IDARA (INSTITUTING WATER DEMAND MANAGEMENT IN JORDAN)

Affordable Housing for the Future Competition: Innovative Ideas for the Design of a Model Water- and Energy-Efficient Low-Income Apartment Building in Abu Alanda, Jordan - A Reference Guide to Architects, Engineers, and Developers.

February 2012

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IDARA – Affordable Housing for the Future Competition Report

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CREDITS

This reference guide was prepared by Joud Khasawneh of the Center for the Study of the Built Environment (CSBE), in coordination with mechanical engineering consultant Muthafar Emeish.

The guide was reviewed and edited by Mohammad al-Asad and Lara Zureikat of CSBE.

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ABBREVIATIONS AND ACRONYMS

HUDC	Housing and Urban Development Corporation
IDARA	Instituting Water Demand Management in Jordan
ASHRAE	American Society for Heating Ventilation and Air Conditioning Engineers

INTRODUCTION

Instituting Water Demand Management in Jordan (USAID-IDARA) organized a competition for energy-and water-efficient practices in the low-income housing sector in Amman. This task is part of a larger scope focused on disseminating water- and energy-efficient practices among housing institutions and practicing architects and engineers. The competition focused on the apartment building as the target building type, since it represents the majority of new available housing typologies in Amman. USAID-IDARA coordinated with the Housing and Urban Development Corporation (HUDC) to locate an actual site for the competition, and a site in the Abu-Alanda 'Decent Housing for Decent Living' projects was chosen.

The competition was announced in January 2010 (Click here to view the Competition Announcement). Thirteen submissions were received and reviewed in mid 2010 by a jury comprised of six distinguished architects: Tawfiq Abu-Hantash, Meisa Batayneh Maani, Khaled Jayyousi, Farouq Yaghmour, Ayman Zuaiter, and Richard Brittain. Following the jury deliberations, three projects were awarded and asked to further develop their designs in a second-round competition (Click here to read the jury reports). Winners were chosen based on the following criteria:

1. Offering creative solutions to water and energy efficiency.
2. Consideration of the apartment building type and possible conservation aspects in its design.
3. Satisfaction of aesthetic and functional aspects.
4. Cultural and social suitability of the design to the customs of the intended inhabitants.
5. Responsiveness to site location and topography.
6. Responsiveness to climatic conditions in the region.
7. The use of local building materials and construction methods, as well as ease of implementation.
8. Low construction costs, as well as low running costs.
9. Scalability and applicability of the design or major ideas in the design to other site locations and building types in Jordan.

Even though not all the entries expressed high standards in terms of fulfilling these criteria, many of them suggested innovative solutions to water- and energy-efficiency in the housing sector in Jordan. The following report summarizes these ideas and assesses them. The report ends with a comparative matrix listing the best three water and energy efficient solutions suggested for each design and construction aspect of the project.

This report is intended to act as a reference on water- and energy-efficient apartment buildings for architects, engineers, contractors, and developers working in the low-income housing sector.

SUMMARY AND ASSESSMENT OF WATER AND ENERGY EFFICIENT IDEAS PRESENTED IN THE ENTRIES

This section summarizes and assesses each of the submitted designs. The assessments are arranged according to the following topics: Urban design, building design, building technology, electro-mechanical systems, and building use.

Entry 1 - **By: Nader Chalfoun, Omar Al-Hassawi, Virginia Cardona, and Natalia Pineyro; Additional Support: Mark Fredrickson**

Click here to view entry submission.

Urban Design

- The buildings are directed along the east-west axis, with the longest façade oriented towards the south. This allows them to utilize the southern sun's rays during the cool winter months.

- Compact Mass:
  The building masses are compacted to maximize open space and insure that buildings do not cast shade upon each other.

Building Design

- Orientation:
  The orientation of the building towards the south does not equally benefit the four apartments on each floor, with some apartments having a mostly northern exposure, and a very small segment facing south.

- The compact masses of the buildings help decrease their external surfaces, which are susceptible to heat gain and loss.

- Layout:
  - The southern apartments are well laid-out, with living spaces facing south, and services and bedrooms facing north. The northern apartments have fewer spaces facing south, and their living rooms have very small openings facing south.
  - Water-served spaces are located adjacent to each other. This helps decrease the length of hot water pipes connecting the boilers (or heaters) to the faucets in the kitchens and bathrooms, and also minimizes heat loss in the pipes.

- Placement of Openings:
  The design of the building induces cross ventilation from the north facade to the south one. Openings are mostly located along the buildings' north and south facades. However, the staircase blocks part of the north side of the building and

prevents the wind from entering the opposite apartment. The buildings fail to take advantage of the prevailing winds that come from the west as there are very few openings facing that direction.

- Architectural Features & Landscaping Elements:
    - Shading: The design uses efficient permanent shading solutions for windows along the west and south façades. The shading detail below (Fig. 1-1) allows for the low winter sun to penetrate the windows, while keeping the higher summer sun out. This detail of shading works best along the south façades, but is not very useful along the west and east façades, since the sun's rays are almost perpendicular to the windows at sunrise and sunset. Balconies are also used to shade some spaces along the south façades.

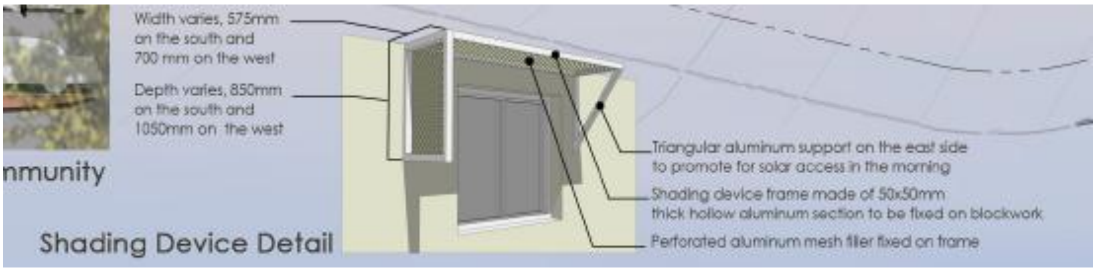

Fig. 1-1 Shading detail

    - Landscaping: The design suggests the use of drought tolerant plants irrigated by harvested rainwater collected in a tank to mediate the micro climate in the area. This is essential for conserving water for landscaping, but special care should be given to other water conserving landscape principles. There also are other possibilities for benefitting from landscaping to save energy, such as locating tall evergreen trees near west façades to block winter winds and shade the summer sun.

<u>Building Technology</u>

- Walls and Wall Materials:
    - The design suggests a lightweight construction system for walls, with insulation covering the external side of the walls. The wall section consists of a 20 cm thick hollow-core block work, and a 7.5 cm thick insulation layer. This type of construction lowers the thermal mass, which allows the building to heat and cool quickly. This type of design is not very efficient in the Mediterranean climate of Jordan, where temperatures vary greatly between night and day. A larger thermal mass makes the walls act as reservoirs of heat, and delays the transfer of heat from outside to inside once the cool night sets in.

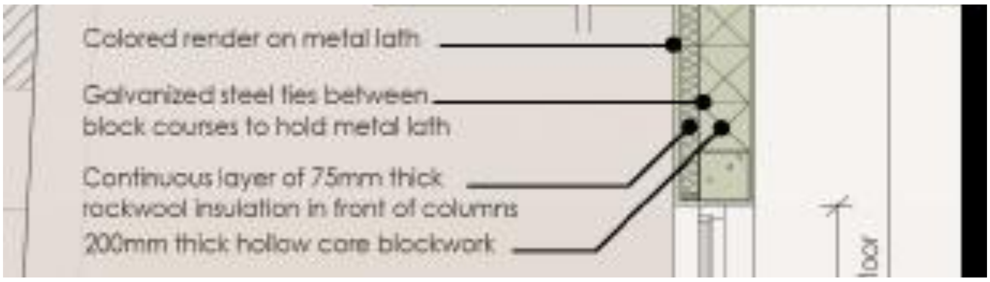

Fig. 1-2 Wall construction detail

- o Insulation is important to lower heat transmittance between inside and outside. The design offers a very consistent distribution of the insulation material, and successfully treats thermal bridges (around the balconies, roof slabs, columns, and lintels).

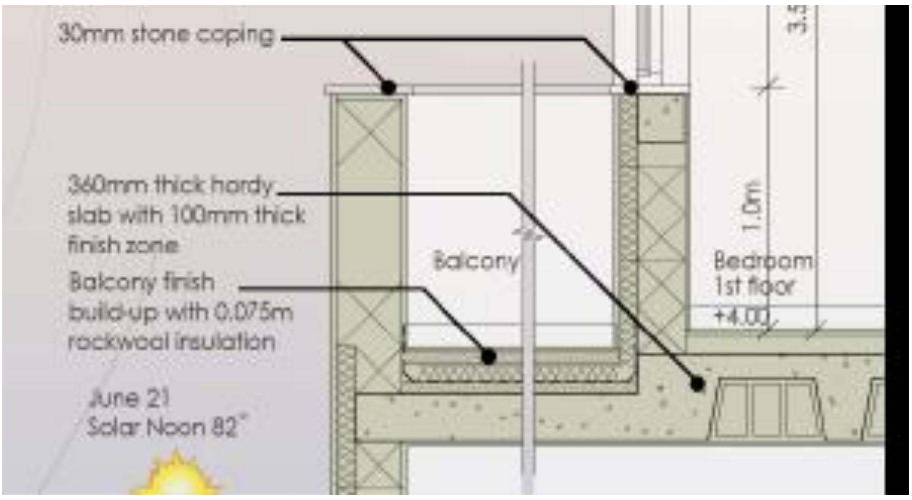

Fig. 1-3 Treatment of insulation to prevent thermal bridges around floor slabs and balconies

- Roof:

  The roof is designed with a 7.5 cm thick insulation layer. The insulation of the roof is very important for comfort especially in the summer in Jordan when the sun is almost perpendicular to the roof. This design suggests using rockwool as an insulation material. The use of rockwool for the insulation of the roof is unrealistic because the material is highly compressible, and using high density boards for protecting it would be very expensive. More importantly, any water/moisture penetration into this material would drastically reduce its insulation capability. A harder and more water-resistant insulation material is needed in this case. It is recommended to use high density polystyrene or foam insulation.

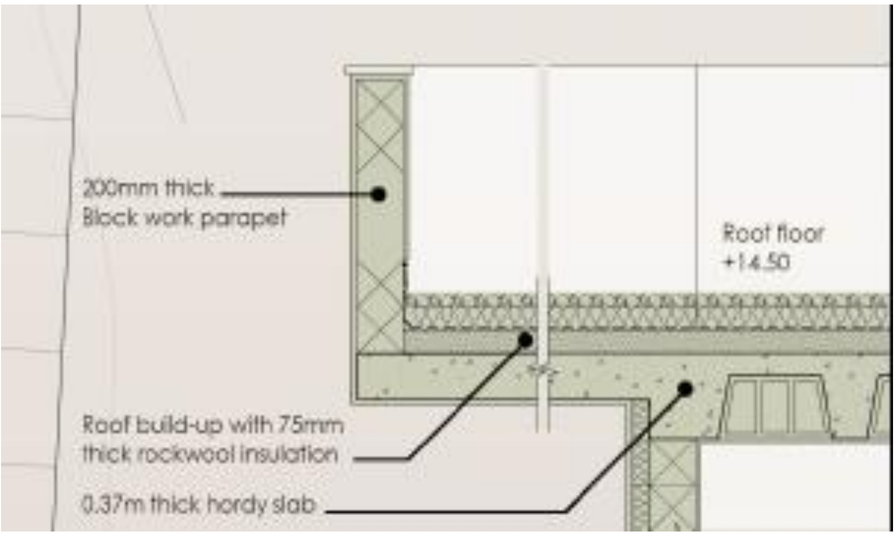

Fig. 1-4 Roof detail

- Floor Slabs:

  The floor slabs are also insulated to prevent heat loss through the ground. This is important for thermal comfort and energy efficiency in the winter in Amman. However, this is not usually carried out in intermediate floors, especially in low-cost housing.

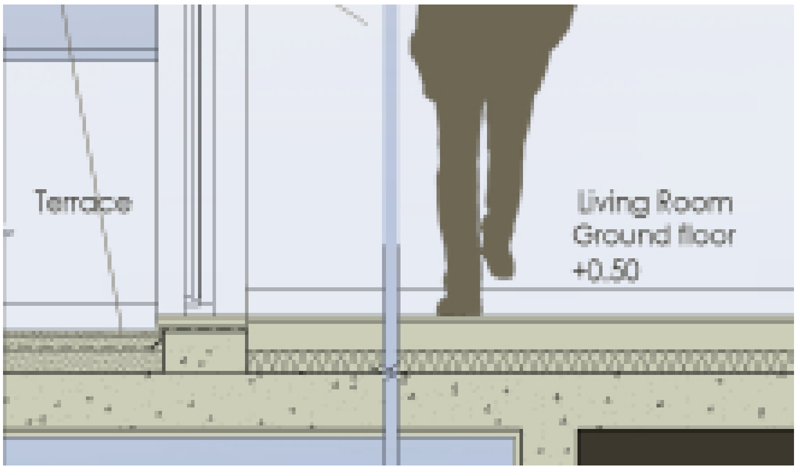

Fig. 1-5 Floor detail

- Windows:

  The design suggests the use of double glazed, low-emission, sliding aluminum windows. Double glazing is important for minimizing heat gain and loss through windows and doors, which are considered to be the least thermally insulated surfaces in a house. Sliding windows, however, are not air-tight and it is recommended to use turning window panes over sliding ones to reduce air infiltration as they are more air tight.

Electro-mechanical Systems

- Domestic Hot Water Supply:
  The design suggests using a solar system for the heating of domestic water. However, no specific designs are provided.

- Heating System:
  The report only mentions the need for a heating system. However, neither the report nor the drawings show any heating system.

- Cooling System:
  The report states that the simulation program "eQuest" showed that no cooling system is needed due to the passive design used for the project.

  Provided careful consideration is given for passive cooling and ventilation, there should be no need for installing a cooling system, especially in low cost housing.

- Energy Generation:
  No suggestion for an energy generation system, aside from the solar panels for heating water, is provided in the design.

- Energy Efficient Fixtures and Appliances:
  No suggestion regarding the use of energy efficient equipment is provided in the design.

- Water Demand Reduction:
  In addition to the previously mentioned consideration of landscaping, the design recommends the installation of water efficient fixtures. However, no specifications are given. Such fixtures are readily available in the market and at reasonable prices, and they include:
  a- Water saving faucets and shower heads
  b- Dual flush toilet cisterns

- Efficient Water Supply:
  - Graywater Recycling:
    There was no suggestion for such a system. A graywater recycling is recommended, since it would reduce the domestic water consumption by almost 30% if used for toilets flushing.

  - Rainwater Harvesting:
    The design utilizes a rainwater harvesting system. Rainwater harvesting is a good idea. However, the costs of building such a system should be minimized. Furthermore, water treatment is needed to prevent water contamination resulting from stagnation and other factors.

Building Use

No special considerations were made for the effect of user behaviors in energy and water efficiency.

Entry 2 - **By: Jansana . Alshibly Architects: Antonio Jansana and Ali Alshibly – Second Prize Winners (2 Submissions)**

Click here to view entry's first round submission, and click here to view entry's second round submission.

Urban Design

- The buildings in the southern section of the site are better oriented than those in the northern section. Each building has an equal façade length along the southern direction, which maximizes solar heat gain in the winter.

- The design favors fragmentation over compactness of the building masses to achieve best value for each apartment in terms of south facing facades and maximum privacy. This insures good air circulation and resolves the design challenges posed by the site's steep topography.

