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1. Abstract:

This report details the cooling load calculations for a single-story villa with a basement located in Adan, Kuwait, considering the peak design conditions at 3:00 pm solar time, as per ASHRAE standards. The comprehensive analysis encompasses the assessment of total conduction, solar radiation, and internal thermal energies across various rooms and areas within the villa. Conduction heat transfer is examined in the building envelope including walls, glass, doors, partitions, and ceilings, while solar heat gains are calculated exclusively for glass surfaces. Internal loads are attributed to occupants, lighting, and equipment. By aggregating the solar radiation, conduction, and internal loads, the report determines the total energy influx into the villa, from which the requisite air conditioning capacity is derived to maintain indoor comfort. The findings provide crucial insights for designing efficient cooling systems tailored to the harsh climatic conditions of Kuwait.

2. Introduction:

Heat loss calculations are made to determine a building heating load. Under the fairly static conditions experienced under the assumptions used to make such calculations, Ahead loss at and a heating load are functionally identical. Heat loss (the simultaneous summation of all heat flows out of a building) is synonymous with heating load (the capacity of equipment required to account for such a load). The same is not true of a heat gain and a cooling load. Heat gain is a simultaneous summation of all heat flows into a building along with those flows generated inside the building. Cooling load is the capacity of equipment required to account for such a load. Due to the dynamic nature of heat gain and the opportunities for heat storage (capacitance) that accompany dynamic loads, heat gain is often not equal to cooling load. Gains that enter a building but are stored in materials or furnishings do not have to a handled at that time and are not included in cooling load. In general, convective and latent heat flows are instantaneous, flow equals load. Radiant loads tend to be partially stored in a building (what percentage depends upon a number of factors), flow does not equal load. As with heat loss, it is necessary to calculate a design load to characterize building performance during over-heated period (normally summer) conditions. Design cooling load calculations are normally made to size HVAC (heating, ventilating, and air-conditioning) systems and their components. A building experiences a range of cooling loads in any given year, ranging in magnitude from zero (no cooling required) to whatever the maximum load happens to be that year. A design cooling load is a load near the maximum magnitude, but is not normally the maximum. This should become clear when the assumptions behind the calculations are understood. Design cooling load is intended to summarize all the cooling loads experienced by a building under a specific set of assumed conditions.

The assumptions behind design cooling load are as follows:

1. Weather conditions are selected from a long-term statistical database. The conditions will not necessary represent any actual year, but are representative of the location of the building. ASHRAE has tabulated such data, as have other groups. The designer may select a severity of weather that seems appropriate for the building type in question although energy codes often specify what data shall be used (to minimize over-sized systems).

2. The solar loads on the building are assumed to be those that would occur on a clear day in the month chosen for the calculations.

3. The building occupancy is assumed to be at full design capacity.

4. All building equipment and appliances are considered to be operating at a reasonably representative capacity.

5. Lights are assumed to be operating as expected for a typical day of design occupancy.

6. Latent as well as sensible loads are considered.

7. Heat flow is analyzed assuming dynamic conditions, which means that heat storage in building envelope and interior materials is considered.

The above assumptions make calculation of design cooling load much more complicated and complex than calculations of design heat loss (with its many simplifying assumptions). Unfortunately, there is no way around this--especially in a cooling

load dominant climate as occurs in much of the southern United States. The total building cooling load will involve heat transferred through the building envelope and heat generated by occupants, equipment, and lights. The envelope heat flows are termed external loads, in that they originate with the external environment. The other loads are termed internal loads, in that they are generated from within the building itself. The percentage of external versus internal load varies with building type, site climate, and building design decisions. The total building cooling load also consists of sensible load components and latent load components. The sensible loads will affect dry bulb air temperature; the latent loads will affect absolute (and relative) humidity. Buildings are classified as envelope-load-dominated and interior-load-dominated. Envelope-dominated buildings (also called external-load-dominated) experience the majority of their cooling loads as a result of the interaction between the exterior environment and the interior environment. Interior (or internal) load-dominated buildings experience the majority of their cooling loads as a result of activities occurring within the building. It is useful to be able to predict whether a building will be dominated by internal or external loads as this information should substantially change the focus of design efforts related to energy efficiency.

3. Objective:

1. To determine cooling load of a residential building.
2. To learn how to master the cooling load calculations.

4. Basement Calculations:

4.1 Total cooling load for below- grade room:

External LOADS	Conduction	**Item**	**Orientation**	**Area, ft²**	**U Btu/hr.ft².F ’**	**CLTD , ºF**		**Total Cooling, Btu/hr**
		Wall	E	131.81	0.107	43.15		608.5734
		Wall	N	199.06	0.107	28.15		599.5787
		Glass	E	27.438	0.65	32.15		573.3856
		Partition (wall)	-	119.436	0.2	Δt	19	453.8568
		Partition (wall)	-	39.812	0.2	Δt	0	0
		Partition (wall)	-	147.3044	0.2	Δt	0	0
		Partition (wall)	-	19.906	0.2	Δt	0	0
		Partition (door)	-	21.52	0.57	Δt	0	0
		Total Conduction						**2235.395**
	Solar	**Item**	**Orientation**	**Area, ft²**	**SC**	**Max SHG**	**CLF**	
		Glass (shaded)	N	27.438	0.73	45	0.2	180.27
		Total Solar						**180.27**
Internal loads		**Item**		**N**	**HG**	**CLF**	**Load Limit**	
		People						
		Sensible		5	710	1		3550
		Latent		5	1090	1		5450
		Lights		12	1964.16	1		1964.16
		Equipments						
		TV		1	256	0.83		212.48
		Receiver		1	102.4	0.83		84.992
		DVD		1	61.43	0.56		34.4008

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	Ventilation	N	Q, cfm/person	Δt, ºF	ΔW	
	Sensible	5	15	39.8	-	3283.5
	Latent	5	15	-	0.01	3630
	Total Internal Load					**18209.53**
TOTAL LOAD						**20625.195**

