Evaluation of Villas Codes in Dubai Green Building Regulation and Specification.

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Abstract

Dubai development plan expects the population growth to 18.8 million by 2023. In accommodating the requirements of that future growth, Dubai government showed highly interest in decreasing villas energy consumption. About 57 codes related to villas were issued in Dubai Green Buildings Regulations and Specifications (GBRS) in 2011 became mandatory in 2014. Avilla in Jumeirah Park was selected as the case study where IESVE energy model used in simulating the thermal performance of building envelope. Comparisons presented between the original design and the improvement envelope's elements to evaluate the efficiency of the issued codes, separately. Finally, assembly comparisons built on applying all the improved elements in one new envelope in contrast with the original design. Consequently, results highlighted the ability to achieve electricity saving potential up to 20.5% of building's energy consumption by assembling the best practices of all elements.

Keywords: envelope, energy consumption, green regulations.

1 INTRODUCTION

"Green Economy for Sustainable Development" the initiative of H.H Sheikh Mohamed bin Rashid Al Maktoum in 2012 aimed to achieve 5% of the city total energy by renewable supply in 2030 [1]. UAE points buildings energy consumption as 15%. That calls the Road Map (REMap)'s target in sharing the 29% from building sectors of renewable energy which will be able to cut domestic consumption in UAE. The highest energy consumption of Dubai as 36% pushed the government to issue Dubai Supreme Council of Energy in 2011, and new regulations and policies in terms of energy efficiency and buildings [2]. That encouraged issuing Dubai Demand Side Management Strategy (DSM) plan in 1980 while updated in 2013, to contain 8 programs where building regulations is a main part considering power saving potential from 2013 to 2030 as: 28%. Dubai Municipality (DM) issued Decree No. 66 in 2001 evaluated standards focuses on new buildings' insulation. That followed by Abu Dhabi Estidama Pearl Rating System (AD-EPRS), and the Leadership in Energy and Environmental Design (LEED). Although, DM and Dubai Energy and Water Authority (DEWA) published Dubai GBRS in 2011 to be mandated in 2014 forms a market shift in implementing robust city method and transfer Dubai to the Green Economy [1].

Buildings cooling load in UAE is 47% exceed to 60% in summer, where envelope thermal insulation is effective factor [2]. Dubai Statistic Center [3] showed residential consumption as 30.80% of the city consumption. That pointed 79,108 villas in Dubai divided into privet and investment villas. Hence, this paper aimed to enhancing villas energy performance through modifying envelope's design according to GBRS while recommends the best practices for all. The study will investigate in thermal insulation performance as U-value between the issued circulars of DM and GBRS codes.

2 LITERATURE REIVEW

Approving Decree 66/2003 [4] was the start of providing buildings technical specifications for thermal insulation systems and controlling air condition consumption. In 2008, Trakhees [5] published Green Building Regulation No. GB-001 for Green Building Environment, Health, and Safety division (EHS) under LEED version 2.2. In 2009, EHS Regulation [6] add technical guidelines for residential building. In 2011, GBRS [7] was published in supporting Dubai Strategic Plan for future development that revoked all previous relative regulations. GBRS depends on 2 energy methods: elemental method (complying of the regulations' codes), and Performance method (calculations, simulations and energy models).

In 2012, Dubai Central Laboratory [8] issued the Manual of Green Building Materials. In 2013, Trakhees [9] issued Regulation GB-4.0 under LEED-NC-v3.0. In addition, Circular no.198, DM issued excel summary file [10] to direct and classify the requirements of external wall U-value while provides materials specifications and the approved supplier. That enhanced in March 2014 with publishing the 6 types of "GB Insulation Sections for Villas" [11]. Another excel summery file was presented for glazing [12]. In 2014, Trakhees [13] developed villas and residential green regulations (GB- 8.0). Building Permit Section in 2014 [14] published user guide for green buildings illustrating the process of submitting a green building permit. To Sum up, Table 1compares all Dubai previous regulations in terms of envelope value.

