High Performance Hawaii Classroom Prototypes

Integrated design for visual and thermal comfort, as well as optimal energy efficiency

See the Hawaii High Performance School Guidelines for more details.

DBEDT
THE DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
STATE OF HAWAII

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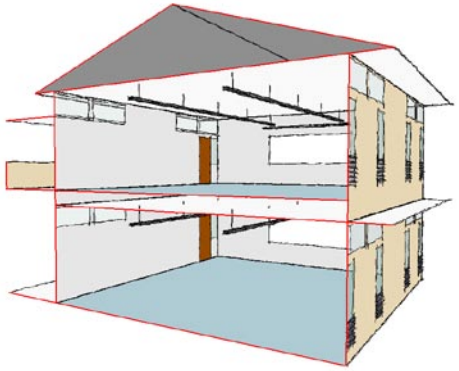
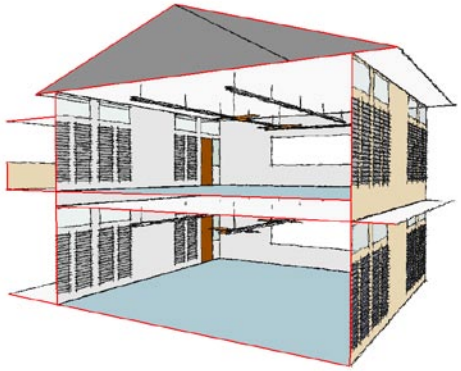
Integrated Engineered Solutions

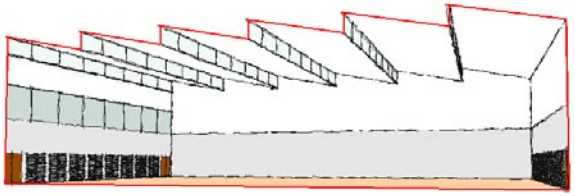
A classroom building designed for daylighting and choice of air conditioning and natural ventilation (mixed mode).



A portable classroom designed with daylighting and mixed-mode ventilation.



A naturally ventilated classroom.



Daylighting options for gymnasiums.

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Mixed-Mode Ventilation Classroom Prototype

Daylighting & Lighting Features

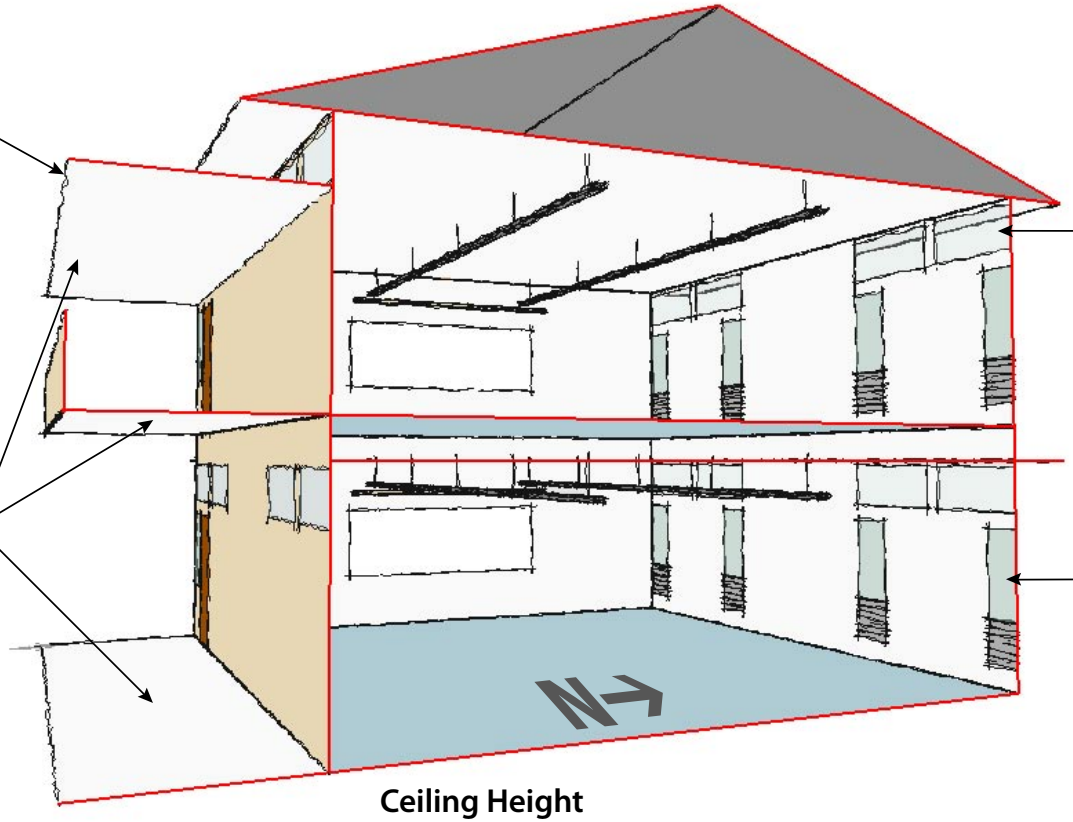
Lightshelf
Top of walkway cover should be white to improve daylight penetration on second floor.