Building Design

- Orientation:
  The buildings are successfully oriented to ensure equal southern exposure among apartments.

- Compact Mass:
  As mentioned earlier, fragmentation is favored over compactness to achieve other goals.

- Layout:
  - The living areas in each apartment receive large amounts of sunlight through their southern exposures. Half of the spaces (primarily bedrooms) are located to the east, and the other half are located to the west of the buildings. These spaces may be uncomfortable during the summer. However, this problem is solved by the suggested installation of external movable shading elements that can be used when needed.
  - The layout offers an opportunity to minimize the length of water pipes in the building since most water-served spaces are located adjacent to each other. Minimizing the length of the pipes cuts costs and minimizes heat loss from hot water in the pipes. The suggested centralized supply system of hot water reduces this advantage, since the hot water will have to run considerable distances before reaching its destination.

- Placement of Openings:

  Openings along the north facades are minimized. This is important since north facing windows offer no advantages regarding heat gain. The placement of openings could have been studied more carefully to provide for more cross ventilation, especially that provided by western summer breezes.

- Architectural Features and Landscaping Elements:
  - Deep balconies are utilized to shade the largely glazed south façade in the summer.
  - The design emphasizes the use of movable external shading elements to offset direct sunlight during the summer along the south, east, and west facades.
  - At certain locations, the design suggests the use of fixed wooden lattice work to shade part of the balconies and the water tanks.
  - Local trees and xerophilous plants are used in the landscaping and are irrigated using recycled graywater. However, there are other water conserving landscaping principles that should be given more consideration in the design.
  - Compacted soil and local stone pavements are to be used from local site materials. These materials are cheaper to obtain and easier to maintain. The compacted soil materials reduce storm water runoff compared to other mortared hard-scaped surfaces and allow water to be absorbed to feed aquifers.

Building Technology

- Walls:
  - The design focuses on using local materials from the site for site work, such as gabion walls and dry stone walls. This minimizes cost and increases sustainability in terms of using materials.
  - The design suggests a pre-industrialized drywall construction system of external and internal walls. This system consumes less water during the construction phase, optimizes the construction period, and minimizes construction waste. However, it is unconventional in Jordan and would take more time to construct. Also, the system includes the use of large amounts of steel, which would raise construction costs considerably.

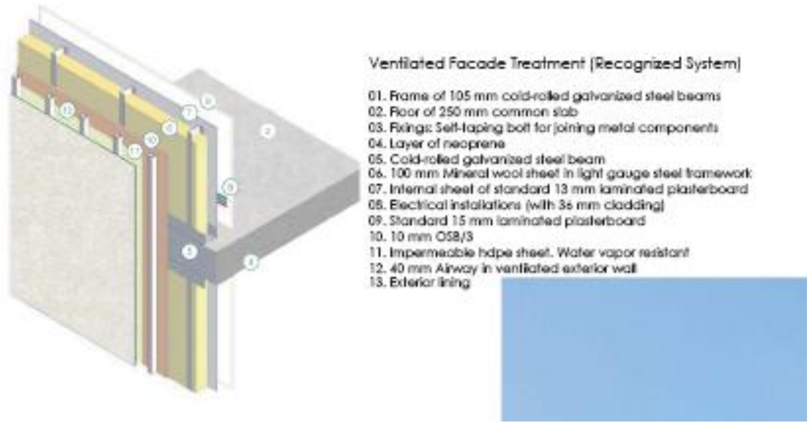

Fig. 2-1 Wall detail

- Insulation: the dry wall system allows for proper distribution of insulation material and avoids thermal bridges. The U values for walls suggested in the report (0.5W/m^2°C) are in accordance with the latest energy saving codes, which require a wall U value of (0.57W/m^2°C). This will achieve considerable energy savings in heating and cooling.

- Roof:
  The design suggests roof insulation. The insulation U value for the roof (0.5W/m^2°C) is excellent and is now required by insulation codes in Jordan.

- Floor Slabs:
  No special treatment for the floor slabs is mentioned. The insulation of floor slabs reduces energy consumption and is recommended, especially for the lowest slabs.

- Windows:
  The design suggests using double glazed windows. This is recommended since double glazed windows reduce heat loss/gain. It is also recommended to use turning window panes over sliding ones to reduce air infiltration as they are tighter.

Electro-mechanical Systems

- Domestic Hot Water Supply:
  The project suggests using a solar heating system for hot water generation. The second round submission suggests centralizing the solar system for the entire block, and placing it in the central park. This system is suggested to support another diesel powered boiler. The preheated water is used as a deposit for the boilers. The hot water is then distributed among the apartment buildings. Although centralized power generation might be cheaper to install, considerable energy will be lost as water moves through the long pipes. Billing problems also may arise with such a system.

- Heating System:

  The project suggests a two-stage system for heating. The first stage depends on solar power for heating water. The first round submission suggests a second stage "Central Biomass Boiler" for each two blocks. This is not practical for the following reasons:

  - It will be difficult to obtain the biomass fuel
  - Biomass boilers are not common. Service and maintenance may not be easy to provide
  - A central boiler usually will create billing problems. For example, it will be difficult to convince people to pay for their energy needs, or to disconnect service from those who do not pay, etc.
  - It is better in Jordan to use a solar power system for domestic hot water generation since it is cleaner, and since solar energy is abundant and may easily be used for water heating.

  The second round submission replaced the biomass boiler with two central boilers for the entire strip. As mentioned above, this would result in energy loss resulting from the lengthy pipes and also would result in billing problems unless a specific billing system that allows each unit to be billed separately is devised. The design suggests the creation of local companies that would manage such district systems. This is not usually applied in Jordan, and would need considerable governmental involvement, particularly in terms of devising new laws and regulations.

- Cooling System:

  The design does not suggest the installation of a cooling system. It instead concentrates on using cross ventilation for cooling the apartments.

- Energy Generation:

  No strategy for energy generation is suggested in the project.

- Energy Efficient Fixtures and Appliances:

  No suggestions for energy efficient appliances and fixtures are provided.

- Water Demand Reduction:

  In addition to the considerations for water demand that are suggested for the landscape design, the report suggests using water saving faucets and dual flush tanks. These are common and easily found in the market. It is strongly recommended that such fixtures are used.

- Efficient Water Supply:

  - Graywater Recycling

    The design suggests using a graywater treatment system for toilet flushing. Such systems are becoming more common and are easy to maintain. It is recommended to use such systems.

The second round submission suggests centralizing the system. This is impractical and not necessary, as the savings from using a central unit will be offset by increases in the cost of pipes and infrastructure works.

- Rainwater Harvesting

  The design in the first round submission suggests using a rainwater harvesting system that supports the graywater system. This is a good idea provided that the initial cost for constructing the rainwater tank is not high. Considerations should be made for assuring water quality and preventing contamination.

Building Use

Integrating movable shading elements in the design allows the inhabitants to control the spaces of their residences according to their individual needs. This would be an advantage if the inhabitants are aware of how to use these elements to their maximum potential. Using these elements also requires the inhabitants to constantly interact with the surrounding environment.

Entry 3 - By: Emtairah Consulting Corporation and CEC Design

Click here to view entry submission.

General Comment

The design does not address the challenges made by the site as it does not provide a response to the site's steep topography.

Urban Design

- All buildings have their main facade – with larger windows – facing south, with a maximum deviation of 15°. This direction assures optimum solar gain into the apartments in the winter, and shading from the sun's higher angle in the summer.

- To ensure winter solar heat gain for all buildings, the plot division was reorganized, and the area dedicated for a central park was distributed along the entire block site.

- Compact Mass:
  Mass is compacted to maximize open spaces and minimize the shading effect of buildings on each other. This also maximizes the buildings' solar heat gain in the winter.

Building Design

- Orientation:
  The four apartments on each floor are relatively well oriented towards the south.

- The building's compact mass helps decrease the external surface of the building, which is susceptible to heat gain and loss.

- Layout:
  - All living spaces have an exposure that allows for solar winter heat gain through the south facade. The apartments are well distributed with living spaces to the south, and services and some of the bedrooms to the north. The northern apartments have less space facing south.
  - Water-served spaces are located adjacently. This decreases the length of hot water pipes connecting boilers (or heaters) to the faucets in the kitchens and bathrooms. This also minimizes heat loss in the pipes. If a central heating system is installed in each building, this would cut down the length of the pipes between apartments.
  - The bathrooms and water closets are poorly ventilated.

- Placement of Openings:
  The design of the building induces cross ventilation from the north to the south. Openings mostly face the buildings' north and south sides. However, the building fails to take advantage of the prevailing western winds.

- Architectural Features and Landscaping Elements:
  - Shading: The windows are designed with external movable blinds, cutting off direct radiation but permitting daylight to enter in the summer.
  - Landscaping: Car access, parking, and entrances are mainly located along the north and the east, while green areas with walkways, sitting areas, and children's playgrounds are towards the south and west. This creates a protected outdoor environment for the inhabitants with sunny spaces in the winter and shaded ones in the summer.
  - The landscaping uses graywater. Although the project doesn't show the design for landscaping, the concept for green areas is based on a low maintenance landscape scheme, and it uses high-growth trees to provide shading (thus contributing to energy efficiency and outdoor comfort), and also uses drought resistant plants.

Building Technology

- Walls:
  - The design suggests the use of sandwich blocks with a 100 mm core of expanded polystyrene. The insulation is important to lower heat transmittance between the inside and outside. The U value resulting from this insulation is very low (0.29W/m^2°C), more specifically 40% lower than that recommended by code (0.57W/m^2°C). While this low U value would drastically reduce the heating and cooling loads for the building, the feasibility of using such high thickness should be evaluated.

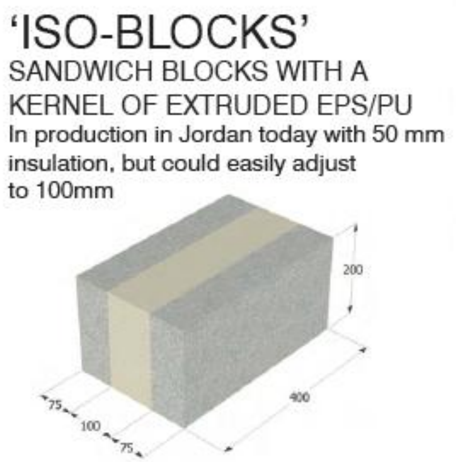

Fig. 3-1 Detail drawing of a sandwich block

- The design also does not show how insulation around columns - where the block work does not continue – is to be treated. Without such a treatment, thermal bridges will form around the columns.

- Roof:
  - The roof is designed with a 300 mm-thick insulation layer, giving it a U-value of (0.13W/m²°C). The insulation of the roof is very important for comfort especially in the summer in Jordan, when the sun is almost perpendicular to the roof. However, this is an over-exaggerated insulation thickness, and the extra costs may be unjustified.

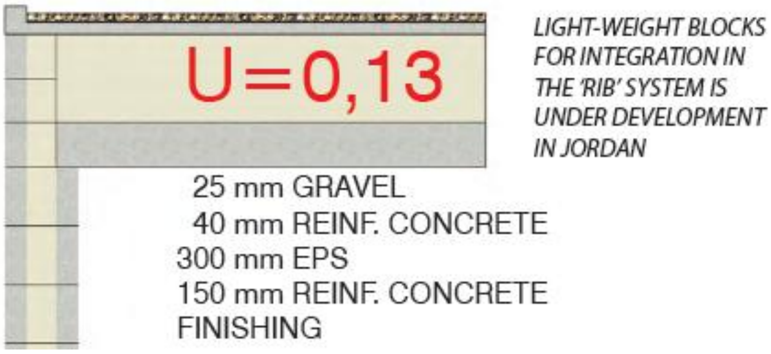

Fig. 3-2 Detail drawing of roof insulation

  - The slabs are located along the inner side of the sandwich blocks. This is an easy method of maintaining equal distribution of the insulation material throughout the height of the façade, thus limiting the possibility of the formation of thermal bridges. This, however, may be seismically unstable when exceeding certain heights.

- Floor Slabs:

  The floor slabs are also insulated with a 200 mm thick layer of expanded polystyrene to prevent heat loss through the ground. This is important for thermal comfort and energy efficiency in the winter in a climate such as that of Amman. Such insulation thicknesses, however, are too high, and insulating intermediate floor slabs is usually not necessary, especially in low-income housing.

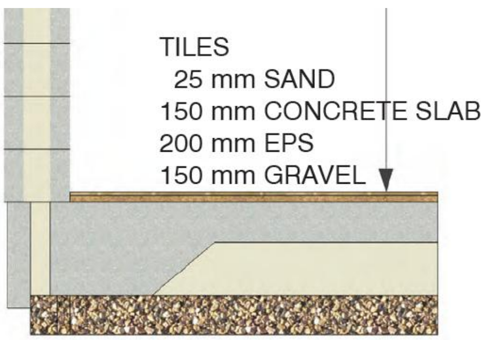

Fig. 3-3 Detail drawing of floor slab

- Windows:

  The design suggests the use of double glazed windows, but does not specify their U value, their shading coefficient, or whether they are sliding or tilting.

Electro-mechanical Systems

- Domestic Hot Water Supply:
  - The report suggests the use of a solar heating system. However, no preliminary design is provided. Using solar heating systems is feasible in Jordan, but the issue of available space on the roofs of apartment buildings should be taken into consideration since items such as water tanks usually occupy these roofs.

    An auxiliary water heating system will still be needed (electrical, LPG, or diesel) during the winter season.
  - The report assumes that each apartment will consume 30L/day. This is a very low value as most standards specify around 50 to 100L/person per day.

- Heating Ssystem:

  The report states that no heating is required. However, based on the simulation given in the project's report, the temperature in some rooms will not reach the human comfort limit of 20°C specified by standards. A heating system therefore will be needed.

- Cooling System:

  The project's report states that no cooling is required. However, the simulation submitted shows that the temperature of some rooms will exceed the human comfort limit allowed by standards (27°C). This means that cooling will be required. Nevertheless cooling is not as critical as heating, and a cooling system does need to be installed.

- Energy Generation:

  The project considers using a photovoltaic system for power generation, but argues that such a system is not feasible considering current Jordanian regulations.

- Energy Efficient Fixtures and Appliances:

  The project suggests using energy efficient fixtures such as low energy consuming refrigerators and washing machines, and LED lighting. These are currently available in the market at reasonable prices.

- Water Demand Reduction:

  In addition to choosing low-maintenance, drought-tolerant plants in the landscaping design, the project suggests using low flow faucets. The project recommends using low flow flush toilets of 2.5L/flush. However, these fixtures are not available in Jordan. So far 3.5L/flush toilets are available in the market, but in very limited supplies. Three and six Liter dual flush toilets, however, are widely available in the Jordanian market.

- Efficient Water Supply:
    - Graywater Recycling:
      The project suggests using a graywater system filtered by plant roots for irrigation. This is sufficient if no direct contact with humans is guaranteed. This type of irrigation is suitable for trees and inedible plants. However, if graywater is to be used for toilet flushing, then a mechanical graywater treatment system incorporating pumps, filters, and dosing equipment will be needed.

    - Rainwater harvesting
      The project suggests using a rainwater harvesting system for toilet flushing. It also suggests using rainwater for irrigation, as it is not recommended to keep water stagnant for long periods of time. In order to keep rainwater circulating without extra cost, it is recommended to collect rainwater but to use it as quickly as possible for purposes such as plant irrigation and flushing toilets.

