Abu Alanda Housing Competition

Report and Cost Analysis

July, 2010

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1. Design Approach and Methodology

In low-income housing projects adoption of passive design principles become so important because of limitations of budget for capital investment and running costs. These principles contribute to a large extent to the heating, cooling and natural ventilation of the living spaces and keeping the need for other mechanical systems, that add to the initial and running costs and contribute to the CO2 emissions, to the minimum.

Passive solar concepts have been utilized and incorporated into the architectural design of the proposed apartment building. These included having a rectangular floor plan, elongated on an east-west axis; a glazed south-facing wall; a thermal storage media exposed to the solar radiation which penetrates the south-facing glazing; overhangs and shading devices which sufficiently shade the south-facing glazing from the summer sun; and small windows on the east and west and north walls.

Looking at the general approach currently adopted in apartment buildings in Jordan, little attention is paid to creating a communal space for the flats' residents. There is a debate about viability of such spaces in our community and if it can be successful or not. In this proposal we encourage creating such spaces as they enhance the sense of community and provide a green space to meet in a safe, secure and healthy environment. One of the core elements of the urban design proposal is to provide communal open space for each building which is essential in creating sustainable communities within affordable housing schemes. The site natural topography and the surrounding street levels allowed us to achieve this along with the required density.

The plot land was divided into three strips: the building strip which include the footprint of the building itself and a 3.5m buffer for private gardens at ground and basement levels, the second 3m strip is building pedestrian entrances from upper and lower streets and for circulation of residents into the shared garden. The third strip is the shared garden strip which includes terraced communal gardens. The overall layout will look like strips of built up areas and soft landscaping areas. This allows penetration of wind and optimum exposure to sun.

Green areas will minimize the heat island effect and cool the breezes for a more comfortable indoor and out door spaces within the project. This will be enhanced by planting deciduous shade trees close to the southern façade of the building and the pathways to provide protection from the summer sun and let winter sun in for passive heating.

There have been attempts from the beginning to create variations between the building flats not only for modifying the uniformity of the prevailing apartment buildings design approach but also to enhance the energy efficiency of the building and create a comfortable and livable flats. One of those attempts is creating roof gardens at the same levels of the upper flats. Among the several environmental and economic benefits of these roof gardens are enhancing the insulation efficiency, providing shaded green gaps within the building mass and better natural ventilation.

The building floor plan is arranged to have the living and kitchen rooms facing south and overlooking the shared garden area and bedrooms to the northern side of the building.

The building structure has been organized in a modular system where these modules can protrude as cantilevers or recessed form the main structure. This has provided opportunities to have balconies as extension to the living spaces and provided needed shade on the facades particularly for protection from the summer sun. We also believe that this modular system creates an adaptable flat space that is reflected on the flat interior design to respond to the individual needs and tastes and also helped in creating a pleasing façade rhythm. Justification of the structural design of the cantilevers is presented in section 4 of this report.

2. Energy efficiency

2.1. Passive Solar design

Passive design careful organization of spaces has resulted in an efficient building that draws in solar energy. External blockwork walls are fully insulated, providing high thermal mass that retains the heat. The large internal volumes and generous windows allow air to circulate through the flat eliminating the need for cooling devices.

Because of the large openings at the southern façade, the living rooms will act as an engine rooms for concentrated passive solar heating for the flats. In winter they heat up and disperse warm air into the surrounding rooms. In summer, when windows are opened up they minimize concentration of trapped heat. Stable internal temperatures are maintained through high performance insulation in the walls and roof.

It is believed that incorporating of those passive solar systems will cut down the energy requirements by at least one third.

2.2. Natural Ventilation

Having large openings on the southern facade and small openings on the northern facade will maximize cross ventilation through the flat. Cross ventilation through flats happens through doors and windows and through air grills installed within the internal partitions of the rooms.