Overhangs
Block direct sun for visual comfort and lower cooling loads. Protect walls from moisture: size them smaller on north side and larger on south.

Reflective Exterior Surfaces
Pale colors on walkway, walkway ceilings, and overhangs improve daylight penetration.

Reflective Interior Surfaces
White ceiling and interior wall surface are necessary for daylight and electric lighting efficiency.

Orientation
Maximize north-facing windows. Shade south-facing windows. Minimize east- and west-facing windows to control heat and glare.



Daylight Windows
Locate daylight windows flush to ceiling and side walls to illuminate interior surfaces evenly. They should total approximately 50 ft^2 on north and south walls (assuming a classroom of about 900 ft^2). Specify high light transmission glass.

View Windows
These are not a primary source of daylight. Specify glass with a solar heat gain coefficient of 0.35 or less. Place some or all view windows as close as possible to the corner of the room to help illuminate the teaching wall. Operable blinds for privacy are optional.

Ceiling Height
A 10 foot ceiling affords deeper daylight penetration, better electric lighting performance, and improved natural ventilation airflow.

Direct/Indirect Lighting
Two rows of T-8 lamp fixtures parallel to the daylight windows, 0.9 watts/ft^2 or less, provide backup to daylighting.

Occupancy Sensor
Install dual technology occupancy sensors: manual-on, auto-off.

