

SOIL AS SKIN

ANCIENT RAMMED EARTH AND PASSIVE SOLAR TECHNOLOGIES IN THE MODERN AGE



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Canton de Berne



ADVANCED
BUILDING SKINS

AGENDA

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PROJECT INTRODUCTION



- Brief description
- Location
- Facts and challenges

PROJECT DEVELOPMENT



- Our approach
- Research and design
- Testing, developing and constructing

PROJECT RESULTS



- What we learned
- Benefits
- Summary



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PROJECT INTRODUCTION

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Ecological, sustainable and self-contained campus designed to provide quality education and facilities for 240 students, with expansion for up to 300 students by 2020. This new campus is part of a comprehensive school development project (spiritually and financially supported by His Holiness the 14th Dalai Lama), which has been collaboratively researched, designed and is being implemented with the local community.



FULLY BASED ON PASSIVE SOLAR ENERGY

- Heating
- Electricity
- Ventilation
- Hot water

ENHANCED LADAKHI BUILDING TECHNOLOGY AND MATERIAL

- Stabilized rammed earth insulated walls
- Window decoration
- Clay roof
- Double glazing

ENHANCED LADAKHI CONCEPTS

- Water supply and distribution using canal systems
- Channel irrigation system
- Composting toilets

ADAPTATION OF NEW CONCEPTS

- Passive solar construction details
- Water treatment systems
- Waste management
- Construction planning and management