Table 1: concluded parameters of buildings envelopes regulations in Dubai sustainability history.

<table>
<tr><td rowspan="3">Organization</td><td rowspan="3" colspan="2">Issue/ year</td><td colspan="12">U-value (W/m².k)</td></tr>
<tr><td rowspan="2" colspan="2">Roof</td><td rowspan="2">Wall</td><td colspan="3">Floor</td><td colspan="6">Glazing (glazing area / external wall area)(Glass +Frames)</td></tr>
<tr><td colspan="2">Ground floor</td><td>Typical floor</td><td>≤40%</td><td>SC</td><td>40%-60%</td><td>SC</td><td>60%≤</td><td>SC</td></tr>
<tr><td>Legal Affairs Department</td><td colspan="2">Decree 66/2003</td><td colspan="2">0.44</td><td>0.57</td><td colspan="3">-</td><td>3.28</td><td>0.4</td><td>2.1</td><td>0.35</td><td>2.5</td><td>0.76</td></tr>
<tr><td>Trakhees</td><td colspan="2">GB-001/2008</td><td colspan="12">Description Regulation</td></tr>
<tr><td>DM</td><td>GBRS /2011</td><td>Code 501.01</td><td colspan="2">0.3</td><td>0.57</td><td colspan="2">0.3</td><td>-</td><td>2.1</td><td>0.4</td><td>1.9</td><td>0.32</td><td>1.9</td><td>0.25</td></tr>
<tr><td>DM</td><td>GBRS /2011</td><td>Code 805</td><td colspan="6"></td><td colspan="2">2.1- 3.28</td><td colspan="4">2.1</td></tr>
<tr><td>DM</td><td colspan="2">Circular 198- U-value calculation/2012</td><td colspan="2">0.3</td><td>0.57</td><td colspan="2">0.57</td><td>-</td><td colspan="6"></td></tr>
<tr><td>Trakhees</td><td colspan="2">GB-4.0/2013</td><td colspan="12">Description Regulation</td></tr>
<tr><td>Trakhees</td><td colspan="2">GB-8.0/2014</td><td colspan="2">0.25</td><td>0.28</td><td colspan="2">0.57</td><td>-</td><td><30%
2.1</td><td>0.29</td><td colspan="2">>30%
1.9</td><td colspan="2">SC
0.24</td></tr>
<tr><td rowspan="7">DM</td><td colspan="14">Circular 198- GB insulation for villas</td></tr>
<tr><td colspan="2">Type 1</td><td rowspan="6">0.962- 15 cm screed</td><td rowspan="6">1.256– 5 cm screed</td><td>≈ 0.4879</td><td rowspan="6">0.57 insulated</td><td rowspan="6">0.78 non insulated</td><td rowspan="6">2.89 non insulated</td><td rowspan="6" colspan="6">Note: Induction (≈) is for refer to DM-Excel files. Type 1: Expanded polystyrene (CIBSE) selected for the insulation layer from material list ID 105 row no. 198 while thickness is followed cavity wall system 35. Type 2: applies AAC block wall according to the material list ID99- row no.187. Type 3: cladding layer – ID 400, row no. 566.</td></tr>
<tr><td colspan="2">Type 2</td><td>≈0.3167</td></tr>
<tr><td colspan="2">Type 3</td><td>≈0.3482</td></tr>
<tr><td colspan="2">Type 4</td><td>0.4700</td></tr>
<tr><td colspan="2">Type 5</td><td>0.3800</td></tr>
<tr><td colspan="2">Type 6</td><td>0.3723</td></tr>
</table>