4.2 Total cooling load for Below- grade living room:

		Item	Orientation	Area, ft^2	U Btu/hr.ft^2.F '	CLTD , ºF		Total Cooling, Btu/hr
External LOADS	**Conduction**	Wall	N	495.6594	0.107	28.15		1492.951
		Wall	W	513.3488	0.107	33.15		1820.874
		Wall	S	756.428	0.107	33.15		2683.088
		Wall	E	119.436	0.107	43.15		551.442
		Wall	E	27.8684	0.107	43.15		128.6698
		Wall	N	73.6522	0.107	28.15		221.8441
		Wall	E	29.59	0.107	43.15		136.6185
		Glass	S	11.9436	0.65	32.15		249.5914
		Glass	W	11.9436	0.65	32.15		249.5914
		Glass	S	11.9436	0.65	32.15		249.5914
		Glass	W	15.12856	0.65	32.15		316.1491
		Below grade	-	189.376	0.0489	Δt	19	176
		Partition (wall)	-	2868.186	0.2	Δt	0	0
		Door	-	1743.981	0.6	Δt	19	19881.38

		Floor	-	19.906	0.145	Δt	19	54.84
		Partition (wall)	-	19.906	0.2	Δt	0	0
		Partition (wall)	-	93.5582	0.2	Δt	0	0
		Partition (wall)	-	39.812	0.2	Δt	0	0
		Partition (wall)	-	119.436	0.2	Δt	19	453.8568
		Partition (wall)	-	18.292	0.2	Δt	0	0
		Partition (door)	-	17.216	0.57	Δt	19	186.4493
		Total Conduction						**28852.94**
	Solar	**Item**	**Orientation**	**Area, ft²**	**SC**	**Max SHG**	**CLF**	
		Glass (shaded)	N	11.9436	0.73	45	0.4	156.94
		Glass (sunlit)	W	7.76	0.73	215	0.53	645.504
		Glass (shaded)	N	4.18	0.73	45	0.2	27.46
		Glass (shaded)	N	5.3	0.73	45	0.2	34.82
		Glass (shaded)	N	11.9436	0.73	45	0.4	156.94
		Glass (sunlit)	W	9.833	0.73	215	0.53	817.94
		Total Solar						**1839.604**
Internal loads		**Item**		**N**	**HG**	**CLF**	**Load Limit**	
		People						
		Sensible		15	710	1		10650
		Latent		15	1090	1		16350
		Lights		44	7201.92	1		7201.92

	Equipments					
	TV	1	256	0.83		212.48
	Receiver	1	102.4	0.83		84.992
	DVD	1	61.43	0.56		34.4008
	Ventilation	**N**	**Q, cfm/person**	**Δt, ºF**	**ΔW**	
	Sensible	15	15	39.8	-	9850.5
	Latent	15	15	-	0.01	10890
	Total Internal Load					**55274.29**
TOTAL LOAD						**85966.834**

4.3 Total Cooling Load for Basement:

Item	Cooling Load (Btu/hr)
Room	20,625.195
Living Room	85,966.834
Total	**106,592.03**
Total Cooling Load in tons	**8.88**

1. **Ground Floor Calculations:**

5.1 Living Room:

		Item	Orientation	Area, m^2	U , Btu/hr.ft^2.F	CLTD , ºF		Total Cooling, Btu/hr
External LOADS	Conduction	Wall 1,2,4,6,7,10,IIW,P1door	E	25.952	0.107	28.15		841.095444
		Wall 3,IIIW,11,4W,12,13b,15,16,18 ,P2door	S	31.102	0.107	33.15		1187.04696
		Wall	N	44.474	0.107	28.15		1441.38713
		Wall 5,17	SE	13.394	0.107	40.15		619.14432
		Wall 14	SW	5.143	0.107	33.15		196.289065
		Wall	NE	8.436	0.107	37.15		360.820695
		Glass 1	E	3.043	0.65	32.15		684.240155
		Glass 2	E	3.9201	0.65	32.15		881.462318
		Glass 3	S	3.9201	0.65	32.15		881.462318
		Glass 4	S	3.18	0.65	32.15		715.045578
		Partition 1,2 (doors)	-	11.0644	0.6	Δt	19	1357.20356
		Partition (Wall) p2,p3,p4,p5	-	25.53	0.2	Δt	0	0
		Partition (Wall) P6,p7	-	10.693	0.2	Δt	19	437.215384
		Partition 3 (Bathroom door)	-	1.8	0.57	Δt	19	209.75544
		Partition 5 (Bathroom door)	-	1.8	0.57	Δt	19	209.75544
		Ceiling	-	152.96	0.078	Δt	0	0
		Floor	-	152.96	0.078	Δt	0	0
		Total Conduction						**10021.924**
	Solar	Item	Orientation	Area, m^2	SC	Max SHG	CLF	
		Glass 1 (shade)	N	3.043	0.73	45	0.20	215.119408
		Glass 2 (shade)	N	3.9201	0.73	45	0.20	277.124413
		Glass 3 (shade)	N	3.9201	0.73	45	0.20	277.124413
		Glass 4 (shade)	N	3.18	0.73	45	0.20	224.804376
		Total Solar						**994.17261**
Internal loads		Item		N	HG	CLF	Load Limit	
		People						
		Sensible		30	245	1		7350
		Latent		30	155	1		4650
		Lights		75	12276	1		12276
		Ventilation		N	Q ,cfm/person	Δt , ºF	ΔW	
		Sensible		30	15	39.8	-	19701
		Latent		30	15	-	0.01	21780
		Total Internal Load						**65757**
TOTAL LOAD								**76773.1**

