



**An- Najah National University**

**Faculty of Engineering & Information Technology**

**Building Engineering Department**

**Graduation Project Report- 2**

**Integration Redesign for The Multifunctional Building-Abd Al Naser Saad Al Deen**

**Shakaa in Nablus**

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**This report is presented in partial fulfillment of the requirements for a Bachelor's  
degree in Building Engineering.**

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## DEDICATION.

. بسم الله الرحمن الرحيم

"وقل اعملوا فسيرى الله عملكم ورسوله و المؤمنون"

صدق الله العظيم

إلهي لا يطيب الليل إلا بشركك و لا يطيب النهار إلا بطاعتك، و لا تطيب اللحظات إلا بذكرك، و لا تطيب الآخرة إلا بعفوك  
و لا تطيب الجنة إلا برويتك الله جل جلاله.

إلى من بلغ الرسالة وأدى الأمانة، ونصح الأمة، إلى نبي الرحمة ونور العالمين، سيدنا محمد صلى الله عليه وسلم.

إلى من كلله الله بالهبة والوقار، إلى من علمني العطاء بدون انتظار، إلى من أحمل أسمه بكل افتخار، أرجو من الله أن يمد  
في عمرك لترى ثمارا حان وقت قطافها بعد طول انتظار وستبقى كلماتك نجوم أهتدي بها اليوم وفي الغد وإلى الأبد، والذي  
العزير.

إلى ملاكي في الحياة، إلى معنى الحب وإلى معنى الحنان والتفاني، إلى بسمه الحياة وسر الوجود إلى من كان دعائها سر  
نجاحي وحنانها بلسم جراحي ويدها وقوفي بعد سقوطي، إلى أعلى ما في الوجود، أُمي الحبيبة.

إلى إخوتي ورفقاء دربي ، معكم أكون أنا وبدونكم أكون لا شيء، في نهاية مشواري أريد أن أشكركم على مواقفكم النبيلة،  
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## **DISCLAIMER**

This report was written by student(s) at the Building Engineering Department, Faculty of Engineering, An-Najah National University. It has not been altered or corrected, other than editorial corrections, as a result of assessment and it may contain language as well as content errors. The views expressed in it together with any outcomes and recommendations are solely those of the student(s). An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

# Table of Contents

<b>1 INTRODUCTION.....</b>	<b>2</b>
<b>1.1 Introduction .....</b>	<b>2</b>
<b>1.2 Project problem. ....</b>	<b>2</b>
<b>1.3 Objectives .....</b>	<b>2</b>
<b>1.4 Methodology.....</b>	<b>3</b>
<b>1.5 Limitations &amp; Constraints .....</b>	<b>3</b>
<b>1.6 Codes and Standards.....</b>	<b>4</b>
<b>1.7 Earlier coursework .....</b>	<b>4</b>
<b>1.8 Organization of the Report.....</b>	<b>5</b>
<b>2 ENVIROMANTAL- ARCHITECTURAL ASPECT .....</b>	<b>7</b>
<b>2.1 Literature review.....</b>	<b>7</b>
2.1.1 Self-contained.....	7
2.1.2 Office Space .....	8
2.1.3 Stores.....	9
2.1.4 Other Services and Spaces in Students’ Houses. ....	10
1.1.1 .....	10
1.1.2 .....	10
1.1.3 .....	10
2.1.5 Safety and Security. ....	15
2.1.6 Fire Safety.....	15
<b>2.2 Site analysis.....</b>	<b>15</b>
2.2.1 General Information. ....	16
2.2.2 Neighborhood Context. ....	17
2.2.3 Site and Zoning. ....	18
2.2.4 Natural Features. ....	18
2.2.5 Circulation. ....	19
2.2.6 Sensory. ....	20
2.2.7 Human and Cultural.....	20
2.2.8 Climate.....	20
<b>2.3 Case study analysis.....</b>	<b>23</b>
<b>2.4 Architectural Analysis.....</b>	<b>28</b>
2.4.1 Self-contained (Studios). ....	28
2.4.2 Retail Stores.....	29
2.4.3 Parking.....	29
2.4.4 Other Facilities.....	29
2.4.5 Environmental stranded values.....	29

<b>2.5</b>	<b>Modifications .....</b>	<b>29</b>
2.5.1	Repetitive-floors.....	29
2.5.2	First – second floor (Stores).....	32
2.5.3	Ground Floor.....	35
2.5.4	Parking.....	37
<b>2.6</b>	<b>Environmental Aspects.....</b>	<b>39</b>
2.6.1	Before Modification.....	39
2.6.2	After Modification.....	43
<b>2.7</b>	<b>Thermal Insulation .....</b>	<b>46</b>
2.7.1	Materials.....	48
2.7.2	Heating and cooling design results.....	52
2.7.3	Simulation results.....	55
<b>2.8</b>	<b>Architectural Drawings.....</b>	<b>57</b>
2.8.1	Parking Floor.....	57
2.8.2	Ground Floor.....	59
2.8.3	Stores’ Floor.....	60
2.8.4	Dormitory Floors.....	62
2.8.5	Elevations.....	63
2.8.6	Sections.....	65
2.8.7	3D-View.....	66
Chapter Three:.....		<b>69</b>
<b>3</b>	<b>STRUCTURAL ASPECT .....</b>	<b>70</b>
<b>3.1</b>	<b>Introduction .....</b>	<b>70</b>
<b>3.2</b>	<b>Distribution of column centers and shear walls:.....</b>	<b>70</b>
<b>3.3</b>	<b>Design Code.....</b>	<b>72</b>
<b>3.4</b>	<b>Loads:.....</b>	<b>72</b>
<b>3.5</b>	<b>Load Combinations.....</b>	<b>75</b>
<b>3.6</b>	<b>Materials.....</b>	<b>75</b>
<b>3.7</b>	<b>Structural Checks.....</b>	<b>76</b>
3.7.1	Compatibility Check.....	76
3.7.2	Equilibrium Check.....	77
3.7.3	Internal Force check.....	78
<b>3.8</b>	<b>Slab Thickness.....</b>	<b>79</b>
<b>3.9</b>	<b>Deflection check:.....</b>	<b>80</b>
<b>3.10</b>	<b>Seismic design: .....</b>	<b>81</b>
3.10.1	SEISMIC ZONE FACTOR (Z):.....	82
3.10.2	Soil profile type.....	82
3.10.3	Acceleration-Dependent Seismic Coefficient (CA) .....	83

3.10.4	Velocity-Dependent Seismic Coefficient (Cv) .....	84
3.10.5	important factor: .....	84
3.10.6	Over strength factor: .....	85
3.10.7	load combination:.....	86
3.10.8	mass source definition:.....	87
3.10.9	Seismic checks: .....	88
<b>3.11</b>	<b>Required Design elements:.....</b>	<b>90</b>
3.11.1	Column Design:.....	90
3.11.2	Slab and beams design: .....	94
3.11.3	Footing design: .....	98
<b>4</b>	<b>ELECTRO - MECHANICAL DESIGN. ....</b>	<b>104</b>
<b>4.1</b>	<b>Lighting. ....</b>	<b>104</b>
4.1.1	Introduction.....	104
4.1.2	Lux Level. ....	104
4.1.3	Artificial lightings design.....	105
<b>4.2</b>	<b>Power.....</b>	<b>151</b>
4.2.1	Introduction.....	151
4.2.2	Lighting and Socket Power. ....	151
4.2.3	Main Distribution Board (MDB).....	160
<b>4.3</b>	<b>Mechanical Design. ....</b>	<b>161</b>
4.3.1	Water supply system. ....	161
4.3.2	Drainage System.....	171
<b>4.4</b>	<b>HVAC system design.....</b>	<b>174</b>
4.4.1	Introduction.....	174
4.4.2	Values of heating and cooling from Design Builder for all spaces:.....	174
4.4.3	VRF system: .....	177
4.4.3.2	Fan coil:.....	180
4.4.4	VRF (Variable Refrigerant Flow) Air Handling Unit Selection: .....	185
4.4.5	HVAC plans from AutoCAD: .....	191
<b>4.5</b>	<b>Fire System.....</b>	<b>193</b>
4.5.1	Introduction.....	193
4.5.2	Requirements for fire system. ....	193
4.5.3	Fire System. ....	194
<b>4.6</b>	<b>Acoustical design.....</b>	<b>199</b>
4.6.1	Introduction.....	199
•	<b>Software.....</b>	<b>199</b>
4.6.2	Acoustical software results.....	204
<b>5</b>	<b>QUANTITY SURVEYING COST ESTIMATION. ....</b>	<b>227</b>
<b>5.1</b>	<b>Introduction .....</b>	<b>227</b>
<b>5.2</b>	<b>Methodology.....</b>	<b>227</b>

5.3 Budget development and cost estimate .....227

## List of Figures

FIGURE 1 METHODOLOGY OF PROJECT ASPECTS	3
FIGURE 2 ENCLOSED OFFICE LAYOUT.	9
FIGURE 3 OPEN OFFICE LAYOUT	9
FIGURE 4 LIFT DESIGN.	12
FIGURE 5 A PLAN OF LOBBY INCLUDING LIFTS	13
FIGURE 6NUMBER AND LAYOUT OF PARKING LOTS	14
FIGURE 7PARKING DESIGN	14
FIGURE 8 CONTENT OF SITE ANALYSIS	16
FIGURE 9 SITE PLAN	17
FIGURE 10 THE NEIGHBORHOOD AND SURROUNDING FACILITIES.	18
FIGURE 11THE TOPOGRAPHY OF THE AREA.	19
FIGURE 12 A POSSIBLE OPTIONS TO REACH THE SITE.	20
FIGURE 13 SHADOWS AT 8AM	21
FIGURE 14SHADOWS AT 12PM	21
FIGURE 15 SHADOWS AT 6PM	22
FIGURE 16 CASE STUDY ON A MIXED-USE PROJECT: KUMRU	23
FIGURE 17 LOCATION OF KUMRU ANKARA	23
FIGURE 18 BASIC LEVELS IN THE BUILDING	24
FIGURE 19 MASTER-SITE- PLAN	25
FIGURE 20 GROUND FLOOR PLAN	25
FIGURE 21 HOME OFFICE BLOCK	26
FIGURE 22 RESIDENTIAL BLOCK	26
FIGURE 23 SOCIAL CENTER FLOOR	27
FIGURE 24 RESIDENTIAL BLOCK EXCLUSIVE FLOOR DOWNSTAIRS	27
FIGURE 25 RESIDENTIAL BLOCK EXCLUSIVE FLOOR UPSTAIRS	28
FIGURE 26 FLOOR PLAN BEFORE MODIFICATION	30
FIGURE 27FLOOR PLAN AFTER MODIFICATION.	30
FIGURE 28 DOUBLE ROOM BEFORE MODIFICATION	31
FIGURE 29 MODIFIED ROOM	31
FIGURE 30 FLOOR WITHOUT A LOBBY.	32
FIGURE 31FLOOR AFTER THE LOBBY WAS ADDED.	32
FIGURE 32 FIRST FLOOR BEFORE MODIFICATION	33
FIGURE 33 FIRST FLOOR AFTER MODIFICATION	33
FIGURE 34STUDY AREA SPACE ON THE ORIGINAL PLAN	34
FIGURE 35STUDY AREA ON THE FIRST FLOOR	34
FIGURE 36LAUNDRY ROOM PLAN.	35
FIGURE 37 GROUND FLOOR PLAN BEFORE MODIFICATION	36
FIGURE 38 GROUND FLOOR PLAN AFTER MODIFICATION	36
FIGURE 39 CONTROL ROOM.	37
FIGURE 40 SECURITY ROOM PLAN.	37
FIGURE 41 1-FLOOR PARKING LOT	38
FIGURE 42 2-FLOOR PARKING LOT.	38
FIGURE 43EXTERNAL WALL COMPONENTS BEFORE MODIFICATION.	40
FIGURE 44WALL DETAILING.	40
FIGURE 45EXTERNAL SHEAR WALL BEFORE MODIFICATION.	40
FIGURE 46INTERNAL SHEAR WALL BEFORE MODIFICATION.	41
FIGURE 47INTERNAL WALLS BETWEEN STUDIOS.	41
FIGURE 48 INTERNAL WALL COMPONENTS.	42
FIGURE 49 DAYLIGHT FACTOR ANALYSIS RESULTS.	43
FIGURE 50EXTERNAL WALL AFTER MODIFICATION.	44
FIGURE 51GLASS PROPERTIES.	44

FIGURE 52DF RESULTS FROM REVIT	45
FIGURE 53DF RESULTS FROM REVIT.	45
FIGURE 54MODEL FOR BUILDING SHOWING LOUVERS-1	46
FIGURE 55MODEL FOR BUILDING SHOWING LOUVERS-2	47
FIGURE 56MODEL FOR BUILDING SHOWING LOUVERS-3	47
FIGURE 57CROSS-SECTION OF THE EXTERNAL WALL	48
FIGURE 58 U-VALUE FOR EXTERNAL WALL	48
FIGURE 59CROSS-SECTION OF THE INTERIOR PARTITIONS	49
FIGURE 60U-VALUE FOR INTERIOR PARTITIONS	49
FIGURE 61CROSS-SECTION OF ROOF	50
FIGURE 62U-VALUE FOR ROOF	50
FIGURE 63GLASS TYPE.	50
FIGURE 64 U-VALUE FOR ROOF	51
FIGURE 65CROSS-SECTION OF FLOOR	51
FIGURE 66U-VALUE FOR FLOOR	51
FIGURE 67HEAT LOSS WITHOUT INSULATION	52
FIGURE 68 HEATING CAPACITY.	52
FIGURE 69 HEAT LOSS AFTER INSULATION	53
FIGURE 70 HEATING CAPACITY AFTER INSULATION.	53
FIGURE 71TEMPERATURE AND HEAT GAIN WITHOUT INSULATION.	54
FIGURE 72 TOTAL DESIGN COOLING CAPACITY	54
FIGURE 73TEMPERATURE AND HEAT GAIN AFTER INSULATION.	54
FIGURE 74TOTAL DESIGN COOLING CAPACITY AFTER INSULATION.	54
FIGURE 75 PARKING AFTER MODIFICATION.	57
FIGURE 76 FLOOR AREA OF THE PARKING	58
FIGURE 77GROUND FLOOR PLAN.	59
FIGURE 78PLANS OF BOTH SECURITY AND CONTROL ROOM.	60
FIGURE 79 FLOOR PLAN	60
FIGURE 80FLOOR AREA PLAN	61
FIGURE 81 LAUNDRY ROOM AND WCS.	61
FIGURE 82 STUDY AREA PLAN.	61
FIGURE 83 FLOOR PLAN.	62
FIGURE 84FLOOR AREA PLAN	62
FIGURE 85 NORTH ELEVATION	63
FIGURE 86 SOUTH ELEVATION.	64
FIGURE 87 EAST ELEVATION.	64
FIGURE 88WEST ELEVATION.	65
FIGURE 89 SECTION A-A	65
FIGURE 90 SECTION B-B	66
FIGURE 913D VIEW OF THE BUILDING-1	66
FIGURE 92 3D VIEW OF THE BUILDING -2	67
FIGURE 93 3D VIEW OF THE BUILDING- 3	67
FIGURE 94-3D VIEW OF THE BUILDING -4	68
FIGURE 95COLUMNS CENTERLINES BEFORE MODIFICATION.	70
FIGURE 96COULMNS CENTERLINES AFTER MODIFICATION.	71
FIGURE 97 LIVE LOADS IN BASEMENT STORY	73
FIGURE 98LIVE LOADS IN PARKING STORY.	73
FIGURE 99LIVE LOADS IN RESIDENTIAL STORY.	74
FIGURE 100 COMPATIBILITY CHECK RESULT.	76
FIGURE 101RESULTS FROM ETABS.	78
FIGURE 102 SECTION IN THE TOW WAY RIBBED SLAB (CM).	79
FIGURE 103MAXIMUM DEFORMATION ALLOWED.	80
FIGURE 104MAXIMUM DEFORMATION FROM LIVE LOAD (ETABS)	80
FIGURE 105 MAXIMUM DEFORMATION FROM SERVICE LOAD (ETABS)	81

FIGURE 106SEISMIC HAZARD MAP	82
FIGURE 107 SOIL PROFILE TYPE.	83
FIGURE 108SEISMIC COEFFICIENT CA.	83
FIGURE 109 SEISMIC COEFFICIENT CV.	84
FIGURE 110IMPORTANT FACTOR I.	84
FIGURE 111 OVER STRENGTH FACTOR R.	85
FIGURE 112MASS SOURCE.	87
FIGURE 113DRIFT CHECK	88
FIGURE 114MAXIMUM STORY DISPLACEMENT FROM RESPONSE STORY	89
FIGURE 115CHECK COLUMN	90
FIGURE 116COLUMN LAYOUT.	91
FIGURE 117COLUMN DETAILING.	92
FIGURE 118SECTION IN COLUMN 1, 4, 5.	92
FIGURE 119SECTION IN COLUMN 7.	93
FIGURE 120SECTION IN COLUMN 2, 3, 6, 8.	93
FIGURE 121LAYOUT BEAMS IN PARKING STORY.	94
FIGURE 122LAYOUT BEAMS IN BASEMENT STORY.	95
FIGURE 123LAYOUT BEAMS IN STORE AND RESIDENTIAL STORY.	96
FIGURE 124DETAILING SLAB.	97
FIGURE 125PUNCHING SHEAR CHECK.	99
FIGURE 126PUNCHING SHEAR RATIO IN C7.	100
FIGURE 127SHEAR IN FOOTING.	101
FIGURE 128DETAILING FOOTING.	102
FIGURE 129 VIEW OF THE LOBBY AFTER DESIGN.	106
FIGURE 130 LUMINAIRE MODEL SPECIFICATION	106
FIGURE 131 LOBBY'S LUMINAIRES LAYOUT.	107
FIGURE 132 RESULTS ON PLAN.	108
FIGURE 133VIEW OF THE ENTRANCE.	109
FIGURE 134LUMINAIRE MODEL SPECIFICATION	110
FIGURE 135ENTRANCE 'S LUMINAIRES LAYOUT.	110
FIGURE 136RESULTS ON ENTRANCE'S PLAN.	111
FIGURE 137VIEW OF THE CAFETERIA.	112
FIGURE 138 LUMINAIRE MODEL'S SPECIFICATION.	113
FIGURE 139CAFETERIA'S LUMINAIRE LAYOUT PLAN	113
FIGURE 140 RESULTS ON CAFETERIA'S PLAN.	114
FIGURE 141VIEW OF THE ADMINISTRATION ROOM.	115
FIGURE 142 LUMINAIRE MODEL'S SPECIFICATION.	115
FIGURE 143ADMINISTRATION'S LUMINAIRE LAYOUT PLAN.	116
FIGURE 144RESULTS ON ADMINISTRATIONS PLAN.	117
FIGURE 145VIEW OF THE ACCOUNTANT ROOM	118
FIGURE 146LUMINAIRE MODEL'S SPECIFICATION 1	119
FIGURE 147LUMINAIRE MODEL'S SPECIFICATION2.	119
FIGURE 148ACCOUNTANT'S LUMINAIRE LAYOUT PLAN.	120
FIGURE 149RESULTS ON ACCOUNTANTS PLAN	120
FIGURE 150 VIEW OF THE SECRETARY ROOM	121
FIGURE 151LUMINAIRE MODEL'S SPECIFICATION.	121
FIGURE 152 SECRETARY'S LUMINAIRE LAYOUT PLAN.	122
FIGURE 153RESULTS ON SECRETARY PLAN.	123
FIGURE 154VIEW OF THE SECURITY ROOM.	124
FIGURE 155LUMINAIRE MODEL'S SPECIFICATION.	125
FIGURE 156SECURITY'S LUMINAIRE LAYOUT PLAN.	125
FIGURE 157RESULTS ON SECURITY PLAN	126
FIGURE 158 VIEW OF THE CONTROL ROOM.	127
FIGURE 159LUMINAIRE MODEL'S SPECIFICATION.	128

FIGURE 160CONTROL ROOMS' LUMINAIRE LAYOUT PLAN.	128
FIGURE 161RESULTS ON CONTROL ROOM PLAN	129
FIGURE 162VIEW OF THE CORRIDOR.	130
FIGURE 163LUMINAIRE MODEL'S SPECIFICATION	131
FIGURE 164CORRIDORS' LUMINAIRE LAYOUT PLAN.	131
FIGURE 165RESULTS ON CORRIDOR PLAN	132
FIGURE 166VIEW OF THE WC.	133
FIGURE 167LUMINAIRE MODEL'S SPECIFICATION	133
FIGURE 168WCS' LUMINAIRE LAYOUT PLAN	134
FIGURE 169RESULTS ON WCS PLAN	135
FIGURE 170VIEW OF THE STUDY AREA.	136
FIGURE 171LUMINAIRE MODEL'S SPECIFICATION	137
FIGURE 172 STUDY AREAS' LUMINAIRE LAYOUT PLAN	137
FIGURE 173RESULTS ON STUDY AREA PLAN	138
FIGURE 174VIEW OF THE LAUNDRY.	139
FIGURE 175 LUMINAIRE MODEL'S SPECIFICATION.	140
FIGURE 176 LAUNDRY LUMINAIRE LAYOUT PLAN.	140
FIGURE 177RESULTS ON PLAN	141
FIGURE 178VIEW OF THE STORE	142
FIGURE 179LUMINAIRE MODEL'S SPECIFICATION.	143
FIGURE 180STORE LUMINAIRE LAYOUT PLAN	143
FIGURE 181RESULTS ON STORE PLAN.	144
FIGURE 182VIEW OF THE DORM.	145
FIGURE 183LUMINAIRE MODEL'S SPECIFICATION.	146
FIGURE 184 DORM LUMINAIRE LAYOUT PLAN	146
FIGURE 185RESULTS ON DORM PLAN.	147
FIGURE 186LUMINAIRE MODEL'S SPECIFICATION.	148
FIGURE 187WC LUMINAIRE LAYOUT PLAN	149
FIGURE 188 RESULTS ON WC PLAN.	150
FIGURE 189MAIN BOARD	160
FIGURE 190 WATER SUPPLY (GRONDZIK, KWOK, STEIN, & REYNOLDS, 2010, P.872)	161
FIGURE 191 DOMESTIC HOT WATER CONSUMPTION (GRONDZIK, KWOK, STEIN,& REYNOLDS, 2010, P.944).	162
FIGURE 192 WATER SUPPLY FIXTURE UNITS (GRONDZIK, KWOK, STEIN, & REYNOLDS, 2010, P.991)	163
FIGURE 193 WATER FLOW RATE (GRONDZIK, & KWOK, 2015, P.919)	164
FIGURE 194 DIAMETER & PRESSURE DROP PER 100 FT(PSI) FOR STEEL PIPE	165
FIGURE 195DIAMETER & PRESSURE DROP PER 100 FT(PSI) FOR PLASTIC PIPE	166
FIGURE 196DRAINAGE FIXTURE UNITS (GRONDZIK& KWOK, 2015, P.945).	171
FIGURE 197HORIZONTAL FIXTURE BRANCHES AND STACKS (GRONDZIK& KWOK, 2015, P.946)	172
FIGURE 198BUILDING DRAINS AND SEWERS (GRONDZIK& KWOK, 2015, P.948)	172
FIGURE 199SIZE AND DEVELOPED LENGTH OF STACK VENTS AND VENT STACKS (GRONDZIK & KWOK, 2015, P.947)	173
FIGURE 200 OUTDOOR UNIT	177
FIGURE 201VRF SYSTEM	178
FIGURE 202 CATALOGUE DIFFUSER SPECIFICATION.	179
FIGURE 203FAN COIL CATALOGUE	180
FIGURE 204 VRF SYSTEM	185
FIGURE 205VRF SYSTEM FOR BUILDING FROM DESIGN BUILDER PROGRAM	191
FIGURE 206GROUND FLOOR HVAC PLAN	191
FIGURE 207STORE FLOOR HVAC PLAN	192
FIGURE 208RESIDENTIAL FLOOR HVAC PLAN	192
FIGURE 209FIRE FIGHTING SYSTEMS REQUIRED IN DORMITORY.	193
FIGURE 210 SPRINKLER PROPRIETIES	194
FIGURE 211CO2 EXTINGUISHER	196
FIGURE 212MANUAL ALARM SYSTEM	197

FIGURE 213 SOUND & LIGHT ALARM SYSTEM	197
FIGURE 214 FIRE-HOSE.	198
FIGURE 215 LITERATURE REVIEW.	199
FIGURE 216 REVERBERATION TIME STANDARDS	200
FIGURE 217 STI STANDARDS	201
FIGURE 218 ARTICULATION INDEX STANDARDS	201
FIGURE 219 ARTICULATION LOSS STANDARDS	201
FIGURE 220 SPL STANDARDS	202
FIGURE 221 NC STANDARDS	202
FIGURE 222 STC STANDARDS	203
FIGURE 223 LOBBY PLAN	204
FIGURE 224 LOBBY FROM EASE	205
FIGURE 225 ROOM VOLUME FROM EASE	205
FIGURE 226 RT FROM EASE:	206
FIGURE 227 SPL GRAPH	206
FIGURE 228 SPL DISTRIBUTION	207
FIGURE 229 STI GRAPH	207
FIGURE 230 STI DISTRIBUTION	208
FIGURE 231 CAFETERIA PLAN	208
FIGURE 232 CAFETERIA FROM EASE:	209
FIGURE 233 VOLUME FROM EASE	209
FIGURE 234 RT FROM EASE	210
FIGURE 235 SPL GRAPH	211
FIGURE 236 SPL DISTRIBUTION	211
FIGURE 237 STI DISTRIBUTION	212
FIGURE 238 STI GRAPH	212
FIGURE 239 STUDY AREA PLAN	213
FIGURE 240 STUDY AREA FROM EASE:	214
FIGURE 241 VOLUME FROM EASE	214
FIGURE 242 RT FROM EASE	215
FIGURE 243 SPL GRAPH	216
FIGURE 244 SPL DISTRIBUTION	216
FIGURE 245 ARTICULATION INDEX DISTRIBUTION	217
FIGURE 246 STI GRAPH	217
FIGURE 247 STI DISTRIBUTION	218
FIGURE 248 SHOP AREA PLAN	218
FIGURE 249 SHOP AREA FROM EASE.	219
FIGURE 250 SHOP AREA VOLUME	219
FIGURE 251 RT FROM EASE	220
FIGURE 252 SPL GRAPH	220
FIGURE 253 SPL DISTRIBUTION	221
FIGURE 254 STI GRAPH	221
FIGURE 255 STI DISTRIBUTION	222
FIGURE 256 STC STANDARDS	222
FIGURE 257 SECTION IN EXTERNAL WALL	223
FIGURE 258 STC FOR EXTERNAL WALL.	223
FIGURE 259 SECTION IN INTERNAL PARTITIONS	224
FIGURE 260 STC FOR INTERNAL PARTITIONS	224
FIGURE 261 EXTERNAL GLAZING	225
FIGURE 262 EXTERNAL GLAZING STC	225

## List of Tables

TABLE 1MINIMUM SIZE OF A ROOM.	7
TABLE 2 PERSONAL HYGIENE FACILITIES' MINIMUM FLOOR AREAS	8
TABLE 3 SPACE ALLOCATION	8
TABLE 4 MIN AREA OF STORES	10
TABLE 5THERMAL DEMANDS	10
TABLE 6 LIGHTINGS DEMAND	10
TABLE 7 COMMON DIMENSIONS OF STAIRS	12
TABLE 8 LIFT SPECIFICATIONS	13
TABLE 9 ENERGY RESULT WITHOUT INSULATION.	55
TABLE 10 TIME COMFORT WITHOUT INSULATION	55
TABLE 11ENERGY RESULT WITH INSULATION.	55
TABLE 12 TIME COMFORT WITH INSULATION	56
TABLE 13END USES.	56
TABLE 14 WEIGHT OF SLABS AND BEAMS.	77
TABLE 15 WEIGHT OF SHEAR WALLS AND COLUMN.	77
TABLE 16 EQUILIBRIUM CHECK	77
TABLE 17INTERNAL FORCES CHECK.	78
TABLE 18ULTIMATE LOAD COMBINATIONS.	86
TABLE 19SERVICE LOAD COMBINATION	87
TABLE 20RECOMENDED LUX LEVEL	104
TABLE 21 RESULTS SUMMERY FOR LOBBY.	107
TABLE 22RESULTS SUMMERY FOR ENTRANCE.	111
TABLE 23RESULTS SUMMERY FOR CAFETERIA,	114
TABLE 24RESULTS SUMMERY FOR ADMINISTRATION.	116
TABLE 25RESULTS SUMMERY FOR ACCOUNTANT.	120
TABLE 26RESULTS SUMMERY FOR SECRETARY.	122
TABLE 27RESULTS SUMMERY FOR SECURITY.	126
TABLE 28RESULTS SUMMERY FOR CONTROL ROOM..	129
TABLE 29RESULTS SUMMERY FOR CORRIDOR.	132
TABLE 30RESULTS SUMMERY FOR WC..	134
TABLE 31RESULTS SUMMERY FOR STUDY ROOM.	138
TABLE 32RESULTS SUMMERY FOR LAUNDRY.	141
TABLE 33RESULTS SUMMERY FOR STORE..	144
TABLE 34RESULTS SUMMERY FOR DORM,.	147
TABLE 35RESULTS SUMMERY FOR WC.	149
TABLE 36GF LIGHTING POWER.	151
TABLE 37CROSS-SECTIONAL TABLE	152
TABLE 38POWER FOR EACH SOCKET.	152
TABLE 39SUM OF POWER IN EACH SPACE.	153
TABLE 40FIRST LIGHTING POWER.	154
TABLE 41CROSS-SECTIONAL TABLE	155
TABLE 42POWER FOR EACH SOCKET.	155
TABLE 43SUM OF POWER IN EACH SPACE.	156
TABLE 44 REPETITIVE FLOOR LIGHTING POWER.	157
TABLE 45CROSS-SECTIONAL TABLE	158
TABLE 46POWER FOR EACH SOCKET.	158
TABLE 47SUM OF POWER IN EACH SPACE.	159
TABLE 48TOTAL POWER FOR MAIN DISTRIBUTION BOARD.	160
TABLE 49WATER USAGE.	162
TABLE 50PRESSURE/ FLOOR.	163
TABLE 51TOTAL FU S FOR EACH ZONE.	164
TABLE 52WATER FLOW RATE FOR ZONES	165

TABLE 53EFFECTIVE LENGTHS	167
TABLE 54POSSIBLE DIAMETERS AND LOSSES FOR ZONE1	168
TABLE 55POSSIBLE DIAMETERS AND LOSSES FOR ZONE2.	168
TABLE 56POSSIBLE DIAMETERS AND LOSSES FOR ZONE3	169
TABLE 57POSSIBLE DIAMETERS AND LOSSES FOR ZONE4	169
TABLE 58CHOSEN DIAMETER AND TOTAL LOSSES.	170
TABLE 59LOSSES IN FLOORS AND PUMP CALCULATIONS.	170
TABLE 60NUMBER OF DRAINAGE FIXTURE UNITS IN EACH FLOOR.	172
TABLE 61 DIAMETERS AND SLOPE OF THE DRAINAGE SYSTEM.	173
TABLE 62FAN LOAD FOR GROUND FLOOR	181
TABLE 63FAN LOAD FOR STORE FLOOR	181
TABLE 64FAN LOAD FOR FIRST FLOOR	182
TABLE 65 FAN LOAD FOR SECOND FLOOR	182
TABLE 66 FAN LOAD FOR THIRD FLOOR	183
TABLE 67FAN LOAD FOR FOURTH FLOOR	183
TABLE 68FAN LOAD FOR FIFTH FLOOR	184
TABLE 69FAN LOAD FOR SIXTH FLOOR	184
TABLE 70DIAMETER OF DUCT FOR GROUND FLOOR	186
TABLE 71DIAMETER OF DUCT FOR STORE FLOOR	187
TABLE 72 DIAMETER OF DUCT FOR FIRST FLOOR	187
TABLE 73DIAMETER OF DUCT FOR SECOND FLOOR	188
TABLE 74DIAMETER OF DUCT FOR THIRD FLOOR	189
TABLE 75DIAMETER OF DUCT FOR FOURTH FLOOR	189
TABLE 76 DIAMETER OF DUCT FOR FIFTH FLOOR	190
TABLE 77DIAMETER OF DUCT FOR SIXTH FLOOR	190
TABLE 78PIPES DIAMETER.	195
TABLE 79 SPRINKLERS DESIGN AND DISTRIBUTION IN GF FLOOR AND BOTH ZONES IN THE PARKING	195
TABLE 80 SUGGESTED MATERIAL:	204
TABLE 81BOQ.	228

### Nomenclature or list of symbols

- HVAC: Heating, Ventilation, and Air Conditioning.
- DF: Daylight Factor.
- $F_c'$ : compressive strength of concrete.
- $F_y'$ : Yield Strength.
- W: Own Weight.
- SM: Square Meter.
- MDB: Main Distribution Board.
- SDB: Secondary Distribution Board.
- WS: Water Supply
- FC: Fan Coil.
- BOQ: Bill of Quantity.

## Abstract

Multifunctional building is a structure that contains at least two different destination spaces, it allows to use the urban space in a more efficient and compact way. A multifunctional building in Nablus was selected as our graduation project.

This project should cover architectural, structural and environmental aspects, in addition to earthquake resistance. The project aims to assess the architectural, structural and environmental aspects of the multifunctional building according to code requirements and considerations. In addition to analyzing the site in terms of public safety and emergency exits, and ensuring the readiness of the building in the event of a fire. The structural design involves constructing a 3D model for all blocks in the project and the seismic load will be taken into account in the design. The project is also a quantitative survey to estimate the budget of the building.

Initially, the building was studied ecologically by analysing the site and accordingly environmental problems in terms of ventilation, solar radiation and shadows were addressed. Then the architectural aspect was studied and improved. An additional parking floor for cars was added to suit the number of students in the residences, and an emergency staircase was added, in addition to changing some room sizes based on the criteria and adding some facilities to the building. Then the structural aspect was studied and adjustments were made to the column sites.

The building is under construction now, but there are a lot of similar buildings available in Palestine

Chapter One:

Introductory

---

# 1 INTRODUCTION

## 1.1 Introduction

Building type and function are what give an indication of the design and requirements in many aspects. It helps the designer orient and uses the building's space best to serve the building and the consumers in the long run.

Here in Palestine due to the size of cities and lands, the owners mostly tend to exploit their lands in the best way, and from there multi-function buildings became common. Multi-function buildings should cover all the requirements for each function. This project is a multi-function building.

## 1.2 Project problem.

All type of buildings has its own standards that should be satisfied throughout the design and construction phase. In this project some of the standards were not achieved. And since the project is a multi-function building, each space was analyzed according to its function. Problems that should be solved are:

- Dimension of some spaces.
- Fire safety system.
- Spaces agreement according to the bubble diagram.
- Unavailability of some facilities that should be included in a type of building.

## 1.3 Objectives

The project's main objective is to devise a design that simulates the development around the world, in addition to being an eco-friendly building that fulfils the basic criteria of these buildings.

Objectives will be divided into three categories:

- Architectural objectives:
  - To conduct a literature review.
  - To carry over a comprehensive redesign compared with standards.
- Environmental objectives:
  - To analyse the passive environmental design.

- Structural objectives:  
-To study structural design.

## 1.4 Methodology

This project will be implemented based on many research methods, and standards for the project in terms of use and evaluation of the site from architectural, environmental, and structural aspects.

Figure 1 elaborates more on these aspects.



*Figure 1 Methodology of project aspects*

## 1.5 Limitations & Constraints

The design constraints should be identified and some discussions on their realization are to be included. Some realistic design constraints are shown in the following lists:

- Economies include budget limitations, the cost of similar or related products, and maintenance costs.
- Environments - such as energy consumption, environment-friendly power sources, and noise pollution.
- Society - such as assisted living for the disabled and elderly, privacy, and social.

- Politics - such as designs that promote gender and race equality, products that help national security, and designs that help solve common international and national problems.
- Ethics include designs that do not violate safety and health issues, privacy issues, honesty, and truthfulness.
- Health and Safety - such as public safety, the safety of the consumers of the product, and the safety of workers.
- Manufacturability - such as designs that suit current manufacturing technology and designs that can be physically implemented.
- Sustainability - such as reliability and durability of the design, designs that support future upgrades, designs, and signs that are resilient to a range of environmental conditions.

## 1.6 Codes and Standards.

It is important to have a scientific basis that can be referenced to evaluate any structure in all respects, hence the importance of having building codes, as it represents a guide to help the designer produce the best facility.

The following is a list of standard books and references used:

- Architects' Data (Neufert 2002).
- Time saver building types, Tsaveaver interior design.
- Metric Hand Book Planning and Design Data.
- Mechanical and electrical equipment for buildings (MEEB eleven edition).

## 1.7 Earlier coursework

This part is a brief overview of the coursework and how it was used in the implementation of the project.

*-Designing buildings using a computer course-10611320:*

In architectural design, this course was relied upon. Two basic programs were used:

1. AutoCAD program, which had a major role in drawing all the diagrams.

2. Revit program, which shows the three-dimensional building.

*-The standards of architectural design course- 10611260:*

The importance of this course is summarized by knowing the basic functions of each space in the building and linking them together.

*- The heat simulation of the course of the building- 10611531:*

In environmental design, this course was relied upon, in which the thermal insulation values, the cooling values, and the heating values for the building were calculated.

*-Advanced Computer Aided Building Design course- 10611521:*

Through which they si, the shadows and the solar were analyzed-

*The integration of building systems-10611460:*

Through this, the environmental analysis procedures of the building were understood in a way that is compatible with all aspects.

## 1.8 Organization of the Report.

project consists of 5 chapters, and each chapter will explain its title in detail.

-The first chapter will be an introduction to the project, where a brief overview of the project and the basic criteria used in the research and investigation will be explained.

-The second chapter, in which the building's current architectural and environmental design will be explained, and the architectural standards will be presented and compared.

-The third chapter, in which the structural design will be studied.

-The fourth chapter, in which a tentative cost estimate must be prepared, to identify a tentative budget.

-The fifth chapter, contains references and an authentication paper.

Chapter two:

Environmental - Architectural Aspects.

---

## 2 ENVIROMANTAL- ARCHITECTURAL ASPECT

In this chapter, the architectural aspects will be discussed.

### 2.1 Literature review

Multi-functional buildings combine more than one type of space, and mostly it has more than two-floor stories. In this project, there are diverse spaces, as listed below.

- Self-contained (Studios).
- Offices
- Kitchen and cafeteria
- Reception and circulation areas
- Stores
- Stairs
- Elevators
- Parking

#### 2.1.1 Self-contained

- Self-contained flat – a unit of accommodation behind the flat entrance door consisting of two or more habitable rooms plus kitchen and bathroom facilities.
- Self-contained studio – a self-contained unit of accommodation behind the studio entrance door consisting of one habitable room only used for sleeping/living plus kitchen and bathroom facilities.

Room sizes – studio flats depend on the number of beds and kitchen location.

As shown in Table 1, these are the minimum sizes of the room.

*Table 1 Minimum size of a room.*

Minimum floor area where kitchen facilities are located within the room	
Single	Double (one household)
12m <sup>2</sup>	14m <sup>2</sup>

Personal hygiene facilities also have minimum floor areas according to the standards shown in Table 2.

*Table 2 Personal hygiene facilities' minimum floor areas*

Sanitary facilities in appropriate room	Minimum floor area*
Bath only	2.3m <sup>2</sup>
Bath & WHB	2.5m <sup>2</sup>
Bath, WC & WHB	2.8m <sup>2</sup>
Shower only	1.7m <sup>2</sup>
Shower & WHB	2.0m <sup>2</sup>
Shower & WC & WHB	2.2m <sup>2</sup>
WC & WHB	1.2m <sup>2</sup>

### 2.1.2 Office Space

Offices are one of the most used spaces in the world, as the uses of spaces are variable according to the type of work and the purpose. Therefore, it is essential to design them according to the correct standards to be satisfactory for the user. As stated by the standards there is numerous type of offices and according to their function, the minimum size of the area was decided in Table 3.

*Table 3 Space Allocation*

Space Type	Functional Assignment	Space Allocation	
		m <sup>2</sup>	ft <sup>2</sup>
Enclosed	Frequent meetings with up to two others and/or requiring confidentiality, security, visual and acoustical privacy. Typical assignment for position involved with counseling, human resources management or other sensitive situations requiring ongoing visual and acoustical privacy.	9.3	100
Open	Concentrated multi-source paperwork: compiling information, reading, writing, analyzing, calculating and referencing multiple sources of material; allows for manual and automated drafting functions. Typical assignment for managerial, professional or technical staff.	9.3	100

The layout of the offices.

- The enclosed is shown in Figure 2.

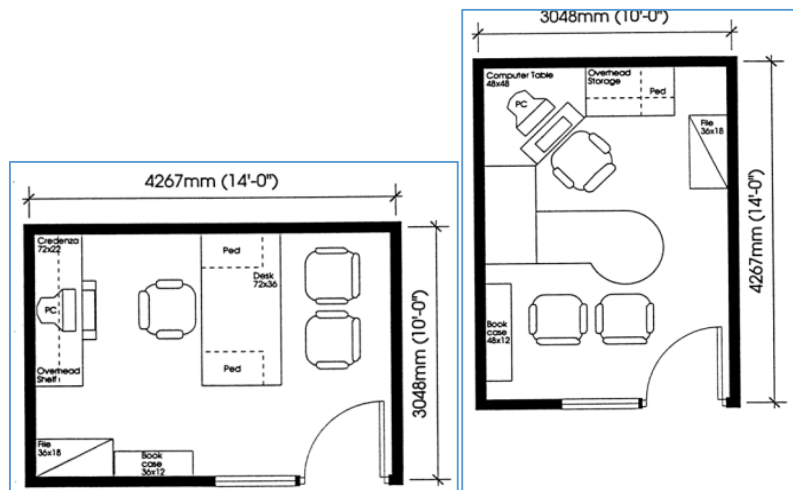


Figure 2 Enclosed office layout.

- The open as noticed in Figure 3.

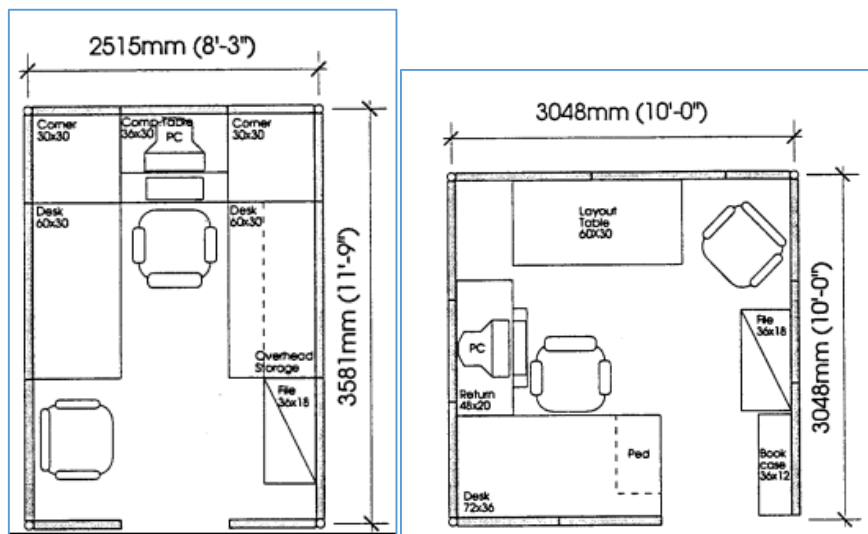


Figure 3 Open office layout

### 2.1.3 Stores

Commercial spaces are the most widespread and used, and one of the most important goals of stores is to earn, and that cannot be done unless the space is suitable for customers. Therefore, standards should be taken into consideration. As shown below, the standards for the dimension (Table 4), temperature and ventilation( Table 5), and lighting (Table 6).

Table 4 Min area of stores

Categories	Dimensions (Meters)	Total Area (Sq. Meters)
Convenience Shop	2.5 * 3.0	7.5
Demand Shop	3.0*5.0	15
Impulse Shop	3.0*7.5	22.5
Departmental Store		Minimum 57.0
Commercial Showers		Minimum 70.0

Source: NRM

Table 5 Thermal demands

	Temperature (°C)	Air infiltration (Changes/hour)	Ventilation allowance (W/m <sup>3</sup> °C)
Small shops	18	1	0.33
Large shops	18	½	0.17
Department stores	18	¼	0.08
Fitting rooms	21	1½	0.50
Store rooms	15	½	0.17

Table 6 Lightings Demand

Lighting	Standard service illuminances (lux)	Notes
Conventional shops	500	Concentrated over displays
Supermarkets	500	Usually increased to 700–800 lux with three levels of control: 100 per cent – sales, 50 per cent – stacking, 30 per cent – security
Covered shopping centres	100–200	Malls, arcades, precincts
Lifts, main circulation	150	
Staffrooms	150	
External covered ways	30	

## 2.1.4 Other Services and Spaces in Students' Houses.

### 2.1.4.1 Kitchen-Dining Area.

In student accommodation, kitchen/dining rooms provide a key social focus for each group of students that they serve, with opportunities for casual encounters, friendship, and support. Kitchen/dining rooms can be arranged to overlook the common.

Areas such as entrances, stairs, and halls, provide further opportunities for interaction and a degree of security through informal supervision. Kitchens will be heavily used

and should allow several people to prepare food simultaneously. They must be designed to be functional, robust, and easy to clean. As a guide, a length of the work surface of approximately 3600 mm, including the cooker and sink, will be sufficient for five people. Circulation space between units should be 1200 mm minimum.

#### 2.1.4.2 Reception and Circulation Areas

Entrances should be light and welcoming and avoid a mean or utilitarian character – the design should create an identity for There may be a staffed reception or porter’s lodge or office in larger residences lodge or office. In other schemes, provision may be required for a temporary reception to receive students at the start of term or conference guests in the holidays. In up-market commercial reception’s design and ‘branding’ the reception is important and a more generous area with seating will be required.

#### 2.1.4.3 Laundry Room

A laundry serving groups of residents should be provided with washing and drying machines of a robust commercial type. Provide a minimum of one washer for every 35 students and one dryer for every 30 students. Plus, a sink for hand-washing clothes, facilities for ironing and folding clothes, and seats for waiting. Floor finishes shall be durable, slip-resistant, easily cleaned materials that are resistant to water permeation.

Floor drain:

- Floor drains are required in laundry facilities.
- The floor drains serve to handle the occasional overflow and facilitate floor washing.
- The floor must slope toward the drain.

Dimension depends on number of machines used.

#### 2.1.4.4 Internal stairs

- Internal stairs come in three basic forms:
- Private stairs as would be found in domestic situations.
- Utility stairs that cover escape and maintenance requirements.
- General access stairs that cover most of the remaining circumstances.

The width of internal stairs should not be less than 1.2 m wide.

(There is no minimum in domestic situations but 850 mm is suggested with 600 mm when the stair is serving only one room.).

Treads of internal stairs should be consistent throughout the flight with a rise and going as shown in Table 7.

Table 7 Common dimensions of stairs

The range of permissible design dimensions for common stairs.				
	Rise (mm)		Going (mm)	
	Minimum	Maximum	Minimum	Maximum
Private stairs	150	220	220	300
Utility stairs	150	190	250	400
General access stairs	150	170	250	400

There should be no open risers (except in domestic situations where they are constructed).

#### 2.1.4.5 Lifts

In most circumstances, a passenger lift is the most suitable method of vertical transportation within buildings. Because they rely on a power source they should always also have fire-protected stair access provided as well. They also come in a wide range of sizes from a simple two-story hydraulic lift to the sophisticated operating systems needed in 100-story skyscrapers. A lift car size of 2000 mm wide by 1400 mm deep will provide adequate space for any wheelchair and several other users although (Figure 4) illustrates the minimum size required.

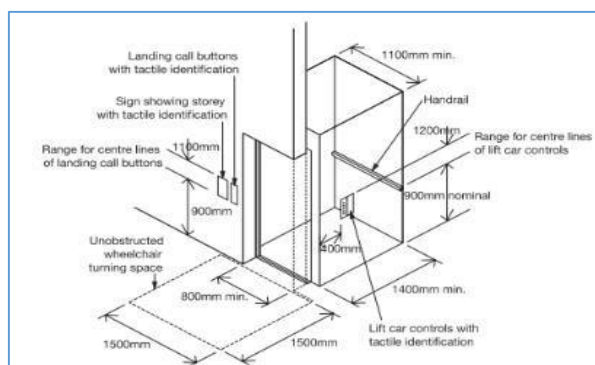


Figure 4 Lift Design.

A well-designed passenger lift provision will include most, if not all, of the inclusive design principles. Lifting platforms, like stair lifts, are not replacements for a good passenger lift service and therefore are also not ideal. Both require continuous pressure control devices which can be too strenuous for some users to maintain.

Lifting platforms have the same speed restriction and minimum platform size for single wheelchair users. In addition, however, they are also restricted to a 2000 mm travel if they are not enclosed. Where they are enclosed, the minimum. According to the standards, there are specifications for lifts' size as shown in Table 8.

Table 8 Lift specifications

Effective lift system design is a specialist design function but some basic assumptions can be made relating to car size, shaft dimensions and traffic flows.						
	Car size C × D	Shaft size A × B	Machine room S × R	Load rating (Kg)	Rated Capacity (people)	Design Capacity (people)
Light traffic				320	4	3.6
	1100 × 950	1800 × 1600	3200 × 2500	400	5	
				450	6	5.0
	1100 × 1400	1800 × 2100	3700 × 2500	630	8	6.3
	1350 × 1400	1900 × 2300	3700 × 2500	800	10	7.6
	1100 × 2100	1800 × 2600	4200 × 2500	1000	13	9.1
General purpose lifts	1600 × 1400	2400 × 2300	4900 × 3200	1000	13	9.1
	1950 × 1400	2600 × 2300	4900 × 3200	1250	16	
				1275	16	11.0
	1950 × 1750	2600 × 2600	5500 × 3200	1600	21	13.5
	1600 × 2400	2400 × 3000	5800 × 3200	1800	24	14.9
	1500 × 2700	2400 × 3300	5800 × 3200	2000	26	16.0
	1800 × 2700	2700 × 3300	5800 × 3500	2500	33	19.0

Note: machine room sizes are for traction lifts, the size is considerably reduced for hydraulic lifts.

Figure 5 below, is an example of a plan of the lobby including lifts.

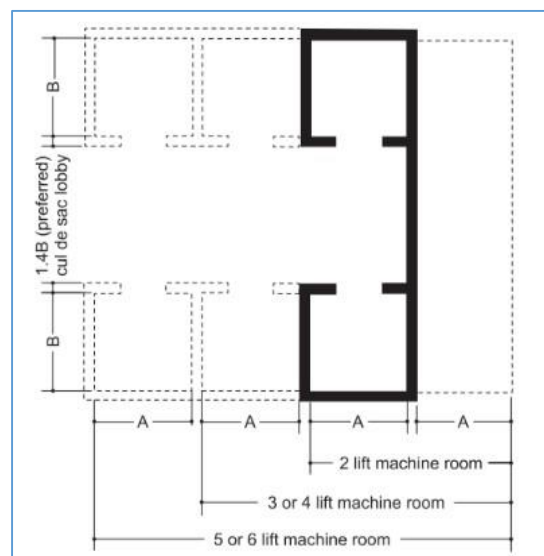


Figure 5 a Plan of lobby including lifts

### 2.1.4.6 Parking

Parking lots are a feature of every city and suburban area, cleared area that is intended for parking vehicles, especially in shopping centres, sports stadiums, digital centres, and other places. Parking requirements are shown in Figure 6 and Figure 7.

Type of building	Car parking provision	Loading/unloading provision	
Officers	Staff: one space for each 25 m <sup>2</sup> of gross floor area, or one space for each managerial and executive staff, plus one space per four others Visitors: 10% of staff parking provision	General minima: Gross floor space not exceeding: 100 m <sup>2</sup> 500 1000 each additional 1000 m <sup>2</sup>	Minimum space required: 50 m <sup>2</sup> 100 150 25 m <sup>2</sup>

Figure 6 Number and layout of parking lots

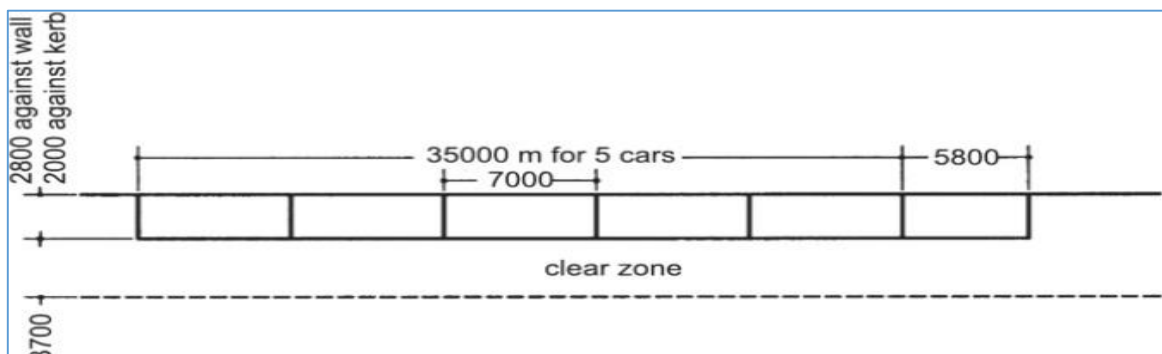
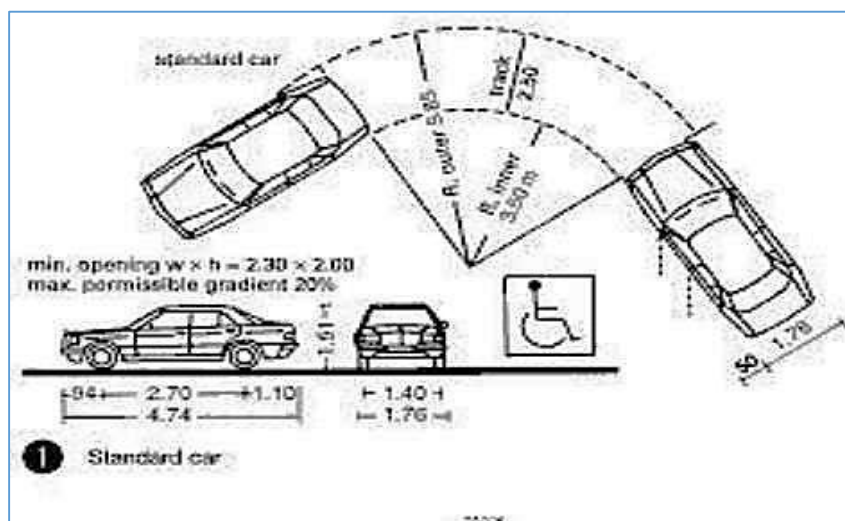


Figure 7 Parking design

The number of parking spaces for the student's dormitory is 1 parking space for every 4 students.

### 2.1.5 Safety and Security.

The design should address potential risks of attack, vandalism, and theft. Personal safety is a major issue in student housing and students often return home late at night. Theft is also a common problem, as students' own computers and other valuable equipment. For that, security should be in lobbies to prevent any type of unfamiliar action.

### 2.1.6 Fire Safety

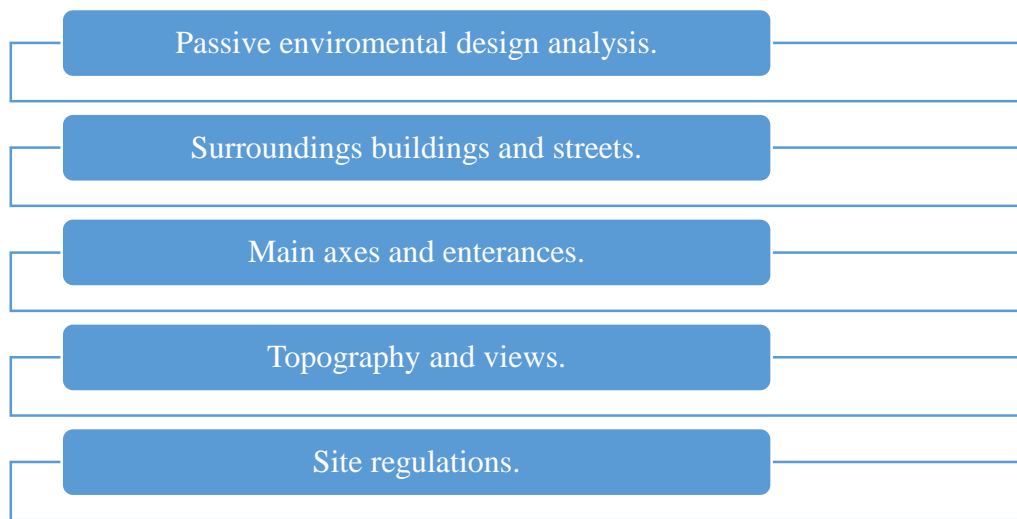
Provision of a Protected Escape Route.

The protected escape route leads from the flat letting to the street exit through the building and normally includes staircases, passageways, landings, and protected lobbies. Protection is provided by fire doors and partitions with varying degrees of fire resistance. The building regulations benchmark provision is 60 minutes of fire resistance for partitions & floors. Purpose build blocks will have been designed to this standard. However, this will not be possible in most existing conversion flat buildings and lesser fire resistance of 30 minutes will be accepted with appropriate automatic fire detection. A partition constructed of lath and plaster, in sound condition, with appropriate automatic fire detection will be deemed to satisfy this requirement. The protected escape route must be kept clear of rubbish, furniture, and other stored items.

## 2.2 Site analysis

Architecture site analysis is the process of researching and analyzing the social, historical, climatic, geographical, legal, and infrastructural characteristics of a given site, and synthesizing these analyses into visual information - usually in the form of site analysis diagrams. This process is used as a starting point for developing strategies related to the environment during the design process that will come later.

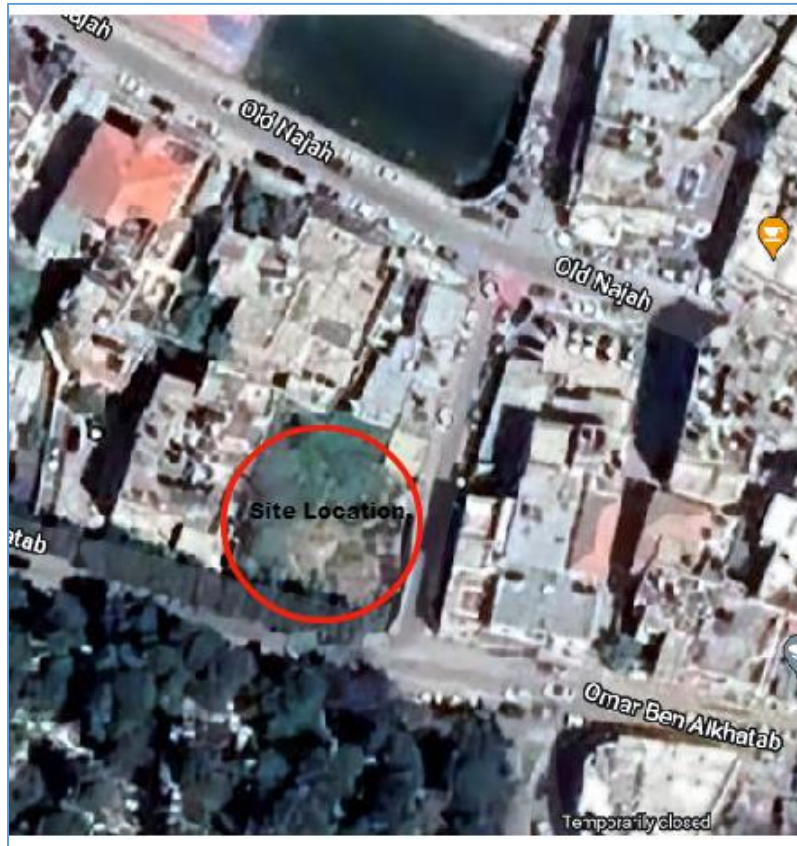
Figure 8 below shows what site analysis includes.



*Figure 8 Content of site analysis*

### 2.2.1 General Information.

The project is located in Nablus City; it is mainly on the University Street. The area is sorted as liveable where it has all the needed facilities. Figure 9 below shows the site plan of the building.



*Figure 9 Site Plan*

### 2.2.2 Neighborhood Context.

The buildings in the neighbourhood are diverse, as next to the building are a soap factory, residential buildings, and a cemetery. The neighbourhood also contains shops, schools, restaurants, supermarkets, pharmacy, schools, a church, a mosque, and most importantly, it is close to the university. The condition of the buildings in the area is good, they are old and new.

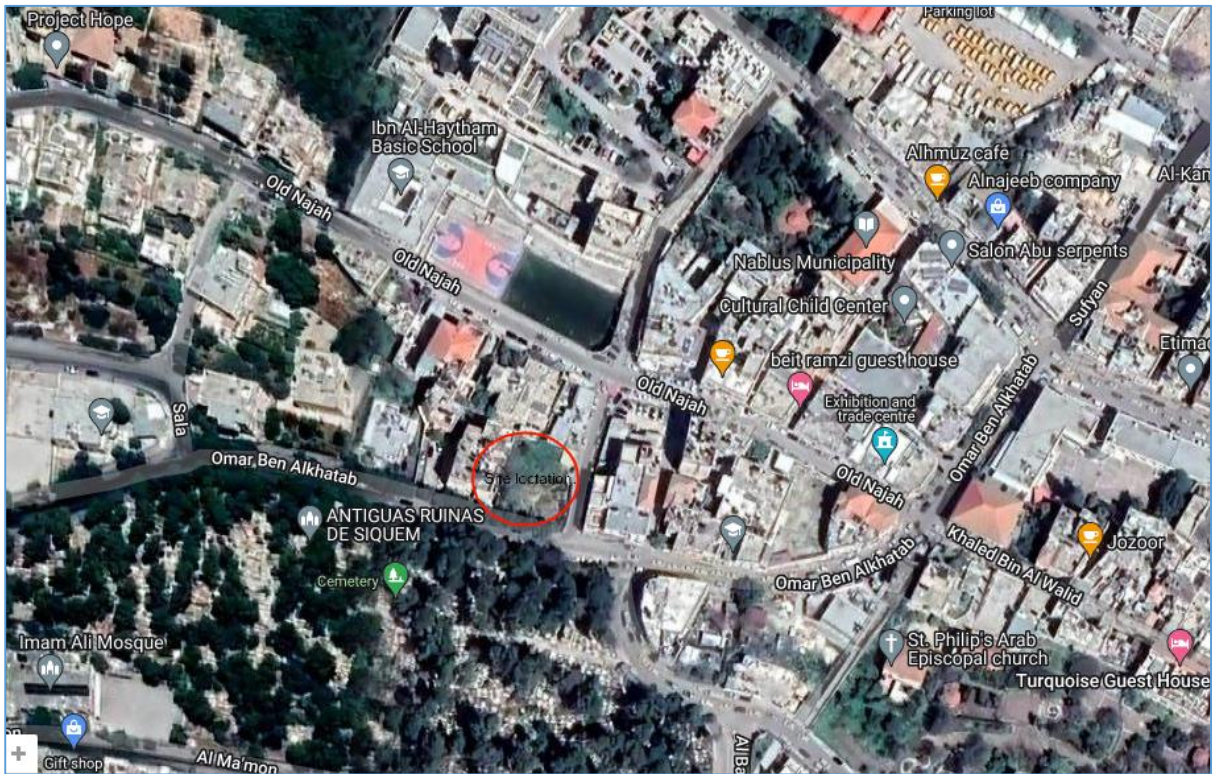


Figure 10 The Neighborhood and Surrounding facilities.

### 2.2.3 Site and Zoning.

The site area is 684.8m<sup>2</sup>, it is a multi-functional building but mostly could be sorted as residential building. As mentioned above the building on a main street which make it easy to find public transportation as Taxis.

### 2.2.4 Natural Features.

Topography of the site is as shown it could be considered as mountains. Which will be considered in the design phase. Figure 11 shows the topography of the land.



Figure 11 The Topography of the Area.

### 2.2.5 Circulation.

The site is located on two streets, one main and the other a subsidiary, which means there are several roads leading to the site as shown in Figure 12, which facilitates the transportation process. It was also mentioned that the building is located on a main street with easy access to public transportation.

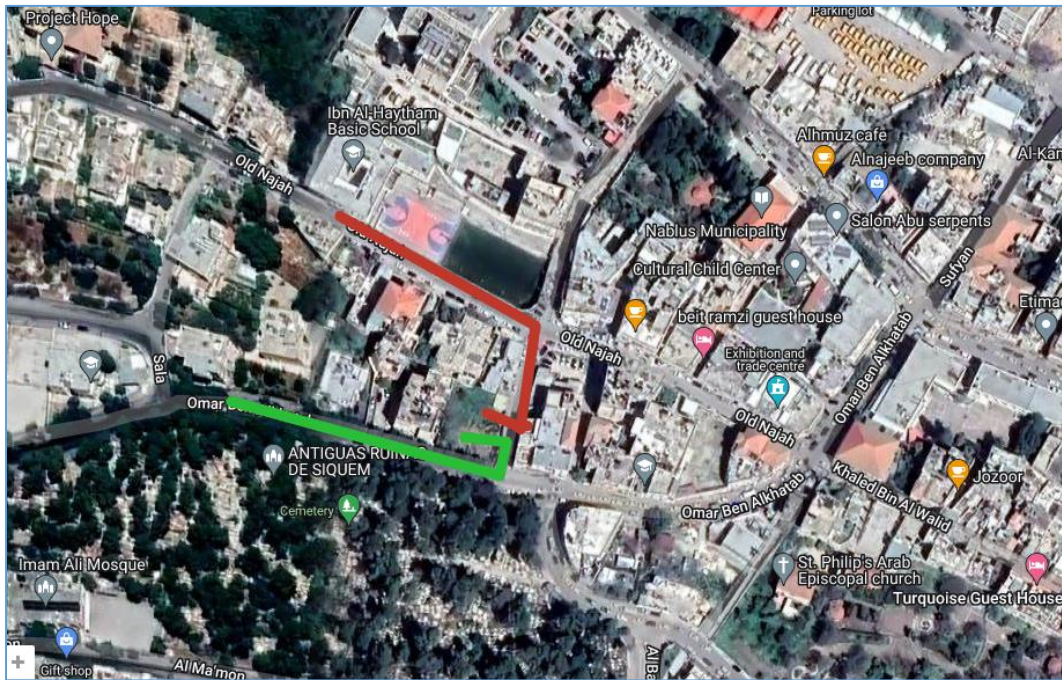


Figure 12 A possible options to reach the site.