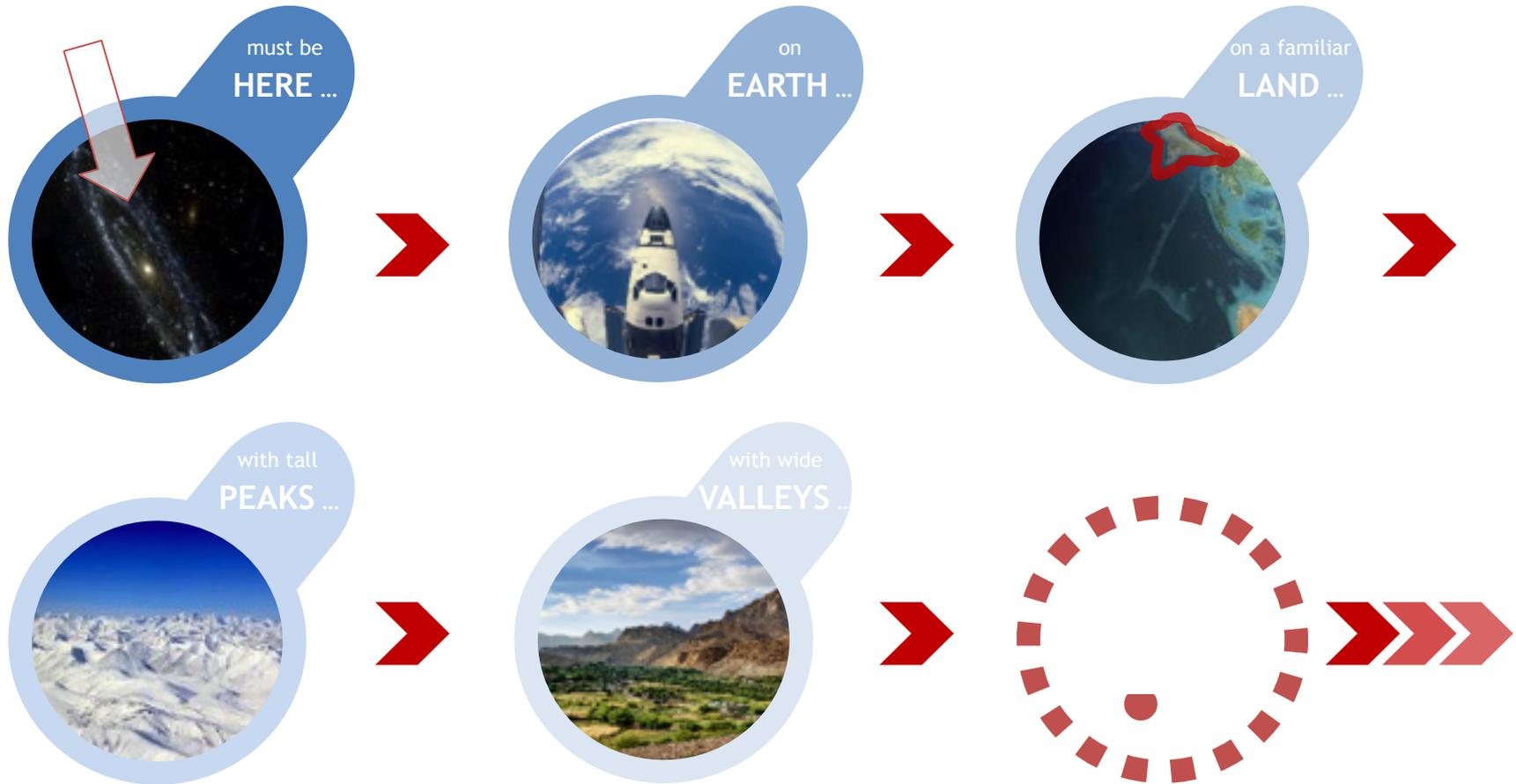


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PROJECT INTRODUCTION - LOCATION

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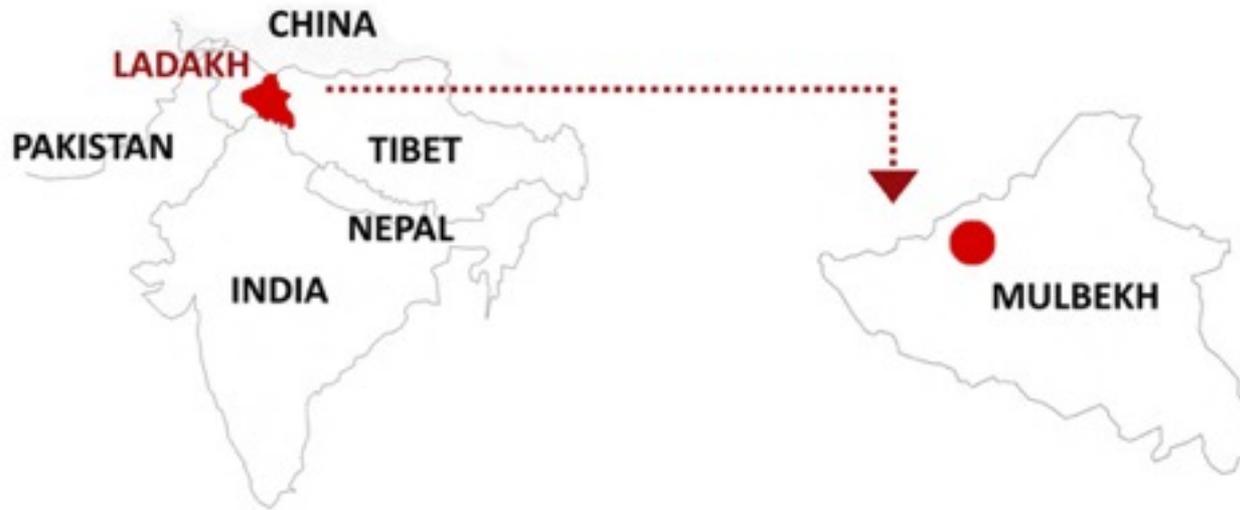
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PROJECT INTRODUCTION - LOCATION

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LADAKH

- “Land of high passes” lies in the Himalayas, inhabited by people of Indo-Aryan and Tibetan descent.
- One of the most sparsely populated regions in Jammu and Kashmir.
- Its history are closely related to that of Tibet.

MULBEKH

- One of the few Buddhist villages in Kargil district on the way to Kashmir.
- Located in Mulbekh valley, 7 hours from the capital, **LEH**.
- The population of Mulbekh valley is 6000 residents, spread widely.

LEH

- The capital of Ladakh situated at 3,500 metres above sea level.
- Population is approximately 22,000.
- Its history goes far back to 9th century AD.