All ventilation within flats will happen naturally without the need for any mechanical devices, which contribute to cutting down of initial as well as maintenance, operation and repair costs. Two shafts adjacent to the stairwells will also provide natural ventilation for the car parking at the basement floors. This was enhanced by providing openings at the car park basement levels.

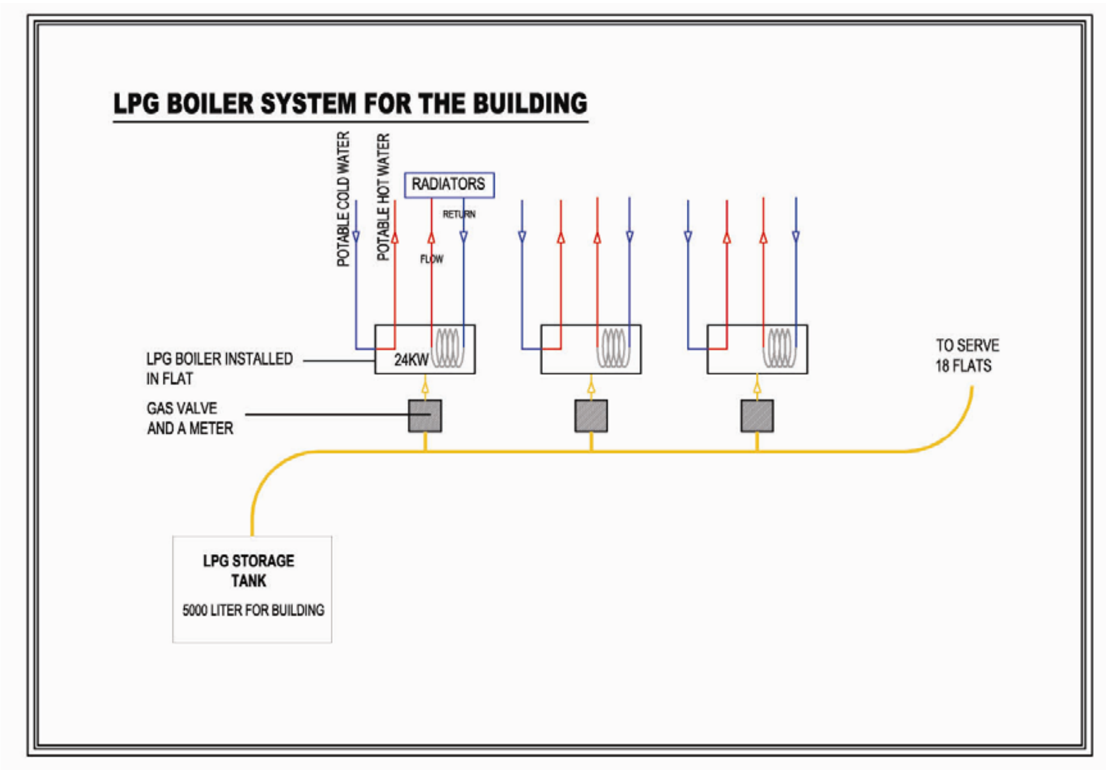
2.3. Heating System Proposed

Gas boilers are installed in each flat and fed by a common LPG tank of 5000 liters capacity to serve each building (18 flats). Each gas inlet has a valve and a gas meter for organizing the billing system. Installation of boilers within the flats' kitchens will save piping and prevent heating loss and will also save space within the mechanical services plant. This system is more efficient in terms of its performance and also a cleaner system with less CO2 emissions.

Heating will be provided for the entire building by using 18 LPG boilers located within residential units, circulating pumps, pipe work to provide hot water to radiator units. The LPG boiler also provides domestic hot water as a back for the solar hot water system described in section 2.3. This will increase the energy efficiency of the boiler and reduce the gas bill. A combined LPG tank of 5000 liters capacity will be installed for each building.

Figure 01 presents the heating system proposed. The same gas will also be used for cooking purposes. Through this system we estimate the savings of 30% of the initial cost and 35% of the running costs compared with regular/diesel boiler systems.