### 2.2.6 Sensory.

The location overlooks two streets, which makes the view from the building promising. The noise level reaches its peak at the peak that when the university near the site is open because the main street connects two essential areas of the city. The level of pollution may also be high due to automobile exhaust.

### 2.2.7 Human and Cultural.

Since the area is close to the university, most of its residents are students and conservative Palestinian families. The area is characterized by being well-served and safe and has no criminal history, which will serve the building and users in the future.

### 2.2.8 Climate.

The longer side of the building faces east and west, while all balconies face north and south. This means, that the solar lighting in the building is distributed from all sides. The wind in Nablus is North-West wind, and since the building is exposed on the north side, it will be a good windway. On the other hand, both the orientation of the building and the surrounding effect the shadow. Figure 13, Figure 14, and Figure 15 show shadows on different times periods.

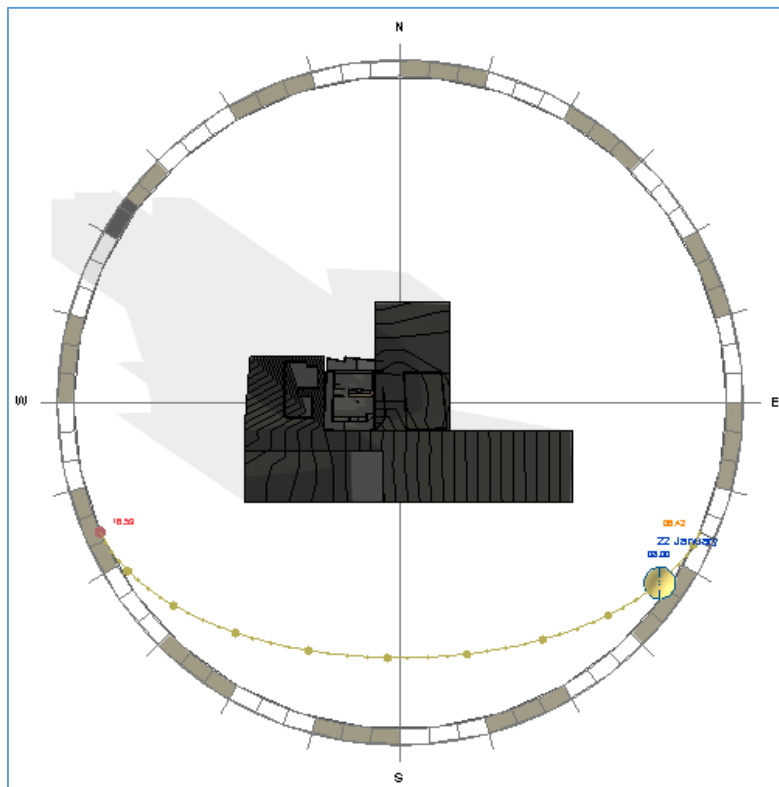


Figure 13 Shadows at 8am

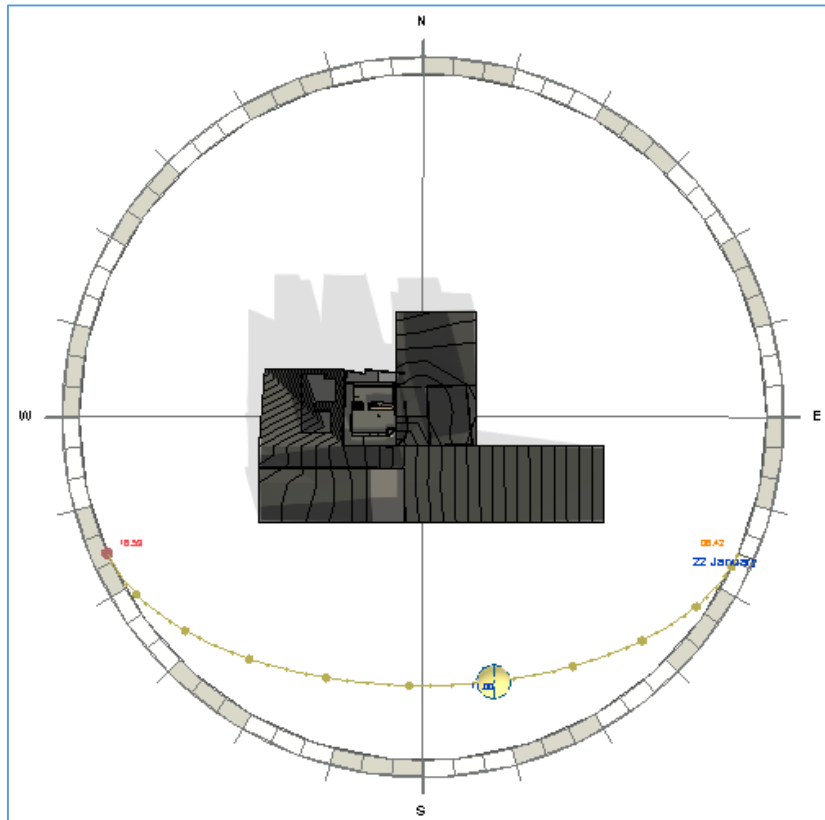


Figure 14 Shadows at 12pm

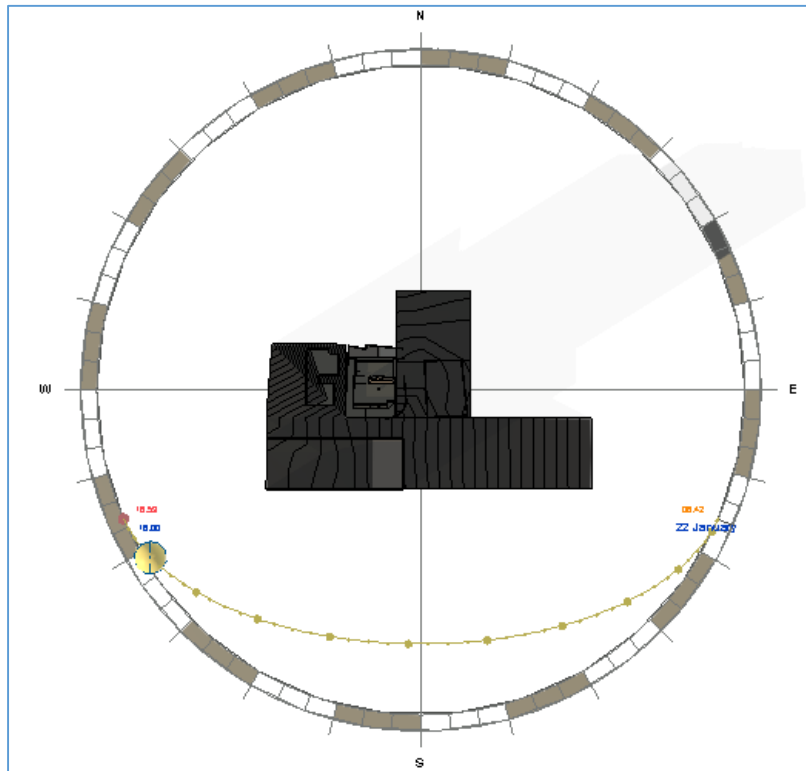


Figure 15 Shadows at 6pm

## 2.3 Case study analysis

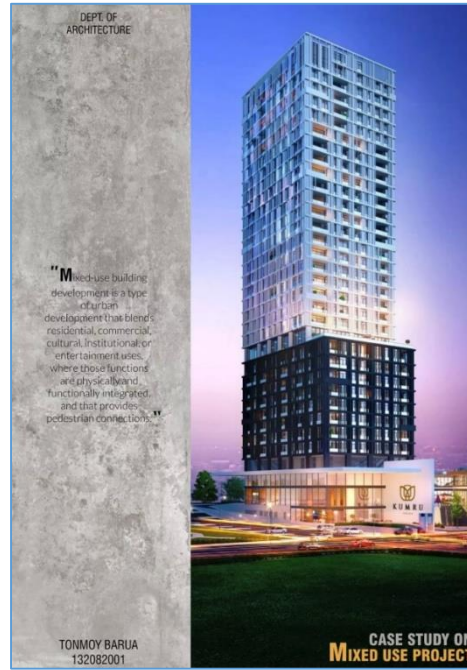


Figure 16 Case Study on a mixed-use project: Kumru

Kumru Ankara-shown in Figure 16- was designed in one of the most important residential areas of Ankara, Cankaya, Yıldız neighborhood, parallel to the Turan Günes Boulevard which is one of the main axes of the Ankara. The Kuru Ankara project, which was brought to life in the capital Ankara Çankaya, is being constructed by the Kuzu Group This Kumru Ankara project, is next to Bars Manço Park and was delivered in September 2017.

Figure 17 shows the location of this project.



Figure 17 Location of Kumru Ankara

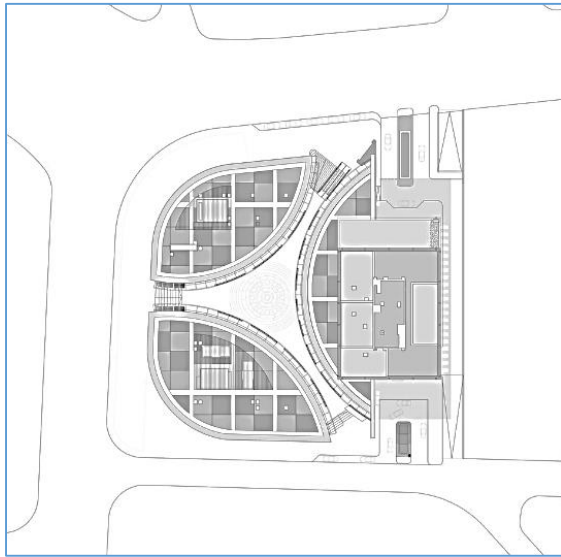


*Figure 18 Basic levels in the building*

The building is planned according to the three basic levels as shown in Figure 18. The first one is a public platform. The second one is the inner courtyard, which has a close relationship with the road. And the last one is the upper platform where flats were constructed.

The social facility created on the 11th floor provides a synergy of the housing groups formed by the upper and lower blocks as an activity area that has a clear city view. A fitness center, swimming pool, and playground are provided on this level which brings people together. The location of the design has a strong potential to be able to provide a nice city view to the users. Therefore, a 360-degree city view is provided in the houses. In different directions, diverse scenic houses include diverse units that can address different lifestyles. The architectural approach emphasizes the environmental and energy sensitivity issues, and the concept of green building is adopted as a sustainable understanding. The roof gardens built on the commercial units provide a green area contribution to the upper town and at the same time, the gardens strengthen the view of the houses. While Kumru Ankara presents a new public space to the city's social life cycle, the strong relationship it establishes with the city also provides a rich living space to its users.

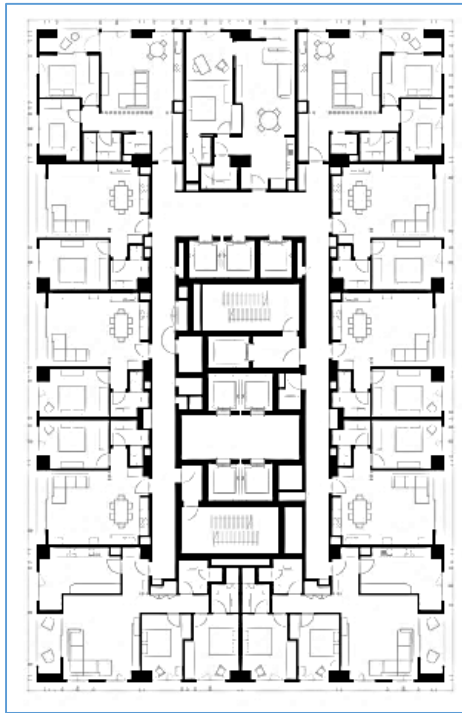
The figures below (Figure 19, Figure 20, Figure 21, Figure 22, Figure 23, Figure 24, and Figure 25) show the floor plans of the project.



*Figure 19 Master-site- plan*



*Figure 20 Ground floor plan*



*Figure 21 Home office block*



*Figure 22 Residential block*



Figure 23 Social Center floor

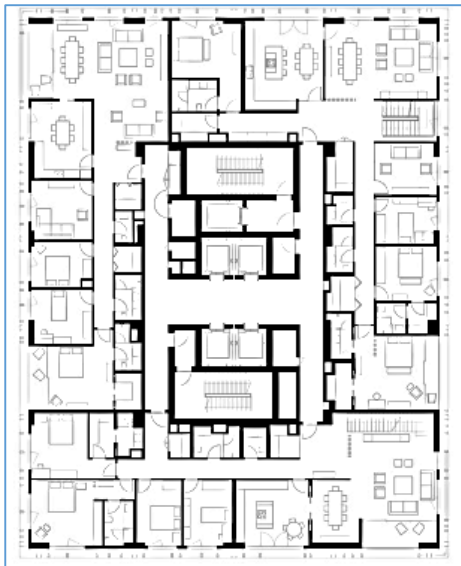


Figure 24 Residential block exclusive floor  
downstairs



*Figure 25 Residential block exclusive floor upstairs*

## 2.4 Architectural Analysis.

In this section, each space in the project will be compared to the standards. Also, will include any space that should be available in the building.

### 2.4.1 Self-contained (Studios).

As mentioned in the literature review there are two types of self-contained spaces, with a minimum area of

- Single. → $12m^2$
- Double. → $14m^2$

In this project, all single rooms (studios), met the standards by the size of the room.

On the other hand, some of the double rooms were smaller than the minimum area.

And will be crowded and uncomfortable for double. In this case, some of the double rooms will be turned into single rooms.

### 3.2.1 Offices.

Due to what where shown in the literature review both types of offices should have a minimum area of  $9m^2$ . Which was achieved in the project design.

#### 2.4.2 Retail Stores.

The stores in this project are considered demand shops. According to the standards, the minimum area of the shops is  $15m^2$ , due to that, all shops met the standards

#### 2.4.3 Parking

Parking was fit to the standards as for the size and dimension, but the number of cars provided is less than required. Where 1 parking should available for every 4 students.

#### 2.4.4 Other Facilities.

Based on the literature review, some facilities should be available:

- Laundry room
- Fire stairs

#### 2.4.5 Environmental stranded values.

- Daylight factor 0.01-0.05

### 2.5 Modifications

As demonstrated by the comparison in the previous section, modifications are required to meet the standards which will ensure the best experience for the end user. As demonstrated by the comparison in the previous section, modifications are required to meet the standards which will ensure the best experience for the end-user. The modification will be shown according to each floor of the building and have been modified.

#### 2.5.1 Repetitive-floors.

In this section the modification on the studios-floor will be shown. The floor plans are shown below Figure 26, Figure 27.

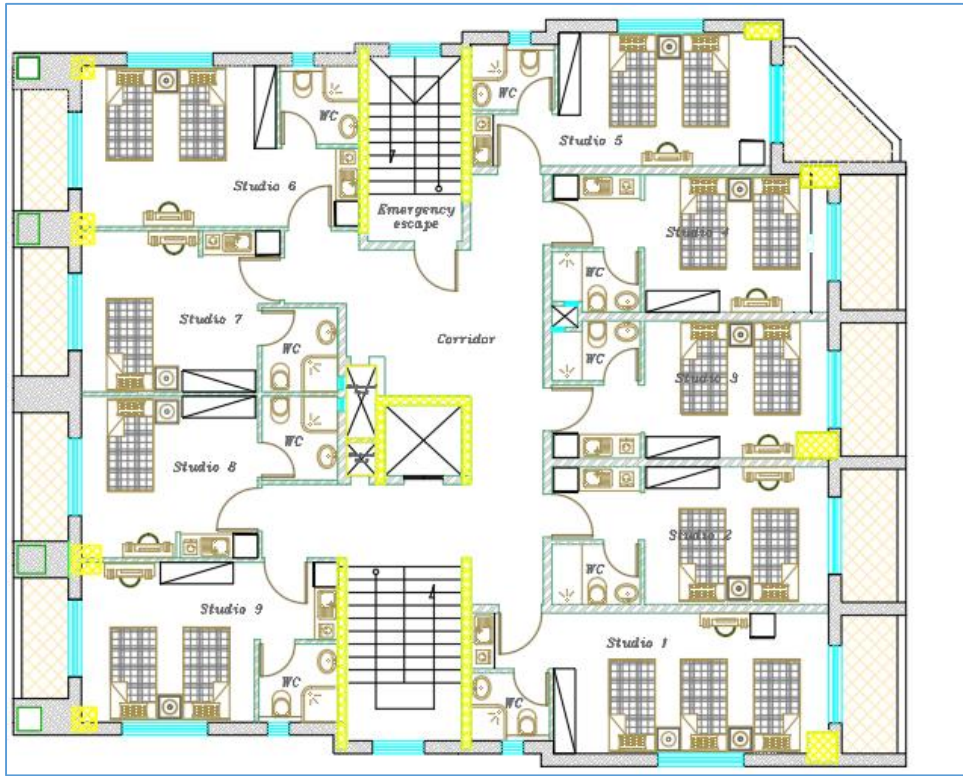


Figure 26 Floor plan before modification

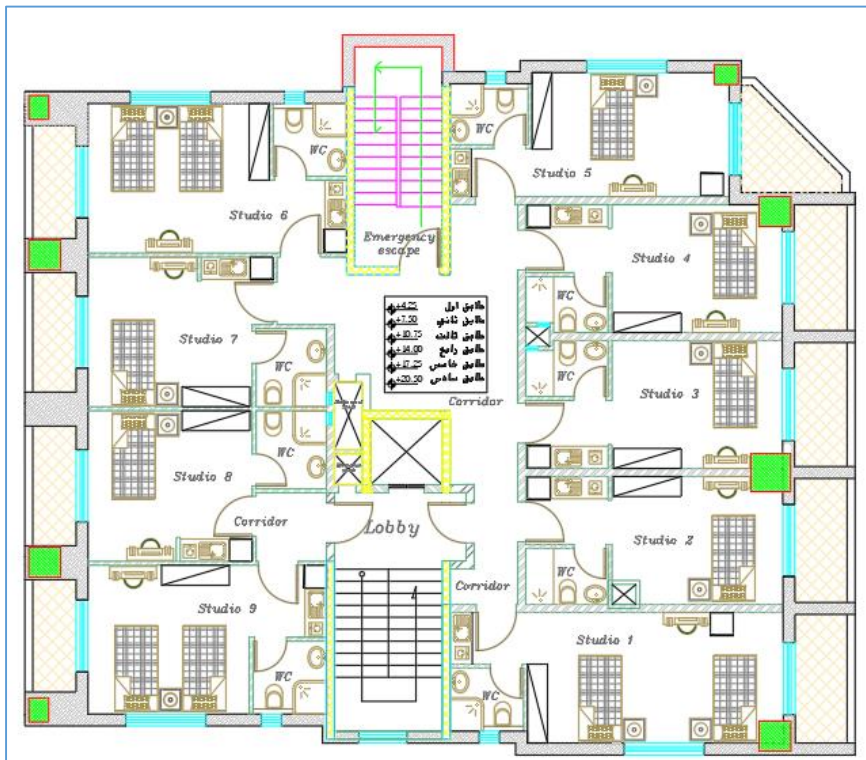


Figure 27 Floor plan after modification.

### 2.5.1.1 Studios

As mentioned in the previous section some of the double rooms did not achieve the standard minimum size. And according to that some of them were changed into a single room. The modification is shown in Figure 28, Figure 29.

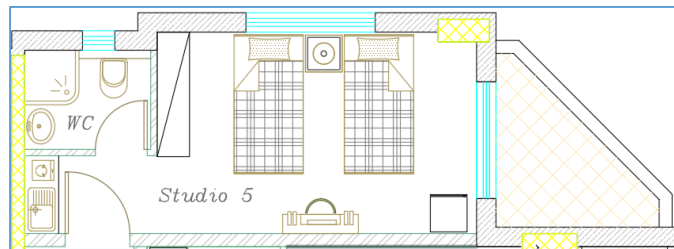


Figure 28 Double room before modification



Figure 29 Modified room

### 2.5.1.2 Lobbies.

Since privacy is a major concern in private buildings, lobbies are one of the suggestions used to create a type of privacy for the user, which was not achieved in the design, where the stairs and elevator were open directly to the floor. Due to that, a lobby was added taking into consideration the fire escape route. As shown in Figure 30, and Figure 31 these are the before and after.

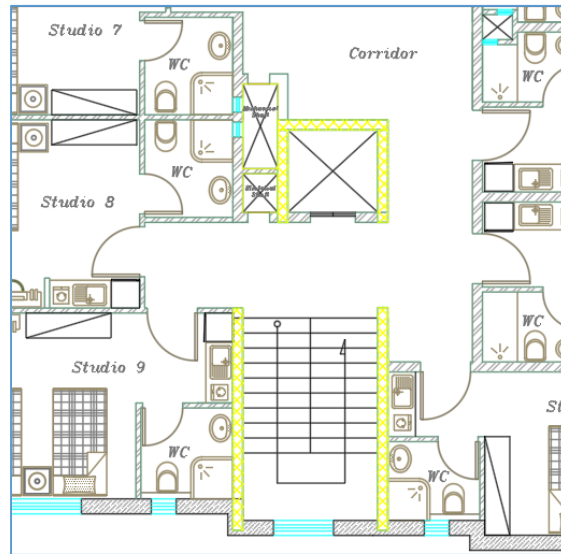


Figure 30 floor without a lobby.

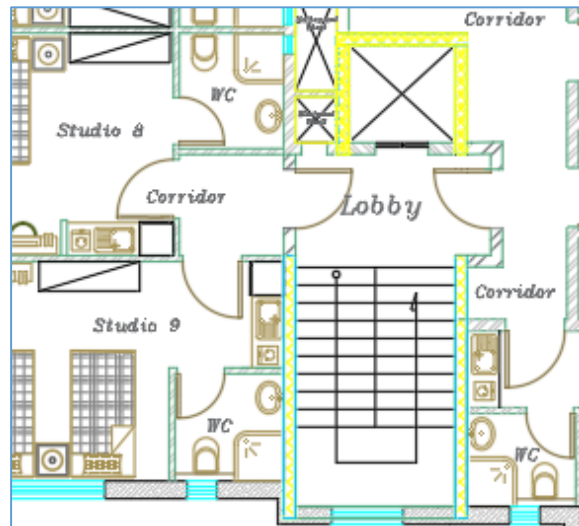


Figure 31 floor after the lobby was added.

### 2.5.2 First – second floor (Stores).

These two floors are used for stores. And since all shops are larger than the minimum size no modification were needed. On the other hand, the space was not used in the best way, where it was wasted on storage areas for the small shops. Based on that, some of the facilities that were required according to the standards were added to this floor. Floor plans are shown in Figure 32 & Figure 33.

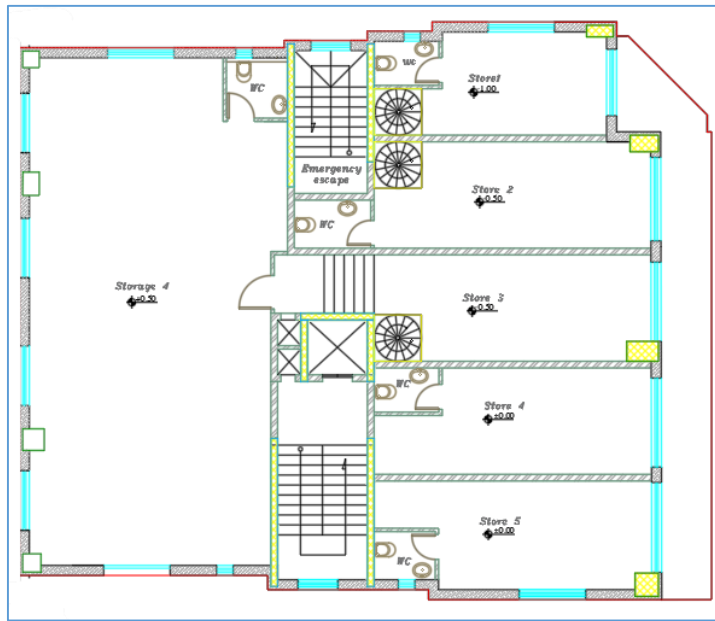


Figure 32 First floor before modification

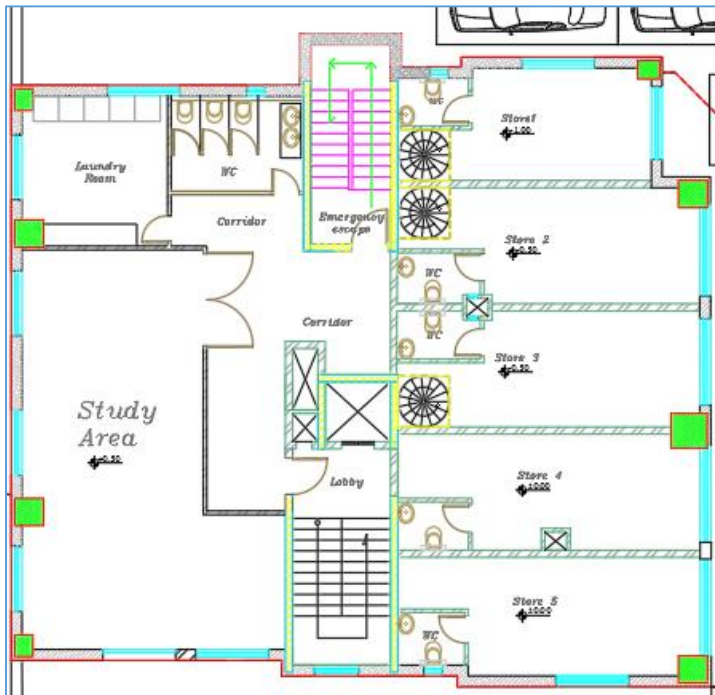


Figure 33 First floor after modification

### 2.5.2.1 Study area

Study areas in students' buildings have no standard size, it mostly depends on the available space. On the other hand, it is essential to locate it in a quiet place, and since it was located on the ground floor and it is a public floor with all offices and reception and other facilities it was not suitable for the Study area. Figure 34 & Figure 35 show Study area in original plan and after modification.

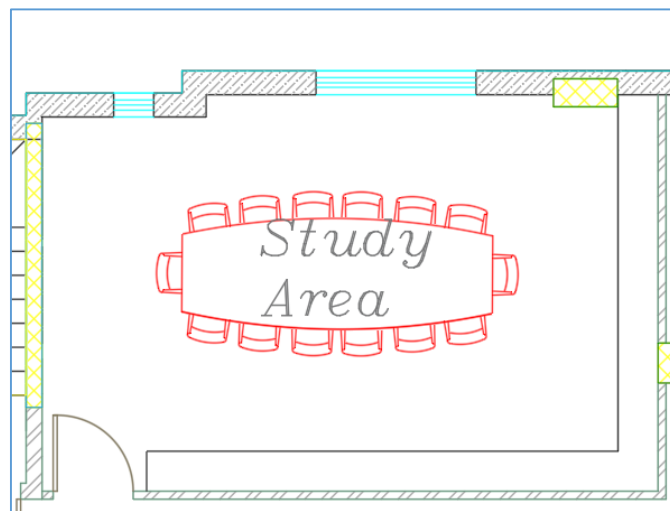


Figure 34 Study Area space on the original plan

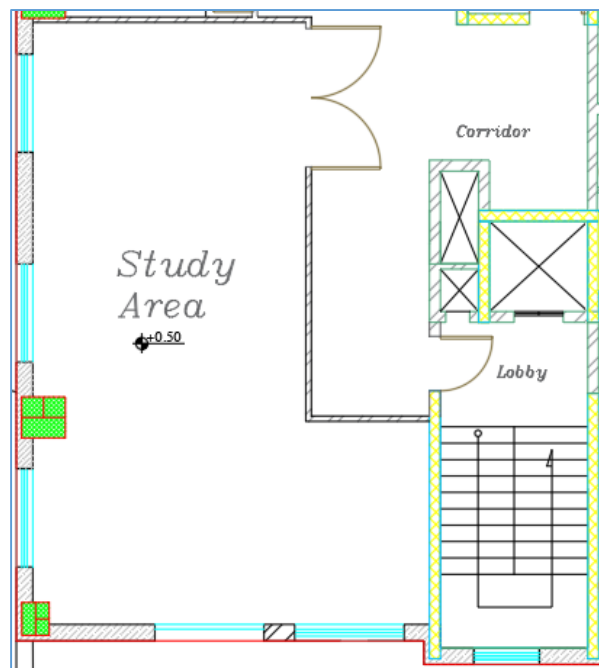


Figure 35 Study area on the first floor

### 2.5.2.2 Laundry room.

As discussed above, one of the facilities that should be available in the dormitory building is laundry rooms. And since it was not available in the original plans it was added on the current floor with all the required number of machines. Figure 32 shows the laundry room plan.

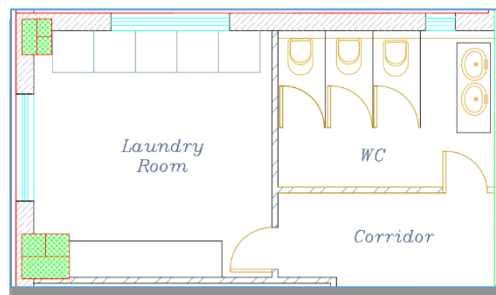


Figure 36 Laundry room plan.

### 2.5.3 Ground Floor.

The ground floor is used for the guests, administration, and food court.

In the previous design, the study area was on the ground floor and since the floor is mostly crowded and not quiet it was moved to the first floor as stated in the previous section. Due to the move of the study area, the food area was expanded which will help to serve a bigger number of users. Also, it becomes close and separated from the other floor which was not achieved in the previous design. Also to achieve the best security a security room was added to the entrance. In addition, a fire control room, as shown in Figure 37, and Figure 38.



Figure 37 Ground floor plan before modification

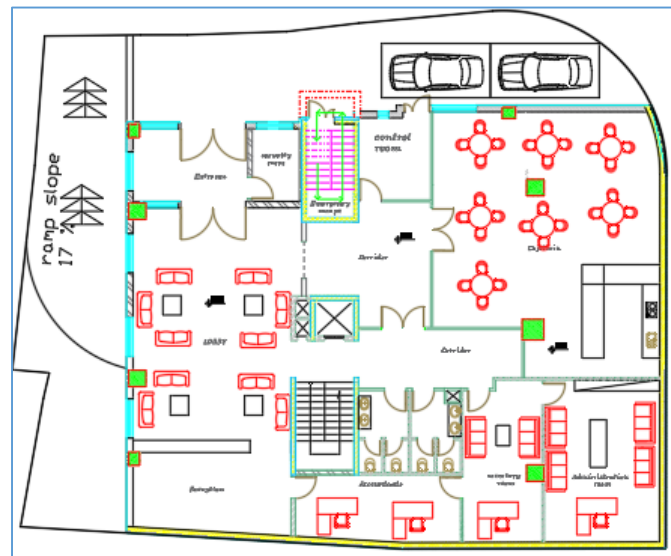


Figure 38 Ground floor plan after modification

### 2.5.3.1 Control room.

The control room was added according to the safety standards, and it is used to control the system and organize the evacuation in case of an emergency. Figure 39 Show the room.

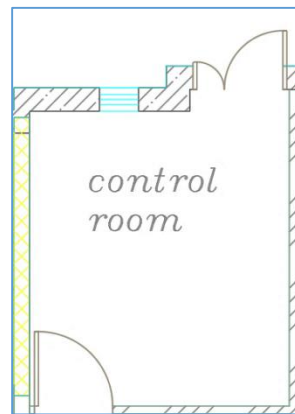


Figure 39 Control room.

### 2.5.3.2 Security room

As mentioned in the previous section security is one of the major concerns, especially it is a dormitory building. For that matter, a security room was added to make sure that building is monitored and visitors are same. It was located in the entrance of the building. The security room is shown in Figure 40.



Figure 40 Security room plan.

### 2.5.4 Parking

Based on the standards for every 4 students 1 parking space should be provided And since every studio's floor has 12 users 3 parking spaces are required for every floor and since there are 6 floors 18 parking spaces should be provided and for the administration, 4 spaces, in total at least 22 parking spaces should be available.

According to this, no need for another parking floor to be added to the building since one parking with the front parking cover the required number of spaces as Figure 41 and Figure 42 show.

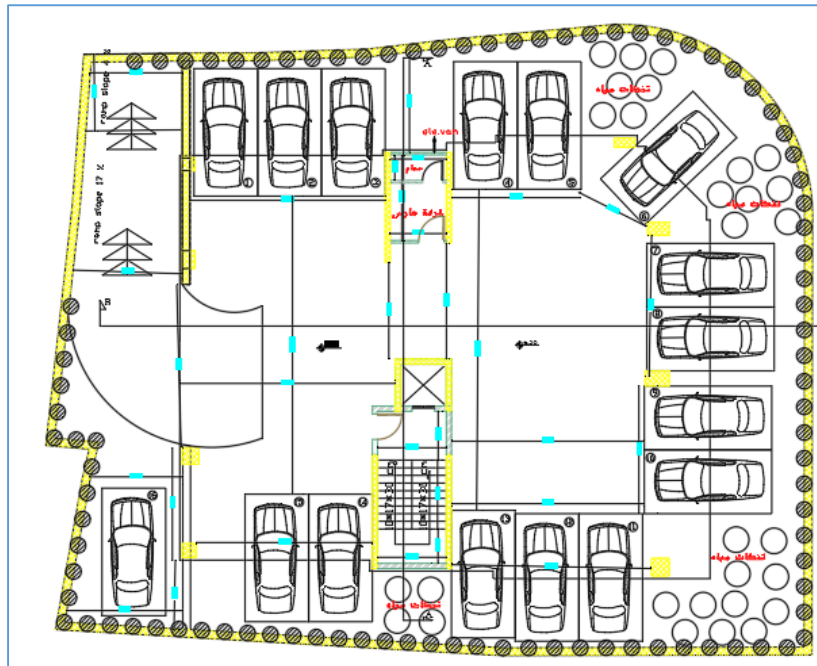


Figure 41 1-floor parking lot

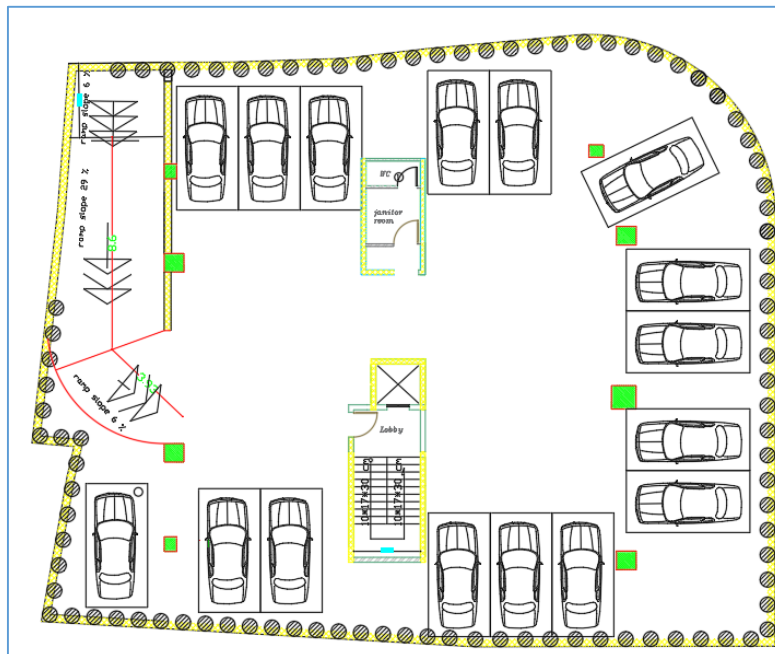


Figure 42 2-floor parking lot.

## 2.6 Environmental Aspects.

Like every other aspect of the space, the environmental part is one of the essential things to consider while designing, as it significantly impacts the user experience. As a result, the space was studied with daylight factor and heating and cooling values. Below will be shown the layer of the walls, the value of cooling and heating of the spaces, and, Daylight factor before and after the modification.

### 2.6.1 Before Modification.

Many factors can impact the heating and cooling load together with the Daylight factor. Wall layers could play an enormous role in the cooling and heating load, on the other hand, the glazed area impacts the daylight factor.

**NOTE:** For the Daylight factor results shown are for store 5

#### 2.6.1.1 Wall Layers.

As mentioned above wall layers impact the cooling and heating load, which will affect the HVAC system. In this project there are three type of walls

- External Walls
- Interior Walls
- Shear Walls.

Each will be shown below.

##### 2.6.1.1.1 External Walls.

The external walls have 30 cm thickness. Figure 43 and Figure 44 show the components of the wall.

Family:	Basic Wall					
Type:	External Wall					
Total thickness:	0.3000 (Default)	Sample Height:	6.0960			
Resistance (R):	0.3626 (m <sup>2</sup> ·K)/W					
Thermal Mass:	419.59 kJ/(m <sup>2</sup> ·K)					
Layers						
EXTERIOR SIDE						
	Function	Material	Thickness	Wraps	Structural Material	Variable
1	Finish 1 [4]	Brick, Eng	0.1000	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	<b>Core Bound Layers Abo</b>	<b>0.0000</b>				
3	Structure [1]	Concrete	0.0800	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
4	Structure [1]	Brick, Eng	0.1000	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	<b>Core Bound Layers Belo</b>	<b>0.0000</b>				
6	Finish 2 [5]	Plaster	0.0200	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 43 External Wall Components before modification.

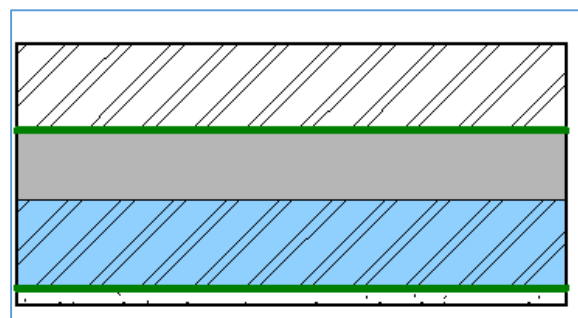


Figure 44 Wall Detailing.

### 2.6.1.1.2 Shear Wall.

There are two type of shear wall used in the building, External and internal both are shown below.

- External Shear Wall.

This wall is used in the external walls of the building. Figure 45 shows the components

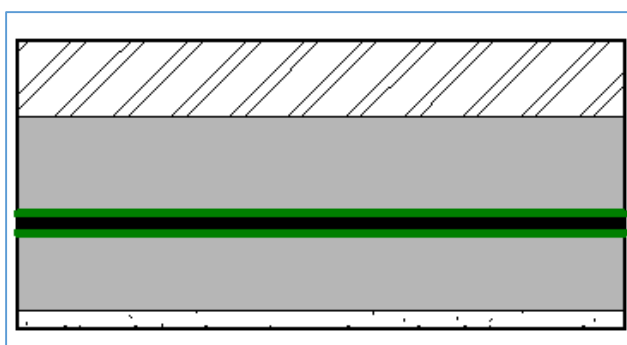
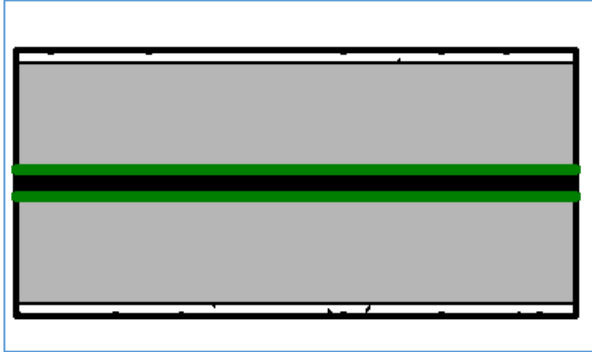


Figure 45 External Shear Wall before modification.

Family:	Basic Wall					
Type:	External Shear Wall					
Total thickness:	0.3000 (Default)	Sample Height:	6.0960			
Resistance (R):	0.3105 (m <sup>2</sup> ·K)/W					
Thermal Mass:	479.74 kJ/(m <sup>2</sup> ·K)					
Layers						
EXTERIOR SIDE						
	Function	Material	Thickness	Wraps	Structural Material	Variable
1	Finish 2 [5]	Brick, Eng	0.0800	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Structure [1]	Concrete	0.1000	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	<b>Core Bound Layers Abo</b>	<b>0.0000</b>				
4	Structure [1]	Steel, Car	0.0200	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
5	<b>Core Bound Layers Belo</b>	<b>0.0000</b>				
6	Structure [1]	Concrete	0.0800	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- Internal Shear Wall.

The wall is used in the stairs inside of the building.



Family: Basic Wall  
 Type: Shear wall  
 Total thickness: 0.2000 (Default)      Sample Height: 6.0960  
 Resistance (R): 0.1926 (m<sup>2</sup>K)/W  
 Thermal Mass: 338.64 kJ/(m<sup>2</sup>K)

Layers

EXTERIOR SIDE						
	Function	Material	Thickness	Wraps	Structural Material	Variable
1	Finish 2 [5]	Plaster	0.0100	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Structure [1]	Concrete	0.0800	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Core Bounda	Layers Abo	0.0000			
4	Structure [1]	Steel, Car	0.0200	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
5	Core Bounda	Layers Belo	0.0000			
6	Structure [1]	Concrete	0.0800	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

INTERIOR SIDE

Figure 46 Internal Shear Wall Before Modification.

### 2.6.1.1.3 Internal Walls.

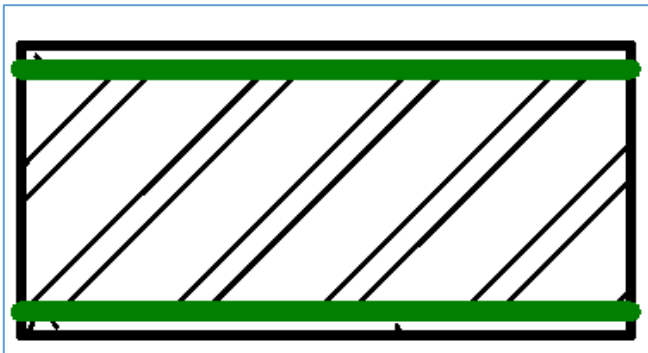
There are two types of internal walls, one used inside of the rooms to spirit it components and one that is used between studios (rooms).

- Walls used between studios.

The Figure 47 below shows the components of the wall.

- Internal Wall

Figure 48 shows walls that used to spirit room components (Kitchen, WC, etc.).



Family: Basic Wall  
 Type: Wall Between Studios.  
 Total thickness: 0.2000 (Default)      Sample Height: 6.0960  
 Resistance (R): 0.2760 (m<sup>2</sup>K)/W  
 Thermal Mass: 264.77 kJ/(m<sup>2</sup>K)

Layers

EXTERIOR SIDE						
	Function	Material	Thickness	Wraps	Structural Material	Variable
1	Finish 2 [5]	Plaster	0.0200	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Core Bounda	Layers Above	0.0000			
3	Structure [1]	Brick, Engin	0.1600	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
4	Core Bounda	Layers Below	0.0000			
5	Finish 2 [5]	Plaster	0.0200	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 47 Internal Walls between Studios.

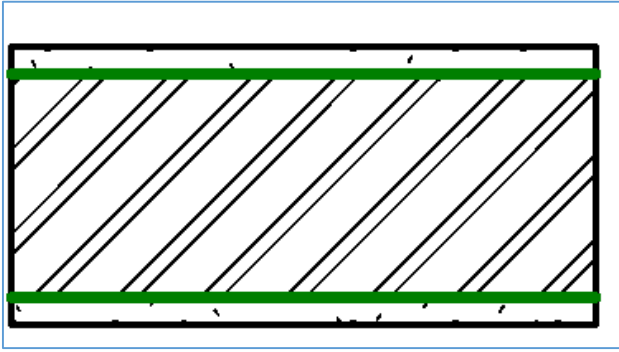


Figure 48 Internal Wall Components.

Family:	Basic Wall					
Type:	intwall					
Total thickness:	0.1200 (Default)	Sample Height:	6.0960			
Resistance (R):	0.1627 (m <sup>2</sup> ·K)/W					
Thermal Mass:	160.10 kJ/(m <sup>2</sup> ·K)					
Layers						
EXTERIOR SIDE						
	Function	Material	Thickness	Wraps	Structural Material	Variable
1	Finish 2 [5]	Plaster	0.0100	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Core Bounda	Layers Above	0.0000			
3	Structure [1]	Brick, Engin	0.1000	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
4	Core Bounda	Layers Below	0.0000			
5	Finish 2 [5]	Plaster	0.0100	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### 2.6.1.2 Daylight Factor.

Daylight factor is impacted by the glazed area and by the properties of it. As mentioned above the results shown in Figure 49 are for Store 5.

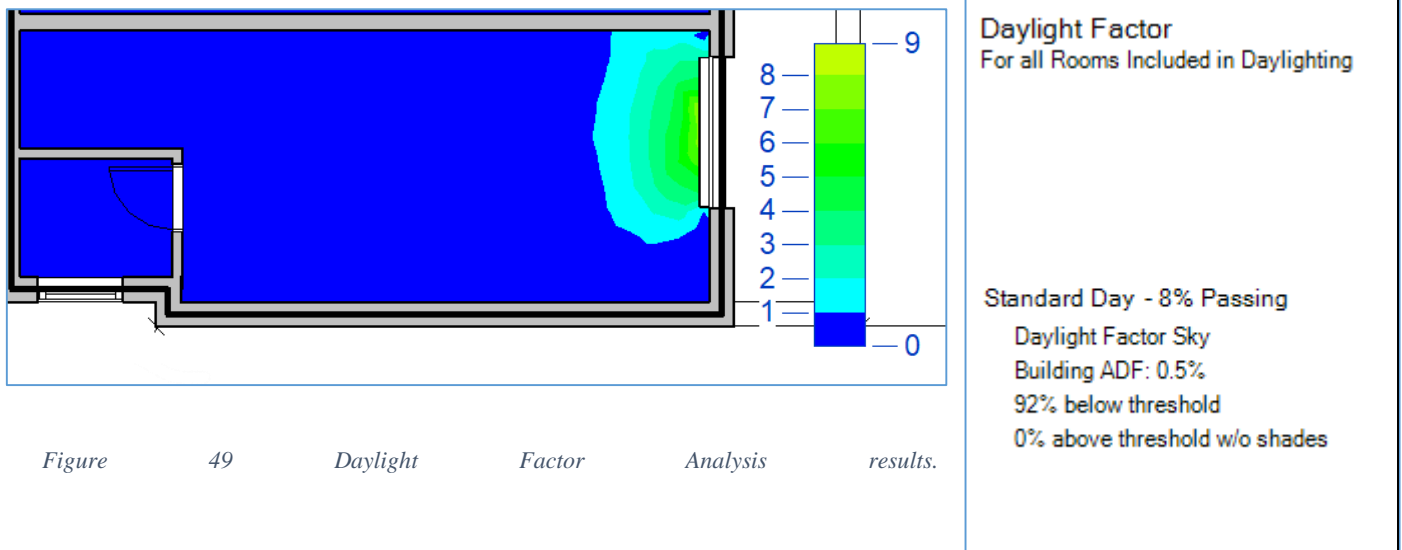


Figure 49 Daylight Factor Analysis results.

### 2.6.2 After Modification.

As mentioned above many factors can impact the heating and cooling load together with the Daylight factor. Due to that, a modification was done to some of the wall layers according to the need.

**NOTE:** The Daylight factor results shown are for store 5.

#### 2.6.2.1 Walls Layer.

Wall layers were modified as needed to reduce the cooling and heating load, to make sure that the building is as efficient as possible. Only external walls were modified since had no insulation.

##### 2.6.2.1.1 External Walls.

As shown above, external wall components had no insulation, which led to a gain in cooling and heating loads. Also, it means that the user will not be as comfortable throughout the year. Figure 50 shows the wall component after modification.

Family: Basic Wall  
 Type: External wall  
 Total thickness: 0.3000 (Default)      Sample Height: 6.0960  
 Resistance (R): 1.3571 (m<sup>2</sup>·K)/W  
 Thermal Mass: 402.52 kJ/(m<sup>2</sup>·K)

Layers

EXTERIOR SIDE						
	Function	Material	Thickness	Wraps	Structural Material	Variable
1	Finish 1 [4]	Brick, Eng	0.1000	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Thermal/Air	Fiberglass	0.0200	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	<b>Core Bound Layers Abo</b>		<b>0.0000</b>			
4	Structure [1]	Concrete	0.0600	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
5	Structure [1]	Block	0.1000	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	<b>Core Bound Layers Belo</b>		<b>0.0000</b>			
7	Finish 2 [5]	Plaster	0.0200	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

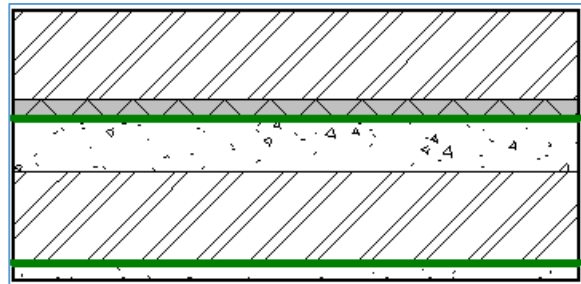


Figure 50 External wall after modification.

### 2.6.2.2 Daylight Factor.

After Modifying the glazed area and properties of the glass (Figure 51) the DF analysis results are as shown in Figure 52 and Figure 53.

Visual Light Transmittance	0.700000
Solar Heat Gain Coefficient	0.400000
Thermal Resistance (R)	0.5000 (m <sup>2</sup> ·K)/W
Heat Transfer Coefficient (U)	2.0000 W/(m <sup>2</sup> ·K)

Figure 51 Glass Properties.

Lighting Analysis - Results Summary

**Daylight Factor**  
For all Rooms Included in Daylighting

Standard Day - 12% Passing

Daylight Factor Sky

Building ADF: 0.9%

88% below threshold

0% above threshold w/o shades

Figure 52DF Results From Revit

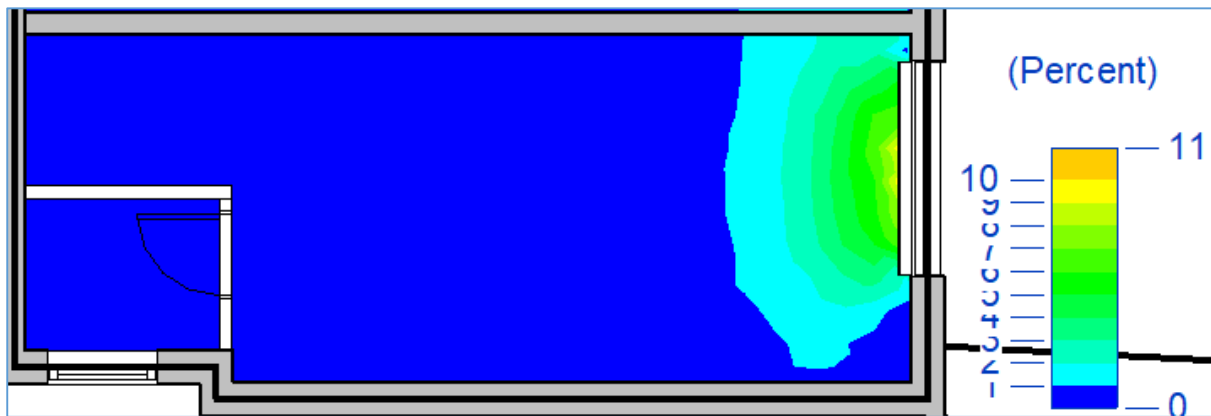
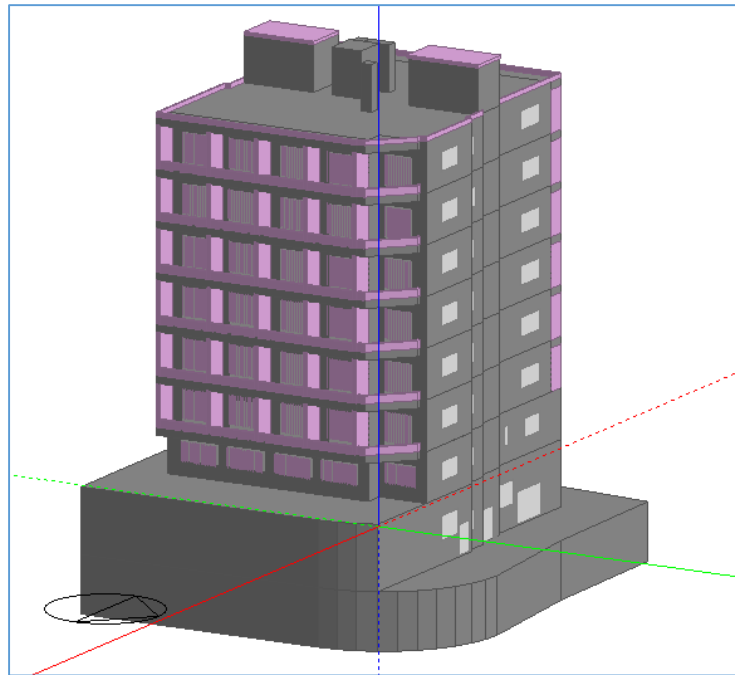


Figure 53DF Results from Revit.

From the results shown above, it is noticed that even with the modification still artificial lighting is needed in the space.

## 2.7 Thermal Insulation

Through Design Builder, the building was modelled. Cooling design, heating design and simulation results were found out. The results were not good, so some modifications were done by adding thermal insulation for the floors, walls and ceiling, using low emission glass in addition to add louvers. Figure 54, Figure 55 and Figure 56 shows building's views



*Figure 54 Model for building showing louvers-1*

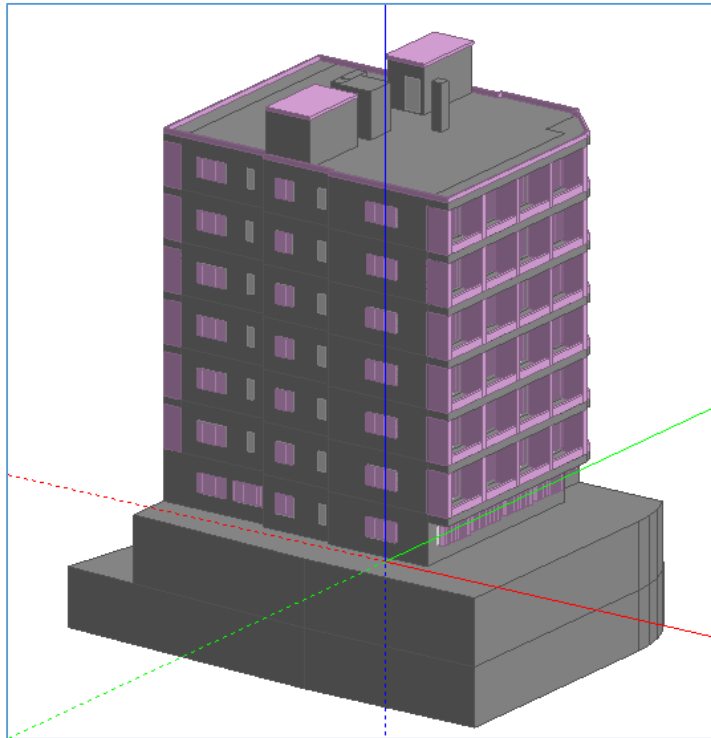


Figure 55 Model for building showing louvers-2

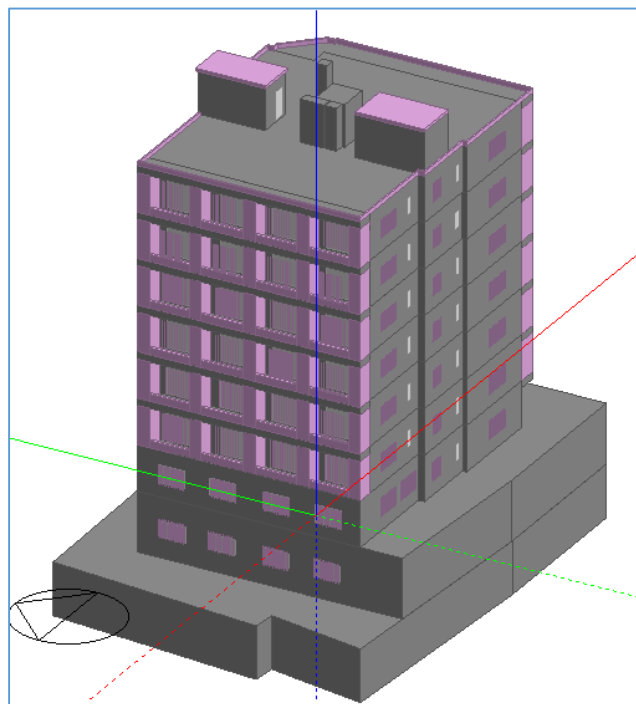


Figure 56 Model for building showing louvers-3

## 2.7.1 Materials

### 2.7.1.1 External wall materials

External wall materials and U-value are shown in Figure 57 and Figure 58.



Figure 57 cross-section of the external wall

<b>U-Value (W/m<sup>2</sup>-K)</b>	<b>0.355</b>
------------------------------------	--------------

Figure 58 U-value for external wall

### 2.7.1.2 Interior partitions

Interior partitions materials and U-value are shown in Figure 59 and Figure 60.

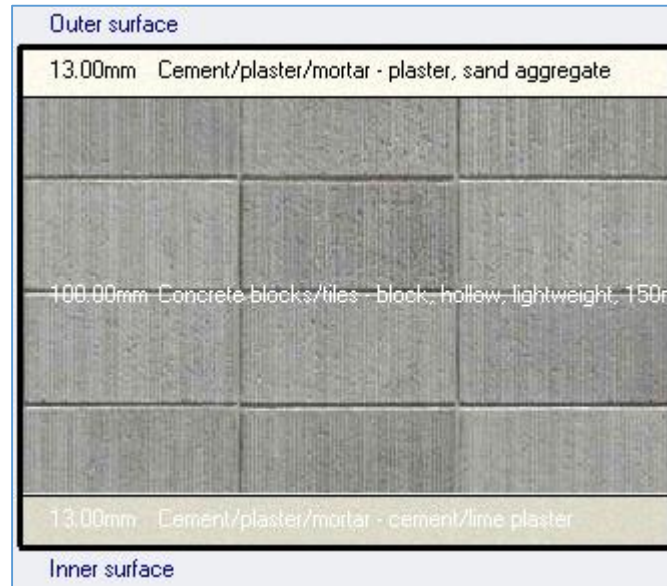


Figure 59 cross-section of the Interior partitions

U-Value (W/m <sup>2</sup> -K)	1.998
-------------------------------	-------

Figure 60 U-value for interior partitions

### 2.7.1.3 Roof materials

Roof materials and U-value are shown in Figure 61 and Figure 62.

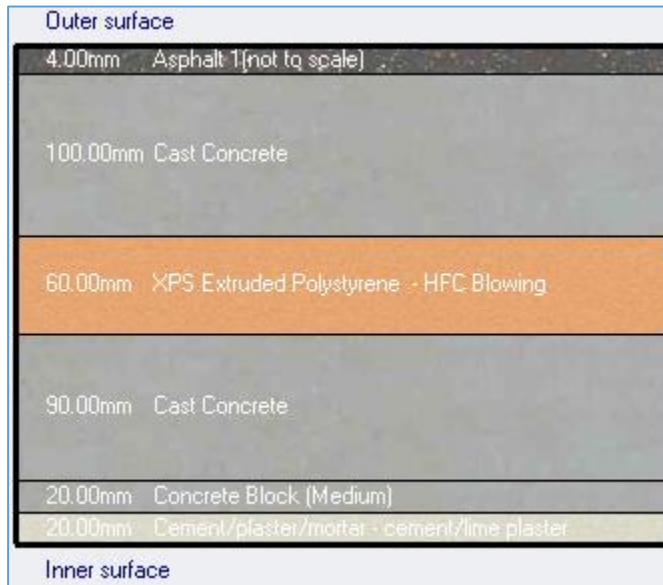


Figure 61 cross-section of roof

U-Value (W/m2-K)

0.424

Figure 62 U-value for roof

### 2.7.1.4 Glazing materials:

Glazing materials and U-value are shown in Figure 63 and Figure 64.

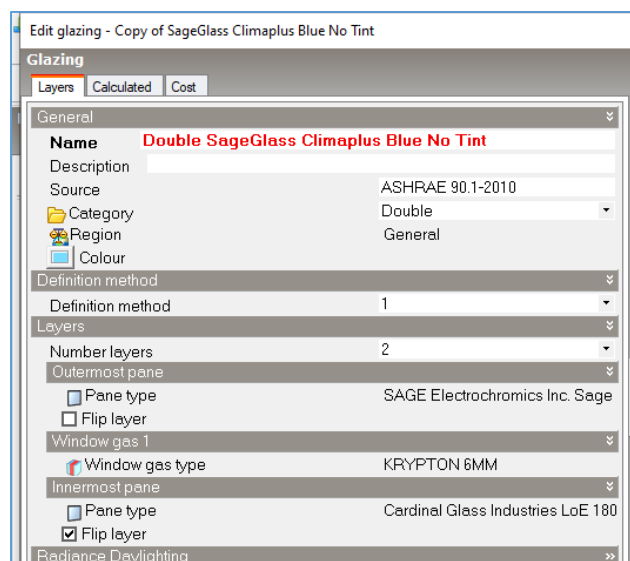


Figure 63 Glass type.

<b>U-Value (W/m<sup>2</sup>-K)</b>	<b>1.283</b>
------------------------------------	--------------

Figure 64 U-value for roof

2.7.1.5 Internal floor

Internal floor materials and U-value are shown in Figure 65 and Figure 66.

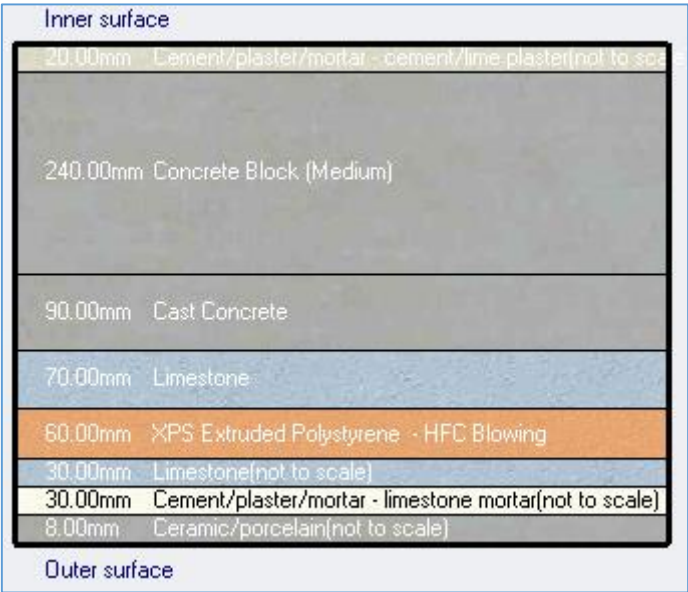


Figure 65 cross-section of floor

<b>U-Value (W/m<sup>2</sup>-K)</b>	<b>0.364</b>
------------------------------------	--------------

Figure 66 U-value for floor

## 2.7.2 Heating and cooling design results.

The results shown for the heating and cooling designs are compared between the building with insulation and the building before insulation.

### 2.7.2.1 Heating design.

After calculation the results are before insulation is shown in Figure 67 and after adding the insulation as shown in Figure 69. The total heating capacity for both types are as shown in Figure 68 and Figure 70.

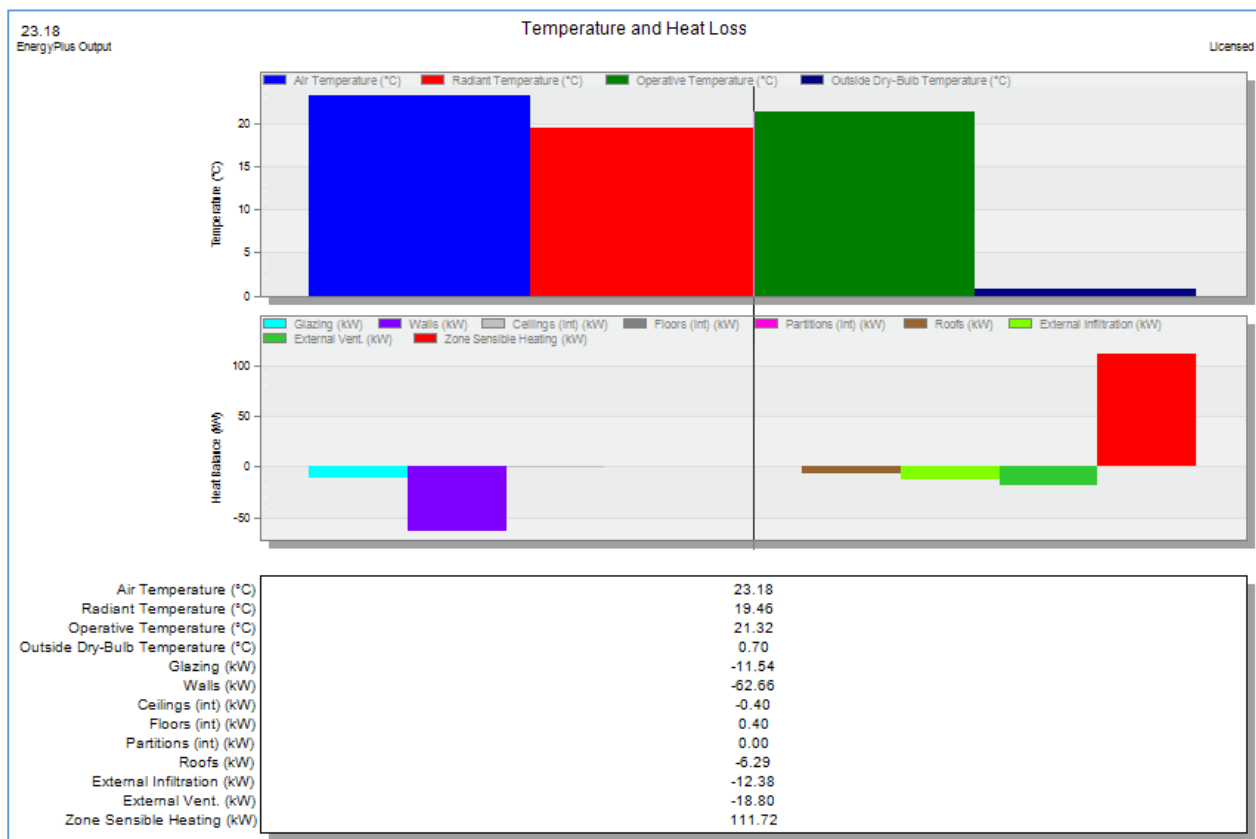


Figure 67 Heat loss without insulation

Building 2 Total Design Heating Capacity = 139.600 (kW)

Figure 68 Heating Capacity.

