COMPARING APARTMENT BALCONY DESIGN OPTIONS IN TORONTO FOR USEABILITY, HEALTHY LIGHTING AND DAYLIGHT AVAILABILITY

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ABSTRACT

The design of apartment balconies impacts the energy use, quality of life, and health and well-being of residents. This simulation-based study analyzed and compared open air and glass-enclosed inset balconies for two typical unit sizes in multi-unit residential buildings (MURB) in Toronto, Canada. The case study evaluated balcony options based on impact on unit lighting, and tested various balcony sizes that would enable different uses. The simulation results were compared with lighting criteria for Leadership in Energy and Environmental Design (LEED) Standard and the circadian lighting credit for the WELL Building Standard. Findings include recommendations for design options that enable balcony uses as dining and living spaces, and relating to the impacts of balcony designs on building performance. Daylight and healthy lighting were evaluated both for the unit, and on the balcony as its own usable space. Future work should compare simulation findings to occupant satisfaction in field studies.

Keywords: Balcony Design, Daylight Availability, Healthy Lighting.

1 INTRODUCTION

Balconies are a typical feature of high density apartment buildings in Toronto, and these spaces can provide residents with important access to the outdoors, and their glazed operable doors provide fresh air and daylight. Most new apartments are small, and when designed appropriately, balconies can be utilized to extend the indoor spaces outside to enhance and improve the quality of life and wellbeing of the occupants. The objectives of this study were to evaluate how different balcony design options in multi-unit residential buildings (MURB) could be used to provide more functional spaces and promote occupant well-being. Different balcony designs were tested for their ability to extend living and dining spaces into the outdoors and to create all-season balconies. This study evaluated how open-air and glass enclosed balcony designs compare in terms of daylight availability and healthy daylighting for the units, and the impacts of how enlarging the balcony to accommodate a living and dining space impacted daylight availability and healthy daylighting for the units.

2 BACKGROUND

Daylight availability is a key factor in MURB design, and balcony designs impact potential energy use, quality of life, and health and well-being. A recent study of urban balconies addressed the impacts of balcony design on daylight (Peters and Kesik 2020). In their study, design parameters including geometry and size of balcony, location of the balcony in relation to the unit and the material of the balcony railings were considered significant. The findings revealed that all balconies negatively affect the daylight in the unit and have various effects on daylight penetration (Peters and Kesik 2020). In a study by Ribeiro, Ramos and Flores-Colen (2019), different types of balconies and their impacts on daylight availability were analyzed. Protruding balconies, shaded balconies and glazed balconies were studied with regard to their impacts of lighting comfort. Ribeiro, Ramos and Flores-Colen (2019) research concluded that balconies help to block undesirable penetration of sunlight while shaded balconies filter and control the passage of light to reduce glare. The authors found that glazed balconies contributed to the light barrier effect where the amount of daylight is reduced when passing through an additional glazing layer (Ribeiro, Ramos and Flores-Colen 2019). Wilson, Jorgensen and Johannesen (2000) investigated the impact of glazed balconies on lighting comfort, and concluded that glazed balconies contribute to an undesirable barrier effect that decreased daylight penetration in the living spaces (Wilson, Jorgensen and Johannesen 2000). The study showed that an open balcony with 1.5 meters of depth and 2.5 meters of height can decrease daylight penetration by 30-35 percent and up to 60 percent when glass is added to enclose the balcony (Wilson, Jorgensen and Johannesen 2000).

Researchers have noted that MURB are understudied in terms of daylighting as opposed to other typologies like office buildings. The study of office buildings contributes to a big portion of current daylight research, but the need to study MURB typology is just as important (Peters and Kesik, 2020). Furthermore, to date, research on apartment balconies has focused on the energy efficiency (Catalina et al. 2019), thermal bridging (Aghasizadeh, Kari and Fayaz 2022) and resilience (Chen 2012) in balcony designs as they impact the apartment units. However, little has been studied about the qualities of the balconies as spaces of their own, such as the relationship between size, location and functionality in various balcony options. There are few balcony guidelines and occupant preference and satisfaction studies of balconies. The "Growing Up Vertical Guidelines" is a Toronto guideline designed to integrate family suitable design elements into MURB development (City of Toronto 2020). These guidelines state that balconies should be a minimum of 2.4 meters deep and 2.7 meters wide to maximize daylight access, safety, flexibility and adaptability. The balcony should be designed so that it can be used for family dining and socializing, extend the interior space and provide access to fresh air. Significantly, the guidelines recommend that an ideal balcony should provide space for seating, play and landscape planters (City of Toronto 2020). Another City of Toronto report, "Design Consideration in Developing Alternative Housing Guide" argues that apartment balconies should aim to provide adequate space for various activities (City of Toronto 2017). The document states that residents prefer additional balcony space to be used as living and gardening space. It argues that the importance of balconies increases as the area of the housing unit decreases (City of Toronto 2017). A recent study found that a balcony is the most sought-after place by home users during the lockdown period of COVID-19 as it allows numerous social activities and practices, such as gardening, leisure, recreation and exercise (Bettaieb and Alsabban 2020). That study concluded that balconies should be at least 6 square meters per apartment to allow for those functions (Bettaieb and Alsabban 2020).