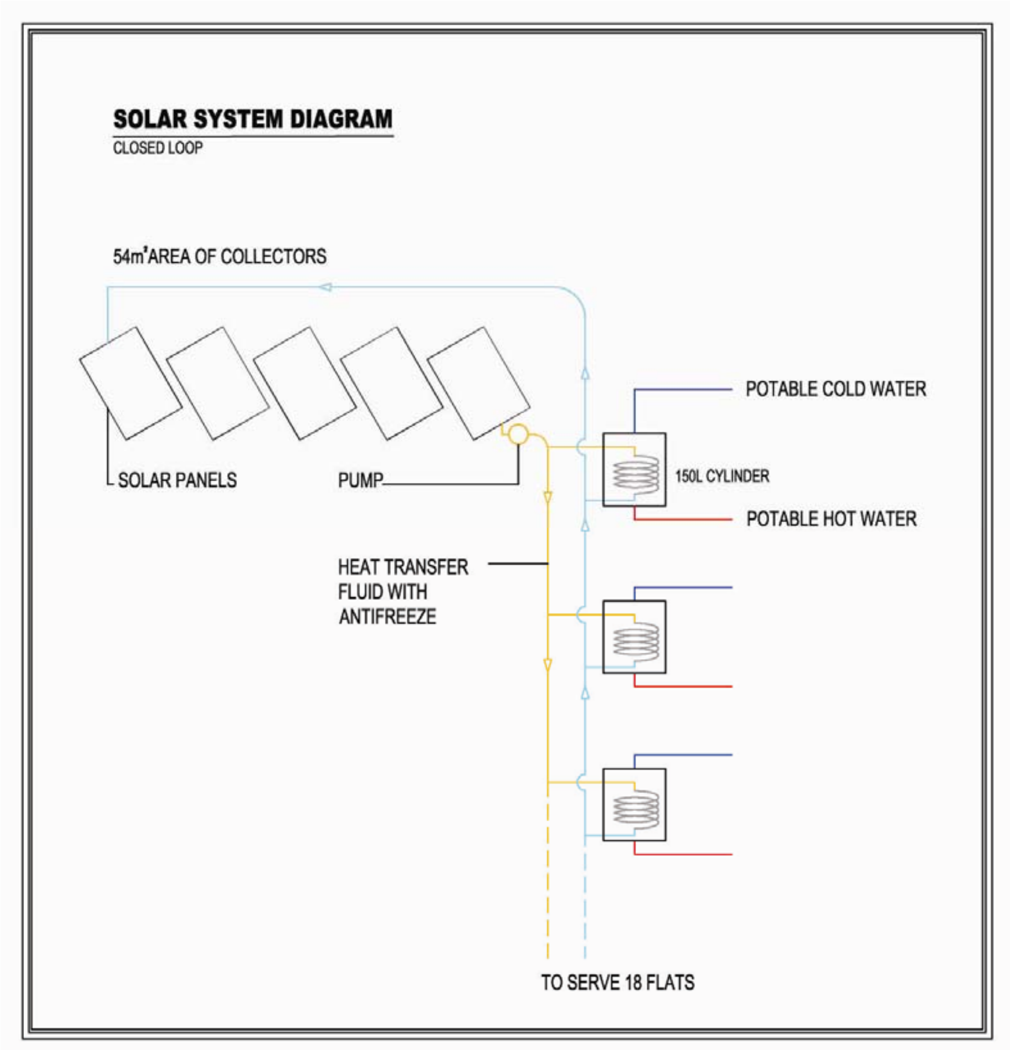
Figure 01: Heating System



2.3. Solar Hot water System

A common closed loop solar system has been used to provide domestic hot water to sanitary fixtures and kitchen. This system consists of flat plate collectors, electric pump and a closed loop using heat-transfer fluid with antifreeze and heat exchanger to transfer heat to potable water. A cylinder of 150 liters storage capacity will be installed in bathroom mezzanine within each flat. Figure 02 demonstrates the solar hot water system proposed.