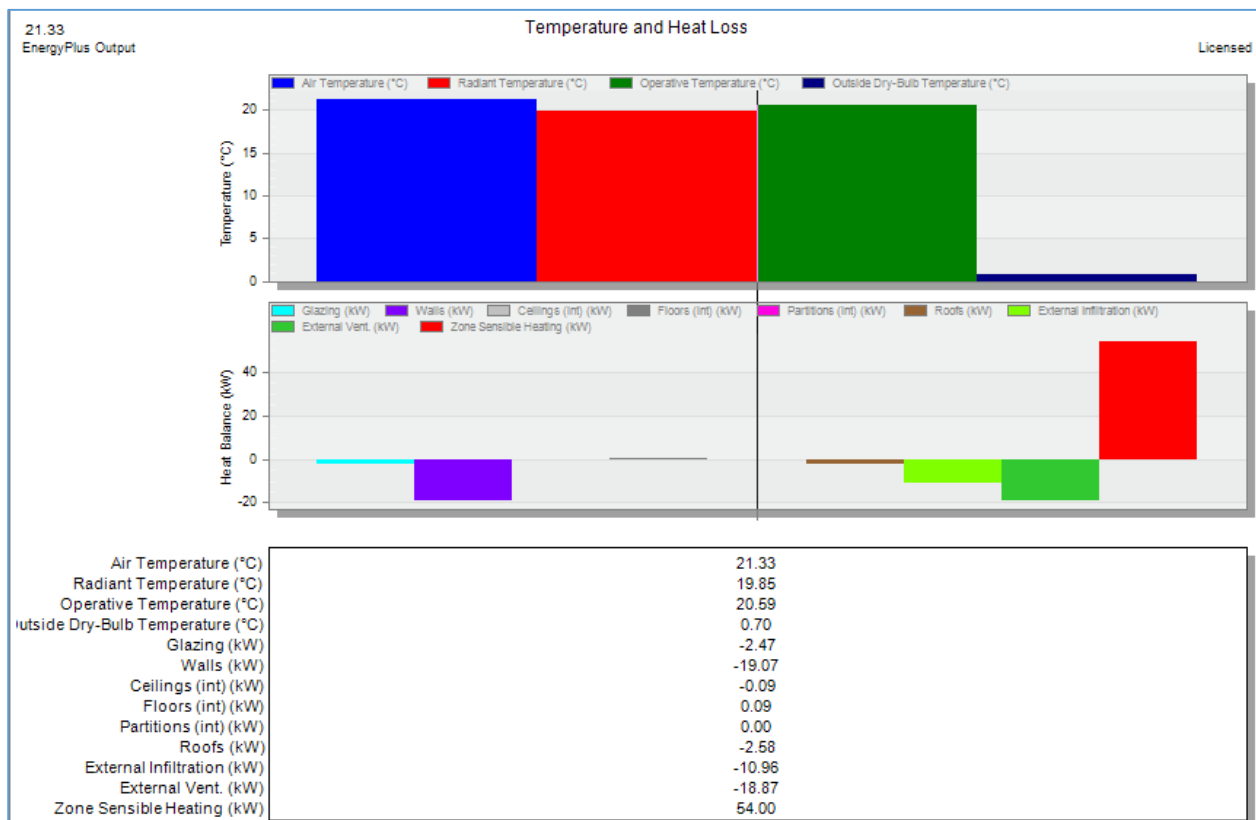


Figure 69 Heat loss after Insulation

Building 2 Total Design Heating Capacity = 67.510 (kW)

Figure 70 Heating Capacity after insulation.

The temperature is very small compared to the case without insulation, due to the addition of insulation materials in the walls and environmental modifications as changing the type of windows and adding louvers, which leads to increase comfort for users. (Heat loss from external walls and windows decreased)

### 2.7.2.2 Cooling Design.

After calculation the results are before insulation is shown in Figure 67 and after adding the insulation as shown in Figure 69. The total heating capacity for both types are as shown in Figure 68 and Figure 70.

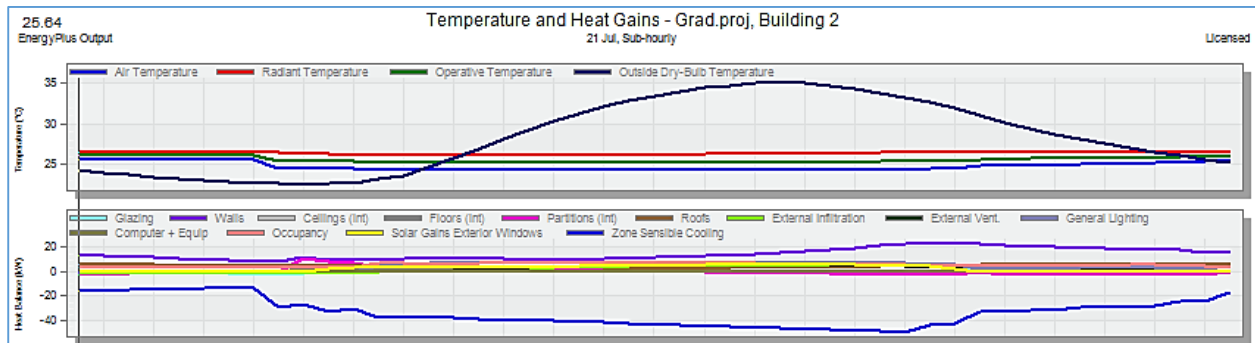


Figure 71 Temperature and heat gain without insulation.

<b>Totals</b>	<b>68.86</b>
---------------	--------------

Figure 72 Total design cooling capacity

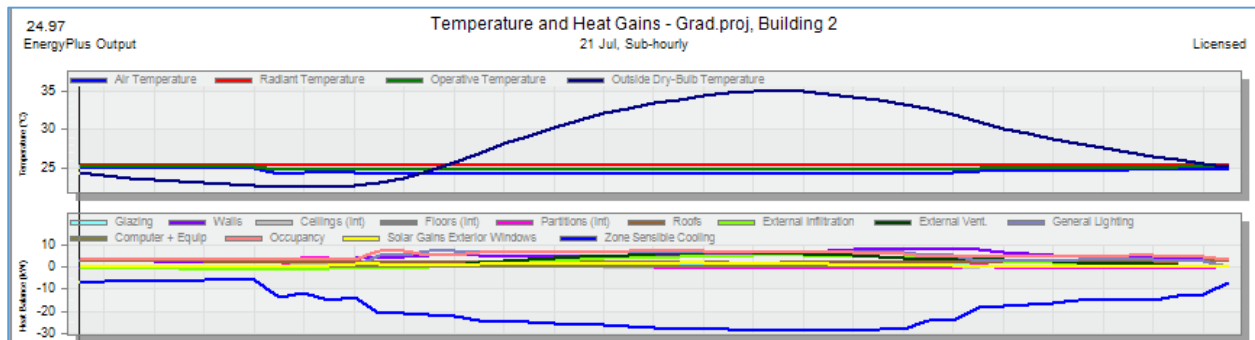


Figure 73 Temperature and heat gain after Insulation.

<b>Totals</b>	<b>43.49</b>
---------------	--------------

Figure 74 Total design cooling capacity after insulation.

The heat gains in case one is less than the case without insulation. For example, heat gain from external walls and glass windows was reduced as a result of changing the type of windows, adding louvers and adding insulation materials for walls. So the cooling system will be smaller and result in lower annual energy consumption.

### 2.7.3 Simulation results.

#### 2.7.3.1 Results before insulation.

The energy results and time comfort before insulation are shown in Table 9 and Table 10.

*Table 9 Energy result Without insulation.*

	Total Energy [kWh]	Energy Per Total Building Area [kWh/m <sup>2</sup> ]	Energy Per Conditioned Building Area [kWh/m <sup>2</sup> ]
Total Site Energy	572377.54	318.65	318.65
Net Site Energy	572377.54	318.65	318.65
Total Source Energy	1939184.51	1079.58	1079.58
Net Source Energy	1939184.51	1079.58	1079.58

The difference between district cooling and district heating is not ok.

*Table 10 Time comfort Without insulation*

	Facility [Hours]
Time Setpoint Not Met During Occupied Heating	9.50
Time Setpoint Not Met During Occupied Cooling	0.00
Time Not Comfortable Based on Simple ASHRAE 55-2004	6290.50

#### 2.7.3.2 Results after insulation.

The energy results and time comfort after insulation are shown in Table 11 and Table 12.

*Table 11 Energy result with insulation.*

	Total Energy [KWh]	Energy Per Total Building Area [KWh/m <sup>2</sup> ]	Energy Per Conditioned Building Area [KWh/m <sup>2</sup> ]
Total Site Energy	433595.38	101.03	189.30
Net Site Energy	433595.38	101.03	189.30
Total Source Energy	1489655.23	295.42	461.18
Net Site Energy	1489655.23	295.42	461.18

Table 12 Time comfort with insulation

Comfort and Setpoint Not Met Summary	
	Facility [Hours]
Time Setpoint Not Met During Occupied Heating	1825.83
Time Setpoint Not Met During Occupied Cooling	178.83
Time Not Comfortable Based on Simple ASHRAE 55-2004	3320.17

From the previous table, it can be seen that the number of hours' thermal comfort in case one is less than case without insulation, which indicates the efficiency of insulation and environmental modifications.

Table 13 End Uses.

End Uses						
	Electricity [kWh]	Natural Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	0.00	0.00	0.00	0.00	43448.19	0.00
Cooling	0.00	0.00	0.00	38104.81	0.00	0.00

The difference between district cooling and district heating from Table 13 is batter.

## 2.8 Architectural Drawings.

As shown in the previous sections, the project was modified to meet all the required standards and requirements to make it fool proof that all end-users got the best experience, along with a well-arranged space containing all facilities that could be needed by the end-user.

### 2.8.1 Parking Floor.

Since that most of people now days have cars, parking is one of the most important facility in a building. According to the standards for dormitory building, foe every four students one parking space should be provided. Due to that, no additional parking floor was added. Parking Plan and floor area are shown in Figure 75, and Figure 76.

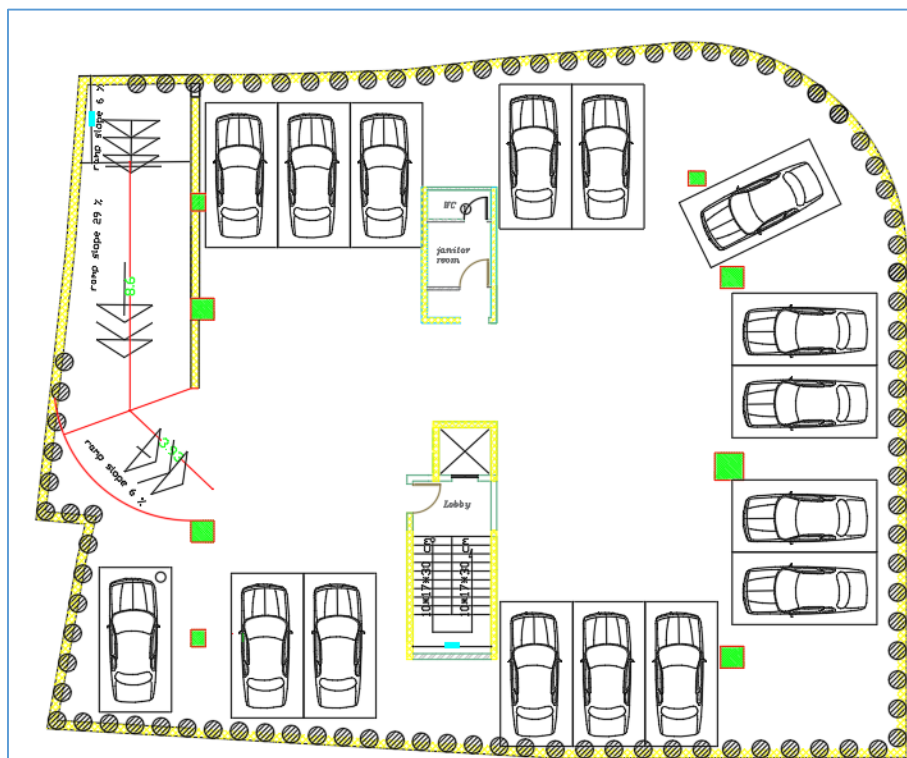


Figure 75 Parking After Modification.

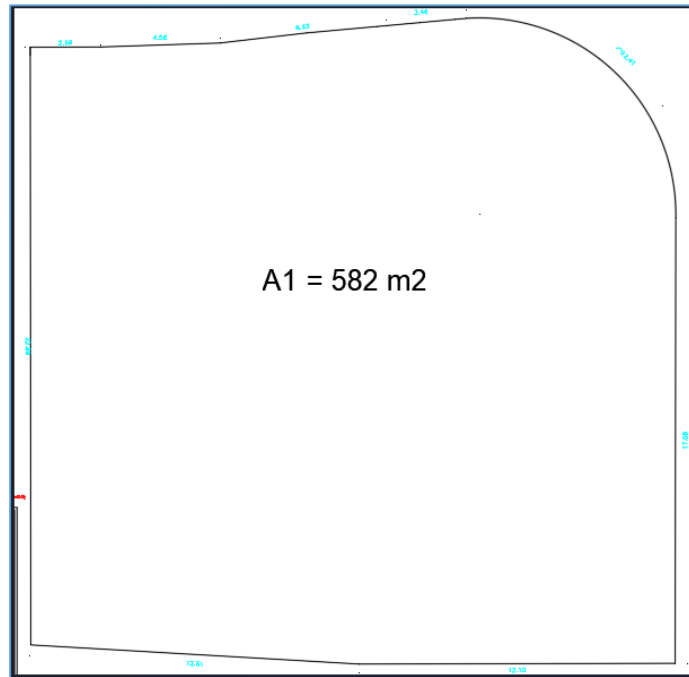


Figure 76 Floor Area of the Parking

### 2.8.2 Ground Floor.

The ground floor is the main floor which all the visitors and students living in the building are using, so it is a public floor that would be loud and occupied. Mainly, since the floor has both offices and reception. In the previous design plan, the ground floor did not meet the standards, due to the spaces included on the ground floor and the lack of privacy for the students. As a result of that, some spaces were moved from the floor and other required facilities that should be included in residential buildings were added.

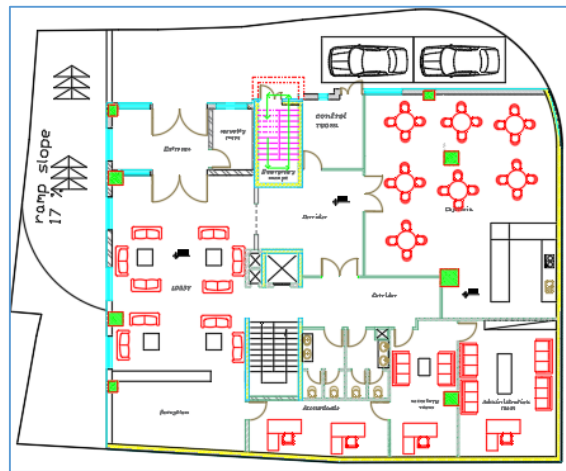


Figure 77 Ground Floor Plan.

The facilities that were added

- Security Room
- Control Room (Central Control Panel).

On the other hand, Study Area were moved from the floor.

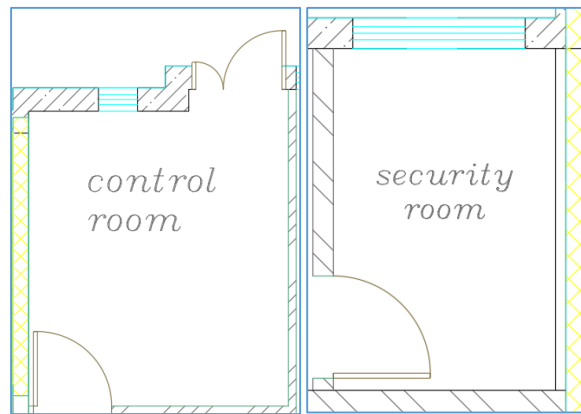


Figure 78 Plans of both Security and Control Room.

### 2.8.3 Stores' Floor.

In the original plans, the area of the floor was not used in the best way, meanwhile, the dimension of the stores themselves are as stated in the standards. Due to that, the space of the floor was rearranged to be used practically. Figure 79 and Figure 80 shows the floor plan and floor area.

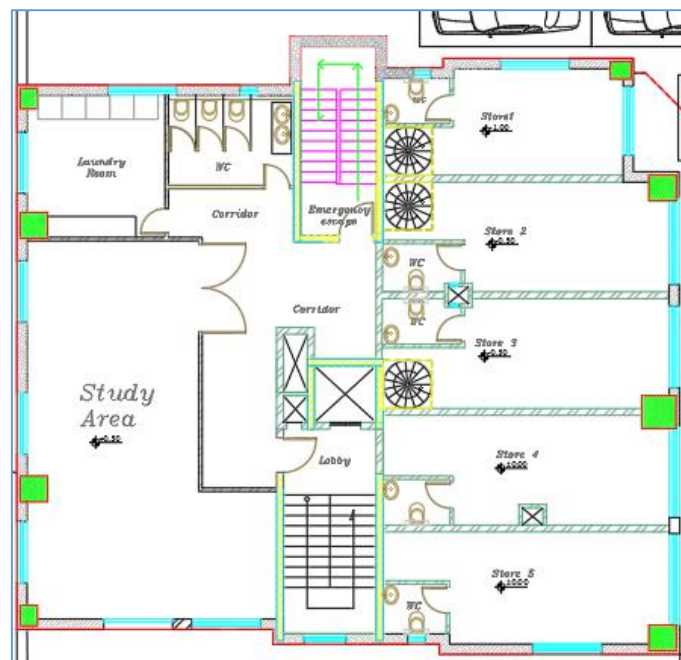


Figure 79 Floor Plan

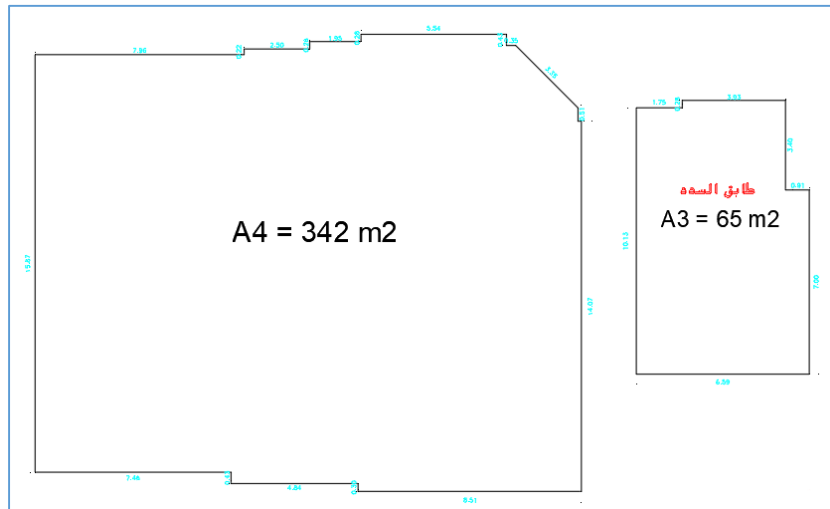


Figure 80 Floor Area Plan

The study area was moved to the floor since it is separate entirely from the store, which means the floor is quieter for the student so they can focus. Also, the laundry room was added as required in the standards. Figure 81 & Figure 82 shows the floor plan.

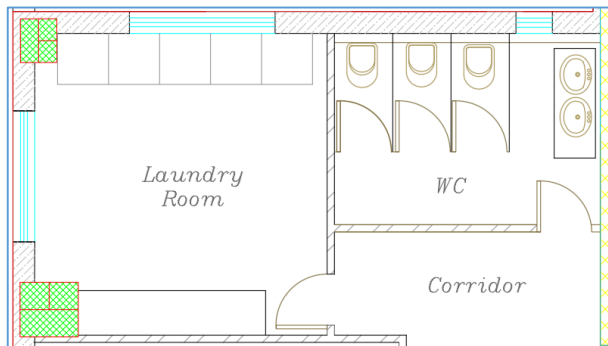


Figure 81 Laundry Room and WCS.

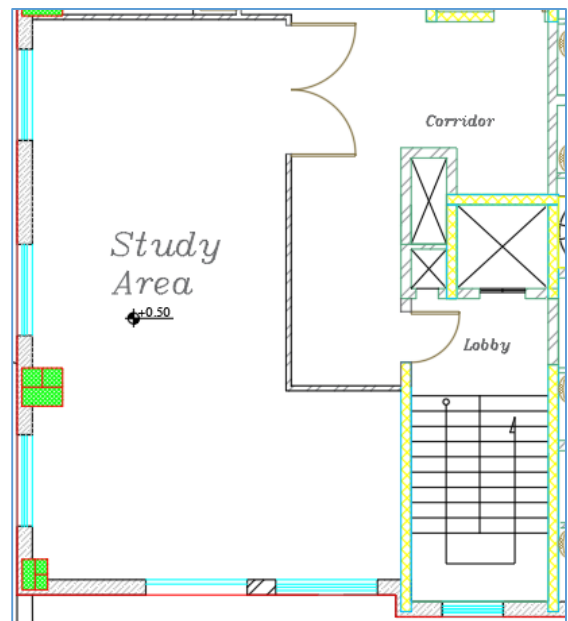


Figure 82 Study Area plan.

### 2.8.4 Dormitory Floors.

These floors had minimalist changes, where most of the rooms met the standards, on the other hand, the privacy on the floor layout was weak since there is no lobby when the floor is entered which is against the standards requirements. The floor was modified to meet the standards whit adding a lobby and adjusting some of the studios. Figure 83 and Figure 84 show the floor plan, including the lobby, and floor area plan.

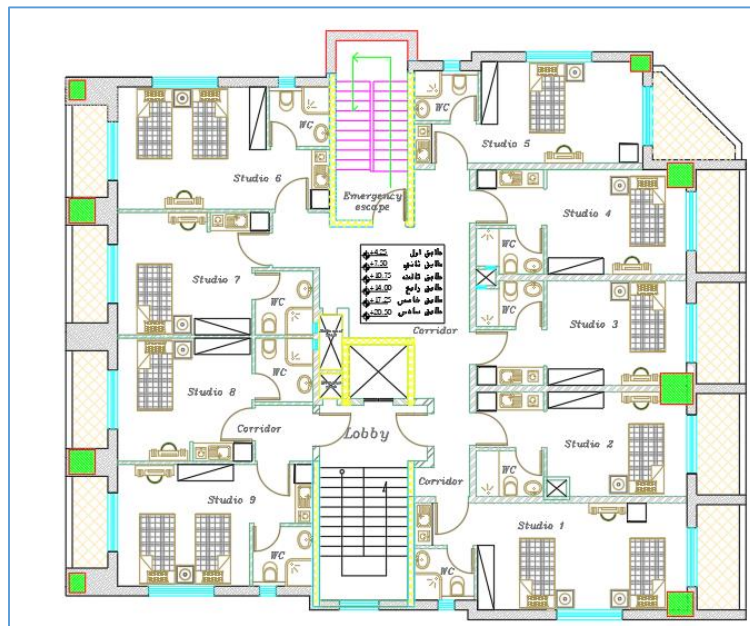


Figure 83 Floor plan.

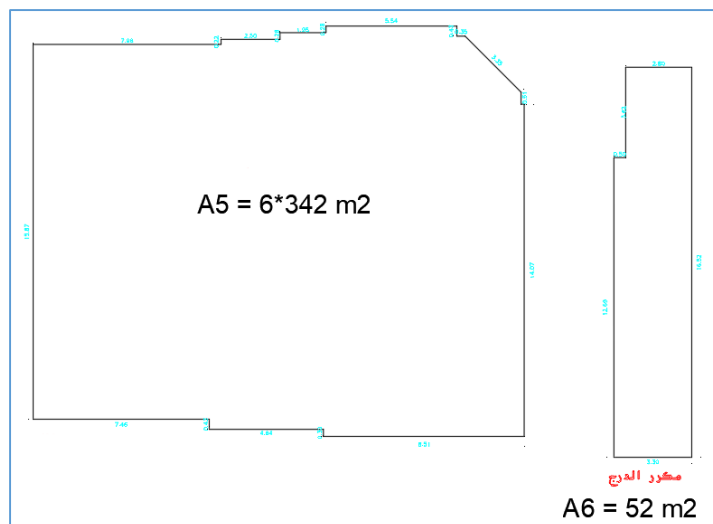


Figure 84 Floor Area Plan

### 2.8.5 Elevations.

In this section the elevation of the building will be shown

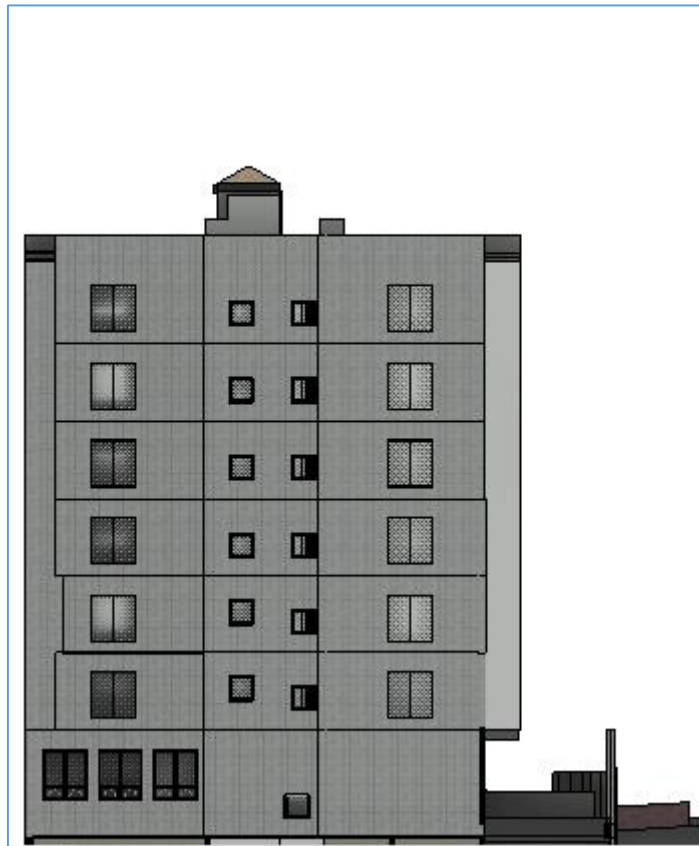
- North Elevation Figure 85.
- South Elevation Figure 86.
- East Elevation Figure 87.
- West Elevation Figure 88.



*Figure 85 North Elevation*



*Figure 86 South Elevation.*



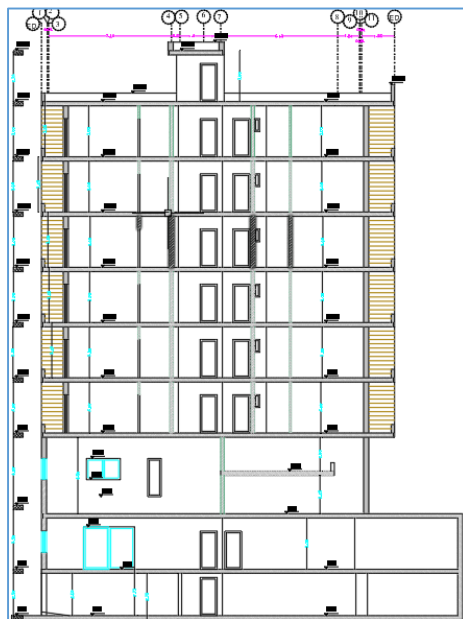
*Figure 87 East Elevation.*



*Figure 88 West Elevation.*

### 2.8.6 Sections.

In this section two sections of the building will be included. Figure 89 and Figure 90 show sections of the building.



*Figure 89 Section A-A*

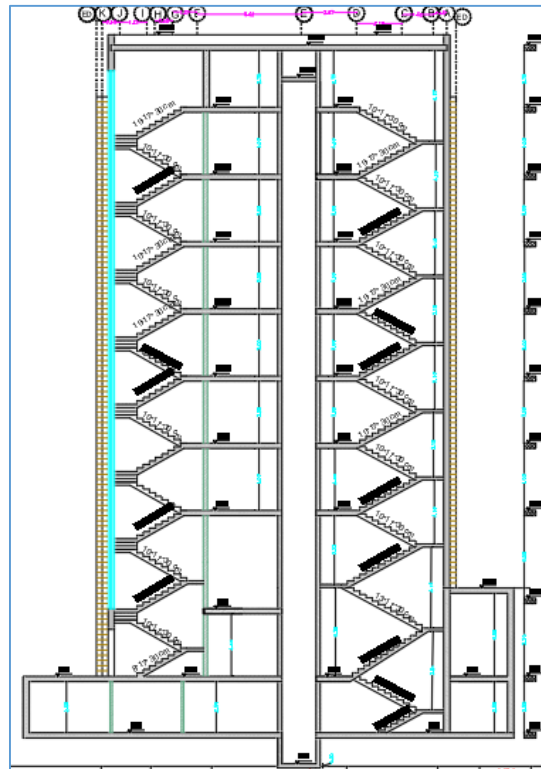


Figure 90 Section B-B

### 2.8.7 3D-View.

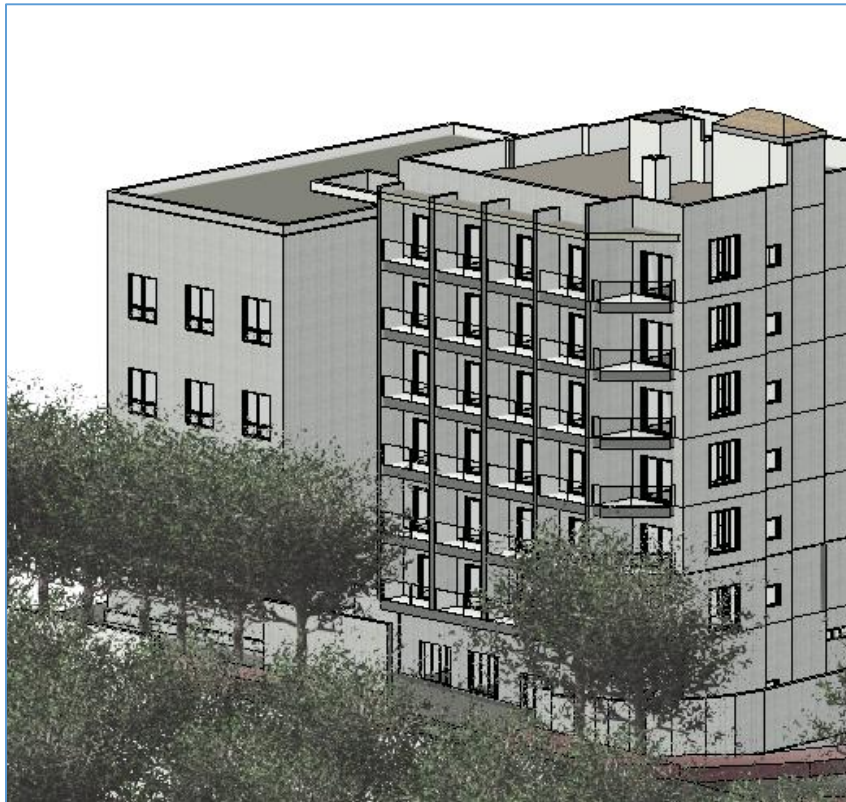
An overview of the building as 3D View are shown below Figure 91, Figure 92, Figure 93, and, Figure 94.



Figure 913D view of the building-1



*Figure 92 3D view of the building -2*



*Figure 93 3D view of the building- 3*



*Figure 94-3D view of the building -4*

# Chapter Three: Structural Aspects.

### 3 STRUCTURAL ASPECT

In this chapter the structural aspects will be discussed.

#### 3.1 Introduction

In construction, design is the process of creating a solution to a project brief and then preparing instructions allowing that solution to be constructed. It is a process of creating the description of a new facility, usually represented by detailed plans and specifications.

#### 3.2 Distribution of column centers and shear walls:

At this stage, a proposal will be made for the columns and their places will be distributed, then the slabs and beams will be drawn, and the ways of distributing the loads will be determined according to the shape of the slab. Figure 95 and Figure 96 show the centrelines of columns.

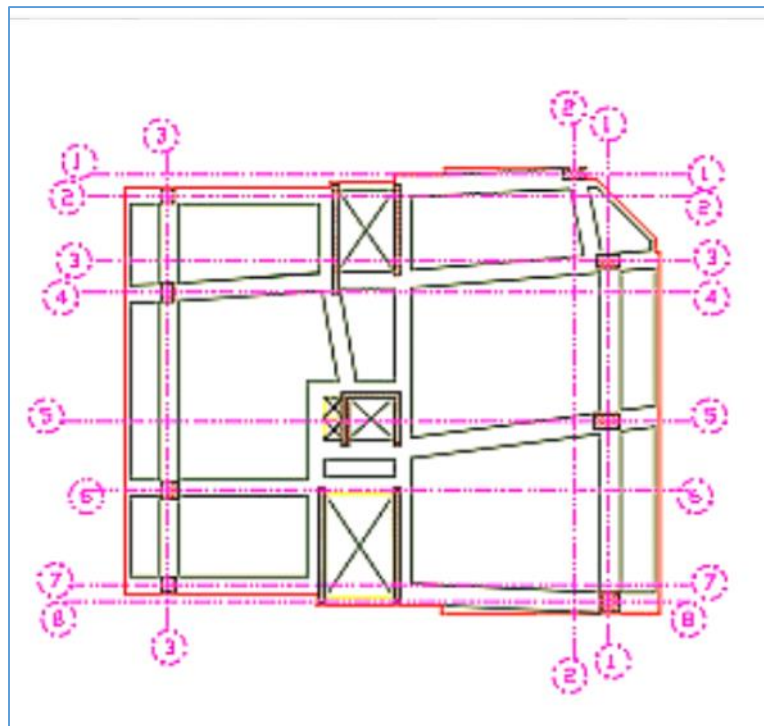


Figure 95 Columns centerlines before Modification.

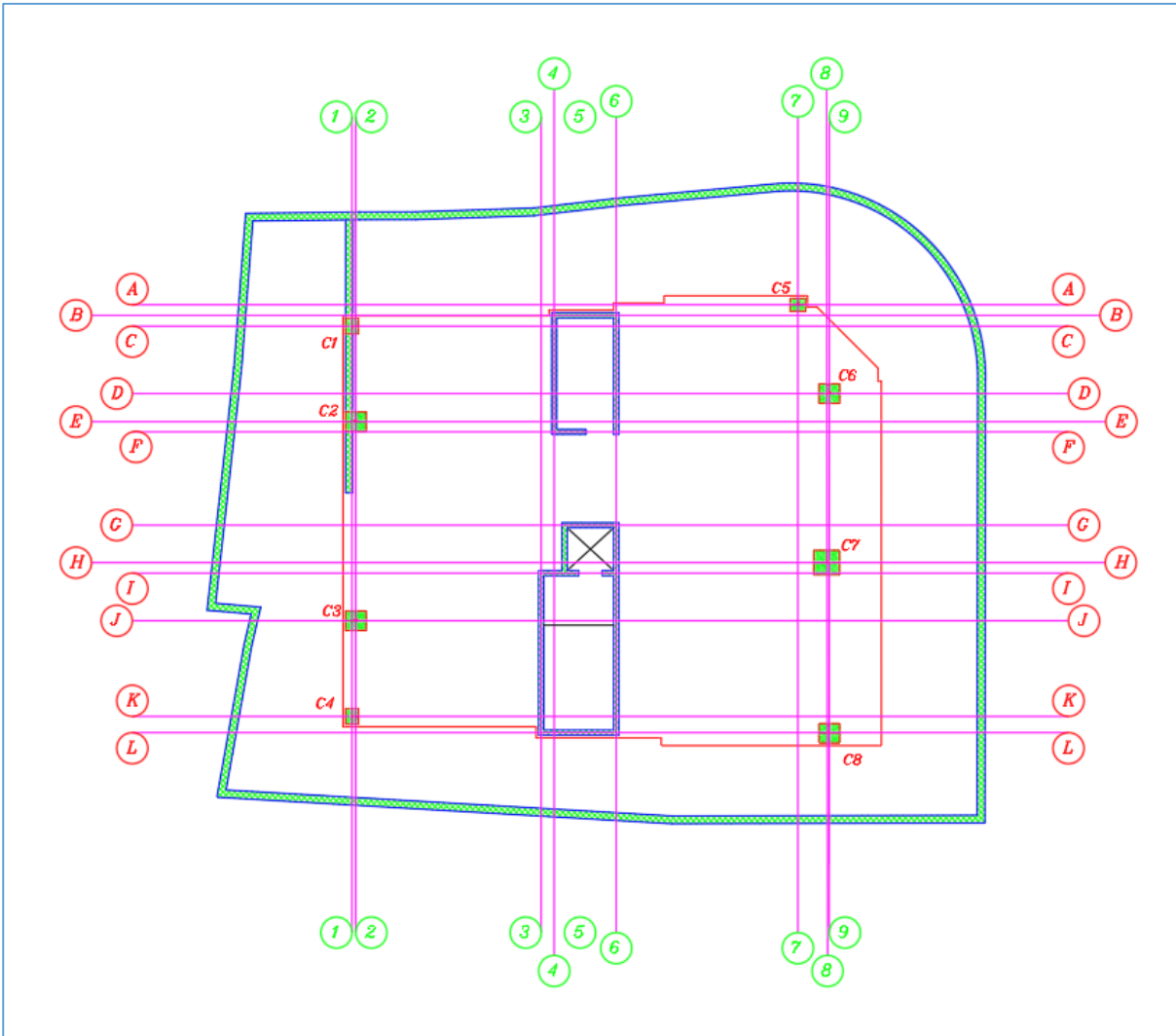


Figure 96 Columns Centerlines After Modification.

### 3.3 Design Code.

- ACI 319
- ASCE.
- UBC 97.

### 3.4 Loads:

➤ Dead load:

**For ribbed slab 33cm**

$weight = ((total\ volume\ of\ rib) - (volume\ of\ block)) \times density$  of concrete +  $volume\ of\ block * density\ of\ block$

$$((0.55 \times 0.55 \times 0.330) - (0.40 \times 0.40 \times 0.24)) \times 25 + (0.4 \times 0.4 \times 0.24) \times 12 = 2\ KN/Rib^2$$

$$weight = \frac{2}{0.55^2} = 6.62\ KN/m^2$$

**For solid slab 33 cm**

$$Wt = 1.00 \times 1.00 \times 0.33 \times 25$$

$$Wt = 8.25\ KN/SM.$$

**For solid slab 20 cm**

$$Wt = 1.00 \times 1.00 \times 0.2 \times 25$$

$$Wt = 5\ KN/SM.$$

➤ Superimposed dead load (SID):

$$SID\ used = 4\ KN/m^2$$

➤ Live load (L.L):

$$L.L\ used\ for\ residential = 3\ KN/m^2$$

$$L.L\ used\ for\ parking = 5\ KN/m^2$$

$$L.L\ used\ for\ store = 5\ KN/m^2$$

$$L.L\ used\ for\ staircase\ slab = 20\ KN/m^2$$

$$L.L\ used\ for\ front\ store = 20\ KN/m^2$$

The following pictures show the distribution of live loads on the floors

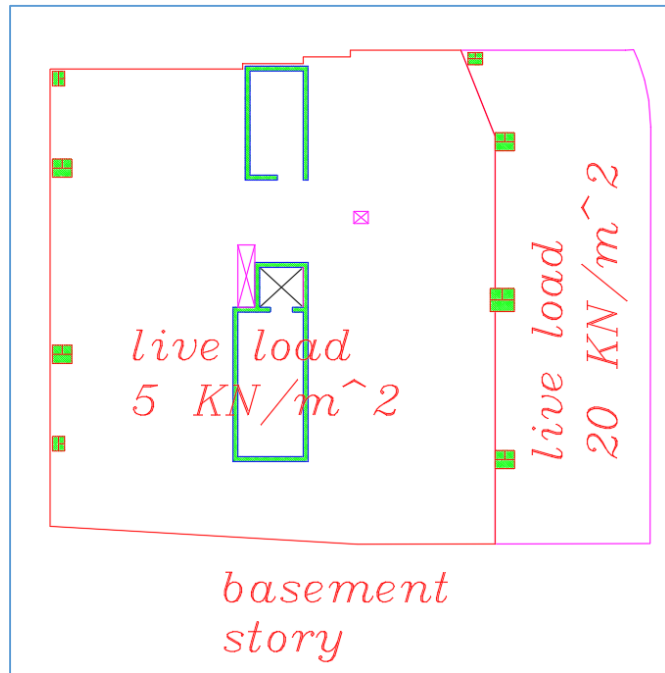


Figure 97 live loads in basement story

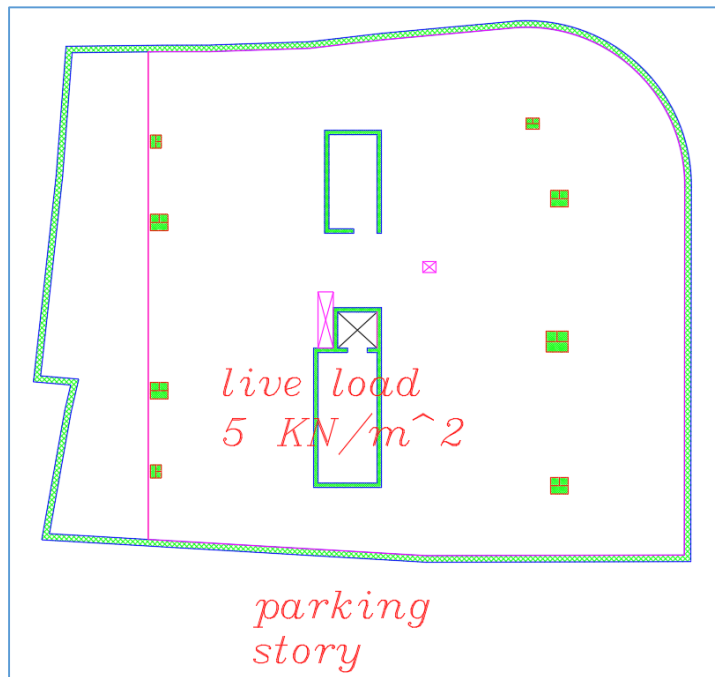


Figure 98 live loads in parking story.

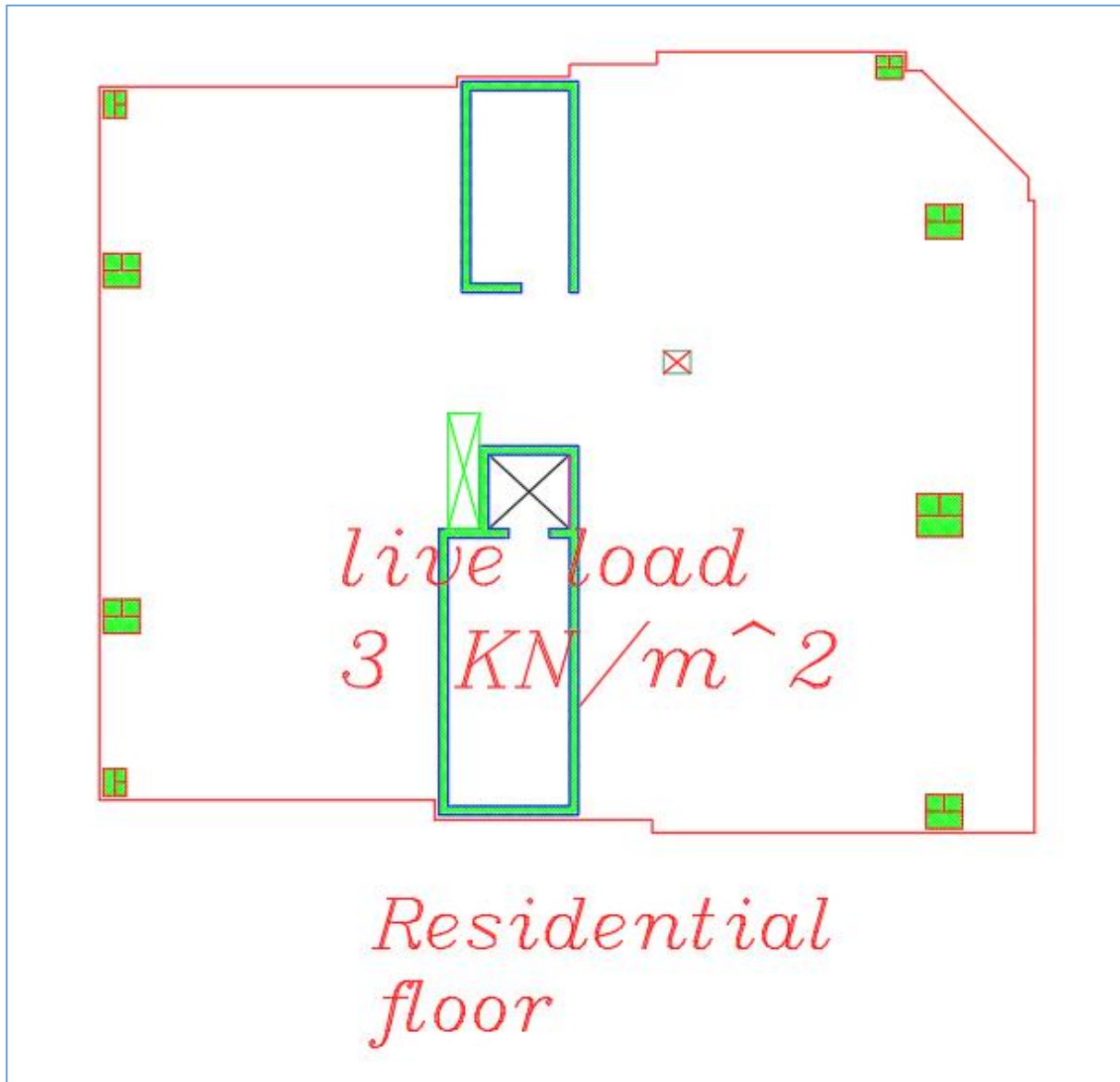


Figure 99 live loads in residential story.

➤ External wall load.

Height wall=3.1 m

Wall load (KN/M) = Thickness x density x height of wall.

Name	Thickness (M)	Density(KN/CM)	Th*Den*Height (KN/M)
Stone	0.05	25	3.875
Plane concrete	0.15	2	10.695
Block	0.1	12	3.72
Plaster	0.02	23	1.426
Weight of external wall (KN/M)			19.716

Use wall load = 19.5 KN/m.

Reducing the load due to window and door openings.

### 3.5 Load Combinations.

The basic ultimate load combinations used for the design according to ACI, and UBC97 are:

1. 1.4D.
2. 1.2D+ 1.6L.
3. Service load.
4. Envelope.

### 3.6 Materials.

The material used is defined as:

- Concrete:
  - Compressive strength for column ( $f_c$ ) = 28 MPa
  - Compressive strength for the rest of the structural elements (beams, slabs, and shear walls) ( $f_c$ )= 28 MPa.
- Steel reinforcement:
  - Yielding strength of steel  $f_y$  = 420 MPa.

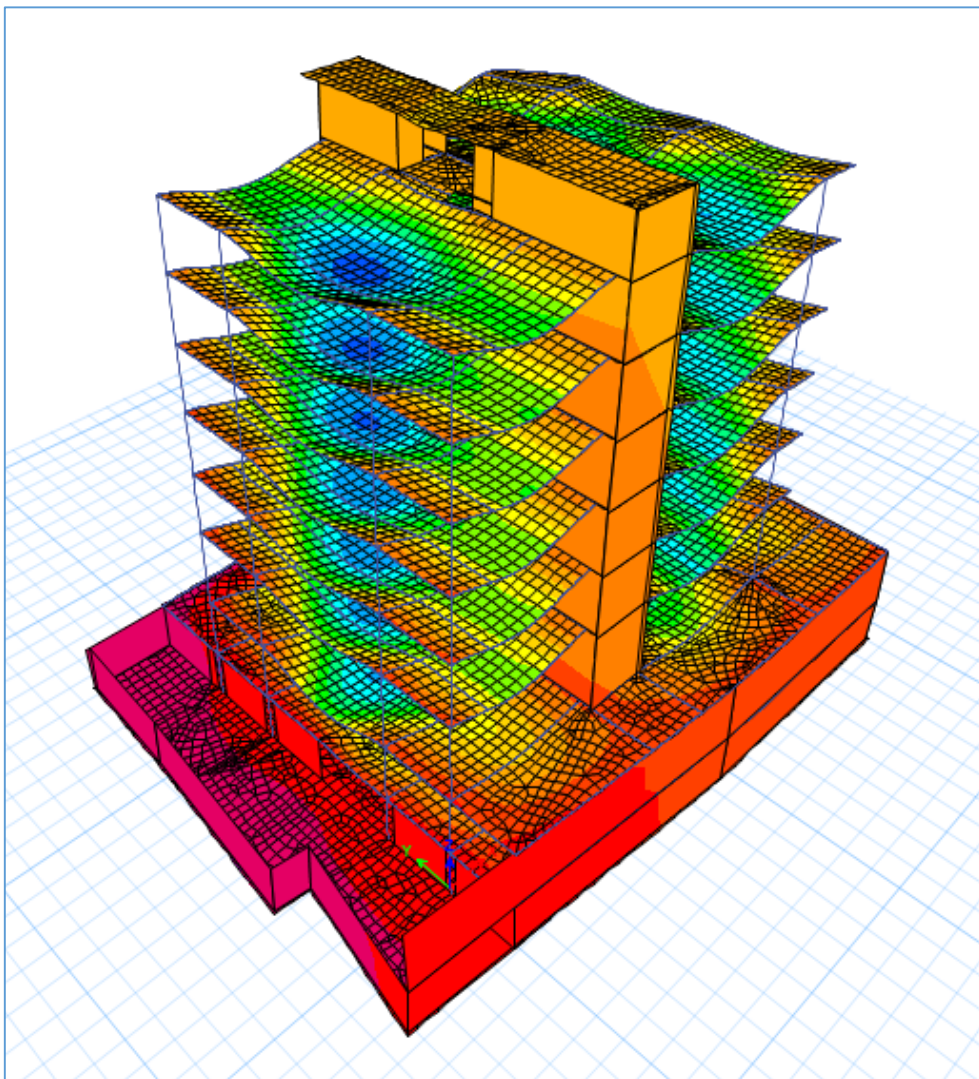
### 3.7 Structural Checks.

In this section the structural checks will be shown

- Compatibility.
- Equilibrium.
- Stress-strain.

#### 3.7.1 Compatibility Check.

The result of the compatibility check is shown in Figure 100.



*Figure 100 Compatibility check result.*

### 3.7.2 Equilibrium Check.

The following Table 14 shows the weight of slabs and beams.

Table 14 Weight of slabs and beams.

	area slab	area beam	w slab	w beams	weight slab	Weight beams	sum weight
story 1	570.17	202.79	6.62	1.63	3774.5254	330.5477	4105.0731
story 2	359.8	104.94	6.62	1.63	2381.876	171.0522	2552.9282
story 2 solid 33	132.67	0	8.25	0	1094.5275	0	1094.5275
story3-8	342.09	110.07	6.62	1.63	2264.6358	179.4141	2444.0499
stair story	50.42	0	5		252.1	0	252.1
<b>Total</b>							22668.9282

The following Table 15 shows the weight of shear walls and column.

Table 15 Weight of shear walls and column.

	number	h	density	sum weight
c50*60	3	25.1	25	4518
c 75*80	4	25.1	25	12048
c 95*100	1	25.1	25	4769
shear wall	35.02	27.6	25	4832.76
shear wall	103.39	2.5	25	1292.375
shear wall	44.42	3.1	25	688.51
shear wall	12.66	2.5	25	158.25
<b>sum weight</b>				28306.895

The following Table 16 shows the equilibrium check.

Table 16 Equilibrium check

load	Etabs	manual	error %	Case
live	16500	16475.99	0.0664	Error <5 %
SD	13365.832	13357.3948	0.063167	Error <5 %
WALL	9739.0647	9910.485	-1.72969	Error <5 %
Dead	50361.702	50975.82	-1.20472	Error <5 %

The building is equilibrium.

### 3.7.3 Internal Force check.

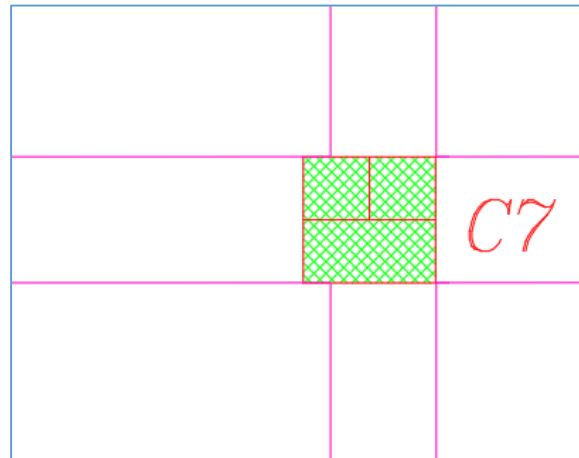


Table 17 explains internal force check for columns

Table 17 Internal Forces Check.

column	etabs	manual	Difference %
<b>C7 (100*95)</b>	9752	9741.845	0.104132

Accepted Error within 10 %.

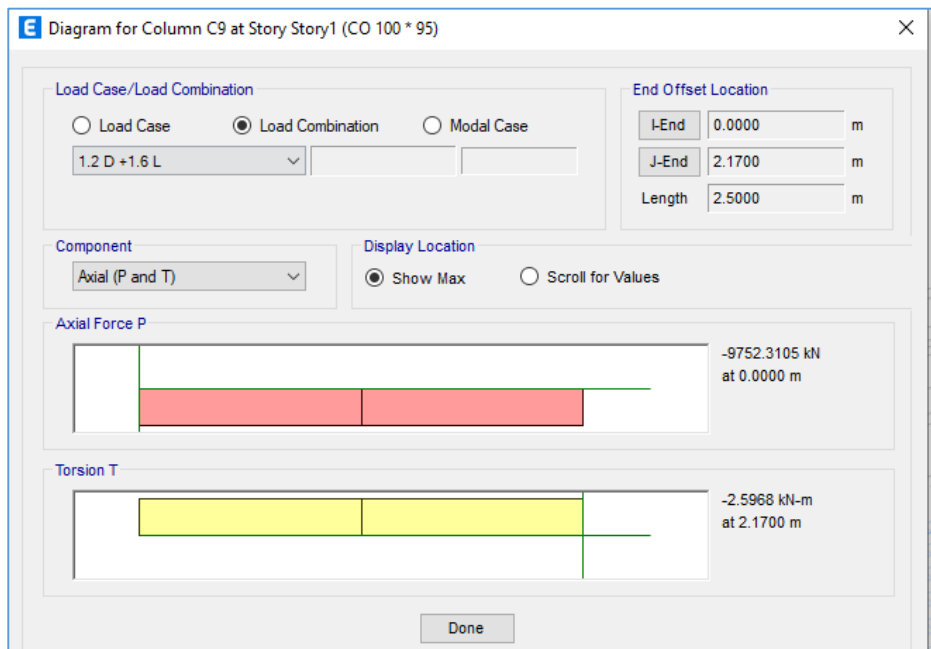


Figure 101 Results from Etabs.

### 3.8 Slab Thickness.

According to the ACI code, the thickness of a two-way ribbed slab can be calculated due to deflection.

## Solid slab thickness

**Table 8.3.1.1—Minimum thickness of nonprestressed two-way slabs without interior beams (in.)<sup>[2]</sup>**

$F_y$ (Mpa)	Without drop panels <sup>[3]</sup>			With drop panels <sup>[3]</sup>		
	Exterior panels		Interior panels	Exterior panels		Interior panels
	Without edge beams	With edge beams <sup>[4]</sup>		Without edge beams	With edge beams <sup>[4]</sup>	
280	$l_n/33$	$l_n/36$	$l_n/36$	$l_n/36$	$l_n/40$	$l_n/40$
420	$l_n/30$	$l_n/33$	$l_n/33$	$l_n/33$	$l_n/36$	$l_n/36$
560	$l_n/27$	$l_n/30$	$l_n/30$	$l_n/30$	$l_n/33$	$l_n/33$

<sup>[1]</sup> $l_n$  is the clear span in the long direction, measured face-to-face of supports (in.).

$$l_{nmax} = 8150 \text{ mm}$$

$$h_{solid} = \frac{8150}{33} = 247 \text{ mm}$$

$$h_{req. \text{ of solid slab}} = 270 \text{ mm.}$$

I solid = I ribbed

$$\frac{1000 \cdot 270^3}{12} = \frac{550 \cdot h^3}{12}$$

$$h_{eq} = \sqrt[3]{\frac{1000 \cdot 270^3}{550}} = 329 \text{ mm} \quad \text{then use } h = 33 \text{ cm.}$$

Figure 102 shows a section in the slab with dimension.

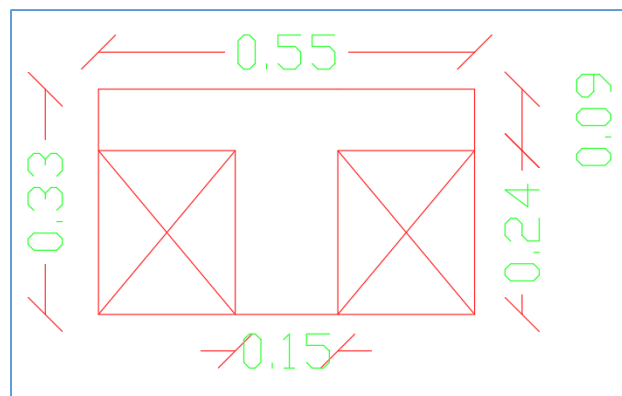


Figure 102 Section In the tow way ribbed slab (cm).

When the live load is high, we use a solid slab, thus the thickness of the slab in front of the store = 33 cm (Two way solid)

Thickness of slab stair = 20 cm (two ways solid)

### 3.9 Deflection check:

This table shows the maximum deformation allowed.

Type of member	Deflection to be considered	Deflection limitation
Flat roofs not supporting or attached to nonstructural elements likely to be damaged by large deflections	Immediate deflection due to live load $L$	$l/180^*$
Floors not supporting or attached to nonstructural elements likely to be damaged by large deflections	Immediate deflection due to live load $L$	$l/360$
Roof or floor construction supporting or attached to nonstructural elements likely to be damaged by large deflections	That part of the total deflection occurring after attachment of nonstructural elements (sum of the long-term deflection due to all sustained loads and the immediate deflection due to any additional live load) <sup>†</sup>	$l/480^‡$
Roof or floor construction supporting or attached to nonstructural elements not likely to be damaged by large deflections		$l/240^§$

\*Limit not intended to safeguard against ponding. Ponding should be checked by suitable calculations of deflection, including added deflections due to ponded water, and considering long-term effects of all sustained loads, camber, construction tolerances, and reliability of provisions for drainage.  
<sup>†</sup>Long-term deflection shall be determined in accordance with 9.5.2.5 or 9.5.4.3, but may be reduced by amount of deflection calculated to occur before attachment of nonstructural elements. This amount shall be determined on basis of accepted engineering data relating to time-deflection characteristics of members similar to those being considered.  
<sup>‡</sup>Limit may be exceeded if adequate measures are taken to prevent damage to supported or attached elements.  
<sup>§</sup>Limit shall not be greater than tolerance provided for nonstructural elements. Limit may be exceeded if camber is provided so that total deflection minus camber does not exceed limit.

Figure 103 maximum deformation allowed.

the maximum deformation from live load = 20 KN/m<sup>2</sup>

$$\frac{L}{360} = \frac{6000}{360} = 16.67 \text{ mm}$$

The following figure shows the max deflection from live load by ETABS:

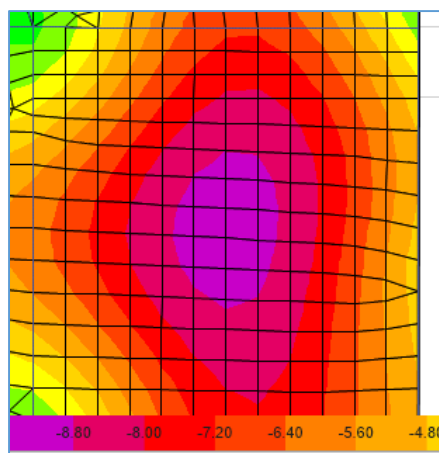


Figure 104 maximum deformation from live load (Etabs)

Maximum deformation = 8 mm < 16.67 mm

$$\text{The maximum deformation from service load} = \frac{L}{240} = \frac{8150}{240} = 33.96 \text{ mm}$$

The following figure shows the max deflection from service load by ETABS:

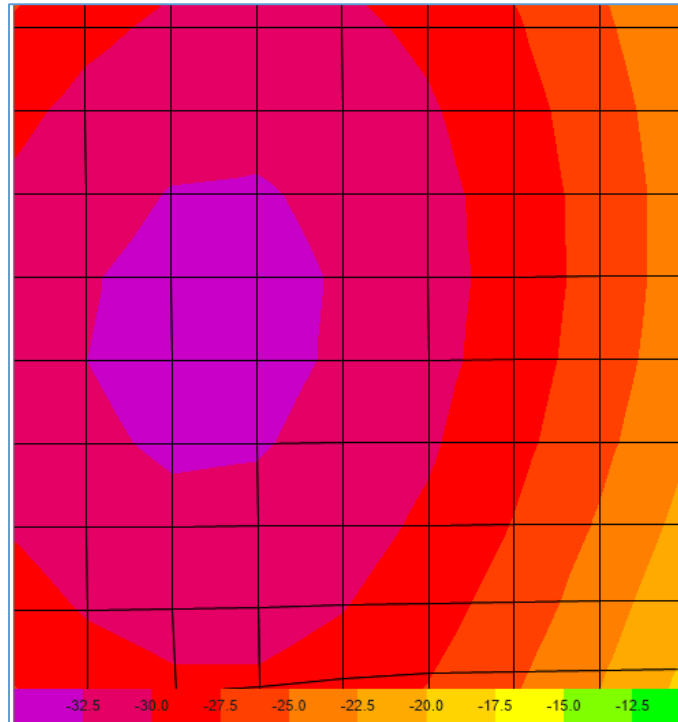


Figure 105 maximum deformation from service load (Etabs)

Maximum deformation = 32.5 mm < 33.96 mm

### 3.10 Seismic design:

**Seismic load analysis:** The seismic analysis will be done on this model according to UBC-97 code.

There are some parameters that should be defined during the seismic analysis as follows:

### 3.10.1 SEISMIC ZONE FACTOR (Z):

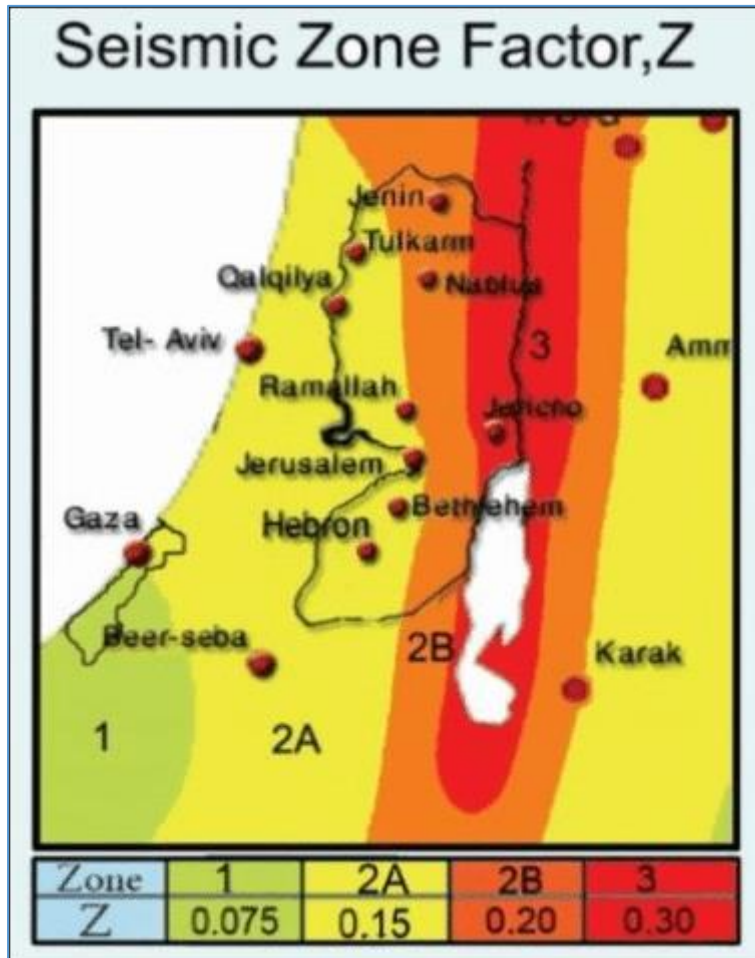


Figure 106 Seismic hazard map

The building is located in Nablus city which mean the seismic zone is 2B and from the, map above the seismic zone factor = 0.2.

### 3.10.2 Soil profile type.

The soil under the building with bearing capacity =200 KN/m<sup>2</sup>. Its mean that the soil profile is SD.

**TABLE 16-J—SOIL PROFILE TYPES**

SOIL PROFILE TYPE	SOIL PROFILE NAME/GENERIC DESCRIPTION	AVERAGE SOIL PROPERTIES FOR TOP 100 FEET (30 480 mm) OF SOIL PROFILE		
		Shear Wave Velocity, $V_s$ feet/second (m/s)	Standard Penetration Test, $\bar{N}$ [or $\bar{N}_{60}$ for cohesionless soil layers] (blows/foot)	Undrained Shear Strength, $\bar{s}_u$ psf (kPa)
$S_A$	Hard Rock	> 5,000 (1,500)	—	—
$S_B$	Rock	2,500 to 5,000 (760 to 1,500)		
$S_C$	Very Dense Soil and Soft Rock	1,200 to 2,500 (360 to 760)	> 50	> 2,000 (100)
$S_D$	Stiff Soil Profile	600 to 1,200 (180 to 360)	15 to 50	1,000 to 2,000 (50 to 100)
$S_E^1$	Soft Soil Profile	< 600 (180)	< 15	< 1,000 (50)
$S_F$	Soil Requiring Site-specific Evaluation. See Section 1629.3.1.			