5.2 Room:

		Item	Orientation	Area, m^2	U ,Btu/hr.ft^2.F	CLTD , ºF		Total Cooling, Btu/hr
xternal LOADS	Conduction	Wall a	W	9.916	0.107	33.15		378.456614
		Wall (W1)	W	2.7029	0.107	33.15		103.159579
		Wall (W2)	S	2.7029	0.107	33.15		103.159579
		Wall b	S	9.916	0.107	33.15		378.456614
		Glass 1	W	3.9201	0.650	32.15		881.462318
		Glass 2	S	3.9201	0.650	32.15		881.462318
		Partition 1 (doors)	-	1.8	0.570	Δt	0	0
		Partition (Wall)	-	16.65	0.200	Δt	0	0
		Partition (Wall)	-	6.845	0.200	Δt	19	279.87836
		Partition (Wall)	-	4.44		Δt	0	0
		Ceiling	-	20.25	0.078	Δt	0	0
		Floor	-	20.25	0.078	Δt	0	0
		Total Conduction						**3006.03538**
	Solar	Item	Orientation	Area, m^2	SC	Max SHG	CLF	
		Glass 1 (shade)	N	3.9201	0.73	45	0.20	277.124413
		Glass 2 (shade)	N	(0.1) 3.9201	0.73	45	0.20	27.7124413
		Glass 2 (sunlit)	W	(0.9) 3.9201	0.73	215	0.53	3157.83269
		Total Solar						**3462.66954**
Internal loads		Item		N	HG	CLF		
		People						
		Sensible		6	245	1		1470
		Latent		6	155	1		930
		Lights		10	1636.8	1		8184
		Appliances						
		TV		1	256	0.83		212.48
		Receiver		1	102.4	0.83		84.992
		Ventilation		N	Q , cfm/person	Δt , ºF	ΔW	
		Sensible		6	15	39.8	-	3940.2
		Latent		6	15	-	0.01	4356
		Total Internal Load						**8296.2**
TOTAL LOAD								**14764.9**

5.3 Kitchen:

		Item	Orientation	Area, m^2	U , Btu/hr.ft^2.F	CLTD , ºF		Total Cooling, Btu/hr
External LOADS	Conduction	Wall a	W	11.026	0.107	33.15		420.821161
		Wall b	W	3.58	0.107	33.15		136.635204
		Glass	W	3.043	0.650	32.15		684.240155
		Wall c	W	1.11	0.107	33.15		42.3645464
		Partition 4	-	11.47	0.2	Δt	0	0
		Partition 8	-	4.07	0.2	Δt	0	0
		Partition 9,10,11,12,15	-	37.444	0.2	Δt	0	0

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		Partition (door)	-	1.8	0.57	Δt	0	0
		Partition 13	-	11.026	0.2	Δt	19	450.831088
		Partition 14	-	8.066	0.2	Δt	0	0
		Partition (door)	-	1.8	0.57	Δt	19	209.75544
		Partition 16	-	12.95	0.2	Δt	19	529.4996
		Ceiling	-	59.375	0.078	Δt	0	0
		Floor	-	59.375	0.078	Δt	0	0
		Total Conduction						**2474.14719**
	Solar	Item	Orientation	Area, m^2	SC	Max SHG	CLF	
		Glass (sunlit)	W	(0.75)3.043	0.73	215	0.53	2042.73804
		Glass (shade)	N	(0.25)3.043	0.73	45	0.20	53.7798519
		Total Solar						**2096.518**
Internal loads		Item		N	HG	CLF		
		People						
		Sensible		10	245	1		2450
		Latent		10	155	1		1550
		Lights		20	3273.6	1		3273.6
		Appliances						
		Refrigerator						
		Sensible		-	300	1		300
		Latent		-	0	1		
		Freezer						
		Sensible		-	1840	1		1840
		Latent		-	0	1		
		Microwave						
		Sensible		-	8970	0.64		5740.8
		Latent		-	0	0.64		0
		Gas Oven						
		Hooded		-	250	0.71		177.5
		Ventilation		N	Q , cfm/person	Δt , ºF	ΔW	
		Sensible		10	15	39.8	-	6567
		Latent		10	15	-	0.01	7260
		Total Internal Load						**29158.9**
TOTAL LOAD								**33729.57**

5.4 Total Cooling Load For Ground Floor:

Item	Cooling Load (Btu/hr)
Room	14,764.9
Living Room	76,773.1
Kitchen	33,729.57
Total	**125,267.57**
Total Cooling Load in tons	**10.44**

5. First Floor Calculations:

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6.1 Total cooling load for Room1

		Item	Orientation	Area, ft^2	U , Btu/hr.ft^2.F	CLTD , ºF	Total Cooling,
External LOADS	Conduction	Wall	E	140.8	0.107	43.15	650.08
		Wall	N	132.76	0.107	28.15	399.88
		Partition	-	201.152	0.2	ΔT=19	764.377
		Partition	-	60.34	0.2	ΔT=19	229.292
		Partition	-	28.161	0.2	ΔT=0	0
		Partition	-	80.461	0.2	ΔT=0	0
		Partition	-	48.276	0.2	ΔT=0	0
		Partition	-	48.276	0.2	ΔT=0	0
		Glass	E	34.3	0.65	215	4793.425
		Glass	N	22.867	0.65	45	668.86
		Glass	E	22.867	0.65	32.15	477.86
		Door	-	21.174	0.57	ΔT=0	0
		Door	-	21.174	0.57	ΔT=19	229.31
		Ceiling	-	415.3	0.078	43.15	1397.77
		Total Conduction					**9610.854**
	Solar	**Item**	**Orientation**	**Area, ft^2**	**SC**	**Max SHG**	**CLF**
		Glass	N	22.867	0.73	45	0.20	150.2362
		Glass(Shade)	N	22.867	0.73	45	0.20	150.23
		Glass(Shade)	N	40.23	0.73	45	0.20	264.3111
		Total Solar						**564.7835**
Internal loads		**Item**		**N**	**HG**	**CLF**	**Load Limit**	
		People						
		Sensible		3	245	1		735
		Latent		3	155	1		465
		Lights		25	4092	1		4092
		Equipment						
		TV		1	256	0.83		212.48
		Receiver		1	102.4	0.83		84.992
		DVD Player		1	61.43	0.56		34.4
		Ventilation		**N**	**Q, cfm**	**Δt ,ºF**	**ΔW**	
		Sensible		3	15	39.8	-	1970.1
		Latent		3	15	-	0.01	2178
		Total Internal Load						**9771.972**
TOTAL LOAD								**19947.61**

