

Background and Context

This long-term school project began in 1997 when the Drukpa Trust (under the patronage of the Dalai Lama) initiated a masterplanning effort with Arup Associates. From this planning, detailed designs for several phases of development were prepared. The school will serve 750 elementary and high school students when all phases are completed. In addition to providing for typical school functions, students from distant towns and villages (and their house parents) will reside in on-site dormitories.

Arup has provided a leave-of-absence for an architect or engineer from the design team so they might reside at the school during the summer months to assist local builders with the project. The building team is a diverse group, which include British design professionals, Pujabi carpenters, and Nepalese laborers. The construction of the first building proved to be a learning experience about design appropriateness, materials supply, local construction techniques, and project management.



5.2 A series of outdoor classrooms comprise the courtyard of the Druk White Lotus School. The planter boxes shown in this photo await the planting of deciduous trees. CAROLINE SOHIE, ARUP PLUS ARUP ASSOCIATES

The overriding design goal for the school was to provide flexible, high-quality teaching spaces in a sustainable building. The design and construction were to respect local building materials and appropriate building technologies (both traditional and modern). The school should be a model of appropriate and sustainable modernization for Ladakh. Underlying this intent was an imperative to

DRUK WHITE LOTUS SCHOOL



5.1 The Druk White Lotus School site is in a high desert valley bounded on the north by mountains. CAROLINE SOHIE, ARUP PLUS ARUP ASSOCIATES

LOCATION

Shey, Ladakh, India
Latitude 34°N
Longitude 77° 40'E

HEATING DEGREE DAYS:

14,785 base 65°F
[8214 base 18°C]

COOLING DEGREE DAYS

0 base 50°F
[0 base 10°C]

SOLAR RADIATION

Jan 640 Btu/ft²/day
[2.02 kWh/m²/day]
Jun 1,886 Btu/ft²/day
[5.95 kWh/m²/day]

ANNUAL PRECIPITATION

2 in. [50 mm]

BUILDING TYPE

School

CLIENT

Drukpa Trust

DESIGN TEAM

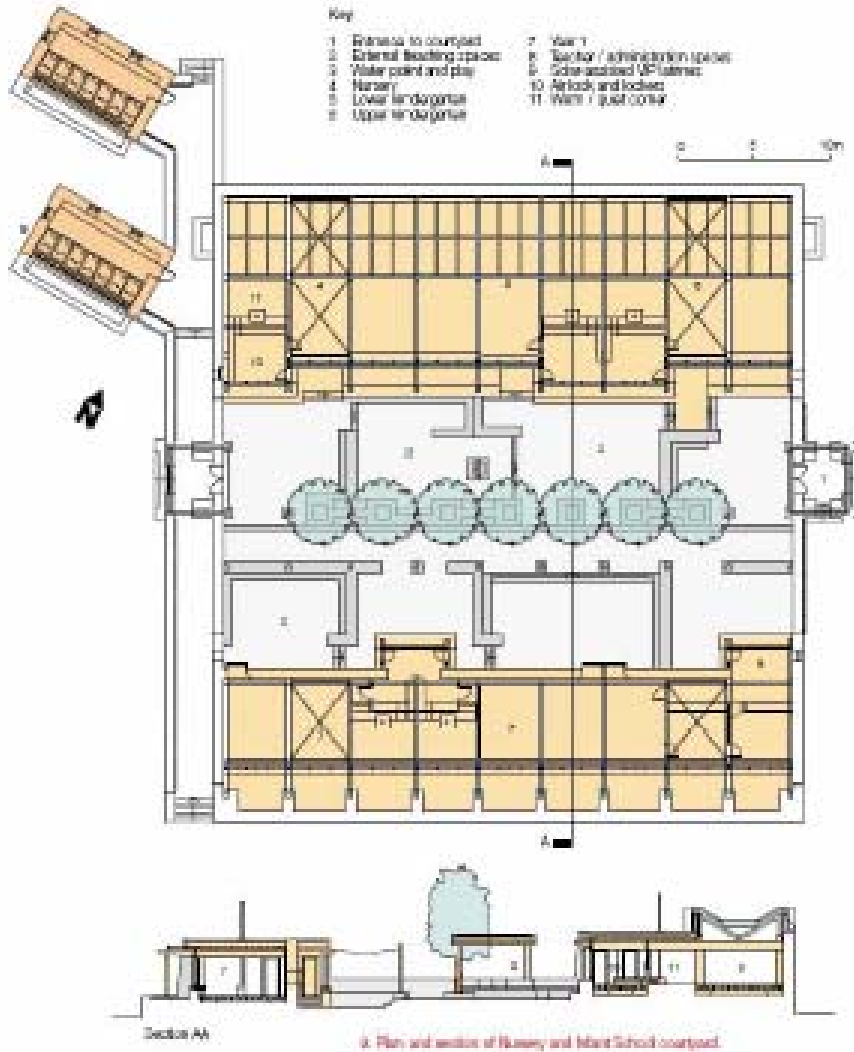
Arup Associates and Ove Arup & Partners

COMPLETION

Phase 1: 2001
Phase 2: 2004
All phases by 2009

use no imported energy, to maximize the potential of solar radiation in a high desert climate, and to provide potable water and treat wastewater on site.