<sup>1</sup>Soil Profile Type  $S_E$  also includes any soil profile with more than 10 feet (3048 mm) of soft clay defined as a soil with a plasticity index,  $PI > 20$ ,  $w_{mc} \geq 40$  percent and  $s_u < 500$  psf (24 kPa). The Plasticity Index,  $PI$ , and the moisture content,  $w_{mc}$ , shall be determined in accordance with approved national standards.

Figure 107 Soil profile type.

### 3.10.3 Acceleration-Dependent Seismic Coefficient (CA)

The seismic coefficient ( $ca$ ) can be obtained from the following Figure 108. (at soil profile  $sc$  and  $z = 0.2$   $CA = 0.28$ )

**TABLE 16-Q—SEISMIC COEFFICIENT  $C_a$**

SOIL PROFILE TYPE	SEISMIC ZONE FACTOR, Z				
	Z = 0.075	Z = 0.15	Z = 0.2	Z = 0.3	Z = 0.4
$S_A$	0.06	0.12	0.16	0.24	$0.32N_v$
$S_B$	0.08	0.15	0.20	0.30	$0.40N_v$
$S_C$	0.09	0.18	0.24	0.33	$0.40N_v$
$S_D$	0.12	0.22	0.28	0.36	$0.44N_v$
$S_E$	0.19	0.30	0.34	0.36	$0.36N_v$
$S_F$	See Footnote 1				

<sup>1</sup>Site-specific geotechnical investigation and dynamic site response analysis shall be performed to determine seismic coefficients for Soil Profile Type  $S_F$ .

Figure 108 Seismic coefficient  $C_a$ .

### 3.10.4 Velocity-Dependent Seismic Coefficient (Cv).

The seismic coefficient from Figure 109 is 0.4 from table at  $z = 0.2$ , and soil profile = Sd

**TABLE 16-R—SEISMIC COEFFICIENT  $C_v$**

SOIL PROFILE TYPE	SEISMIC ZONE FACTOR, Z				
	Z = 0.075	Z = 0.15	Z = 0.2	Z = 0.3	Z = 0.4
$S_A$	0.06	0.12	0.16	0.24	$0.32N_v$
$S_B$	0.08	0.15	0.20	0.30	$0.40N_v$
$S_C$	0.13	0.25	0.32	0.45	$0.56N_v$
$S_D$	0.18	0.32	0.40	0.54	$0.64N_v$
$S_E$	0.26	0.50	0.64	0.84	$0.96N_v$
$S_F$	See Footnote 1				

<sup>1</sup>Site-specific geotechnical investigation and dynamic site response analysis shall be performed to determine seismic coefficients for Soil Profile Type  $S_F$ .

Figure 109 Seismic coefficient  $C_v$ .

### 3.10.5 important factor:

The building important factor = 1 from Figure 110

**TABLE 16-K—OCCUPANCY CATEGORY**

OCCUPANCY CATEGORY	OCCUPANCY OR FUNCTIONS OF STRUCTURE	SEISMIC IMPORTANCE FACTOR, I	SEISMIC IMPORTANCE FACTOR, $I_p$	WIND IMPORTANCE FACTOR, $I_w$
1. Essential facilities <sup>2</sup>	Group I, Division 1 Occupancies having surgery and emergency treatment areas Fire and police stations Garages and shelters for emergency vehicles and emergency aircraft Structures and shelters in emergency-preparedness centers Aviation control towers Structures and equipment in government communication centers and other facilities required for emergency response Standby power-generating equipment for Category 1 facilities Tanks or other structures containing housing or supporting water or other fire-suppression material or equipment required for the protection of Category 1, 2 or 3 structures	1.25	1.50	1.15
2. Hazardous facilities	Group H, Divisions 1, 2, 6 and 7 Occupancies and structures therein housing or supporting toxic or explosive chemicals or substances Nonbuilding structures housing, supporting or containing quantities of toxic or explosive substances that, if contained within a building, would cause that building to be classified as a Group H, Division 1, 2 or 7 Occupancy	1.25	1.50	1.15
3. Special occupancy structures <sup>3</sup>	Group A, Divisions 1, 2 and 2.1 Occupancies Buildings housing Group E, Divisions 1 and 3 Occupancies with a capacity greater than 300 students Buildings housing Group B Occupancies used for college or adult education with a capacity greater than 500 students Group I, Divisions 1 and 2 Occupancies with 50 or more resident incapacitated patients, but not included in Category 1 Group I, Division 3 Occupancies All structures with an occupancy greater than 5,000 persons Structures and equipment in power-generating stations, and other public utility facilities not included in Category 1 or Category 2 above, and required for continued operation	1.00	1.00	1.00
4. Standard occupancy structures <sup>3</sup>	All structures housing occupancies or having functions not listed in Category 1, 2 or 3 and Group U Occupancy towers	1.00	1.00	1.00
5. Miscellaneous structures	Group U Occupancies except for towers	1.00	1.00	1.00

Figure 110 important factor I.

### 3.10.6 Over strength factor:

Over strength (R): The used structural system in the building from Figure 111 is #2-3-a which is Building frame system with concrete shear walls. Factor R = 5.5.

BASIC STRUCTURAL SYSTEM <sup>2</sup>	LATERAL-FORCE-RESISTING SYSTEM DESCRIPTION	R	μ	HEIGHT LIMIT FOR SEISMIC ZONES 3 AND 4 (feet)
				× 304.8 for mm
1. Bearing wall system	1. Light-framed walls with shear panels			
	a. Wood structural panel walls for structures three stories or less	5.5	2.8	65
	b. All other light-framed walls	4.5	2.8	65
	2. Shear walls			
	a. Concrete	4.5	2.8	160
	b. Masonry	4.5	2.8	160
	3. Light steel-framed bearing walls with tension-only bracing	2.8	2.2	65
	4. Braced frames where bracing carries gravity load			
	a. Steel	4.4	2.2	160
	b. Concrete <sup>3</sup>	2.8	2.2	—
c. Heavy timber	2.8	2.2	65	
2. Building frame system	1. Steel eccentrically braced frame (EBF)	7.0	2.8	240
	2. Light-framed walls with shear panels			
	a. Wood structural panel walls for structures three stories or less	6.5	2.8	65
	b. All other light-framed walls	5.0	2.8	65
	3. Shear walls			
	a. Concrete	5.5	2.8	240
	b. Masonry	5.5	2.8	160
	4. Ordinary braced frames			
	a. Steel	5.6	2.2	160
	b. Concrete <sup>3</sup>	5.6	2.2	—
c. Heavy timber	5.6	2.2	65	
5. Special concentrically braced frames				
a. Steel	6.4	2.2	240	
3. Moment-resisting frame system	1. Special moment-resisting frame (SMRF)			
	a. Steel	8.5	2.8	N.L.
	b. Concrete <sup>4</sup>	8.5	2.8	N.L.
	2. Masonry moment-resisting wall frame (MMRWF)	6.5	2.8	160
	3. Concrete intermediate moment-resisting frame (IMRF) <sup>5</sup>	5.5	2.8	—
	4. Ordinary moment-resisting frame (OMRF)			
a. Steel <sup>6</sup>	4.5	2.8	160	
b. Concrete <sup>7</sup>	3.5	2.8	—	
5. Special truss moment frames of steel (STMF)	6.5	2.8	240	
4. Dual systems	1. Shear walls			
	a. Concrete with SMRF	8.5	2.8	N.L.
	b. Concrete with steel OMRF	4.2	2.8	160
	c. Concrete with concrete IMRF <sup>5</sup>	6.5	2.8	160
	d. Masonry with SMRF	5.5	2.8	160
	e. Masonry with steel OMRF	4.2	2.8	160
	f. Masonry with concrete IMRF <sup>3</sup>	4.2	2.8	—
	g. Masonry with masonry MMRWF	6.0	2.8	160
	2. Steel EBF			
	a. With steel SMRF	8.5	2.8	N.L.
	b. With steel OMRF	4.2	2.8	160
	3. Ordinary braced frames			
	a. Steel with steel SMRF	6.5	2.8	N.L.
	b. Steel with steel OMRF	4.2	2.8	160
	c. Concrete with concrete SMRF <sup>3</sup>	6.5	2.8	—
	d. Concrete with concrete IMRF <sup>3</sup>	4.2	2.8	—
	4. Special concentrically braced frames			
	a. Steel with steel SMRF	7.5	2.8	N.L.
b. Steel with steel OMRF	4.2	2.8	160	
5. Cantilevered column building systems	1. Cantilevered column elements	2.2	2.0	35 <sup>7</sup>
6. Shear wall-frame interaction systems	1. Concrete <sup>8</sup>	5.5	2.8	160
7. Undefined systems	See Sections 1629.6.7 and 1629.9.2	—	—	—

Figure 111 Over strength factor R.

### 3.10.7 load combination:

According to UBC -97 , there are two group of combination :

#### Ultimate combination:

- 1.4 D
- 1.2D + 1.6 L
- 1.2D +L + E
- .9 D + E Which  $E = \rho E_h + E_v$

$\rho$ : Redundancy factor and it shall be taken (1) because the structure is located in seismic zone 2 .

$$E_h = EQ_x + 0.3 EQ_y \text{ OR } EQ_y + .3 EQ_x$$

$$E_v = 0.5 \cdot 0.28 I D, E_v = 0.14D.$$

Table 18 shows the ultimate load combination

Table 18 Ultimate load combinations.

ultimate load	
<b>U1</b>	1.4D
<b>U2</b>	1.2D+1.6L
<b>U3</b>	1.34D+L+EQx+0.3EQy
<b>U4</b>	1.34D+L-EQx-0.3EQy
<b>U5</b>	1.34D+L+0.3EQx+Eqy
<b>U6</b>	1.34D+L-0.3EQx-EQy
<b>U7</b>	0.76D+EQx +0.3EQy
<b>U8</b>	0.76D-EQx -0.3EQy
<b>U9</b>	0.76D+0.3EQx +EQy
<b>U10</b>	0.76D-0.3EQx -EQy
<b>Envelope</b>	Max(U1,U2,U3,U4,U5,U6,U7,U8,U9,U10)

#### Service load combination:

- D
- D+L
- D+E/1.4
- .9 D ± E/1.4
- D + .75 (L+E/1.4)

Table 19 shows the service load combination.

Table 19 Service load combination

service load	
S1	D
S2	D+L
S3	$D+0.71EQ_x+0.21EQ_y$
S4	$D-0.71EQ_x-0.21EQ_y$
S5	$D+0.21EQ_x+0.71EQ_y$
S6	$D+0.21EQ_x+0.71EQ_y$
S7	$D+0.75L+0.54EQ_x+0.16EQ_y$
S8	$D+0.75L-0.54EQ_x-0.16EQ_y$
S9	$D+0.75L+0.16EQ_x+0.54EQ_y$
S10	$D+0.75L-0.16EQ_x-0.54EQ_y$
S11	$0.9D+0.71EQ_x+0.21EQ_y$
S12	$0.9D-0.71EQ_x-0.21EQ_y$
S13	$0.9D+0.21EQ_x+0.71EQ_y$
S14	$0.9D+0.21EQ_x+0.71EQ_y$
Envelope	$\text{Max}\{S1,S2,S3,S3,S4,S5,S6,S7,S8,S9,S10,S11,S12,S13,S14\}$

### 3.10.8 mass source definition:

Figure 112 show mass source in seismic design:

Mass Source Definition											
File Edit Format-Filter-Sort Select Options											
Units: As Noted Hidden Columns: No Sort: None											
Filter: None											
	Name	Is Default	Include Lateral Mass?	Include Vertical Mass?	Lump Mass?	Source Self Mass?	Source Added Mass?	Source Load Patterns?	Move Mass Centroid?	Load Pattern	Multiplier
	MsSrc1	Yes	Yes	No	Yes	No	No	Yes	No	SD	1
▶	MsSrc1									Dead	1
	MsSrc1									WALL	1
	MsSrc1									Live	0.25

Figure 112 Mass source.

### 3.10.9 Seismic checks:

#### 3.10.9.1 Period check:

$$T = Ct * hn^{\frac{3}{4}}$$

Ct is a factor given by UBC 97 code:

- Ct = 0.0853 for steel moment-resisting frames
- Ct = 0.0731 for reinforced concrete moment-resisting frames and eccentrically braced frames.
- Ct = 0.0488 for all other buildings.

hn: building height = 27.6m

The building was considered as a bearing shear wall system.

Ct = 0.0488.

$$T = 0.0488 \times 27.6^{\frac{3}{4}} = 0.58763 \text{ sec.}$$

Tetabs <= 1.4 T

Tetabs,x = 2.229 sec.

3-D View Mode Shape (Modal) - Mode 2 - Period 2.22914024719879

Tetabs,y = 2.328 sec.

3-D View Mode Shape (Modal) - Mode 1 - Period 2.32843520800824

Then use  $T = 1.4T = 1.4 \times 0.58763 = 0.822682 \text{ sec.}$

#### 3.10.9.2 Drift check:

STORY	HEIGHT	Dis-x	Dis- Y	Drift -X	Drift -Y	delta -x	delta -y	delta -limit
0		13	17.5					
1	2500	14.2	21.2	1.2	3.7	4.62	14.245	50
2	3100	20.3	24.2	6.1	3	23.485	11.55	62
3	4000	22.5	23.3	2.2	-0.9	8.47	-3.465	80
4	3100	28.6	25.5	6.1	2.2	23.485	8.47	62
5	3100	35	27.8	6.4	2.3	24.64	8.855	62
6	3100	41.7	30.1	6.7	2.3	25.795	8.855	62
7	3100	48.6	32.2	6.9	2.1	26.565	8.085	62
8	3100	55.4	34.7	6.8	2.5	26.18	9.625	62
9	2500	61	32.4	5.6	-2.3	21.56	-8.855	50

Figure 113 Drift check

Drift check is ok

### 3.10.9.3 Maximum story displacement from response story:

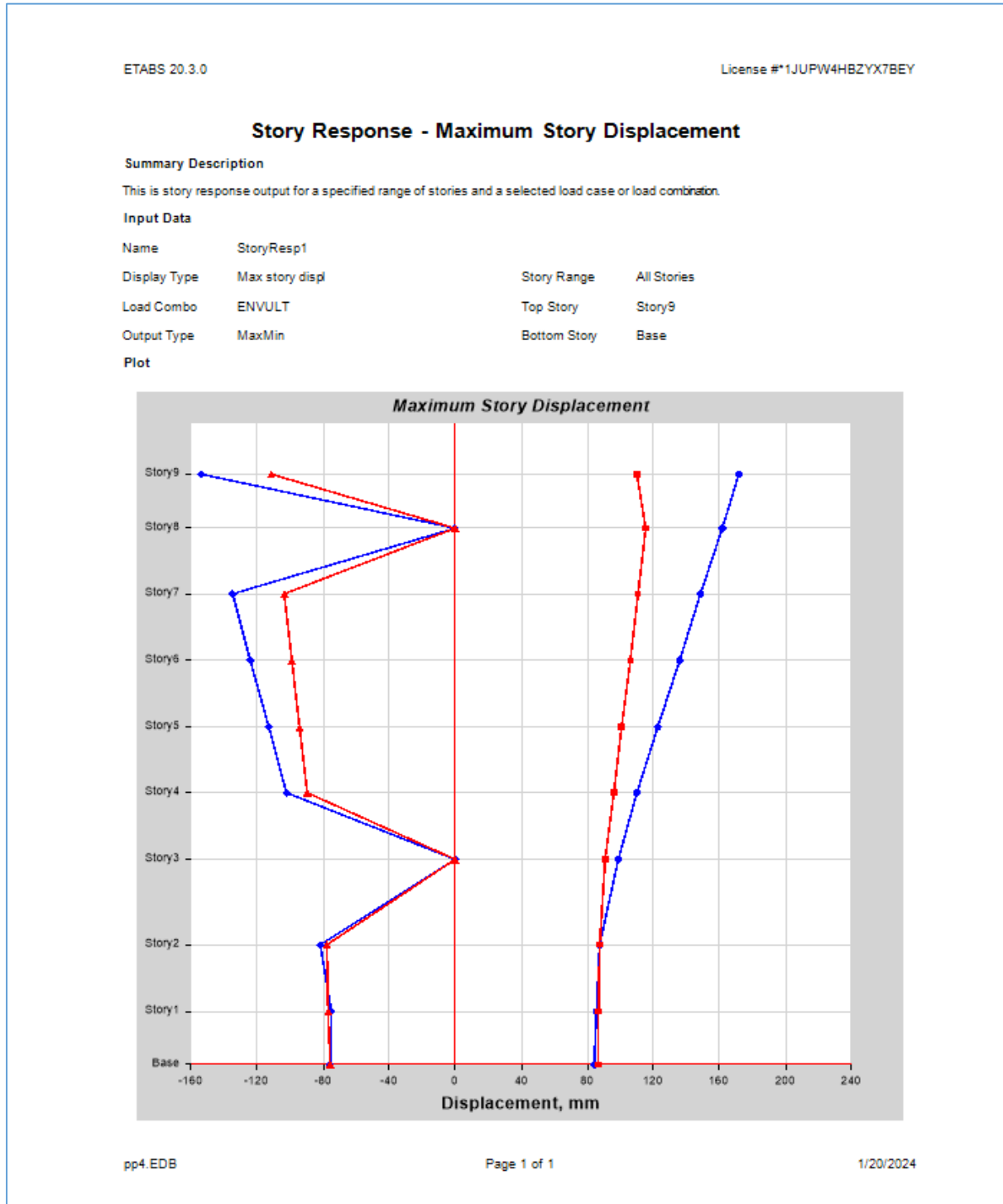


Figure 114 maximum story displacement from response story

#### 3.10.9.4 Base shear check:

- EQ max from ETABS = 5174
- $V = \min (2.5 \cdot C_a / T) * W * (I / R)$
- $CV = 0.28$
- $I = 1$
- $R = 5.5$
- $T = 0.823$

$$V = \min (0.625, 0.486) \times 50976 \times (1 / 5.5) = 4955 \text{ KN}$$

$$\text{Error} = ((4955 - 5174) / 5174) \times 100\% = 4.24\% < 5\% \dots \text{OK}$$

### 3.11 Required Design elements:

#### 3.11.1 Column Design:

Check column design shown in Figure 115 from Etabs

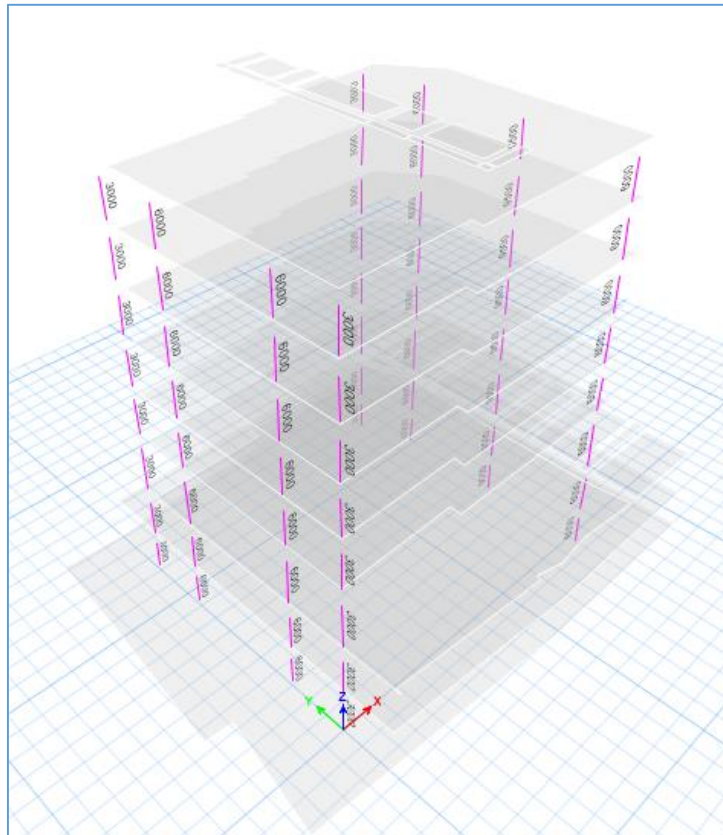


Figure 115 check column

### 3.11.1.1 Column layout:

Column layout shown in Figure 116.

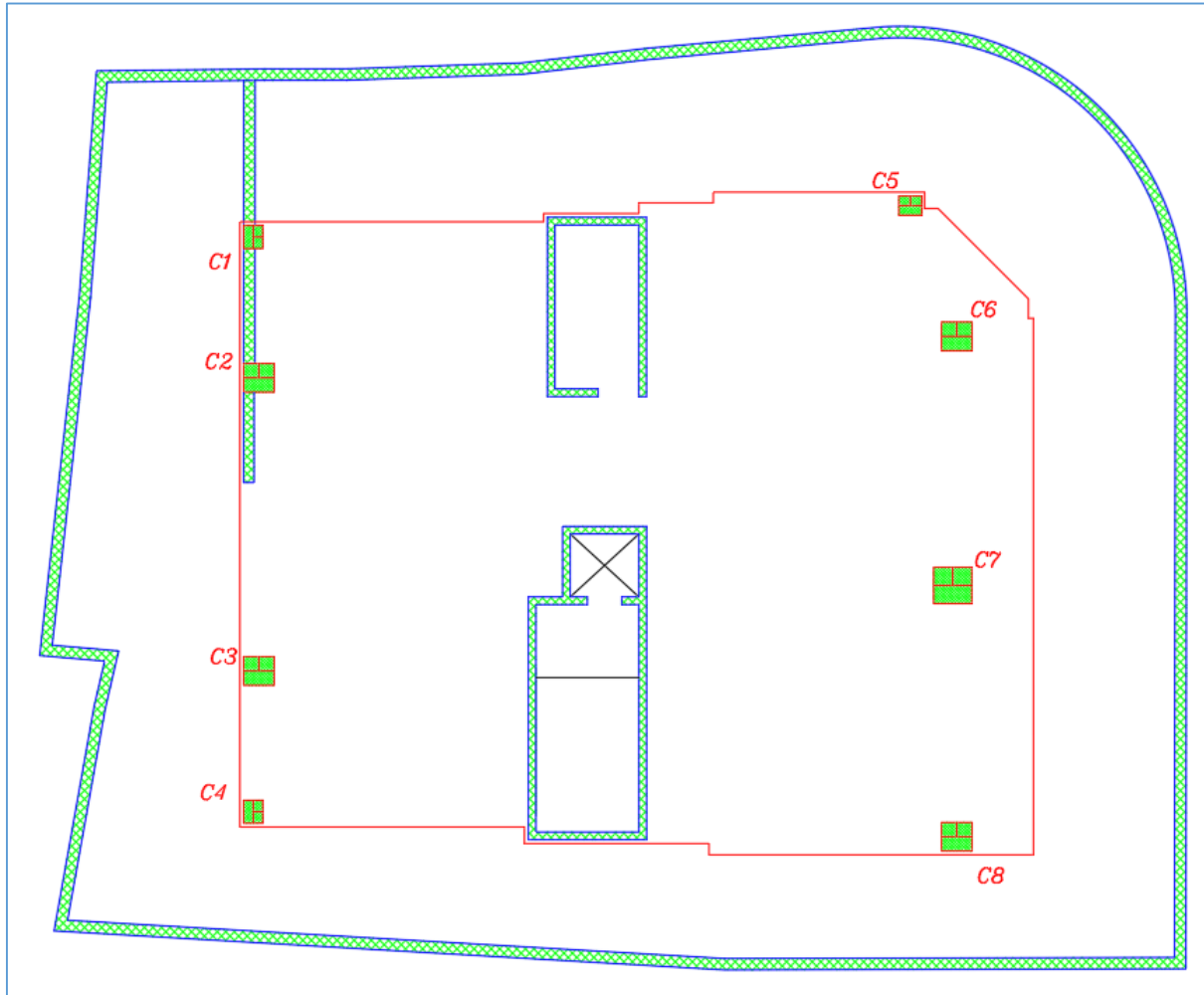


Figure 116 column layout.

### 3.11.1.2 Column detailing:

Column detailing is shown in Figure 117, Figure 118, Figure 119, and Figure 120.

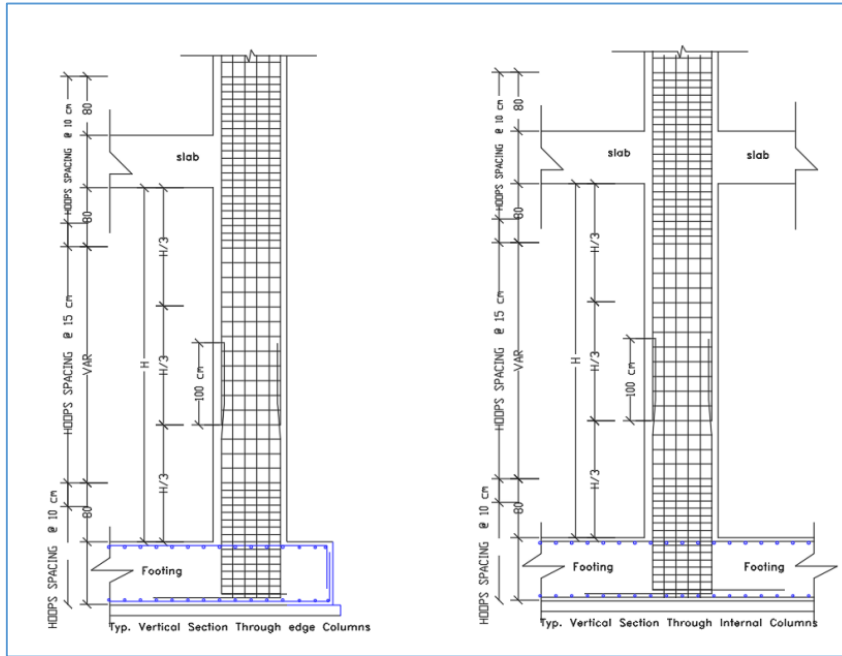


Figure 117 column detailing.

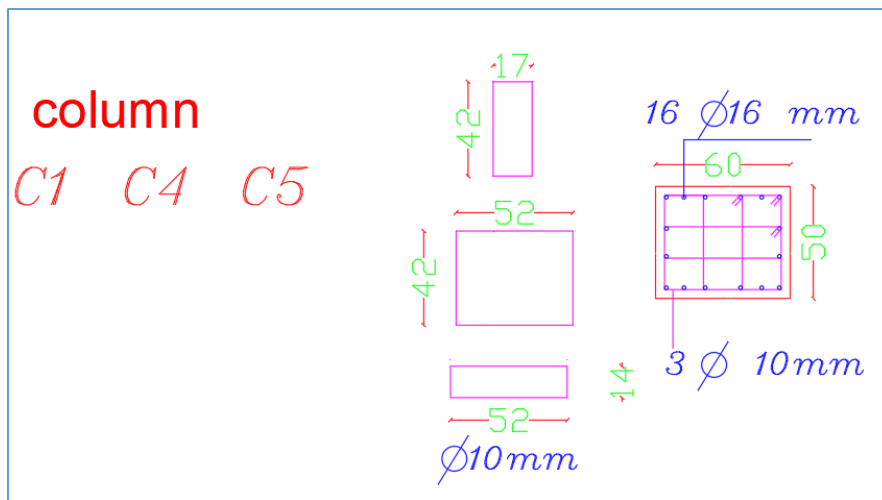


Figure 118 section in column 1, 4, 5.

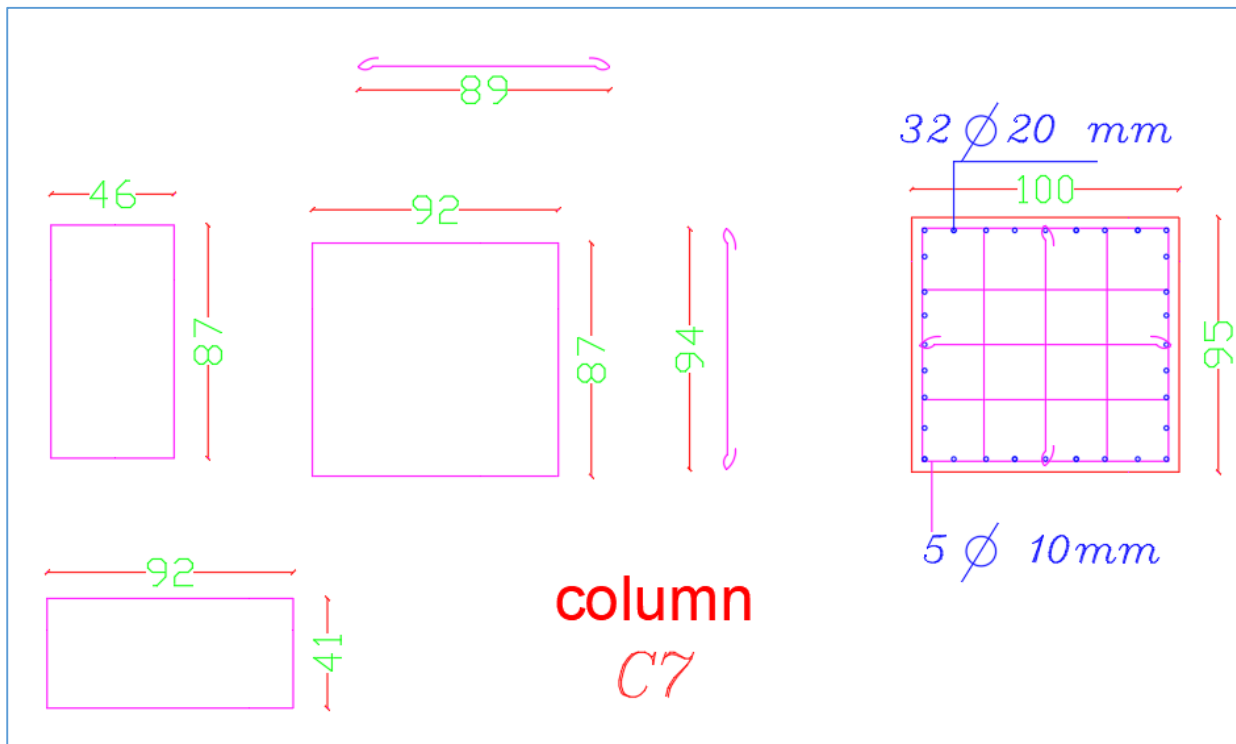


Figure 119 section in column 7.

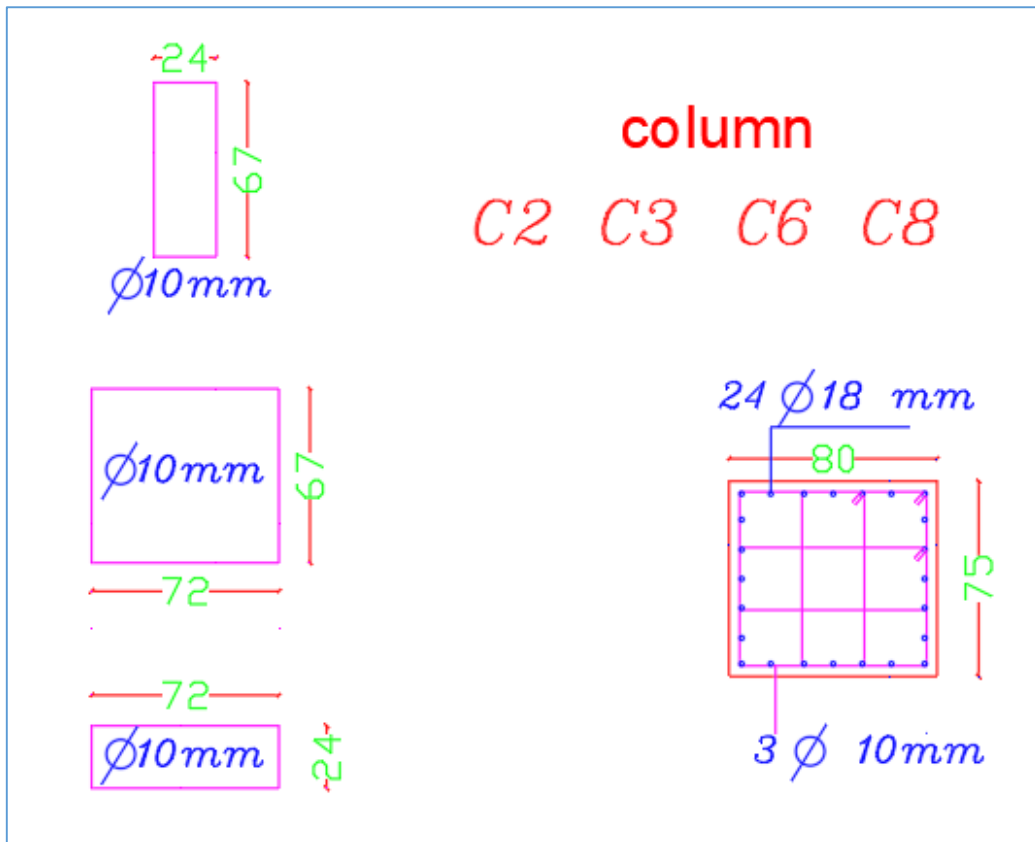


Figure 120 section in column 2, 3, 6, 8.

### 3.11.2 Slab and beams design:

#### 3.11.2.1 Layout beam and slab.

Beams layout are shown in Figure 121, Figure 122 and Figure 123.

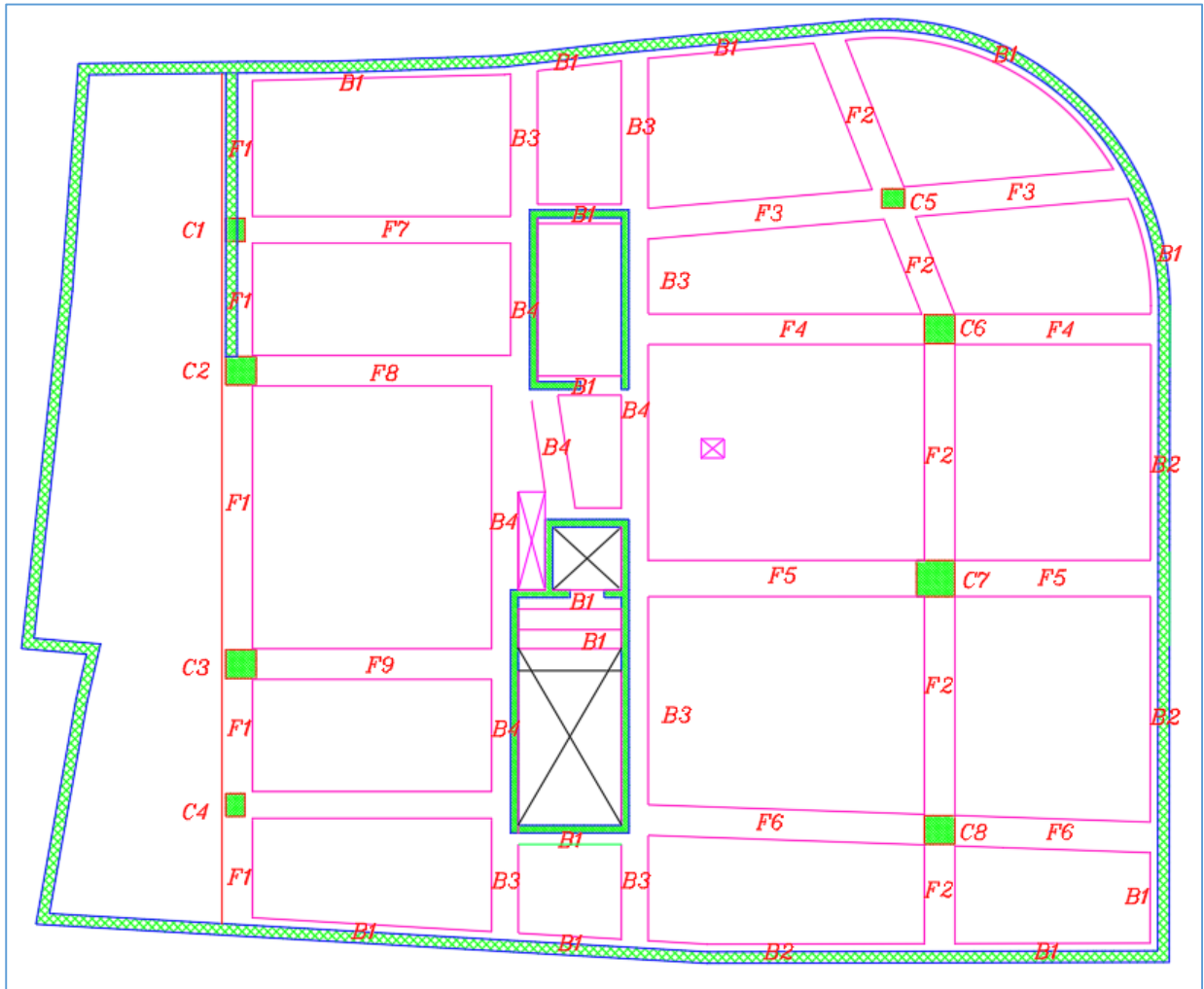


Figure 121 layout beams in parking story.

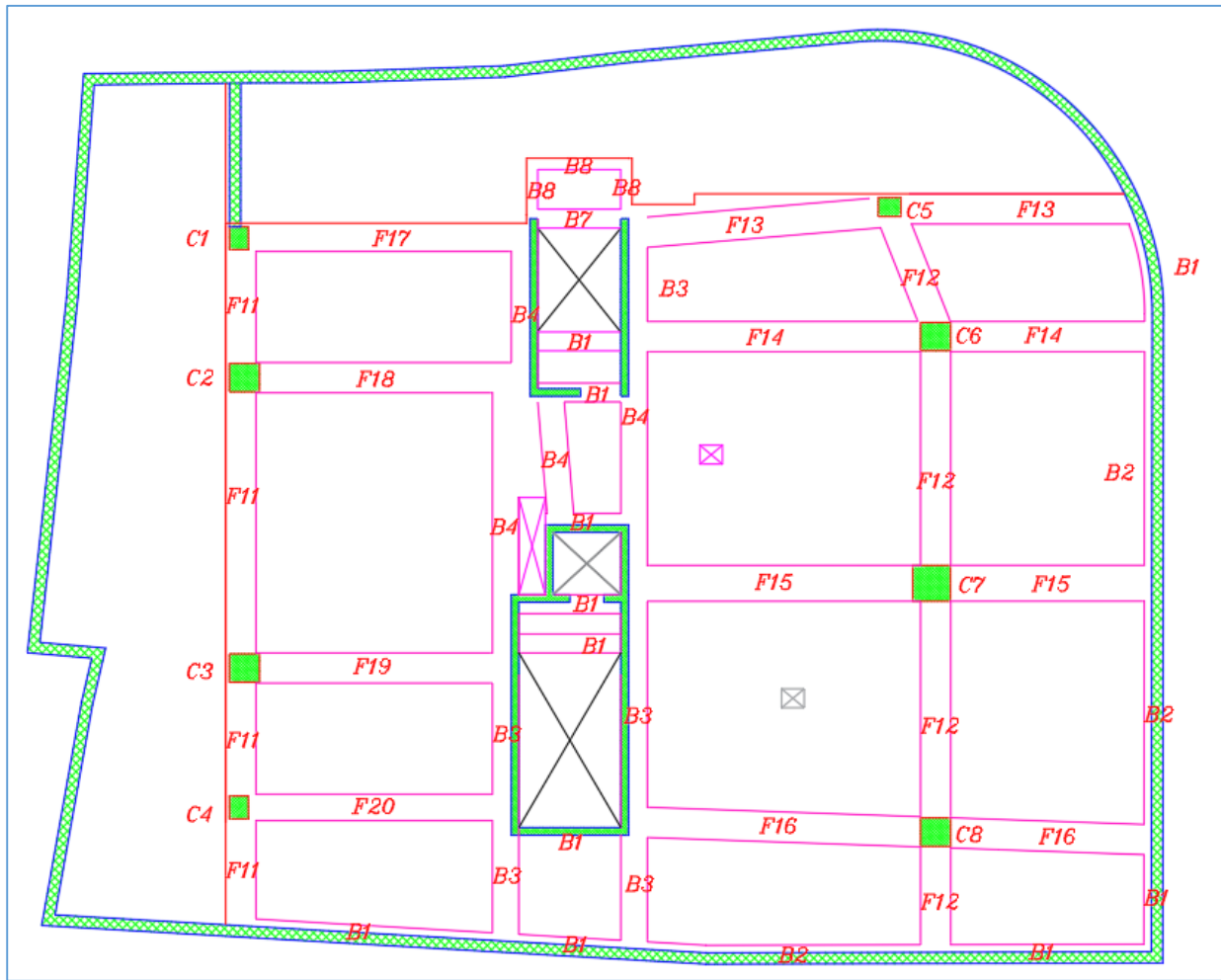


Figure 122 layout beams in basement story.

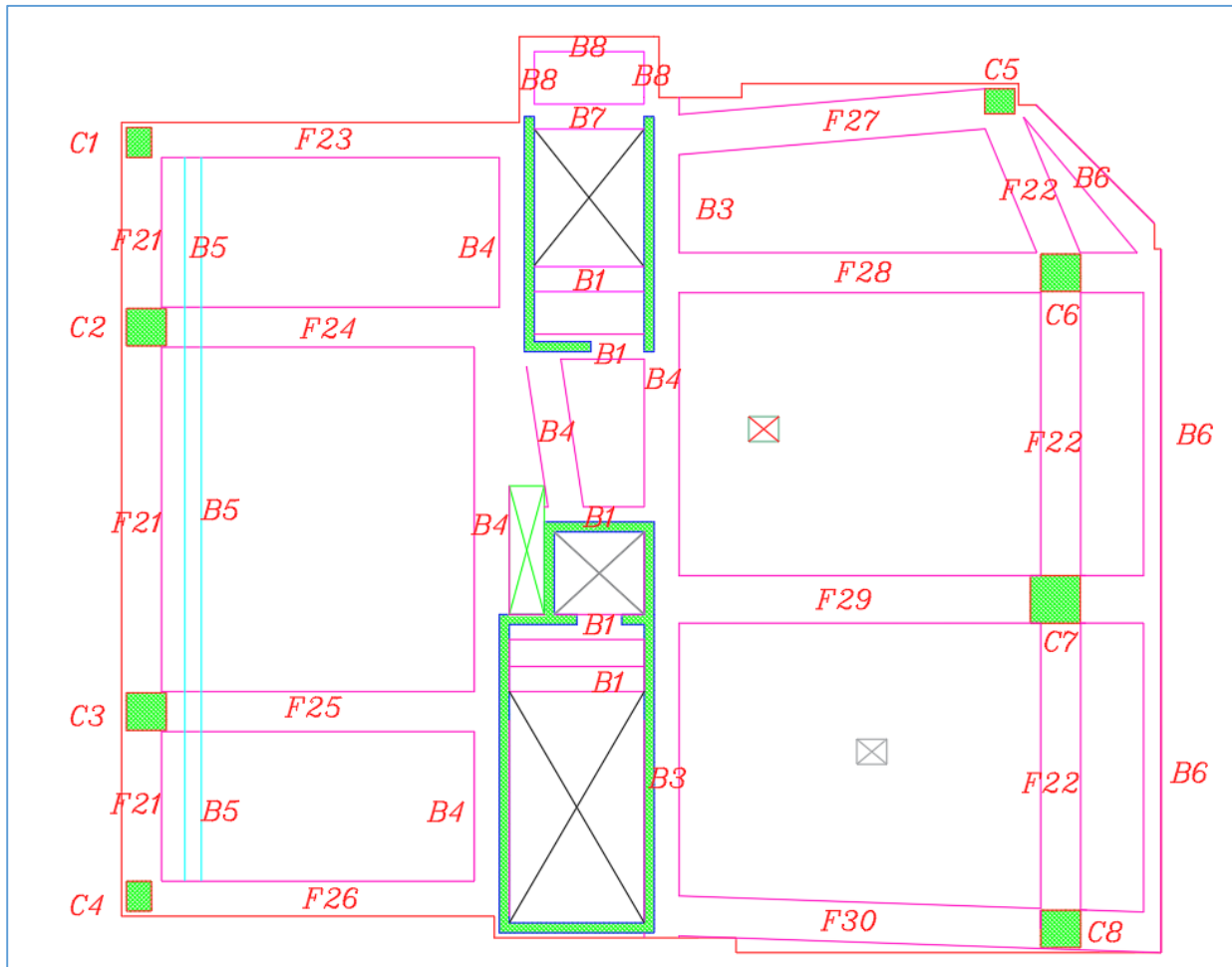


Figure 123 layout beams in store and residential story.

### 3.11.2.2 Check shear in slab.

Solid slab 33 cm

$$\Phi V_c = (0.75/6) * \sqrt{f_c} * b * d = (0.75/6) * \sqrt{28} * 1000 * 300 = 198.43 \text{ KN}$$

$$\Phi V_c > V_u = 160 \text{ KN}$$

Ribbed slab 33 cm

$$\Phi V_c = (0.75/6) * \sqrt{f_c} * b * d = (0.75/6) * \sqrt{28} * 150 * 300 = 29.77 \text{ KN}$$

$$\Phi V_c < V_u = 110 \text{ KN}$$

$$(V_u / F_y * d) = A_s / S$$

$$(80 * 1000) / (420 * 300) = 100 / S$$

$$S = 157.5 \text{ mm}$$

Use  $S_{min} = d/2$  .... The use 1  $\Phi 8 \text{ mm}$  @ 150 mm.

### 3.11.2.3 Detailing slab.

Slab detailing is shown in Figure 124.

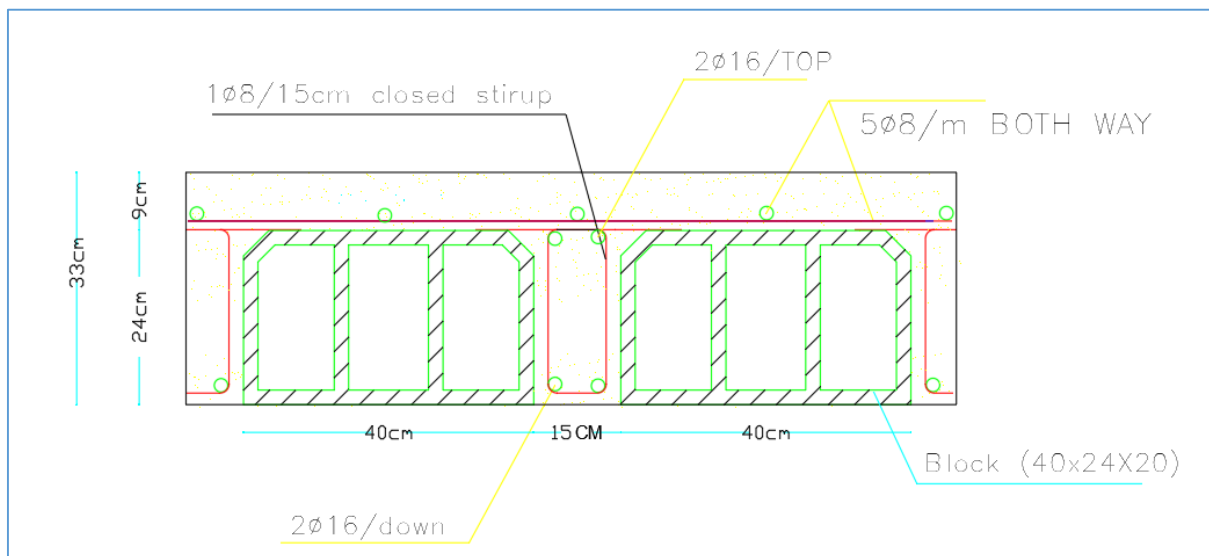


Figure 124 detailing slab.

### 3.11.3 Footing design:

#### 3.11.3.1 Footing stresses

Soil allowable bearing capacity = 200 KN/m<sup>2</sup>.

Footing type: Mat footing

*Weight building = D.L + L.L + S.D + WALL + MAT FOOTING*

load	manual
live	16475.99
SD	13357.3948
WALL	9910.485
Dead	50975.82
MAT	17106.75
TOTAL	107826.44

*Bearing capacity mat footing = Area × q*

$$= 684.27 \times 200 = 136845 \text{ KN} > 107827 \text{ KN}$$

Footing stresses < allowable bearing capacity ...is ok

### 3.11.3.2 Punching shear check:

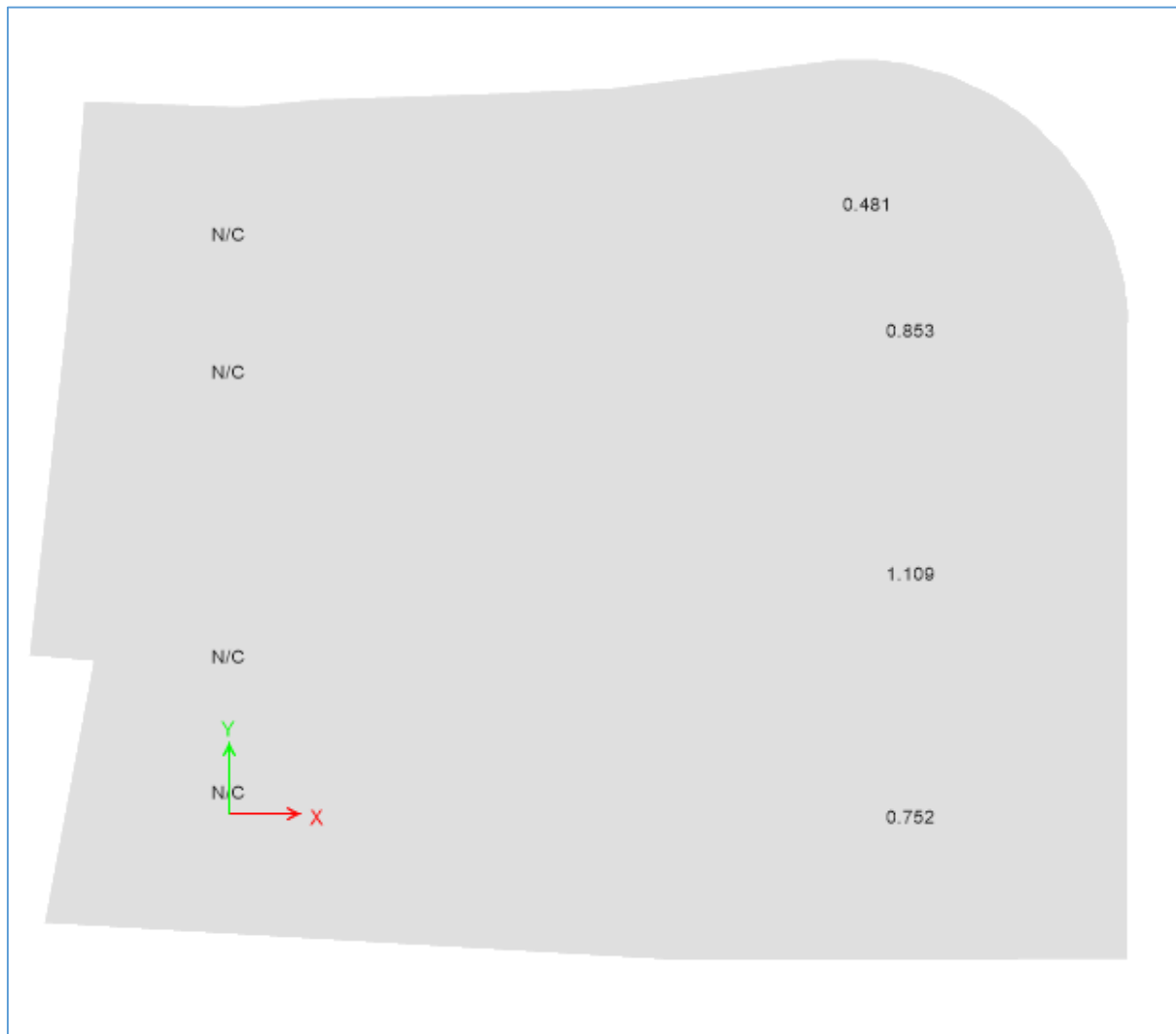


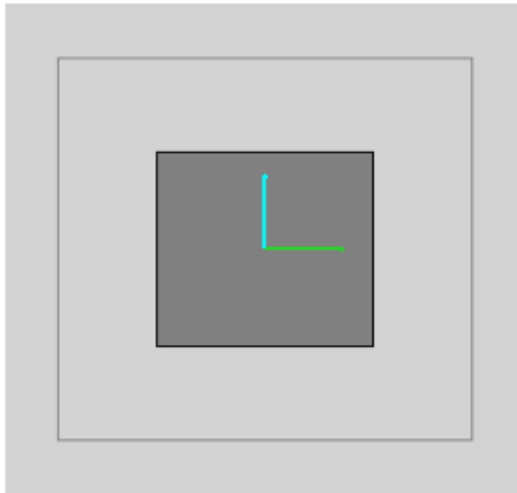
Figure 125 punching shear check.

As shown, all ratios  $< 1$  Except for column number 7

## ACI 318-19 Punching Shear Check & Design

### Geometric Properties

Combination = DS1bS3  
Story = Base  
Point Label = 82  
Column Shape = Rectangular  
Column Location = Interior  
Global X-Coordinate = 18.4496 m  
Global Y-Coordinate = 5.9342 m



### Column Punching Check

Avg. Eff. Slab Thickness = 0.916 m  
Eff. Punching Perimeter = 7.564 m  
Cover = 0.084 m  
Conc. Comp. Strength = 28000 kN/m<sup>2</sup>  
Reinforcement Ratio = 0  
Section Inertia I22 = 4.286466 m<sup>4</sup>  
Section Inertia I33 = 4.456637 m<sup>4</sup>  
Section Inertia I23 = 0 m<sup>4</sup>  
Gamma  $v_2$  = 0.396831  
Gamma  $v_3$  = 0.403177  
Moment Mu2 = 446.018 kN-m  
Moment Mu3 = 1231.9854 kN-m  
Shear Force = -9124.7175 kN  
Unbalanced Moment Mu2 = 176.9938 kN-m  
Unbalanced Moment Mu3 = 496.7085 kN-m  
Max Design Shear Stress = 1462.26 kN/m<sup>2</sup>  
Conc. Shear Stress Capacity = 1318.13 kN/m<sup>2</sup>  
Punching Shear Ratio = 1.11

Figure 126 punching shear ratio in C7.

$$V_{\text{design}} = \text{max shear} - \text{concrete shear stress capacity}$$

$$= 1462.26 - 1318.13 = 144.13 \text{ KN}$$

$$\frac{v}{F_y * d} = \left( \frac{A_s}{S} \right)$$

$$\frac{144.13}{420 * 930} = \left( \frac{100}{S} \right), S = 271 \text{ mm}$$

Use 1 phi 8 mm @ 25 cm

### 1. Shear check:

$$V_u = \frac{2}{3} * (F_y)^{0.5} * d$$

$$V_u = \frac{2}{3} (420)^{0.5} * 930 = 3280 \text{ KN}$$

Max shear in footing < V concrete

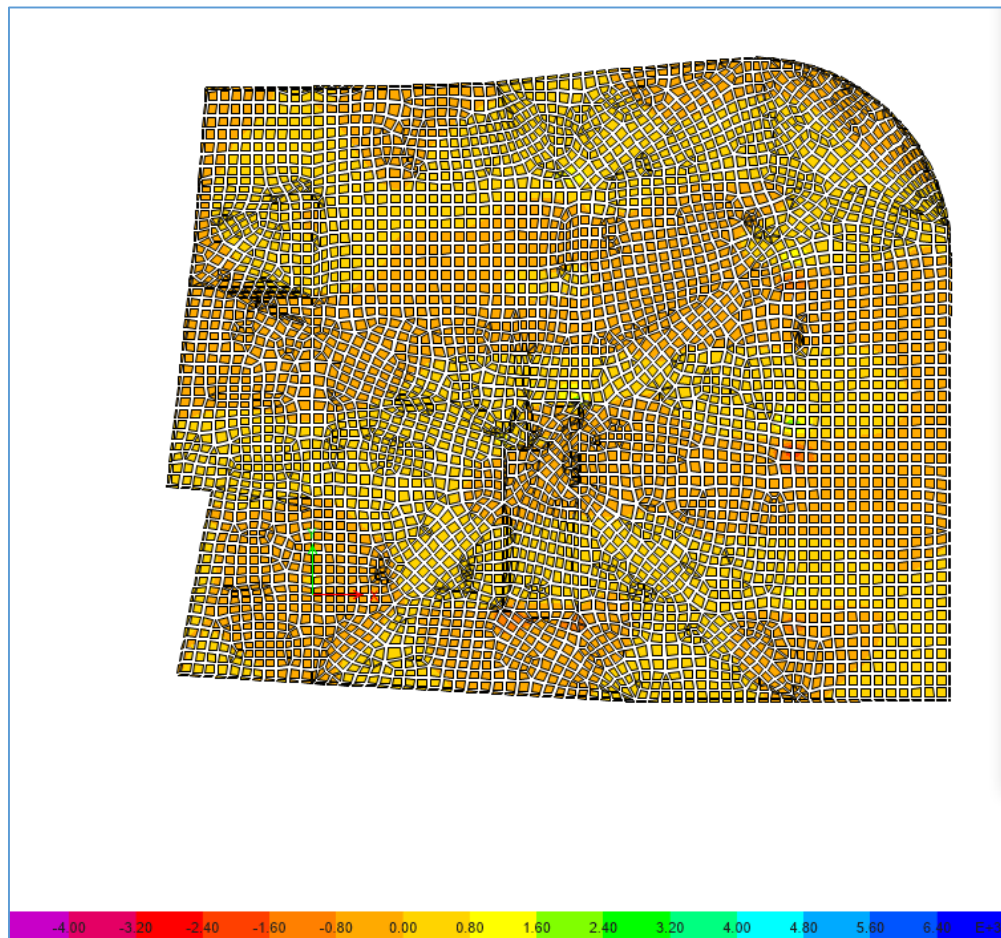


Figure 127 Shear in footing.

### 3.11.3.3 Detailing footing.

Footing detailing is shown in Figure 128.

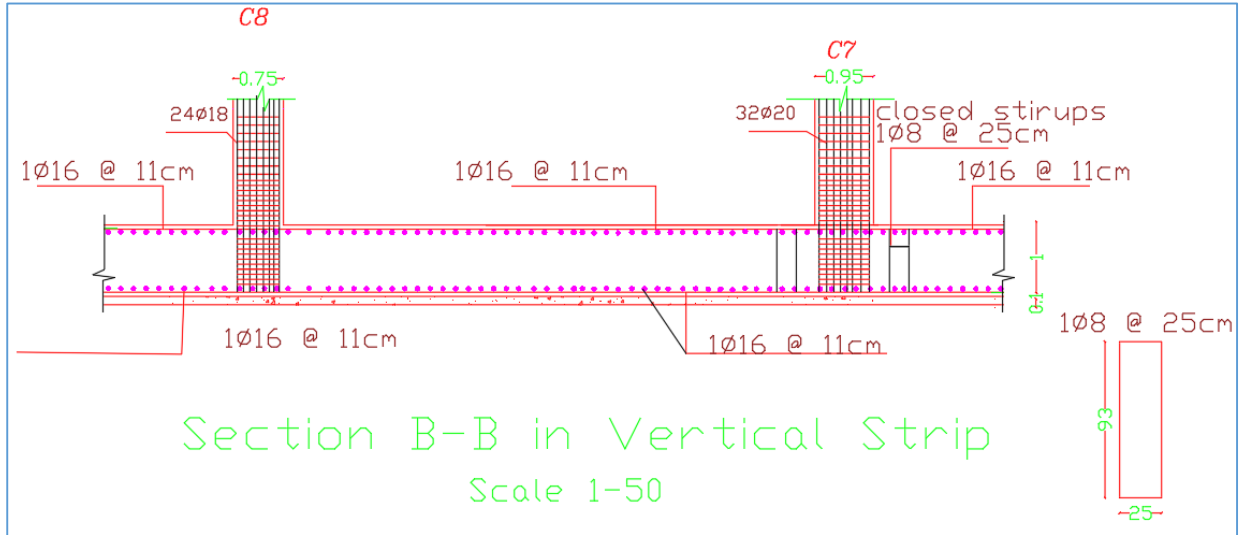


Figure 128 detailing footing.

## Chapter Four:

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## Electro - Mechanical Design.

## 4 ELECTRO - MECHANICAL DESIGN.

### 4.1 Lighting.

#### 4.1.1 Introduction.

Lighting is one of the most essential elements of space comfort, it can affect people's experience. Lighting's shape, color, focus, type of luminaire, efficiency, power, and flux depend on the space function. Also, the layout of lighting plays a big role in the space's comfort. Since the project has different spaces each space was designed to achieve the needed values to provide a comfortable space.

#### 4.1.2 Lux Level.

Table 20 Recommended lux level

ROOM TYPE	LIGHT LEVEL (FOOT CANDLES)	LIGHT LEVEL (LUX)	IECC 2021 LIGHTING POWER DENSITY (WATTS PER SF)
Cafeteria - Eating	20-30 FC	200-300 lux	0.40
Corridor - General	5-10 FC	50-100 lux	0.41
Office - Private / Closed	30-50 FC	300-500 lux	0.74
Parking - Interior	5-10 FC	50-100 lux	0.15
Dormitory - Living Quarters	20-30 FC	200-300 lux	0.50
Restroom / Toilet	10-30 FC	100-300 lux	0.63
Lobby - Office/General	20-30 FC	200-300 lux	0.84

Table 20 shows the recommended lux level according to the space function. All recommended lux levels were taken into consideration while designing.

#### 4.1.3 Artificial lightings design.

In this section, the artificial lighting will be designed with the best-fitted luminaire that will achieve the targeted lux with suitable lighting temperature and color, Using DiaLUX software while taking energy consumption into consideration.

The reflection factors used according to the DiaLUX software are the following:

Ceiling: 75

Floor: 60

Wall: 30

One room of each category will be designed using DiaLUX, taking into account the function of space. The luminaires were chosen with specifications that fit the space standards, the luminaires were distributed uniformly in the space until uniformity was achieved.

##### 4.1.3.1 Ground Floor.

The spaces that will be covered are.

- Lobby
- Entrance
- Cafeteria
- Offices.
- Corridors
- Security room
- Control room
- WC

#### 4.1.3.1.1 Lobby.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_2$	Index
Working plane (Lobby) Perpendicular illuminance (adaptive) Height: 0.000 m, Wall zone: 0.000 m	427 lx ( $\geq 300$ lx) ✓	174 lx	550 lx	0.41 ( $\geq 0.40$ ) ✓	0.32	WP10

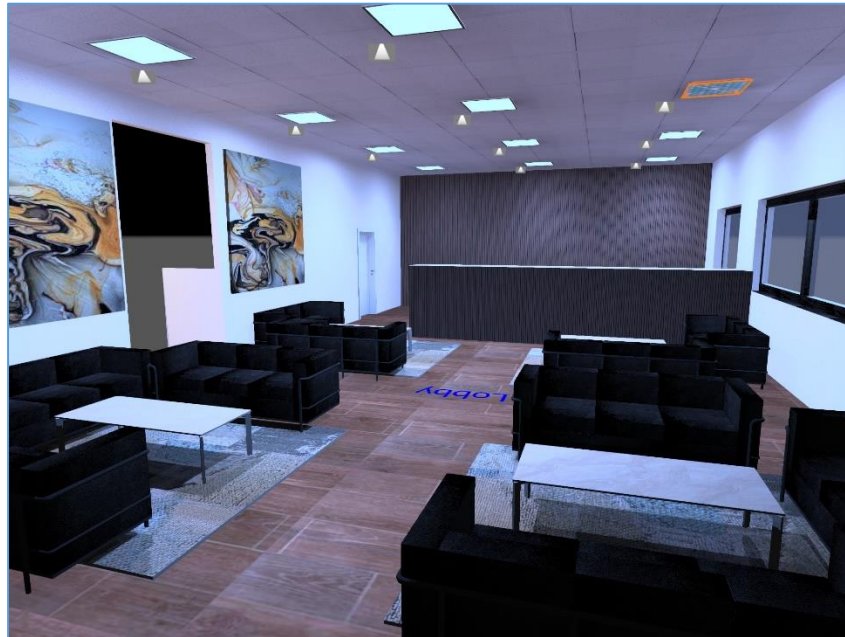


Figure 129 View of the Lobby after design.

The type of luminaire was chosen according to their specification and its lux level. Figure 130 shows the luminaire model used.



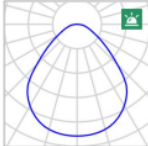
Luminaire layout plan			
			
Manufacturer	Opplé	P	34.0 W
Article No.	542003116100	P <sub>Emergency lighting</sub>	3.7 W
Article name	LEDPanelS-P6 Sq595-34W-BLE2-940-U19-WL	$\Phi_{Luminaire}$	4080 lm
		$\Phi_{Emergency lighting}$	449 lm
Fitting	1x LEDPanelS-P6 Sq595-34W-BLE2-940-U19-WL	ELF	11 %

Figure 130 Luminaire model specification

Figure 131 Shows the layout of luminaires

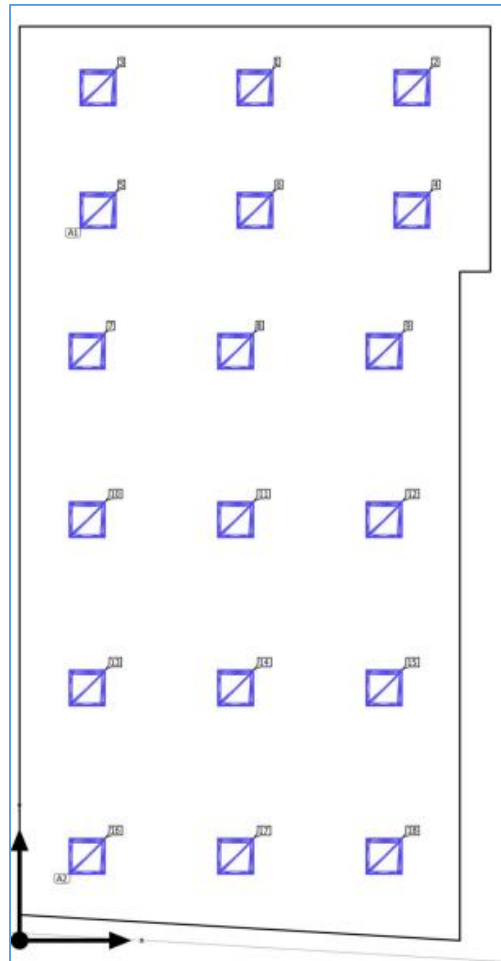


Figure 131 Lobby's Luminaires layout.