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PROJECT INTRODUCTION - LOCATION

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Mulbekh valley, 2012



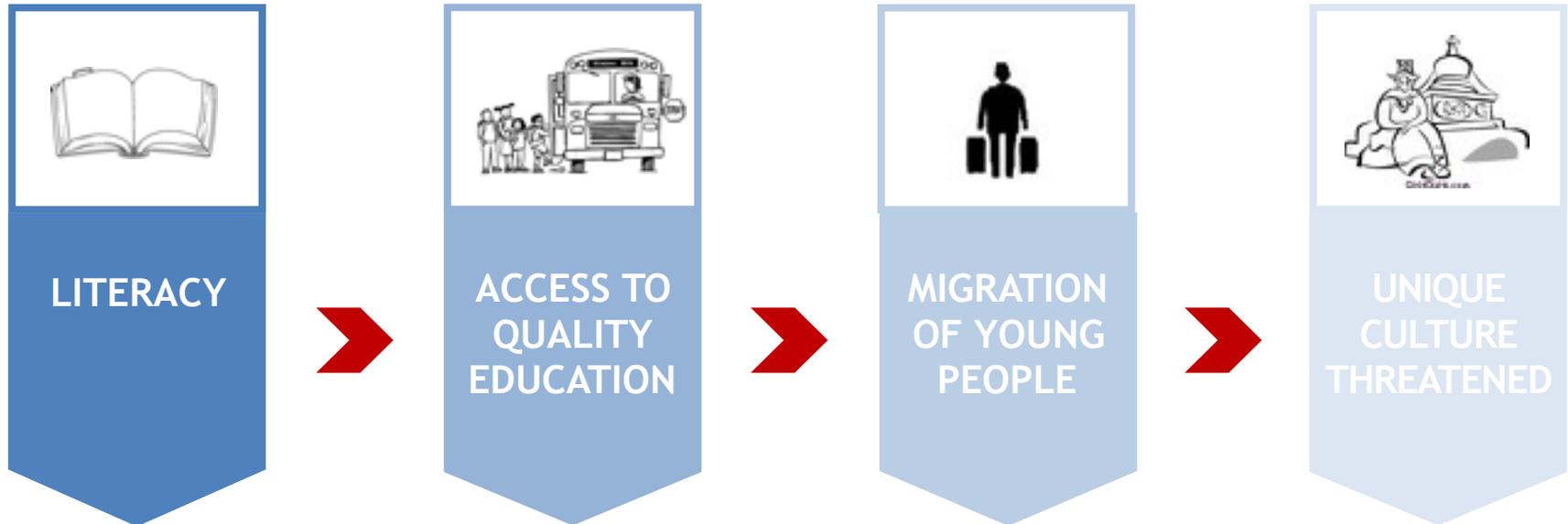
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PROJECT INTRODUCTION - FACTS AND CHALLENGES

SOCIOLOGICAL

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- Literacy rate in Kargil District is 58% (74% males; 41% females)
- Literacy rate in Leh District is 62% (72% males; 50% females)
- 65% of children attend school
- Pass rate at school leaving level (grade 10) is 5-10%

- Walking distance 3-5 km up to 1 day away
- Lack of long-term committed qualified and experienced teachers
- Lack of quality educational infrastructure and facilities

- Children and young people are leaving the valley to get better and higher education and career opportunities elsewhere
- Small percentage of young people who left to get their education elsewhere return back

- Loss of traditions, unique culture and identity
- Extinction of rural villages and settlements
- Big cities are becoming overcrowded - housing, water and waste problems



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PROJECT INTRODUCTION - FACTS AND CHALLENGES

GEOGRAPHICAL

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- 30 c in the winter + 30 c in the summer

mountain desert

limited construction material

4-6 month construction season

shortage of skilled workers

+ 3500 m above sea level

complicated terrain



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PROJECT DEVELOPMENT - OUR APPROACH