3 METHODS

This study analyzed daylight availability, healthy daylighting, and balcony design options for different balcony sizes and uses for a number of small apartment units and balcony designs in Toronto. In particular, the project focused on comparing inset balcony options for glass enclosed and open-air designs for their ability to meet performance targets for: 1) daylight availability according to the LEED Daylight Credit; 2) healthy lighting according to the WELL v1 standard Circadian Lighting Credit; and 3) usability and size of the balcony. To meet these objectives, the project used environmental simulation to predict performance. The research considered two common apartment unit types and explored the possibilities of balconies as functional spaces. Specifically, this research project aimed to examine the impacts of balcony designs on daylight and human centric lighting.

The research work had five parts: (1) Three-dimensional modeling of a number of apartment unit floor plans in Rhino; (2) Studies about balcony functionality (3) Daylight availability simulations with ClimateStudio; (4) Healthy lighting simulation with ALFA; (5) Evaluation against design metrics including the LEED and WELL Building Standards. All these steps were followed for both unit types, enclosed and open air, in four orientations. The term 'building orientation' is the positioning of a building in relation to the sun. The four orientations used in this study include south, east, north, and west. In step 2, certain parameters were tested to explore design options that enable balcony design options to be used as dining and living spaces. A workflow of the research is illustrated in Figure 1 below.

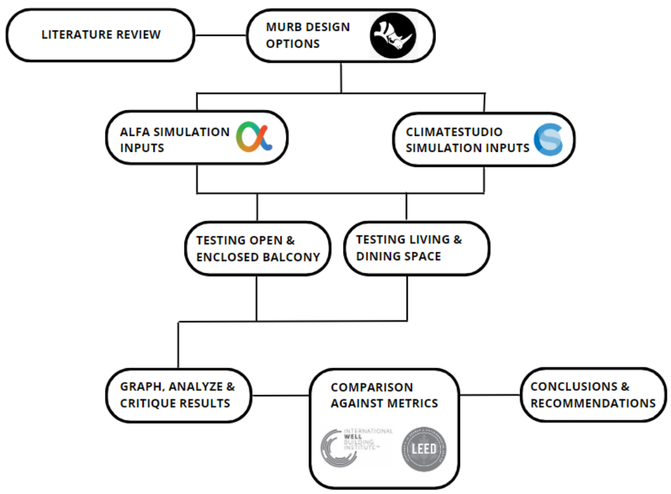

Figure 1: Project Workflow.

3.1 Design Options Tested and Compared

Typical Toronto floor plans were examined and identified from online sources. As Toronto continues to densify, dwelling sizes are shifting towards smaller units and higher density. Therefore, the need to investigate human centric lighting and access to daylight in smaller units was considered highly relevant, and was a focus for this study. For this research, studio and one bedroom apartment units were studied. The studio units studied were small with little distinction between sleeping, living and eating areas. Bathrooms in this unit type were a similar size as bathrooms in other unit types and therefore seemed proportionally quite large. The balcony in this unit type was small and did not meet the City of Toronto 2020 guidelines. In this study, the G24 unit layout from the Dundas Square Garden, depicted in Figure 2, was chosen as a typical studio apartment unit.

Figure 2: Plan, section and exterior photograph of the Dundas Square Gardens, Unit type G24, designed in 2019, unit aspect ratio 1:1.8.

One bedroom, one bay, dwellings are also common unit layouts in Toronto. The designs typically have light from only one side and orientation, and interior windows are often used to provide light for the inboard bedrooms. In this study, a typical dwelling from the Residence of 488 University Avenue was selected and is depicted in Figure 3.

Figure 3: Plan, section and exterior photograph of the Residence of 488 University Avenue, built in 2017 with an aspect ratio of 1:2.6.