After calculation the results came as shown in Table 21 and .

Table 21 Results summery for lobby.

	Symbol	Calculated	Target	Check	Index
Working plane	$\dot{E}_{\text{perpendicular}}$	427 lx	$\geq 300$ lx	✓	WP10
	$U_o$ (gr)	0.41	$\geq 0.40$	✓	WP10
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	18	$\leq 22$	✓	
Energy estimation <sup>(2)</sup>	Consumption	[1469.04 - 2203.20] kWh/a	max. 3900 kWh/a	✓	
Room	Lighting power density	5.56 W/m <sup>2</sup>	-		
		1.30 W/m <sup>2</sup> /100 lx	-		

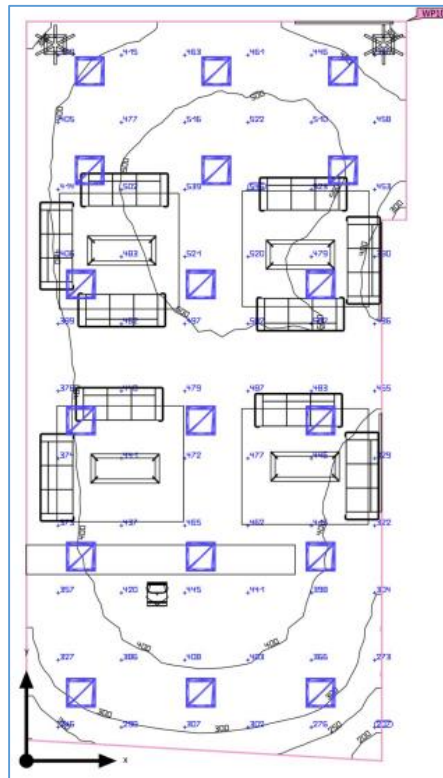


Figure 132 Results on plan.

the space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

#### 4.1.3.1.2 Entrance.

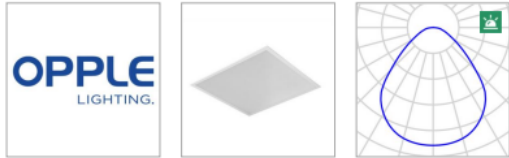
Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_2$	Index
Working plane (Entrance) Perpendicular illuminance (adaptive) Height: 0.000 m, Wall zone: 0.000 m	155 lx ( $\geq 100$ lx) ✓	25.0 lx	242 lx	0.16 ( $\geq 0.15$ ) ✓	0.10	WP8



Figure 133View of the Entrance.

The type of luminaire was chosen according to their specification and its lux level. Figure 134 shows the luminaire model used.

**Luminaire layout plan**



Manufacturer	Oppla	P	34.0 W
Article No.	542003116100	P <sub>Emergency lighting</sub>	3.7 W
Article name	LEDPanelS-P6 Sq595-34W-BLE2-940-U19-WL	Φ <sub>Luminaire</sub>	4080 lm
		Φ <sub>Emergency lighting</sub>	449 lm
Fitting	1x LEDPanelS-P6 Sq595-34W-BLE2-940-U19-WL	ELF	11 %

Figure 134 Luminaire model specification

Figure 135 Shows the layout of luminaires

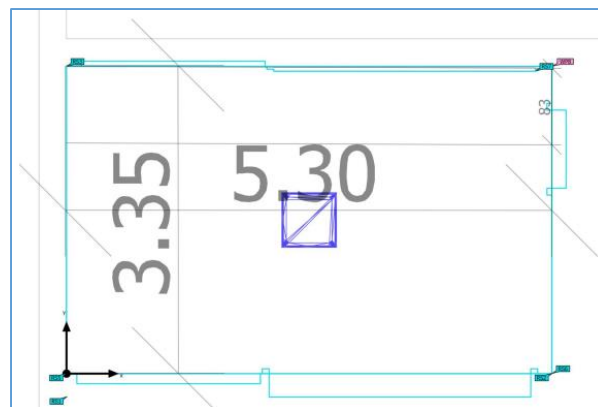


Figure 135 Entrance 's Luminaires layout.

After calculation the results came as shown in Table 22 and Figure 136.

Table 22 Results summary for Entrance.

Results					
	Symbol	Calculated	Target	Check	Index
Working plane	$E_{\text{perpendicular}}$	155 lx	$\geq 100$ lx	✓	WP8
	$U_o$ (gr)	0.16	$\geq 0.15$	✓	WP8
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	16	$\leq 22$	✓	
Energy estimation <sup>(2)</sup>	Consumption	[41.24 - 65.45] kWh/a	max. 650 kWh/a	✓	
Room	Lighting power density	1.92 W/m <sup>2</sup>	-		
		1.25 W/m <sup>2</sup> /100 lx	-		

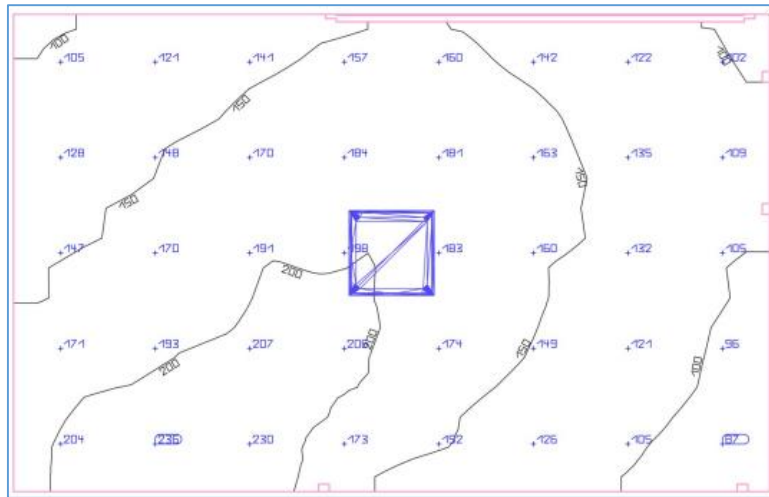


Figure 136 Results on Entrance's plan.

the space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

### 4.1.3.1.3 Cafeteria.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_0$ ( $g_1$ ) (Target)	$g_2$	Index
Working plane (Cafeteria) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	282 lx ( $\geq 50.0$ lx) ✓	121 lx	368 lx	0.43 ( $\geq 0.010$ ) ✓	0.33	WP1



Figure 137View of the Cafeteria.

The type of luminaire was chosen according to their specification and its lux level. Figure 138 shows the luminaire model used.



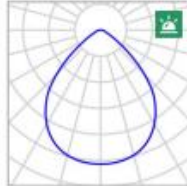
			
<b>Manufacturer</b>	Philips	<b>P</b>	28.5 W
<b>Article name</b>	RC461B PSD W60L60 ELD3 1 xLED40S/940	<b>P<sub>Emergency lighting</sub></b>	28.5 W
<b>Fitting</b>	1x	<b>Φ<sub>Luminaire</sub></b>	4000 lm
		<b>Φ<sub>Emergency lighting</sub></b>	4000 lm
		<b>ELF</b>	100 %

Figure 138 Luminaire model's specification.

Luminaire layout plan shown in Figure 139.

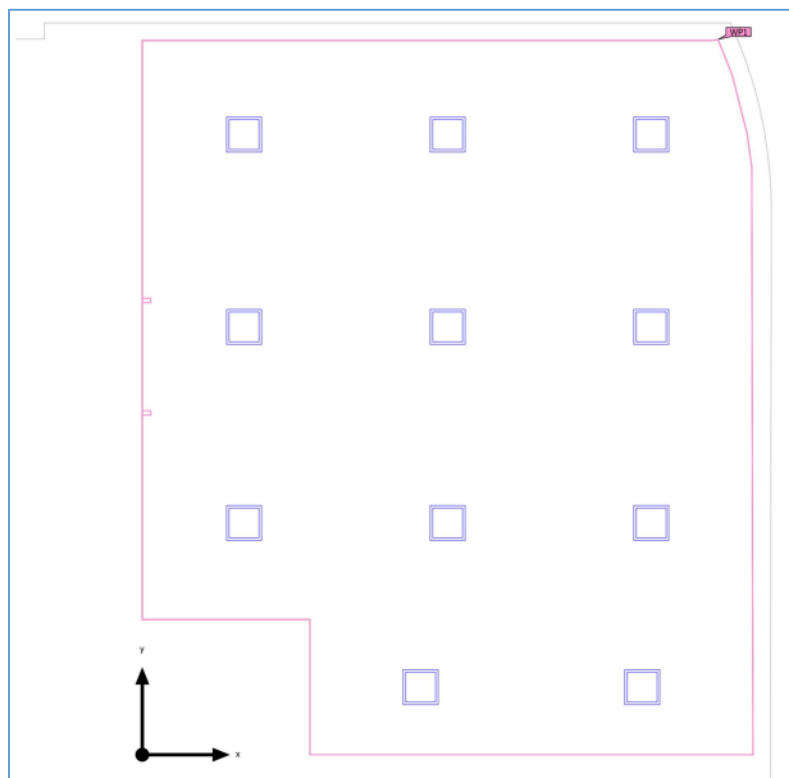


Figure 139 Cafeteria's luminaire layout plan

After calculation the results came as shown in Table 23 and Figure 140.

Table 23 Results summary for Cafeteria,

Results					
	Symbol	Calculated	Target	Check	Index
Working plane	$E_{\text{perpendicular}}$	282 lx	$\geq 50.0$ lx	✓	WP1
	$U_o$ (gr)	0.43	$\geq 0.010$	✓	WP1
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	16	$\leq 22$	✓	
Energy estimation <sup>(2)</sup>	Consumption	[921.19 - 1222.65] kWh/a	max. 4250 kWh/a	✓	
Room	Lighting power density	2.61 W/m <sup>2</sup>	-		
		0.92 W/m <sup>2</sup> /100 lx	-		

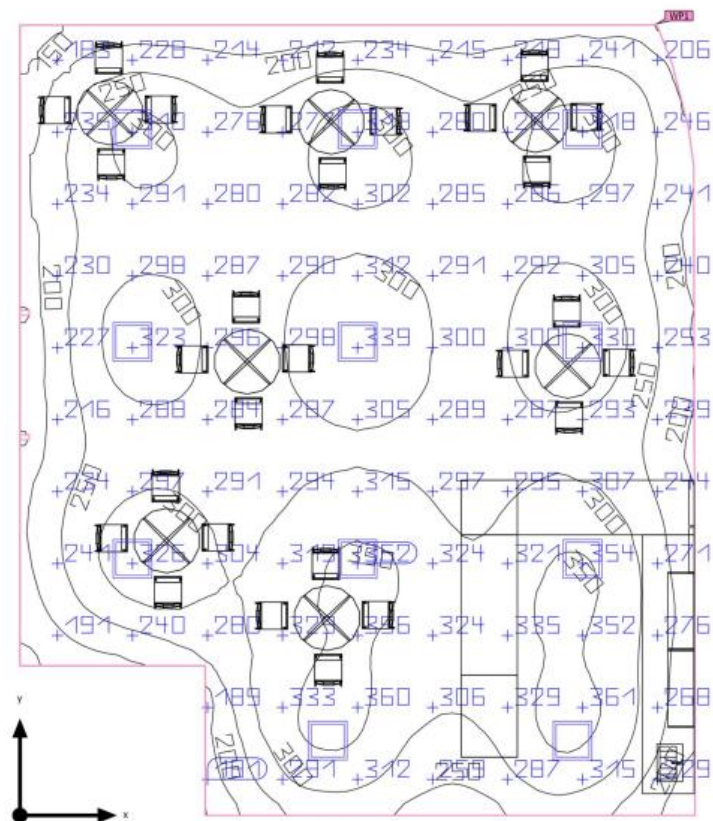


Figure 140 Results on Cafeteria's plan.

the space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

#### 4.1.3.1.4 Administration room.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_2$	Index
Working plane (Administration) Perpendicular illuminance (adaptive) Height: 0.700 m, Wall zone: 0.000 m	659 lx ( $\geq 500$ lx) ✓	403 lx	809 lx	0.61 ( $\geq 0.60$ ) ✓	0.50	WP2

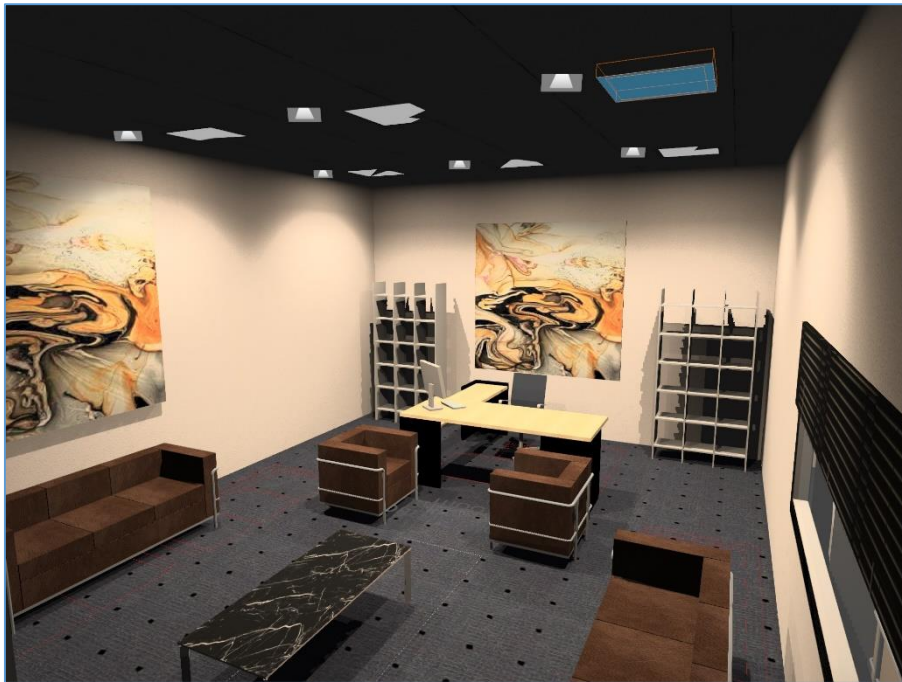


Figure 141 View of the Administration room.

The type of luminaire was chosen according to their specification and its lux level. Figure 142 shows the luminaire model used.



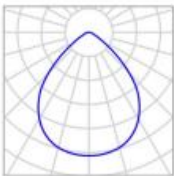
			
Manufacturer	Philips	P	28.5 W
Article name	RC461B PSD W60L60 ELD3 1 xLED40S/940	$\Phi_{Luminaire}$	4000 lm
Fitting	1x		

Figure 142 Luminaire model's specification.

Luminaire layout plan shown in Figure 143

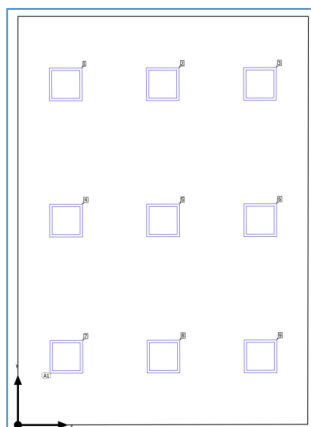


Figure 143 Administration's luminaire layout plan.

After calculation the results came as shown in Table 24 Figure 144

Table 24 Results summary for Administration.

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{\text{perpendicular}}$	659 lx	$\geq 500$ lx	✓	WP2
	$U_o (g_1)$	0.61	$\geq 0.60$	✓	WP2
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	16	$\leq 19$	✓	
Energy estimation <sup>(2)</sup>	Consumption	494 kWh/a	max. 1400 kWh/a	✓	
Room	Lighting power density	6.49 W/m <sup>2</sup>	-		
		0.99 W/m <sup>2</sup> /100 lx	-		

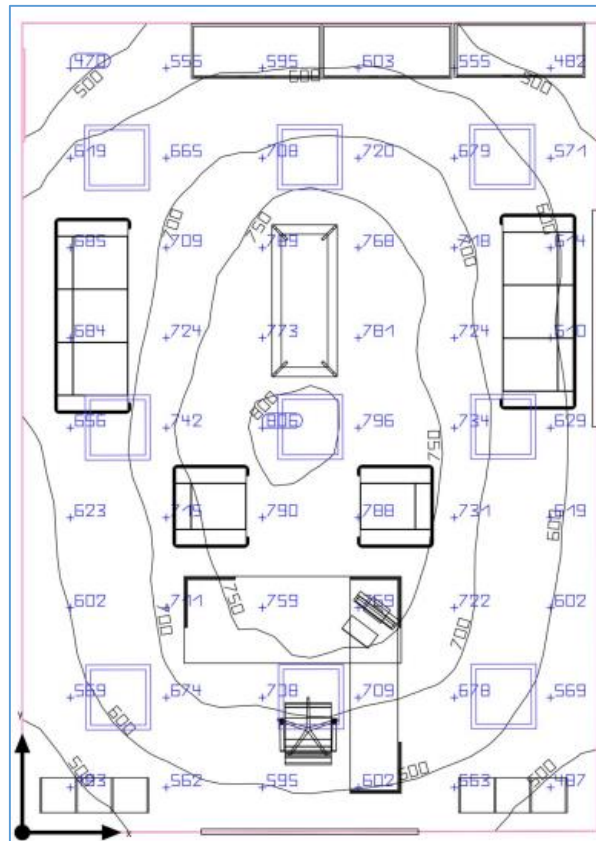


Figure 144 Results on Administrations plan.

the space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

#### 4.1.3.1.5 Accountant room.

Properties	$E$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_2$	Index
Working plane (Accountants)	537 lx	252 lx	677 lx	0.47	0.37	WP4
Perpendicular illuminance (adaptive)	$\geq 500$ lx			$\geq 0.40$		
Height: 0.750 m, Wall zone: 0.000 m	✓			✓		

Utilisation profile: Offices (5.26.2 Writing, typewriting, reading, data processing)

Notes on planning:  
The results were calculated without consideration of objects and furniture. No results were determined on their surfaces.

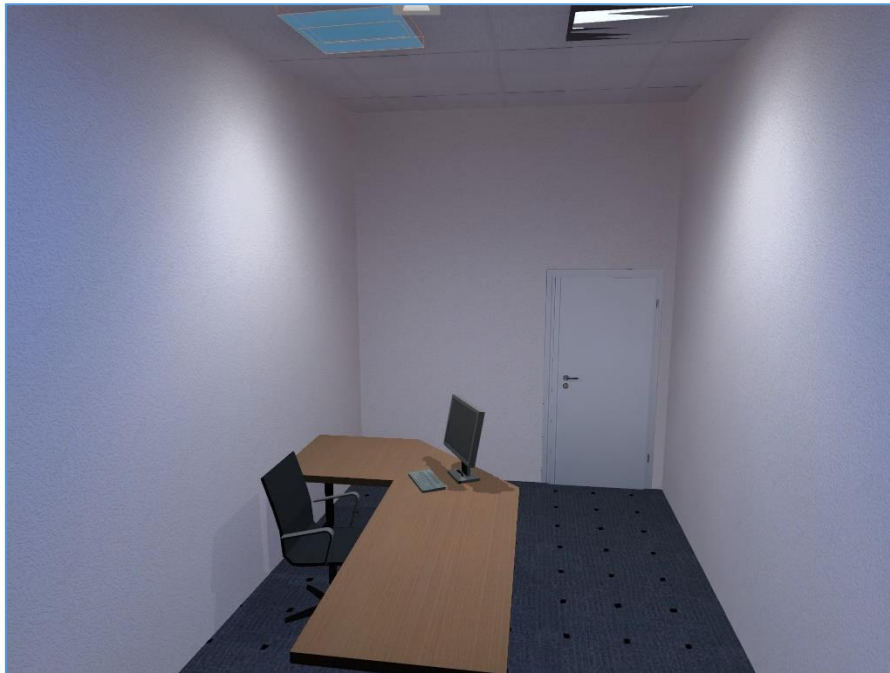


Figure 145 View of the Accountant room

The type of luminaire was chosen according to their specification and its lux level. Figure 146 and Figure 147 shows the luminaires model used.



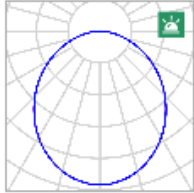
			
Manufacturer	RZB	P	42.0 W
Article No.	312383.0031.2.730	P <sub>Emergency lighting</sub>	42.0 W
Article name	TRIONA round A	Φ <sub>Luminaire</sub>	3251 lm
Fitting	1x LED TuneableWhite 865	Φ <sub>Emergency lighting</sub>	3251 lm
		ELF	100 %

Figure 146 Luminaire model's specification 1



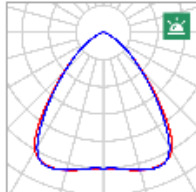
			
Manufacturer	Philips	P	25.0 W
Article name	RC342B LED36S/940 PCS W62L62	P <sub>Emergency lighting</sub>	25.0 W
Fitting	1x	Φ <sub>Luminaire</sub>	3598 lm
		Φ <sub>Emergency lighting</sub>	3598 lm
		ELF	100 %

Figure 147 Luminaire model's specification 2.

Luminaire layout plan shown in Figure 148.

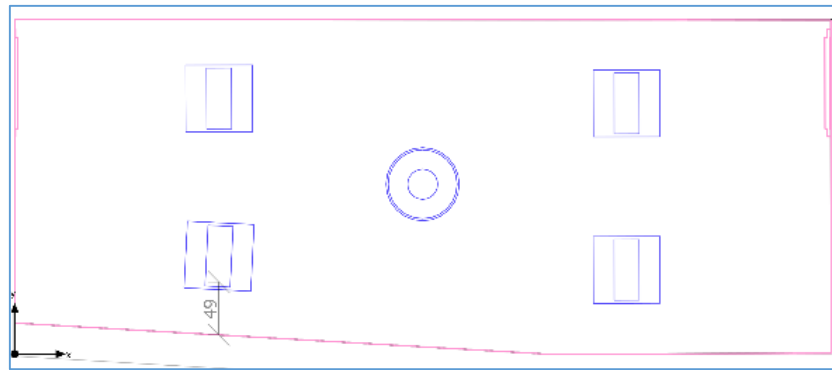


Figure 148 Accountant's luminaire layout plan.

After calculation the results came as shown in Table 25 and Figure 149.

Table 25 Results summary for Accountant.

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{\text{perpendicular}}$	537 lx	$\geq 500$ lx	✓	WP4
	$U_0$ (g <sub>i</sub> )	0.47	$\geq 0.40$	✓	WP4
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	18	$\leq 19$	✓	
Energy estimation <sup>(2)</sup>	Consumption	351 kWh/a	max. 850 kWh/a	✓	
Room	Lighting power density	6.19 W/m <sup>2</sup>	-		
		1.15 W/m <sup>2</sup> /100 lx	-		

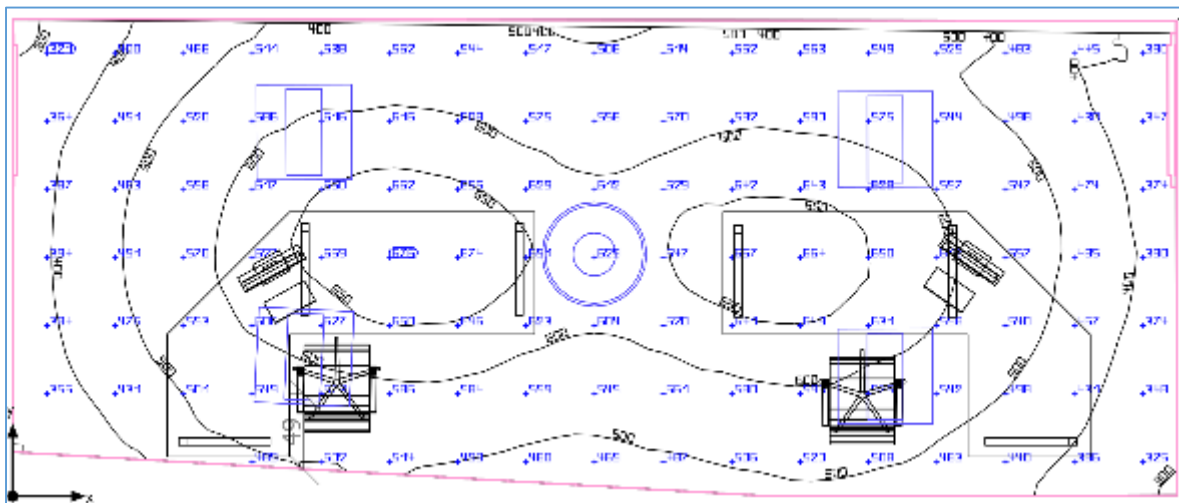


Figure 149 Results on Accountants plan

#### 4.1.3.1.6 Secretary's room.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_2$	Index
Working plane (Secretary) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	426 lx ( $\geq 300$ lx) ✓	225 lx	626 lx	0.53 ( $\geq 0.40$ ) ✓	0.36	WP3



Figure 150 View of the Secretary room

The type of luminaire was chosen according to their specification and its lux level. Figure 151 shows the luminaires model used.



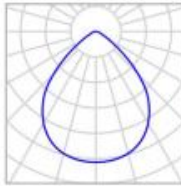
			
Manufacturer	Philips	P	28.5 W
Article name	RC461B PSD W60L60 ELD3 1 xLED40S/940	$\Phi_{Luminaire}$	4000 lm
Fitting	1x		

Figure 151 Luminaire model's specification.

Luminaire layout plan shown in Figure 152.

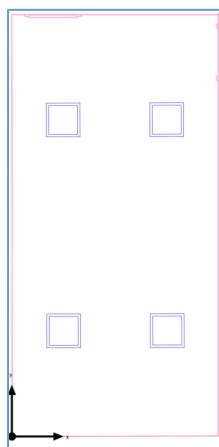


Figure 152 Secretary's luminaire layout plan.

After calculation the results came as shown in Table 26 and Figure 153.

Table 26 Results summary for Secretary.

	Symbol	Calculated	Target	Check	Index
Working plane	$\dot{E}_{\text{perpendicular}}$	426 lx	$\geq 300$ lx	✓	WP3
	$U_o$ (gr)	0.53	$\geq 0.40$	✓	WP3
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	16	$\leq 19$	✓	
Energy estimation <sup>(2)</sup>	Consumption	15.4 kWh/a	max. 1000 kWh/a	✓	
Room	Lighting power density	4.19 W/m <sup>2</sup>	-		
		0.98 W/m <sup>2</sup> /100 lx	-		

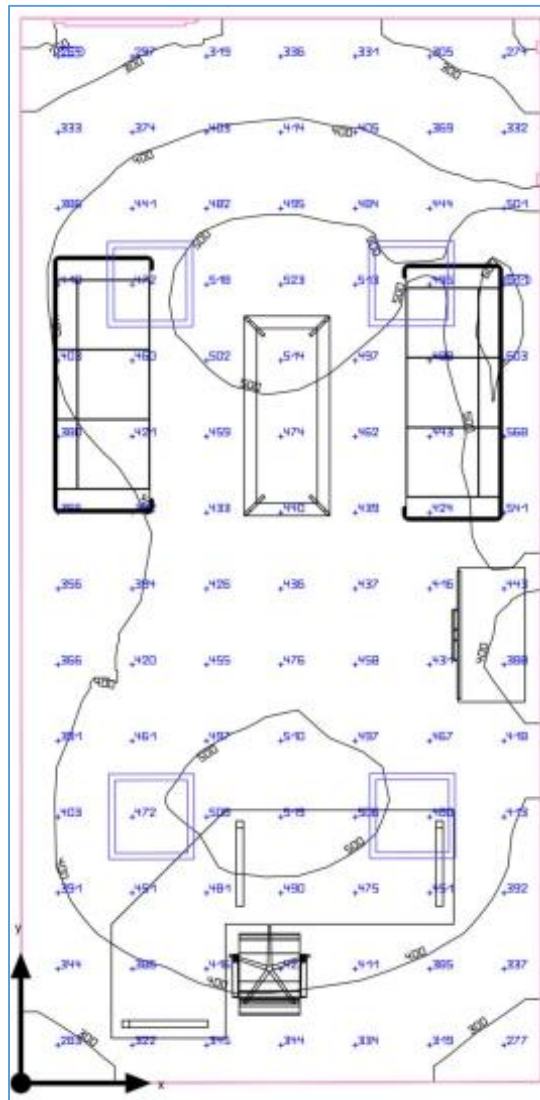


Figure 153 Results on Secretary plan.

the space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

#### 4.1.3.1.7 Security room.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_z$	Index
Working plane (Security Room) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	302 lx ( $\geq 300$ lx) ✓	207 lx	373 lx	0.69 ( $\geq 0.60$ ) ✓	0.55	WP7

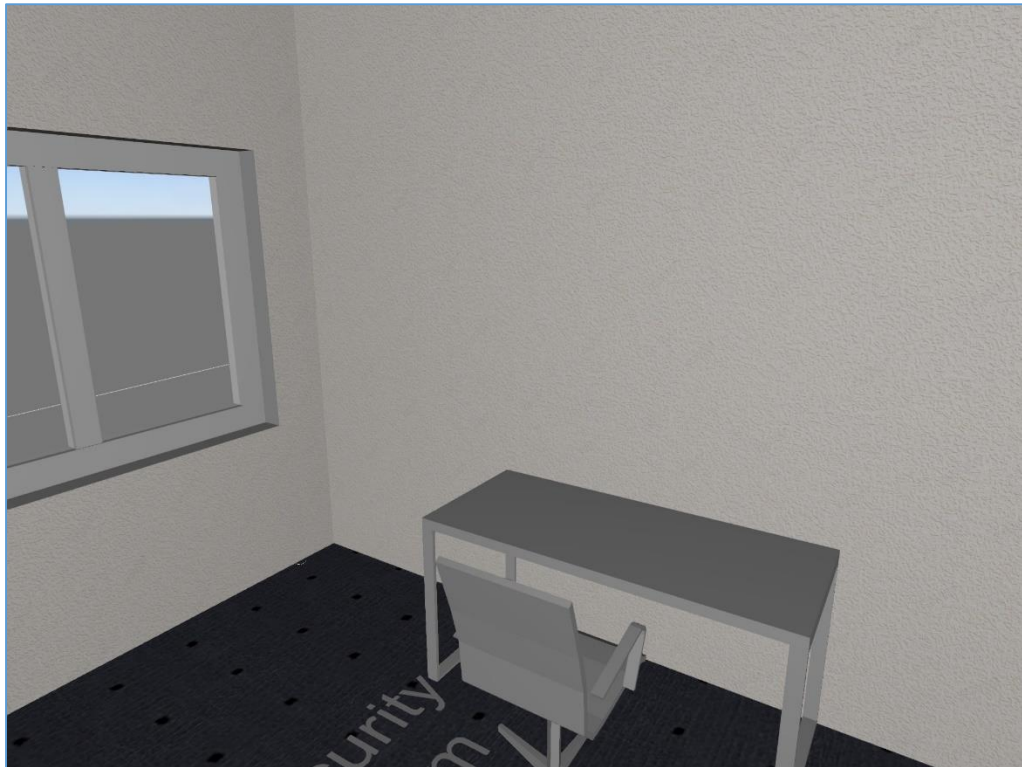


Figure 154 View of the Security room.

The type of luminaire was chosen according to their specification and its lux level. Figure 155 shows the luminaires model used.



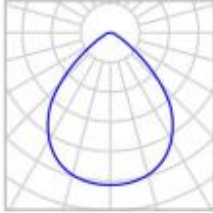
			
Manufacturer	Philips	P	28.5 W
Article name	RC461B PSD W60L60 ELD3 1 xLED40S/940	$\Phi_{\text{Luminaire}}$	4000 lm
Fitting	1x		

Figure 155 Luminaire model's specification.

Luminaire layout plan shown in Figure 152.

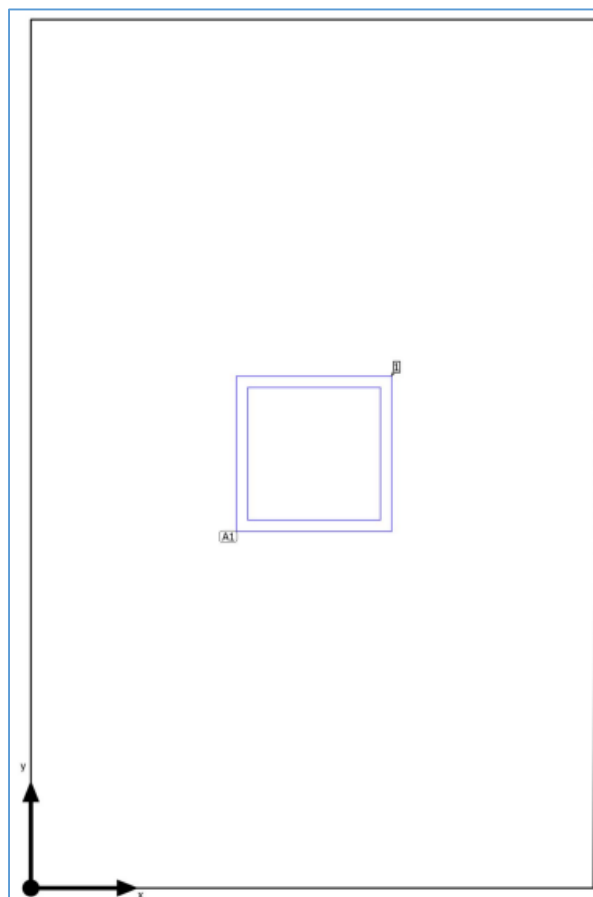


Figure 156 Security's luminaire layout plan.

After calculation the results came as shown in Table 27 and Figure 157.

Table 27 Results summary for Security.

	Symbol	Calculated	Target	Check	Index
Working plane	$E_{\text{perpendicular}}$	302 lx	$\geq 300$ lx	✓	WP7
	$U_o$ (g <sub>r</sub> )	0.69	$\geq 0.60$	✓	WP7
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	16	$\leq 19$	✓	
Energy estimation <sup>(2)</sup>	Consumption	[34.57 - 54.86] kWh/a	max. 300 kWh/a	✓	
Room	Lighting power density	3.93 W/m <sup>2</sup>	-		
		1.30 W/m <sup>2</sup> /100 lx	-		

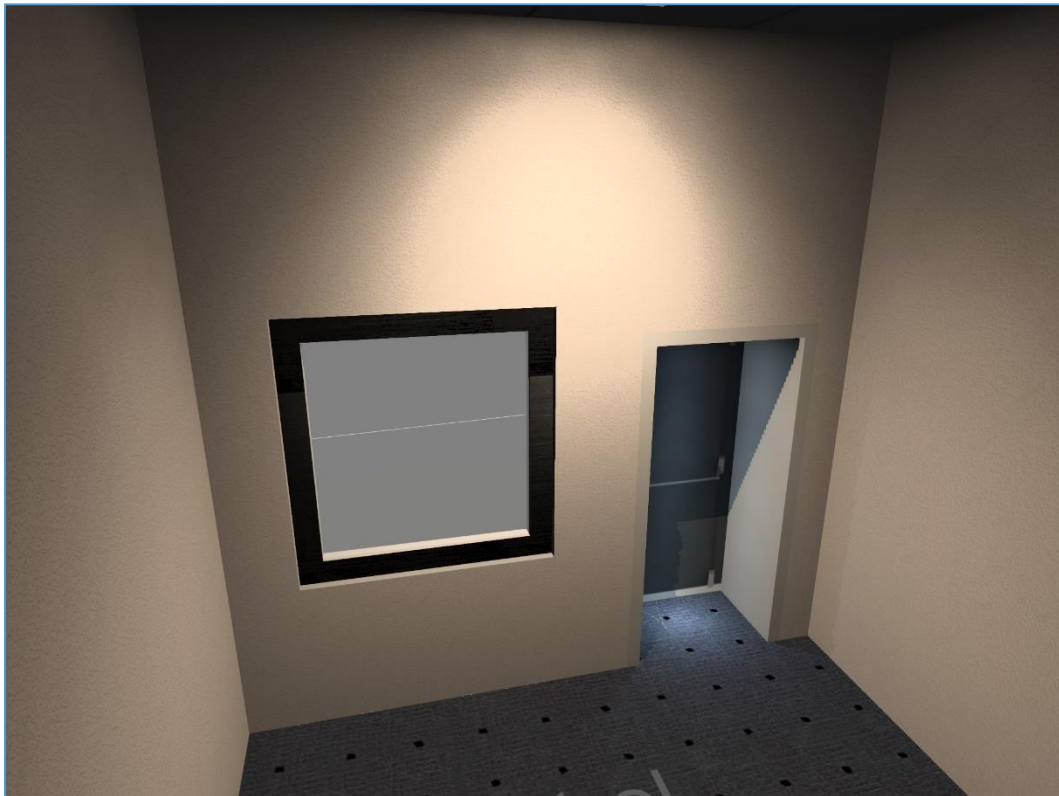


Figure 157 Results on Security plan

the space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

#### 4.1.3.1.8 Control room.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_2$	Index
Working plane (Control room) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	564 lx ( $\geq 500$ lx) ✓	334 lx	734 lx	0.59 ( $\geq 0.50$ ) ✓	0.46	WP6



*Figure 158 View of the Control room.*

The type of luminaire was chosen according to their specification and its lux level. Figure 159 shows the luminaires model used.



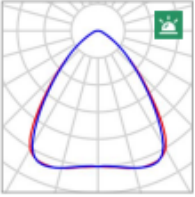
			
Manufacturer	Philips	P	25.0 W
Article name	RC342B LED36S/940 PCS W62L62	P <sub>Emergency lighting</sub>	25.0 W
Fitting	1x	Φ <sub>Luminaire</sub>	3598 lm
		Φ <sub>Emergency lighting</sub>	3598 lm
		ELF	100 %

Figure 159 Luminaire model's specification.

Luminaire layout plan shown in Figure 160.

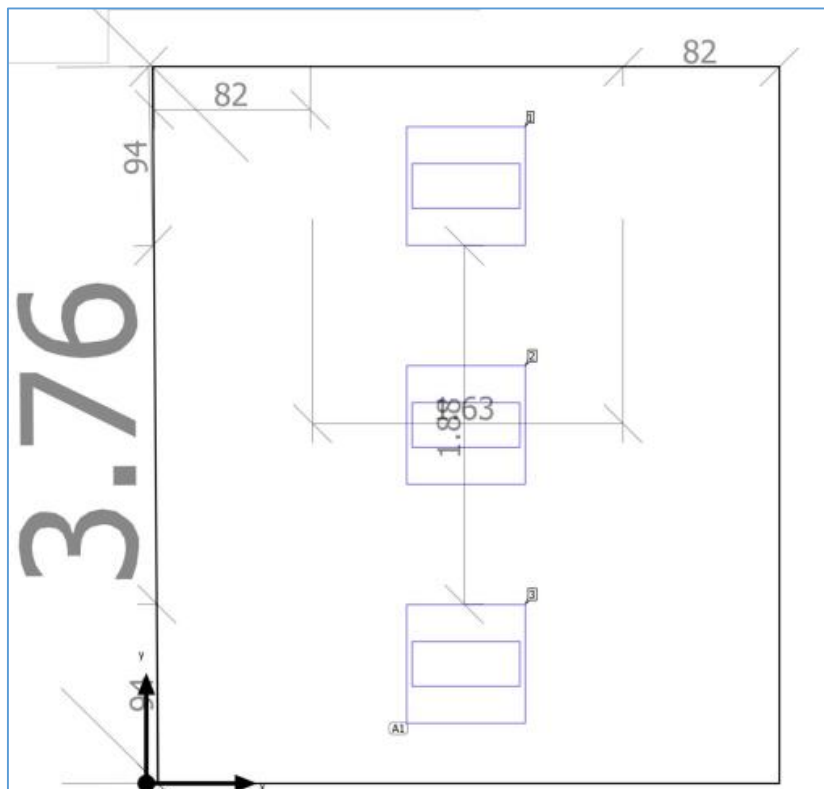


Figure 160 Control rooms' luminaire layout plan.

After calculation the results came as shown in Table 28 and Figure 161.

Table 28 Results summary for Control room..

	Symbol	Calculated	Target	Check	Index
Working plane	$E_{\text{perpendicular}}$	564 lx	$\geq 500$ lx	✓	WP6
	$U_o (g_t)$	0.59	$\geq 0.50$	✓	WP6
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	17	$\leq 19$	✓	
Energy estimation <sup>(2)</sup>	Consumption	[116.96 - 185.63] kWh/a	max. 450 kWh/a	✓	
Room	Lighting power density	6.08 W/m <sup>2</sup>	-		
		1.08 W/m <sup>2</sup> /100 lx	-		

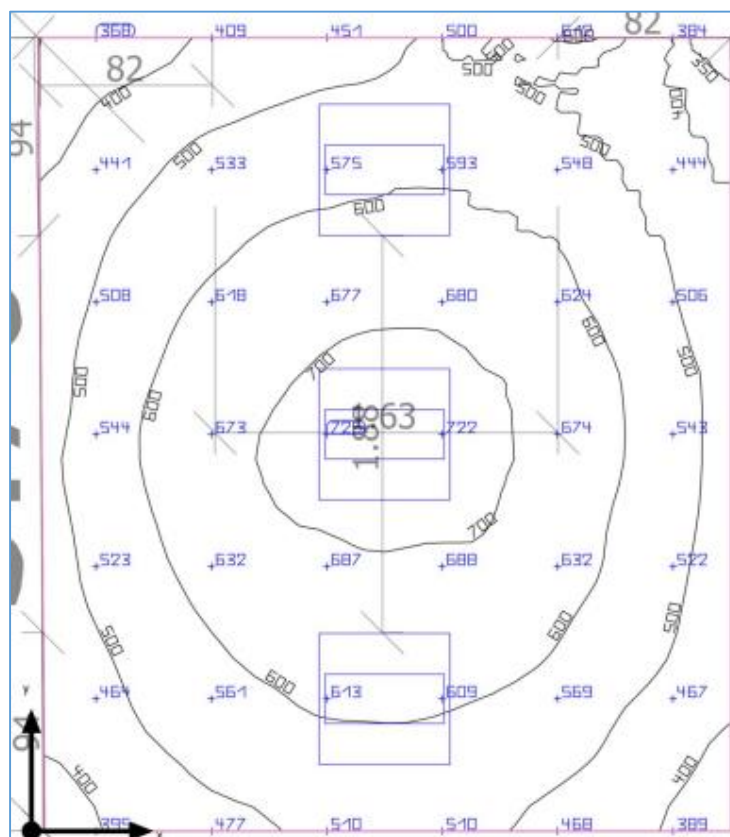


Figure 161 Results on Control room plan

the space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

4.1.3.1.9 Wc.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_2$	Index
Working plane (Corridor) Perpendicular illuminance (adaptive) Height: 0.000 m, Wall zone: 0.000 m	309 lx (≥ 100 lx) ✓	162 lx	459 lx	0.52 (≥ 0.40) ✓	0.35	WP9



Figure 162 View of the Corridor.

The type of luminaire was chosen according to their specification and its lux level. Figure 163 shows the luminaires model used.



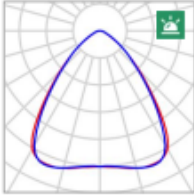
			
Manufacturer	Philips	P	25.0 W
Article name	RC342B LED36S/940 PCS W62L62	P <sub>Emergency lighting</sub>	25.0 W
Fitting	1x	Φ <sub>Luminaire</sub>	3598 lm
		Φ <sub>Emergency lighting</sub>	3598 lm
		ELF	100 %

Figure 163 Luminaire model's specification

Luminaire layout plan shown in Figure 164.

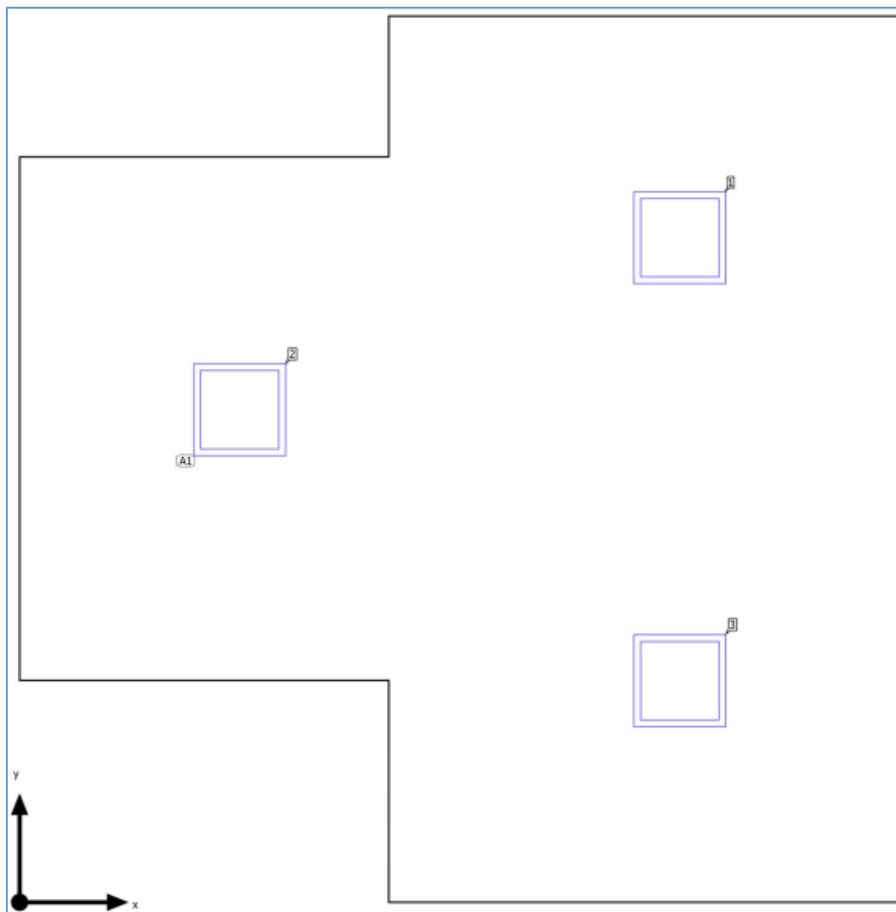


Figure 164 Corridors' luminaire layout plan.

After calculation the results came as shown in Table 29 and Figure 165.

Table 29 Results summary for Corridor.

	Symbol	Calculated	Target	Check	Index
Working plane	$E_{\text{perpendicular}}$	309 lx	$\geq 100$ lx	✓	WP9
	$U_0$ (g <sub>t</sub> )	0.52	$\geq 0.40$	✓	WP9
Glare valuation <sup>(1)</sup>	$R_{UG,max}$	16	$\leq 28$	✓	
Energy estimation <sup>(2)</sup>	Consumption	94.0 kWh/a	max. 1000 kWh/a	✓	
Room	Lighting power density	3.13 W/m <sup>2</sup>	-		
		1.01 W/m <sup>2</sup> /100 lx	-		

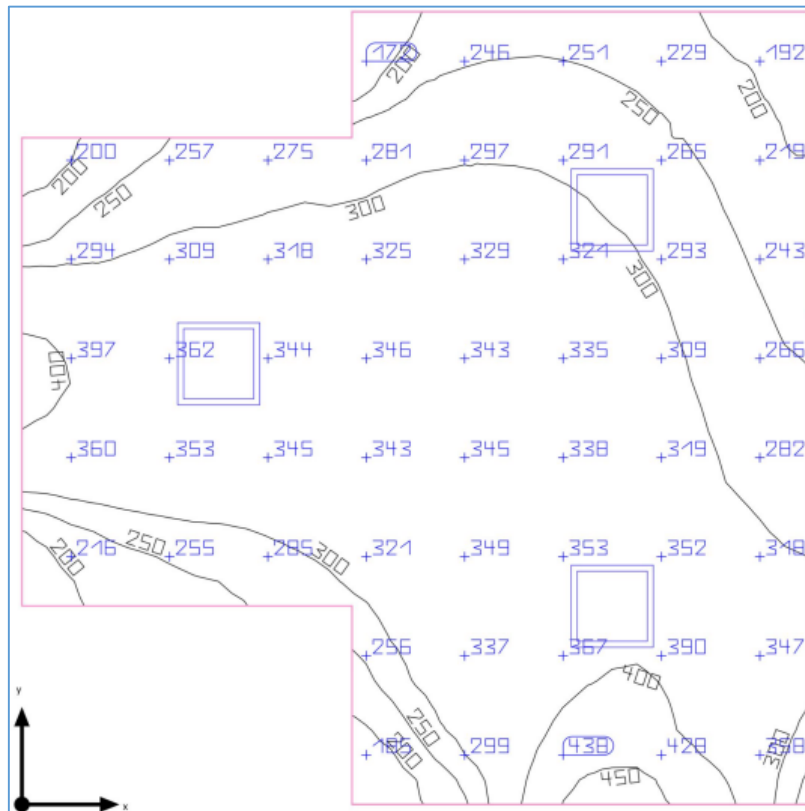


Figure 165 Results on Corridor plan

the space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

#### 4.1.3.1.10 WC.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_2$	Index
Working plane (WC) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	395 lx ( $\geq 200$ lx) ✓	263 lx	763 lx	0.67 ( $\geq 0.40$ ) ✓	0.34	WP5

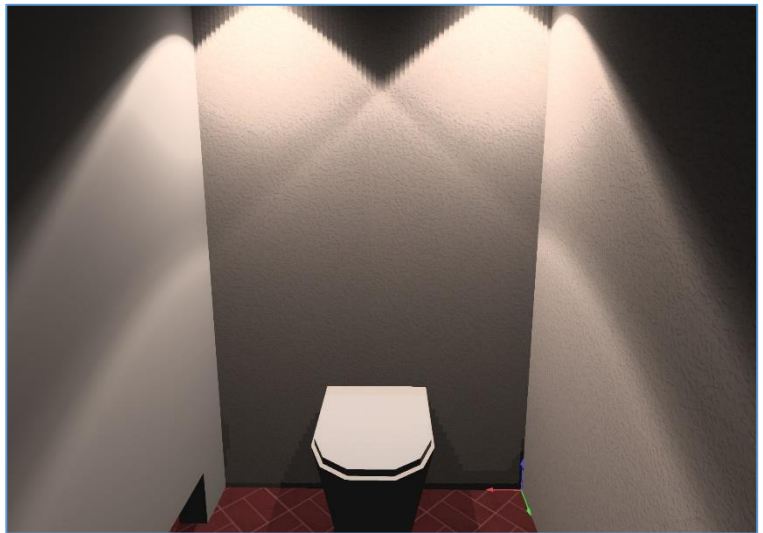


Figure 166 View of the WC.

The type of luminaire was chosen according to their specification and its lux level. Figure 167 shows the luminaires model used.



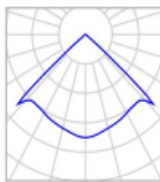



							
Manufacturer	SLV	P	8.5 W	Manufacturer	Opplé	P	34.0 W
Article No.	1006307	$\Phi_{Luminaire}$	572 lm	Article No.	542003116100	P <sub>Emergency lighting</sub>	3.7 W
Article name	OCULUS WL			Article name	LEDPanelS-P6 Sq595-34W-BLE2-940-U19-WL	$\Phi_{Luminaire}$	4080 lm
Fitting	1x LED dim-to-warm 3000K Standard			Fitting	1x LEDPanelS-P6 Sq595-34W-BLE2-940-U19-WL	$\Phi_{Emergency lighting}$	449 lm
						ELF	11 %

Figure 167 Luminaire model's specification

Luminaire layout plan shown in Figure 168.

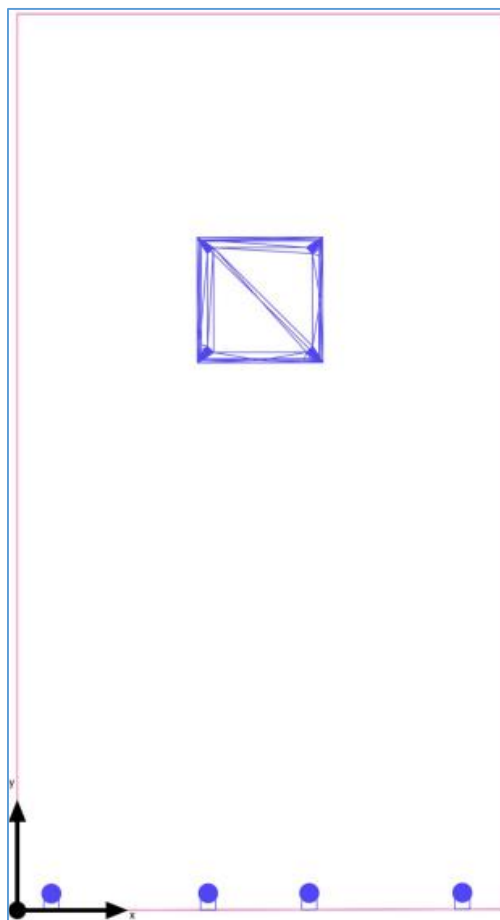


Figure 168WCs' luminaire layout plan

After calculation the results came as shown Table 30 in and Figure 169.

Table 30Results summery for WC..

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{\text{perpendicular}}$	395 lx	$\geq 200$ lx	✓	WP5
	$U_o (g_1)$	0.67	$\geq 0.40$	✓	WP5
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	25	$\leq 25$	✓	
Energy estimation <sup>(2)</sup>	Consumption	56.1 kWh/a	max. 350 kWh/a	✓	
Room	Lighting power density	6.93 W/m <sup>2</sup>	-		
		1.75 W/m <sup>2</sup> /100 lx	-		

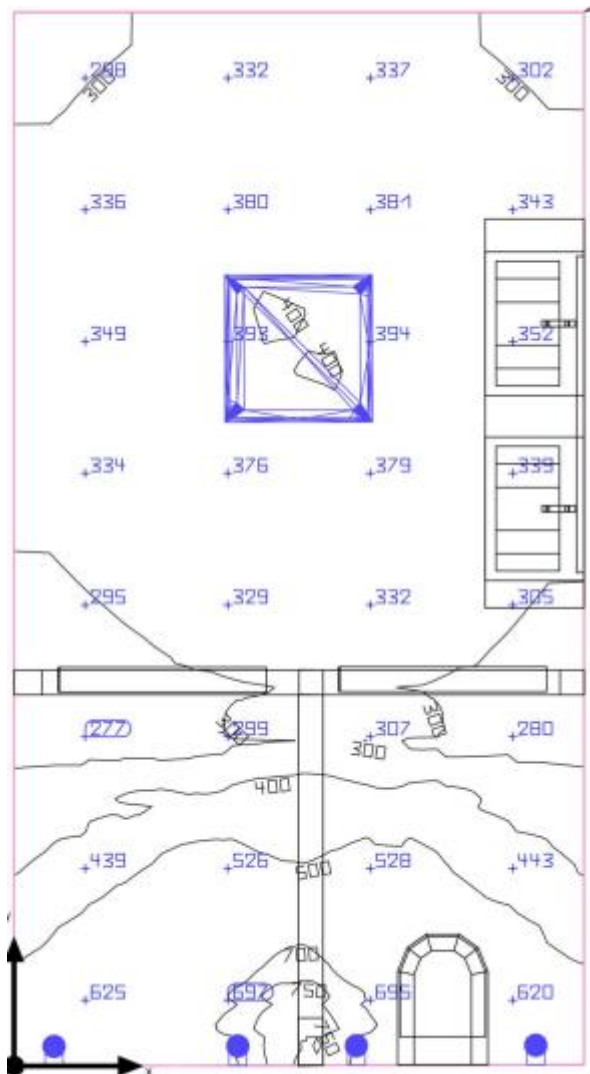


Figure 169 Results on WCS plan

the space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

#### 4.1.3.2 First floor.

The spaces that will be covered are.

- Study Area.
- Laundry.
- Store.

##### 4.1.3.2.1 Study Area.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_2$	Index
Working plane (Study Area) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	566 lx ( $\geq 500$ lx) ✓	285 lx	727 lx	0.50 ( $\geq 0.50$ ) ✓	0.39	WP3



Figure 170View of the Study Area.

The type of luminaire was chosen according to their specification and its lux level. Figure 167 shows the luminaires model used.

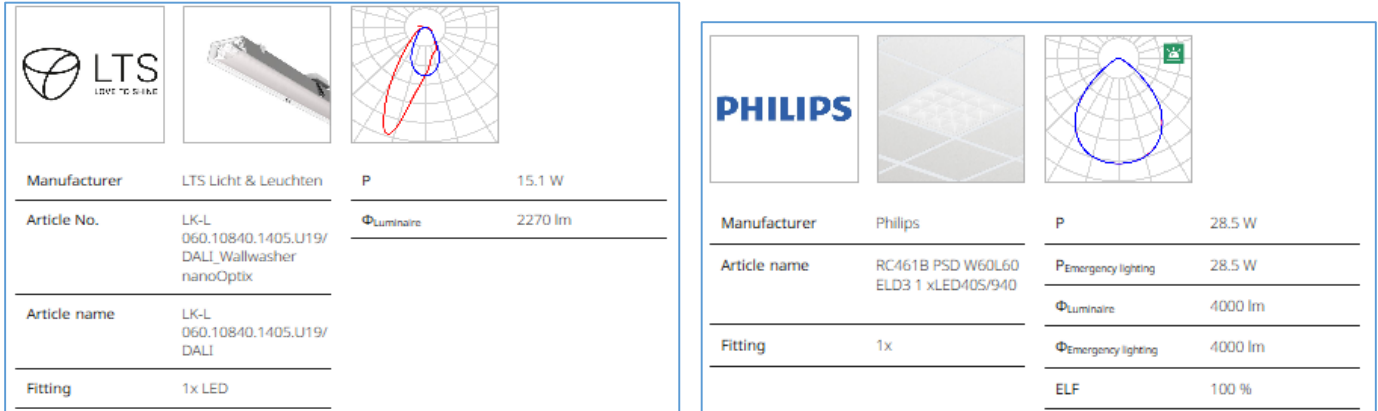


Figure 171 Luminaire model's specification

Luminaire layout plan shown in Figure 172

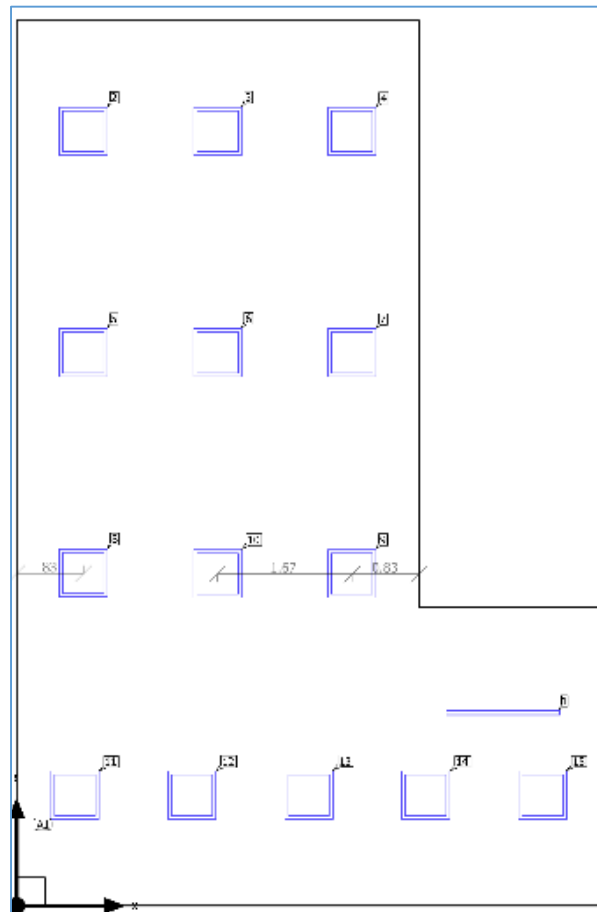


Figure 172 Study Areas' luminaire layout plan

After calculation the results came as shown Table 31 in and Figure 173

Table 31 Results Summary for Study room.

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{\text{perpendicular}}$	566 lx	$\geq 500$ lx	✓	WP3
	$U_0$ (gr.)	0.50	$\geq 0.50$	✓	WP3
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	16	$\leq 19$	✓	
Energy estimation <sup>(2)</sup>	Consumption	[994.01 - 1490.76] kWh/a	max. 2250 kWh/a	✓	
Room	Lighting power density	6.53 W/m <sup>2</sup>	-		
		1.15 W/m <sup>2</sup> /100 lx	-		

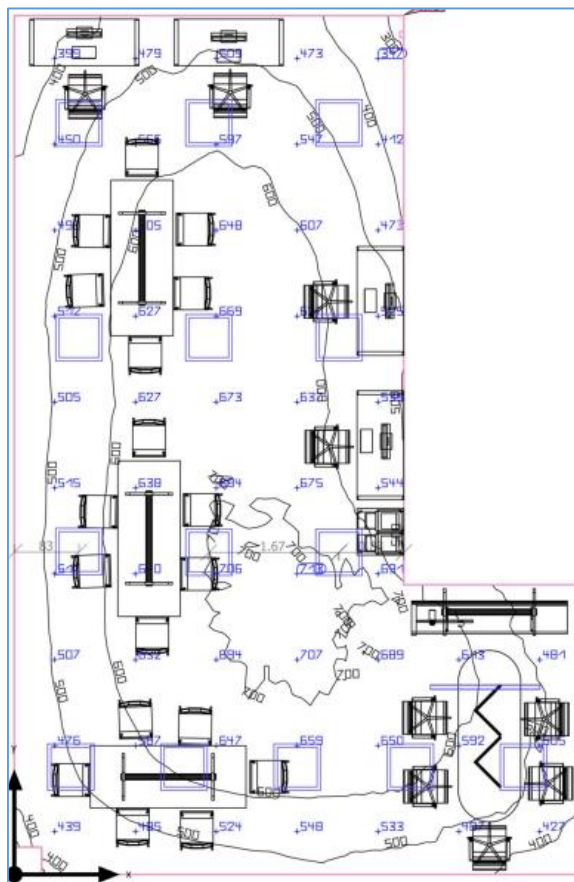


Figure 173 Results on study area plan

The space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

#### 4.1.3.2.2 Laundry.

Properties	E (Target)	E <sub>min</sub>	E <sub>max</sub>	U <sub>0</sub> (g <sub>1</sub> ) (Target)	g <sub>2</sub>	Index
Working plane (Laundry ) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	325 lx (≥ 300 lx) ✓	221 lx	409 lx	0.68 (≥ 0.60) ✓	0.54	WP4



*Figure 174View of the Laundry.*

The type of luminaire was chosen according to their specification and its lux level. Figure 175 shows the luminaires model used.



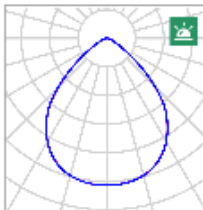
			
Manufacturer	Philips	P	28.5 W
Article name	RC461B PSD W60L60 ELD3 1 xLED40S/940	P <sub>Emergency lighting</sub>	28.5 W
Fitting	1x	Φ <sub>Luminaire</sub>	4000 lm
		Φ <sub>Emergency lighting</sub>	4000 lm
		ELF	100 %

Figure 175 Luminaire model's specification.

Luminaire layout plan shown in Figure 176.

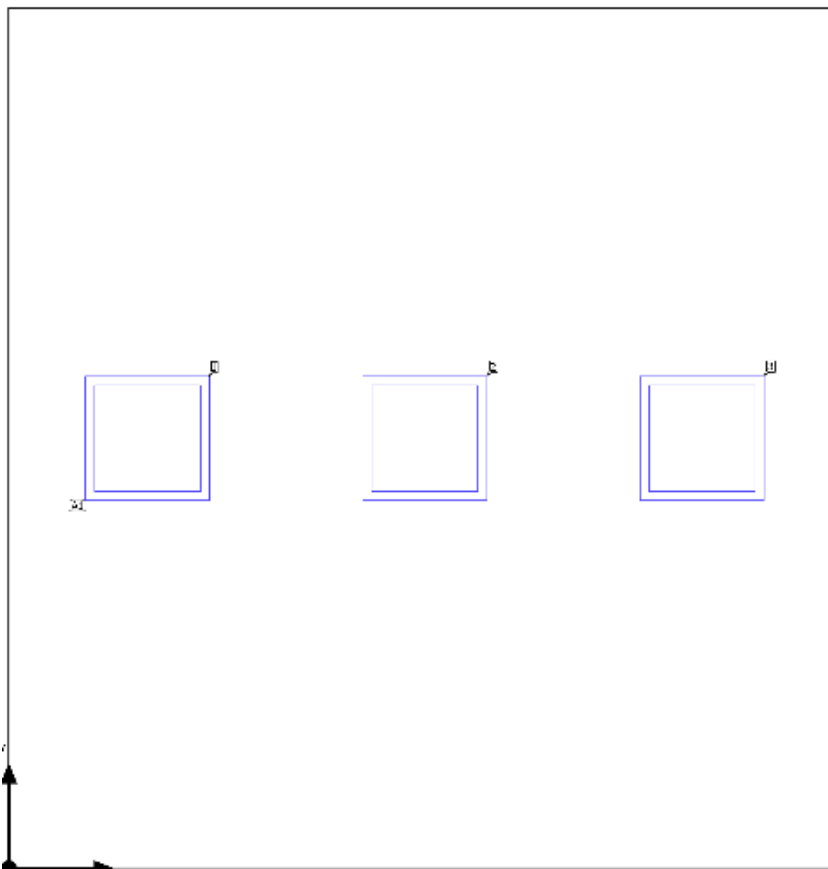


Figure 176 Laundry luminaire layout plan.

After calculation the results came as shown in and Figure 177

Table 32 Results Summary for Laundry.