Figure 02: Solar Hot Water System



2.4. Roof Services Plant

Services plant for the solar flat plates and potable water tanks is located on the upper roof. We calculated that the area required for solar collector will be 54m2. solar collectors and water tanks will contribute to the insulation of the roof by providing shade.

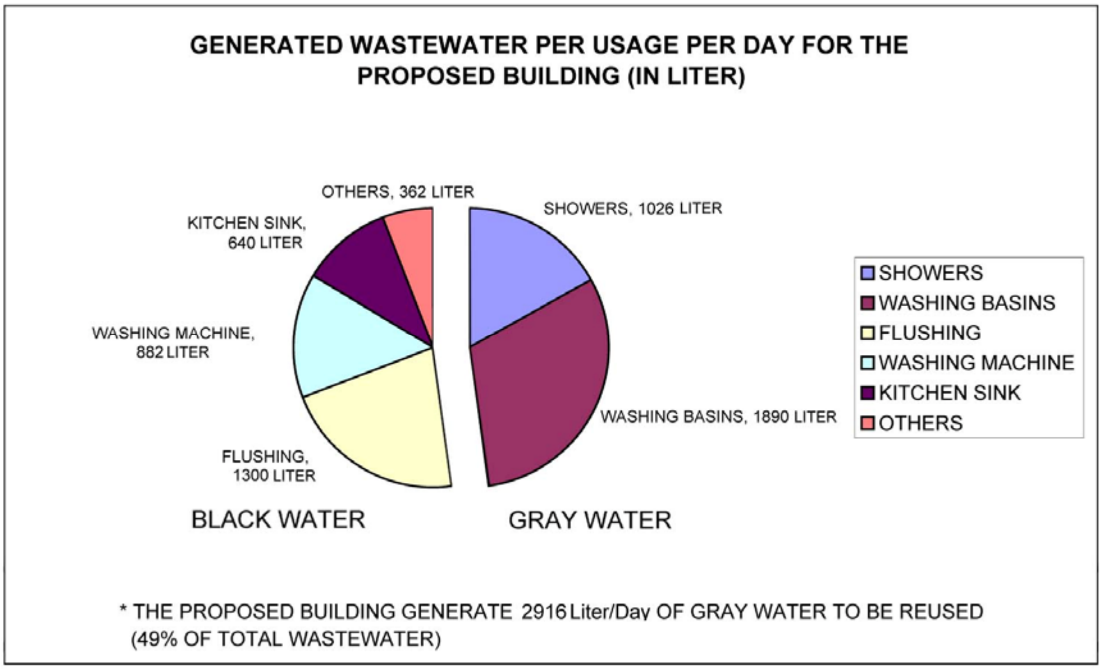
2.5. Energy Efficient Lighting Fixtures

Compact fluorescent lighting bulbs will be used for more efficient lighting. This will save around 40% on electrical bills and have a life span of almost 8 years.

3. Water efficiency

The general water needs in Jordan is estimated at 100 Liters per day per person. 30% of this amount is consumed for gardening purposes. The rest is consumed in showers, washing basins, laundry and other domestic uses. Figure 03 shows the calculated water consumption per day for the proposed building distributed among different domestic usages. The average annual rainfall in the project area is about 300mm. The design proposal includes gray water reuse and rainwater harvesting schemes.

Figure 03: Generated Wastewater



The use of native plants for minimum water consumption. drought-tolerant and indigenous trees will minimize the irrigating requirements once plants are established. Establishment period may last from 18 months to 24 months. The following table presents the amounts of irrigation water required for the building plot (1000m2 of soft landscaping)

Table 01: Estimated Irrigation Requirements

Years	Irrigation (m3 per m2)	Total annual required irrigation (m3)
1-2	0.35	350
2-5	0.30	300
5-10	0.25	250
10-20	0.20	200

Other means used for water efficiency included using of open grid paving for pathways and gathering areas to reduce runoff and evaporation rates. Colored gravel like tuff and mulch beds will also contribute in keeping moisture in the soil. Refer to section 5: Construction and Landscaping Materials.