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COMMUNITY
BASED
COLLABORATION
AND CAPACITY
BUILDING

RESEARCH

DESIGN

PLANNING

TESTING

CONSTRUCTION



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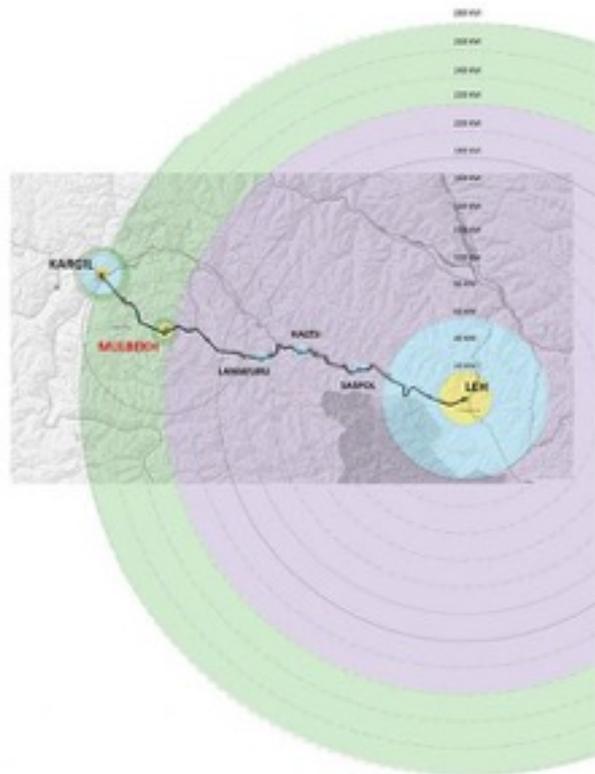
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PROJECT DEVELOPMENT - RESEARCH AND DESIGN

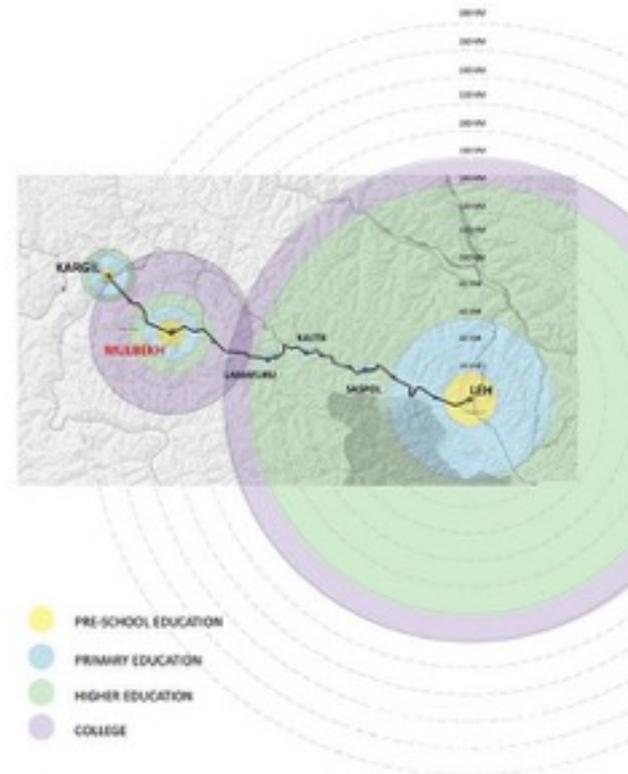
DEMOGRAPHIC - REGIONAL EDUCATION DISTRIBUTION

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EXISTING DISTRIBUTION OF EDUCATION IN THE REGION



EXPECTED DISTRIBUTION OF EDUCATION AFTER PROJECT COMPLETION



Existing and expected distribution of education in Leh (Buddhist) and Kargil (Muslim) district after the new ecological campus in Mulbekh is completed.



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PROJECT DEVELOPMENT - RESEARCH

ARCHITECTURE, BUILDING MATERIAL AND TECHNOLOGY

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TRADITIONAL ARCHITECTURE

- Two-floor building divided into summer - 1st floor, with large windows, and winter part.
- Typical structure: Mud brick wall, mud plaster, wooden floor/ceiling, flat mud/clay roof, small wood frame windows in the ground floor (winter) and north walls.
- New trends in architecture: one-floor building, concrete frame structure, concrete and mud brick infill, concrete floor slab and floor, pitched corrugated iron sheet roof, aluminum windows.



CONSTRUCTION MATERIAL & TECHNOLOGY

- Traditional mud brick walls.
- New concrete frame structure with brick infills - concrete and mud bricks.
- Mud wall structures have a long history but are seen as a substandard ancient technique. They are used only to divide and protect land.
- Roofs are typically constructed with branches, straw/hay, mud layers to fall and clay layers as waterproofing (Markalak).