	Symbol	Calculated	Target	Check	Index
Working plane	$E_{\text{perpendicular}}$	325 lx	$\geq 300$ lx	✓	WP4
	$U_o (g_i)$	0.68	$\geq 0.60$	✓	WP4
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	17	$\leq 25$	✓	
Energy estimation <sup>(2)</sup>	Consumption	[117.41 - 192.38] kWh/a	max. 600 kWh/a	✓	
Room	Lighting power density	5.16 W/m <sup>2</sup>	-		
		1.59 W/m <sup>2</sup> /100 lx	-		

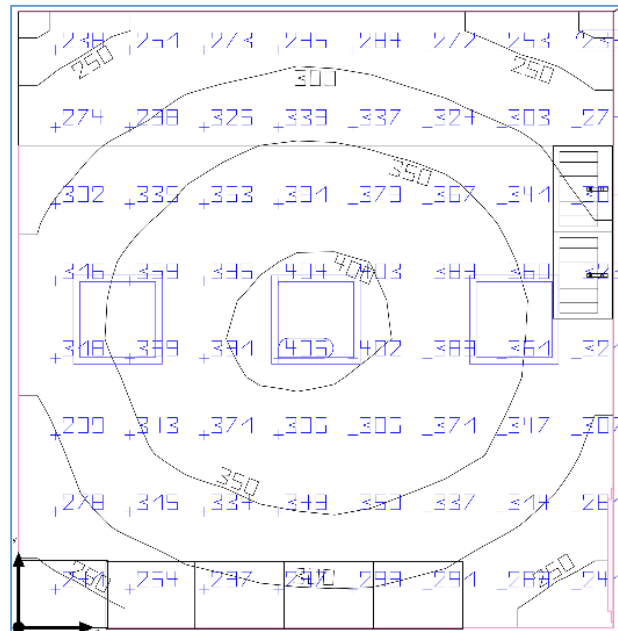


Figure 177 Results on plan

The space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

#### 4.1.3.2.3 Store.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_0 (g_1)$ (Target)	$g_2$	Index
Working plane (Store) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	463 lx ( $\geq 300$ lx) ✓	259 lx	559 lx	0.56 ( $\geq 0.40$ ) ✓	0.46	WP6



*Figure 178 View of the Store*

The type of luminaire was chosen according to their specification and its lux level. Figure 179 shows the luminaires model used.


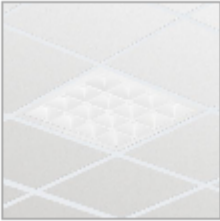
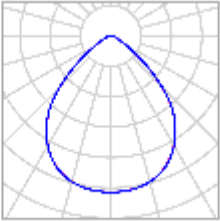
			
Manufacturer	Philips	P	28.5 W
Article name	RC461B PSD W60L60 ELD3 1 xLED40S/940	$\Phi_{\text{Luminaire}}$	4000 lm
Fitting	1x		

Figure 179 Luminaire model's specification.

Luminaire layout plan shown in Figure 180

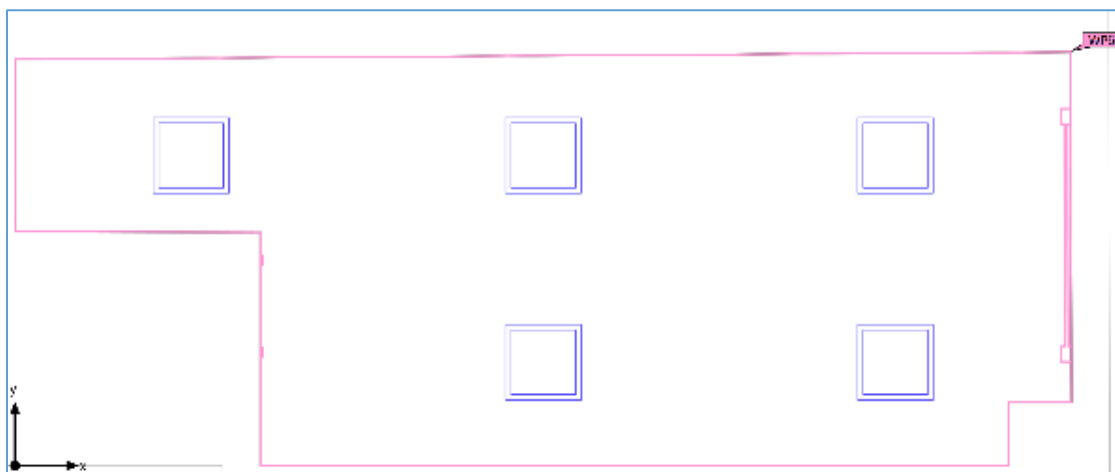


Figure 180 Store luminaire layout plan

The space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

After calculation the results came as shown Table 33 in and Figure 181.

Table 33 Results Summary for Store..

	Symbol	Calculated	Target	Check	Index
Working plane	$E_{\text{perpendicular}}$	463 lx	$\geq 300$ lx	✓	WP6
	$U_o (g_1)$	0.56	$\geq 0.40$	✓	WP6
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	16	$\leq 22$	✓	
Energy estimation <sup>(2)</sup>	Consumption	[376.25 - 513.00] kWh/a	max. 850 kWh/a	✓	
Room	Lighting power density	6.14 W/m <sup>2</sup>	-		
		1.33 W/m <sup>2</sup> /100 lx	-		

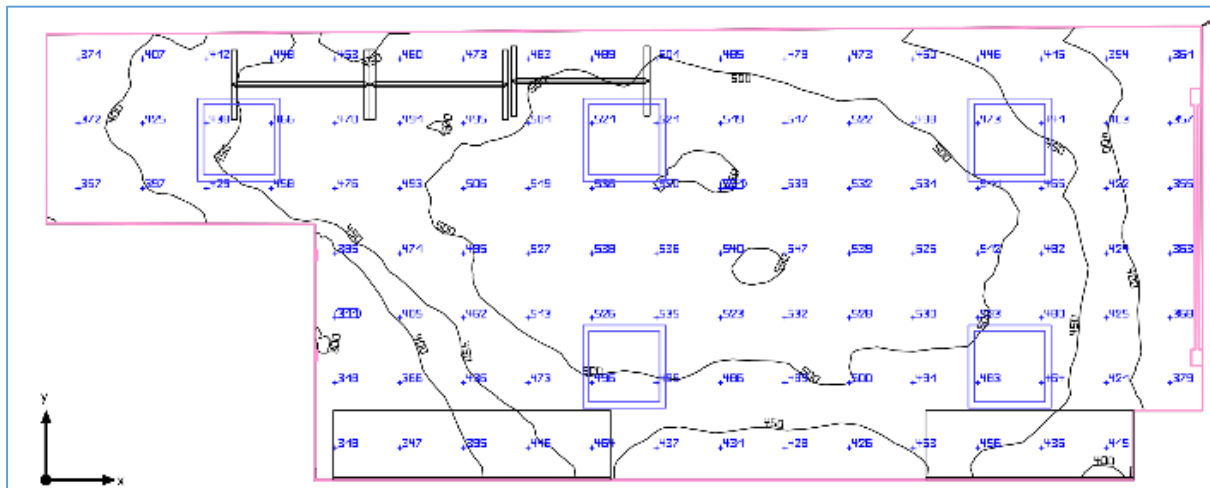


Figure 181 Results on store plan.

The space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

### 4.1.3.3 Repetitive floor.

The spaces that will be covered are.

- Dorm.
- Privet Wc.

#### 4.1.3.3.1 Dorm.

Properties	$\bar{E}$ (Target)	$E_{min}$	$E_{max}$	$U_o (g_1)$ (Target)	$g_2$	Index
Working plane (DOORM1) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	572 lx ( $\geq 500$ lx) ✓	382 lx	733 lx	0.67 ( $\geq 0.50$ ) ✓	0.52	WPS



Figure 182 View of the Dorm.

The type of luminaire was chosen according to their specification and its lux level. Figure 183 shows the luminaires model used.



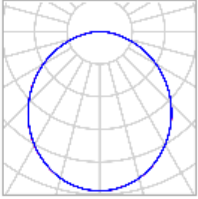
			
Manufacturer	LIGMAN	P	48.8 W
Article No.	ARD-80231-O-W40	$\Phi_{\text{Luminaire}}$	6647 lm
Article name	Arden 3 Surface ceiling luminaires		
Fitting	1x ARD-80231-O-W40		

Figure 183 Luminaire model's specification.

Luminaire layout plan shown in Figure 184

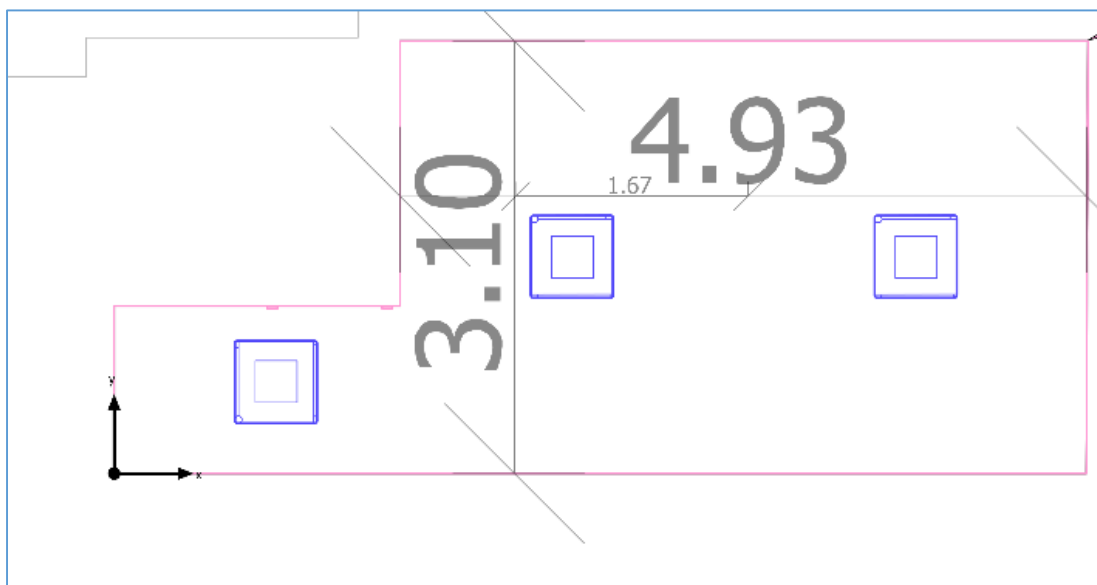


Figure 184 Dorm luminaire layout plan

After calculation the results came as shown Table 34 in and Figure 185.

Table 34 Results Summary for Dorm,.

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{\text{perpendicular}}$	572 lx	$\geq 500$ lx	✓	WP5
	$U_o (g_1)$	0.67	$\geq 0.50$	✓	WP5
Energy estimation <sup>(2)</sup>	Consumption	[228.31 - 362.34] kWh/a	max. 650 kWh/a	✓	
Room	Lighting power density	8.24 W/m <sup>2</sup>	-		
		1.44 W/m <sup>2</sup> /100 lx	-		

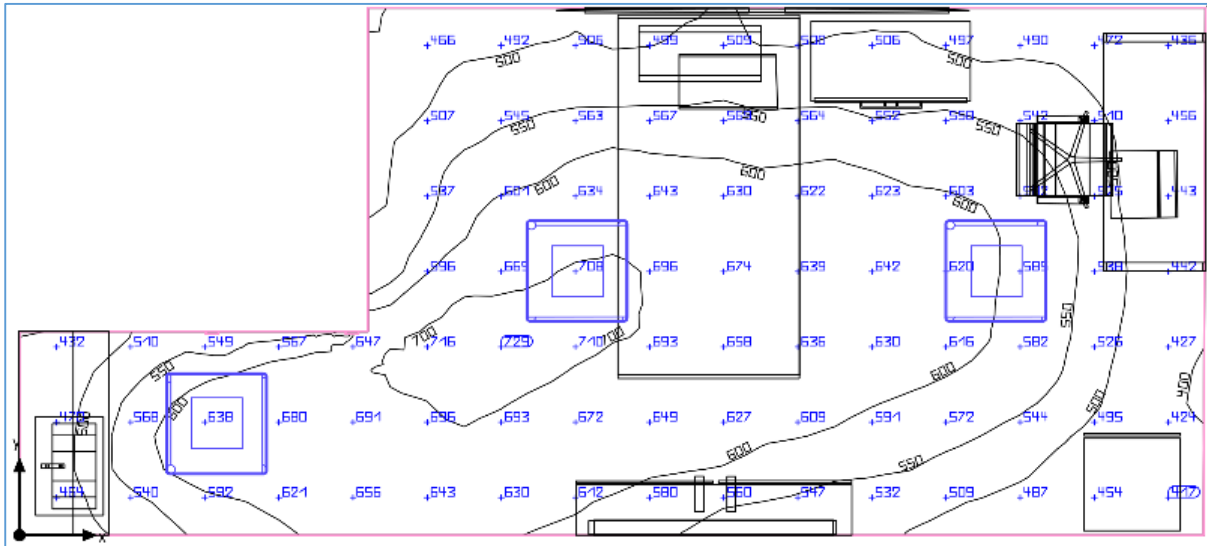


Figure 185 Results on Dorm plan.

The space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

#### 4.1.3.3.2 Privet Wc.

Properties	E (Target)	E <sub>min</sub>	E <sub>max</sub>	U <sub>0</sub> (g <sub>1</sub> ) (Target)	g <sub>2</sub>	Index
Working plane (WC) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	262 lx (≥ 200 lx) ✓	139 lx	361 lx	0.53 (≥ 0.40) ✓	0.39	WP6



The type of luminaire was chosen according to their specification and its lux level. Figure 186 shows the luminaires model used.



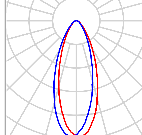
			
Manufacturer	SLV	P	72.0 W
Article No.	1002025	Φ <sub>Luminaire</sub>	3800 lm
Article name	KALU		
Fitting	1x LED QPAR111 GU10 17,5W 950lm 4000K 140°, 1x LED QPAR111 GU10 17,5W 950lm 4000K 140°, 1x LED QPAR111 GU10 17,5W 950lm 4000K 140°, 1x LED QPAR111 GU10 17,5W 950lm 4000K 140°		

Figure 186 Luminaire model's specification.

Luminaire layout plan shown in Figure 187.

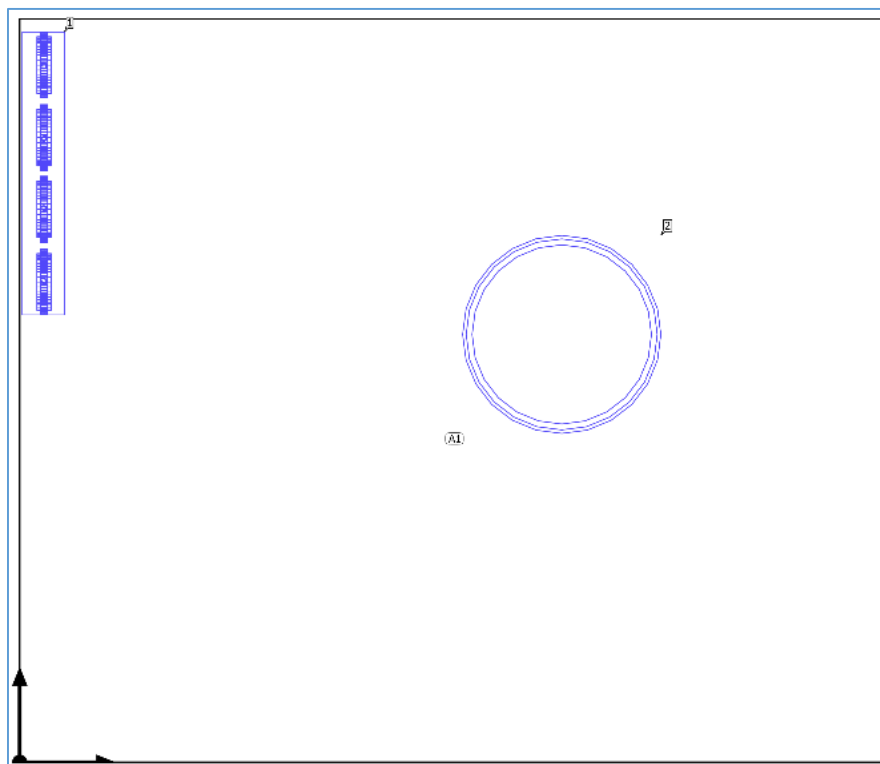


Figure 187 WC luminaire layout plan

After calculation the results came as shown Table 35 in and Figure 188

Table 35 Results Summary for WC.

	Symbol	Calculated	Target	Check	Index
Working plane	$\dot{E}_{\text{perpendicular}}$	262 lx	$\geq 200$ lx	✓	WP6
	$U_o (g_1)$	0.53	$\geq 0.40$	✓	WP6
Glare valuation <sup>(1)</sup>	$R_{UG, \text{max}}$	20	$\leq 25$	✓	
Energy estimation <sup>(2)</sup>	Consumption	[52.50 - 83.32] kWh/a	max. 150 kWh/a	✓	
Room	Lighting power density	34.84 W/m <sup>2</sup>	-		
		13.28 W/m <sup>2</sup> /100 lx	-		

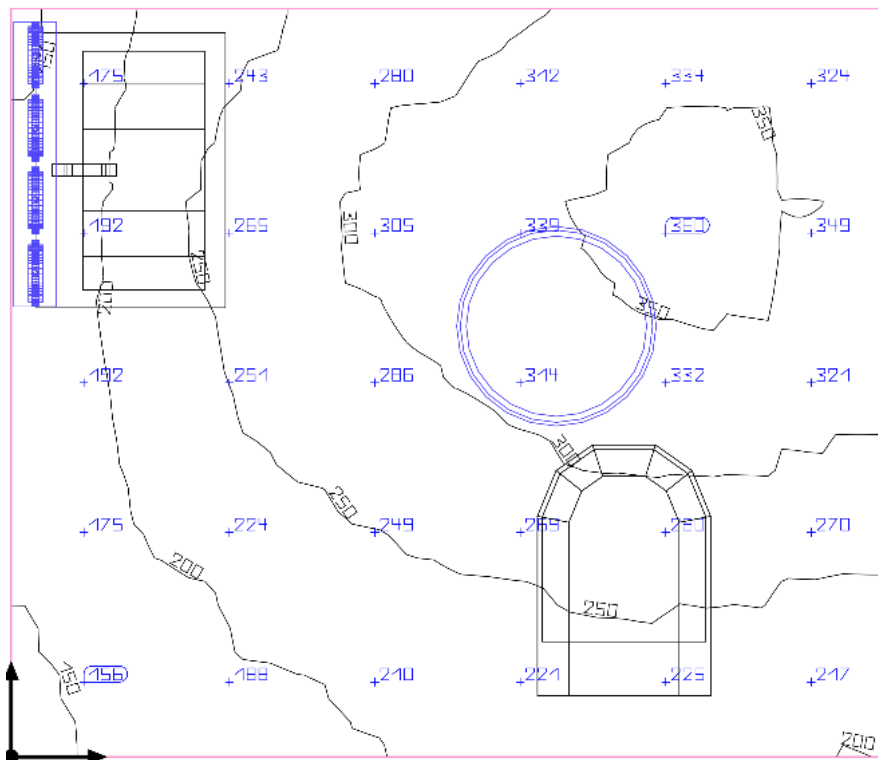


Figure 188 Results on WC plan.

The space's artificial lighting design achieves all the requirements and specifications, the light is distributed well and the glare is within the right range and not annoying.

## 4.2 Power.

### 4.2.1 Introduction.

In this section, the power is designed, from the sockets to the cables. where power is essential to achieve human comfort in space. all the elements were designed according to the standards.

### 4.2.2 Lighting and Socket Power.

In this section the lighting power and socket power will be calculated for each floor.

- GF floor
- 1-floor
- Repetitive floor.

#### 4.2.2.1 GF Floor.

##### 4.2.2.1.1 Lighting Power.

Table 36 below shows the total power used for lighting the ground floor.

Table 36GF Lighting Power.

GF FLOOR-Lightings								
SPACE	P	ILOOD	ICB	ICABE	#CB	#CB	A mm2	#CB
ENTRANCE	34	0.17171717	0.206060606	0.247273	0.020606	1	1	2
SECURITY	28.5	0.14393939	0.172727273	0.207273	0.017273	1	1	2
CONTROL ROOM	75	0.37878788	0.454545455	0.545455	0.045455	1	1	2
LOBBY-RECEPTION	688.5	3.47727273	4.172727273	5.007273	0.417273	1	1	2
CORRIDOR	85.5	0.43181818	0.518181818	0.621818	0.051818	1	1	2
CORRIDOR 1	114	0.57575758	0.690909091	0.829091	0.069091	1	1	2
CAFETERIA	285	1.43939394	1.727272727	2.072727	0.172727	1	1	2
ACCOUNTANTS	192	0.96969697	1.163636364	1.396364	0.116364	1	1	2
SECRETARY	114	0.57575758	0.690909091	0.829091	0.069091	1	1	2
ADMINISTRATION	256.5	1.29545455	1.554545455	1.865455	0.155455	1	1	2
TOTAL POWER	1873	D-POWER	1498.4					

Demand factor for light = 0.8

*Total power for light = power of light × demand factor*

*Total power for light = (1873) × (0.8) = 1498.4W*

Cable size:

To find the electricity cable diameter for lighting switches the following formula is used:

$$I_{\text{cable}} = 1.2 \times I_{\text{circuit breaker}} \rightarrow 1.2 \times 10 = 12$$

Ampere According to Table 37.

Table 37 Cross-Sectional table

Nominal cross sectional Area (mm <sup>2</sup> )	Current (ampere)
1	11
1.5	13
2.5	18
4	24
6	31
10	42
16	56
25	73
36	90
50	131

I cable = 1.5mm<sup>2</sup>.

#### 4.2.2.1.2 Socket Power.

Since each four socket are Putin on 1 CB the power for each socket was calculated as following Table 38

Table 38 Power for each socket.

GF FLOOR					
# OF OUTLETS	A	I <sub>LOAD</sub>	I <sub>Load/SOCKET</sub>	P	I <sub>LOAD</sub>
4	16	13.33333	3.333333333	660	3.333333

Table 39 shows the total power used in the ground floor.

Table 39 Shows the total socket number and power used in each space

Table 39 shows the total power used in the ground floor.

Table 39 Sum of Power in each space.

GF FLOOR						
SPACE	P	ILOOD	ICB	ICABE	#CB	#CB
ENTRANCE	0	0	0	0	0	0
SECURITY	2640	13.33333333	16	19.2	1	1
CONTROL ROOM	5280	26.66666667	32	38.4	2	2
LOBBY-RECEPTION	7920	40	48	57.6	3	3
CAFETERIA	13200	66.66666667	80	96	5	5
ACCOUNTANTS	2640	13.33333333	16	19.2	1	1
SECRETARY	5280	26.66666667	32	38.4	2	2
ADMINISTRATION	5280	26.66666667	32	38.4	2	2
TOTAL POWER	42240	D-POWER	12672			

Demand factor for power = 0.3

*Total power for power = power of light × demand factor*

*Total power for power = (42240) × (0.3) = 12672W*

#### 4.2.2.1.3 Total Power.

Total power = power light + power socket

$$12672 + 1498.4 = 14170 W$$

Power factor = 0.9 for residential.

$$I_{rated} = 14170 / (220 \times 0.9) = 71.6 A$$

$$I_{design} = 1.2^2 \times 71.6 A = 103.1 A$$

Cable size 36 mm<sup>2</sup>

#### 4.2.2.2 First-floor.

##### 4.2.2.2.1 Lighting Power.

The following Table 40 shows the total power needed for the first floor.

Table 40 First Lighting Power.

LIGHTING 1- FLOOR						
SPACE	P	ILOAD	ICB	ICABE	#CB	#CB
STORE1 +WC1	144	0.727272727	0.872727	1.047273	0.087273	1
STORE2 +WC2	144	0.727272727	0.872727	1.047273	0.087273	1
STORE3 +WC3	144	0.727272727	0.872727	1.047273	0.087273	1
STORE4 +WC4	172.5	0.871212121	1.045455	1.254545	0.104545	1
STORE5 +WC5	172.5	0.871212121	1.045455	1.254545	0.104545	1
CORRIDOR	171	0.863636364	1.036364	1.243636	0.103636	1
STUDY AREA	456	2.303030303	2.763636	3.316364	0.276364	1
LUNDARY	85.5	0.431818182	0.518182	0.621818	0.051818	1
WC	114	0.575757576	0.690909	0.829091	0.069091	1
LOBBY	28.5	0.143939394	0.172727	0.207273	0.017273	1
TOTAL POWER	1632	D-POWER	1305.6			

Demand factor for light = 0.8

*Total power for light = power of light × demand factor*

*Total power for light = (1632) × (0.8) = 1305.6W*

Cable size:

To find the electricity cable diameter for lighting switches the following formula is used:

$$I_{\text{cable}} = 1.2 \times I_{\text{circuit breaker}} \rightarrow 1.2 \times 10 = 12$$

Ampere According to Table 37.

Table 41 Cross-Sectional table

Nominal cross sectional Area (mm <sup>2</sup> )	Current (ampere)
1	11
1.5	13
2.5	18
4	24
6	31
10	42
16	56
25	73
36	90
50	131

I cable = 1.5mm<sup>2</sup>.

#### 4.2.2.2 Socket Power.

In this floor there are special loads, four sockets connected on circuit breaker and three sockets connected on one circuit breaker power for each socket was calculated as following Table 42.

Table 42 Power for each socket.

1- FLOOR									
# OF OUTLETS	A	ILOAD	Iload/SOCKET	P	ILOAD	ICB	ICABE	#CB	#CB
4	16	13.33333	3.333333333	660	3.333333	4	4.8	0.25	1
3	16	13.33333	4.444444444	880	4.444444	5.333333	6.4	0.333333	2
1	16	13.33333	13.33333333	2640	13.33333	16	19.2	1	3

Table 43 Shows the total socket number and power used in each space

Table 43 Sum of Power in each space.

TOTAL POWER					
SPACE	P	ILOOD	ICB	ICABE	#CB
STORE1 +WC1	5280	26.66666667	32	38.4	2
STORE2 +WC2	5280	26.66666667	32	38.4	2
STORE3 +WC3	5280	26.66666667	32	38.4	2
STORE4 +WC4	5280	26.66666667	32	38.4	2
STORE5 +WC5	5280	26.66666667	32	38.4	2
CORRIDOR	2640	13.33333333	16	19.2	1
STUDY AREA	10560	53.33333333	64	76.8	4
LUNDARY	13200	66.66666667	80	96	5
TOTAL POWER	52800	D-POWER	15840		

Demand factor for power = 0.3

*Total power for power = power of light × demand factor*

*Total power for power = (52800) × (0.3) = 15840W*

#### 4.2.2.2.3 Total Power.

Total power = power light + power socket

15840 + 1305.6 = 17145.6 W

Power factor = 0.9 for residential.

*I rated = 15840 / (220 × 0.9) = 80A*

*I design = 1.2<sup>2</sup> × 80A = 115.2A*

Cable size 36 mm<sup>2</sup>

#### 4.2.2.3 Repetitive floor.

##### 4.2.2.3.1 Lighting Power.

Table 44 below shows the total power used by lightings.

Table 44 Repetitive floor Lighting Power.

2-6 FLOOR					
SPACE	P	ILOAD	ICB	ICABE	#CB
STUDIO+WC1	193	0.97474747	1.169697	1.403636	0.11697
STUDIO+WC2	193	0.97474747	1.169697	1.403636	0.11697
STUDIO+WC3	193	0.97474747	1.169697	1.403636	0.11697
STUDIO+WC4	193	0.97474747	1.169697	1.403636	0.11697
STUDIO+WC5	193	0.97474747	1.169697	1.403636	0.11697
STUDIO+WC6	193	0.97474747	1.169697	1.403636	0.11697
STUDIO+WC7	193	0.97474747	1.169697	1.403636	0.11697
STUDIO+WC8	193	0.97474747	1.169697	1.403636	0.11697
STUDIO+WC9	193	0.97474747	1.169697	1.403636	0.11697
LOBBY	28.5	0.14393939	0.172727	0.207273	0.017273
CORRIDOR 1	142.5	0.71969697	0.863636	1.036364	0.086364
CORRIDOR 2	28.5	0.14393939	0.172727	0.207273	0.017273
TOTAL POWER	1550.5	D-POWER	1240.4		

Demand factor for light = 0.8

*Total power for light = power of light × demand factor*

*Total power for light = (1550.5) × (0.8) = 1240.4W*

Cable size:

To find the electricity cable diameter for lighting switches the following formula is used:

$$I_{\text{cable}} = 1.2 \times I_{\text{circuit breaker}} \rightarrow 1.2 \times 10 = 12$$

Ampere According to Table 45

Table 45 Cross-Sectional table

Nominal cross sectional Area (mm <sup>2</sup> )	Current (ampere)
1	11
1.5	13
2.5	18
4	24
6	31
10	42
16	56
25	73
36	90
50	131

I cable = 1.5mm<sup>2</sup>.

#### 4.2.2.3.2 Socket Power.

Since each four socket are Putin on 1 CB the power for each socket was calculated as following Table 46.

The furniture of the rooms were taking into consideration while distributing the sockets.

Table 46 Power for each socket.

2-6 FLOOR									
# OF OUTLETS	A	ILOAD	Iload/SOCKET	P	ILOAD	ICB	ICABE	#CB	#CB
4	16	13.33333	3.333333333	733.3333	3.703704	4.444444	5.333333	0.277778	1

Table 47 Shows the total socket number and power used in each space

Table 47 Sum of Power in each space.

2-6 FLOOR					
SPACE	P	ILOOD	ICB	ICABE	#CB
STUDIO+WC1	5280	26.6666667	32	38.4	2
STUDIO+WC2	5280	26.6666667	32	38.4	2
STUDIO+WC3	5280	26.6666667	32	38.4	2
STUDIO+WC4	5280	26.6666667	32	38.4	2
STUDIO+WC5	5280	26.6666667	32	38.4	2
STUDIO+WC6	5280	26.6666667	32	38.4	2
STUDIO+WC7	5280	26.6666667	32	38.4	2
STUDIO+WC8	5280	26.6666667	32	38.4	2
STUDIO+WC9	5280	26.6666667	32	38.4	2
TOTAL POWER	47520	D-POWER	14256		

Demand factor for power = 0.3

*Total power for power = power × demand factor*

*Total power for power (47520) × (0.3) = 114256W*

#### 4.2.2.3.3 Total Power.

Total power = power light + power socket

1240.4 + 114256 = 15496.4 W

Power factor = 0.9 for residential.

*I rated = 17080 / (220 × 0.9) = 86.3A*

*I design = 1.2<sup>2</sup> × 86.3A = 124.2A*

Cable size 36 mm<sup>2</sup>

### 4.2.3 Main Distribution Board (MDB).

$$\text{Total power} = \sum \text{Total power of each floor}$$

Results are shown in Table 48

Table 48 Total power for main distribution board.

GF	14170.4
1-FLOOR	17145.6
6 FLOORS	92978.4
CHILLIER	120000
<b>TOTAL POWER</b>	<b>244294.4</b>

$$I_{rated} = 244294.4 / (\sqrt{3} \times 220 \times 0.9) = 712.34 A$$

$$I_{c.b} = 1.15 \times 712.34 = 819.2 A$$

Hence, the circuit breaker needed 1000 Amb.

$$I_{cable} = 1.15 \times 819.2 = 942 \text{ Amb.}$$

The cross-sectional area needed for cable = 3 \* 240 mm<sup>2</sup>

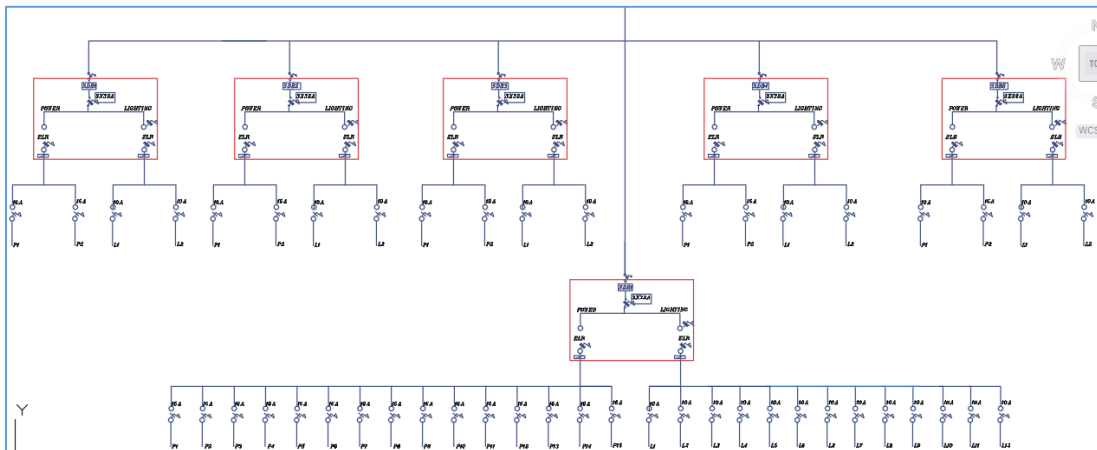


Figure 189 Main Board

## 4.3 Mechanical Design.

### 4.3.1 Water supply system.

The water supply system is a crucial part of any building, it's essential to supply the building with the proper amount of water mainly since water is a significant key to people's daily. in this section, the water supply will be designed with the diameters of the pipes and the pressure required for water on the floors.

**TABLE 20.2 Planning Guide for Water Supply\***

Building Usage	Per Capita (as Listed) Daily Usage	
	Gallons	Liters
Airports (per passenger)	3-5	11-19
Apartments, multiple-family (per resident)	60	227
Bath houses (per bather)	10	38
Camps		
Construction, semipermanent (per worker)	50	189
Day with no meals served (per camper)	15	57
Luxury (per camper)	100-150	378-568
Resorts, day and night, with limited plumbing (per camper)	50	189
Tourist, with central bath and toilet facilities (per person)	35	132
Cottages with seasonal occupancy (per resident)	50	189
Courts, tourist, with individual bath units (per person)	50	189
Clubs		
Country (per resident member)	100	378
Country (per nonresident member present)	25	95
Dwellings		
Boardinghouses (per boarder)	50	189
Additional kitchen requirements for nonresident boarders	10	38
Luxury (per person)	100-150	378-568
Multiple-family apartments (per resident)	40	151
Rooming houses (per resident)	60	227
Single family (per resident)	50-75	189-284
Estates (per resident)	100-150	378-568
Factories (per person per shift)	15-35	57-132
Highway rest area (per person)	5	19
Hotels with private baths (two persons per room)	60	227
Hotels without private baths (per person)	50	189
Institutions other than hospitals (per person)	75-125	284-473
Hospitals (per bed)	250-400	946-1514
Laundries, self-service (per washing)	50	189
Livestock (per animal)		
Cattle (drinking)	12	45
Dairy (drinking and servicing)	35	132
Goat (drinking)	2	8
Hog (drinking)	4	15
Horse (drinking)	12	45
Mule (drinking)	12	45
Sheep (drinking)	2	8
Steer (drinking)	12	45
Motels with bath, toilet, and kitchen facilities (per bed space)	50	189
With bed and toilet (per bed space)	40	151
Parks		
Overnight, with flush toilets (per camper)	25	95
Trailer, with individual bath units, no sewer connection (per trailer)	25	95
Trailer, with individual bath, connected to sewer (per person)	50	189
Picnic		
With bath houses, showers, and flush toilets (per picnicker)	20	76
With toilet facilities only (per picnicker)	10	38
Poultry		
Chickens (per 100)	5-10	19-38
Turkeys (per 100)	10-18	38-68
Restaurants with toilet facilities (per patron)	7-10	26-38
Without toilet facilities (per patron)	2 1/2-3	9-11
With bar/cocktail lounge (additional quantity per patron)	2	8
Schools		
Boarding (per pupil)	75-100	284-378
Day, with cafeteria, gymnasium, and showers (per pupil)	25	95
Day, with cafeteria but no gymnasiums or showers (per pupil)	20	76
Day, without cafeteria, gymnasium, or showers (per pupil)	15	57
Service stations (per vehicle)	10	38
Stores (per toilet room)	400	1514
Swimming pools (per swimmer)	10	38
Theaters		
Drive-in (per car space)	5	19
Movie (per auditorium seat)	5	19
Workers		
Construction (per person per shift)	50	189
Day (school or office, per person per shift)	15	57

Figure 190 water supply (Grondzik, Kwok, Stein, & Reynolds, 2010, P.872)

The daily usage was calculated from Figure 190 according to the space function and the number of users per day the results are as shown in Table 49.

Table 49 Water Usage.

Water Supply				
Space	Number	Per Capita Daily Usage	L/day	m3/L
studios	72	151	10872	10.872
Lundryary	2	1000	2000	2
Cafetera	28	75	2100	2.1
office	5	57	285	0.285
Total			15257	15.257

#### 4.3.1.1 Domestic hot water consumption.

TABLE 21.10 Domestic Hot Water, Commercial/Institutional

Type of Building	Maximum Hour	Maximum Day	Average Day
Men's dormitories	3.8 gal (14.4 L)/student	22.0 gal (83.4 L)/student	13.1 gal (49.7 L)/student
Women's dormitories	5.0 gal (19 L)/student	26.5 gal (100 L)/student	12.3 gal (46.6 L)/student
Motels: no. of units <sup>a</sup>			
20 or less	6.0 gal (23 L)/unit	35.0 gal (132.6 L)/unit	20.0 gal (75.8 L)/unit
60	5.0 gal (20 L)/unit	25.0 gal (94.8 L)/unit	14.0 gal (53.1 L)/unit
100 or more	4.0 gal (15 L)/unit	15.0 gal (56.8 L)/unit	10.0 gal (37.9 L)/unit
Nursing homes	4.5 gal (17 L)/bed	30.0 (114 L)/bed	18.4 gal (69.7 L)/bed
Office buildings	0.4 gal (1.5 L)/person	2.0 gal (7.6 L)/person	1.0 gal (3.8 L)/person
Food service establishments:			
Type A—full meal restaurants and cafeterias	1.5 gal (5.7 L)/max meals/h	11.0 gal (41.7 L)/max meals/h	2.4 gal (9.1 L)/avg meals/day <sup>b</sup>
Type B—drive-ins, grilles, luncheonettes, sandwich and snack shops	0.7 gal (2.6 L)/max meals/h	6.0 gal (22.7 L)/max meals/h	0.7 gal (2.6 L)/avg meals/day <sup>b</sup>
Apartment houses: no. of apartments			
20 or less	12.0 gal (45.5 L)/apt.	80.0 gal (303.2 L)/apt.	42.0 gal (159.2 L)/apt.
50	10.0 gal (37.9 L)/apt.	73.0 gal (276.7 L)/apt.	40.0 gal (151.6 L)/apt.
75	8.5 gal (32.2 L)/apt.	66.0 gal (250 L)/apt.	38.0 gal (144 L)/apt.
100	7.0 gal (26.5 L)/apt.	60.0 gal (227.4 L)/apt.	37.0 gal (140.2 L)/apt.
200 or more	5.0 gal (19 L)	50.0 gal (195 L)/apt.	35.0 gal (132.7 L)/apt.
Elementary schools	0.6 gal (2.3 L)/student	1.5 gal (5.7 L)/student	0.6 gal (2.3 L)/student <sup>b</sup>
Junior and senior high schools	1.0 gal (3.8 L)/student	3.6 gal (13.6 L)/student	1.8 gal (6.8 L)/student <sup>b</sup>

Figure 191 Domestic hot water consumption (Grondzik, Kwok, Stein, & Reynolds, 2010, P.944).

In a building, 3.8 liters per student is needed for water supply in a day. The largest number of users of the building per day is about 90 users, the total daily water needed is 342 liters/day, which equal 0.35 m3 /day.

### 4.3.1.2 Diameter Calculations.

#### 4.3.1.2.1 Water Pressure.

In this building, roof tanks will be used, the water pressure will be  $0.433h$ , where  $h$  is the distance between the lavatory and the middle of the tank.

The pressure of each floor was calculated as shown in Table 50.

Table 50 Pressure/ floor.

FLOOR	GF	1	2	3	4	5	6	7
PSI	41.19751	36.5805458	31.96358	27.34662	22.7296595	18.1127	13.4957353	8.878773

#### 4.3.1.2.2 Water Supply Fixture.

Fixture	Occupancy	Type of Supply Control	Load Values in WSFU		
			Cold	Hot	Total
Bathroom group	Private	Flush tank	2.7	1.5	3.6
Bathroom group	Private	Flush valve	6	3	8
Bathtub	Private	Faucet	1	1	1.4
Bathtub	Public	Faucet	3	3	4
Bidet	Private	Faucet	1.5	1.5	2
Combination fixture	Private	Faucet	2.25	2.25	3
Dishwashing machine	Private	Automatic		1.4	1.4
Drinking fountain	Offices, etc.	¼ in. (9.5 mm) valve	0.25		0.25
Kitchen sink	Private	Faucet	1	1	1.4
Kitchen sink	Hotel, restaurant	Faucet	3	3	4
Laundry trays (1 to 3)	Private	Faucet	1	1	1.4
Lavatory	Private	Faucet	0.5	0.5	0.7
Lavatory	Public	Faucet	1.5	1.5	2
Service sink	Offices, etc.	Faucet	2.25	2.25	3
Shower head	Public	Mixing valve	3	3	4
Shower head	Private	Mixing valve	1	1	1.4
Urinal	Public	1 in. (25 mm) flush valve	10		10
Urinal	Public	¾ in. (19 mm) flush valve	5		5
Urinal	Public	Flush tank	3		3
Washing machine, 8 lb (3.6 kg)	Private	Automatic	1	1	1.4
Washing machine, 8 lb (3.6 kg)	Public	Automatic	2.25	2.25	3
Washing machine, 15 lb (6.8 kg)	Public	Automatic	3	3	4
Water closet	Private	Flush valve	6		6
Water closet	Private	Flush tank	2.2		2.2
Water closet	Public	Flush valve	10		10
Water closet	Public	Flush tank	5		5
Water closet	Public or private	Flushometer tank	2		2

Figure 192 Water Supply Fixture Units (Grondzik, Kwok, Stein, & Reynolds, 2010, P.991)

Using Figure 192 above the WFUs were found to be as shown in Table 51

Table 51 Total FUs for each Zone.

Zone	FUS
ZONE1	51
ZONE2	78
ZONE3	34
ZONE4	62

#### 4.3.1.2.3 Water Flow rates.

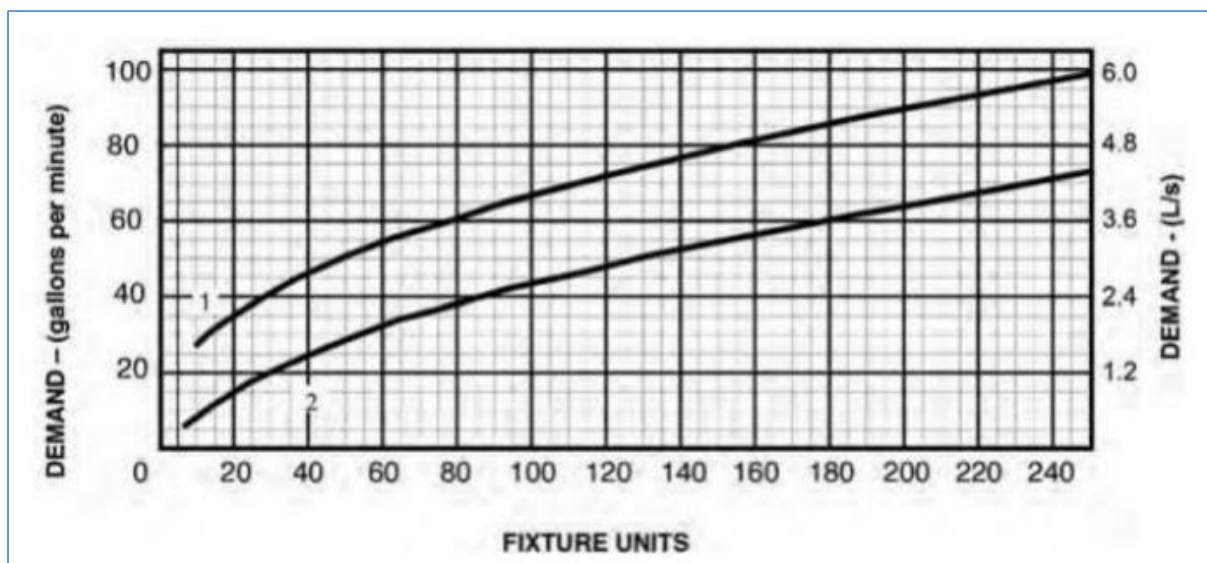


Figure 193 Water flow rate (Grondzik, & Kwok, 2015, P.919)

From Figure 193 above the flow rate was found to be as shown in Table 52

Table 52 Water flow rate for zones

ZONES	PIPE	FU'S	water flow
ZONE1	Vertical	51	29
	horizontal	17.1	14
	Branch	2.2	3
ZONE2	Vertical	78	39
	horizontal	30	20
	Branch	4	4.5
ZONE3	Vertical	34	22
	horizontal	11.4	10
	Branch	2.2	3
ZONE4	Vertical	62	35
	horizontal	28	18
	Branch	4	4.5

4.3.1.2.4 Determined diameter pipe & pressure drop.

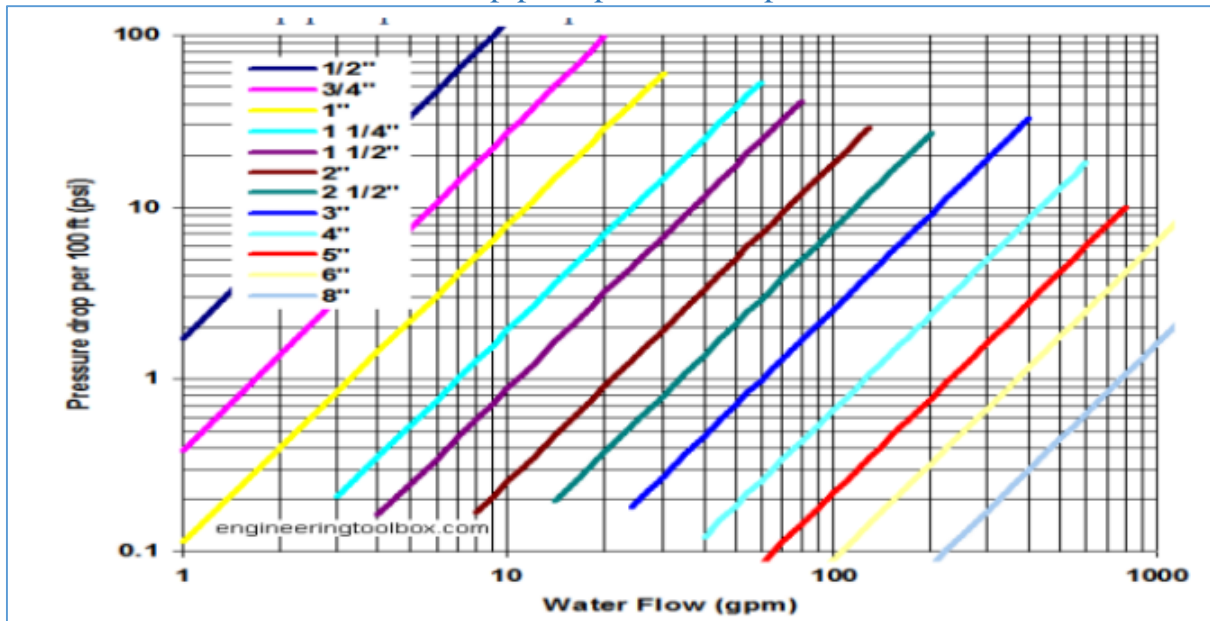


Figure 194 Diameter & pressure drop per 100 ft(psi) for steel pipe

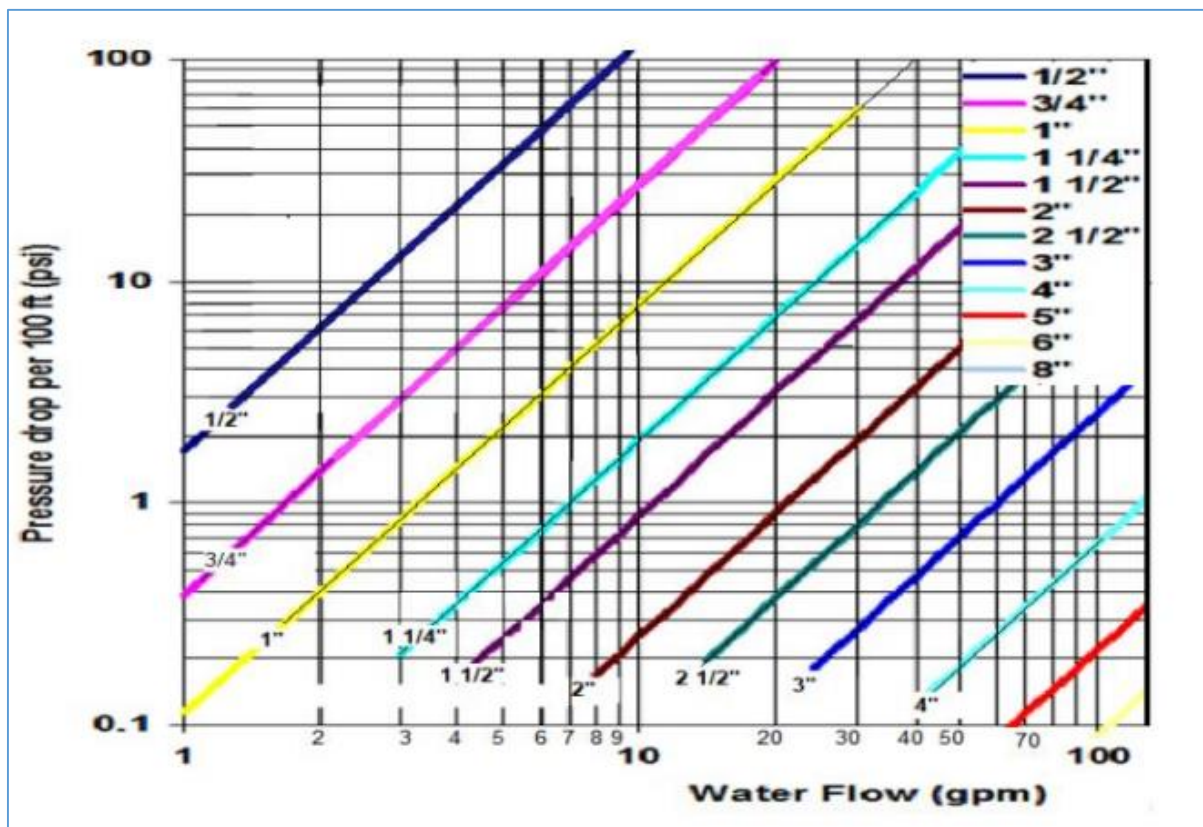


Figure 195 Diameter & pressure drop per 100 ft (psi) for plastic pipe

### Friction Pressure Loss in Water Meters

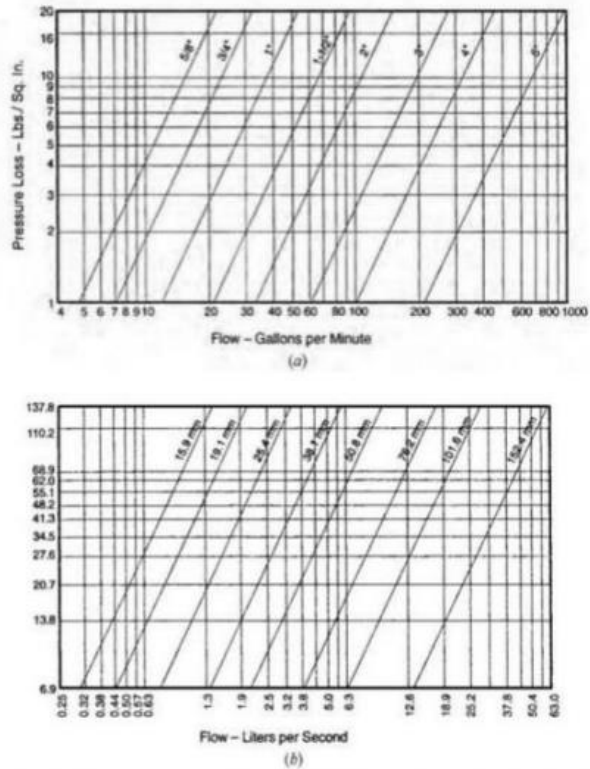


Fig. 21.63 Pressure losses in disk-type water meters. (a) I-P units. (b) SI units. (Reprinted by permission from the 1997 Uniform

To find the diameters and losses the effective length was calculated for each water line that serve a different zone as shown in Table 53

From figures above the possible diameters and losses for vertical, meter, horizontal & branches were determined as shown in Table 54, Table 55, Table 56 and Table 57.

Table 53 Effective Lengths

ZONES	PIPE	L	E.L
ZONE1	Vertical	83.36	125.04
	horizontal	11.5	13.8
	Branch	13.12	15.744
ZONE2	Vertical	104.7	157.05
	horizontal	11.5	13.8
	Branch	32	38.4
ZONE3	Vertical	83.36	125.04
	horizontal	18.7	22.44
	Branch	20	24
ZONE4	Vertical	115	172.5
	horizontal	13.12	15.744
	Branch	40	48

Table 54 Possible Diameters and losses for Zone1

ZONE1				
virtical				
daiminsion	5'	4'	3'	2.5'
loss/100	0.3	0.9	3.5	9
loss/125	0.375	1.125	4.375	11.25
horizontal				
daiminsion	2 1/2'	2	1 1/2'	1 1/4'
loss/100	0.15	0.4	1.2	2.7
loss/13.8	0.0207	0.0552	0.1656	0.3726
meter				
daiminsion	1 1/4'	1	3/4'	5/6'
loss/100	0.5	1.3	3.5	8
BRANCH				
daiminsion	2 1/2'	2	1 1/2'	1 1/4'
loss/100	0.2	0.4	1.6	3
loss/15.7	0.0314	0.0628	0.2512	0.471

Table 55 Possible Diameters and losses for Zone2.

ZONE2				
virtical				
daiminsion	6'	5'	4'	3'
loss/100	0.12	0.2	1.5	5
loss/157	0.1884	0.314	2.355	7.85
horizontal				
daiminsion	3'	2	1 1/2'	1 1/4'
loss/100	0.15	0.4	1.2	2.7
loss/13.8	0.0207	0.0552	0.1656	0.3726
meter				
daiminsion	1 1/2'	1 1/4'	1	3/4'
loss/100	0.7	1.2	2.7	4.5
BRANCH				
daiminsion	2 1/2'	2 1/2'	2	1 1/2'
loss/100	0.4	1	3	9
loss/38	0.152	0.38	1.14	3.42

Table 56 Possible Diameters and losses for Zone3

ZONE3				
virtical				
daiminsion	5'	4'	3'	2.5'
loss/100	0.3	0.9	3.5	9
loss/125	0.375	1.125	4.375	11.25
horizontal				
daiminsion	3'	2	1 1/2'	1 1/4'
loss/100	0.4	1	4	8
loss/22.4	0.0896	0.224	0.896	1.792
meter				
daiminsion	1 1/4'	1	3/4'	5/6'
loss/100	0.3	0.7	1.7	4
BRANCH				
daiminsion	3'	2 1/2'	2	1 1/2'
loss/100	0.4	1	3	9
loss/38	0.152	0.38	1.14	3.42

Table 57 Possible Diameters and losses for Zone4

ZONE4				
virtical				
daiminsion	6'	5'	4'	3'
loss/100	0.23	0.5	1.2	6
loss/172.5	0.39675	0.8625	2.07	10.35
horizontal				
daiminsion	2 1/2'	2	1 1/2'	1 1/4'
loss/100	0.2	0.4	1.4	2
loss/15.74	0.03148	0.06296	0.22036	0.3148
meter				
daiminsion	2 1/2'	2	1 1/2'	1 1/4'
loss/100	0.6	1.5	3.8	5.5
BRANCH				
daiminsion	4'	3'	2 1/2'	2
loss/100	0.18	0.7	2.1	4
loss/48	0.0864	0.336	1.008	1.92

The diameters of the pipes were chosen according to the least losses, Table 58 shows the diameters chosen.

Table 58 Chosen Diameter and total losses.

WS1					
LINE	VERTICAL	METER	HORIZONTAL	BRANCH	Total Loss
daiminsion	4'	1 1/4'	1 1/4'	1 1/4'	2.466
loss/100	1.125	0.5	0.37	0.471	
WS2					
LINE	VERTICAL	METER	HORIZONTAL	BRANCH	Total Loss
daiminsion	4'	1 1/2'	1 1/2'	2 1/2'	3.61
loss/100	2.36	0.7	0.17	0.38	
WS3					
LINE	VERTICAL	METER	HORIZONTAL	BRANCH	Total Loss
daiminsion	4'	1 1/4'	1 1/4'	2 1/2'	3.605
loss/100	1.125	0.3	1.8	0.38	
WS4					
LINE	VERTICAL	METER	HORIZONTAL	BRANCH	Total Loss
daiminsion	4'	2'	2'	2'	5.553
loss/100	2.07	1.5	0.063	1.92	

The need of pumps and limiters were determined in Table 59.

Table 59 Losses in floors and pump Calculations.

# FLOOR	WS	Available pressure	Critical pressure	Maximum Allowable	Total loss	Max-tot.loss	limeter capcity	pump capacity
2-FLOOR	WS1	31.9635837	12	19.9635837	2.466	17.4975837	22 Psi	-
	WS2	31.9635837	12	19.9635837	3.61	16.3535837	21Psi	-
	WS3	31.9635837	12	19.9635837	3.605	16.3585837	21 Psi	-
	WS4	31.9635837	12	19.9635837	5.553	14.4105837	20 Psi	-
3-FLOOR	WS1	27.34662161	12	15.34662161	2.466	12.88062161	17 Psi	-
	WS2	27.34662161	12	15.34662161	3.61	11.73662161	16Psi	-
	WS3	27.34662161	12	15.34662161	3.605	11.74162161	16Psi	-
	WS4	27.34662161	12	15.34662161	5.553	9.79362161	14Psi	-
4-FLOOR	WS1	22.72965952	12	10.72965952	2.466	8.26365952	8 Psi	-
	WS2	22.72965952	12	10.72965952	3.61	7.11965952	7 Psi	-
	WS3	22.72965952	12	10.72965952	3.605	7.12465952	7 Psi	-
	WS4	22.72965952	12	10.72965952	5.553	5.17665952	-	-
5-FLOOR	WS1	18.11269743	12	6.11269743	2.466	3.64669743	-	-
	WS2	18.11269743	12	6.11269743	3.61	2.50269743	-	-
	WS3	18.11269743	12	6.11269743	3.605	2.50769743	-	-
	WS4	18.11269743	12	6.11269743	5.553	0.55969743	-	-
6-FLOOR	WS1	13.49573534	12	1.49573534	2.466	-0.97026466	-	5 psi
	WS2	13.49573534	12	1.49573534	3.61	-2.11426466	-	5 psi
	WS3	13.49573534	12	1.49573534	3.605	-2.10926466	-	5 psi
	WS4	13.49573534	12	1.49573534	5.553	-4.05726466	-	5 psi
7-FLOOR	WS1	8.87877325	12	-3.12122675	2.466	-5.58722675	-	5 psi
	WS2	8.87877325	12	-3.12122675	3.61	-6.73122675	-	7 psi
	WS3	8.87877325	12	-3.12122675	3.605	-6.72622675	-	7psi
	WS4	8.87877325	12	-3.12122675	5.553	-8.67422675	-	9 psi

### 4.3.2 Drainage System.

Like the water supply system, the Drainage system is another essential part of buildings. It is crucial to design a system that serves the building and also could be good for the environment, for that the system designed in this building, considered grey water and was separated from black water.

**TABLE 20.2 Drainage Fixture Units (dfu)**

PART A. BY TYPE OF FIXTURE			
Fixture(s)	Drainage Fixture Units (dfu)	Minimum Trap Size	
		in.	mm <sup>a</sup>
Automatic clothes washers: Commercial <sup>b</sup>	3	2	51
Residential	2	2	51
Bathroom group: Water closet (1.6 gpf [6 Lpf]), lavatory, and bathtub or shower; with or without a bidet and emergency floor drain	5	—	—
Bathroom group: Water closet (>1.6 gpf [6 Lpf]), lavatory, and bathtub or shower; with or without a bidet and emergency floor drain	6	—	—
Bathtub <sup>c</sup> (with or without overhead shower or whirlpool)	2	1½	38
Bidet	1	1¼	32
Combination sink and tray	2	1½	38
Dental lavatory	1	1¼	32
Dental unit or cuspidor	1	1¼	32
Dishwashing machine <sup>d</sup> , domestic	2	1½	38
Drinking fountain	0.5	1¼	32
Emergency floor drain	0	2	51
Floor drains	2	2	51
Kitchen sink, domestic	2	1½	38
Kitchen sink, domestic, with food waste grinder and/or dishwasher	2	1½	38
Laundry tray (1 or 2 compartments)	2	1½	38
Lavatory	1	1¼	32
Shower	2	1½	38
Service sink	2	1½	38
Sink	2	1½	38
Urinal	4	e	
Urinal, 1 gal (3.8 L) per flush or less	2 <sup>f</sup>	e	
Urinal, nonwater supplied	0.5	e	
Wash sink (circular or multiple) each set of faucets	2	1½	38
Water closet, flushometer tank, public or private	4 <sup>f</sup>	e	
Water closet, private (1.6 gpf [6 Lpf])	3 <sup>f</sup>	e	
Water closet, private (>1.6 gpf [6 Lpf])	4 <sup>f</sup>	e	
Water closet, public (1.6 gpf [6 Lpf]),	4 <sup>f</sup>	e	
Water closet, public (flushing >1.6 gpf [6 Lpf])	6 <sup>f</sup>	e	

PART B. BY SIZE OF TRAP		
Fixture Drain or Trap Size		Drainage Fixture Unit (dfu) Value
in.	mm <sup>a</sup>	
1¼	32	1
1½	38	2
2	51	3
2½	64	4
3	76	5
4	102	6

Figure 196 Drainage fixture units (Grondzik & Kwok, 2015, P.945).

From Figure 196 the total drainage fixture units in the building were calculated as shown in Table 60

Table 60 Number of drainage fixture units in each floor.

FLOOR	TYPE	NO. FIXTURE	FU	TOTAL
GF	WC	4	4	16
	Lavatory	4	1	4
	Sink	1	2	2
1-floor	WC	8	4	32
	Lavatory	7	1	7
2-6 floors	WC	9	4	36
	Lavatory	9	1	9
	Shower	9	2	18
	Sink	9	2	18
Total FU				142

**TABLE 20.3 Horizontal Fixture Branches and Stacks<sup>a</sup>**

Diameter of Pipe		Horizontal Branch	Maximum Total Number of dfu Allowable		
			Stacks <sup>b</sup>		
in.	mm <sup>c</sup>		One Branch Interval	Three Branch Intervals or Less	Greater than Three Branch Intervals
1½	38	3	2	4	8
2	51	6	6	10	24
2½	64	12	9	20	42
3	76	20	20	48	72
4	102	160	90	240	500
5	127	360	200	540	1100
6	152	620	350	960	1900
8	203	1400	600	2200	3600
10	254	2500	1000	3800	5600
12	305	3900	1500	6000	8400
15	381	7000	id	id	id

Figure 197 Horizontal Fixture Branches and Stacks (Grondzik & Kwok, 2015, P.946)

**TABLE 20.5 Building Drains and Sewers**

Diameter of Pipe		Maximum Number of dfu Connected to Any Portion of the Building Drain or Building Sewer, Including Branches of the Building Drain <sup>a</sup> Fall, in. per ft (% slope)			
(in.)	(mm) <sup>b</sup>	¼% (0.5%)	½% (1.04%)	¾% (2.1%)	1½% (4.2%)
2	51			21	26
2½	64			24	31
3	76		36	42	50
4	102		180	216	250
5	127		390	480	575
6	152		700	840	1000
8	203	1400	1600	1920	2300
10	254	2500	2900	3500	4200
12	305	3900	4600	5600	6700
15	381	7000	8300	10,000	12,000

Figure 198 Building Drains and Sewers (Grondzik & Kwok, 2015, P.948)

**TABLE 20.4 Size and Developed Length of Stack Vents and Vent Stacks**

Diameter of Soil or Waste Stack in. (mm) <sup>a</sup>	Total Fixture Units Being Vented (dfu)	Maximum Developed Length <sup>b</sup> of Vent, Feet (m) <sup>c</sup>										
		Diameter of Vent, in. (mm) <sup>d</sup>										
		1½ (38)	1½ (38)	2 (51)	2½ (64)	3 (76)	4 (102)	5 (127)	6 (152)	8 (203)	10 (254)	
1½ (38)	2	30 (9.1)										
1½ (38)	8	50 (15.2)	150 (45.7)									
1½ (38)	10	30 (9.1)	100 (30.5)									
2 (51)	12	30 (9.1)	75 (22.9)	200 (61.0)								
2 (51)	20	26 (7.9)	50 (15.2)	150 (45.7)								
2½/2 (64)	42		30 (9.1)	100 (30.5)	300 (91.0)							
3 (76)	10		42 (12.8)	150 (45.7)	360 (109.7)	1040 (317)						
3 (76)	21		32 (9.8)	110 (33.5)	270 (82.3)	810 (246.9)						
3 (76)	3		27 (8.2)	94 (28.7)	230 (70.1)	680 (207.3)						
3 (76)	102		25 (7.6)	86 (26.4)	210 (64.0)	620 (189.0)						
4 (102)	43		25 (7.6)	35 (10.7)	85 (25.9)	250 (76.2)	980 (298.7)					
4 (102)	140		25 (7.6)	27 (8.2)	65 (19.8)	200 (61.0)	750 (228.6)					
4 (102)	320			23 (7.0)	55 (16.8)	170 (51.8)	440 (135.0)					
4 (102)	540			21 (6.4)	50 (15.2)	150 (45.7)	580 (176.8)					
5 (127)	190				28 (8.5)	82 (25.0)	320 (97.5)	990 (301.8)				
5 (127)	490				21 (6.4)	63 (19.2)	250 (76.2)	760 (231.6)				
5 (127)	940				18 (5.5)	53 (16.2)	210 (64.0)	670 (204.2)				
5 (127)	1400				16 (4.9)	49 (14.9)	190 (57.9)	590 (179.8)				
6 (152)	500					33 (10.1)	130 (39.6)	400 (121.9)	1000 (304.8)			
6 (152)	1100					26 (7.9)	100 (30.5)	310 (94.5)	780 (237.7)			
6 (152)	2000					22 (6.7)	84 (25.6)	260 (79.2)	660 (201.2)			
6 (152)	2900					20 (6.1)	77 (23.5)	240 (73.2)	600 (182.9)			
8 (203)	1800						31 (9.4)	95 (29.0)	240 (73.2)	940 (286.5)		
8 (203)	3400						24 (7.3)	73 (22.3)	190 (57.9)	729 (222.4)		
8 (203)	5600							20 (6.1)	62 (18.9)	160 (48.8)	610 (185.9)	
8 (203)	7600							18 (5.5)	56 (17.1)	140 (42.7)	560 (170.7)	
10 (254)	4000								31 (9.4)	78 (23.8)	310 (94.5)	960 (292.6)
10 (254)	7200								24 (7.3)	60 (18.3)	240 (73.2)	740 (225.6)
10 (254)	11,000								20 (6.1)	51 (15.5)	200 (61.0)	630 (192.0)
10 (254)	15,000								18 (5.5)	46 (14.0)	180 (54.9)	571 (174.2)

Figure 199 Size and Developed Length of Stack Vents and Vent Stacks (Grondzik & Kwok, 2015, P.947)

Using Figures above both diameters and slope were calculated as shown in Table 61.