3.1. Gray Water Reuse

The gray water system is used to collect the gray water only from showers, washing basins. Assuming use of water saving devices, almost 3 cubic meters of gray water will be generated every day from the apartment building. Almost half of this amount is required for reuse in flushing toilets and the other half for irrigation purposes.

Grey water from showers and basins is filtered by a sand-gravel bed with bamboo and supplies the water for the garden irrigation via subsurface irrigation channels. A separate network for toilet flushing will be installed within the building. Each building installs a filter unit and a storage tank of 45m3 capacity which overflows into sewage system. This system will save potable water and will offer financial savings to municipal sewage treatment facilities as it diminishes sewer flows.

3.2. Rainwater Harvesting

One of the main features of this project is the rainwater harvesting scheme. The project harvest rainwater via the roof of the building and store it in a 120m3 reservoir located under the parking adjacent to the upper street. Which then irrigates the shared garden and private gardens by gravity through subsurface irrigation channels covered by gravel. A valve installed to ensure that runoff from the first spell of rain is flushed out and does not enter the system

Rainwater harvesting scheme is also used in the central garden which uses the catchments area of the upper street and walkways to collect the rain in a wet pond with plants and bushes to remove a range of pollutants from runoff. The wet pond will make a nice water and natural feature in the garden and will also increase property value.

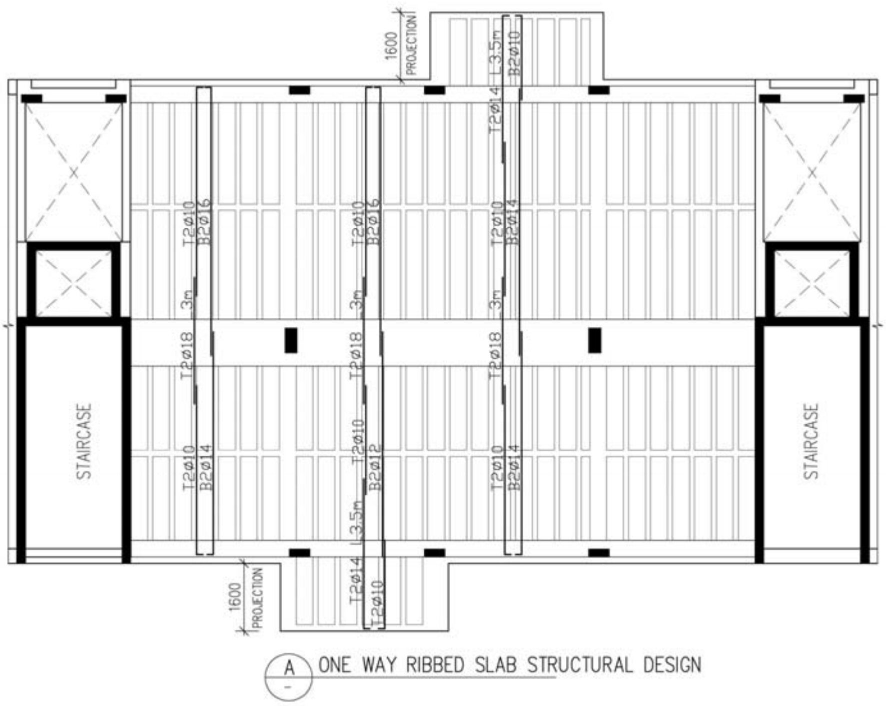
3.3. Domestic Water System

Domestic water supply system will comprise water Storage tanks of 4m3 capacity in the basement levels and 2m3 capacity on service roof plant for each flat. A pump room shall be provided adjacent to the basement water tanks to house the water lifting pumps to lift water to roof water tanks. Water saving devices to be used on faucets, mixers. This is known to save about 30% of domestic consumption.