Several studies highlighted the significant impact on reducing energy consumption by improve the thermal performance of building envelope. Radhi [15] presented a study focused on applying the recently green regulations in Bahrain to reduce energy use. The study found that insulation codes can reduce only 25% of total energy consumption which set 40% reduction of energy as difficult target to achieve in such a region by applying only the envelope codes [15]. Al Awadhi et al [16] investigated on the ability to improve envelope insulation according to Estidama codes for villas built in Abu Dhabi where results asserted on the ability to save 27.5%-30.8% of the annual energy. Al Sallal, Al-Rais, and Dalmouk [17] investigated on the ability of improving building energy performance by applying DM regulation 66 standards found the ability to save 67% of cooling energy and 49% of electricity in case of improving 12.4% of wall, 9.8% of windows and 45.8% other indoor factors. Results found about 21.8% reduction of the annual cooling load by improve envelope insulation.

3 METHODOLOGY

A "Regional Traditional Villa" approved in 2007 as an investment residential building arrayed 265 times, was the selected a case study from Jumeirah Park – Dubai. According to the recommended energy methods by GBRS, this paper will focused on performance method by simulating a villa energy model in 20 tests. That separately considering envelope elements as wall, roof, floor, and glazing while ended by a performance simulation assembling the best specifications in term of thermal properties for all elements. According to comparison in Table 1, the study will highlight the improvements between Dubai different codes and circulars for each elements and it's effect on villa energy performance.

Integrated Environmental Solutions' Virtual Environment (IESVE) approved it's validation in studding Building Information Modeling (BIM), study [18] evaluated building performance analysis software recorded the highest efficient results for IESVE. Hence, IESVE was recommended for this study as an accurate, and efficient tool in calculating and simulating thermal and energy performance.

Dubai climatic data was the essential input parameters depends on GBRS [7] code 501.03 and agreed with DM [4] for Decree 66/2003 which fixed outdoor condition as Dry Bulb DB 46°C, Wet Bulb WB 29°C, and 25°N latitudes. Moreover, air conditioning profile was fixed according to IESVE data base to domestic occupancy 50% profile for family contains cooling load parameters as the main concern in this paper. In addition, HVAC Coefficient of Performance COP will consider as 2.5 [19].

4 RESULTS and DISCUSSION

4.1 Case Study

By referring to the villa original drawings, table 2 highlighted the main design

Table 2: Case Study Analysis - Regional Traditional villa, Jumeirah Park.

Parameters						**Comments**
Floors No.	G+1	Land Area (m^2)	610	Total Height (m)	+8.9	
Area Use	2 family area, 4 bedrooms + mid, 6 bathroom, 1 office, 1 made room, 1 kitchen, 1store, 1 laundry room, 3 dress rooms.					(Ref. DWG: A-101) and Figure 3
G- Floor Area (m^2)	262 (186 +76)	G- Built up – External Wall Area (m^2)	479	G- Built up– Glazing Area (m^2)	74	G- Floor Area = G-built-up+ annexes (Garage, Logia, Entrance. Garage is separate zone full closed has 2 large metal doors. Consider only glazing doors. Other metal and wood doors are considered in thermal study but not in opening area.
F- Floor Area (m^2)	170	Truss Area (m^2)	90	F-External Wall Area (m^2)	215	
F – Glazing Area (m^2)	23		Total Glazing/ External Wall Area- % (G+F)/ (Built up G+F)		(74+23)/(479+215) = 14% < 40%	
Shading Devices	Fixed vertical devices – non-openable, Mashrabyaa form 20 mm gap to the windows glass. (Ref. DWG: A-103).					(Ref. DWG: A-705). Logia is also considered as a horizontal shading devise for the back elevation extend to 3.75m.

parameters. Villa's landscape includes pack yard with swimming pool, pump room, and water tank while surrounded with blocked fence for all side except the front. Design analysis points glazing ratio as 14% over the built-up area (without annexes) which classify glazing as <40% according to the mentioned regulations.