Building Use

The buildings for this entry are to be comfortable throughout the year without using heating or cooling systems. This requires the users to assume an active role in climate control through taking the following actions:

1. Controlling ventilation: the buildings' windows may be opened or closed. During the winter, only minimal ventilation is recommended to ensure healthy internal air quality. In the summer, night ventilation is preferable to allow for cooler breezes to enter the buildings. The cooler breezes in the night will help cool off the building from the heat that accumulates during the day.
2. Shading: the windows are all equipped with operable shades. This helps the residents control their internal spaces by closing the blinds during hot summer days.
3. Achieving comfortable temperature ranges: the design uses a wide comfort temperature range that extends between 19 and 29° C. The design suggested that this wide range is amenable through controlling users' clothing, i.e. thick clothing in the winter and lighter clothing in the summer. However, the above temperatures are not in accordance with the thermal comfort temperature range set by international standards such as those of the American Society for Heating Ventilation and Air Conditioning Engineers (ASHRAE). The design also does not incorporate back-up systems for extreme weather situations. Moreover, the project energy simulation was carried out for a middle floor. Top floors, however, will have higher energy losses/gains that will result in a higher indoor temperature range.

Entry 4 - **By: Alasir Architects - Sustainable Solutions**

Click here to view entry submission.

Urban Design

- The orientation of the buildings is directed along an east-west axis, with the longest façade directed towards the south. This orientation will allow the buildings to take advantage of the southern sun during the winter.

- The building mass is compact and maximizes open space, but the buildings are lined close to each other, increasing the chances of their casting shade on each other. This will prevent the sun from fully reaching the buildings in the winter.

Building Design

- Orientation:
  The orientation of the buildings towards the south is designed in a manner that gives all apartments on each floor equal access to the southern sun. The apartments at the east and west also have an eastern or western exposure, depending on their location.

- The compact masses of the buildings help decrease their external surface that are susceptible to heat gain and loss.

- The buildings are split into two strips along the east - west axis that are separated by two courts. The resulting openings in the buildings encourage the flow of the prevailing western air through them, and the two courts create vertical wind tunnels that encourage the draw of hot air upwards and out of the buildings.

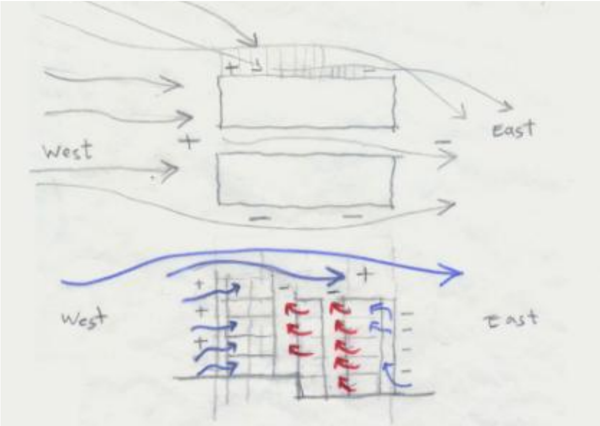

Fig. 4-1 Entry's massing concept

- Layout:

- All apartments are distributed linearly along a north – south axis. This ensures effective cross ventilation. The use of split levels in each apartment allows the air to move easily from warmer locations to cooler ones.
- The kitchens and bathrooms in the central apartments are not well ventilated.

- Placement of Openings:

  The design of the buildings induces cross ventilation from the north facade to the south facade. Openings are mostly located along the north and south sides of the buildings. Moreover, the split in the buildings encourages the cool western winds to enter the apartments (if the windows are open) and creates a draft in the center of each apartment. This gives the occupants the ability to adjust their living environment according to their particular needs.

- Architectural Features and Landscaping Elements:

  No special architectural features are suggested in the design. As for landscaping, the design suggests the use of evergreen trees as windshields to screen buildings. However, no consideration is given to other water conserving landscape design principles.

Building Technology

- Walls:
  - The drawings suggest a typical wall section using 50 mm extruded polystyrene as insulation, but the report mentions a 30 mm layer. Both these insulation thicknesses will not satisfy the requirements set by codes (0.57W/m²°C). Eight centimeters of expanded polystyrene is recommended to meet those requirements, and it also costs less.
  - The design does not mention any special treatment of the insulation around structural columns to avoid thermal bridges.

- Roof:
  - The report suggests using foam concrete insulation for the roof. However, foam concrete does not meet code requirements for insulation, which specify a heat transfer coefficient (U-value) of 0.57W/m² °C. Using polystyrene insulation is recommended instead.

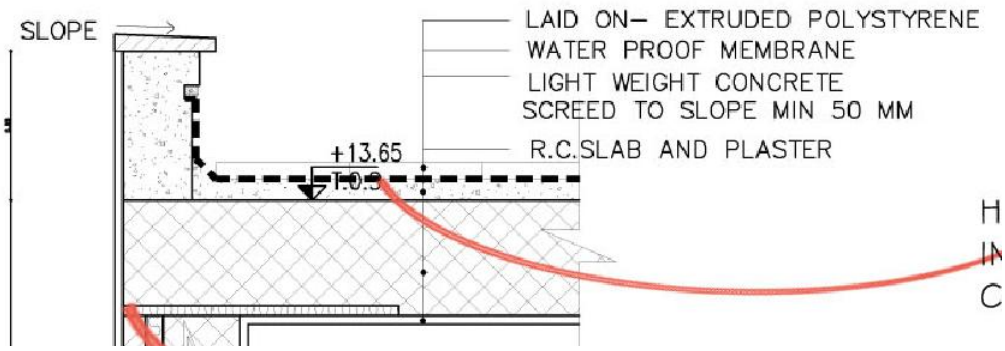

Fig. 4-2 Detail drawing of the roof

- Floor slabs:
  - The external edges of all floor slabs are insulated to prevent the formation of thermal bridges around these structural elements.
  - Floor slabs that are in direct contact with the ground are not insulated as most are floor slabs located in service rooms and car parks, which do not require heating or cooling. It still is preferable in such situations to insulate the ceilings of these service floors to prevent heat transfer between them and the apartments.

- Windows:

  The project does not specify any kind of glazing. It is recommended to use double glazed windows. These contribute to the reduction of cooling and heating loads, and also sound pollution.

Electro-mechanical Systems

- Domestic Hot Water Supply:

  The project suggests using a solar heating system for producing hot water, but does not specify what kind of system. Solar domestic water heating systems are feasible in Jordan. However, for a building with a high number of apartments, the availability of space on the roof may be a problem.

- Heating System:

  The project does not suggest the use of a heating system. A heating system is needed in Amman.

- Cooling System:

  No cooling system is used.

- Energy Generation:

  No energy generation system, such as a photovoltaic one, is suggested.

- Energy Efficient Fixtures and Appliances:

  The project does not specify the use of energy saving refrigerators and washing machines or energy efficient lighting fixtures.

- Water Demand Reduction:

  The report does not recommend the use of any water saving fixtures or a system for reducing water demand in landscaping. It is highly recommended to use aerated faucets and dual flush toilets, as they are readily available in the market and at reasonable prices. Following water-conserving principles in the landscaping, such as using drought-tolerant plants and installing water conserving irrigation networks, is also recommended.

- Efficient Water Supply:
    - Graywater Recycling

      The project recommends the use of a graywater treatment system, but fails to specify it. There are several graywater treatment systems available in the market. It is recommended to use a graywater treatment system to reduce water consumption.
    - Rainwater Harvesting

      The report suggests using rainwater harvesting system. However it doesn't specify how the water will be used. The use of rainwater for toilet flushing and irrigation is a good idea provided the initial cost for constructing the rain water tank is not high. The project suggests a manual pump system to decrease costs, but this is not practical. An electrical transfer pump is recommended instead.

Building use

The project suggests the development of a user manual to help reduce energy consumption. This idea is recommended to guide occupants and help them achieve maximum efficiency in water and energy consumption.

Entry 5 -   By: Osama Al-Masri and Saba Al-Nuseirat

Click here to view entry submission.

Urban Design

- The buildings along the southern section of the site are better oriented than those along its northern section.

- The design favors fragmentation over compactness of the building masses to achieve the best arrangement for each apartment in terms of openings. Buildings are lined closely so that they may cast shade upon each other. This would limit each building's access to the sun in the winter.

Building Design

- Orientation:
  Although buildings are oriented to the south, individual apartments do not have equal exposure to the southern sun. Two of the four apartments on each floor are oriented towards the north, depriving them of access to passive solar heating.

- Compact Mass:
  As mentioned earlier, fragmentation is favored over compactness to achieve other goals.

- Layout:
  - As mentioned earlier, the different apartments on each floor have differing orientations. This means that some apartments don't have a south facing façade. Thus, not all apartments have equal access to the warm southern sun or to cooling western winds.
  - Water-served spaces are not grouped together, which increases the length of pipes needed for the project, and increases the loss of heat in hot water pipes.

- Placement of Openings:
  The openings for all apartments are the same regardless of their direction. No attention is given to the location of the openings and the effect of their location on heating and cooling loads.

- Architectural Features and Landscaping Elements:
  - The design suggests the development of a roof garden on the top of the 3rd floor southern apartment of each building. In addition to enhancing the quality of living in those apartment buildings, roof gardens can be beneficial in terms of storm water retention, providing additional thermal resistance for the roof (the extra layer of soil can increase the roof's insulating capacities, and the shade from the greenery can further offset the sun's heat during the

summer). However, roof gardens increase structural loads on the roof, which may require extra investment costs.

  - The south façades are adorned with sun breakers that allow them to benefit from sunlight during the winter, while blocking the sun's rays during the summer. For the same reason, balconies along the south facades also are sheltered.
  - The design suggests adopting the principles of water conserving landscaping by increasing hardscaped areas to collect rainwater, using trees for shading, using drought tolerant plants that do not consume large amounts of water, using mulches, and using efficient irrigation systems. Yet these ideas are not well reflected in the design drawings.
  - The design also suggests the use of landscaping for energy conserving purposes, such as using tall evergreens to block off the strong winter winds coming from the west, and using deciduous trees along the east and south sides to allow solar gain in the winter, but to prevent it in the summer. These are low-cost, easily adopted concepts that can have a positive effect on the building's energy performance.

Building Technology

- Walls:
  - The design focuses on using local and commonly used materials for walls. This minimizes cost.
  - The design suggests a solid wall system with insulation wrapped around it from the outside, as in the image below. The main advantage of this system is that it easily avoids the formation of thermal bridges. However, adding the plaster to the insulation will be a challenge, as connecting the insulation to the wall will not be possible without the use of a steel mesh or other materials. The solid system means that the wall's whole thermal mass is from the inner side, so it will take longer to heat and cool spaces. This is advantageous in the summer, when the wall would function as a heat reservoir during the day, and would emit the heat during the cooler night hours.

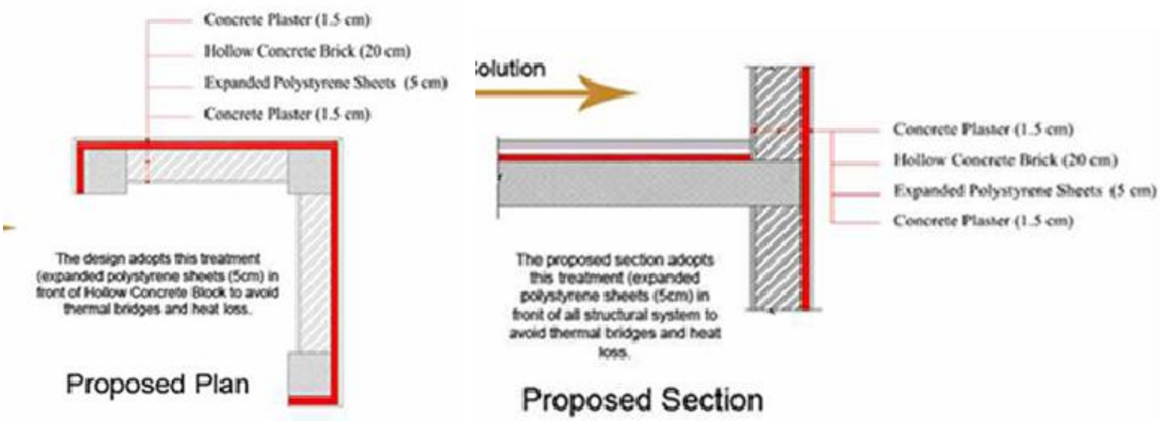

Fig. 5-1 Wall detail in plan and section

- Insulation: The entry report suggests using 5 cm of expanded polystyrene as insulation in order to achieve a U value of 0.569. This value is adequate and meets local codes. Furthermore, expanded polystyrene is relatively cheap and locally available.

- Roof:
  - The report suggests using the roofing construction system shown below, with a 5 cm polystyrene insulation layer. This is a low value and does not meet the requirements set by local codes, which stipulate a heat transfer coefficient of 0.57W/m2 C. The polystyrene used for the roof should be of high density and with a minimum thickness of 8 cm in order to satisfy the codes.

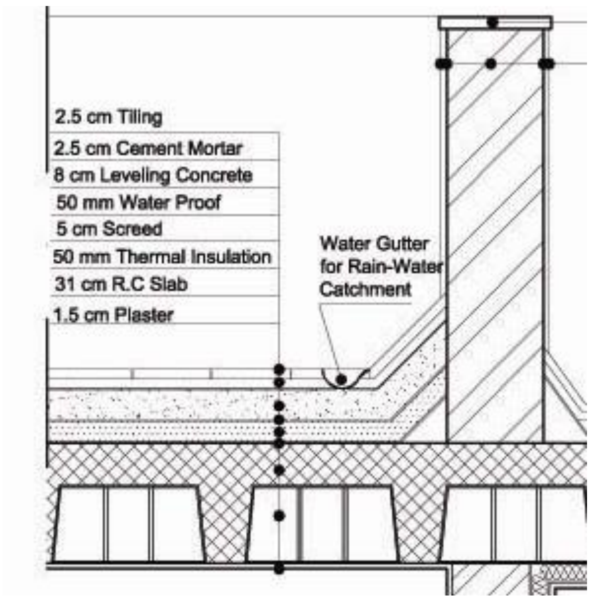

Fig. 5-2 Detail drawing showing roof construction

  - The design suggests using a green roof in some areas. This is a good way of reducing heating and cooling loads. It is, however, expensive. Planted roofs require special structural loads. They also need a proper water drainage system and additional water proofing.

- Floor Slabs:
  - Floor slabs in the design are insulated with a layer composed of 3 mm thick rolls of bitumen with mat polyester, and an additional protective layer of nylon.
  - Floor slabs with direct contact with the ground are not insulated, noting that these are floor slabs for service rooms and car parks, which do not require heating or cooling. It is preferred in such a situation to insulate the ceilings of these service floors to prevent heat transfer between them and the apartments.

- Windows:
  - The report suggests the use of single glazed windows. These are not recommended, as they will increase both heating and cooling loads.

Electro-mechanical Systems

- Domestic Hot Water Supply and Space Heating:
  - The design suggests an integrated system for domestic water and space heating. The system is composed of evacuated tube solar collectors, boilers, storage tanks, and local radiators. This system can save considerable amounts of energy. The independent solar heating system for each apartment is a good approach, but the area of collectors proposed for each apartment is too small to be used for heating, and will only be feasible for domestic hot water heating. A minimum of 12 - 14 m^2 of solar collectors will be needed for such tasks. Hence, a large area will be required on the roof, which might not be available. In addition, the structural loads on the building resulting from this large number of units will have to be calculated.
  - Since backup boilers and storage tanks are needed, installation costs will go up. Also, the tanks will require extra space.
  - Under-floor heating provides better heat distribution than local radiators, and requires lower water temperatures to work efficiently. Yet, this type of heating is more costly.