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6.2 Total cooling load for Room2

		Item	Orientation	Area, ft^2	U , Btu/hr.ft^2.F	CLTD , ºF		Total Cooling, Btu/hr
External LOADS	Conduction	Wall	S	189.08	0.107	33.15		670.67
		Wall	W	160.922	0.107	33.15		570.79
		Partition	-	100.57	0.2	ΔT=19		382.16
		Partition	-	40.23	0.2	ΔT=19		152.87
		Glass	W	34.301	0.65	32.15		716.8
		Glass	S	34.301	0.65	32.15		716.8
		Door	-	21.17	0.57	ΔT=0		0
		Door	-	21.17	0.57	ΔT=19		229.27
		Ceiling	-	224.884	0.078	43.15		756.87
		Total Conduction						**4196.288**
	Solar	**Item**	**Orientation**	**Area, ft^2**	**SC**	**Max SHG**	**CLF**	
		Glass (shade)	N	22.867	0.73	45	0.20	150.24
		Glass (shade)	N	22.867	0.73	45	0.20	150.24
		Total Solar						**300.47238**
Internal loads		**Item**		**N**	**HG**	**CLF**	**Load Limit**	
		People						
		Sensible		3	245	1		735
		Latent		3	155	1		465
		Lights		20	3264	1		3264
		Equipments						
		TV		1	256	0.83		212.48
		DVD Player		1	61.43	0.56		34.4
		Receiver		1	102.4	0.83		84.99
		Ventilation		N	Q, cfm	Δt ,ºF	ΔW	
		Sensible		3	15	39.8	-	1970.1
		Latent		3	15	-	0.01	2178
		Total Internal Load						**8943.97**
TOTAL LOAD								**13440.7304**

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6.3 Total cooling load for Room3

		Item	Orientation	Area, ft^2	U , $Btu/hr.ft^2.F$	CLTD , ^oF	Total Cooling, Btu/hr
External LOADS	Conduction	Partition	-	100.576	0.2	ΔT=19	382.1888
		Partition	-	120.69	0.2	ΔT=19	458.622
		Wall	S	160.92	0.107	33.15	570.79
		Wall	W	120.67	0.107	33.15	428.022
		Glass	W	34.301	0.65	32.15	716.8
		Glass	S	34.301	0.65	32.15	716.8
		Door	-	16.939	0.57	ΔT=19	183.449
		Door	-	21.17	0.57	ΔT=0	0
		Ceiling	-	330.81	0.078	43.15	1113.4
		Total Conduction					**4570.09**
	Solar	**Item**	**Orientation**	**Area, ft^2**	**SC**	**Max SHG**	**CLF**
		Glass	S	34.3	0.73	98.5	0.94	2318.36101
		Glass	N	34.3(0.1)	0.73	45	0.20	22.5351
		Glass	W	34.3(0.9)	0.73	215	0.53	2567.87465
		Total Solar						**5171.555**
Internal loads		**Item**		**N**	**HG**	**CLF**	**Load Limit**	
		People						
		Sensible		3	245	1		735
		Latent		3	155	1		465
		Lights		10	1636.8	1		1636.8
		Equipments						
		TV		1	256	0.83		212.48
		DVD Player		1	61.43	0.56		34.4
		Receiver		1	102.4	0.83		84.992
		Ventilation		**N**	**Q, cfm**	**Δt ,^oF**	**ΔW**	
		Sensible		3	15	39.8	-	1970.1
		Latent		3	15	-	0.01	2178
		Total Internal Load						**7316.772**
TOTAL LOAD								**16795.63**

6.4 Total cooling load for Room4

		Item	Orientation	Area, ft^2	U , $Btu/hr.ft^2.F$	CLTD , ^oF		Total Cooling, Btu/hr
External LOADS	Conduction	Partition	-	100.576	0.2	ΔT=19		382.188
		Partition	-	104.6	0.2	ΔT=19		397.48
		Wall	N	112.645	0.107	28.15		339.3
		Wall	W	144.83	0.107	33.15		513.72
		Glass	N	34.301	0.65	32.15		716.8
		Glass	W	34.301	0.65	32.15		716.8
		Door	-	21.17	0.57	ΔT=0		0
		Ceiling		258.64	0.078	43.15		870.5
		Total Conduction						**3936.7926**
	Solar	**Item**	**Orientation**	**Area, ft^2**	**SC**	**Max SHG**	**CLF**	
		Glass	N	34.3	0.73	45	0.20	225.351
		Glass	N	34.3(0.1)	0.73	45		22.5351
		Glass	W	34.3(0.9)	0.73	215		2567.87465
		Total Solar						**3078.541**
Internal loads		**Item**		**N**	**HG**	**CLF**	**Load Limit**	
		People						
		Sensible		3	245	1		735
		Latent		3	155	1		465
		Lights		10	1636.8	1		1636.8
		Equipments						
		TV		1	256	0.83		212.48
		DVD Player		1	61.43	0.56		34.4
		Receiver		1	102.4	0.83		84.992
		Ventilation		**N**	**Q, cfm**	**Δt ,^oF**	**ΔW**	
		Sensible		3	15	39.8	-	1970.1
		Latent		3	15	-	0.01	2178
		Total Internal Load						**7316.772**
TOTAL LOAD								**14069.3207**