As a result of a successful pre-construction planning and design efforts, the first phase of the school was completed under budget and also within acceptable local cost constraints—around 15% of the cost of a similar school in the UK. The design team intends to inform ongoing design and construction decisions by tapping into experiences from Phase 1. An attempt will also be made to optimize expenditures, given the limited resources of the client and the balancing of value between capital investments and financially sustainable operations.



5.03 Plan and site section showing nursery and infant school courtyard. ARUP ASSOCIATES

Design Intent and Validation

This ambitious project was intended to become a model sustainable school—a vision presented at the September 2002 Johannesburg Earth Summit. The Druk White Lotus School addressed (and will address) the realities of construction, energy, site infrastructure, buildings, material resource use, and project management in a challenging site context. The project also serves to demonstrate a new approach to teaching in a unique rural community. This demonstration should contribute to the development of appropriate building technologies and methodologies in remote locations worldwide.

Arup developed and used powerful software tools to analyze the performance of the ventilated Trombe walls, the feasibility of using wool as a thermal insulation, the desirability of double glazing, and the application of daylighting. The design team also had access to the firm’s broad seismic engineering experience. Many in Arup have experience examining the effects of earthquakes, often in developing countries. Lessons learned from these experiences were applied on the Druk White Lotus project. The resulting design balances economic and environmental factors while meeting the needs of the school’s students and teachers.

As reported in the *Arup Journal*, Arup Project Director Rory McGowan said: “We had great ambitions when we began this project believing that high-powered engineering software and the latest thinking in design could be applied just as easily to Ladakh as to a London office block.” Arup realized that this approach wouldn’t work when it became clear that the cost and difficulty of importing materials to the remote site would make the use of mud brick, granite, and wood preferable to steel. Site manager Sonam Angdus, who was raised in the nearby village of Shey, said: “Everyone agreed on granite walls with a mud core. These are stable and well insulated and they blend in naturally with the surroundings. They are also available locally.”



5.4 Arup designed the project to work with local construction crews. CAROLINE SOHIE, ARUP PLUS ARUP ASSOCIATES



5.5 The Druk White Lotus School classrooms appear to emerge from the landscape. Their orientation takes advantage of early morning solar access.

CAROLINE SOHIE, ARUP PLUS ARUP ASSOCIATES

Strategies

The Druk White Lotus School employs a range of green design strategies appropriate to its remote high desert climate.

Passive solar heating. The classroom buildings are oriented 30° east of true south with an elongated east-west axis to assure early morning warm up. There is abundant sunshine all year long in the high desert climate—even during the winter when temperatures can fall to -22°F [-30°C]. Indirect gain Trombe walls (made of ventilated mud brick) and granite cavity walls with double glazing provide evening heating in the dormitories. Small wood stoves are provided for back-up heating. All residential buildings are oriented on a true north-south axis to maximize daily solar gains. The solar-assisted latrines have a solar wall (Figure 5.xx) facing directly south for the same reason.

Superinsulation. The roofs are constructed using local poplar rafters, willow sheathing topped with mud and rock wool, and felt insulation. The weather skin is of sand and aluminum sheets.

Air locks. Air locks are provided at the entries to the classroom buildings; these act as a buffer between the cold exterior and the warm interior in the winter.

Daylighting. The classrooms are designed to optimize the use of daylight. In the wider Nursery and Kindergarten Building, light admitted by the direct gain solar windows is balanced by toplighting provided by north- and south-facing clerestories diffused by a splayed ceiling. No electric lighting is typically used in the classrooms.

Natural ventilation. All the rooms have well-shaded operable windows that allow cross-ventilation that provides a cool, glare-free, teaching environment.

Migration. Migration involves moving from one environment to a more comfortable or interesting environment. The courtyards between the classroom buildings are subdivided into smaller spaces where classes may be held on mild, sunny days. The school buildings and courtyard trees provide shade and wind protection for these spaces.