In applying the performance method, IESVE used to design the villa energy model. Tests input parameters for the villa thermal specification were pointed in table 3. As-built U-values are classified this villa as well insulated building, applied Decree 66/2003. Thermal simulation for test 1, records the villa annual cooling load, and electricity consumption in table 4.

Table 3: Case Study Thermal Properties - Regional Traditional villa, Jumeirah Park.

Envelope Elements		**U-value (w/m².k)**	**Specification**	**Reference – DWG no.**
Windows	With frame	3.0143	Double Glazed – Clear float glass except bathrooms are translucent glass, 6-12-6mm thickness, aluminum frames, single side fixation.	DWG: A-704
	Only glass	2.8221		
External Wall		0.2118	External plaster layer, 250mm thick insulated block wall, internal plaster and paint.	DWG: A-103
Ground Floor		0.3704	Ceramic tiles, plaster, polypropylene separation and protection sheet, 50mm vapour insulation, 2 bitumen layers (water proof membrane), 30mm screed, 150 reinforced concrete, Sand.	DWG:S-000 and A-103
Roof		0.5550	Flat Roof – Layers from outside to inside: concrete tiles, plaster, polypropylene separation and protection sheet, 50mm extracted polystyrene thermal insulation, 2 bitumen layers (water proof membrane), 30mm screed, 200 reinforced concrete, and plaster.	DWG: S-000, A-710 and A-103

Table 4: Test 1- Original case – U-value (W/m²k): 0.555 Roof, 0.2118 Wall, 0.3704 Floor, 3.0143 Windows.

Annual Cooling Load (MWh)	45.9019
Annual Electricity (Mwh)	18.36076

4.3Glazing

About 6 codes in GBRS were mainly focused on improving windows performance while the aim of this paper called code 807 for shading as an effective factors asserts on it's ability to save 9-14% of cooling load energy consumption especially for villas. Code 501.01 mentioned the minimum envelope performance requirements in term of glazed area and fenestration. The code classified glazing into 3 categories according to GBRS in table 1 and agreed with [12]. But confliction is built with GBRS-codes 805 for glazing ratio < 40% mentioned the maximum acceptable U-value as 3.28W/m²k while 2.1W/m²k is for glazing >40 which agreed with Decree 66/2003 asserts on the need to update code 805.

According to the mentioned glazing parameters in table 2 and 3. Improving the glass performance for the category of <40% needs triple glazing windows with air cavity as 6-14-8-14-6mm to achieve the recommended U-value by code 501.01-GBRS (table 1). Results in table 5 finds the ability to reduce 5.9% of the annual cooling load.

Table 5: Test 2-Glazing- GBRS – U-value (W/m²k): 2.1 Windows.

Annual Cooling Load (Mwh)	43.1718
Annual Saving %	5.9%

Even of the affordability limitation of the triple glazed option, but it seems more effective in achieving the code 501.01 limits, keeps the main responsible in improve windows performance on the glass where optimize frames only can reduce 15% of the window total U-value. However, improving both frames and glass by conserving the double glazed character as 8-16-8mm can reduce 19% of U-value but not achieve GBRS limits.

4.4 Roof

GBRS-Code 501.01 points roof U-value in table 1. Results presents in table 6, finds that reducing 46% of U-value can save 8.67% of cooling energy consumption. More results highlighted by comparing GBRS and Circular no.198, DM [11], show the increase in roof U-values about 76% for 5cm and 68.8% for 15 cm screeds are negatively increased about 23.4% and 13.6% of cooling load consumption in contrast with Test1. This confliction between Regulations can form an obstacle in submitting a green building permit [14] where DM encouraged using [10] and [11] as main requirements which rose up the importance of enhancing coordination process between different sectors of Dubai governments.

Table 6: Results of Roof Regulations Tests.