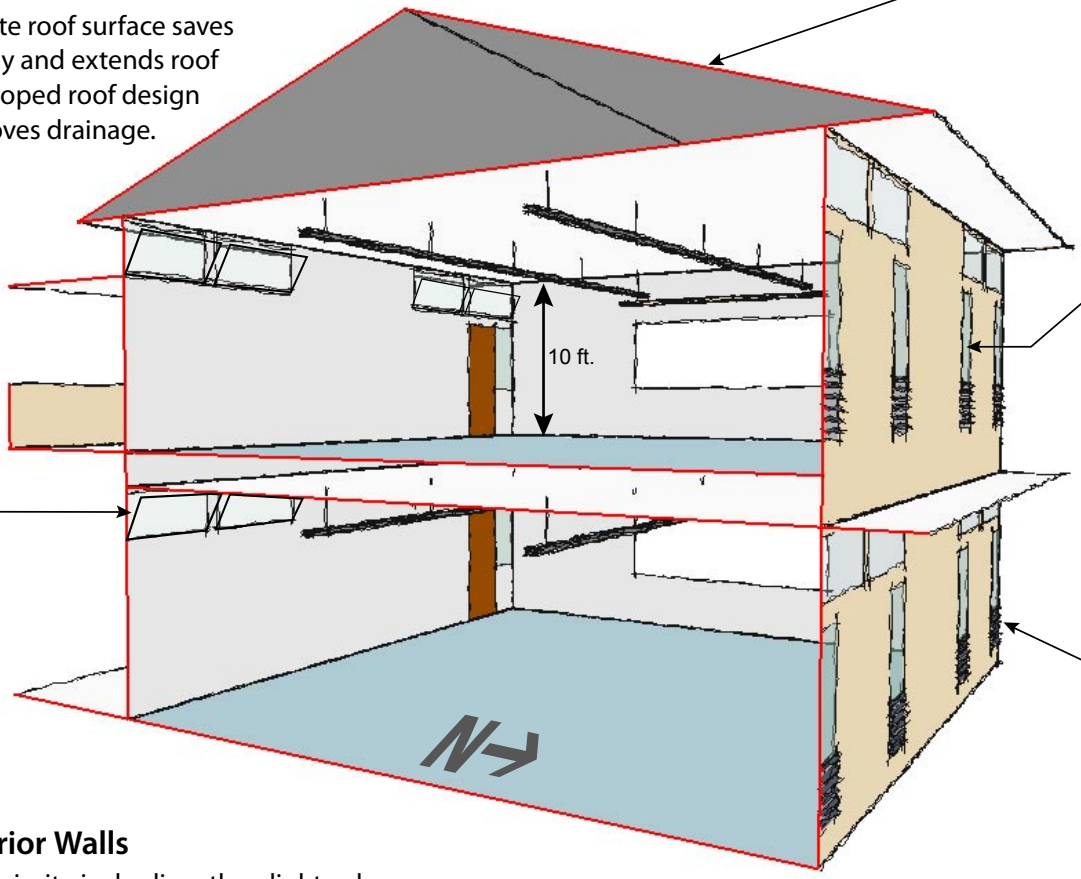
Daylighting Controls
Use dimming ballasts with photocell control.

Ventilation & Envelope Features

Cool Roof
A white roof surface saves energy and extends roof life. Sloped roof design improves drainage.

Radiant Barrier
Attic allows use of radiant barriers as an alternative to batt or foam board insulation.

Acoustic Materials
Sound absorbing materials may be appropriate on the interior surface of all walls except the teaching wall to reduce reverberation time.



Natural Ventilation Inlets
Ventilation area should total approximately 40 ft^2 per each opposing wall at occupant level (assuming a classroom of about 900 ft^2). North side for prevailing winds and simpler shading. Operable windows seal tightly for warm season. Casement, awning, or hopper-type windows are appropriate.*

Natural Ventilation Outlets
Outlets should equal inlets in area, for total of about 80 ft^2 on both walls. They can be either high or low on the wall.

Secure Natural Ventilation
Lower portion of inlet can be left open for night cooling. Fixed exterior louvers prevent rain intrusion and provide security.

Exterior Walls
First priority is shading, then light color. Concrete mass construction provides temperature moderating and acoustical benefits. No insulation is necessary for concrete mass walls. Use R-13 or radiant barrier in framed walls.

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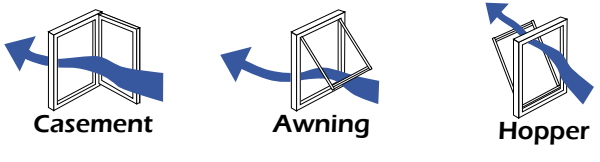


Integrated Design Strategies

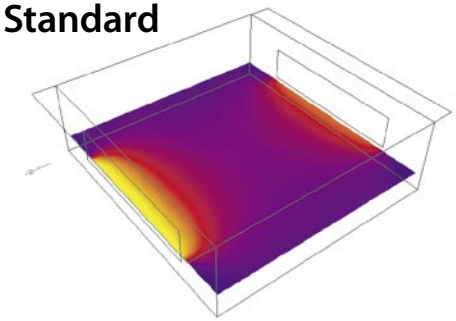
There are a few simple integrated design strategies behind the choice of classroom features illustrated on the preceding pages.