6.5 Total cooling load for Room5

External LOADS	**Conduction**	**Item**	**Orientation**	**Area, ft²**	**U , Btu/hr.ft².F**	**CLTD , ºF**		**Total Cooling, Btu/hr**
		Partition	-	108.622	0.2	ΔT=19		412.7636
		Partition	-	80.461	0.2	ΔT=19		305.75
		Wall	N	96.55	0.107	28.15		290.8134
		Glass	N	34.301	0.65	32.15		716.8
		Door	-	21.17	0.57	ΔT=0		0
		Ceiling	-	177.26	0.078	43.15		596.6
		Total Conduction						**2322.73**
	Solar	**Item**	**Orientation**	**Area, ft²**	**SC**	**Max SHG**	**CLF**	
		Glass	N	34.3	0.73	45	0.2	225.351
		Total Solar						**225.351**
	Internal loads	**Item**		**N**	**HG**	**CLF**	**Load Limit**	
		People						
		Sensible		3	245	1		735
		Latent		3	155	1		465
		Lights		10	1636.8	1		1636.8
		Equipments						
			TV	1	256	0.83		212.48
			DVD Player	1	61.43	0.56		34.4
			Receiver	1	102.4	0.83		84.99
			Printer	1	1500	0.56		840
		Mini-Computer		1	1000	0.82		820
		Ventilation		**N**	**Q, cfm**	**Δt ,ºF**	**ΔW**	
		Sensible		3	15	39.8	-	1970.1
		Latent		3	15	-	0.01	2178
		Total Internal Load						**8976.77**
TOTAL LOAD								**11524.85**

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6.6 Total cooling load for living room

External LOADS	Conduction	**Item**	**Orientation**	**Area, ft^2**	**U , $Btu/hr.ft^2.F$**	**CLTD , F**	**Total Cooling, Btu/hr**
		Partition	-	120.69	0.2	ΔT=19	458.622
		Partition	-	52.3	0.2	ΔT=19	198.47
		Wall	SW	56.86	0.107	33.15	201.68
		Wall	SE	56.86	0.107	40.15	244.273
		Glass	S	21.173	0.65	32.15	442.46
		Glass	S	21.173	0.65	32.15	442.46
		Glass	S	21.173	0.65	32.15	442.46
		Glass	S	21.173	0.65	32.15	442.46
		Ceiling	-	815.932	0.078	43.15	2746.18
		Total Conduction					**5619.065**
	Solar	**Item**	**Orientation**	**Area, ft^2**	**SC**	**Max SHG**	**CLF**
		Glass	N	21.173	0.73	45	0.20	139.10661
		Glass	N	21.173	0.73	45	0.20	139.10661
		Glass	N	21.173	0.73	45	0.20	139.10661
		Glass	N	21.173	0.73	45	0.20	139.10661
		Total Solar						**556.42644**
Internal loads		**Item**		**N**	**HG**	**CLF**	**Load Limit**	
		People						
		Sensible		7	245	1		1715
		Latent		7	155	1		1085
		Lights		60	9792	1		9792
		Equipments						
			TV	1	256	0.83		212.48
			DVD Player	1	61.43	0.56		34.4
			Receiver	1	102.4	0.83		84.99

	Mini-Computer	1	1000	0.82		820
	Ventilation	**N**	**Q, cfm**	**Δt ,ºF**	**ΔW**	
	Sensible	7	15	39.8	-	4596.9
	Latent	7	15	-	0.01	5082
	Total Internal Load					**13743.87**
TOTAL LOAD						**25087.335**

6.7 Total Cooling Load in First Floor:

Item	**Cooling Load (Btu/hr)**
Room 1	19,947.61
Room 2	13,440.7304
Room 3	16,795.63
Room 4	14,069.3207
Room 5	11,524.85
Living Room	25,087.335
Total Cooling Load	**100,865.476**
Total Cooling Load in tons	**8.41**

7. Villa total cooling load:

Floor	**Cooling Load (Btu/hr)**
Basement	**106,592.03**
Ground	**125,267.57**
First	**100,865.476**
Total Cooling Load	**332,725.08**
Total Cooling Load in tons	**27.73**

8. Sample Calculations:

8.1 Design Conditions (summer):

- **Outdoor Design condition :** 115ºF (DB) , 69ºF (WB) , 28% (RH) , 0.0173w
- **Indoor Design condition :** 76ºF (DB) , 62ºF (WB) ,50% (RH) , 0.0093 (w)
- **Daily Range :** 27.7^0 F
- **Ground Temperature :** 35ºC
- **Latitude :** 29.5º North
- **Solar Time :** 15:00 hr
- **July 21st**

8.2 External Parameters:

8.2.1 Roof:

Assume 4 in. wood with 2 in. insulation
U = 0.078 Btu/hr.ft^2.ºF (Table28)
CLTD = 24ºF (Table 29), with suspended ceiling

$$CLTD_{corr} = [(CLTD + LM)K + (78 - t_R) + (t_o - 85)]f$$

LM = 1 (table 32)
f = 1 (ducts)
K = 1 (Dark colored area)
t_o = 115 - 27.7/2 = 101.15ºF

$CLTD_{corr}$ = 43.15º F

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8.2.2 Wall:

Assume **Group B** (4 in Face Brick + 2 in. insulation + 8 in concrete block) → Table 30
→ **U = 0.107 Btu/hr.ft^2.ºF**

$$CLTD_{corr} = [(CLTD + LM)K + (78 - t_R) + (t_o - 85)]$$

Orientation	CLTD values From Table 31 (ºF)		Corrected CLTD (ºF)
North	9	→	28.15
East	24		43.15
South	14		33.15
West	14		33.15
South-East	21		40.15
South-West	14		33.15
North-East	18		37.15

- **Below-Grade:**
  From table 5.9 at depth 3.2 m, using extrapolation → U = 0.0489 Btu/hr.ft^2.ºF
- **Basement Floor:**
  From table 5.9 at depth 3.2 m, using extrapolation → U = 0.145 Btu/hr.ft^2.ºF
- **Partition (Wall):**
  Assume (4 in Heavy weight concrete + 2 in. insulation) Group D →
  U = 0.200 Btu/hr.ft^2.ºF