Test No#	Regulation	U-Value (W/m²k)	Annual Cooling Load (MWh)	Annual Saving %
3	GBRS	0.30	41.9194	8.67%
4	DM-15cm-C198	0.962	52.1785	-13.6%
5	DM-5cm-C198	1.2568	56.6657	-23.4%
6	KNAUF 30% + GBRS- Veg.	0.25+ 0.30	41.4074	9.79%
7	KNAUF30%+ GBRS- Veg.	0.14+ 0.30	41.2673	10%
8	KNAUF50%+ GBRS- Veg.	0.25+ 0.30	41.0730	10.5%
9	KNAUF50%+ GBRS- Veg.	0.14+ 0.30	40.8493	11%
Note	Negative sign (-) in annual saving % is an indication for the improper process of those results where consumption increased presenting no save.			

GBRS recommended using vegetated roof in 2 codes. Code 302.01 for Local Species fixes the minimum percentage of green area includes green roof and surrounding land as 25% of the land. And green vegetated roof in code 304.02 as at least 30% of roof area. That forms benefits for thermal and acoustic insulation. The code recommends green roof design must include waterproof layers or membranes between the roof and the soil, impermeable layer, and native plants. That agreed with the description of previous Dubai regulations but no thermal specification had been recommended for vegetated roof even in [8]. However, conflicts between regulations appeared in the minimum percentage of vegetated roof area where Decree 174/2009 approved on Decree171/2009 to vegetate 50% as minimum of roof [20].

To find the effective application of vegetated roof, 30%, and 50% vegetated roof area was simulated in 4 tests using the minimum U-value can achieve with a vegetated roof as 0.25 w/m²k and maximum as 0.14 w/m²k according to KNAUF Insulation report [21] for warm deck green roof. U-value calculations for the vegetated area combined flat roof U-value in GBRS as 0.3 w/m²k with KNAUF U-values. In calculating U-value of the vegetated area (U_{Veg}), (U=1/R) ($R_T = R_1 + R_2$) where R is resistant. Minimum U-value is 0.136 w/m²k while maximum is 0.095 w/m²k. Consequently, results was highlighted in table 6 where the 30% vegetated area shows that using 0.136 w/m²k in Test 6 is equal about 55% reduction of U-value in Test 3 while 75% reduction in Test 1 which rose up the ability to save 9.79% of the annual cooling load according to the original case study. Test 7 was repeated of Test 6 but in Appling U-value as 0.095 w/m²k form 82.8% redetection of U-value in contrast with Test 1 which save about 10% of annual cooling consumption. Furthermore, Test 8 and Test 9 examined minimum and maximum U-values but for 50% vegetated area asserts on the ability to save 10.5% and 11% of cooling load, respectively.

4.5 Wall

GBRS presents code 501.01 points external wall thermal requirements while clear difference were highlighted with DM [11] in table 1. Sevens tests built to examine the U-values difference and it’s effect on cooling load energy consumption (table7). In comparisons with Test 1, Test 10 finds that

3.5% increasing in U-value is directly reflected on increase cooling consumption about 29.7%, in the improperly direction. The proposals for villa insulation of DM [11] also show increase in U-value in contrast with Test 1, but it still considered lower than value in Test 10 for code 501.01 of GRRS. All mentioned values of thermal performance in terms of external wall, are limited, keeping the thick insulated block wall in Test 1 (table 3) as the best option for wall U-value in this study. On the other hand, comparing all issued codes in table 1 and 7 spot Test 12 as the best practice between codes with lower U-value and lower effect on increasing consumption. That to assert on the importance of improving the regulations of external wall thermal properties to match the market requirements and available products.

Table 7: Results of Wall Regulations Tests.

Test No#	Regulation	U-Value (W/m²k)	Annual Cooling Load (Mwh)	Annual Saving %
10	GBRS	0.57	59.5757	-29.7%
11	DM(1)-C198	0.4879	56.4742	-23%
12	DM(2)-C198	0.3167	49.9677	-8.85%
13	DM(3)-C198	0.3482	51.1725	11.48%
14	DM(4)-C198	0.47	55.7974	21.55%
15	DM(5)-C198	0.38	52.3799	-14%
16	DM(6)-C198	0.3723	52.0895	-13.4%

4.6 Floor

GBRS-Code 501.01 highlights ground floor U-value (table 1) while the DM proposals [11] records higher value in table 8.