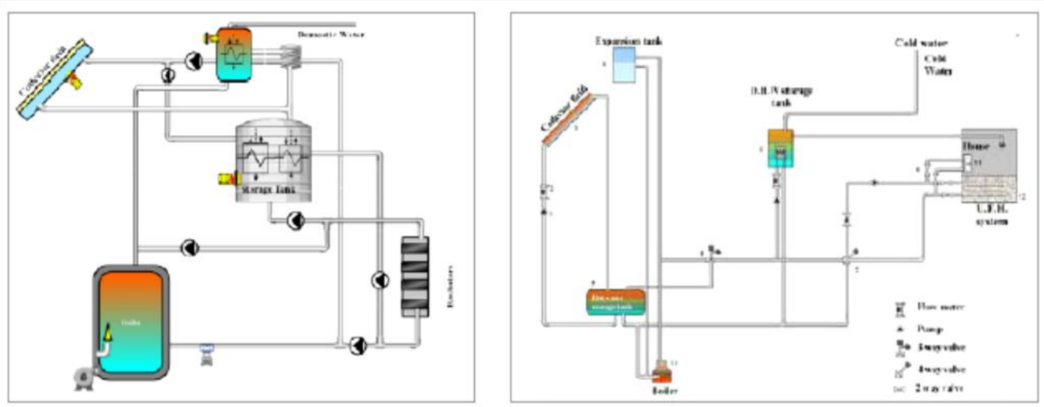

Fig. 5-3 Schematic diagram of the heating system

- Cooling System:
  The design does not suggest a need for installing a cooling system.

- Energy Generation:
  No energy generation systems are suggested.

- Energy Efficient Fixtures and Appliances:
  No suggestions for energy efficient appliances and fixtures are provided.

- Water Demand Reduction:
  The design recommends the use of water saving faucets and toilets. Such systems are available in the market and are reasonably priced. The design also pays attention to the principles of water conserving landscaping.

- Efficient Water Supply:
  - Graywater Recycling
    The report suggests using a graywater treatment system that can be used for all non-potable purposes such as toilet flushing and irrigation. Such systems are becoming more common and are easy to maintain. It is recommended to use such systems.

    The design suggests a storage tank for graywater. This will require treatment of the graywater to avoid odor problems.

  - Rainwater Harvesting
    The report suggests using a rainwater harvesting system, which will support the graywater system. This is a good approach considering that the rainwater will be continuously used and not left stagnant in the tank, as this can cause contamination problem. However, the cost of the rainwater harvesting system should not be high as the rainy season is short and the amount of collected water will be relatively small.

<u>Building Use</u>
No special considerations are made regarding the effect of user behavior on energy and water efficiency.

Entry 6 - By: Office for Modern Buildings (OMB)

Click here to view entry submission.

Urban Design

- All buildings are successfully oriented to the south. In order to achieve an optimal orientation, the buildings to the north of the site are divided into two masses.

- Compact mass: The massing of buildings is compact. The buildings' shading effect on each other is minimized and the extra space between them is utilized as children's playgrounds.

Building Design

- Orientation:
  All the apartments have equal southern exposures.

- Compact Mass:
  The massing of the buildings is compact. This reduces the external surface of each building that is exposed to the elements.

- Layout:
  - All four apartments on each floor have southern exposures, thus optimizing the benefit of the southern winter sun. Two of the four apartments have living rooms without southern access. As living rooms are expected to have the longest occupation hours during the day, it is preferred that they have a southern exposure. The bedrooms have a southern exposure. However, since they usually are occupied during the night, the benefits from this exposure are limited.
  - The layout offers an opportunity to minimize the length of water pipes needed in each building as most water-served spaces are adjacent. Minimizing the length of the pipes cuts costs, and minimizes heat loss from the hot water in the pipes.

- Placement of Openings:
  Most openings are directed to the south. A limited number of rooms have openings facing east or west, while openings facing north façade are kept to a minimum. The placement of openings seems to have been well studied. Some improvements could have been made to encourage cross ventilation.

- Architectural features & landscaping elements:

- A duplicate external wall lines the south elevation and large parts of the roof. This duplicate skin is proposed to provide shade to the south façade as well as the roof. The duplicate skin is perforated to maintain air circulation and views. The space between the duplicate skin and the south wall includes planters and therefore functions as a green space. The use of this double skin wall is not recommended. The external wall will hinder the entry of the sun's rays during the winter, when it is needed. Alternatively, overhangs can be used to control the entry of the sun during summer.
- The design does not specify any special treatment for landscaping.

Building Technology

- Walls:
  - The design suggests a wall construction that uses 20 cm of Thermostone as insulation with a 5 cm air gap for walls, as in the detail below. This configuration offers appropriate insulation. This type of insulation, however, is expensive and not readily available.

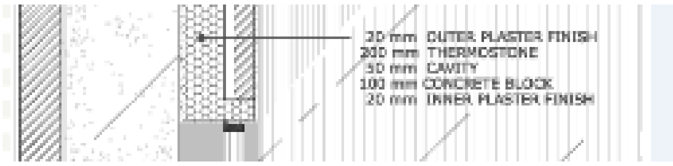

Fig. 6-1 Wall detail

  - Structural elements in the walls are insulated with 5 cm thick strips of polystyrene to avoid thermal bridges.

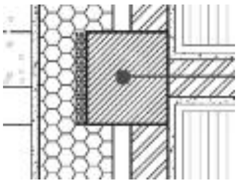

Fig. 6-2 Detail drawing showing the insulation of the column to avoid the formation of thermal bridges

- Roof:

  The design uses the same construction method for roofs and floor slabs as for walls, i.e. Thermostone and insulation strips along structural elements. The roof slab is covered with a corrugated sheet underneath a layer of gravel to collect storm water. The low insulation thickness of the slab along the structural elements may cause thermal bridges. A thicker insulation layer is needed.

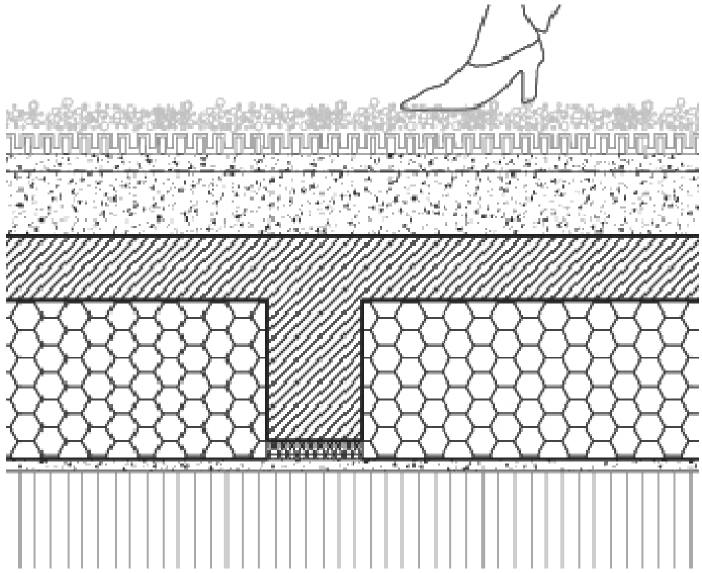

Fig. 6-3 Roof detail

- Floor Slabs:
  The design suggests a similar floor slab construction method to that of the roof. This prevents heat transfer between floors, but it is not very important in intermediate floors.

- Windows:
  The design suggests the use of double glazed windows, which is recommended.

Electro-mechanical Systems

- Domestic Hot Water Supply:
  The design suggests using a solar heating system for hot water. The duplicate skin is used as a structural frame to hold the solar panels, which are installed on the frame using pivot joints. The pivot joints allow for an adaptable orientation of panels as well as easy cleaning and maintenance. However, this system might be hard to install.

- Heating System:
  The report does not suggest any type of heating system.

- Cooling System:
  The design does not suggest the need to install a cooling system.

- Energy Generation:
  No energy generation systems are recommended.

- Energy Efficient Fixtures and Appliances:
  No suggestions for energy efficient appliances and fixtures are provided.

- Water Demand Reduction:

  The report does not mention the use of water saving fixtures although such units are readily available in the market and are reasonably priced. The design also does not specify any solutions for conserving water in the landscaping.

- Efficient Water Supply:
  - Greywater Recycling

    The project does not utilize a graywater treatment system. The technology for graywater treatment is readily available in the market and at reasonable prices.

  - Rainwater Harvesting

    The report suggests using a rainwater harvesting system, which will be used for irrigation and the cleaning of shared facilities.

Building Use

The integration of movable solar panels in the design allows for individual panels to be adapted to achieve optimal orientation. However, constant adjustments and supervision are required to reach such optimal benefits.

Entry 7 - By: Cube Architects: Akram Damisi, Ashraf Damisi, and Firas Thalji

Click here to view entry submission.

Urban Design

- Generally, the buildings located along the southern section of the site are better oriented than those located along its northern section, where the orientation of the plot directed the buildings' orientation. The adherence to the boundaries of the plots was not a requirement in the competition.

- The buildings in the design are spread over most of the plot's area, leaving no more space between buildings than that required for minimum setbacks. This will cause buildings to cast shade onto each other, thus preventing the sun from reaching the south facades.

Building Design

- Orientation:
  Although the buildings are oriented along the east-west axis with a long south façade, the apartments of each floor do not have equal southern exposure. Two of the four apartments on each floor are primarily oriented towards the north, depriving them from access to the sun in the winter.

- Compact Mass:
  The buildings may be considered compact. This limits the area of the external shell of the building that is susceptible to the elements.

- Layout:
  - The two apartments along the south side of each floor have most of their rooms along the south façade (except for services), which allows them to benefit from the southern winter sun. However, the apartments on the other side of the building have all their rooms facing north.
  - The layout offers an opportunity to minimize the length of water pipes needed in the buildings since most water-served spaces are adjacent. Minimizing the length of the pipes cuts costs and minimizes heat loss from the hot water in the pipes.

- Placement of Openings:
  The apartments along the south side of the building have most of their openings facing south. Apartments along the north side have openings mainly facing north. Openings to the east and west are minimal, which prevents the low summer sun in the morning and the afternoon from entering the building.

- Architectural Features and Landscaping Elements:

- The design incorporates a small garden space for each apartment for agricultural purposes. The elevated farming concept is suggested for reasons of economic sustainability. Greenery in front of openings will also aid in cooling the air, as well as shading window openings from the sun. In the winter, it also helps block the wind.
- The planted staircase and the hallways between the apartments function together as a wind catcher. The hallways have overlapping voids that allow cool air coming from the top of the stairwell to circulate. The hallway walls are designed to have a high thermal mass, and function as heat reservoirs that cool the air down. The greenery in the hallway cools the air further, causing it to spiral down the central core and enter the apartments, thus aiding cross air movements.
- For landscaping, the design mainly focuses on agricultural products. However no special considerations are given to the principles of water conserving landscaping.

Building Technology

- Walls:
  No special wall treatment is suggested.

- Roof:
  No Special roof treatment is suggested.

- Floor Slabs:
  No special floor slab treatment is suggested.

- Windows:
  No special window treatment is suggested.

Electro-mechanical systems

- Domestic Hot Water Supply:
  The design suggests installing solar panels on the roof, but does not provide further details.

- Heating System:
  The design does not suggest any type of heating system.

- Cooling System:
  No cooling system is mentioned.

- Energy Generation:
  No energy generation systems are suggested.

- Energy Efficient Fixtures and Appliances:
  No suggestions for energy efficient appliances and fixtures are provided.

- Reduction of water demand:
  The report does not mention the use of water saving fixtures although such units are readily available in the market and at reasonable prices.

- Efficient Water Supply:
  - Graywater Recycling
    The project suggests collecting and reusing graywater. Graywater coming from the sinks and showers goes directly to the garden space of each apartment through an installed filter, as in the figure below. Excess graywater is filtered by the soil of the planters and directed to a master graywater tank.

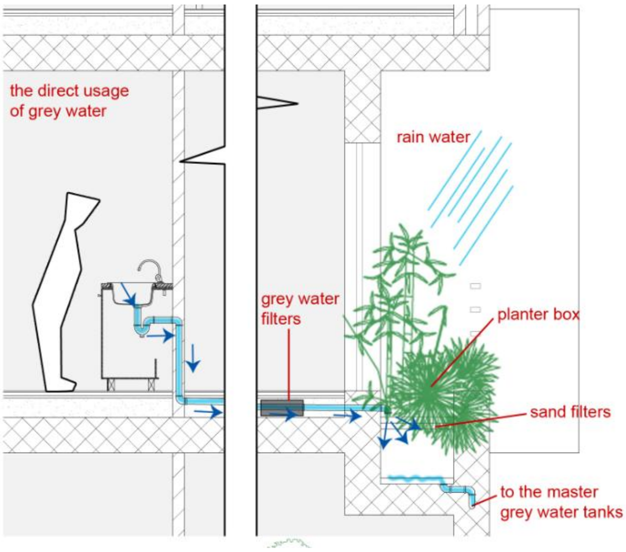

Fig. 7-1 Graywater usage in the apartments

  - Rainwater Harvesting
    The design only considers the collection of rainwater that falls in the planters of the elevated farms. The collected water drains to the master graywater storage tank. This is not effective since the collection of rainwater is only feasible if collected from large areas such as roofs, open courts, and hardscaped areas.

Building Use

No special considerations are specified for building use.

Entry 8 - By: Hamzah Abu-Ragheb and Markus Preller

Click here to view entry submission.

Urban Design

- All buildings in the site are oriented along a southwest – northeast axis. This is not the optimal arrangement to harness the benefits of the southern sun.

- The design favors fragmentation over compactness of the building masses with the aim of expanding the facades that open to the south. Each building has a courtyard, thus doubling its southern facades. The buildings are closely located to each other, causing them to cast shade on each other.

Building Design

- Orientation:
  The apartments of the same floor do not have equal access to the south. One of the two apartments on each floor is oriented primarily towards the northeast and northwest, depriving it from access to the sun in the winter. The other apartment is oriented towards the southeast and southwest, which exposes it to the summer sun all day.

- Compact Mass:
  As mentioned earlier, fragmentation was favored over compactness to achieve other goals.

- Layout:
  - The apartments are designed according to an L-shaped manner along a long corridor. No attention is given to climatic issues in the apartment layouts. Living rooms are located at the northern or southern tips of each building, with openings facing the northeast and northwest, or southeast and southeast. These spaces will be uncomfortable during the early and late hours of the day in the summer. The northern living rooms will be cold in the winter. The southern rooms will have access to the sun all day in the winter, but will be very hot in the summer.
  - Water-served spaces in each apartment are dispersed in the building layout. This results in an additional cost because of longer pipes, and increases heat loss from the hot water in the pipes.

- Placement of Openings:
  The window openings on the buildings' external facades are small, but large openings are placed along the corridor that overlooks the courtyard. This arrangement allows the courtyard to function like a chimney, creating vertical air movement that carries the hot air from the apartments upwards when the

windows are open in the summer. The orientation of these openings, however, is not optimal, as all windows are directed southeast, southwest, northeast, and northwest. As mentioned above, these windows will cause discomfort during the early and late hours of the day. The design remedies this problem by suggesting the use of *mashrabiyyas* (traditional lattice screens) in front of these windows to lessen heat gain, but these *mashrabiyyas* are not suggested for the larger courtyard windows.

- Architectural Features and Landscaping Elements:
  - The courtyard, incorporated in the design, functions mostly as an airshaft that encourages the vertical and horizontal air movement.
  - The design suggests using a shading structure covered with metal sheets to shelter the roof. This will prevent heat gain through the roof slab, and will simplify the harvesting of rainwater.