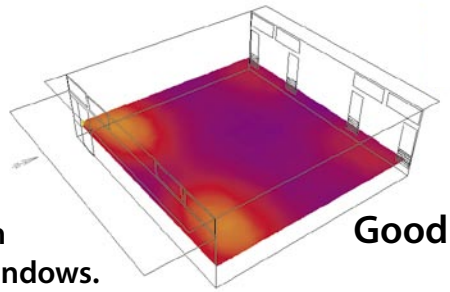
Daylight as Primary Light Source

The number-one strategy is to design for daylight as the primary source of light. Daylight can meet illumination needs for the majority of school hours, given careful attention to design details. Electric lighting should be for nighttime use only. A design that meets all lighting needs with daylight will also result in:

- Improved student test scores and better health in office workers;*
- Significant energy savings;
- Minimized solar heat gain and prevention of direct sun via shading and north/south orientation;
- An opportunity for natural ventilation created by two exterior walls.

Standard





Good

Improved daylight distribution with proper placement of daylighting windows.

Optimal Envelope Design to Minimize Solar Heat Gain

Glazing: All glass not completely shaded from the sun must have a low solar heat gain coefficient. If the window is used to provide daylighting, then ensure that the glass also has a high visible light transmittance (i.e. is "spectrally selective"). A good choice is single-pane laminated glass using a spectrally selective inner plastic layer to provide low solar heat transmission and high visible light transmission. Laminated glass also provides better acoustic performance, security, and safety.

Roofs: After ensuring that the windows are shaded, minimize heat gain through the roof. In this example, a combination of radiant barrier and white roof surface are used as an effective alternative to batt or foam board insulation.

Walls: Shading is the first priority for keeping out solar gain. A pale exterior surface color is also important. Insulation is not necessary for concrete masonry walls in the Hawaii climate, and can actually be detrimental to performance by trapping heat in the room at night.

*"Daylighting in Schools: Reanalysis Report," California Energy Commission, Oct. 2003

Mixed-Mode Ventilation

Throughout Hawaii, comfort can be provided by natural ventilation for most of the year. Designs that allow the air conditioning to be shut off provide major energy savings. The key features illustrated in this classroom prototype include:

- Operable windows that can be tightly sealed on hot days;
- Ventilation inlets on north side (in general) to capture prevailing winds, and where these openings are shaded from direct sun;
- Ventilation inlets as low as possible in the wall to provide air movement at the occupant level;
- Ventilation outlets on the south (leeward) side in the form of operable clerestory windows;
- Secure vents that can be left open at night to cool the building mass.

Resource

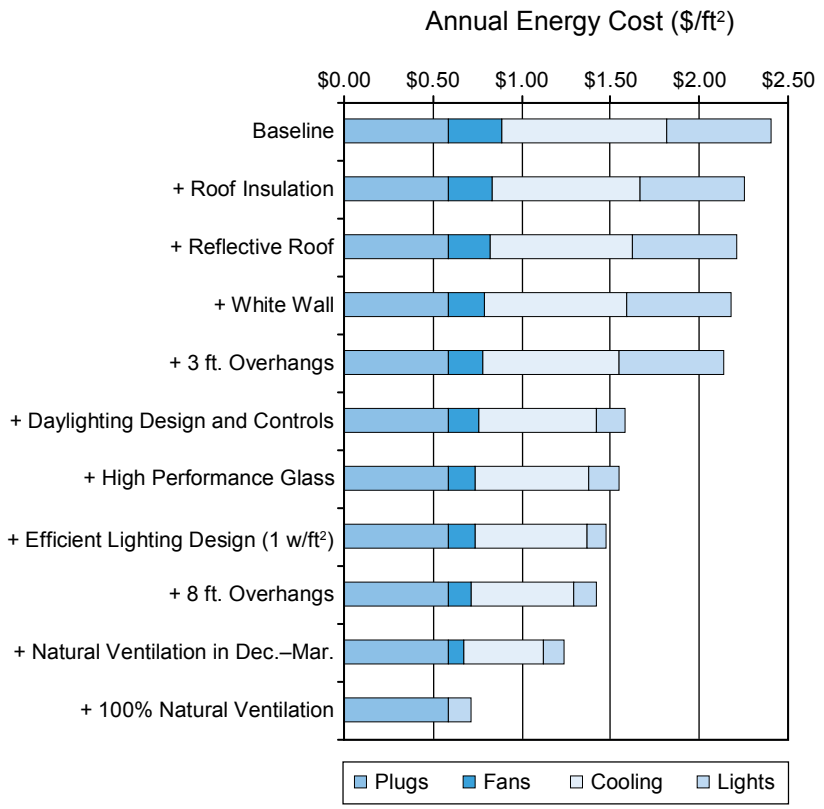
DBEDT's *Hawaii Guidelines for Commercial Building Energy Efficiency* provides many more details than can be covered here, such as:

- Whole building design strategies;
- Daylighting design;
- Electric lighting design;
- Glazing selection;
- Overhang sizing;
- Natural ventilation design;
- Roof design;
- HVAC and dehumidification design.

Cutting Costs

Energy efficiency makes economic sense. The big three money savers are:

- Daylighting,
- Natural ventilation, and
- Roof insulation.



Results of DOE2.1E simulation analysis, with Honolulu climate data, and electricity price of $0.145 per kWh (average rate paid by Oahu schools in 2004). Plug energy based on assumption of 1000 watts, equal to about five computers per classroom.

100% Naturally Ventilated Classroom Prototype

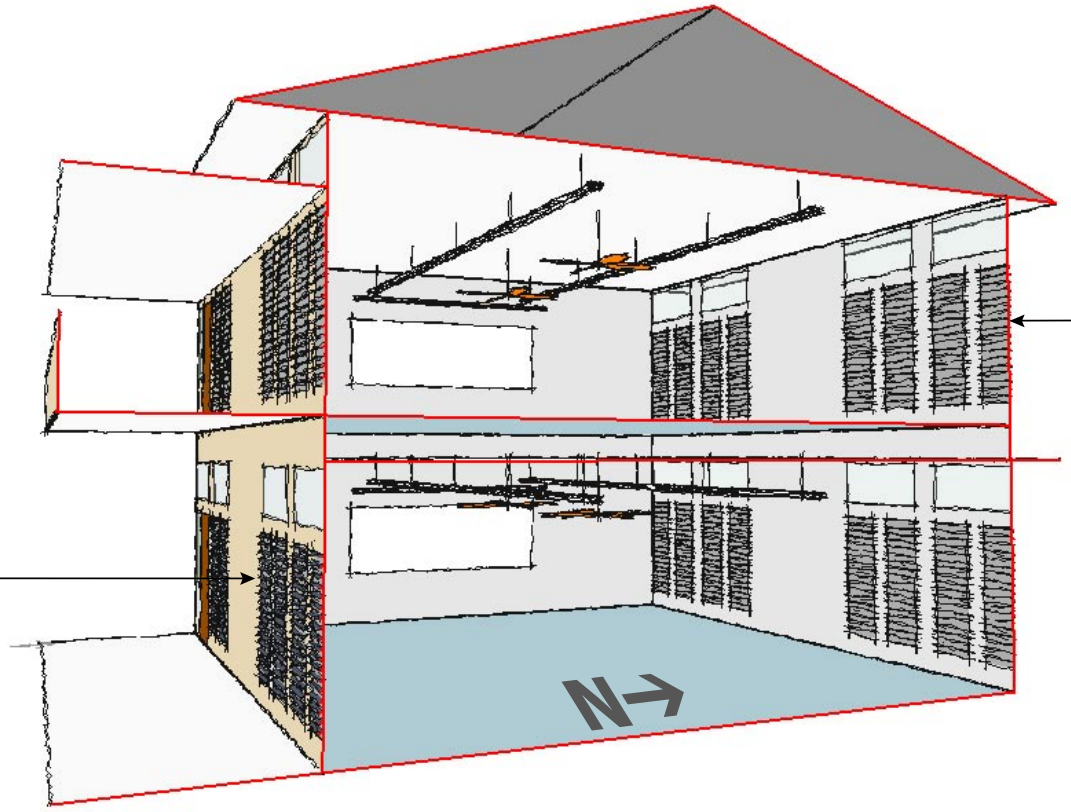
For most Hawaii locations, it is possible to completely eliminate the need for air conditioning. The 100% naturally ventilated design presented here highlights some additional design features.