Placement of the hot water cylinder within the flats will make it close to the points of use for hot water and will conserve water. This is the most cost and energy effective approach. Its believed that minimizing long pipe runs throughout careful planning in the plumping layout will save materials as well as water.

4. Justification of Projections and Structural Design

The structural design uses a one way ribbed slab as shown in Figure 04.



Calculations for reinforcement steel have been carried out and illustrated as follows:

REINFORCEMENT STEEL WEIGHT CALCULATION FOR THE RIBS WITHIN SLAB WITHOUT PROJECTION/ CANTILEVER

Bars	Diameter	No.	Length	Weight/ L.M.	Weight (Kg)
1	10	2	4.5	0.617021429	5.553192857
2	10	2	5	0.617021429	6.170214286
3	14	2	5.5	1.209362	13.302982
4	18	2	3	1.999149429	11.99489657
5	16	2	6.5	1.579574857	20.53447314
				Total	57.55575886
				per sqm	9.624708839

Steel weight = 9.62 Kg/ sqm

REINFORCEMENT STEEL WEIGHT CALCULATION FOR THE RIBS WITHIN SLAB WITH PROJECTION

Bars	Diameter	No.	Length	Weight/ L.M.	Weight (Kg)
1	10	2	2	0.617021429	2.468085714
2	14	2	3.5	1.209362	8.465534
3	12	2	5.5	0.888510857	9.773619429
4	18	2	3	1.999149429	11.99489657
5	10	2	2.5	0.617021429	3.085107143
6	16	2	6.5	1.579574857	20.53447314
7	10	2	5	0.617021429	6.170214286
				Total	62.49193029
				per sqm	9.173800688

Steel weight = 9.18 Kg/ sqm

We Conclude the following:

1. The layout of slab's ribs and beams helped in making the projection without additional reinforcement per sqm
2. quantities of concrete per sqm for projected and unprojected slabs aere almost the same
3. No additional cost per sqm except for the finishing of the projection (floor, ceiling and wall)
4. projections/ cantilevers have no significant implications on estimated construction cost per sqm

5. Construction and Landscaping Materials

In selection of construction materials for the building we took into consideration the cost factor in parallel with material performance, thermal characteristics, and lifespan. Concrete and blockwork is used for the general structure and external walls to work as thermal mass. Self-colored render is used as a finish for its cost and durability. We used a light color for the external skin and roof with Solar Reflectance Coefficient less than 0.7 and a smooth render finish, to have less heat gain/loss. The wall insulation consists of expanded 50mm polystyrene thermal insulation. Thermal bridges are avoided by having continuous sealed external skin. Double glazing aluminum windows to be used for a higher performance of heat gain/loss of the house

Concrete pavement is used as internal finish for flats. It's the most cost and energy efficient alternative. The inherent durability of concrete also saves long-term maintenance and replacement costs. Concrete is a thermally comfortable surface, slow to heat up and cool off, which helps to moderate indoor climate.

Natural local stone and rocks are used for retaining walls. This has less impact on environment, transportation, and need no manufacturing. The overall energy consumption and material waste are minimum. Also provides good drainage qualities for retaining walls.

Colored gravel and open grid paving for garden pathways and gathering areas have been used as part of the landscape scheme. These types of paving will minimize the heat island effect and reduce the run off and rain storm water by increasing the land capability for storm water absorption, reduce evaporation rates and enhance overall benefit from rainwater.

6. Cost Analysis

5.1. Initial Cost

The following table shows breakdown of construction and initial cost for the apartment building. The total cost estimate per –square – meter for the proposed apartment building is 246 JOD.