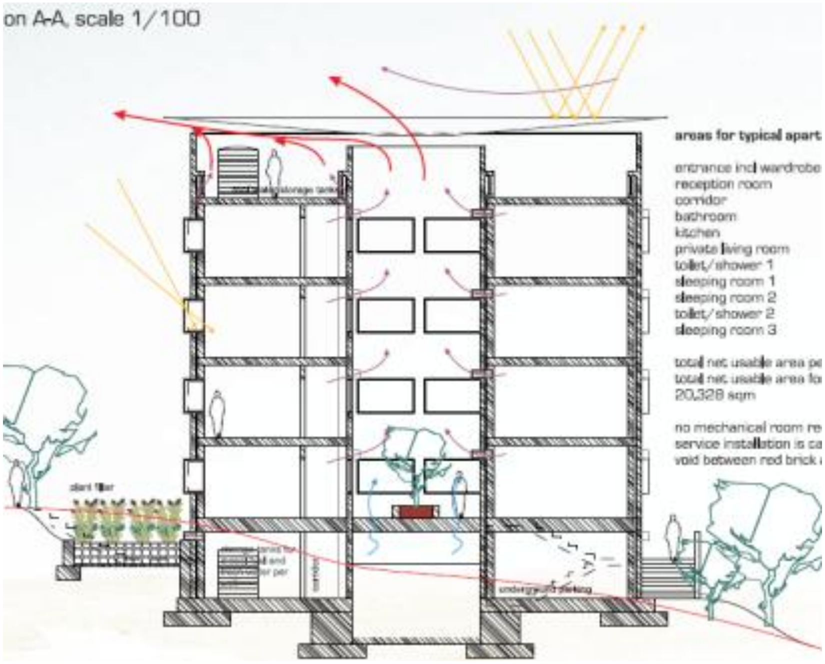

Fig. 8-1 Air circulation schematic

  - No special considerations for water conserving landscaping are mentioned.

Building Technology

- Walls:
  - The wall construction consists of a double wall, one made of compressed earth blocks (CEB), and the other of red brick, with a 60 mm air gap in between. The use of such approach is not sufficient to provide proper insulation for the walls, and it also does not comply with the codes in terms of performance.

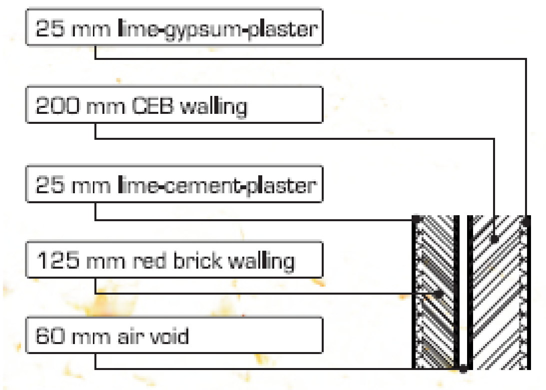

Fig. 8-2 Wall construction detail

- The design focuses on the ability of the wall to breath by using lime-gypsum plaster that can absorb moisture. This kind of design can help in the summer, but more focus should be placed on insulation since Amman has cold winters as well.
- No special treatments are provided in the wall design around structural elements to avoid thermal bridges.
- The report suggests using a 60 mm void for mechanical and electrical networks. This should be thoroughly investigated as 60 mm is not wide enough to accommodate these networks, especially drainage pipes.

- Roof:

  The entry report does not suggest the use of any roof insulation, which is very important for energy reduction, and is required in accordance with local codes.

- Floor Slabs:

  No special treatment for the floor slabs is mentioned.

- Windows:

  The design recommends the use of double glazed recessed windows with *mashrabiyyas* placed along the outer frame. The depth of the recess should be carefully assessed depending on the orientation of each window. The depths suggested in the design seem to be based on a southern orientation. However, most of the windows in the design have other orientations that allow the sun to enter at lower angles during the early or late hours of the day. *Mashrabiyyas* can help limit the sun's entry, but windows along the courtyard do not have *mashrabiyyas* incorporated in the design and therefore will be susceptible to heat gain in the summer.

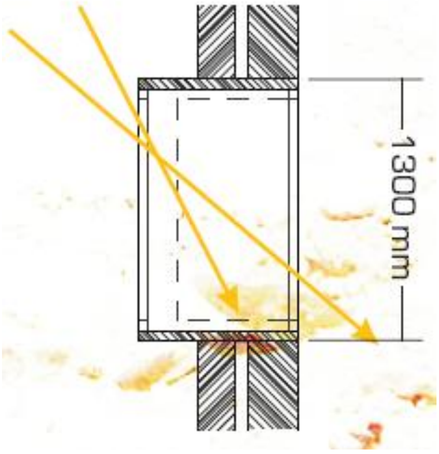

Fig. 8-3 Detail drawing showing window section

Electro-mechanical Systems

- Domestic Hot Water Supply:
  No information is provided on how hot water will be generated.

- Heating System:
  The design does not suggest any type of heating system.

- Cooling System:
  No cooling system is suggested.

- Energy generation:
  No energy generation systems are recommended. Also no space for mechanical equipment is allocated.

- Energy Efficient Fixtures and Appliances:
  No suggestions for energy efficient appliances and fixtures are provided.

- Water Demand Reduction:
  The design does not suggest the use of water saving fixtures although such units are readily available in the market and are reasonably priced. The design also does not specify any water conserving landscaping solutions.

- Efficient Water Supply:
  - Graywater Recycling
    The design suggests using a graywater treatment system that depends on plant roots for filtering. The treated water would be used for washing machines and car washing, in addition to toilet flushing and irrigation. In order to use the graywater for such applications, complex treatment and close monitoring will be needed, since there will be direct human contact with this water.

- Rainwater Harvesting

  The design suggests using a rainwater harvesting system, and storing the collected rainwater with the graywater in an underground tank. This is a good idea provided that the initial cost for constructing the tank is not high.

Building Use

No special regards are given to energy- and water-efficient user behavior in the buildings.

Entry 9 - **By: Turath - Architecture and Urban Design Consultants:**
Rami Daher, Maiss Razem, Shireen Khalidi, Siba Tawalbeh, Mostafa Abu Ghoush, Michel Banna, Mai Jaber, Eyad Azzam, Ahmed Salaimeh, and Hussein Zoubi

Click here to view entry submission.

Urban Design

- All buildings are oriented towards the south to ensure optimum solar exposure during the winter. The shape of the buildings changes based on the plot shape to achieve the optimum orientation.

- Compact Mass:
  The design makes use of the slope to locate parking under the structure. This minimizes spaces that contribute to a heat island effect. Additional green open spaces therefore are made available. Building masses are also compacted to maximize open space and minimize the shading effect of one building on the other.

Building Design

- Orientation:
  The buildings in the design are situated along an east-west axis, where the longest façade faces south. In this configuration, two of the four apartments on each floor are oriented to the south. The other two are oriented to the north, but have living rooms facing south.

- The compact masses of the buildings help decrease their external surfaces, thus limiting heat gain and loss.

- Layout:
  - Although not all the apartments have considerable south facades, careful consideration is made to provide all four apartments with living spaces and balconies with southern exposures. The two southern apartments have living spaces and bedrooms facing south. The northern apartments only have the living rooms facing south.
  - Water-served spaces are located adjacently. This decreases the length of hot water pipes and thus minimizes heat loss in them.
  - Bathrooms open up to shafts. The shafts are intended to function as solar chimneys without the need for mechanical ventilation.

- Placement of Openings:
  Openings mainly face south. Northern windows are limited in number and size. High openings at the top of the main entrance in each apartment are designed to encourage airflow from the apartment through the vertical structure of the

staircase, thus forming a wind tower. However, having such openings along staircases require approval from the Civil Defense Department as staircases should be fire rated since they are considered escape routes.

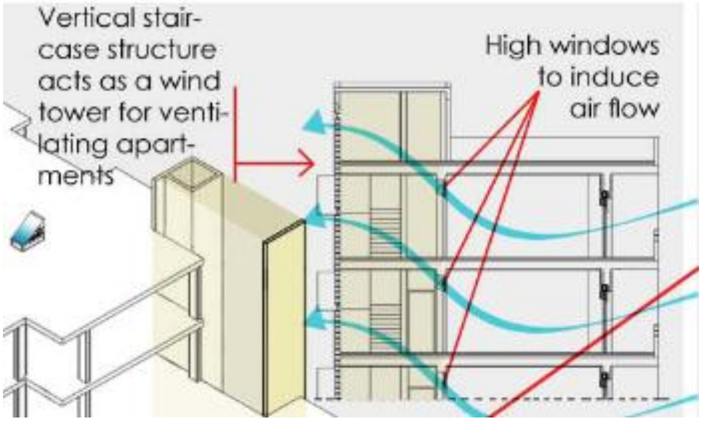

Fig. 9-1 Drawing showing air circulation in an apartment building

- Architectural Features and Landscaping Elements:
  - Shading: Special care is given to shading depending on the orientation of the opening. Further details are discussed below in the 'Windows' section.
  - Solar chimneys: Shafts between apartments are designed to function as solar chimneys. Accumulated solar heat accumulates at the top of the shaft (by means of a glazed surface) and thus encourages air movement from the bathrooms and eliminates the need for mechanical ventilation.

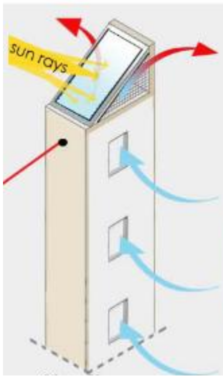

Fig. 9-2 Diagram of the solar chimney

  - Ventilation boxes: Air filtering boxes are introduced on top of each window. These help improve air quality since the area of the project is generally dusty. The introduction of filters, however, will result in a pressure drop and impede air movement from outside to the inside. In this case, mechanical fans may be needed.

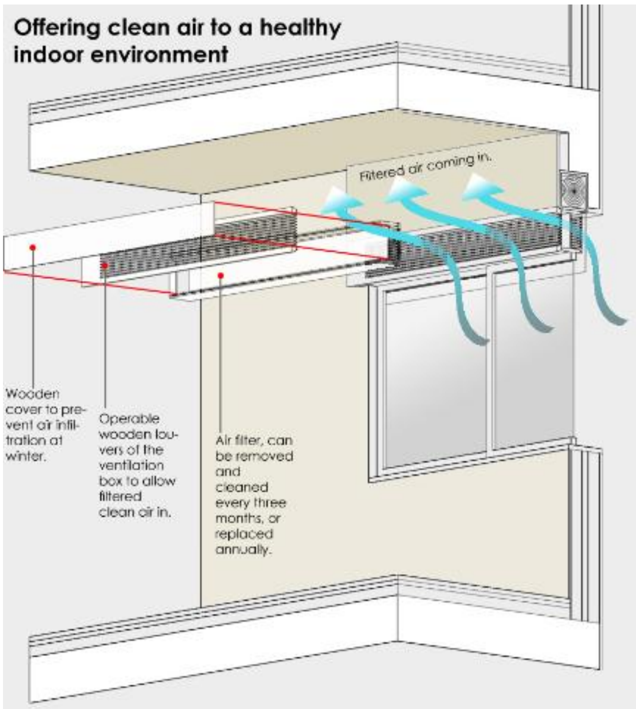

Fig. 9-3 Drawing of a ventilation boxe

- Landscaping: Emphasis is given in the design on the landscape's ability to mitigate climatic forces of sun and wind. Deciduous trees and vines are planted close to the southern facades. Evergreens are planted along the western façade to function as windbreakers.

  The entry report mentions that the design follows water conserving landscape principles but does not mention how.

  Bioswales and holding areas along pervious surfaces are used to remove silt and pollutants from rainwater.

<u>Building Technology</u>

- Walls:
  - The design suggests a cavity wall system for external walls: two layers of hollow concrete brick sandwich with a 50 mm polystyrene insulation layer in between. This insulation arrangement meets the 0.57W/m2C code requirements.

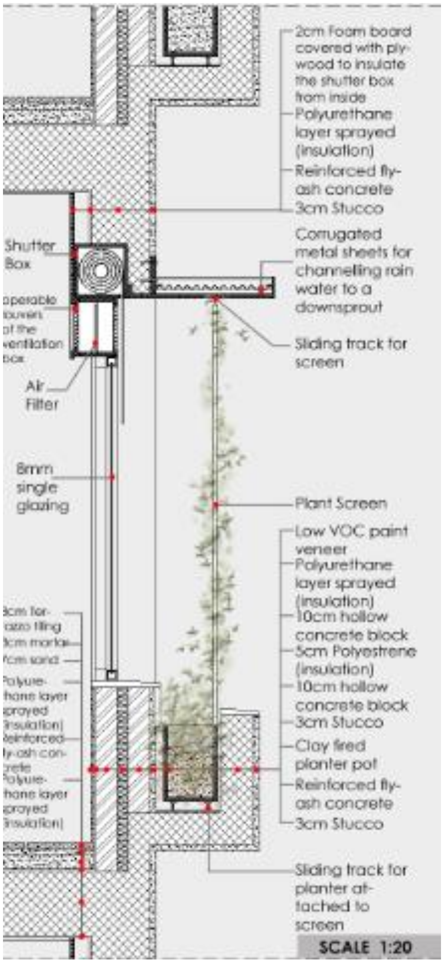

Fig. 9-4 Wall and window section drawing

- The design suggests using a 2 cm foam board covered with plywood to eliminate thermal bridges and air leaks around shutter boxes. This is a good solution, but it might increase costs.
- The design presents methods to prevent thermal bridges near columns and floor slabs. Columns are placed so that insulation is wrapped behind them. A sprayed polyurethane layer is then applied at slab-wall corners.

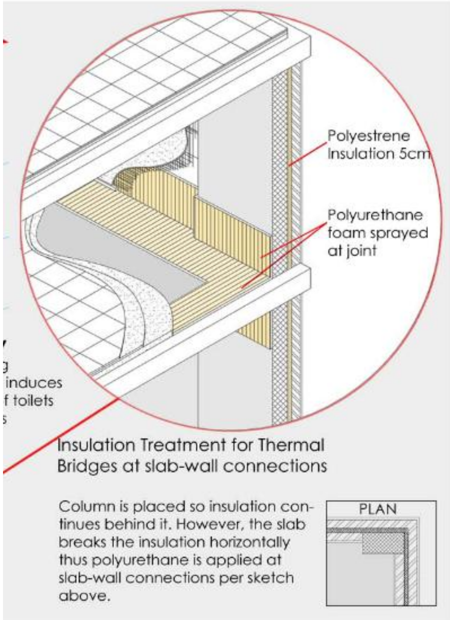

Fig. 9-5 Treatment of insulation around corners to prevent the formulation of thermal bridges

- Internal walls are designed using a green material of recycled paper called 'papercrete', which can be manufactured as a community project. The material has no direct benefits to the conservation of water and energy, but contributes to issues of sustainability.

- Roof:
  Roof slabs and other exposed floor slabs are insulated with a 5 cm layer of polystyrene. A thicker layer of high density insulation will be needed (7 – 8 cm) to comply with the codes.

- Floor Slabs:
  No special treatment is suggested for floor slabs except at the edges near the connection with the external walls, where a layer of polyurethane is sprayed in order to prevent the formation of thermal bridges. This is a good solution for intermediate floors assuming all apartments are being heated during the cold season. Apartments at the ground level or above unheated areas such as mechanical floors and garages will require full insulation.

- Windows:
  - Window design: The shape, size, and treatment of windows on each façade are different depending on orientation. Windows facing south are large and are made of clear glass. Horizontal shade structures made of corrugated sheets shelter these southern windows from the high-angled sun rays in the summer. Sliding screens with attached planters for climbing plants are incorporated into the design to provide a cooling effect during the summer.