South-Side Walkways

Place walkways on south side to prevent shading; leave north side free to maximize daylighting.

Inlets On Both Sides

Equally sized openings on both sides of the classroom at occupant level provide air movement all year, regardless of wind direction.



Ceiling Fans

Two ceiling fans per classroom provide air movement to improve comfort on "Kona weather" days.

Larger Natural Ventilation Inlets

Larger ventilation area helps provide comfort during calm periods, approximately 80 ft^2 vent area on each side (160 ft^2 total) at occupant level (assuming a classroom of about 900 ft^2). Jalousies may be used because a tight seal is not necessary without air conditioning. If opaque jalousies are used, then choose pale colors to improve daylight distribution.

Secure Natural Ventilation

Ensure that at least a portion of the jalousies can be left open at night to cool the mass of the building without compromising security or allowing rain intrusion.

Portable Classroom Prototype

One option for portable classroom design is illustrated here. This classroom could have air conditioning, but is also designed with operable windows for natural ventilation.

Ceiling Height and Roof Insulation

Achieve a 10 foot ceiling height by exposing the roof deck and specifying a white roof, plus insulating with foam board insulation on top of the deck.

Daylight Windows

Avoid blocking light penetration into the classroom with exposed roof beams. Exposed roof beams should be perpendicular to daylight windows.

Extra Shading on South or West Orientation

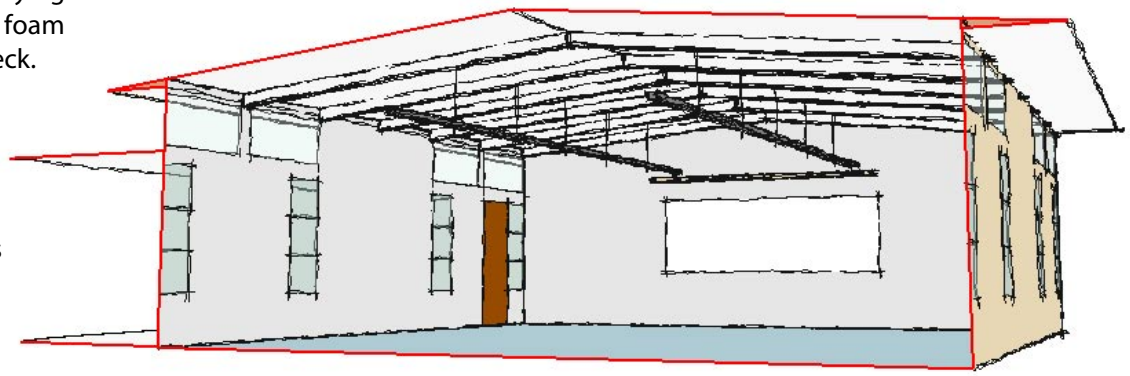
Consider installing a walkway cover/light shelf on south and/or west side, as shown, to prevent direct sun from striking the windows.

Optional Skylights for Daylighting

Skylights can be employed in place of the daylighting glazing (high windows) in this example.

Electric Lighting

The recommendations for the other classrooms apply to portables.



Section view looking west*

Wall Insulation

Insulate with R-13 batt insulation in walls with 2 x 4 framing, or R-19 in 2 x 6 walls: either fiberglass, cellulose, or cotton. As an alternative, use a white or very pale exterior color and a radiant barrier installed in the wall cavity.

Natural Ventilation Inlets

Approximately 40 ft^2 ventilation area per each opposing wall (ideally north and south) at occupant level (assuming a classroom of about 900 ft^2). Operable windows seal tightly for warm season. Casement, awning, or hopper-type windows are appropriate.

*Site constraints may prevent the optimal north/south orientation.