- **Partition (Door):**
  - **Outside Doors : assume 1 3/4 steel door + fiberglass without thermal break**
    → U = 0.6 Btu/hr.ft^2.ºF (table 5.8)
  - **Inside Doors : assume wood 1 3/8 solid core flush door**
    → U = 0.57 Btu/hr.ft^2.ºF (table 5.8)

8.2.3 Windows:

- **Assume double glazing ,Aluminum with thermal break, ¼ in. air space → U from table 5-5a 0.65 BtU/hr.ft^2.ºF**
- **CLTD from table 33 is 14º F → $CLTD_{corr}$ = 32.15º F**
- **Max. SHGF:**

Orientation	Max. SHGF values From Table 34 (BtU/hr.ft^2)
North	45
East	215
South	98.5
West	215

- **CLF :Assume Uncarpeted Floors**

Orientation	CLF values From Table 38
North	0.2
East	0.21
South	0.94
West	0.53

- **SC = 0.73 (Assume open wave fabric and medium colored)**

  From figure 7.12 → I_m → between C and D
  Table 7.5 → Choose (C), insulating glass ¼ in. air space → SC = 0.73

8.3 Internal Parameters:

8.3.1 Lights:

CLF = 1 (24 hr operation)
W = 40 watts, F_{ul} =1 (24 hr operation) , F_{sa} = 1.2

8.3.2 People :

Table 3 for seated, very light work
$(HG)_{sensible}$ = 245 BtU/hr , $(HG)_{latent}$ = 155 BtU/hr
CLF = 1 (24 hr operation)

8.3.3 Equipments:

- **Kitchen: unhooded ,table 8**
  Refrigerator: $(HG)_{sensible}$ = 300 BtU/hr , $(HG)_{latent}$ = 0 BtU/hr
  Microwave : $(HG)_{sensible}$ = 8,970 BtU/hr , $(HG)_{latent}$ = 0 BtU/hr
  Freezer: $(HG)_{sensible}$ = 1,840 BtU/hr , $(HG)_{latent}$ = 0 BtU/hr
  Gas Oven: $(HG)_{hooded}$ = 250 BtU/hr

  CLF values: table 48
  Refrigerator: CLF = 1 (24 hr Operation)
  Microwave : CLF = 0.64 (2 hr operation and from 2:00 pm to 3:00 pm)
  Freezer: CLF = 1 (24 hr Operation)
  Gas Oven: CLF = 0.71 (9:00 am to 5:00 pm)

- **Room: table 9**
  Mini-Computer: HG = 1000 BtU/hr
  Printer: HG = 1500 BtU/hr

  CLF Values: table 48
  Mini-Computer: CLF = 0.82 (10 hr operation, from 10:00 am to 10:00 pm)
  Printer: CLF = 0.56 (2 hr operation time, from 2:00 pm to 3:00 pm)

- **External Data: (internet or manual work)**
  TV: HG = 75 W = 3.4129×75 = 256 BtU/hr
  Receiver: HG = 30 W = 102.4 BtU/hr
  DVD Player: HG = 18 W = 61.43 BtU/hr

  CLF Values: table 48
  For TV and receiver CLF = 0.83 (from 9:00 am to 11:00 pm)
  For DVD player CLF = 0.56 (from 2:00 pm to 4:00 pm)

8.4 Ventilation:

Q = 15 [CFM/Person] × N
ΔW = 0.01, Δt = 39.8° F

$$q_{latent} = 4840\ Q\ \Delta W, \quad q_{sensible} = 1.1\ Q\ \Delta t$$

9. Discussion & Conclusion

1. Total cooling load was evaluated to be 27.73 tons for a 380 m^2 villa using CLTD method.
2. The cooling load for the fist floor is 8.4 tons, 10.4 tons for ground floor and 8.9 tons for the basement.
3. The smallness of this value may be due to totally shading on most of the windows and/or because of draperies or internally shading.
4. The ground floor has the maximum cooling load, and account for nearly 37.5% of the total cooling load that is due high internal loads.
5. The ground floor requires the maximum amount of cooling while the first floor and the basement require the minimum amount of cooling.
6. The orientation of each wall and glass takes an important rule to calculate the cooling load.
7. The wall, which means the wall that separate the outside environment from inside condition at the home has higher insulation material than the partition which is used between two rooms in the floor.
8. The wall must have high insulation material than the partition because it expose to humidity, water, dust and solar radiation.
9. Very small areas compared with others may be ignored if found to have minute influence.
10. As A.C. engineers we should be able to calculate the cooling load required for a space, to determine the satisfactory HVAC System.
11. Internal and external shading play an important role in the cooling load reduction.
12. Windows facing south, east and north are totally shaded while windows facing west have 10-35% shading depending on the floor.
13. For a totally shaded glass a north orientation is used in our calculations.
14. The largest CLTD factor for the wall appears at east orientation so that the wall facing east has the largest conduction (CLTD=43.15).
15. The maximum solar heat gain factor for the windows appear at east and west ordinations (SHGF=215).

10. Villa Pictures:

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Picture 1: totally shaded for windows facing south.

Picture 2: totally shaded for windows facing east.

Picture 3: 25% shaded window facing west.

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Picture 4: 10% shading for window facing west (Ground Floor).

Picture 5: 10% shading for window facing west (First Floor).

Picture 6: 35% shading for window facing west (Basement).

Picture 7: totally shaded window facing east (Basement).

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Picture 8: 20% shading for window facing west (First Floor).