Table 8: Results of Floor Regulations Tests.

Test No.	17	18
Regulation	GBRS	DM-C198
U-Value (W/m²k)	0.30	0.57
Annual Cooling Load (Mwh)	45.1861	47.9804
Annual Saving %	1.55%	-4.5%

Findings recommend Test 17 for GBRS as the best can reduce about 1.55% of cooling energy consumption while Test 18 highlights the limitation of DM-C198 increased about 4.5% of the cooling load considered as negative scenario in this study.

4.7 Optimal/Combined Cases

According to the previous analysis, the best practices for all envelope elements were tested in table 9 by 2 assemblies. Test 19, combined GBRS thermal boundaries for roof, floor, and windows from Tests 3, 17, and 2, respectively, with the best practice for wall from Test 1 in one assembly. Results, finds the ability to reduce about 16.25% of cooling load. Annually saving ability increases in Test 20 by applying 50% as green roof according to Test 9 where reduction of cooling load consumption increased to 18.6%.

Table 9: Results of Assembly Tests.

Test No.	19	20
Assembly	All (T3+T1+T17+T2)	All +Veg. Roof 50% (T9+T1+T17+T2)
Roof	0.30	0.14+ 0.30
Wall	0.2118	0.2118
Floor	0.30	0.30
Windows	2.1	2.1
Annual Cooling Load (Mwh)	38.4389	37.3637
Annual Saving %	16.25%	18.6%
Annual Electricity (Mwh)	15.37556	14.94548
Note	All Saving percentages are compared to Test 1 (original case).	

Arguments can build between the found results in table 9, asserts on the efficiency of thermal properties of GBRS in terms of floor and glazing parameters while limitation were highlighted for roof and wall parameters. That, Decree 174/2009 [20] is more validation in terms of green roof while the best practice for flat roof goes to GBRS.

However, the annually saving of cooling load assemblies from 16.25-18.6% is more closed to the found reduction ability in the paper [2] where 21.8% of saving can be formed by improving envelope insulation for a villa. That reduction was reflected on saving 17.69%– 20.5% of the annual electricity in table 9, converges with rustles in [15] where applying insulation codes can save 25% of total consumption while asserted on the limitation of the issued insulation codes to achieve the 40% reduction of cooling load in case of studying a well-insulated building in gulf region. That also converges to the found ability of saving 27.5% -30% in Al Awadhi study [16] in considering the differences of the selected case study and applied codes.

Referring to [3], where residential buildings consumed 30.80% of total electricity consumption and Jumeirah park villas are covered about 2% of the residential blocks of Dubai. In considering the saving in Test 20-Table 9, such an improvement for a villa arrayed for 265 times can annually save about 3.96 Gwh as 1.82% of Jumeirah park consumption.

5 CONCULASIONS

The paper aimed to evaluate thermal performance of building envelope standards in Dubai green regulation and it's annually effect on electricity and cooling load consumption. The study focused on applying performance method through an energy model simulates Dubai circulars and GBRS codes in 20 tests. Results highlighted conflicts between codes 501.01 and 805 of GBRS while showed differences with other DM regulations; form obstacles in issuing green building permit. GBRS approved the efficiency of envelope thermal codes in terms of glazing, floor, and flat roof, keeping code 501.01 as major for all elements. Otherwise, Limitations were highlighted for green roof and external wall parameters recommending modification for both elements. Finally, the study pointed the ability to save 20.5% of annual electricity consumption, besides, 18.6% of cooling load consumption by applying the best practice for all, that such a modification can save about 1.8% of Jumeirah park annually consumption.

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