HEATING SYSTEMS/RESOURCES

- Kitchen is typically the only warm room in the house.
- Heating happens only during cooking on a metal stove.
- Typical fuel sources of heating: wood branches, dung and kerosene.
- New fuel source of heating: electricity, propane and simple use of passive solar principles.



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PROJECT DEVELOPMENT - RESEARCH

ARCHITECTURE AND BUILDING MATERIAL AND TECHNOLOGY

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PASSIVE SOLAR PRINCIPLES

- Basic use of passive solar principles is used on buildings built in the last 5 years
- Government initiated program to retrofit old houses to passive solar houses.

HOT WATER SYSTEM

- Water is still heated on their traditional stoves
- New technologies based on solar energy: solar panels, solar cookers, solar ovens.



WATER SUPPLY AND DISTRIBUTION

- Water and snow retention reservoir in the mountains.
- Water canals bring water from reservoirs or rivers.
- Irrigation channels.

ELECTRICITY

- Diesel generators in the villages.
- Recently, villages are being centrally connected to hydro plant generated electricity.
- Photovoltaic panels are becoming popular.



TOILETS AND WASTE WATER

- Basic composting toilets emptied once a year.
- No waste water management - brown from the kitchen and bathroom is drained to the ground without any treatment.

TOOLS AND EQUIPMENT

- Very simple hand tools and equipment.
- No electricity-powered tools or equipment.



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PROJECT DEVELOPMENT - DESIGN AND PLANNING

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SOIL

- Stone
- Wood



STABILIZED RAMMED EARTH

- Masonry - mud bricks
- Stone foundation



PASSIVE SOLAR

- Day use buildings
- Night use buildings



CROSS VENTILATION

- Passive solar principle - chimney effect



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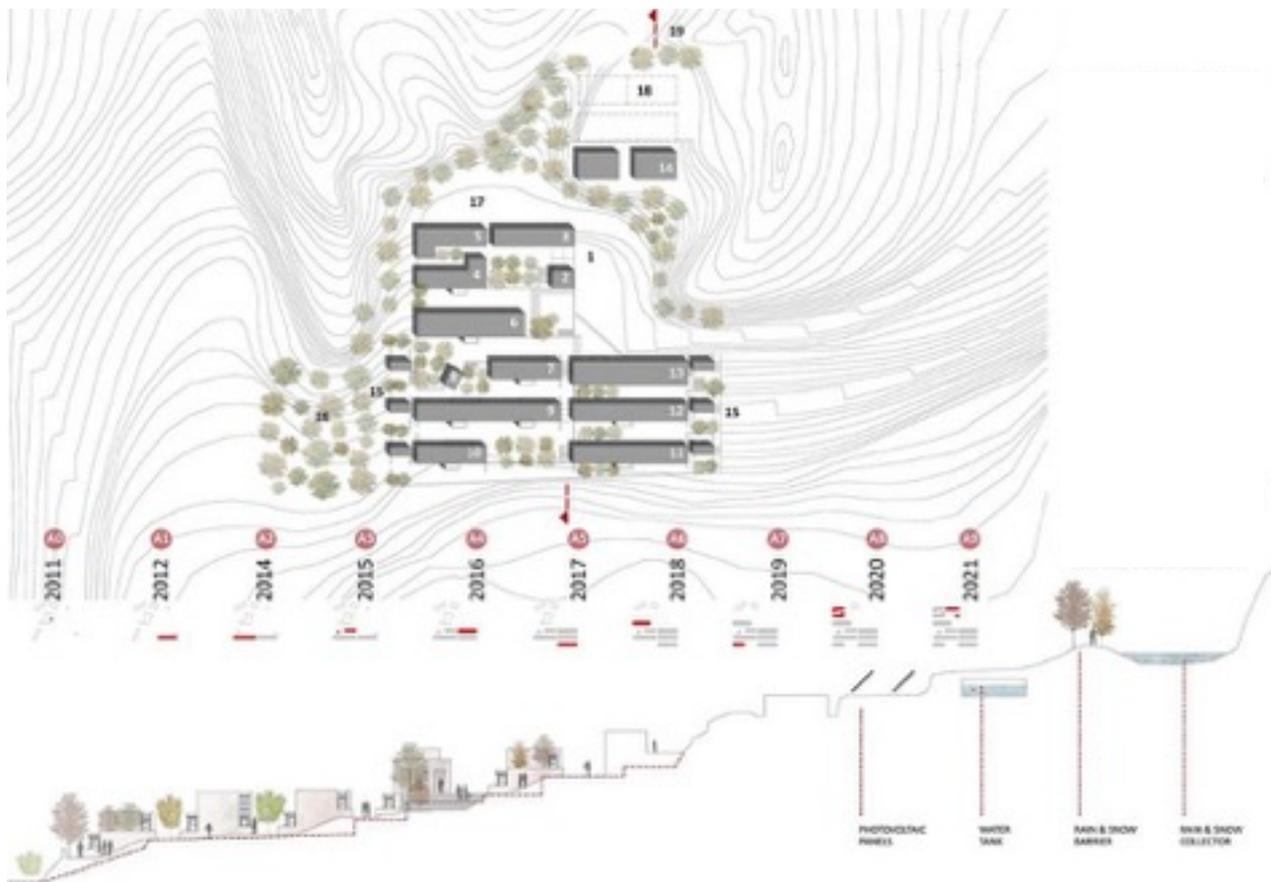