Gymnasium Prototypes

These gym prototypes illustrate several options for harnessing daylight as a primary lighting source. The prototypes also address design features to maximize thermal comfort in gyms using natural ventilation and solar heat gain control. Gyms in Hawaii schools are typically constructed without air conditioning.

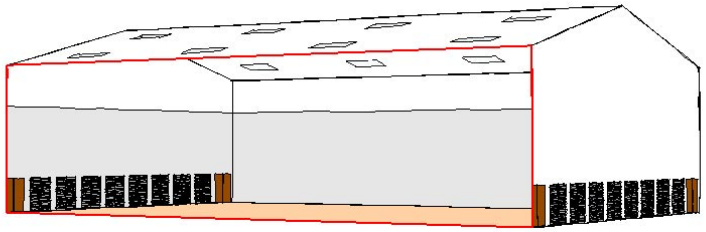
Gym Prototypes with Horizontal Daylighting Glazing

Skylights for Daylighting

Light-diffusing skylights avoid bright spots caused by direct sunlight. Skylight area equals roughly five percent of roof area: 16 skylights, each 4 ft by 8 ft, in this example.

Reflective Interior Surfaces

Color ceiling and walls white—especially the upper portion of the walls—for more efficient lighting performance.



Flexible Orientation

The use of skylights for daylighting frees the designer to choose the building orientation that works best for cross ventilation or fits within other site constraints.

Efficient Lighting

(not shown on illustration)

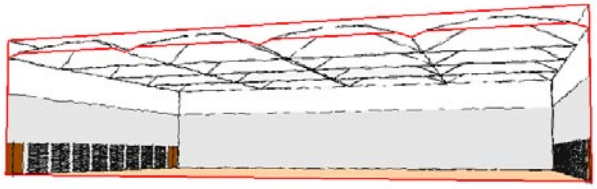
Fixtures with the latest T-5 or T-8 fluorescent lamps are an ideal choice for gyms. Special luminaires are available for this application, more efficient than HID fixtures, and without warmup and restrike time constraints. Fluorescent lamps are much easier to control as part of an automatic daylighting system.

Ventilation Openings

Louvers in opposite walls provide cross ventilation for comfort. Ideally they are located at occupant level and on the longer sides for shorter airflow path across the building. For walls that have bleachers that block access to the lower portion of the wall, provide additional ventilation in other walls.

Envelope Solar Control

Keeping the ceiling and walls cool is critical for maintaining comfort. For the roof, good options include three inches of foam board insulation or two inches of insulation combined with a white membrane. Sloped roof preferred for better drainage. For walls, provide shading with overhangs or paint them white.



Skylights with Splayed Wells

This alternative with splayed skylight wells provides a more comfortable visual environment, and a more evenly illuminated ceiling.

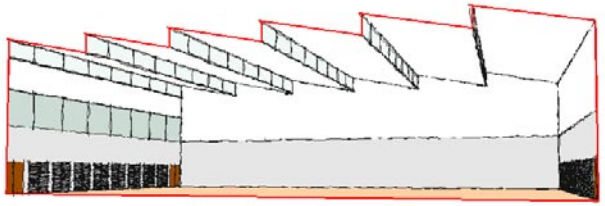
Gym Prototypes with Vertical Daylighting Glazing

Sawtooth Roof Daylighting

North-facing glazing provides excellent daylighting while minimizing solar heat gain.

White Roof Surface

A reflective roof surface significantly increases the amount of light captured by the sawtooth glazing.



Additional Daylighting Windows

Windows on the north wall are recommended for supplemental light at the north end of the gym, because this wall is not directly illuminated by a clerestory. Or, as an alternative, a few skylights in the roof at the north end can provide illumination of the north interior wall.

Clerestory Daylighting

Windows are oriented north/south (only one side appears in the sketch). Avoid east/west orientations due to heat gain and glare problems. Locate clerestory windows in the longer wall. Windows should be as high as possible to improve the depth of daylight penetration into the center of the gym.

Overhangs for Window Shading

Overhangs or other types of exterior shades are necessary to block direct sunlight from entering the gym.