Table 61 Diameters and slope of the drainage system.

Type	Dim	Slope%
vent	4	0
drainge	4	1
sewer	2	2
between manhole	6	1
Vertical stack	4	0

## 4.4 HVAC system design.

### 4.4.1 Introduction

The acronym HVAC stands for heating, ventilation, and air conditioning. It's a collective term for all the different types of cooling and heating systems homeowners use to change the temperature and humidity indoors. HVAC systems also improve indoor air quality through mechanical ventilation and filtration. Some common HVAC systems include central air conditioning units, ductless mini-splits, furnaces, and boilers. HVAC also encompasses large-scale refrigeration in commercial buildings.

The Result from (Design builder) simulation for heating and cooling as follow:

Total design heating load = 66.66 KW.

Total design cooling load= 43.44 KW.

### 4.4.2 Values of heating and cooling from Design Builder for all spaces:

Building	Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)
Building 2	Main.F	MainXF:Corridor1	0.61	0.0371	0.53
Building 2	Main.F	MainXF:Cafeteria	6.2	0.3945	5.39
Building 2	Main.F	MainXF:Corridor	0.89	0.0533	0.77
Building 2	Main.F	MainXF:ContrlRoom	0.62	0.042	0.54
Building 2	Main.F	MainXF:SecretaryR	1.11	0.0708	0.97
Building 2	Main.F	MainXF:Administra	1.85	0.119	1.61
Building 2	Main.F	MainXF:Accontants	1.08	0.0697	0.94
Building 2	Main.F	MainXF:Reception	1.17	0.0735	1.02
Building 2	Main.F	MainXF:Lobby	5.13	0.314	4.46
Building 2	Main.F	MainXF:SecurityRo	0.54	0.0368	0.47
Building 2	Main.F	MainXF:Entrance	0.82	0.0539	0.71
Building 2	Stores	Stores:Laundry	1.5	0.0933	1.3
Building 2	Stores	Stores:Study area	4.81	0.3166	4.18
Building 2	Stores	Stores:corridor	1.15	0.0703	1
Building 2	Stores	Stores:shop area	0.76	0.0496	0.66
Building 2	Stores	Stores:shop area	0.84	0.0551	0.73
Building 2	Stores	Stores:shop area	0.78	0.0488	0.68
Building 2	Stores	Stores:shop area	0.78	0.0489	0.68
Building 2	Stores	Stores:shop area	0.9	0.0573	0.78
Building 2	S.F 6	SXF6:Bedroom	0.37	0.026	0.32
Building 2	S.F 6	SXF6:Bedroom	0.33	0.023	0.28
Building 2	S.F 6	SXF6:Bedroom	0.37	0.0275	0.32
Building 2	S.F 6	SXF6:corridor	1.04	0.0626	0.9
Building 2	S.F 6	SXF6:Bedroom	0.3	0.0211	0.26
Building 2	S.F 6	SXF6:Bedroom	0.46	0.0305	0.4
Building 2	S.F 6	SXF6:Bedroom	0.31	0.0222	0.27
Building 2	S.F 6	SXF6:Bedroom	0.3	0.0211	0.26

Building 2 S.F 6	SXF6:Bedroom	0.29	0.0204	0.25
Building 2 S.F 6	SXF6:corridor	0.11	0.007161	0.1
Building 2 S.F 6	SXF6:Bedroom	0.4	0.0296	0.35
Building 2 S.F 4	SXF4:Bedroom	0.18	0.0124	0.16
Building 2 S.F 4	SXF4:Bedroom	0.14	0.008777	0.12
Building 2 S.F 4	SXF4:Bedroom	0.23	0.0162	0.2
Building 2 S.F 4	SXF4:corridor	1.07	0.0709	0.93
Building 2 S.F 4	SXF4:Bedroom	0.12	0.007589	0.1
Building 2 S.F 4	SXF4:Bedroom	0.23	0.0128	0.2
Building 2 S.F 4	SXF4:Bedroom	0.12	0.007913	0.11
Building 2 S.F 4	SXF4:Bedroom	0.15	0.0105	0.13
Building 2 S.F 4	SXF4:Bedroom	0.16	0.0108	0.14
Building 2 S.F 4	SXF4:corridor	0.13	0.009077	0.12
Building 2 S.F 4	SXF4:Bedroom	0.21	0.014	0.18
Building 2 S.F 3	SXF3:Bedroom	0.19	0.0127	0.16
Building 2 S.F 3	SXF3:Bedroom	0.14	0.009075	0.12
Building 2 S.F 3	SXF3:Bedroom	0.24	0.0165	0.21
Building 2 S.F 3	SXF3:corridor	1.07	0.0707	0.93
Building 2 S.F 3	SXF3:Bedroom	0.12	0.006904	0.11
Building 2 S.F 3	SXF3:Bedroom	0.23	0.0133	0.2
Building 2 S.F 3	SXF3:Bedroom	0.13	0.008214	0.11
Building 2 S.F 3	SXF3:Bedroom	0.16	0.011	0.14
Building 2 S.F 3	SXF3:Bedroom	0.16	0.0112	0.14
Building 2 S.F 3	SXF3:corridor	0.13	0.0091	0.12
Building 2 S.F 3	SXF3:Bedroom	0.22	0.0148	0.19
Building 2 S.F 2	SXF2:Bedroom	0.18	0.0124	0.16
Building 2 S.F 2	SXF2:Bedroom	0.14	0.008798	0.12
Building 2 S.F 2	SXF2:Bedroom	0.23	0.0162	0.2

Building 2 S.F 2	SXF2:corridor	1.07	0.071	0.93
Building 2 S.F 2	SXF2:Bedroom	0.12	0.00768	0.1
Building 2 S.F 2	SXF2:Bedroom	0.23	0.0133	0.2
Building 2 S.F 2	SXF2:Bedroom	0.12	0.007962	0.11
Building 2 S.F 2	SXF2:Bedroom	0.15	0.0102	0.13
Building 2 S.F 2	SXF2:Bedroom	0.16	0.0108	0.13
Building 2 S.F 2	SXF2:corridor	0.13	0.00909	0.12
Building 2 S.F 2	SXF2:Bedroom	0.21	0.0143	0.18
Building 2 S.F 1	SXF1:Bedroom	0.24	0.0169	0.21
Building 2 S.F 1	SXF1:Bedroom	0.2	0.0138	0.17
Building 2 S.F 1	SXF1:Bedroom	0.29	0.0217	0.25
Building 2 S.F 1	SXF1:corridor	0.84	0.0505	0.73
Building 2 S.F 1	SXF1:Bedroom	0.2	0.0124	0.17
Building 2 S.F 1	SXF1:Bedroom	0.25	0.0146	0.22
Building 2 S.F 1	SXF1:Bedroom	0.19	0.0118	0.16
Building 2 S.F 1	SXF1:Bedroom	0.21	0.0155	0.18
Building 2 S.F 1	SXF1:Bedroom	0.21	0.0157	0.18
Building 2 S.F 1	SXF1:corridor	0.09	0.005154	0.07
Building 2 S.F 1	SXF1:Bedroom	0.27	0.0201	0.24
Building 2 S.F 5	SXF5:Bedroom	0.24	0.0165	0.21
Building 2 S.F 5	SXF5:Bedroom	0.19	0.0135	0.17
Building 2 S.F 5	SXF5:Bedroom	0.29	0.0215	0.25
Building 2 S.F 5	SXF5:corridor	0.82	0.0495	0.71
Building 2 S.F 5	SXF5:Bedroom	0.17	0.0108	0.15
Building 2 S.F 5	SXF5:Bedroom	0.29	0.0181	0.25
Building 2 S.F 5	SXF5:Bedroom	0.18	0.0114	0.16
Building 2 S.F 5	SXF5:Bedroom	0.21	0.0155	0.18
Building 2 S.F 5	SXF5:Bedroom	0.21	0.0157	0.18
Building 2 S.F 5	SXF5:corridor	0.08	0.005045	0.07
Building 2 S.F 5	SXF5:Bedroom	0.29	0.0212	0.25

#### 4.4.3 VRF system:

VRF (Variable Refrigerant Flow) stands for variable refrigerant flow, which goes a surprisingly long way toward describing how this system uses refrigerant for both air conditioning and heating. In a nutshell, VRF is a ductless, large-scale system for HVAC that performs at a high capacity.

It consists of an outdoor unit that supplies the fan coils with air, which is connected to diffusers. The number of diffusers is determined based on the airflow.



*Figure 200 Outdoor unit*

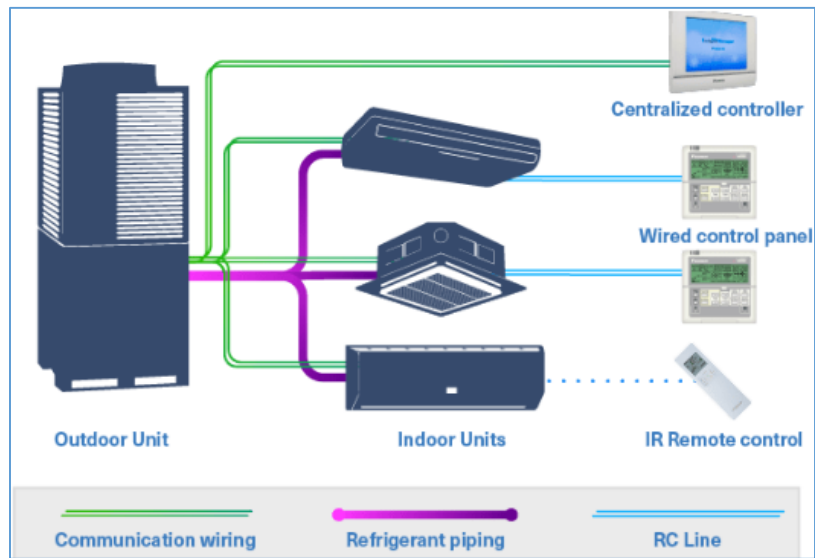
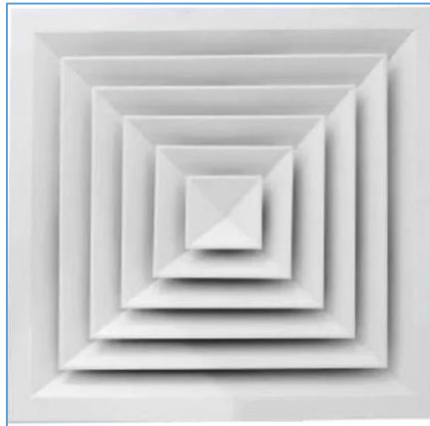


Figure 201VRF system

#### 4.4.3.1 Diffuser



Diffuser from catalogue:


DF / DE		Core 21 						
Supply								
Total pressure drop (Pa)		150 x 150	225 x 225	300 x 300	375 x 375	450 x 450	525 x 525	600 x 600
9	l/s	34	76	135	211	304	413	540
	Min Max (m)	1.0-2.0	1.5-2.5	2.0-3.5	2.5-4.5	2.5-6.0	3.0-6.5	3.5-7.0
	L <sub>w</sub>	-	-	-	23	24	26	28
15	l/s	45	101	180	282	405	551	720
	Min Max (m)	1.0-2.5	2.0-3.5	2.5-5.0	3.0-6.0	3.5-7.5	4.0-8.0	4.5-8.5
	L <sub>w</sub>	-	25	28	30	31	33	35
23	l/s	56	127	225	352	506	689	900
	Min Max (m)	1.5-3.0	2.5-5.0	3.0-6.0	4.0-7.5	4.5-9.0	5.0-10.0	5.5-10.5
	L <sub>w</sub>	27	31	34	36	37	39	41
33	l/s	68	152	270	422	608	827	1080
	Min Max (m)	2.0-3.5	2.5-5.5	3.5-7.5	5.0-9.5	5.5-11.0	6.5-13.0	6.5-13.0
	L <sub>w</sub>	32	36	39	41	42	43	45
43	l/s	79	177	315	492	709	964	1260
	Min Max (m)	2.0-4.5	3.0-6.0	4.5-8.5	5.5-11.0	6.5-13.0	7.5-15.0	7.5-15.0
	L <sub>w</sub>	36	40	43	45	46	48	49

Figure 202 Catalogue Diffuser specification.

The first chosen diffuser with handles 45 L/S airflow, and the dimension of the diffuser is (150x150) mm.

The second chosen diffuser with, handle 68 L/S airflow, and the dimension of the diffuser is (150x150) mm.

The third chosen diffuser with, handle 152 L/S airflow, and the dimension of the diffuser is (225x225) mm.

#### 4.4.3.2 Fan coil:

Fan coils were chosen from the next catalogue.

FWV01-10C*			2-pipe (*=TN or TV)						4-pipe (*=FN or FV)									
			01	02	03	04	05	08	10	01	02	03	04	05	08	10		
Power input			W	37	53	56	98	182	244	37	53	56	98	182	244			
Capacity	Cooling capacity	Total capacity	kW	1.54	2.09	2.93	4.33	4.77	6.71	8.02	1.46	1.90	2.87	4.33	4.67	6.64	7.88	
		Sensible capacity	kW	1.20	1.51	2.11	3.15	3.65	4.91	5.96	1.14	1.51	2.07	3.15	3.57	4.85	5.85	
	Heating capacity (2-pipe)		kW	2.14	2.57	3.81	5.63	6.36	7.83	10.03	-							
	Heating capacity (4-pipe)		kW	-						1.90	2.10	3.08	5.05	5.30	7.91	9.30		
Dimensions	HxWxD	mm	564x774x226		564x984x226	564x1194x226		564x1404x251		564x774x226		564x984x226	564x1194x226		564x1404x251			
			19		20	25	30	31	41	20	21	26	32	33	44			
Machine weight			kg	19		20	25	30	31	41	20	21	26	32	33	44		
Sound level	Sound power			dB(A)	45	50	47	52	56	61	66	45	50	47	52	56	61	66
Water pressure drop	Cooling			kPa	13		11	12	14	12	19	13		11	12	14	12	19
	Heating			kPa	9	11	9		10	9	16	7	8	5	10		8	9
Fan	Air flow rate			m <sup>3</sup> /h	319	344	442	706	785	1011	1393	307	327	431	690	763	998	1362
Water connections	Std. heat exchanger			inch	1/2				3/4		1/2				3/4			
Required power supply			V/f/Hz	230/1/50														
Water flow	Cooling			l/h	265	359	504	745	820	1,154	1,343	251	327	494	745	803	1,142	1,355
	Heating			l/h	265	359	504	745	820	1,154	1,343	196	182	286	396	465	694	816
Coil	Water volume heating			l	-						0.5	0.7	1	1.4		2.1		
Maximum absorbed current			W	0.17	0.24	0.25	0.44	0.43	0.80	1.12	0.17	0.24	0.25	0.44	0.43	0.80	1.12	

Figure 203 Fan coil catalogue

1. Fan coil 2 pipe with capacity 6.71 KW= 6710 W, and Dim (564 x1404 x226).
2. Fan coil 2 pipe with capacity 2.09 KW=2090 W, Dim (564 x774 x226).
3. Fan coil 2 pipe with capacity 2.93 KW=2930 W, Dim (564 x984 x226).

The number of fan coils needed = The Design Cooling load for the space/ Cooling capacity for the unit

Table 62 Fan load for ground floor

Ground floor				Cooling load (W)	Fan load (W)
Space	Air flow (L/S)	Diffuser	Number		
Corridor1	37.1	45	1	530	6710 n=3
Cafeteria	394.5	152	2	5390	
Corridor	53.3	68	1	770	
Control room	42	45	1	540	
Secretary room	70.8	68	1	970	
Administration	119	152	1	1610	
Accountant	69.7	68	1	940	
Reception	73.5	68	1	1020	
Lobby	314	152	2	4450	
Security room	36.8	45	1	470	
Entrance	53.9	68	1	710	

$$m^3/S = 1000L/S$$

Table 63 Fan load for store floor

Store floor				Cooling load (W)	Fan load (W)
Space	Air flow (L/S)	Diffuser	Number		
Laundry	93.3	152	1	1300	6710 n=2
Study area	316	152	2	4130	
Corridor	70.3	68	1	1000	
Shop area	49.6	45	1	650	
Shop area2	55.1	68	1	730	
Shop area3	48.8	68	1	630	
Shop area4	48.9	68	1	630	
Shop area5	57.3	68	1	730	

Table 64 Fan load for first floor

First Floor.				Cooling load (W)	Fan load (W)
Space	Air flow (L/S)	Diffuser	Number		
Bedroom1	16.9	45	1	210	2090 n=2
Bedroom2	13.8	45	1	170	
Bedroom3	21.7	45	1	250	
Corridor1	50.5	68	1	730	
Bedroom4	12.4	45	1	170	
Bedroom5	14.6	45	1	220	
Bedroom6	11.8	45	1	160	
Bedroom7	15.5	45	1	180	
Bedroom8	15.7	45	1	180	
Corridor2	5.15	45	1	70	
Bedroom9	20.1	45	1	240	

Table 65 Fan load for second floor

Second floor				Cooling load (W)	Fan load (W)
Space	Air flow (L/S)	Diffuser	Number		
Bedroom1	12.4	45	1	160	2090 n=2
Bedroom2	8.7	45	2	120	
Bedroom3	16.2	45	1	200	
Corridor1	71	68	1	930	
Bedroom4	7.6	45	1	100	
Bedroom5	13.3	45	1	200	
Bedroom6	7.9	45	1	110	
Bedroom7	10.2	45	1	130	
Bedroom8	10.8	45	1	130	
Corridor2	9.09	45	1	120	
Bedroom9	14.3	45	1	180	

Table 66 Fan load for third floor

<i>Third floor</i>				Cooling load (W)	Fan load (W)
Space	Air flow (L/S)	Diffuser	Number		
Bedroom1	12.7	45	1	160	2090 n=2
Bedroom2	9.07	45	1	120	
Bedroom3	16.5	45	1	210	
Corridor1	70.7	68	1	930	
Bedroom4	6.9	45	1	110	
Bedroom5	13.3	45	1	200	
Bedroom6	8.2	45	1	110	
Bedroom7	11	45	1	140	
Bedroom8	11.2	45	1	140	
Corridor2	9.1	45	1	120	
Bedroom9	14.8	45	1	190	

Table 67 Fan load for fourth floor

<i>Fourth floor</i>				Cooling load (W)	Fan load (W)
Space	Air flow (L/S)	Diffuser	Number		
Bedroom1	12.4	45	1	150	2090 n=2
Bedroom2	8.7	45	1	120	
Bedroom3	16.2	45	1	200	
Corridor1	70.9	68	1	930	
Bedroom4	7.5	45	1	100	
Bedroom5	12.8	45	1	200	
Bedroom6	7.9	45	1	110	
Bedroom7	10.5	45	1	130	
Bedroom8	10.8	45	1	140	
Corridor2	9.07	45	1	120	
Bedroom9	14	45	1	130	

Table 68 Fan load for fifth floor

<b>Fifth floor</b>				<b>Cooling load (W)</b>	<b>Fan load (W)</b>
<b>Space</b>	<b>Air flow (L/S)</b>	<b>Diffuser</b>	<b>Number</b>		
Bedroom1	16.5	45	1	210	2090 n=2
Bedroom2	13.5	45	1	170	
Bedroom3	21.5	45	1	250	
Corridor1	49.5	68	1	710	
Bedroom4	10.8	45	1	150	
Bedroom5	18.1	45	1	250	
Bedroom6	11.4	45	1	160	
Bedroom7	15.5	45	1	180	
Bedroom8	15.7	45	1	180	
Corridor2	5.04	45	1	70	
Bedroom9	21.2	45	1	250	

Table 69 Fan load for sixth floor

<b>Sixth floor</b>				<b>Cooling load (W)</b>	<b>Fan load (W)</b>
<b>Space</b>	<b>Air flow (L/S)</b>	<b>Diffuser</b>	<b>Number</b>		
Bedroom1	26	45	1	320	2090 n=2
Bedroom2	23	45	2	230	
Bedroom3	27.5	45	1	320	
Corridor1	62.6	68	1	900	
Bedroom4	21.1	45	1	250	
Bedroom5	30.5	45	1	400	
Bedroom6	22.2	45	1	270	
Bedroom7	21.1	45	1	250	
Bedroom8	20.4	45	1	250	
Corridor2	7.16	45	1	100	
Bedroom9	29.6	68	1	350	

#### 4.4.4 VRF (Variable Refrigerant Flow) Air Handling Unit Selection:

VRF stands for variable refrigerant flow, which goes a surprisingly long way toward describing how this system uses refrigerant for both air conditioning and heating. In a nutshell, VRF is a ductless, large-scale system for HVAC that performs at a high capacity. VRF allows multiple indoor units to run on the same system, which is designed differently depending on the application. VRF systems are considered either a heat pump system or a heat recovery system, which can heat and cool simultaneously.

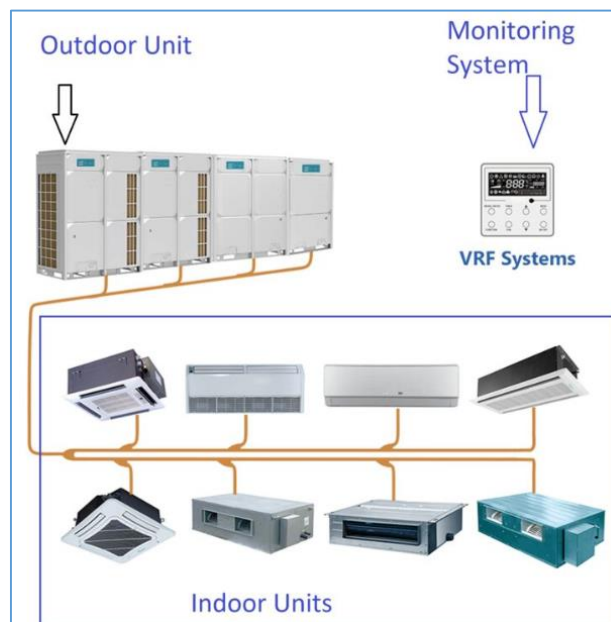


Figure 204 VRF system

The cooling load equals 43.44 KW

VRF units will be used with a capacity of 13 Tons (45.5 KW)

1 ton = 3.5 KW

#### 4.4.4.1 Duct size:

Depending on the required airflow in each area, we will choose the volume. The DUCTULATOR program was used with the channel depth = 300 mm under the drop beams and the Velocity = 5 m/s.

This formula is used for calculate the diameter of duct:

- $\dot{V} = \frac{\pi}{4} \times d^2 \times V$
- $\dot{V}$  : *volmetric flow rate*
- $d$ : *duct diameter*
- $V$ : *velocity*

Table 70 Diameter of duct for ground floor

<b>Ground floor</b>		
<b>Space</b>	<b>Air flow (m<sup>3</sup>/S)</b>	<b>Diameter of duct(m)</b>
<b>Corridor1</b>	0.0371	0.097222576
<b>Cafeteria</b>	0.3945	0.317032418
<b>Corridor</b>	0.00533	0.036850533
<b>Control room</b>	0.042	0.103443883
<b>Secretary room</b>	0.070	0.133545479
<b>Administration</b>	0.119	0.174122001
<b>Accountant</b>	0.069	0.132588151
<b>Reception</b>	0.073	0.136377147
<b>Lobby</b>	0.314	0.282842712
<b>Security room</b>	0.036	0.095770426
<b>Entrance</b>	0.053	0.116203204

Table 71 Diameter of duct for store floor

<b>Store floor</b>		
<b>Space</b>	<b>Air flow (m<sup>3</sup>/S)</b>	<b>Diameter of duct(m)</b>
<b>Laundry</b>	0.0933	0.154177497
<b>Study area</b>	0.316	0.283742056
<b>Corridor</b>	0.0703	0.133831342
<b>Shop area</b>	0.0496	0.112414157
<b>Shop area2</b>	0.0551	0.11848298
<b>Shop area3</b>	0.0488	0.111503906
<b>Shop area4</b>	0.0489	0.111618093
<b>Shop area5</b>	0.0573	0.120825188
<b>Laundry</b>	0.0933	0.154177497
<b>Study area</b>	0.316	0.283742056
<b>Corridor</b>	0.0703	0.133831342

Table 72 Diameter of duct for first floor

<b>First floor</b>		
<b>Space</b>	<b>Air flow (m<sup>3</sup>/S)</b>	<b>Diameter of duct(m)</b>
<b>Bedroom1</b>	0.0169	0.06561808
<b>Bedroom2</b>	0.0138	0.059295224
<b>Bedroom3</b>	0.0217	0.074354976
<b>Corridor1</b>	0.0505	0.113429458
<b>Bedroom4</b>	0.0124	0.056207078
<b>Bedroom5</b>	0.0146	0.060989714
<b>Bedroom6</b>	0.0118	0.05483037
<b>Bedroom7</b>	0.0155	0.062841424
<b>Bedroom8</b>	0.0157	0.063245553
<b>Corridor2</b>	0.00515	0.036222947
<b>Bedroom9</b>	0.0201	0.071561296

Table 73 Diameter of duct for second floor

<b>Second floor</b>		
<b>Space</b>	<b>Air flow (m<sup>3</sup>/S)</b>	<b>Diameter of duct(m)</b>
<b>Bedroom1</b>	0.0124	0.056207078
<b>Bedroom2</b>	0.0087	0.047080362
<b>Bedroom3</b>	0.0162	0.064244755
<b>Corridor1</b>	0.071	0.134495992
<b>Bedroom4</b>	0.0076	0.044003474
<b>Bedroom5</b>	0.0133	0.058211125
<b>Bedroom6</b>	0.0079	0.044863558
<b>Bedroom7</b>	0.0102	0.050977702
<b>Bedroom8</b>	0.0108	0.052455623
<b>Corridor2</b>	0.00909	0.048124044
<b>Bedroom9</b>	0.0143	0.060359855

Table 74 Diameter of duct for third floor

<b>Third floor</b>		
<b>Space</b>	<b>Air flow (m<sup>3</sup>/S)</b>	<b>Diameter of duct(m)</b>
<b>Bedroom1</b>	0.0127	0.056882939
<b>Bedroom2</b>	0.00907	0.048071073
<b>Bedroom3</b>	0.0165	0.064836885
<b>Corridor1</b>	0.0707	0.134211545
<b>Bedroom4</b>	0.0069	0.041928055
<b>Bedroom5</b>	0.0133	0.058211125
<b>Bedroom6</b>	0.0082	0.045707461
<b>Bedroom7</b>	0.011	0.052939095
<b>Bedroom8</b>	0.0112	0.053418192
<b>Corridor2</b>	0.0091	0.048150507
<b>Bedroom9</b>	0.0148	0.061406031

Table 75 Diameter of duct for fourth floor

<b>Fourth floor</b>		
<b>Space</b>	<b>Air flow (m<sup>3</sup>/S)</b>	<b>Diameter of duct(m)</b>
<b>Bedroom1</b>	0.0124	0.056207078
<b>Bedroom2</b>	0.0087	0.047080362
<b>Bedroom3</b>	0.0162	0.064244755
<b>Corridor1</b>	0.0709	0.134401244
<b>Bedroom4</b>	0.0075	0.043713019
<b>Bedroom5</b>	0.0128	0.057106449
<b>Bedroom6</b>	0.0079	0.044863558
<b>Bedroom7</b>	0.0105	0.051721942
<b>Bedroom8</b>	0.0108	0.052455623
<b>Corridor2</b>	0.00907	0.048071073
<b>Bedroom9</b>	0.014	0.059723354

Table 76 Diameter of duct for fifth floor

<b>Fifth floor</b>		
<b>Space</b>	<b>Air flow (m<sup>3</sup>/S)</b>	<b>Diameter of duct(m)</b>
<b>Bedroom1</b>	0.0165	0.064836885
<b>Bedroom2</b>	0.0135	0.058647169
<b>Bedroom3</b>	0.0215	0.074011533
<b>Corridor1</b>	0.0495	0.112300779
<b>Bedroom4</b>	0.0108	0.052455623
<b>Bedroom5</b>	0.0181	0.067907768
<b>Bedroom6</b>	0.0114	0.053893029
<b>Bedroom7</b>	0.0155	0.062841424
<b>Bedroom8</b>	0.0157	0.063245553
<b>Corridor2</b>	0.00504	0.035834012
<b>Bedroom9</b>	0.0212	0.073493359

Table 77 Diameter of duct for sixth floor

<b>Sixth floor</b>		
<b>Space</b>	<b>Air flow (m<sup>3</sup>/S)</b>	<b>Diameter of duct(m)</b>
<b>Bedroom1</b>	0.026	0.081389212
<b>Bedroom2</b>	0.023	0.076549805
<b>Bedroom3</b>	0.0275	0.083704059
<b>Corridor1</b>	0.0626	0.126289527
<b>Bedroom4</b>	0.0211	0.073319821
<b>Bedroom5</b>	0.0305	0.088151578
<b>Bedroom6</b>	0.0222	0.075206721
<b>Bedroom7</b>	0.0211	0.073319821
<b>Bedroom8</b>	0.0204	0.072093358
<b>Corridor2</b>	0.00716	0.042710699
<b>Bedroom9</b>	0.0296	0.086841242

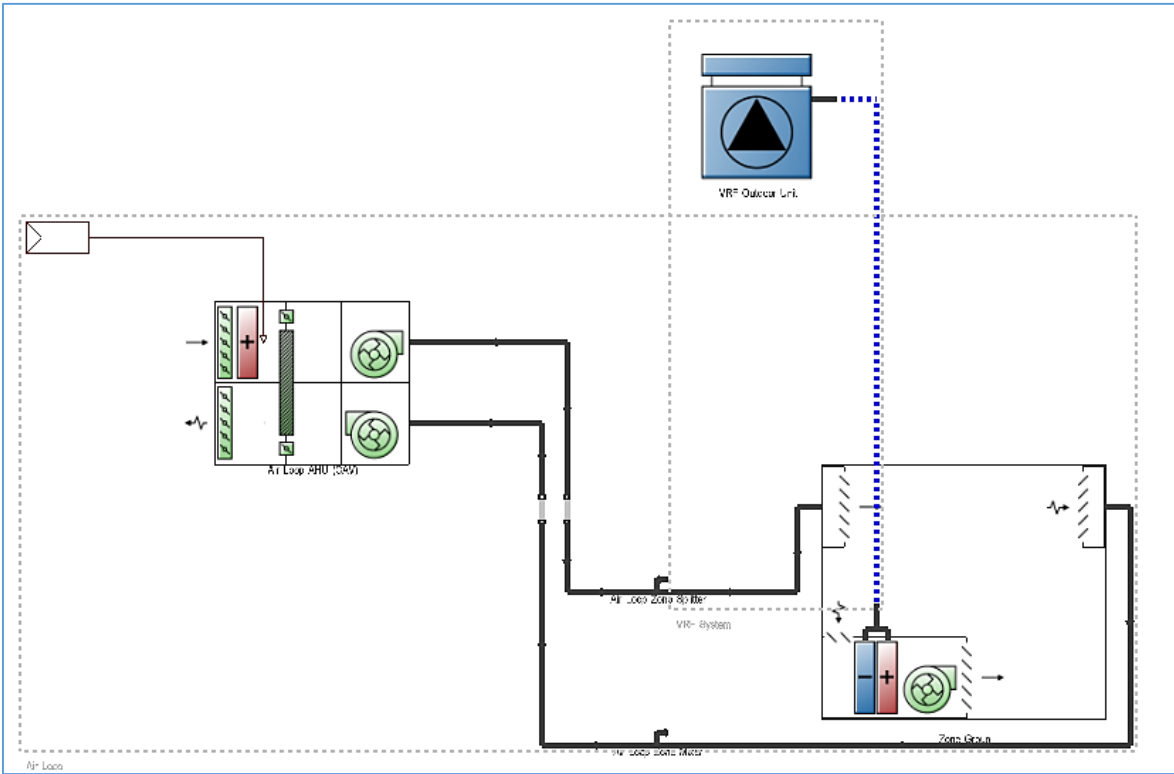


Figure 205 VRF System for building from Design Builder program

4.4.5 HVAC plans from AutoCAD:

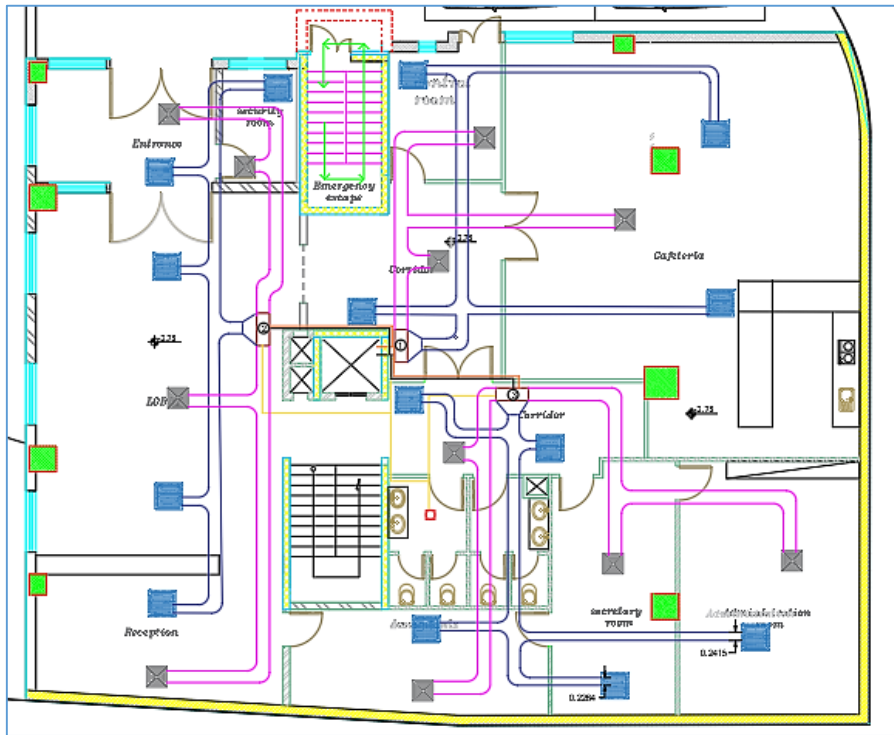


Figure 206 Ground floor HVAC plan

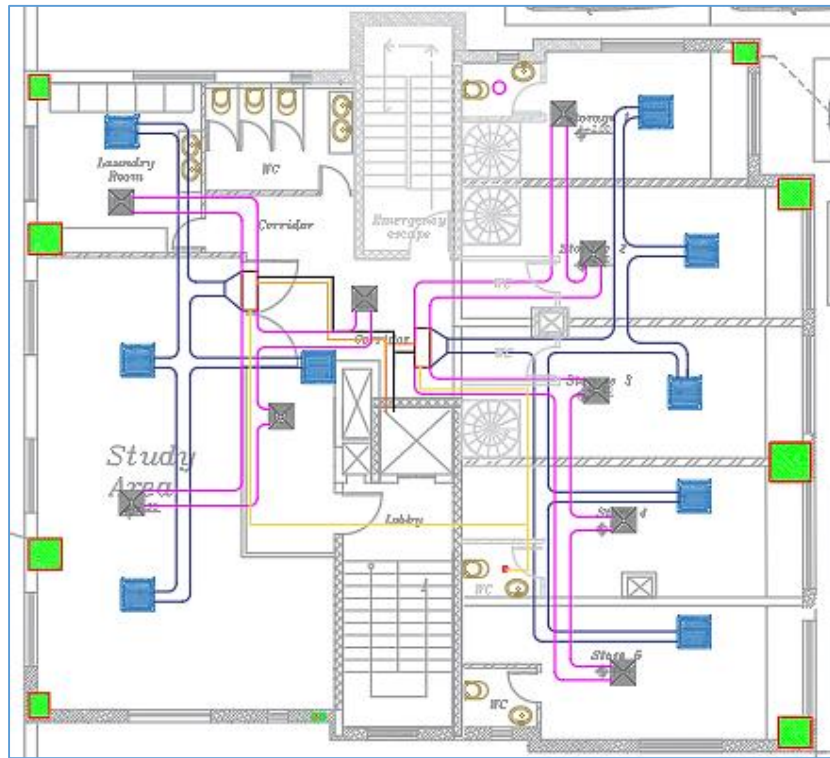


Figure 207 Store floor HVAC plan

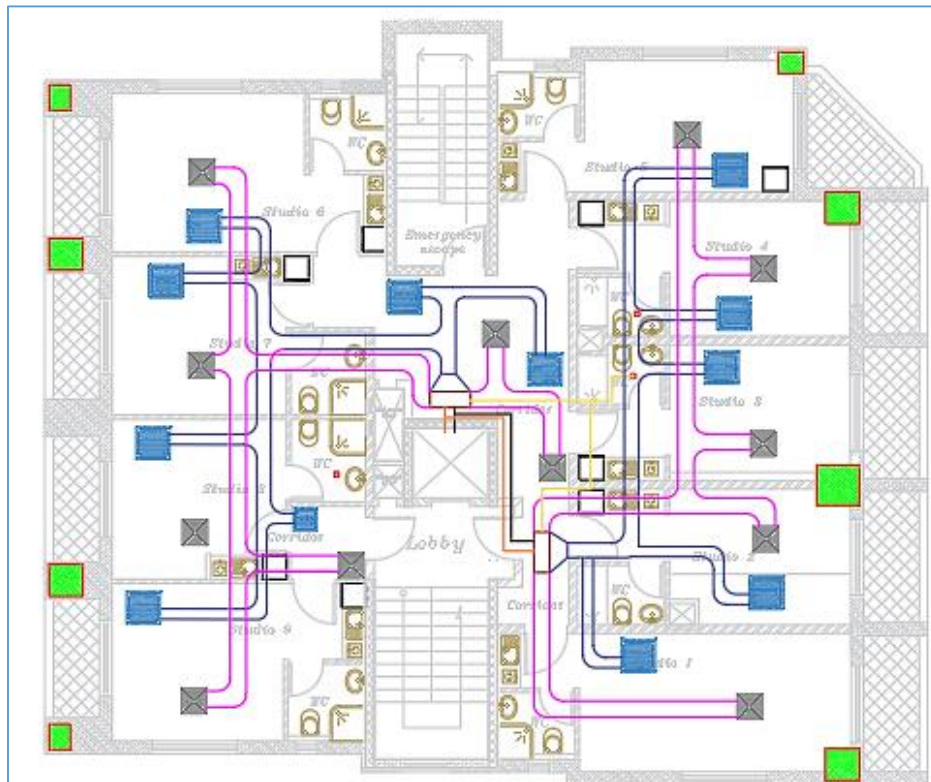


Figure 208 Residential floor HVAC plan

## 4.5 Fire System

### 4.5.1 Introduction.

it's necessary to protect human safety and prevent any hazards humans could be exposed to. therefore, fire protection systems are much needed in buildings to ensure that humans are safe. In this section, fire systems will be designed. both parking and ground floor are designed using sprinklers while the rest of the building is designed using a water hose system.

### 4.5.2 Requirements for fire system.

According to the Palestinian code for fire protection the fire system required in dormitory are as shown in Figure 209

4/4/8 متطلبات الإطفاء:			
يزود السكن الداخلي بنظام للتمديدات والخراطيم الخاصة بمكافحة الحريق، كما تزود المخارج بطفايات يدوية، حسب متطلبات الجهة الرسمية المختصة			
الحالات المطلوبة	النوع		
	معدات الإطفاء اليدوية :	1	
جميع الطوابق	طفايات يدوية	1	
	التركيبات الثابتة : أنظمة خراطيم المياه	2	
جميع الطوابق	النظام الرطب : خراطيم مطاطية	1	
جميع الطوابق	النظام الجاف : - صاعد جاف 3 انش - وقاف حريق 2 انش وقاف حريق خارجي 3 انش ( Siamese connection)	2	

Figure 209 Fire fighting systems required in dormitory.

### 4.5.3 Fire System.

#### 4.5.3.1 Sprinkler firefighting system.

It is a nozzle that converts potential energy (static pressure) to kinetic energy (dynamic pressure) by reducing The cross-sectional area of the pipe to obtain a relationship between flow and pressure. Only new sprinkler heads are used. The performance of the sprinkler head is controlled by five important factors: orifice size, reflector direction, coverage area, melting temperature the sprinkler head explodes, and the rapid response to the fire.

The sprinkler system was considered to be used on a floor according to the spaces on the floor

- Ground floor
- Parking

The building spaces are classified as low hazard according to the Palestinian Code for Fire Prevention and Protection. Each sprinkler covers an area of 12 m<sup>2</sup> and Max. Distance 4.6 m.

**EC-8**  
**Pendent & Recessed Pendent**

- Light hazard
- 3 mm bulb
- Covers areas as large as 20' x 20' (6,1 m x 6,1 m)
- The Series EC-8 Extended Coverage Pendent Sprinklers are decorative glass bulb sprinklers designed for use in light hazard occupancies.
- The recessed version of the EC-8, intended for use in areas with a finished ceiling, uses either the two-piece Recessed Escutcheon.

<b>K FACTOR</b>	K=8.0 (115,2)
<b>THREAD SIZE</b>	3/4" NPT
<b>APPROVALS</b>	UL, C-UL, FM, NYC
<b>TEMPERATURE</b>	135°F/57°C, 155°F/68°C
<b>ESCUTCHEON</b>	Style 30 • Style 40
<b>ESCUTCHEON FINISH</b>	Natural Brass, Signal White, Chrome Plated
<b>SPRINKLER FINISH</b>	Natural Brass, Signal White, Polyester, Chrome Plated
<b>SIN</b>	TY4232
<b>TECH DATA</b>	TFP223

Always refer to the product's Technical Data Sheet for a complete description of all Listing and Approval criteria, design parameters, installation instructions, care and maintenance guidelines, and our limited warranty.

FIRE PROTECTION General Products Catalog

TYCO FIRE PROTECTION PRODUCTS

Sprinkler Wrenches

Figure 210 Sprinkler properties

The diameters of all steel pipe that connect the sprinklers together and connect them with supplier was chosen according to Table 78 and Table 79.

Table 78 Pipes diameter.

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	3 sprinklers	1¼ in.	3 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	10 sprinklers	2 in.	12 sprinklers
2½ in.	30 sprinklers	2½ in.	40 sprinklers
3 in.	60 sprinklers	3 in.	65 sprinklers
3½ in.	100 sprinklers	3½ in.	115 sprinklers
4 in.	See Section 8.2	4 in.	See Section 8.2

Table 79 Sprinklers design and distribution in GF floor and both zones in the parking

ROOM	W	Max. Distance	# of sparks	# of sparks	X	XI2	AS	Y	YI2
GF	24.1	4.6	5.239130435	6	4.0167	2.008333	21	5.2282	2.6141
ZONE1	13.85	4.6	3.010869565	3	4.6167	2.308333	21	4.5487	2.2744
ZONE2	10.3	4.6	2.239130435	3	3.4333	1.716667	21	6.1165	3.0583

#### 4.5.3.2 DETECTORS DISTRIBUTION.

smoke detectors are devices used to detect and sense smoke which will help detect the fire before getting spreads in other spaces.

there are many types of detectors but according to the building's function smoke detector was used.



### 4.5.3.3 EXTINGUISHER

extinguisher is used to stop small fires, it's easy to use and very efficient. there are many types of extinguishers, according to the building and space CO2 Extinguishers it is used in spaces where there are papers and computers.

**SAFERZONE FIRE SAFETY EQUIPMENTS**

**Carbon-di-oxide (Co-2) type fire extinguisher**



**2 Kg Capacity**  
**Rs.3,900/ Unit**

**Specifications:**

- \***BRAND: KKNEX**
- \* Fire class: B & C Class fire
- \*Capacity: 2kg
- \*Design: Bend and horn
- \*Refillable: Yes
- \*Average discharge time: 6to10sec.
- \*Average Range of throw: 2m
- \*Usage: Commercial
- \*Fire rating: 21-B
- \*Open/Close: Wheel type
- \*Certification: B/S
- \*Pressure: 205 Bar
- \*Temperature: -60°c

**Key Features**

- \*99.95% Pure Co2 gas
- \*Bodies CCOE/PESO approved
- \*High quality enamel paint
- \*Brass valve
- \*Shells are Hydro tested to 250 bar
- \*High pressure wire braided hose
- \*No thermal or static shock.

Figure 211 CO2 Extinguisher

### 4.5.3.4 ALARM SYSTEM.

fire alarms are used to notice people and warn them to take safety precautions

there are two types of fire alarms

- 1- Manual fire alarm (Figure 212)
- 2- automatic fire alarm. (Figure 213)



**Features**

- High quality, extruded aluminum.
- Attractive, Low Profile Design
- Built-in intelligent addressable module with Mircom Protocol.
- Pulling the handle initiates the operation of the intelligent module.
- Address is set by the MIX-4090 hand-held device programmer.
- Key switch provided for two (2) stage version.
- Standard Single Gang Mount
- Plastic Rod or Break glass Optional

Figure 212 manual alarm system



Figure 213 Sound & Light Alarm System

#### 4.5.3.5 FIRE HOSE CABINET DISTRIBUTION.

An elevated-pressure tube designed for transporting water or fire-suppressant substances, including foam, for extinguishing fires. Externally, it establishes a connection with either a fire engine or a fire hydrant, while internally it can be permanently affixed to a building's vertical pipe or plumbing system. These hoses were strategically positioned in proximity to emergency exits, with each one covering an approximate distance of 25 meters.

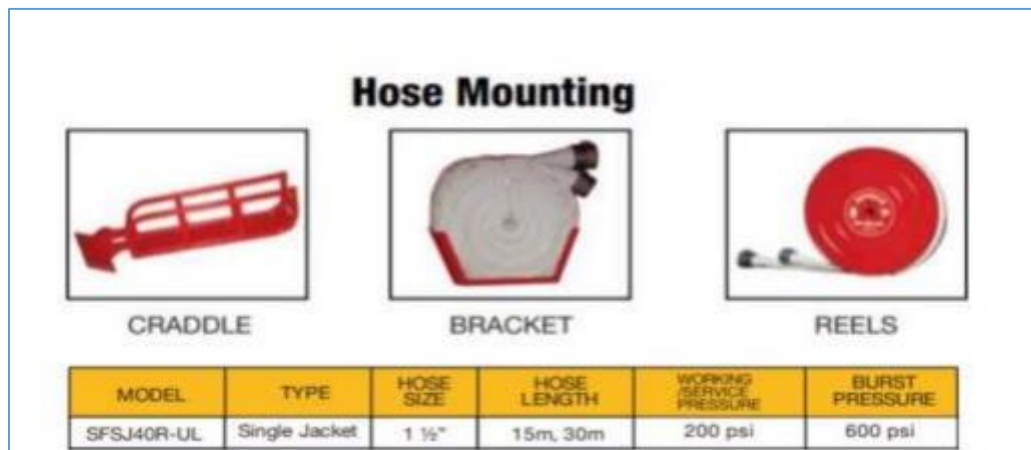


Figure 214 Fire-Hose.

## 4.6 Acoustical design

### 4.6.1 Introduction

Acoustical engineering is the branch of engineering dealing with sound and vibration. It includes the application of acoustics, the science of sound and vibration, in technology. Acoustical engineers are typically concerned with the design, analysis and control of sound.

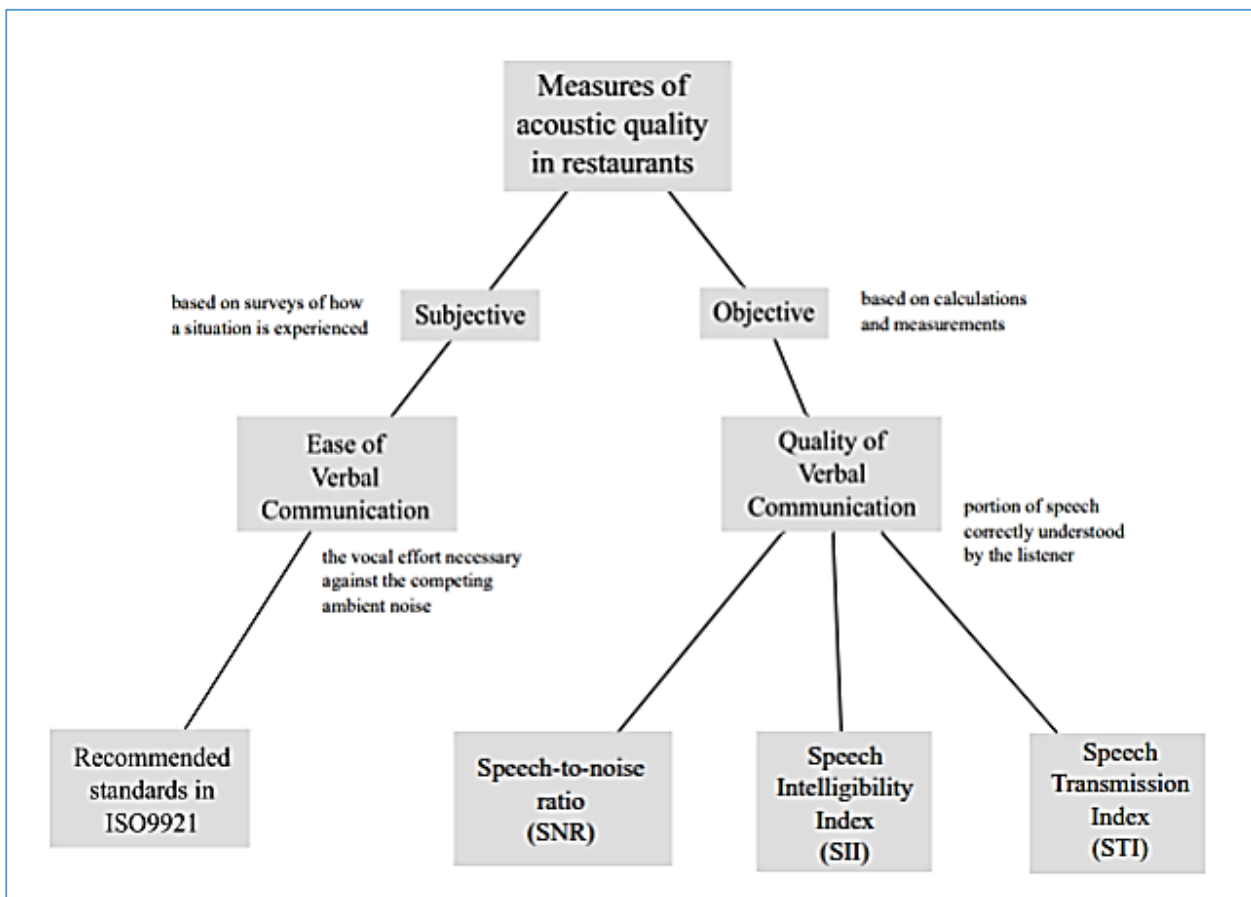


Figure 215 Literature Review.

Software is used for analysis and design.

INSUL: Insulation from sound.

EASE 4.3.

#### 4.6.1.1 Acoustical Design

Convenience in buildings integrates many factors that have to be considered in the pre-design phase of the project to ensure good interaction, minimal conflicts, the overlap between these aspects, and good build performance in the O&M phase. One of these important is the acoustic aspect, which is an essential part of the user's comfort in the facility. Especially with regard to architectural design, it plays an essential role in acoustic performance.

#### 4.6.1.2 Reverberation time:

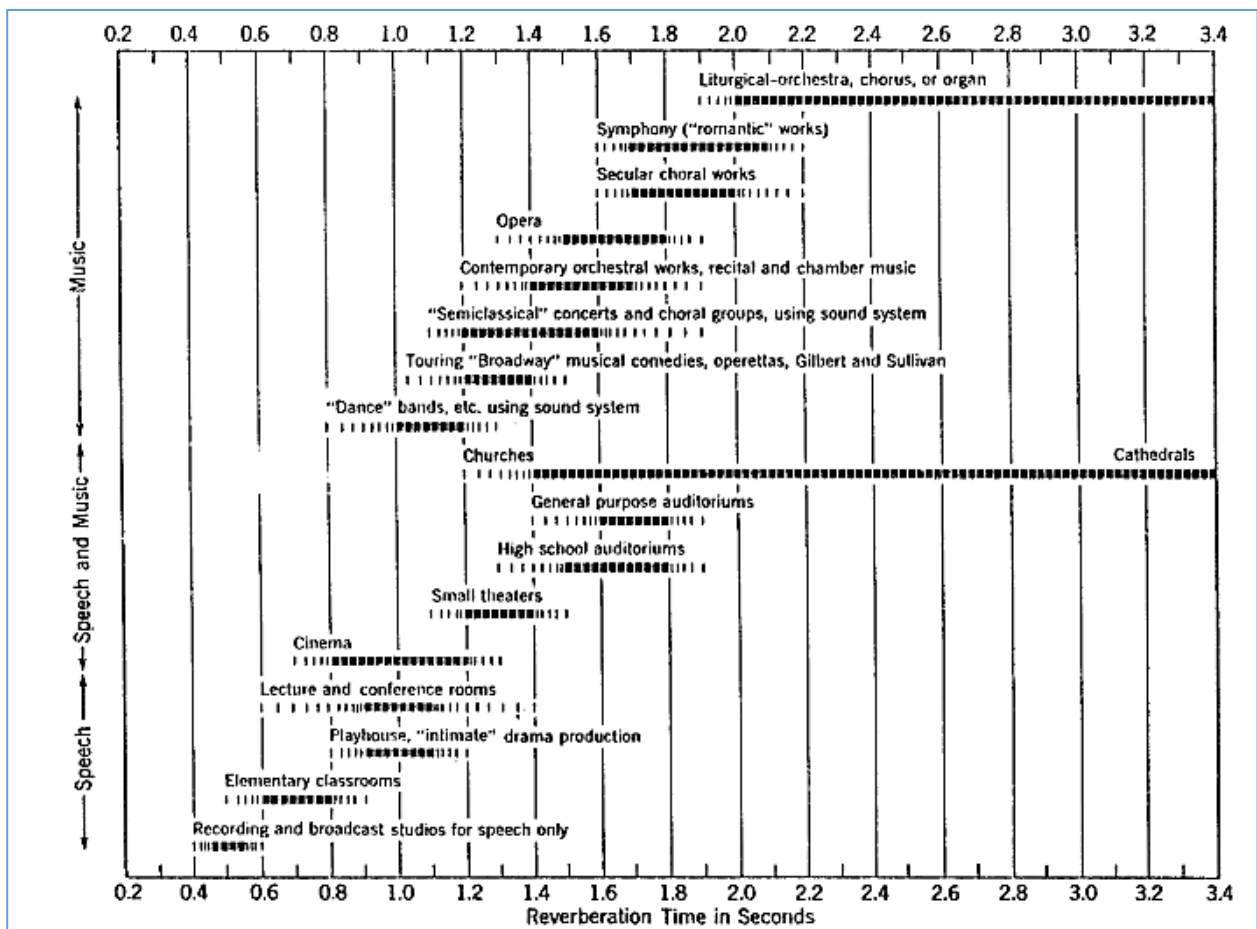


Figure 216 Reverberation time standards

#### 4.6.1.3 Sound transmission index (STI).

STI value	Quality according to IEC 60268-16
0 – 0.3	bad
0.3 – 0.45	poor
0.45 – 0.6	fair
0.6 – 0.75	good
0.75 – 1	excellent

Figure 217 STI standards

#### 4.6.1.4 Articulation index

<u>Articulation Index</u>	<u>Signal to Noise</u>	<u>% Sentences Understood</u>	<u>Intelligibility</u>	<u>Privacy</u>
> 0.4	> 0 dB	> 90	Very Good	None
0.3	-3 dB	80	Good	Poor
0.2	-6 dB	50	Fair	Transitional
0.1	-9 dB	20	Poor	Normal
< 0.05	-12 dB	0	Very Poor	Confidential

Figure 218 Articulation index standards

#### 4.6.1.5 Articulation loss

%AL	100-33%	33-15%	15-7%	7-3%	3-0%
APPRECIATION	unacceptable	problem	acceptable	good	Excellent

Figure 219 Articulation loss standards

#### 4.6.1.6 Sound pressure level (SPL):

Sound Pressure Level (dBA)	Typical Sound	Subjective Impression
150		(Short exposure can cause hearing loss)
140	Jet plane takeoff	
130	Artillery fire, riveting, machine gun	(Threshold of pain)
120	Siren at 100 ft (30 m), jet plane (passenger ramp), thunder, sonic boom	Deafening
110	Woodworking shop, hard-rock band, accelerating motorcycle	Sound can be felt (threshold of discomfort)
100	Subway (steel wheels), loud street noise, power lawnmower, outboard motor	
90	Noisy factory, unmuffled truck, train whistle, machine shop, kitchen blender, pneumatic jackhammer	Very loud, conversation difficult; ear protection required for sustained occupancy
80	Printing press, subway (rubber wheels), noisy office, supermarket, average factory	(Intolerable for phone use)
70	Average street noise, quiet typewriter, freight train at 100 ft (30 m), average radio, department store	Loud, noisy; voice must be raised to be understood
60	Noisy home, hotel lobby, average office, restaurant, normal conversation	
50	General office, hospital, quiet radio, average home, bank, quiet street	Usual background; normal conversation easily understood
40	Private office, quiet home	
30	Quiet conversation, broadcast studio	Noticeably quiet
20	Empty auditorium, whisper	
10	Rustling leaves, soundproof room, human breathing	Very quiet
0		Intolerably quiet Threshold of audibility

Figure 220 SPL standards

#### 4.6.1.7 Noise criteria:

TABLE 19.8 Suggested Noise Criteria Ranges for Steady Background Noise

Type of Space (and Acoustical Requirements)	NC Curve	Equivalent <sup>a</sup> dBA
Concert halls, opera houses, and recital halls (for listening to faint musical sounds).	10–20	20–30
Broadcast and recording studios (distant microphone pickup used).	15–20	25–30
Large auditoriums, large drama theatres, and houses of worship (for excellent listening conditions).	20–25	30–35
Broadcast, television, and recording studios (close microphone pickup only).	20–25	30–35
Small auditoriums, small theatres, small churches, music rehearsal rooms, large meeting and conference rooms (for good listening), or executive offices and conference rooms for 50 people (no amplification).	25–30	35–40
Bedrooms, sleeping quarters, hospitals, residences, apartments, hotels, motels, and so forth (for sleeping, resting, relaxing).	25–35	35–45
Private or semiprivate offices, small conference rooms, classrooms, libraries, and so forth (for good listening conditions).	30–35	40–45
Living rooms and similar spaces in dwellings (for conversing or listening to radio and TV).	35–45	45–55
Large offices, reception areas, retail shops and stores, cafeterias, restaurants, and so forth (for moderately good listening conditions).	35–50	45–60
Lobbies, laboratory work spaces, drafting and engineering rooms, general secretarial areas (for fair listening conditions).	40–45	50–55
Light maintenance shops, office and computer equipment rooms, kitchens, and laundries (for moderately fair listening conditions).	45–60	55–70
Shops, garages, power-plant control rooms, and so forth (for just acceptable speech and telephone communication). Levels above PNC-60 are not recommended for any office or communication situation.	—	—
For work spaces where speech or telephone communication is not required, but where there must be no risk of hearing damage.	—	—

Figure 221 NC standards

#### 4.6.1.8 Sound transmission class (STC)

The following Figure 222 shows the standards for sound transmission class for partitions between various spaces:

**TABLE 19.13 Recommended STC for Partitions; Specific Occupancies**

Type of Occupancy	Wall, Partition, or Panel Between		Sound Insulation Requirement: Background Level in Room Being Considered	
	Room Being Considered	and Adjacent Area	Quiet	Normal
Normal school buildings without extraordinary or unusual activities or requirements	Classrooms	Adjacent classrooms	STC 42	STC 40
		Corridor or public areas	STC 40	STC 38
		Kitchen and dining areas	STC 50	STC 47
		Shops	STC 50	STC 47
		Recreation areas	STC 45	STC 42
	Music practice rooms	Music rooms	STC 55	STC 50
		Mechanical equipment rooms	STC 50	STC 45
		Toilet areas	STC 45	STC 42
		Adjacent practice rooms	STC 55	STC 50
		Corridor and public areas	STC 45	STC 42
Executive areas, doctors' suites; confidential privacy requirements	Office	Adjacent offices	STC 50	STC 45
		General office areas	STC 48	STC 45
		Corridor or lobby	STC 45	STC 42
		Washrooms and toilet areas	STC 50	STC 47
Normal office; normal privacy requirements; any occupancy using rooms for group meetings	Office	Adjacent offices	STC 40	STC 38
		Corridor, lobby, exterior	STC 40	STC 38
		Washrooms, kitchen, dining	STC 42	STC 40
	Conference rooms	Other conference rooms	STC 45	STC 42
		Adjacent offices	STC 45	STC 42
		Corridor or lobby	STC 42	STC 40
		Exterior of building	STC 40	STC 38
		Kitchen and dining areas	STC 45	STC 42
Large offices, drafting areas, banking floors, etc.	Large general office areas	Corridors, lobby, exterior	STC 38	STC 35
		Data-processing area	STC 40	STC 38
		Kitchen and dining areas	STC 40	STC 38
Motels and urban hotels Hospitals and dormitories	Bedrooms	Adjacent bedrooms <sup>a</sup>	STC 52	STC 50
		Bathroom <sup>a</sup>	STC 50	STC 45
		Living rooms <sup>a</sup>	STC 45	STC 42
		Dining areas	STC 45	STC 42
		Corridor, lobby, or public spaces	STC 45	STC 42

Figure 222 STC standards

## 4.6.2 Acoustical software results.

### 4.6.2.1 EASE program.

Table 80 Suggested material:

Name	Material
Floor	Parquet conc
Ceiling	Gypsum 12.5MM
Walls	Plaster/LTHS ,PLYWD 1/2
Windows	Double Glass 6mm

#### 4.6.2.1.1 Lobby (waiting room) acoustical design.

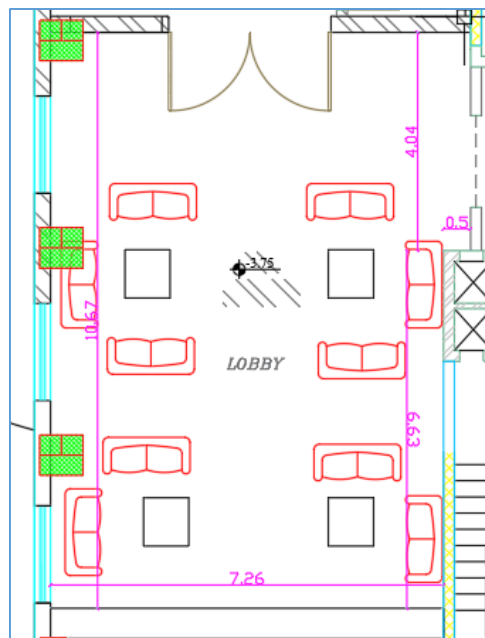


Figure 223Lobby plan

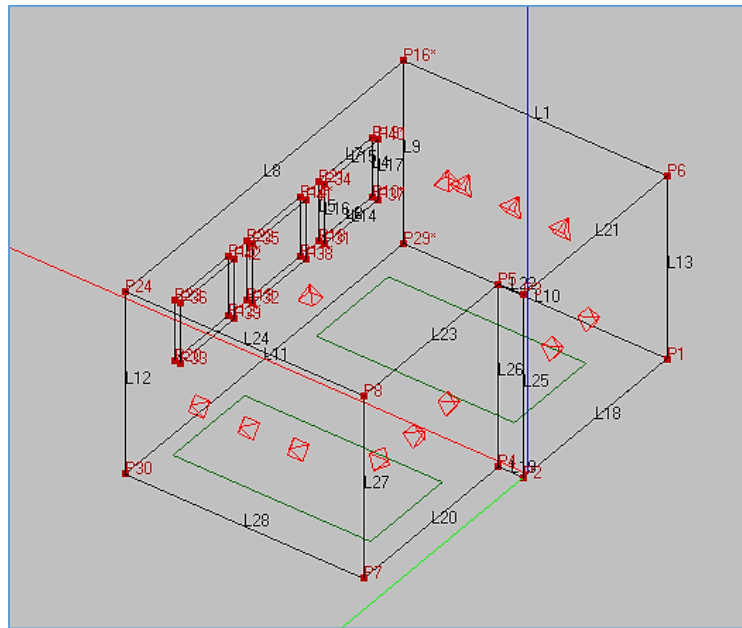


Figure 224 Lobby from EASE

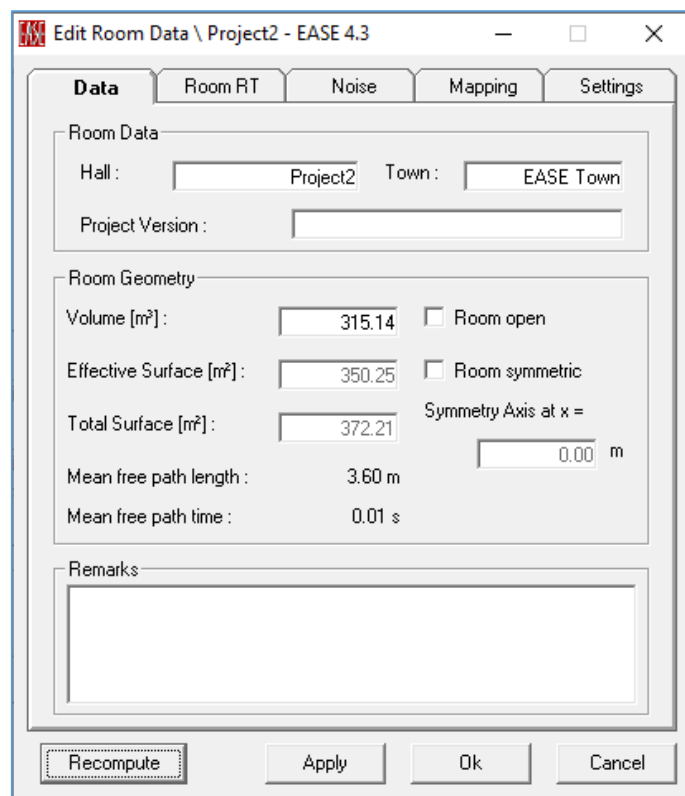


Figure 225 Room volume from EASE

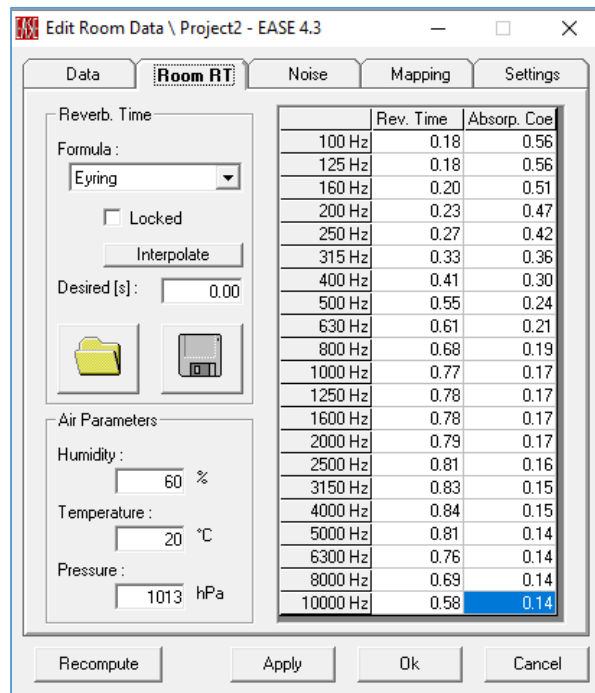


Figure 226 RT from EASE:

RT values are good, less than 1.2 second .