PROJECT DEVELOPMENT - DESIGN AND PLANNING

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PROPOSED MASTER PLAN AND PROJECT PHASES

LEGEND



1. Main entrance
2. Information
3. Administration
4. Library, LKG, UKG
5. Accommodation - Teachers
6. Prayer Hall, Arts Classrooms
7. Labs and Computers
8. Student Centre
9. Classrooms
10. Classrooms
11. Accommodation - Girls
12. Accommodation - Boys
13. Kitchen, Dining Hall, Laundry, Campus Maintenance
14. Photovoltaic Panels
15. Composting Toilets
16. Vegetable Garden, Orchard
17. Staff Carpark
18. Water Tank
19. Rain & Snow Collector



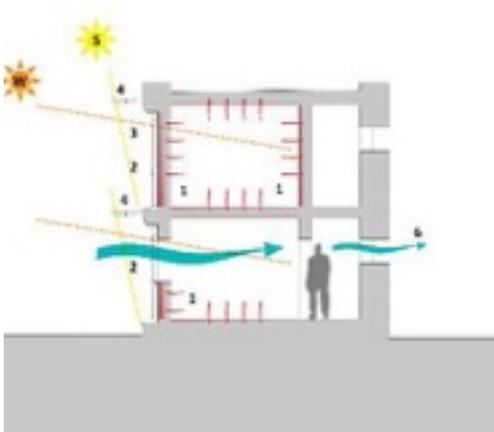
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PROJECT DEVELOPMENT - DESIGN AND PLANNING

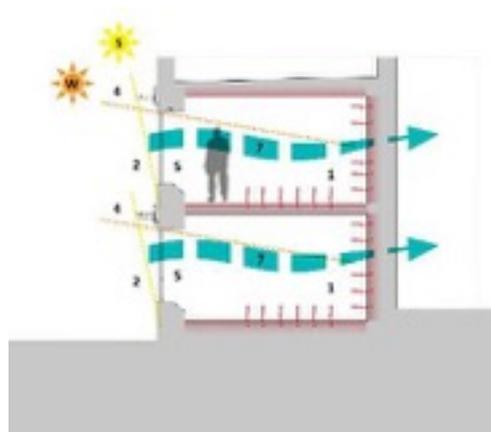
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NIGHT - USE BUILDINGS (ACCUMULATION OF HEAT IN THERMAL MASS)



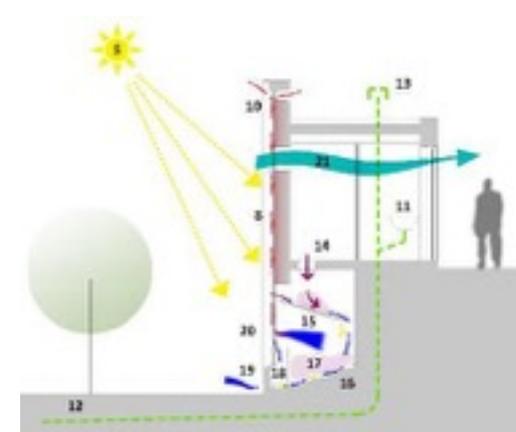
- Strong solar radiation passes through the glass wall and transforms into heat.
- During the day heat is stored in the thermal collector - rammed earth wall.
- After sun sets heat is slowly released inside.