Windows facing east and west are made of clear glass and incorporate colestra (perforated) concrete blocks on the side, which act as a sun barrier. This is generally not effective, as the low sun enters eastern and western windows perpendicularly, especially during the summer. Sliding shades would be more advantageous in this situation.

Northern windows are kept small and are covered with an insulating fabric.

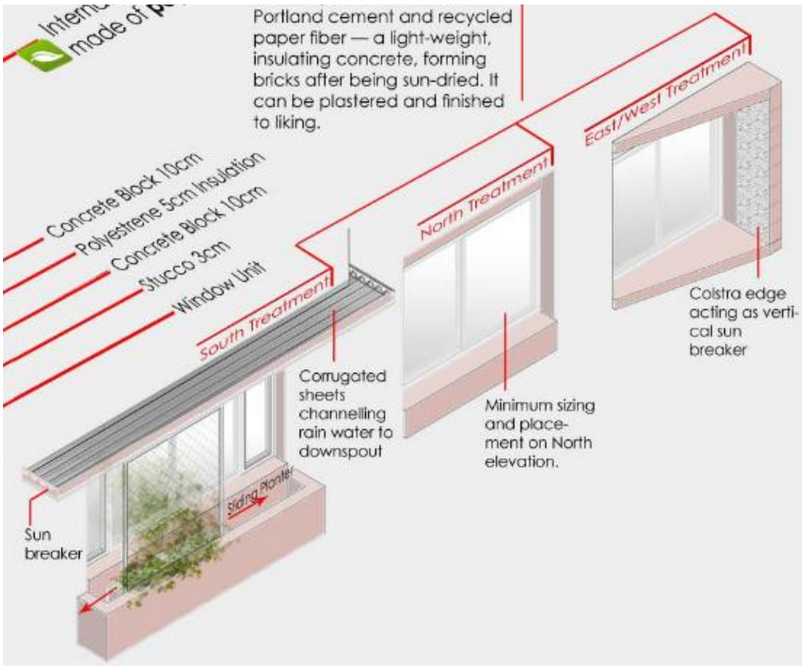

Fig. 9-6 The use of different window designs to accommodate orientation

- Single glazing is used. This is not recommended as it has a high heat transfer coefficient and a high solar heat gain factor. Instead, it is recommended to use double glazed windows with a turning mechanism, as it is more air tight than sliding ones.

Electro-mechanical Systems

- Domestic Hot Water Supply:

  The design suggests using a solar power system for generating hot water. Solar heating of water is feasible in Jordan. Adequate space on the roof should be provided. An innovative solution is needed to minimize piping and heat loss through these pipes as they lead to lower floors, which are furthest from the roof.

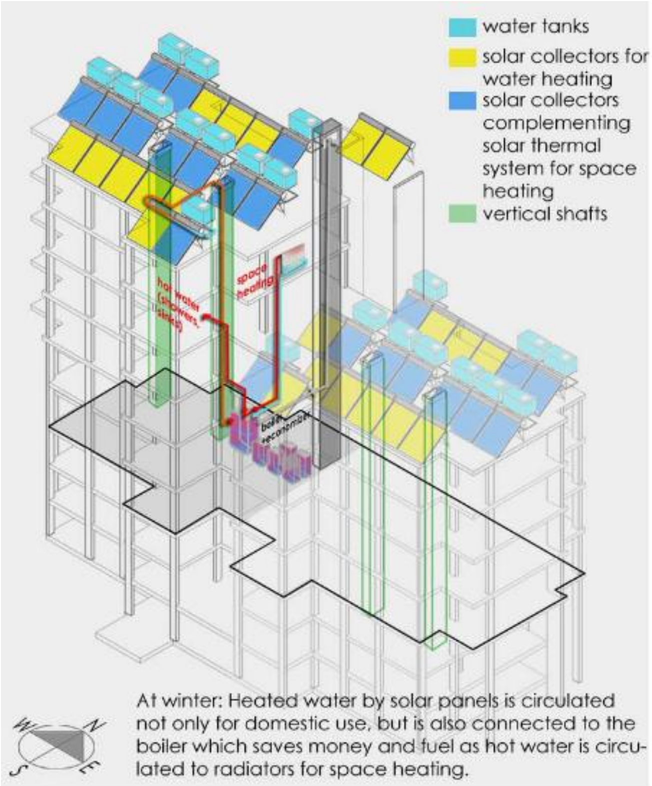

Fig. 9-7 Drawing of the solar heating system

- Heating System:

  The design suggests using solar panels to assist the boilers in a radiator heating system. This is not practical as the boilers work on a temperature range of (70 – 80°C) while solar panels cannot achieve such temperatures, especially during winter.

- Cooling System:

  No cooling system is used.

- Energy Generation:

  The design suggests using Photovoltaic (PV) cells for the production of electricity. PV technology is still expensive in Jordan and not feasible for low-income housing.

- Energy Efficient Fixtures and Appliances:

  The design recommends using energy saving lights. These are common, reasonably priced, and are recommended for use.

- Water Demand Reduction:

  In addition to the recommendations for conserving water demand through landscaping, the design recommends the use of water saving faucets. Such faucets are available in the market and are reasonably priced.

- Efficient Water Supply:
  - Graywater Recycling

The project recommends the use of a graywater treatment system. The project calls for a single common system for all the apartments. The treated water, however, is pumped to separate tanks for each apartment. This will be expensive and will take up needed space on the roof, in addition to requiring extra piping. It is therefore recommended to use a common roof tank that feeds all toilets.

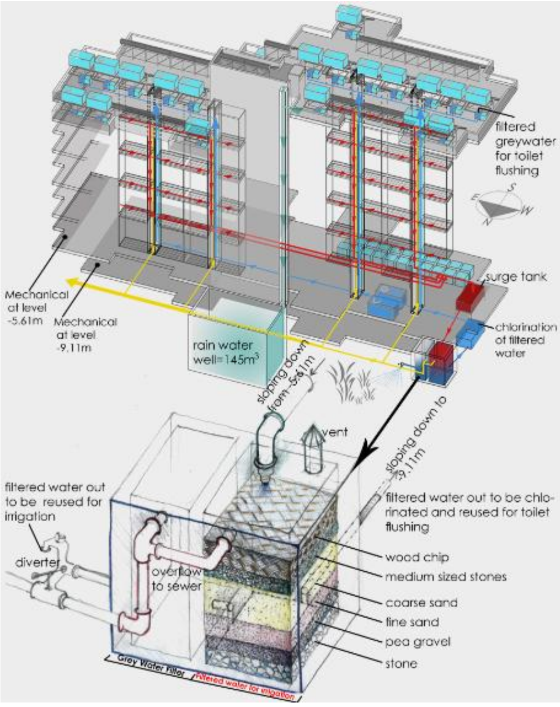

Fig. 9-8 Drawing of the graywater system

- Rainwater Harvesting
  The entry report suggests using rainwater-harvesting system, which will support the graywater system. This is a good idea provided that the initial cost for constructing the rainwater tank is not high.

Building Use

The design involves the users in improving the thermal quality of the indoor space through controlling shades. Windows along the south façade are all equipped with sliding shades and planters.

Entry 10 - **By: Space Design - Architects and Designers**
– Third Prize Winners (2 Submissions)

Click here to view entry's first round submission, and click here to view entry's second round submission.

Urban Design

- The buildings located in the southern section of the site are better oriented than those in the northern section, since plot orientation strongly affects building orientation. The design attempts to change the orientation within each plot, but has not been able to keep the deviation from the east-west axis to 15° or below, which is crucial to maximizing benefits from the southern sun.

- Compact Mass:
  Mass is compacted to maximize open space and minimize the shading effect of one building on the other, thus maximizing access to solar heat gain in the winter for all buildings.

Building Design

- Orientation:
  The orientation of the buildings in the southern section of the site is such that the three apartments on the same floor have equal southern exposure.

- Although the masses of the buildings are compact, the use of perforations in the masses makes them susceptible to heat gain and loss. The perforations, however, are useful for ventilation purposes.

- Layout:
  - The buildings in the southern section of the site all have living spaces with access to the southern sun during the winter. The apartments are well laid-out with living spaces facing south and bedrooms facing north.
  - Water-served spaces are dispersed within the same apartment. This entails higher costs for pipes because of their increased length, and also additional heat loss in the pipes.
  - The design suggests installing grills in the walls between rooms to maximize cross ventilation, but this may compromise privacy.

- Placement of Openings:
  The design of the buildings induces cross ventilation from the north to the south. Openings are mostly located along the north and south sides of the buildings. However, the design fails to take advantage of the prevailing western winds as it provides for few openings facing west.

Openings facing south are large compared to those facing north to help maximize solar gain during the winter.

- Architectural Features and Landscaping Elements:
    - Shading: Overhangs and shading devises are designed to shade the south facing windows from the summer sun. A service floor on the roof houses water storage tanks and solar collectors. This floor provides shading for the roof, and also an extra insulating layer.
    - Landscaping: The design proposes the use of indigenous and drought-tolerant plants. This is recommended to minimize irrigation requirements. Hardscaped surfaces consisting of pathways and gathering areas are paved with open grid paving and gravel beds. These paving materials reduce storm water runoff and evaporation rates, and feed aquifers. They also minimize the heat island effect.

      The plants are irrigated using graywater and harvested rainwater via subsurface irrigation channels. All of these measures correspond with the principles of xeriscaping.

Building Technology

- Walls:
    - The design suggests a cavity wall system for external walls: two layers of hollow concrete brick with a 30 mm extruded polystyrene insulation layer sandwiched between them. In the second stage submission, the insulation was changed to a 50 mm thick expanded polystyrene layer. This insulation thickness complies with the code requirements of 0.57W/m2C, and is also less expensive than the thinner layer.
    - Structural elements are located along the inner side of the wall, and insulation passes uninterrupted behind them. This is a good measure to prevent thermal bridges, provided that structural stability of the external wall is not compromised as this could be seismically unstable in cases where the building is very high.

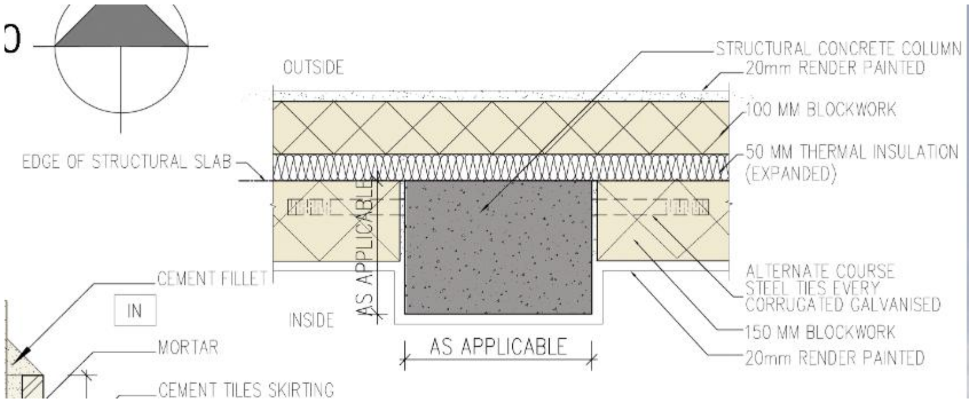

Fig. 10-1 Wall construction detail showing the treatment of insulation around columns

- Roof:
    - The report suggests using 40 mm foam concrete for the roof finish as insulation. This is not enough and does not meet minimum building code requirements, which specify a minimum of 0.55W/m2 C for the roof's heat transfer coefficient, and is equivalent to an 8 cm layer of foam concrete.
    - The design also suggests installing a roof garden to increase the roof's insulation capability. This is a good way of reducing cooling and heating loads. However, it is very expensive to implement since it increases structural loads and needs proper water drainage and a tight waterproofing.
    - The suggested roof detail also does not show how the edge of the slab would be treated to prevent thermal bridges.

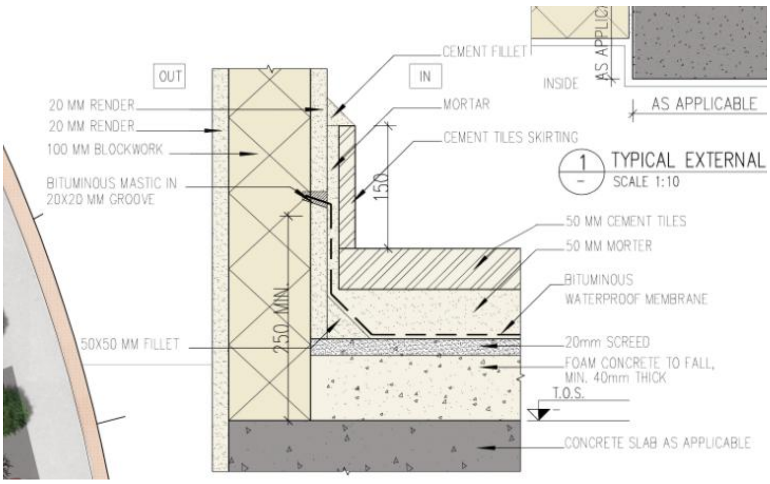

Fig. 10-2 Roof construction detail

- Floor Slabs:
    - The floor slabs are designed to stop at the inner side of the external walls in order to allow the insulation to stretch continuously, thus preventing the formation of thermal bridges at the connections between slabs and walls. This

solution should be verified with a structural engineer as it might be seismically unstable.

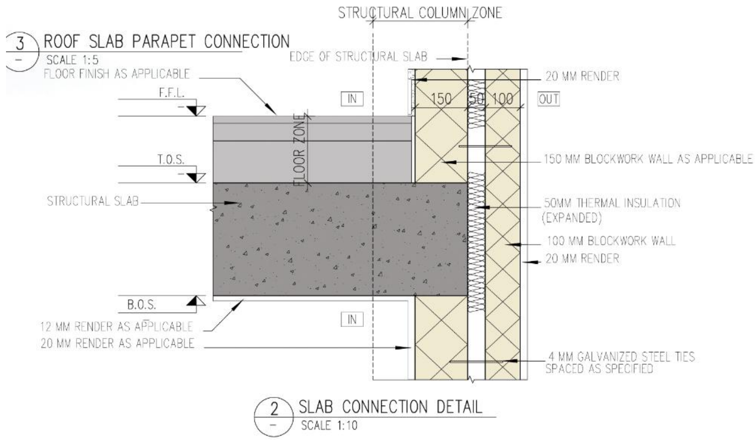

Fig 10-3 Detail drawing showing a floor slab connection with external walls and the treatment of insulation around structural slabs

- The floor slabs are not insulated. At least floor slabs above unheated areas such as car parks need to be insulated. However, it is not critical to insulate intermediate floor slabs, especially in low income housing.
- The design includes many cantilevered areas. No solutions are suggested for preventing thermal bridges from occurring when using cantilevered slabs.

- Windows:

  The design suggests the use of double glazed windows. These are recommended for the reduction of cooling and heating loads. It is further encouraged to use turning windows as they provide better tightness and reduce infiltration.

Electro-mechanical Systems

- Domestic Hot Water Supply:

  The first round submission suggests using a central solar powered system for hot water with supplementary electric heaters. This could be an economical way for producing hot water. However, it could create a billing problem among occupants. Therefore, a billing mechanism needs to be devised for these types of communal systems. Furthermore, there will be heat loss due to the use of longer piping, especially in the lower floors.

  The second round submission replaces this system with a closed loop solar system in which each apartment has its own cylinder. This is an efficient system and effectively solves any possible billing problems. The only power consuming components of this solar system is the circulation pump, which can be billed through a public electric meter in the same manner as elevators and staircase lighting.