Sound pressure level (SPL):

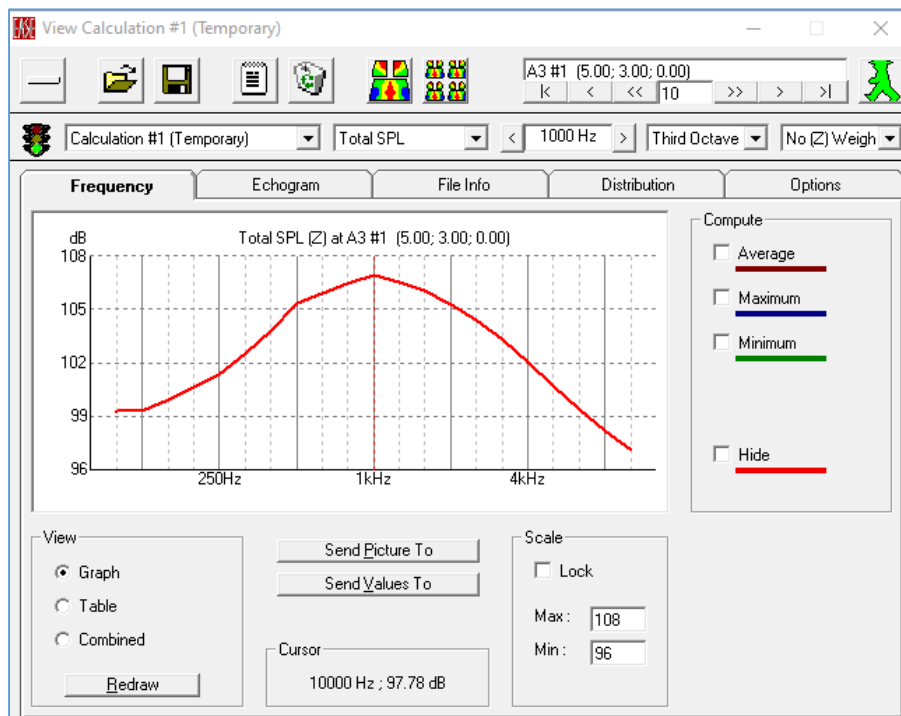


Figure 227 SPL graph

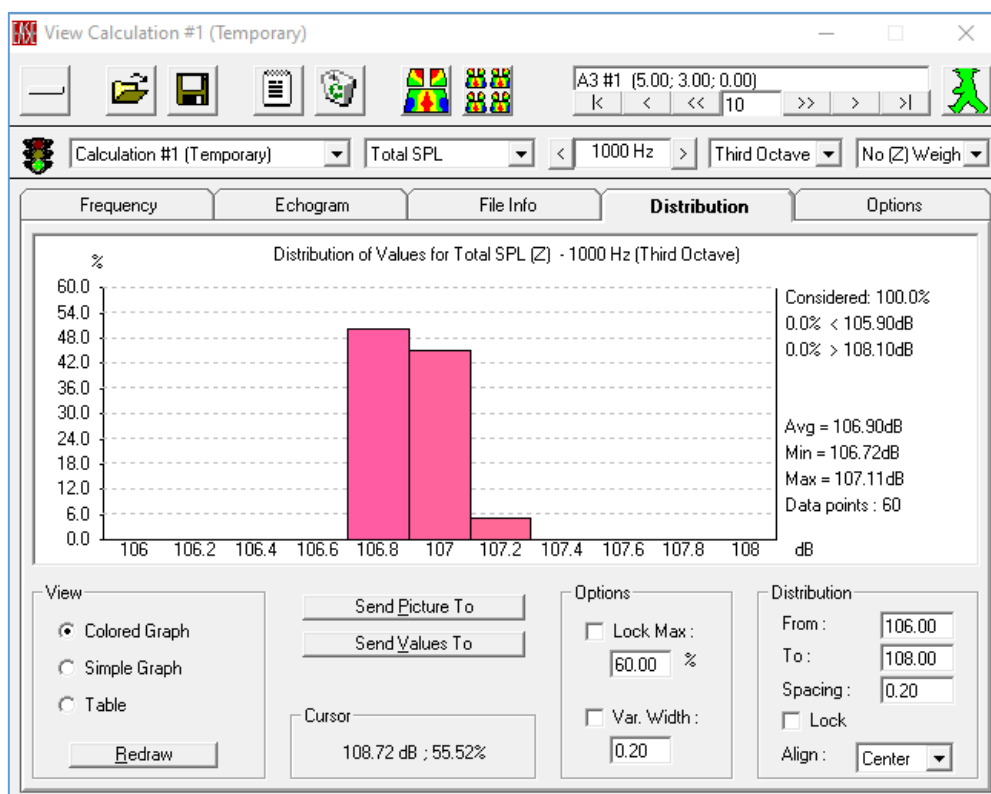


Figure 228 SPL distribution

Sound transmission index (STI):

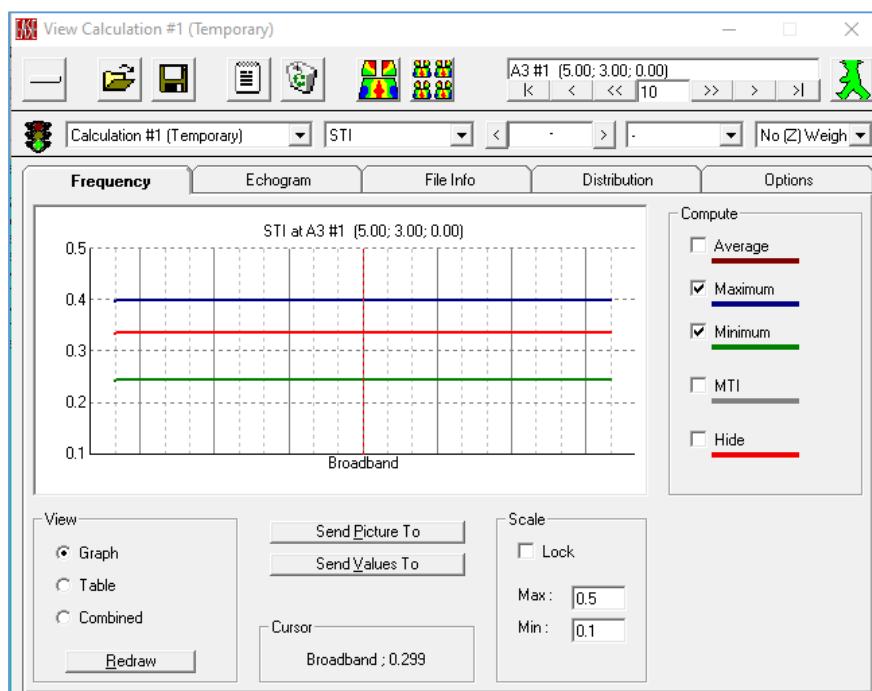


Figure 229 STI graph

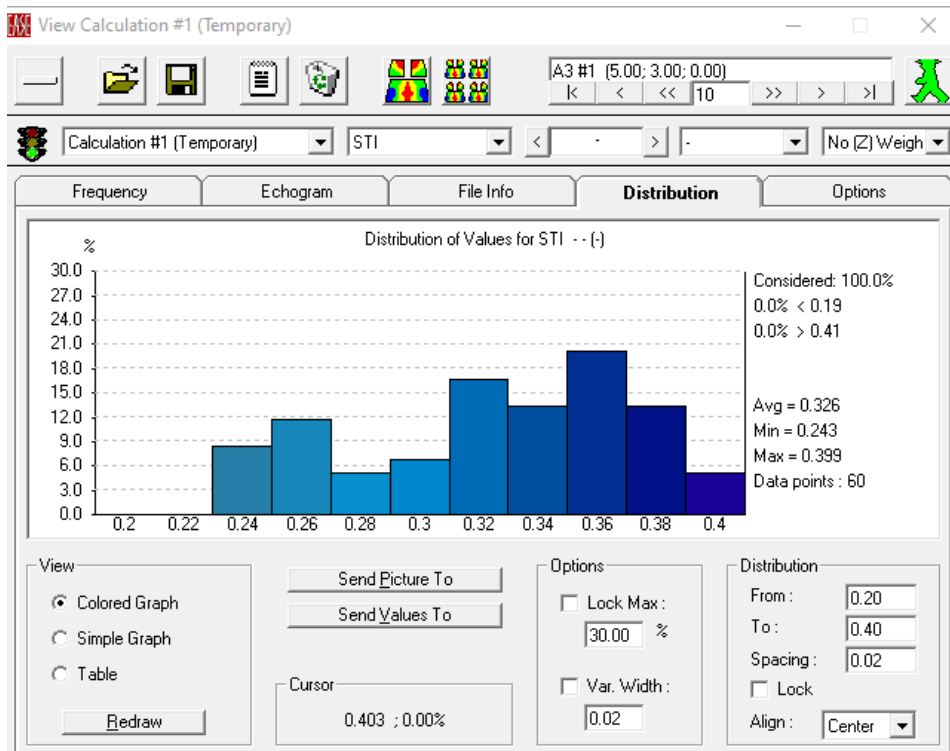


Figure 230 STI distribution

#### 4.6.2.1.2 Cafeteria acoustical design:

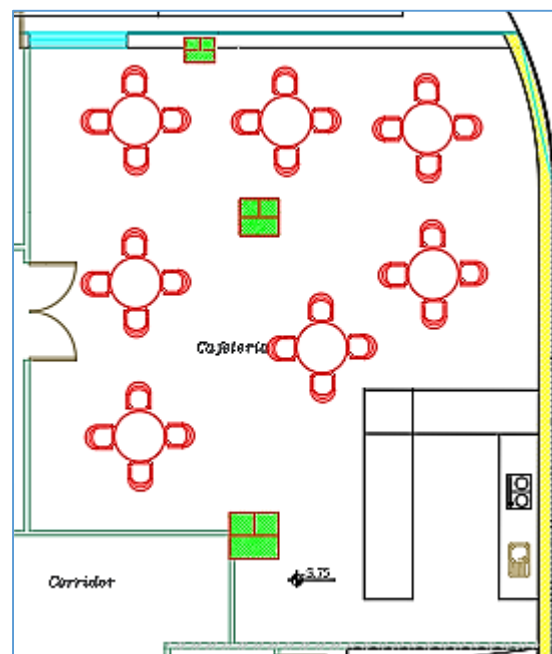


Figure 231 Cafeteria Plan

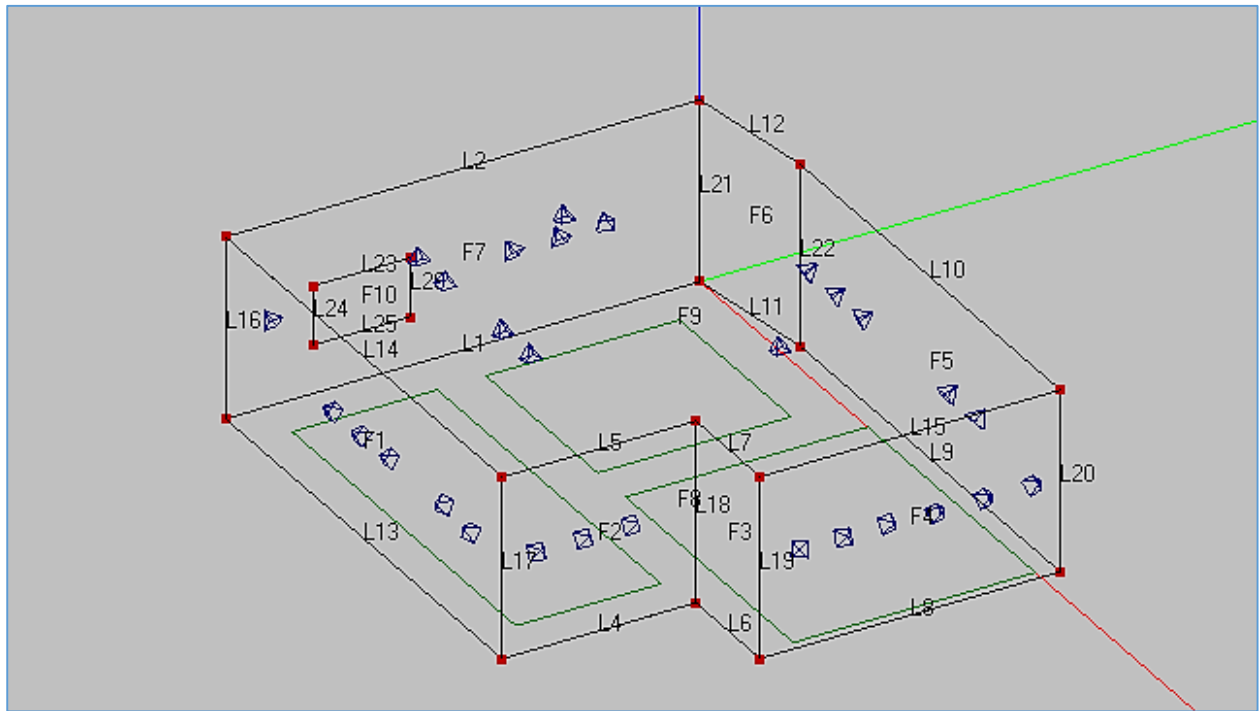


Figure 232 Cafeteria From EASE:

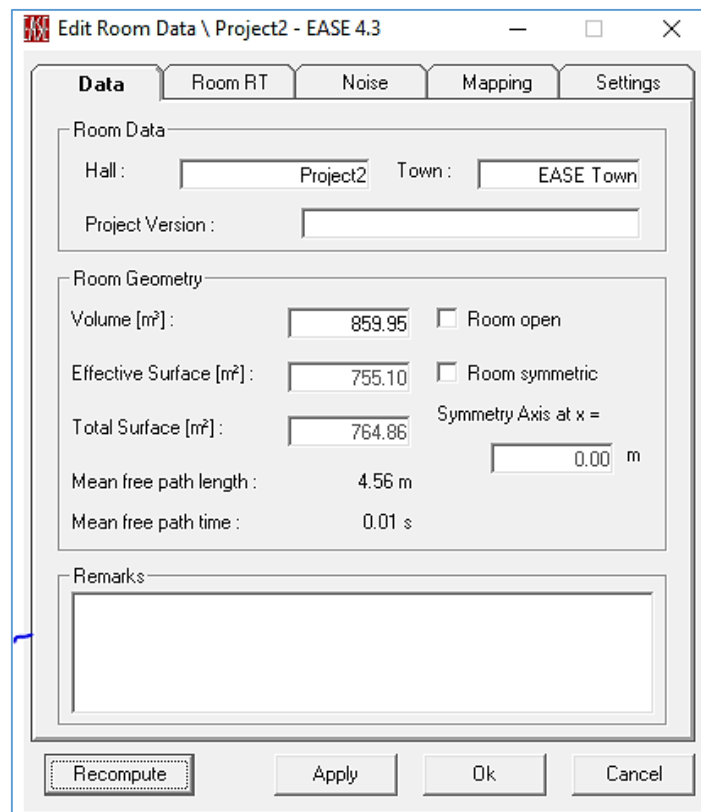


Figure 233 Volume from Ease

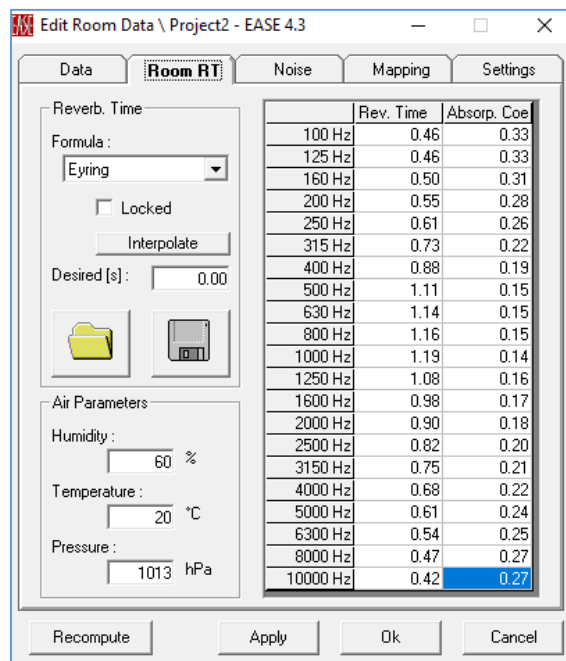


Figure 234 RT from EASE

RT values are good, less than 1.2 second

Sound pressure level (SPL):

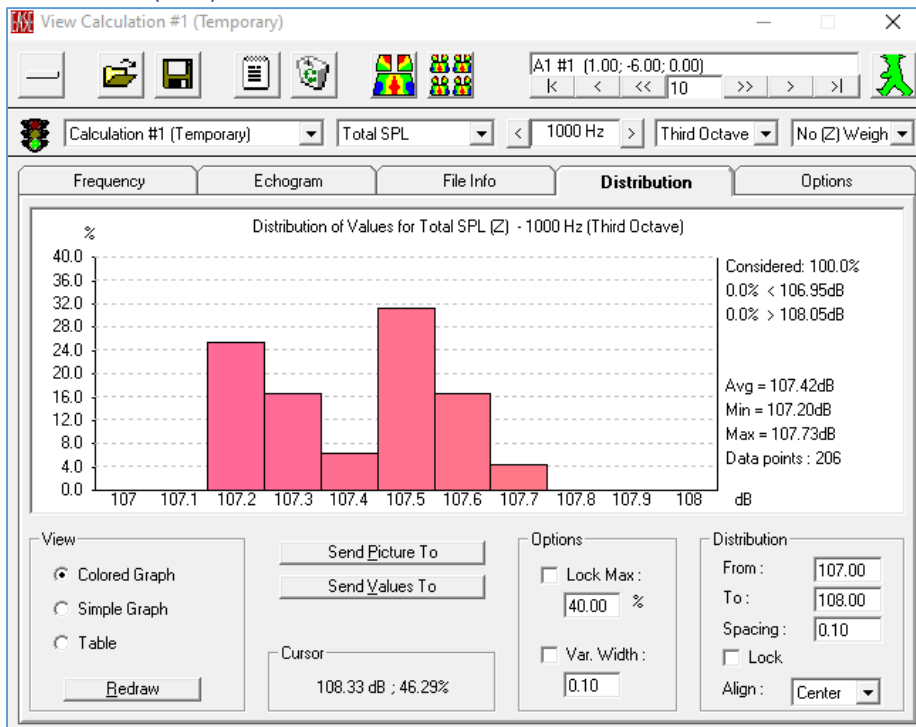


Figure 235 SPL graph

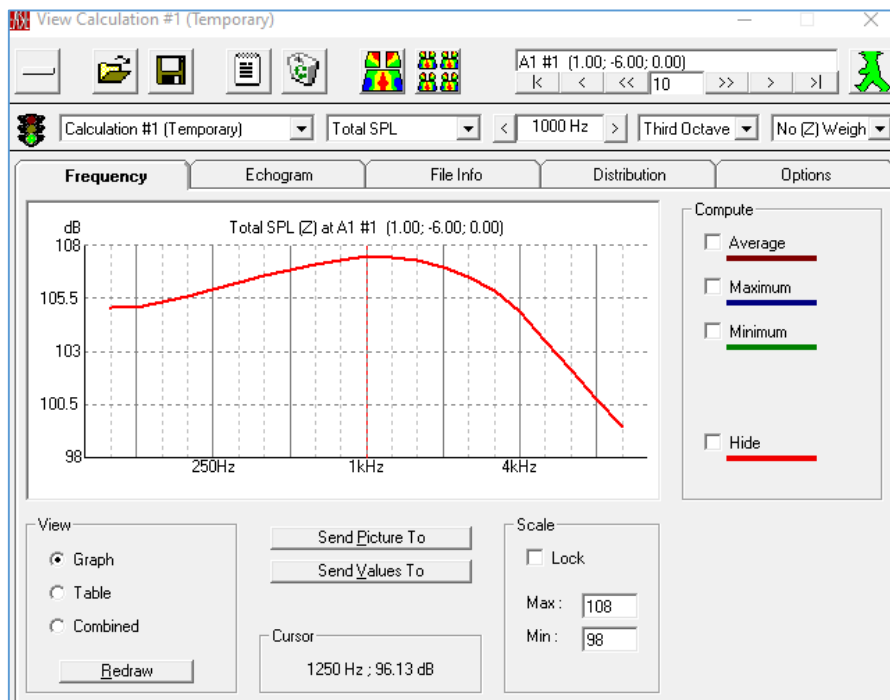


Figure 236 SPL distribution

Sound transmission index (STI):

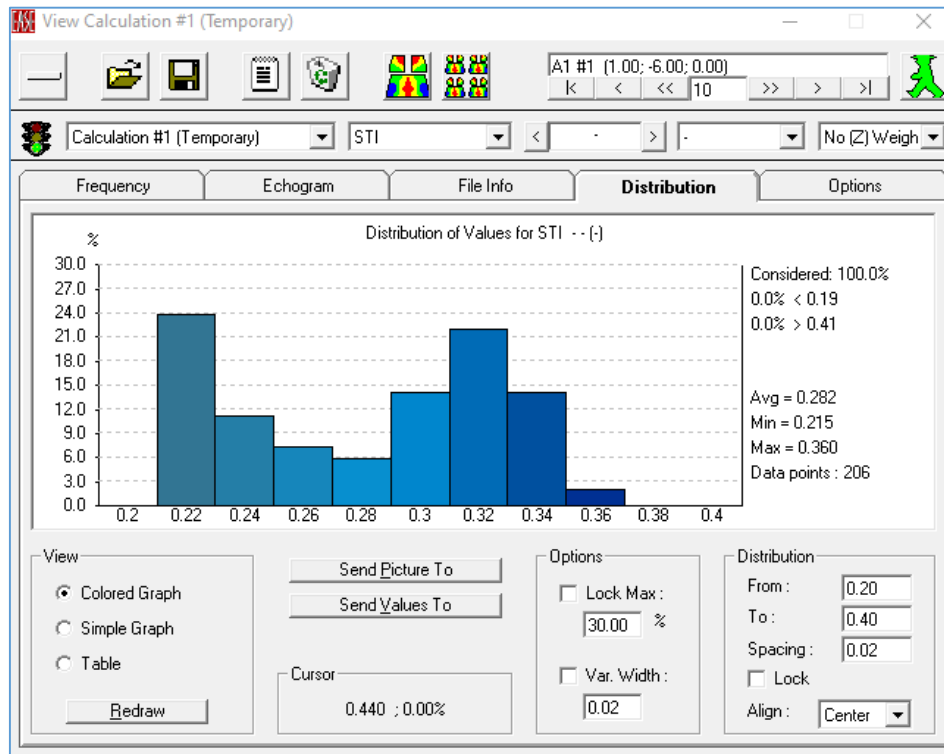


Figure 237 STI distribution

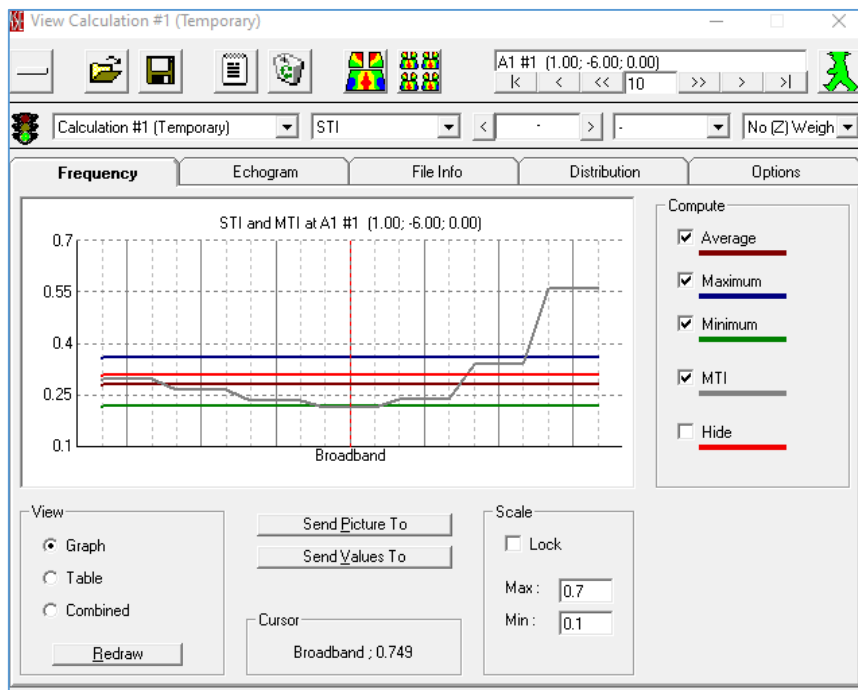


Figure 238 STI graph

4.6.2.1.3 Study area acoustical design.

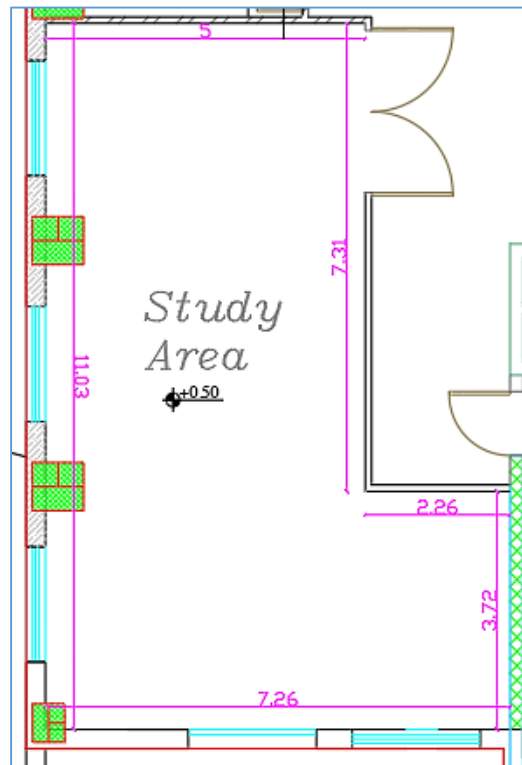


Figure 239 Study area plan

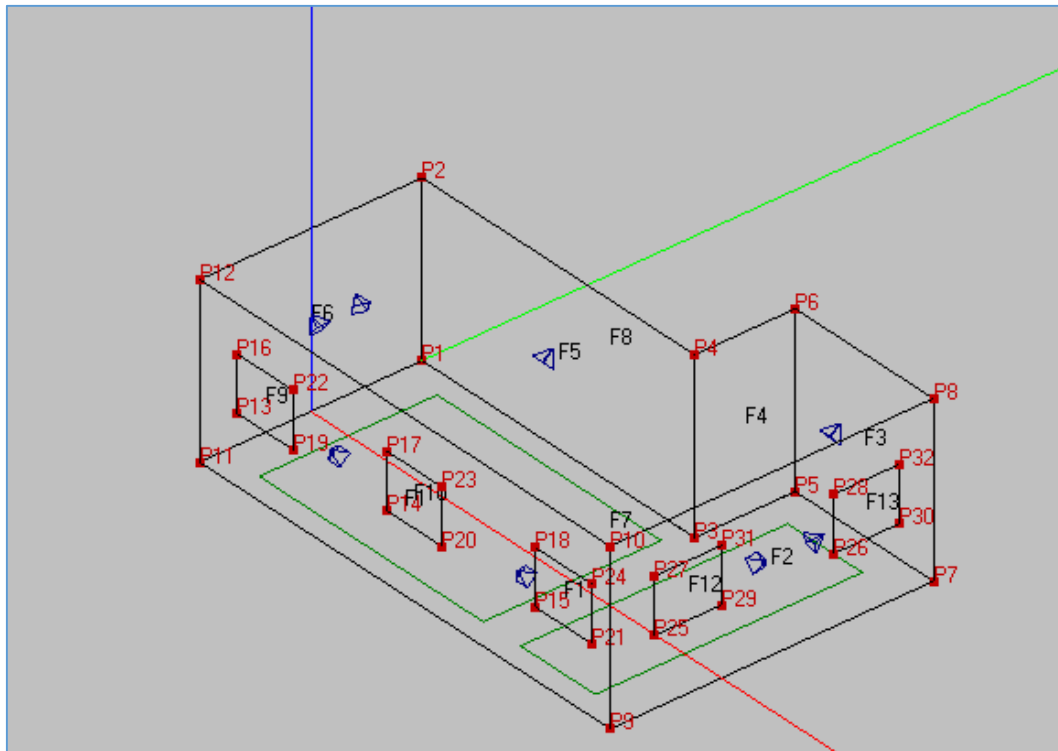


Figure 240 Study area from EASE:

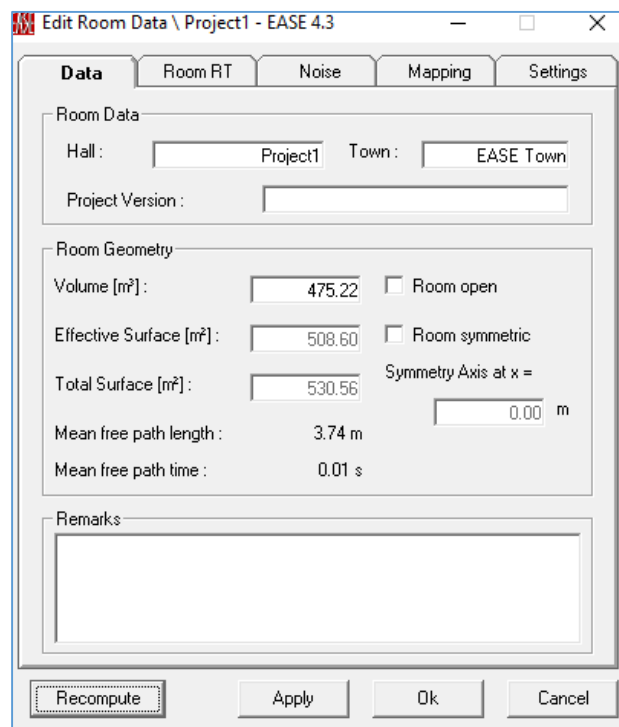


Figure 241 Volume from EASE

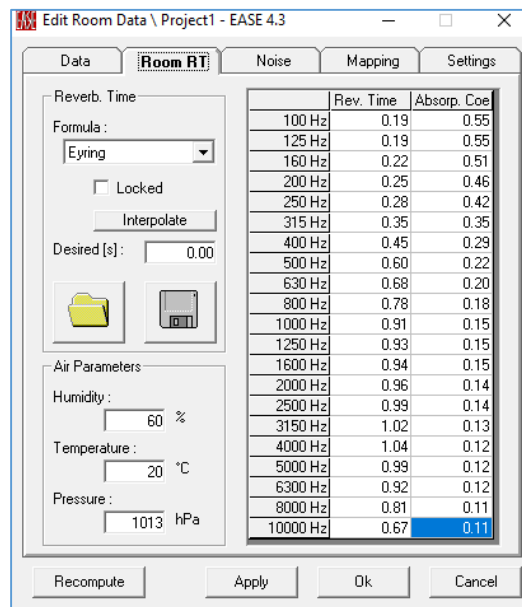


Figure 242 RT from EASE

RT values are good, less than 1.2 second.

Sound pressure level (SPL):

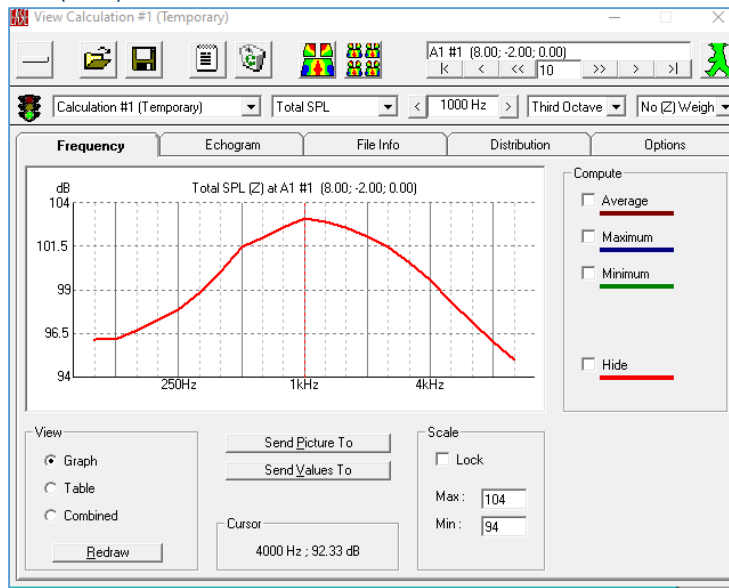


Figure 243 SPL graph

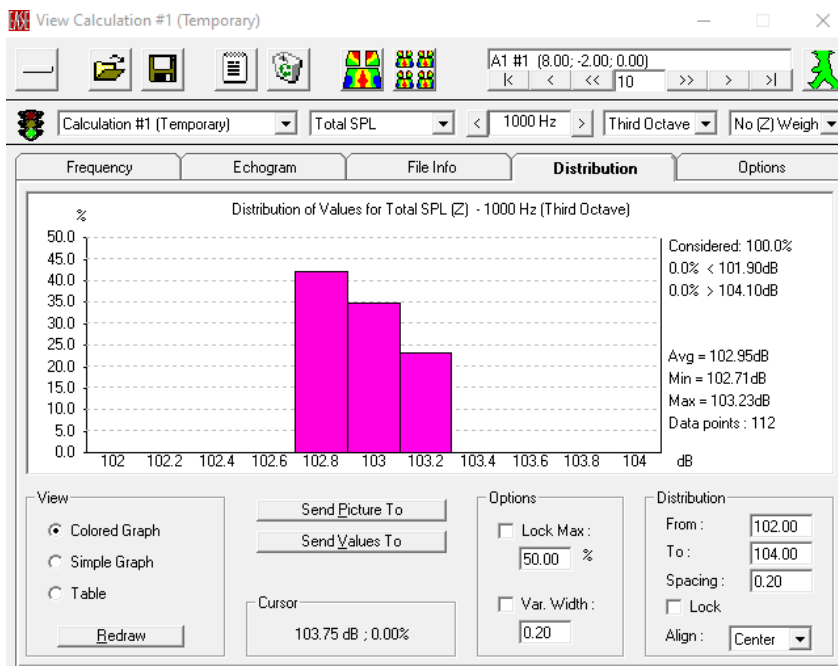


Figure 244 SPL distribution

Articulation index:

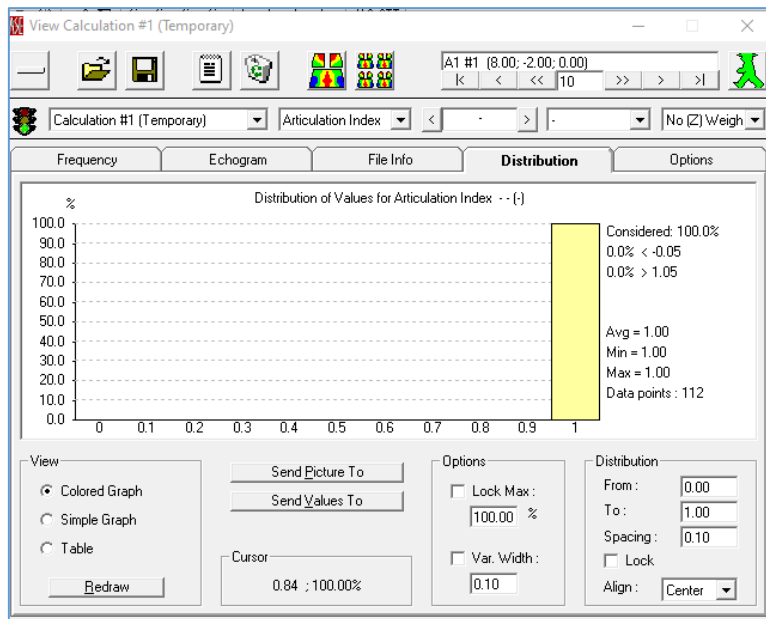


Figure 245 Articulation index distribution

Articulation index is good; it is around 1.

Sound transmission index (STI):

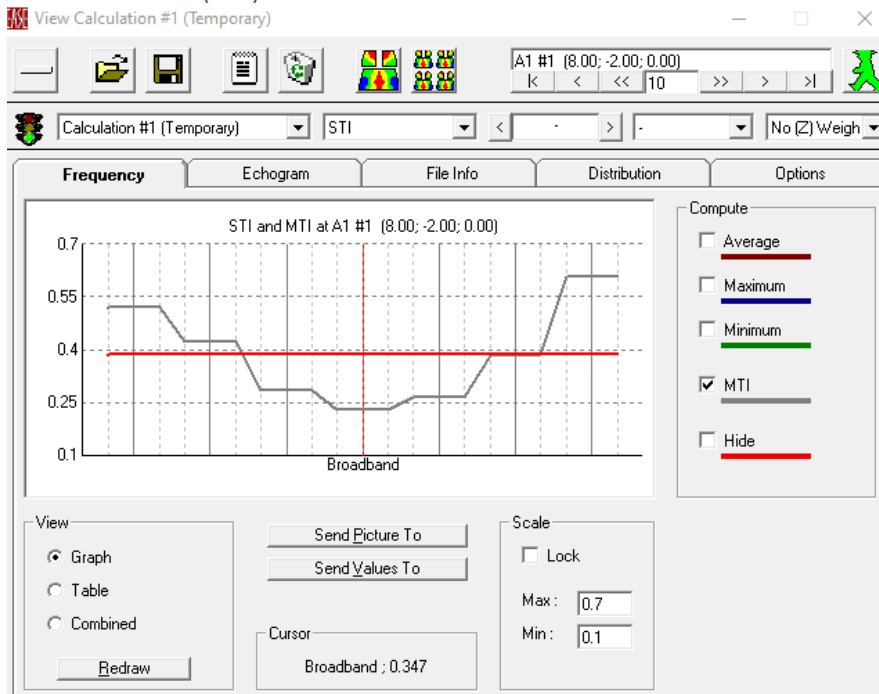


Figure 246 STI graph

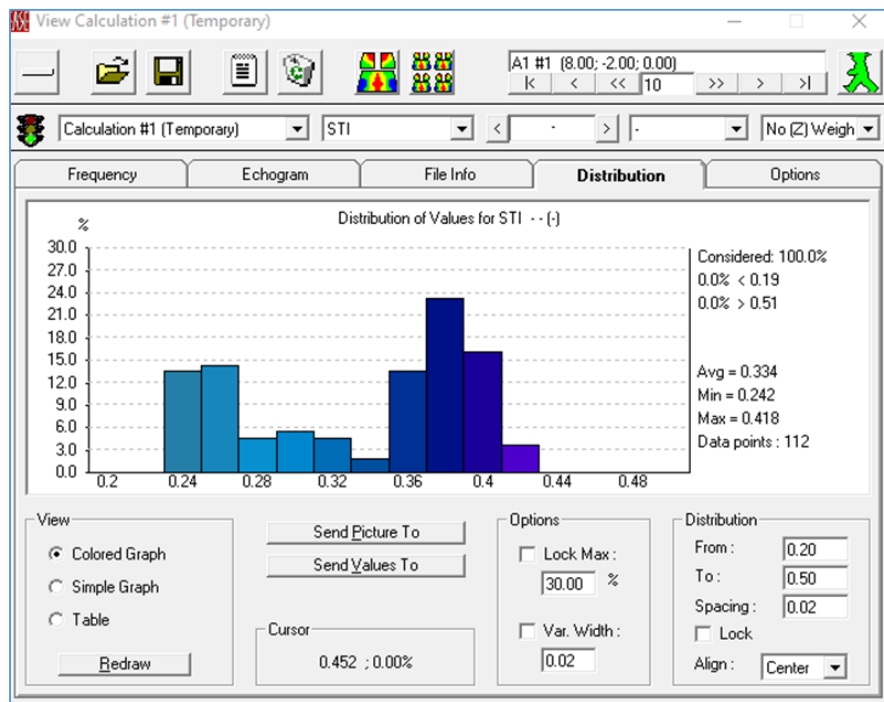


Figure 247 STI distribution

#### 4.6.2.1.4 Shop area acoustical design:

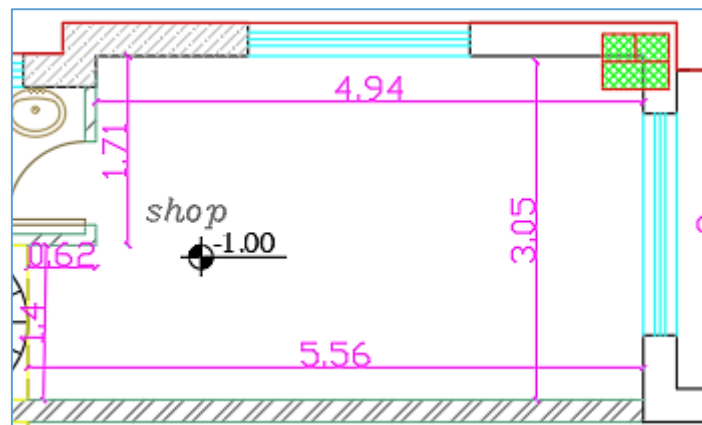


Figure 248 Shop area plan

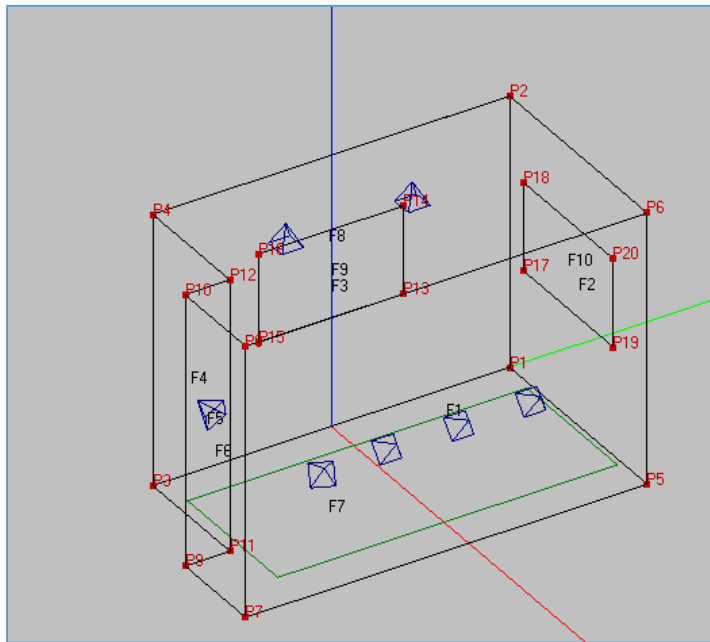


Figure 249 Shop area From EASE.

Edit Room Data \ Text1 - EASE 4.3

**Data** Room RT Noise Mapping Settings

Room Data

Hall:  Town:

Project Version:

Room Geometry

Volume [m<sup>3</sup>]:   Room open

Effective Surface [m<sup>2</sup>]:   Room symmetric

Total Surface [m<sup>2</sup>]:  Symmetry Axis at x =  m

Mean free path length: 2.74 m

Mean free path time: 0.01 s

Remarks

Figure 250 Shop area volume

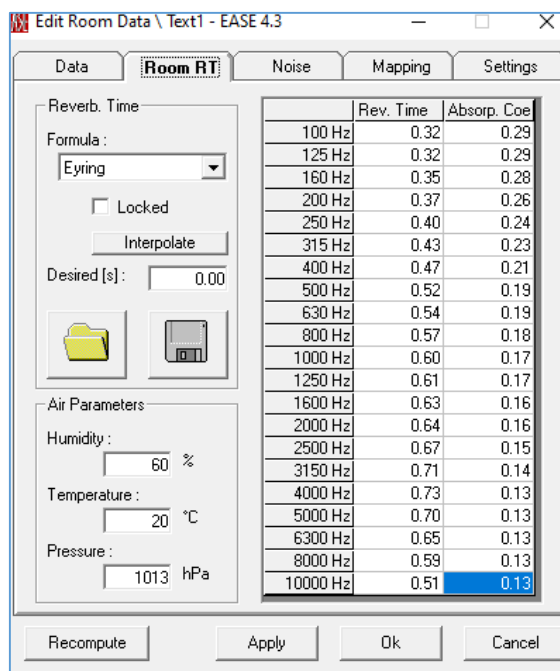


Figure 251 RT from EASE

RT values are good, less than 1.2 second.

Sound pressure level (SPL):

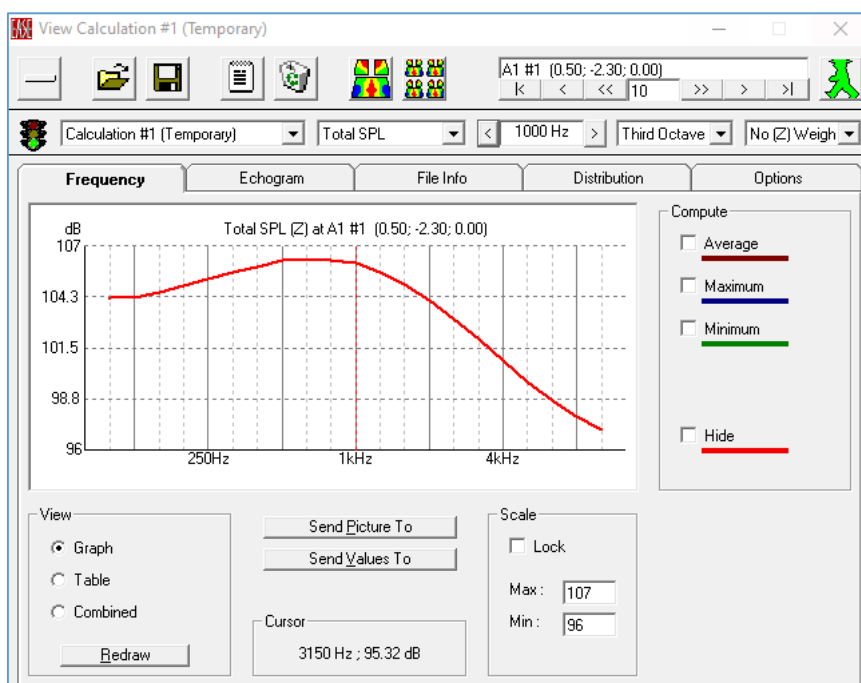


Figure 252 SPL graph

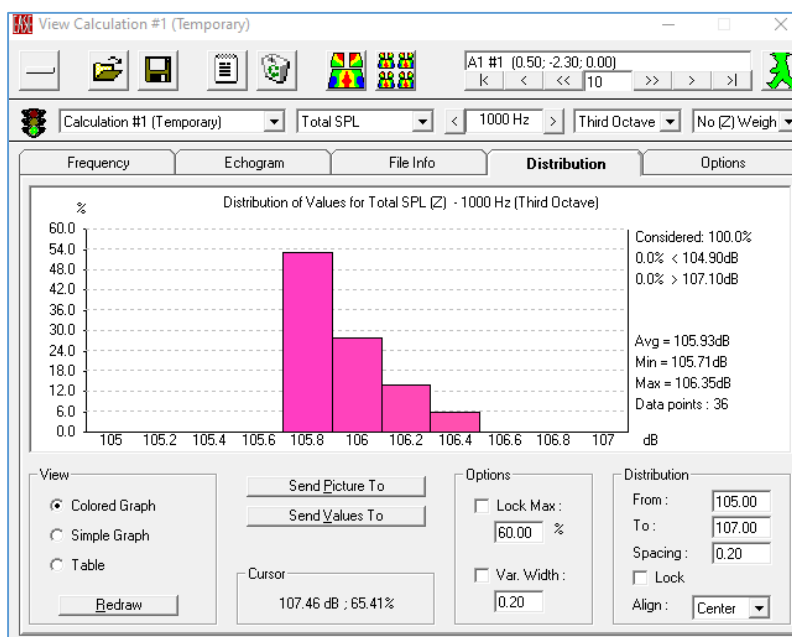


Figure 253 SPL distribution

Sound transmission index (STI):

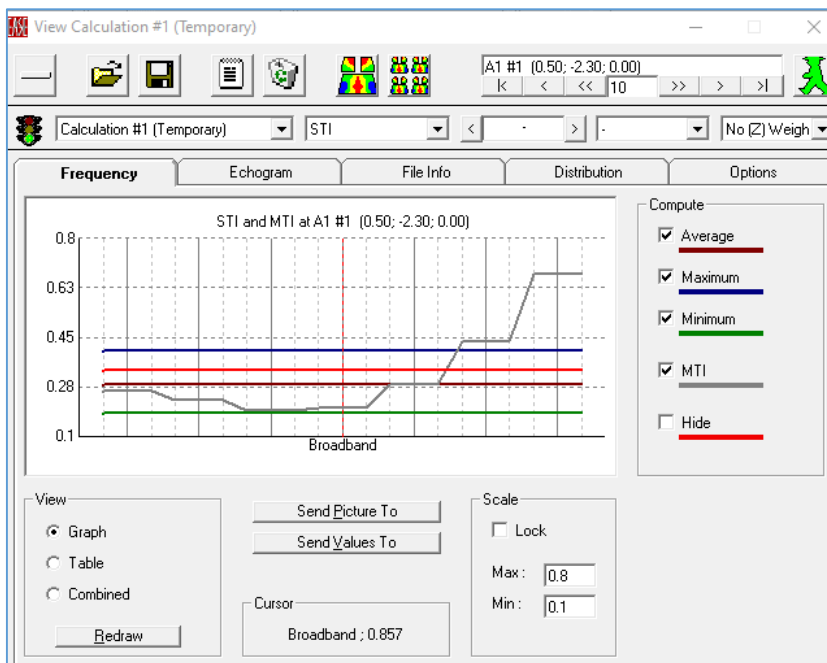


Figure 254STI graph

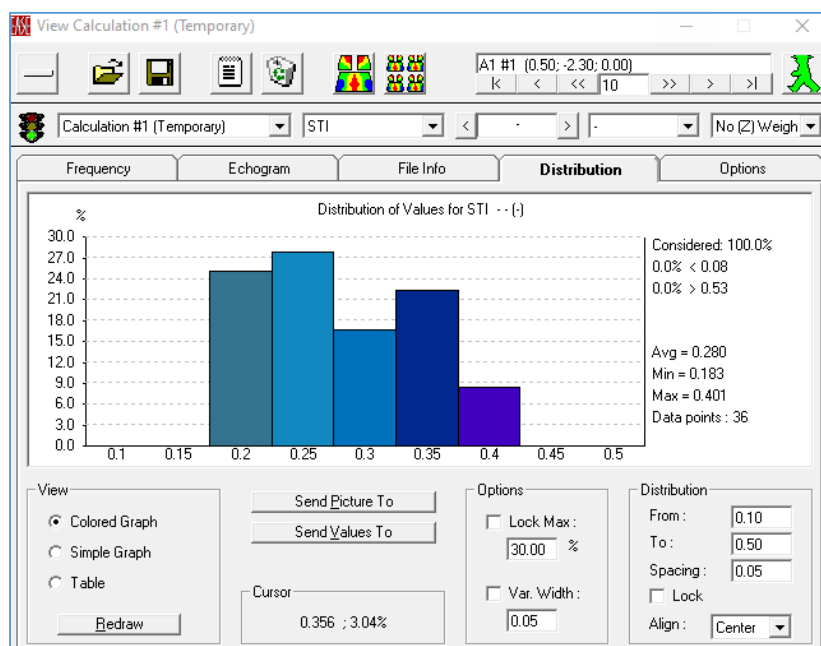


Figure 255 STI distribution

#### 4.6.2.2 INSUL program

##### 4.6.2.2.1 Sound transmission class

STC	What can be heard
25	Normal speech can be understood
30	Loud speech can be understood
35	Loud speech audible but not intelligible
40	Loud speech audible as a murmur
45	Loud speech heard but not audible
50	Loud sounds faintly heard
60+	Good soundproofing; most sounds do not disturb neighboring residents. <sup>[6]</sup>

Figure 256 STC standards

External wall.

Figure 257 shows section in external wall.

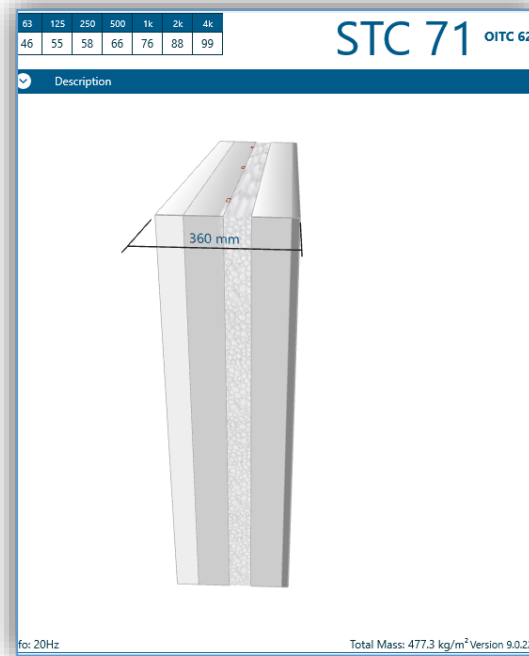


Figure 257 Section in external wall

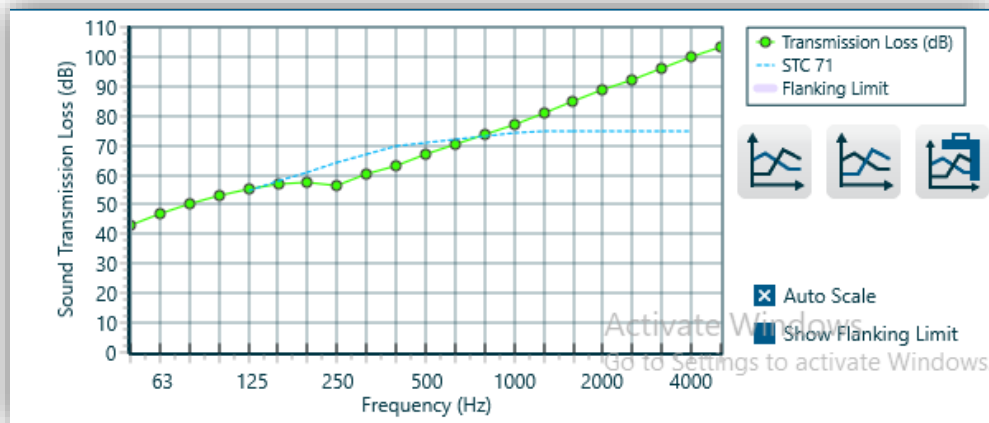


Figure 258 STC For external wall.

From Figure 258, STC is very good, it is more than 60.

Internal Partitions.

Figure 259 shows section in internal partitions.

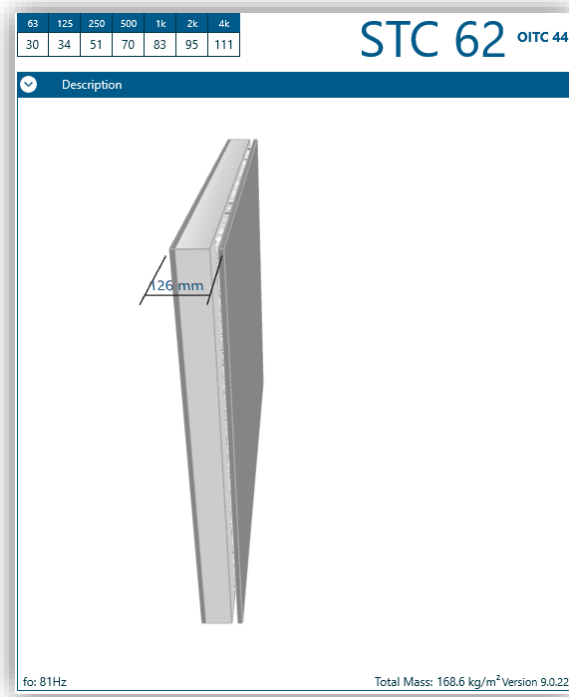


Figure 259 section in internal partitions

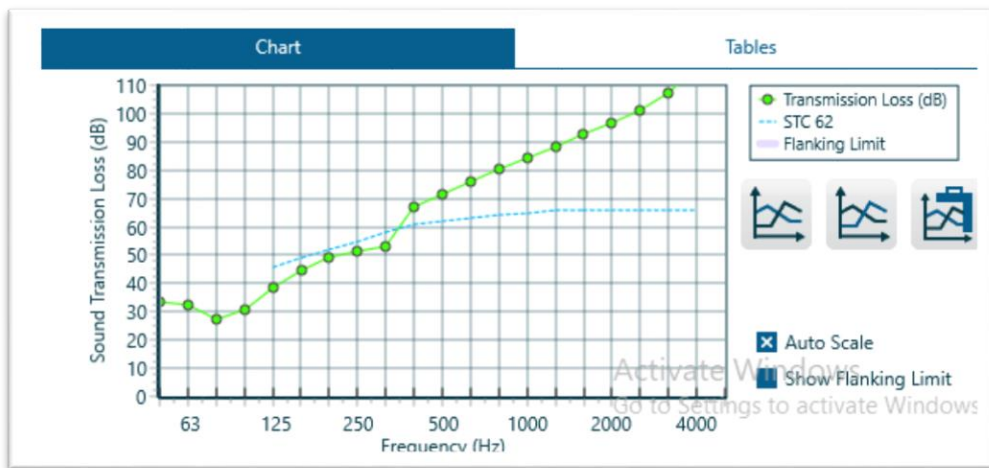


Figure 260 STC For internal partitions

From Figure 260, STC is very good, it is more than 60.

External Glazing.

Figure 261 shows section in Glass.

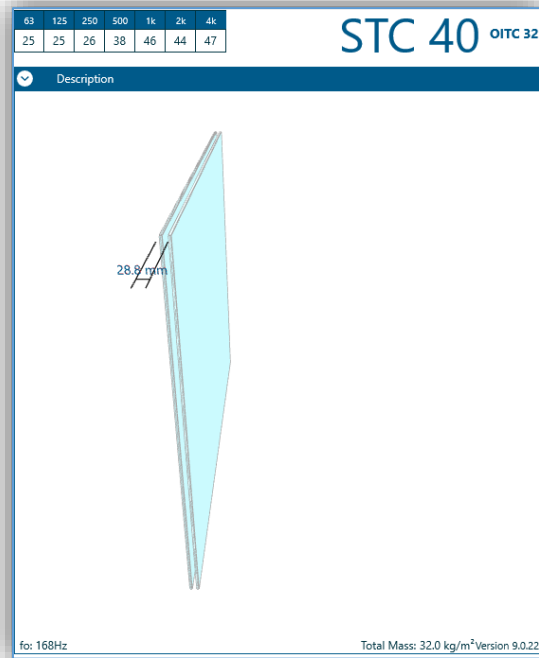


Figure 261 External glazing

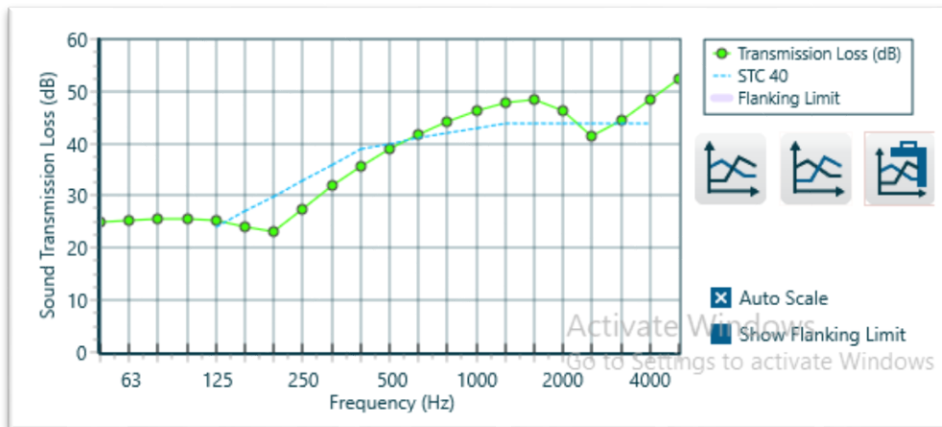


Figure 262 External glazing STC

Figure 262 STC for glass is good, it is in range (35-40).

Chapter Five:

Quantity Surveying and Cost Estimation.

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## 5 QUANTITY SURVEYING COST ESTIMATION.

In this chapter the quantity and cost estimation is shown.

### 5.1 Introduction

Estimating costs is one of the most important and accurate things that are prepared before the implementation of any project, especially in construction projects. The work of a quantity surveyor is critical to ensuring that the construction project budget is used in the most practical and cost-effective way. The quantity surveyor ensures that the planned work is feasible and that the client's funds are wisely invested to achieve a high-level structure that reflects their original plans. This is why one of the key aspects of a quantity surveyor's work is to balance the budget with quality, and make sure they invest in the best people and materials needed for the job. They need to make sure that the budget they allocate to materials is invested wisely, as this literally forms the foundations of any building, big or small.

### 5.2 Methodology

In this project, after the completion of the architectural, environmental and structural section, it is required to prepare a tentative cost estimate in order to identify a tentative budget requirement based on the project information available at hand.

### 5.3 Budget development and cost estimate

The cost of 1 SM for the multifunctional building =(3000 – 3500) Shekel Table 81 shows the bill of quantity and costs:

Table 81BOQ.

Activity ID	Activity name	Unit	Quantity	Unit cost	Total cost
1	Structural Work				
	Structural System				
1.1	Steel	Kg	230500	3.5	806750
1.1.1	Concrete 10cm	Cube	2440	330	805200
1.1.2	Brick 10cm	CM	24000	1.5	36000
1.1.3	Brick rib 24cm	CM	13200	3.5	46200
1.1.4	Brick 20cm	CM	11200	2.5	28000
1.1.5	Stone	SM	2100	130	273000
1.1.6	Contractor cost				700000
1.1.7	Indirect cost & other				180000
	Exavation and soil improvement				150000

2	Finishing				
2.1	Plastering				
2.1.1	ceiling plaster	SM	5982	30	179460
2.1.2	wall plaster	SM	4275	30	128250
2.2	Painting				
2.2.1	ceiling painting	SM	5982	20	119640
2.2.2	wall painting	SM	4275	40	171000
2.3	Tiles				
2.3.1	wall tile	SM	387	150	58050
2.3.2	floor tile	SM	5992	200	1198400
2.4	Windows				
2.4.1	Aluminum window	SM	205	500	102500
2.5	Doors				
2.5.1	single wooden door	Unit	152	2000	304000
2.5.2	single glass door	Unit	54	3000	162000
2.5.3	double wooden door	Unit	5	2700	13500
2.5.4	Entrance door	Unit	3	6700	20100
2.5.5	Emergency door	Unit	9	3000	27000

3	Electrical work				
	Socket				
3.1	Socket	unit	438	22	9636
3.1.1	Lighting unit				
3.2	Square lighting unit	Unit	150	150	22500
3.2.1	Lamp	Unit	128	12	1536
3.2.2	Copper wire roll	Unit	250	100	25000
3.2.3	Plastic electricity tube	Unit	144	70	10080
3.2.4	SDB	Unit	19	1200	22800
3.2.5	MDB	Unit	1	7000	7000
3.2.6	Electrical contractor				50000
3.2.7	Indirect cost & other				20000
4	Mechanical work				
4.1	HVAC				
4.1.1	Chiller	Unit	6	10000	60000
4.1.2	Diffuser	Unit	90	300	27000
4.1.3	Fan coil	Unit	8	2000	16000
4.1.4	Duct	Unit	77	60	4620
4.2	Water supply and Drainage system				
4.2.1	Steel pipe 4"	Unit	700	14	9800
4.2.2	Steel pipe 6"	Unit	130	25	3250
4.2.3	Pvc 16 mm	Unit	5000	5	25000
4.2.4	Pvc 25 mm	Unit	100	15	1500
4.2.5	Pvc 50 mm	Unit	60	30	1800
4.2.6	Collector	Unit	33	600	19800
4.2.7	Bathroom carpentry	Unit	66	1100	72600
4.2.8	Washing Sink	Unit	55	600	33000
4.2.9	Shower Sink	Unit	54	400	21600
4.2.10	Washing Tap	Unit	55	250	13750
4.2.11	Shower tap	Unit	54	170	9180
	Fiting				10000
4.2.12	Manhole	Unit	16	300	4800
4.2.13	Iron water drain	Unit	1	1500	1500
	Contractor				130000
5	Elevator				
5.1	Elevator System				
5.1.1	Elevetor	Unit	1	130000	130000
Total					6142802

Unit cost = total /cost total area

Unit cost = 6142802 /3207 = 1916 NIS/m<sup>2</sup>

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