DAY - USE BUILDINGS (DIRECT HEAT GAIN)



- Solar radiation is directly transformed through large windows into heat - greenhouse effect.
- Small percentage of heat accumulation.
- Outside horizontal louvers to control overheating in the summer.

COMPOSTING TOILET VENTILATION (CHIMNEY EFFECT)



- Solar radiation heats the curtain wall and creates a chimney effect behind.
- Rising hot air, behind the curtain wall, creates negative pressure in the composting area which helps with ventilation and drying/ripening of the compost.

1 ... Thermal Mass (Stabilized Insulated Rammed Earth, 2 ... Double glazing, 3 ... Roller Blind, 4 ... Enhanced Traditional Ladakhi Window Decoration, 5 ... Curtain, 6(7) ... Cross Ventilation, 8 ... Black Corrugated Metal Sheet to create a Chimney Effect, 10 ... Hot Air Exhaust, 11 ... Basin, 12 ... Drainage, 13 ... Sewage Vent, 14 ... Human Waste, 15 ... Separation of Liquid Parts, 16 ... Sloped Perforated Bed, 17 ... Compost, 18 ... Liquid Waste Excess, 19 ... Air Intake, 20 ... Maintenance Access



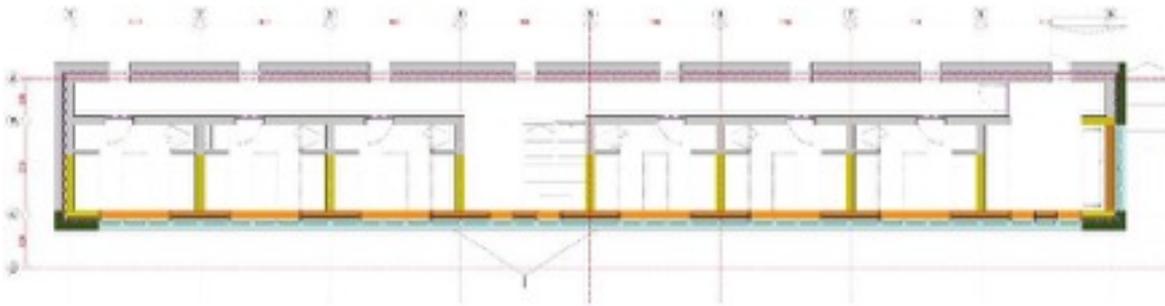
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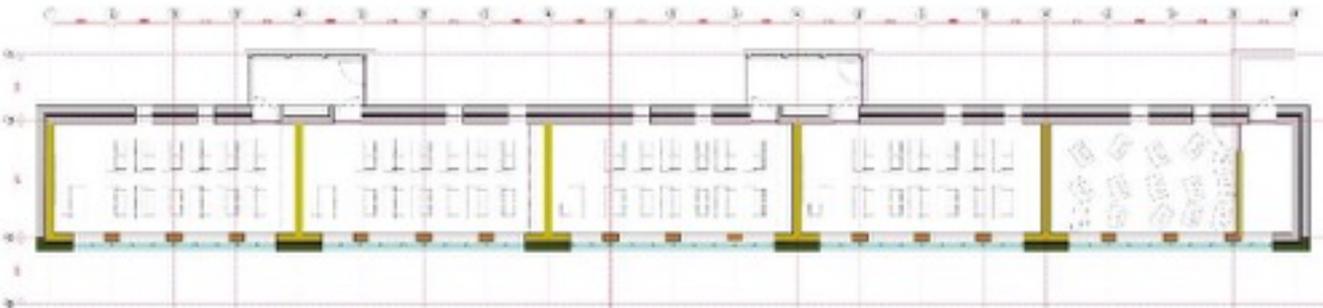
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NIGHT - USE BUILDINGS (ACCUMULATION OF HEAT IN THERMAL MASS - STABILIZED RAMMED EARTH WALLS)