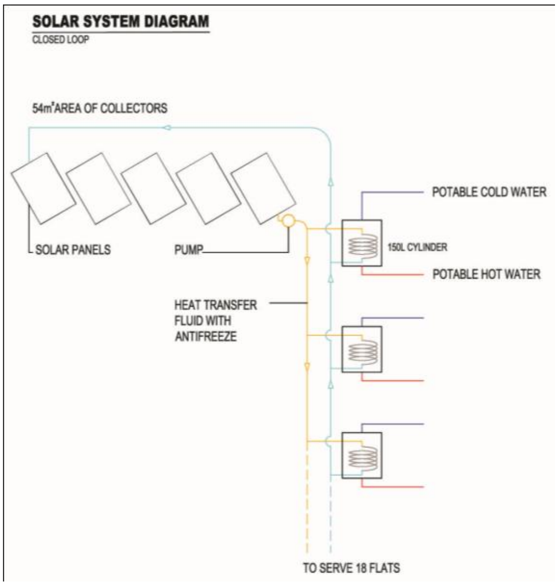

Fig. 10-4 Schematic drawing showing the solar system used in the second round submission

- Heating System:

  The first round submission suggests using three central boilers located on the roof, which distribute hot water to each apartment. Using central boilers is more efficient. However, a problem with billing may arise. Also, no suggestions are provided as to the type of fuel that would be used for the boilers.

  The second round submission suggests installing gas boilers at the balconies of each apartment. Condensing type gas boilers have a much higher efficiency than normal fuel boilers. They also take up much less space and can fit in balconies, thus keeping the much needed roof space available for other items such as water tanks. Their placement in the balconies also saves on piping costs, and saves energy resulting from heat loss in the pipes and higher pumping costs.

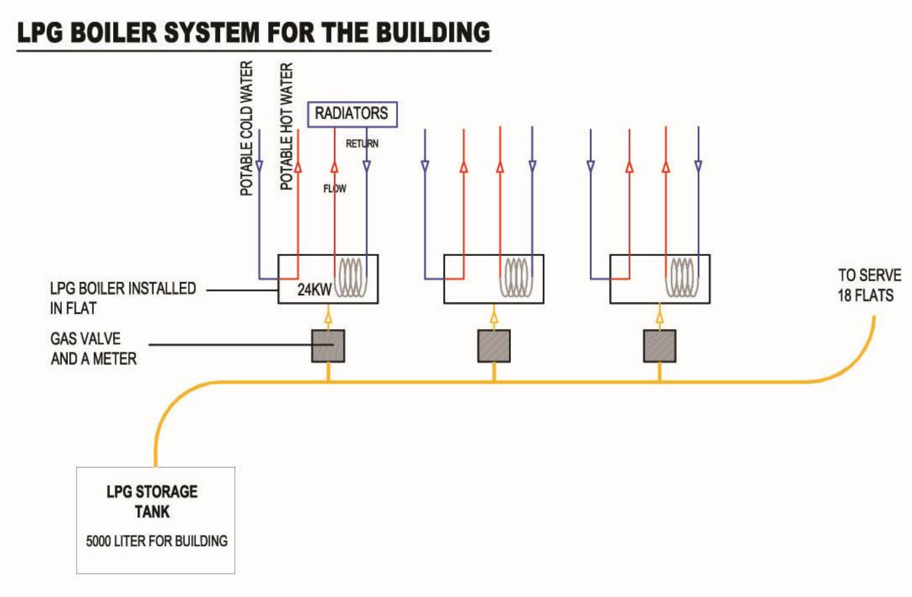

Fig. 10-5 Schematic drawing showing the heating system used in the second round submission

- Cooling System:

  No cooling system is incorporated in the design.

- Energy Generation:

  No energy generation systems are suggested.

- Energy Efficient Fixtures and Appliances:

  The project suggests using energy-efficient lighting fixtures. These save large amounts of energy, and are readily available and reasonably priced. Using energy-efficient appliances is also recommended.

- Water Demand Reduction:

  In addition to following water conserving landscaping principles, the design recommends the use of water saving faucets, which is highly encouraged.

- Efficient Water Supply:
  - Graywater Recycling

    The project suggests using a graywater system for irrigation (and for toilet flushing in the second round submission). The suggested filtering system consists of gravel and bamboo. This is sufficient if no direct contact with humans is guaranteed, as with the irrigation of trees and inedible plants.

    The second round submission suggests keeping this filtering system for irrigation purposes only. Otherwise, a filtering unit and a storage tank are suggested for the water used for toilet flushing. A mechanical filtering and treatment system is recommended for the entire graywater system.

- Rainwater harvesting

  The design suggests using a rainwater harvesting system, which will support the graywater system for irrigation purposes. This is a good idea provided that the initial cost for constructing the rainwater tank is not high.

Building Use

The issue of energy- and water-efficient user behavior in the buildings is not addressed.

Entry 11 - By: Iyad Al-Halis

Click here to view entry submission.

Urban Design

- The buildings in the southern section of the site are better oriented than those in the northern section since plot orientation affects building orientation. The design attempts to change the orientation within each plot, but could not keep deviation from the east-west axis to 15° or below, which is crucial for maximizing the benefits of the southern sun.

- Compact Mass:

  The design proposes breaking the mass of each building into two buildings on each plot. Therefore, instead of fitting four apartments on each building floor, the smaller buildings accommodate two apartments on each floor. The favoring of fragmentation over compactness serves to maximize the provision of daylight and ventilation for each apartment.

  Because of the increased number of buildings on the site, the buildings are very close to each other, which means that they will cast shade upon each other and that there is little open space left. In order to limit this effect, the buildings are staggered to maximize exposure to the sun. The orientation of the buildings along the east-west access transforms the narrow gaps between them into air tunnels, thus maximizing the benefits of natural ventilation during the summer.

Building Design

- Orientation:

  The apartments in the buildings located in the south of the site have adequate southern exposure.

- The compact masses of the individual buildings help decrease their external surface areas, which makes them less susceptible to heat gain and loss.

- Layout:
  - All living spaces have a southern exposure, which allows them to access the winter sun. The apartments are well distributed, with living spaces located along the south and services located along the north. One bedroom in each apartment is directed either to the east or west. However, their windows are narrow and deep, which minimizes their exposure to the direct sun. Water-served spaces are located adjacently. This decreases the length of hot water pipes needed and thus minimizes cost and heat loss in the pipes.

- Placement of Openings:

  The design allows for cross ventilation from north to south. Window and door openings in each room are mostly aligned to increase airflow. Openings mostly face the north and south sides of the buildings. The narrow gaps between the buildings, which run along an east – west axis (i.e. along the direction of the prevailing winds), are utilized to increase the wind's speed. Higher wind speed will encourage air circulation from north and south facing windows.

- Architectural Features and Landscaping Elements:
  - Shading: Solar panels on the roof are organized in the form of pergolas that also shade the roof. This allows them to take on a double function. Maintenance issues for these devices, however, should be considered.
  - Roof vegetable gardens are suggested for economic purposes. The gardens also help in insulating and shading the roof. The garden has a shallow soil bed, which will not add considerable structural loads to the buildings, and will therefore keep construction costs down.
  - Landscaping: The design suggests showcasing water-efficient strategies in landscaping the park area. The park therefore will function as a demonstration garden with illustrative boards and signs that can serve an educational purpose.

Building Technology

- Walls:

  The design suggests constructing walls with solid concrete blocks wrapped with external insulation, and finished with synthetic rendering. The external insulation is a good idea and prevents thermal bridges. However, the design does not give information regarding the insulation thickness. Furthermore, the cost of such insulation and the ability of synthetic materials to withstand physical and thermal stresses should be evaluated. The solid wall construction means that the whole thermal mass of the wall is along the inner side. As a result, it will take longer to heat and cool the interior spaces. This is advantageous in the summer, when the walls function as heat reservoirs during the day and emit heat during the cooler night hours.

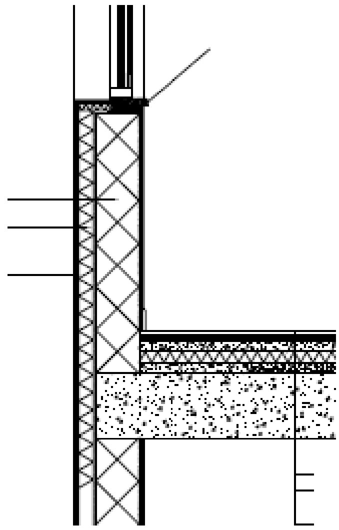

Fig. 11-1 Wall construction detail

- Roof:

  The design does not specify insulation on the roofs, but suggests using solar collectors as shading devices. The shallow soil beds also increase the thickness of the roofs, thus improving their insulating capacities. The insulation of the roofs is still very important since most solar gain during the summer is acquired through the roof.

- Floor Slabs:

  The floor slabs are insulated, but the thickness is not specified in the design. This is good for preserving interior thermal conditions, and preventing heat transfer from one apartment to the other, especially if they have different usage schedules and an under-floor heating system is used. However, insulating floor slabs is not critical in intermediate floors and is an additional cost item.

- Windows:

  The design specifies shutter windows, which are important to guarantee air tightness. The design does not specify the type of glazing to be used in windows. Double glazing is recommended.

<u>Electro-mechanical Systems</u>

- Domestic Hot Water Supply:

  The report suggests using a solar heating system. Hanging solar panels as pergolas solves the problem of space limitations on the roof. However, maintenance procedures for such hanging panels should be considered. Using solar heating systems is feasible in Jordan and is recommended.

- Heating System:
  The report suggests using a solar powered under-floor heating system. The system is backed by electrically operated heat pumps. Such systems have the following disadvantages:
    - This system of evacuated solar collectors is only used in the winter. They may overheat in the summer, and will require another energy load to get rid of the excessive energy that is being generated.
    - The installation of under-floor heating systems is expensive.
    - Utilizing heat pumps to heat water is expensive.

  The report does not state whether the heat pumps are to be installed locally for each apartment or for the collective solar heating tanks. If collective solar heating tanks are used, special attention is needed for developing a billing system.

- Cooling System:
  The design does not utilize a cooling system.

- Energy Generation:
  No energy generation system is suggested.

- Energy Efficient Fixtures and Appliances:
  The design does not provide any suggestions for energy-efficient fixtures. These are recommended and readily available in the market.

- Water Demand Reduction:
  In addition to the water conserving landscape demonstration garden suggested in the design, the report suggests using water saving faucets.

- Efficient Water Supply:
    - Graywater Recycling
      The project utilizes a graywater system. However, it does not specify the filtering method. Graywater is suggested for use in irrigation. With a proper filtering system, it also can be used for flushing toilets.

    - Rainwater Harvesting
      The design suggests using a rainwater harvesting system to support the graywater system. This is a good idea provided that the initial cost for constructing the rainwater tank is not high.

<u>Building Use</u>

No special regard is given to energy- and water-efficient user behavior in the buildings.

Entry 12 - **By: Liyan Al-Jabi, Mohammad Al-Jabi, and Shada Al-Sharif**

Click here to view entry submission.

Urban Design

- The buildings are designed according to a block system, each surrounding a large court. The buildings are slightly elongated along an east-west axis, which increases the length of the southern facades. The court creates another internal southern façade. However, the orientation gradually tilts towards the northeast and southwest, following the orientation of the site.

- Compact mass: The buildings are grouped in larger blocks. Each block fits within two plots. The mass is compacted to increase green areas and to minimize the external skin of the buildings, which is susceptible to heat gain and loss. The court in the middle doubles the buildings' facades, and allows daylight and ventilation to access the depth of the buildings.

- Garages are provided outdoors. Although this brings down construction costs, having these facilities under direct sunlight contributes to the heat island effect. Instead, streets and paved areas should be minimized unless rainwater is collected from them. No mention is given regarding the materials used for paving and hardscaping. Where rainwater is not harvested, open grid pavements are recommended to minimize storm water surges and to allow infiltration through the ground.

Building Design

- Orientation:

  The orientation of the apartments is not taken into consideration in the design. The court shape controlled the distribution of apartments. Some apartments therefore have a main south façade, but others have a north, east, or west main façade.

- The compact masses of the buildings decrease their external surfaces, thus helping minimize heat gain and loss.

- Layout:
  - As mentioned above, the orientation of the apartments is not taken into consideration.
  - Because each floor is different, there is no typical apartment layout. Thus, while in some apartments' water-served spaces are located adjacently; they are dispersed in other apartments. Adjacency of water-served spaces

decreases cost through shorter pipe lengths and minimizes heat loss in hot water pipes.

- Placement of Openings:

  No specific criterion for the placement of openings is followed in the design.

- Architectural features & landscaping elements:
  - The courtyard in each block, together with the cutouts in the building mass, function as conduits for natural ventilation.
  - Landscaping:

    Careful consideration is given to the creation of favorable microclimates using landscaping. Each court includes agricultural allotments distributed among the residents, which create a cooling effect inside the court. Along the western façade, tall deciduous trees are planted to shield off the western sun in the summer. The design does not emphasize water-conserving landscaping principles, although it recommends using native water saving plants where possible.

Building Technology

- Walls:
  - The report suggests using compacted earth walls. This wall material has a high thermal mass, which makes the walls reservoirs of heat and helps delay heat transfer to and from the building. These walls are not widely used in Jordan, however, and their thermal and water proofing characteristics need to be evaluated before use. The wall section suggested in the design is also questionable with regards to the compacted earth's structural integrity and its ability to function as a bearing wall, especially around window lintels and balconies.
  - The walls are insulated using 5 cm thick extruded polystyrene. The wall section shows that the insulation is either sandwiched between two layers of rammed earth, or between the external layer of rammed earth and the structural slab. This is a possible solution for preventing thermal bridges from formulating at the connections between walls and slabs. However, the structural integrity of the wall in this situation needs to be evaluated.

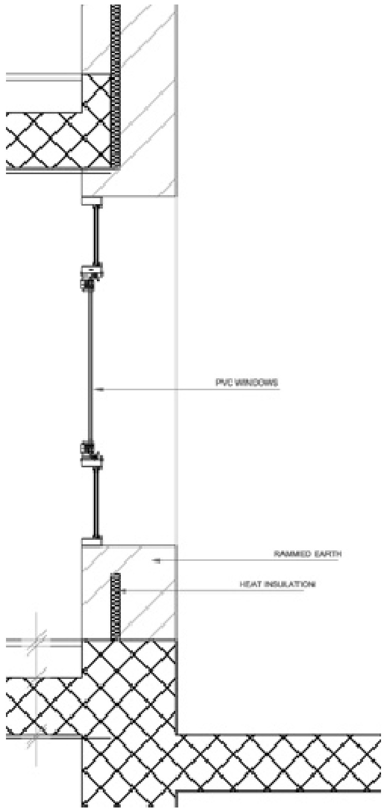

Fig. 12-1 Wall construction detail

- Roof:

  The design suggests using 2 cm polyurethane sheets to insulate the roof. Insulating the roof is very important for energy reduction, and is required in accordance with local codes. However, this insulation thickness is not enough. A minimum thickness of 5 cm of polyurethane is recommended. Furthermore, a type of finish is required to cover the roof insulation, as it is not recommended to expose insulation directly to sunlight. Gravel is one option to consider.