Initial Cost, Lifespan, Replacement and Residual Value (20 years)

Item	Description	Qty	Unit	Price	Initial cost	life	Repl.	Res.
				JOD/Unit	JOD	Yrs	Cost	Value
1	Building substructure	440	sqm	65	28600	100	0	22880
2	Superstructure	3130	sqm	100	313000	100	0	250400
3	Finish materials							
	Flats	2145	sqm	100	214500	50	0	128700
	Basement Parking	425	sqm	50	21250	100	0	17000
	External Façade	2532	sqm	6	15192	100	0	12154
4	Mech. systems							
	Heating system							
	a. LPG Boiler, main LPG storage and piping	18	unit	1600	28800	15	9600	19200
	b. Heating network/radiators	L.S.			39000	100	0	31200
	Solar hot water system							
	a. Solar panel collectors and networking pipes	18	unit	400	7200	15	2400	4800
	b. 150 Liter cylinder	18	unit	200	3600	15	1200	2400
	Domestic water pumps	18		50	900	5	2700	0
	Domestic water networks	18	unit	400	7200	100	0	5760
	Reused gray water network and pump for flushing	18	unit	200	3600	100	0	2880
5	Electrical works							
	Electrical works	18	unit	600	10800	100	0	8640
	Lighting fixtures	18	unit	150	2700	5	8100	0
6	Elevators	2	Unit	10000	20000	20	0	0
7	External works							
	Cut and fill	1340	sqm	8	10720	100	0	8576
	Rain water reservoir	40	sqm	120	4800	100	0	3840
	Gray water reservoir	16	sqm	120	1920	100	0	1536
	Gray water unit	2	L.S.	500	1000	5	3000	0
	Natural Stone walls	48	M.L.	70	3360	100	0	2688
	Natural open tiling slabs	120	sqm	22	2640	100	0	2112
	Pathways	200	sqm	50	10000	100	0	8000
8	Roof Insulation works	480	sqm	20	9600	10	9600	0
9	Soft landscaping	1014	sqm	6	6084	100	0	4867.2
10	Rf Gardens soft landscape	320	sqm	10	3200	100	0	2560
	TOTAL				**769666**		**36600**	**540193**
	Initial cost per sqm of building				**246**			

5.2. Yearly Operating, Maintenance & Repair Costs

Yearly Operating, Maintenance & Repair Costs For The Building

Item	Description	Yearly cost
		JOD
1	Maintenance of external render wall	100
2	Garden and soft landscaping	200
3	Building Guard Salary	3000
4	Pathways and external staircase	120
5	Elevators and stairwells	180
6	Gray water filters	100
7	Domestic Water Bills	720
8	Water supply system	100
9	Irrigation water reservoirs	70
10	Gas for heating system	3780
11	Heating system maintenance	50
12	Electricity bills	144
	Total running cost per year	**8564**

5.3. Life Cycle Cost Analysis for the Building

The formula for Life Cycle Cost Analysis (LCCA) is

LCC = I + Repl. – Res + L(OM&R)

LCC = 769,666 + 36,600 – 540,193 + 20(8,564)

= 437,353 JOD

I: Initial Cost

Repl: Replacement Costs

Res.: Residual Value (resale value, salvage value)

L: Time in years

OM&R: Operating, Maintenance and Repair Costs

7. Area Schedule

LAND AREA	1780
FAR	1.76
BUILT UP AREA	3132.8

FLOOR	TOTAL SQM	ROOF GARDEN SQM	STAIRWELL SQM	PARKING SQM	FALT UNITS	FLATS SQM
B4	310		40	270	0	
B3	310		40	155	1	115
B2	310	40	40	0	2	230
B1	440	40	40		3	360
GF	440	40	40		3	360
1STF	440	40	40		3	360
2NDF	440	40	40		3	360
3RDF	440	40	40		3	360
TOTAL	3130	240		425	18	2145

SOFT LANDSCAPE	1014

HARD LANDSCAPE	767

PLOT NO.	UNITS
667	23
668	23
669	23
670	23
671	20
672	20
673	18
674	18

TOTAL FLAT UNITS **168**