DAY - USE BUILDINGS (DIRECT HEAT GAIN)



GENERAL DESIGN PRINCIPLES

- Shallow rooms with low ceilings
- South facing
- Circulation and storages at the back (north) of buildings
- Entrance halls as buffer zones
- Material with high accumulation properties
- Insulation
- Double glazing
- Passive overheating control system



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WALLS

- Walls not strong enough
- Cracks due to shrinking
- Wall connections not precise
- Wall finishing not consistent - aesthetic issue



FORMWORK

- Traditional formwork (planks) not strong enough
- Formwork connections not precise
- Formwork not stable in heights
- Slow



CURTAIN WALL AND SUN CONTROL

- Overheated building
- Traditional window decoration not deep enough to protect the glass curtain wall
- Glass cracks due to expansion



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PROJECT DEVELOPMENT – TESTING, DEVELOPING AND CONSTRUCTING

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WALLS

- Required strength achieved by finding the right ratio
- Wall shrinking eliminated by using less amount of clay
- Stronger formwork improved wall connections and final wall finish



FORMWORK

- Different materials and systems tested to improve strength
- Waterproofed plywood with steel struts improved strength, stability and quality of walls
- Bigger formwork system increased speed of construction



CURTAIN WALL AND SUN CONTROL

- Overheating controlled by adding horizontal louvers to the Ladakhi window decoration
- Co-designed with local carpenters



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ROOF

- Traditional roof build up
 - Branches
 - Hay/grass
 - Dump soil
 - Clay layers (+ sand layer)



CEILING

- Wooden logs
 - Always odd number per room
- Wooden bond beam
 - Newly introduced to improve overall strength of buildings



SOUTH FACADE

- Glass curtain wall
 - Double glazing, wooden frame
 - Able to open for maintenance
- Stabilized rammed earth wall with black paint
- Enhanced Ladakhi window decoration



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STUDENT ACCOMMODATION BUILDING IN PROGRESS

- Double walls with an air gap to the north, east and west façade
- Small windows to the north façade
- Wooden bond beam tightening walls together
- Enhanced Ladakhi window decoration installation
 - Horizontal louvers support
 - Mud bricks
 - Mud filling
- Curtain wall frame
- Stabilized rammed earth wall
- Enhanced Ladakhi window decoration controlling building overheating



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CLASSROOM BLOCK CONSTRUCTION IN PROGRESS

- Enhanced Ladakhi window decoration including a curtain box
- Large window openings to maximize direct heat gain
- Reinforced stabilized rammed earth pillars
- Stabilized rammed earth walls
- Floor wooden beams
- Wooden bond beam
- Brick staircase
- Floor build up
 - Wooden beams + planks
 - Hay
 - Soil
 - Wooden floor (planks)



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PROJECT RESULTS - SUMMARY

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Compared to the local standards, environment and conditions we have learned that by using a combination of stabilized rammed earth wall structures and passive solar technologies, while respecting the traditional architecture and using locally available building material, both the infrastructure and quality of life can be improved.



STRUCTURAL IMPROVEMENTS

- Strength
- Earthquake resistance
- Durability

HEALTH AND SAFETY IMPROVEMENTS

- Air, sound and heat quality
- Stable indoor humidity and climate
- Chemical free
- Stronger structure - safer

SOCIOLOGICAL IMPROVEMENTS

- Improved access to quality education
- Return to traditional architecture
- Capacity building/development of skills
- More time freed up for women

ECONOMIC IMPROVEMENTS

- Use of local resources
- Reduction of operating cost - heating, cooling, light
- Support of local businesses and creation of new opportunities



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PROJECT RESULTS

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Southeast view, student accommodation (right) and classrooms (left), 2014



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PROJECT RESULTS

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Southwest view, classrooms (left) and student accommodation (right), 2014



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PROJECT RESULTS

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Student accommodation - main activity hall, 2014



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PROJECT RESULTS

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Classrooms - typical classroom, 2014



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Project presentation, Dharamsala, 2011,



Project report, Leh, Ladakh, 2013



Project report, Leh, Ladakh, 2014





THANK YOU / JULLEY.



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