chiller unit
 - Thermally and acoustically insulated ducts
 - Sound absorbing ceiling and wall finishes

INTEGRATION OF DAYLIGHTING AND ELECTRIC LIGHT ILLUMINATES LEARNING



DV delivers conditioned 100% outside air.

The benefits of daylighting features are well documented. In addition to energy savings, industry studies show that a daylit environment boosts student test scores and attendance while saving energy. The Pueblo RC invites daylight in with skylights, daylight windows, and view windows.

In order to take full advantage of the benefits of daylight, the Pueblo RC integrates daylighting with electric lighting systems and controls. These include fenestration controls, light shelves, and electric lighting controls.

FENESTRATION CONTROLS AND DETAILS

Sunlight can create glare and excessive heat gain. To counteract these negative effects while maintaining high levels of visible daylight, the Pueblo RC includes these fenestration controls:

- Upper Daylighting Windows
 - Low-E glazing with 68 percent Visible Light Transmission (VLT)
 - Two-inch window reflective blinds for shade
- Lower View Windows
 - Low-E glazing with 50 percent VLT
 - Microfiber shades for access to views while mitigating glare and heat gain

SKYLIGHTS

The skylights and associated components were carefully designed to obstruct all direct sunlight, reduce glare, and diffuse light.

- Four central skylights provide yearlong day light without the sun angle disadvantages of vertical windows.
- Splayed ceiling, which features a beveled outer edge, contributes to a uniform level of ambient light.
- Skylight reflector maximizes natural light while minimizing direct sunlight.

ADVANCED ELECTRIC LIGHTING

- Classroom Lighting
 - Two drop-pendant, 20 percent direct, 80 percent indirect, double T-8 lamp luminaires achieve horizontal desktop illumination of 30 to 40 footcandles
- Teaching Wall Lighting
 - Three wall-mounted, wall washing fixtures on the teaching wall achieve vertical illumination of 15 footcandles



Direct-indirect lighting (left) and skylight reflectors (right) provide glare-free illumination.

LIGHTING CONTROLS

The Pueblo RC uses two types of automatic controls – occupancy sensors and photo sensors – along with manual controls.

- **Occupancy sensors** automatically turn lights off when rooms are unoccupied for more than 15 minutes.
- **Photo sensors** automatically dim lamps when daylight is plentiful.
- **Manual controls** give teachers greater flexibility in dimming and switching lights.

BUILDING DESIGN AND MATERIALS

For maximum construction and installation cost efficiency, the standard design of the Pueblo RC consists of a rectangular shape. The ceiling height was increased to 10 feet for better light and air distribution. Four skylights over the center of the classroom provide daylight and maximum north, south, east, and west orientation flexibility.

The choice of materials contributes to a high performance classroom. Like a typical high performance school, the Pueblo RC features steel moment frame and stud walls. Sustainable material choices include high recycled content, cement fiber exterior wall board; R-19 walls and floors; burlap-wrapped interior wall finishes that incorporate recycled newspaper and bees wax; natural linoleum flooring; wood floor base; and recyclable aluminum trimming.



This interior elevation shows a light shelf and pendant mounted fixtures. The combination provides abundant light yet reduces glare.

LIGHT SHELVES

Light shelves reflect sunlight onto the ceiling and into the classroom while reducing glare and direct beam sunlight. The Pueblo RC incorporates light shelves at the top of its storage closets, where they draw in a generous amount of daylight.

CONCLUSION

This project demonstrates that relocatable classrooms can – with careful planning and execution – incorporate all of the features of high performance schools. The daylighting, advanced electric lighting, space conditioning, thermal envelope, building materials, and finishes contribute to the health and productivity of students and teachers.

PROJECT TEAM

- Pomona Unified School District (PUSD)
- Modular Structures, International
- Clanton Associates
- Ensar Group
- IBE Mechanical Engineers
- Magnison & Moen
- Multi-Aqua
- Chu+Gooding Architects
- Daly Genik Architects
- J. Heerwagen
- Quest Energy Group
- California High Performance Schools (CHPS)
- California Energy Commission (CEC)
- California Division of the State Architect (CaDSA)

For more resources about how your school or school district can reap the benefits of a high performance relocatable classroom, visit these websites:

- NBI daylight studies: www.h-m-g.com
- Southern California Edison: www.sce.com
- Bright Schools:
www.energy.ca.gov/efficiency/brightschoools/index.html
- Collaborative for High Performance Schools (CHPS):
www.chps.net
- The Daylighting Collaborative: www.ecw.org
- Energy Design Resources: www.energydesignresources.com
- EPA Energy Star Schools:
www.energystar.gov/index.cfm?c=k12_schools.bus_schoolsk12
- Energy Smart Schools, a Rebuild America Campaign:
www.eren.doe.gov/energysmartschools/
- Rebuild America: www.rebuild.org/index.asp
- Savings By Design: www.savingsbydesign.com
- California Energy Commission (CEC) Public Interest Energy Research (PIER) Program: www.energy.ca.gov/pier

For more information, contact your Southern California Edison Account Executive.

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