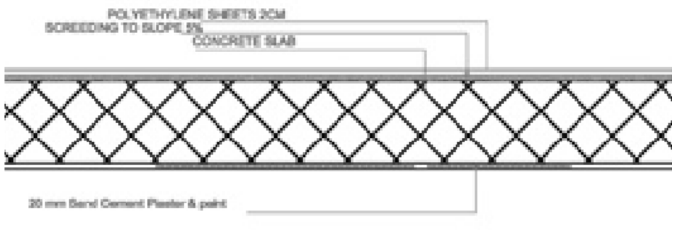

Fig. 12-2 Roof construction detail

- Floor Slabs:

  No special treatment of floor slabs is suggested, except for its external edge, where it is insulated to prevent thermal bridges.

  The slab with a direct contact with the ground needs to be insulated to prevent heat loss between the apartment and the ground.

- Windows:

  The design recommends the use of PVC double-glazed recessed windows. The depth of the recess should be carefully assessed based on orientation in order to achieve effective heating and cooling load reduction.

Electro-mechanical Systems:

- Domestic Hot Water Supply:

  The report recommends the use of a solar powered system for generating hot water. However, no description of the system is given.

- Heating System:

  There is no description of any heating system.

- Cooling system:

  No cooling system is suggested.

- Energy Generation:

  No suggestion is made for an energy generation system.

- Energy Efficient Fixtures and Appliances:

  No suggestion is made regarding energy efficient fixtures or appliances.

- Water Demand Reduction:

  The design suggests the use of dual flush toilets and water saving fixtures. Such equipment is readily available in the market and reasonably priced. The design does not propose measures for water conservation in the landscape.

- Efficient Water Supply:
  - Graywater Recycling:

    The design suggests using a graywater system for irrigating non-agricultural landscaping between buildings. For treating the graywater, "constructed wetland" systems are used. Such systems are low budget, and do not require maintenance, but they are hard to monitor and the quality cannot be guaranteed. Therefore, direct human contact should be limited. Traditional systems where water quality can be monitored are recommended. Note that such systems are inexpensive. Furthermore, the effluent treated graywater can be used for toilet flushing in addition to irrigation.

  - Rainwater Harvesting:

    The entry report suggests the use of a rainwater harvesting system that collects rainwater from the roof. Rainwater is collected for irrigating agricultural areas inside the court, and to support the graywater system.

Building Use

No special regard is given to energy-and water-efficient user behavior in the buildings.

Entry 13 - **By: Mahmoud Saymeh and Lama Abuhassan**
- First Prize Winners (2 Submissions)

Click here to view entry's first round submission, and click here to view entry's second round submission.

Urban Design

- In the first round submission, the design consisted of four blocks in the assigned site of eight plots. Each blocks is massed around a courtyard. The second round submission is an improved version in terms of orientation as the blocks in the northern part of the site are broken in order for the buildings to be oriented towards the south. This direction assures optimal solar exposure in the winter.

- Compact Mass:
  Although the masses are grouped to form courtyards, they are not arranged in a compact manner. Recesses in the blocks transform the buildings into several masses attached to each other by means of staircases and shafts. The design of each block focuses on cooling the building through a careful study of air movement. The grouping of the masses around the court is intended to provide shading. The design, however, fails to maximize heat gain from the sun in the winter.

Building Design

- The orientation of the apartments is not taken into consideration in the design. The shape of the court controls the distribution of the apartments. Thus, some apartments have a main south façade, but others have a north, east, or west one. While some apartments have a southern exposure, others are deprived from such exposure throughout the winter.

- The fragmented masses of the buildings increase their external surface areas, which increases their susceptibility to heat gain and loss.

- Layout:
  - As mentioned above, the orientation of the apartments is not taken into consideration. Some living areas are totally enclosed by other rooms and have no exterior windows. Since living rooms are the rooms with the most occupation duration within the day, they should be more carefully designed to ensure thermal comfort and exposure to the sun and light.
  - Water-served spaces are not located next to each other. This increases the length of pipes, and also increases heat loss in the pipes.

- Placement of Openings:

The design of the buildings induces cross ventilation by placing openings opposite each other as much as possible.

- Architectural features & landscaping elements:
- Architectural Features and Landscaping Elements:
  - Shading: South facing windows are provided with overhangs to limit solar gain in the summer. Western and eastern windows in the first round submission were treated with vertical louvers built into the façade to shade them from the low angles of the sun in the early morning and late afternoon hours. The vertical louvers have been removed in the second round submission for cost reasons.
  - Four wind catchers directed towards the west are incorporated in each block to capture the prevailing winds and to tunnel them through to less ventilated spaces and to the court. This arrangement works well in the summer, but the wind catchers have to be sealed during the winter.

    In the first round submission, the designers suggested using water fountains at the entrance of the court to cool down the entering wind, thus creating a pleasant microclimate in the court and the surrounding spaces. These fountains are replaced in the second round submission by water-sprinkled bamboo beds to make the design more water efficient and to require less maintenance.

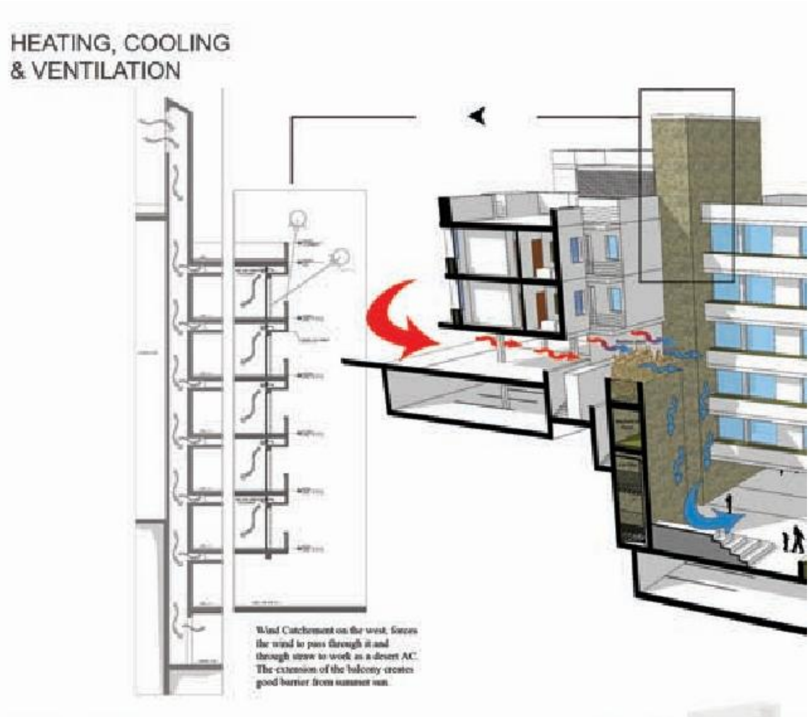

Fig. 13-1 Drawing of the air shafts that are incorporated in the design

  - Landscaping: No attention is given to energy-efficient and water conserving landscaping techniques and principles in the design. However, the suggested plants do not require large amounts of water for irrigation.

Drip irrigation is suggested as the method for irrigation in the landscaping for both the park and courtyard. This methodology is recommended for water conservation and is a principle of water-conserving landscaping.

Building Technology

- Walls:
  - The design suggests building cavity walls with 5 cm of extruded polystyrene for insulation. This is a good thickness, but low density expanded polystyrene can be used to achieve higher thicknesses at a lower cost.

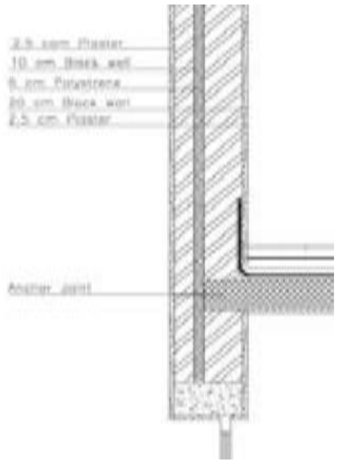

Fig. 13-2 Wall construction detail

  - The design suggests using "Trombe Walls," which assist in heating the apartments during winter. However, these walls must be shaded with a cantilever to prevent the sun from hitting them during the summer, even if an opening is made in the glass to the outside.

Fig. 13-3 Drawing showing air movement in the Thrombe Wall

- In general the submission uses good passive design building technologies. However, it should pay careful attention to orientation and layout configurations and designs to maximize their effects. It is also recommended that these ideas are simulated using thermal simulation software to guarantee proper operation of the systems adopted.

- Roof:

  The second round submission suggests using 5 cm thick expanded polystyrene for insulation, placed below a minimum of 5 cm foam concrete. This follows local codes, which require a minimum roof heat transfer coefficient of 0.55W/m2 C. A 3 cm increase in polystyrene thickness would have been a better solution than the foam concrete.

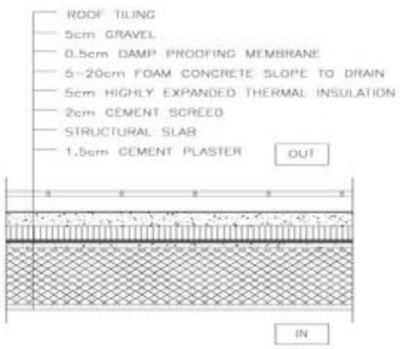

Fig. 13-4 Roof construction detail

- Floor Slabs:
  - The floor slabs are designed to stop at the internal side of the external walls in order to allow the insulation to stretch continuously, thus preventing the formation of thermal bridges at the connections between slabs and walls. This should be verified with a structural engineer, as this solution may be seismically unstable.
  - The roofs of the garages are insulated with 5 cm coated insulation. This is recommended to prevent heat transfer to and from the apartments above the garages.

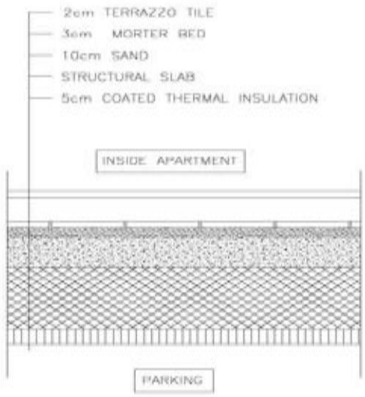

Fig. 13-5 Treatment of the insulation of the floor slab above the parking area

- Windows:
  - The report suggests using double glazing for the windows. This is recommended to reduce heating and cooling loads.
  - The first round submission suggests using tilted windows facing the north and south. This helps reduce heat loads during summer. This idea was abandoned in the second round submission for cost reasons, and western and eastern windows were changed into narrow vertical windows in order to minimize the duration of their exposure to the sun during mornings and afternoons.
  - Collestra (perforated) concrete block facades are used for the east and west elevations of the staircases to minimize heat gain from the sun during the summer.

Electro-mechanical Systems

- Domestic Hot Water Supply:

  The design suggests using a solar system for hot water. However, no description of the system is provided in the first round submission. In the second round submission, the suggested solar powered system comprises of a closed circuit thermosiphon, a solar heating system located at the roof, and a double coil cylinder backed with supplementary heating from the boiler. This system is a good option because it allows for using the solar powered system during the winter by adding antifreeze in the circuit. Although the massing of the overall design allows for shorter pipe lengths, heat loss is expected, as long pipes are needed between the cylinders and the lower apartments. The cylinders are also located externally, which will increase heat loss.

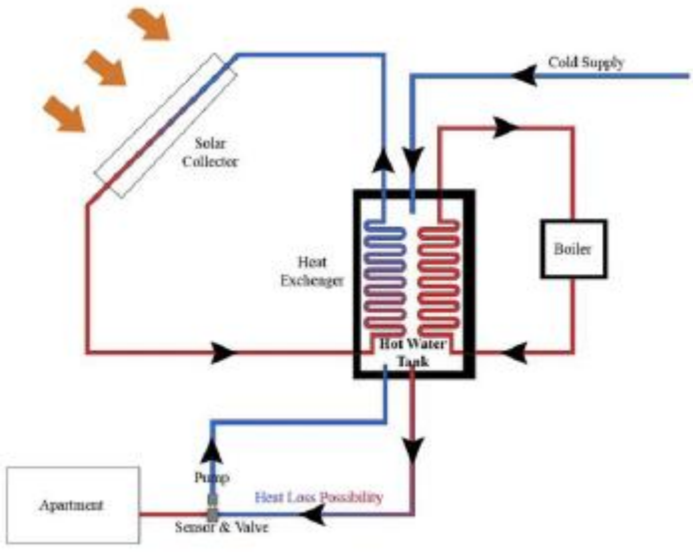

Figure (9): Thermosiphon and Boiler water Heating System

Fig. 13-6 Schematic drawing of the suggested heating system

- Heating System:

  The second round submission suggests using a separate boiler for each apartment. These would feed radiators in each room. Each radiator would have a thermostat that controls the flow of water through it. Although this thermostat, or thermostatic head installed at each radiator, would increase construction costs, it will allow residents to control temperatures in each space according to need. This is an excellent way of reducing energy consumption.

- Cooling System:

  No cooling system is used in the design. However, a desert cooler system is created through the wetted Bamboo installed at the external court.

- Energy Generation:

  No energy generation systems are suggested.

- Energy Efficient Fixtures and Appliances:

  Although no energy efficient fixtures or appliances are suggested, the design recommends installing internal water and electricity meters for the close monitoring of energy consumption. This is a good approach, and allows residents to monitor their consumption habits.

- Water Demand Reduction:

  The design does not mention the use of water saving fixtures although such units are readily available in the market and are reasonably priced. The design however, suggests some measures for the conservation of water consumption in the gardens and park designs.

- Efficient Water Supply:
    - Graywater Recycling

      The project utilizes a graywater treatment system using natural materials such as wood and gravel. The water is then pumped into 22 tanks on the roof, one for each apartment, in addition to an irrigation tank. Using natural materials for toilet flushing is not recommended since the water quality cannot be guaranteed. Furthermore, distributing the graywater over 22 tanks is expensive and unjustified. A common tank may be used to distribute the water to the graywater network, particularly since there are no billing issues to be resolved.

    - Rainwater Harvesting

      The design suggests collecting rainwater from the terraces of the eight plots using gravity to move the water into a tank located at the lowest point in the whole site (in this case, it is the central park). The water is to be used for the irrigation of the park. Using a central tank is recommended instead of building individual storage tanks in each plot. Collecting water from the roofs should also be considered.

<u>Building Use</u>

The design focuses on the role of the residents in controlling their water and energy consumption habits. For example, it recommends installing meters for electricity and water in easily readable locations in each apartment, and suggests installing thermostatic heads to control space heating. This will help each household monitor its consumption of water and energy, and to control it accordingly.

MATRIX OF BEST WATER AND ENERGY EFFICIENT IDEAS*

Entries	1	2		3	4	5	6	7	8	9	10		11	12	13	
		Rnd. 1	Rnd. 2								Rnd. 1	Rnd. 2			Rnd. 1	Rnd. 2
Urban Design				C			A			B						C
Building Design																
Apartment Orientation		C		C	C		A			B						
Compact Mass	B			B			B			B	C			A		
Layout		B		C			A			B			A			
Placement of Openings	C			C	C					B	C		A		C	
Shading		B				C	C			A	A				B	
Passive Ventilation								C	B	C				C	A	
Landscaping	C	C		B		A				A	B					
Building Construction																
Walls	B	B		B		B	B		C	B	B	A	C	B	B	
Roof	C	A		A	C		C			C	C			C	C	C
Floor slabs	A			B	C		B			C			A		B	
Windows	B	B		B			B		B	C	B		C	A	B	
Electro-mechanical Systems																
Domestic Hot Water		B	C		C	B	C			B	C	A	B	C	C	
Heating						B				C	C	A	C		A	
Energy Efficient Fixtures				B						B	B	B			B	
Reducing Water Demand	C	A				A				B	B	B	B	B		
Efficient Water Supply	C	B	C	B	C	A	B		C	B	B	B	B		C	

*Entries with A, B, or C ranking provide the best design and construction solutions respectively.