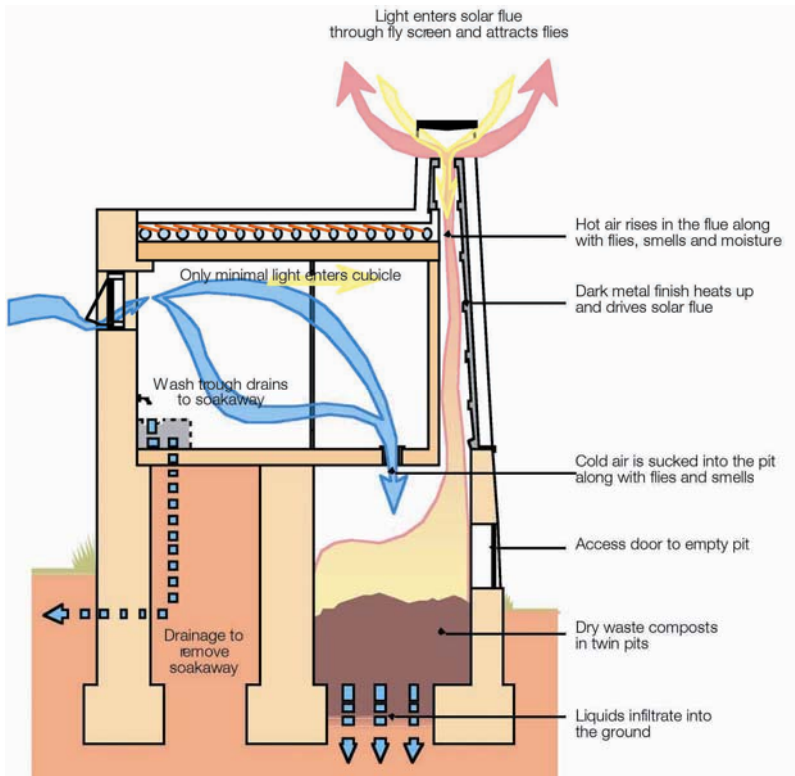
Water use. The Druk White Lotus School is located in a desert, so water is precious. Groundwater extracted from a 105-foot [32 m] deep well is pumped by PV power to a 16,000-gallon [60,560 L] storage tank located on ground higher than the buildings. A new well is planned for a location above the storage tank in order to eliminate the need for pumping. When not needed for pumping, the PV system charges batteries that provide power to the school's computers. Waterless "ventilated improved pit" (VIP) toilets (latrines) use solar-assisted stack ventilators to help process waste into odorless compost—an excellent fertilizer.



5.6 School rooms feature southeast-facing direct gain windows that ensure early morning warm-up in Shey's sunny climate. CAROLINE SOHIE, ARUP PLUS ARUP ASSOCIATES



5.7 Clerestory and view windows provide balanced daylight to the classrooms. CAROLINE SOHIE, ARUP PLUS ARUP ASSOCIATES



5.9 The composting “VIP” latrine uses solar assisted stack ventilation for drying and odor control. ARUP ASSOCIATES



5.8 The splayed roof acts as an indirect daylight source in the classroom. Note the lack of electric luminaires. CAROLINE SOHIE, ARUP PLUS ARUP ASSOCIATES



5.10 The latrine building with solar collector. CAROLINE SOHIE, ARUP PLUS ARUP ASSOCIATES

Materials. Design emphasis was placed on the use of local materials. Soil from the site was used in roof construction and the mud bricks for the inner walls were hand made in Shey. The granite blocks of the exterior wall are formed and finished from stone found on the site or gathered from the surrounding boulder field. Nearby monastery plantations grew the willow used in the roof construction.

How's It Working?

Arup has been monitoring building performance and site comments to provide feedback for its practice. Construction on the school will span up to eight years (2001-2009). A senior design team member visits the site in April (at the beginning of each year's building season), followed by an Arup resident who typically remains on site for around four months starting in June. Building performance feedback was already being collected at the time the Nursery and Infant School and Junior School were completed and brought into use,

The design team and the Drukpa Trust both anticipate a continuous learning process regarding the school's performance as it is used and evolves over the next few years. Lessons learned from this experience will inform the remaining design and construction work.

Sustainable design for this project means that the buildings must be constructed within local cost parameters as well as employ natural and local resources. The Druk White Lotus School has garnered positive feedback from the architectural community. It won World Architecture Awards in 2002 as Best Education Building of the Year, Best Green Building of the Year (joint winner), and Regional Winner—Asia.



5.11 Mud brick walls are made of local materials. ARCHITECTUREWEEK.COM ???



5.12 Granite block facing is stable and also locally obtained. CAROLINE SOHIE, ARUP PLUS ARUP ASSOCIATES



5.13 Roofs are constructed of local poplar rafters and willow sheathing. ARCHITECTUREWEEK.COM ???



5.14 A typical classroom interior. CAROLINE SOHIE, ARUP PLUS ARUP ASSOCIATES

Further Information

Arup Associates WWW site: www.arupassociates.com

Druk White Lotus School WWW site: www.dwls.org

References

Barker, D. 2002. "Building a School in India," *Architecture Week*, 31 July 2002.

Fleming, J. et al. 2002. "Druk White Lotus School, Ladakh, Northern India," *The Arup Journal*, 2/2002.