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12.Appendix

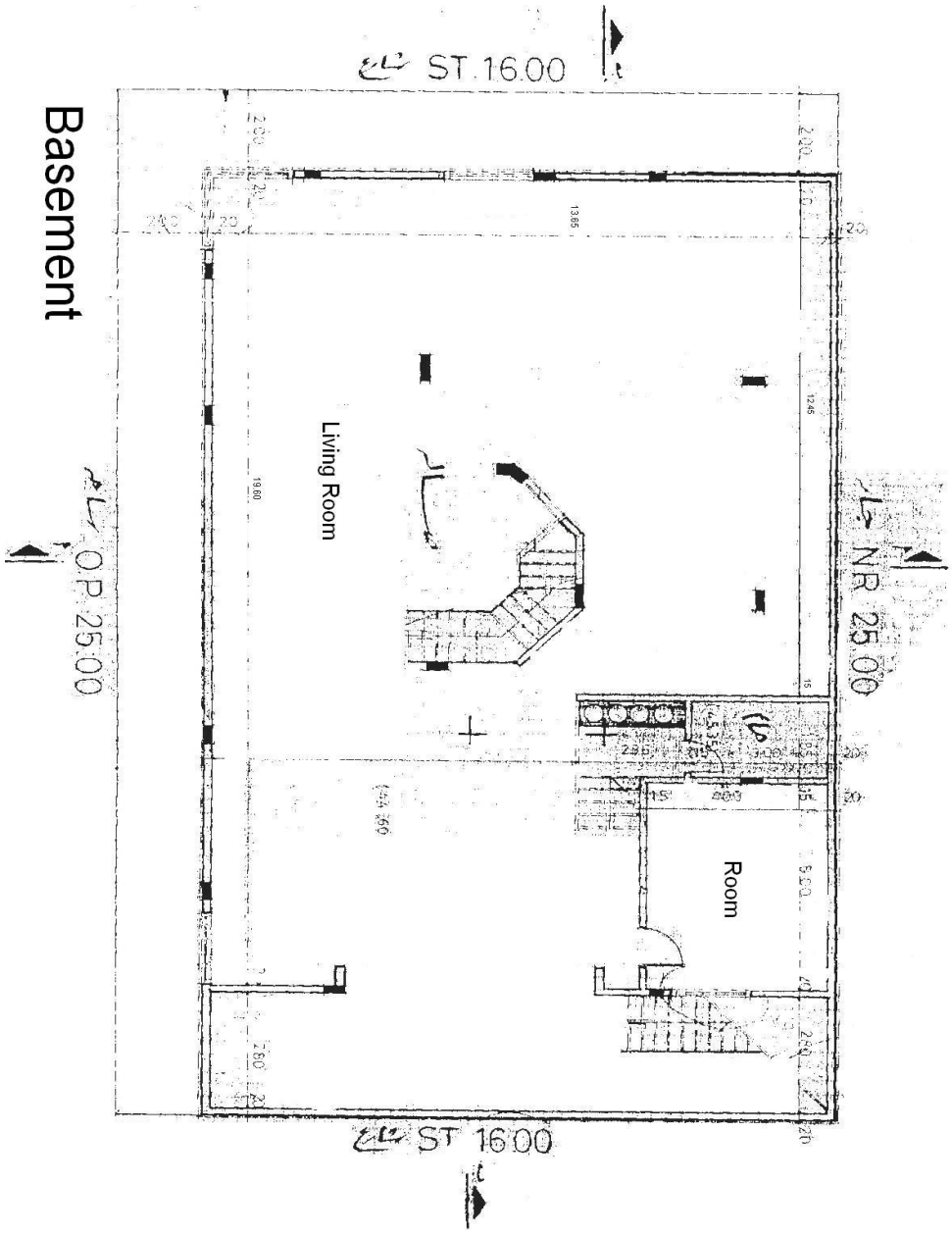

Figure1: The Basement

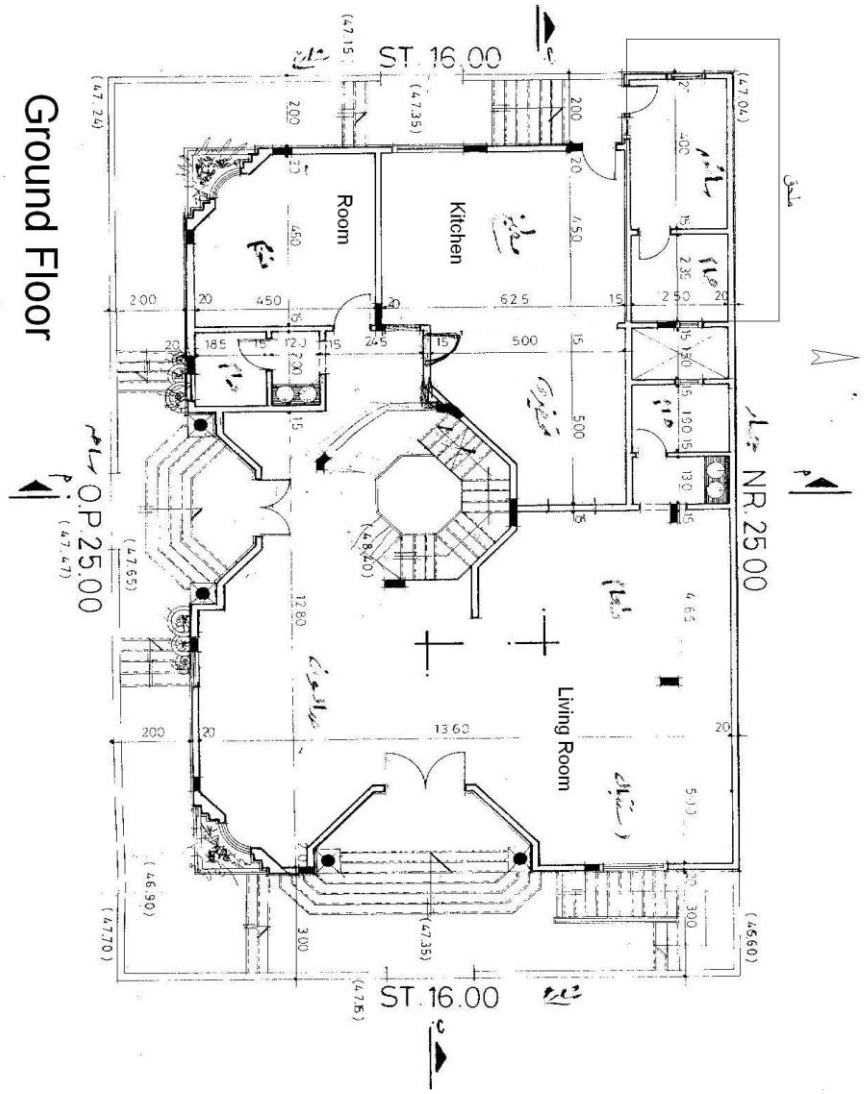

Figure2: The Ground Floor

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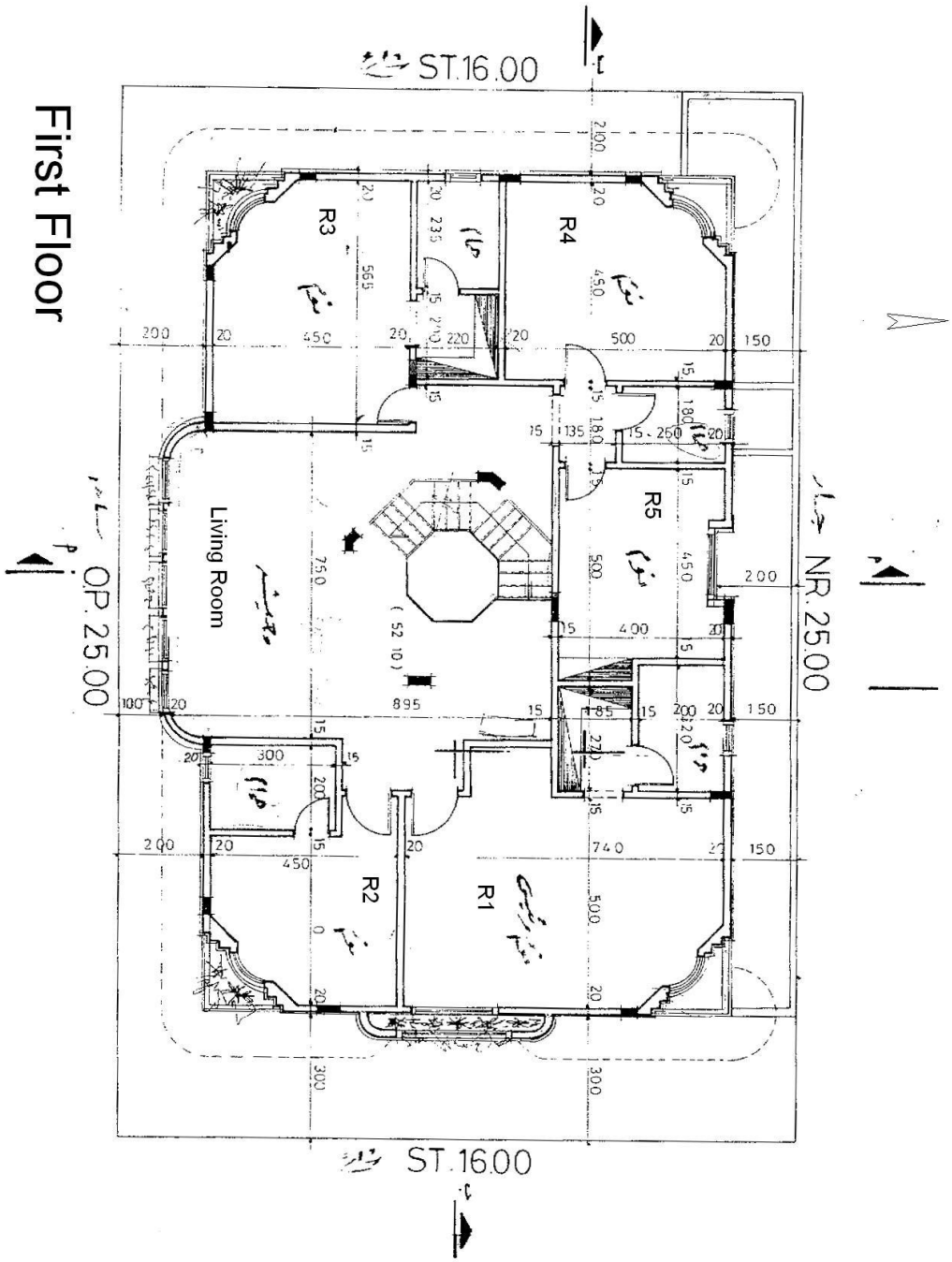

Figure3: First Floor

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"تحليل شامل لأحمال التبريد لتصميم التدفئة والتهوية وتكييف الهواء الأمثل في منطقة العدان، الكويت""

إعداد الباحث:

م. محمد العبيد

الملخص:

يعرض هذا التقرير تفاصيل حسابات أحمال التبريد لفيلا من طابق واحد مع طابق سفلي تقع في عدن، الكويت، مع الأخذ في الاعتبار ظروف التصميم القصوى عند الساعة 3:00 مساءً بالتوقيت الشمسي، وفقًا لمعايير ASHRAE. يشمل التحليل الشامل تقييم التوصيل الكلي والإشعاع الشمسي والطاقات الحرارية الداخلية عبر مختلف الغرف والمناطق داخل الفيلا. يتم فحص انتقال الحرارة بالتوصيل في غلاف المبنى بما في ذلك الجدران والزجاج والأبواب والفواصل والأسقف، في حين يتم حساب مكاسب الحرارة الشمسية حصريًا للأسطح الزجاجية. وتعزى الأحمال الداخلية إلى الركاب والإضاءة والمعدات. ومن خلال تجميع الإشعاع الشمسي، والتوصيل، والأحمال الداخلية، يحدد التقرير إجمالي تدفق الطاقة إلى الفيلا، والذي يتم من خلاله اشتقاق قدرة تكييف الهواء المطلوبة للحفاظ على الراحة الداخلية. توفر النتائج رؤى مهمة لتصميم أنظمة تبريد فعالة مصممة خصيصًا للظروف المناخية القاسية في الكويت.