This study tested different levels of enclosure in inset balconies responding to a study by Nejati, Rodiek and Shepley (2016) that reported that people prefer spending time in rooms with physical access to a balcony, and these were given the highest level of satisfaction and restorative qualities by people surveyed. Both open-air and glass enclosed inset balconies were evaluated. To explore options for more useful balcony sizes, larger options of the typical one-bedroom balcony (Figure 3) were tested, to show how larger balconies could extend living or dining spaces outdoors. Typical apartment furniture was used to determine the modified balcony size (Figure 4).

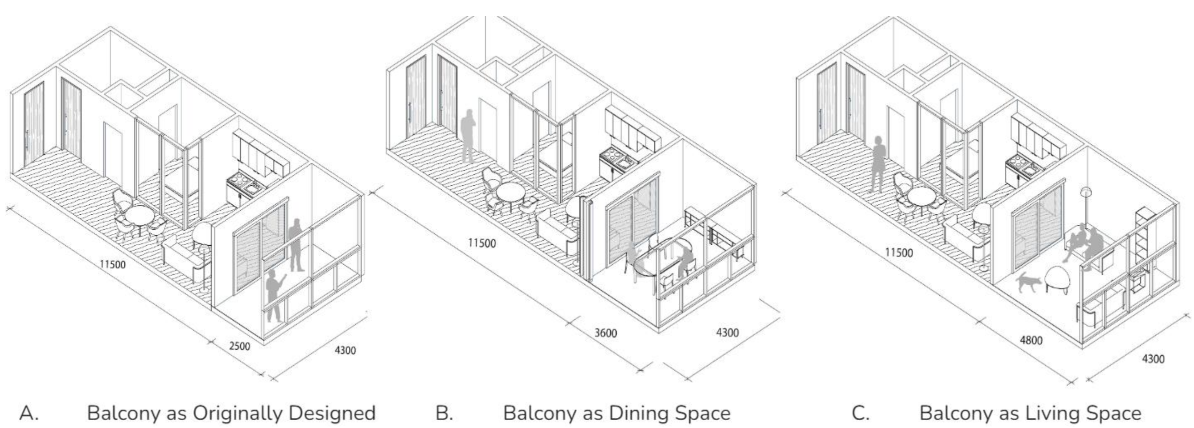

Figure 4: Existing one-bedroom apartment floor plan (left) and updated plan (center and right) when the balcony size is modified to accommodate a living and dining space.

3.2 Daylight Simulation Modeling Parameters

The apartment dwellings that were studied are single aspect, side lit, mid-level units with a floor to ceiling height of 8 feet (2.4 meters). The surrounding buildings' massing context was not modeled. The interior partition walls, dynamic blinds and furniture were also not modeled in order to focus on the effect of the balconies and fenestration systems.

For this research, ClimateStudio was used to calculate daylight availability and compliance with the LEED Daylighting Credit / IES LM-83 through sDA and ASE calculations (U.S. Green Building Council 2022). The Toronto weather file and materials selected from the ClimateStudio Radiance library were used. A summary of the material selection used in the daylight availability simulation is found in Tables 1 & 2. The materials selected in ClimateStudio were consistent with the materials selected for the ALFA simulation.

Table 1: Summary of materials selected in ClimateStudio.

Radiance Library Materials	Type	Surface	Roughness	Rvis (tot)	Rvis (diff)	Rvis (spec)	Tvis (tot)	Tvis (diff)	Tvis (spec)
Light gray floor tile	Glossy	Floor	0.3	41.8%	41.6%	0.2%	0%	0%	0%
Ceiling LM83	Matte	Ceiling	0	70%	70%	0%	0%	0%	0%
White painted walls	Glossy	Wall	0.2	84%	83.6%	0.3%	0%	0%	0%
Aluminum gray cladding	Glossy	Exterior	0.2	47.6%	45.2%	2.4%	0%	0%	0%

Table 2: Summary of glazing materials selected in ClimateStudio.

Radiance Library Materials	Surface	U-Value (W/m2K)	SHGC	TVIS
Low E double pane with argon gas fill	Windows and glass enclosed balcony	1.32	0.369	0.632
Clear single pane	Balustrade glazing	5.82	0.818	0.877

Table 3: Summarized table of ClimateStudio simulation set-up details.

Grid Setup	Occupancy Schedule	Orientation	Weather File	LEED Version
Sensor Spacing: 609.6 mm	8AM - 6PM DST	N, S, W, E	Toronto	LEED V4.1

3.3 Healthy Lighting Analysis using ALFA

ALFA can predict the amount of light absorbed by an observer's non-visual photoreceptors (ipRGCs). The quantity of these non-visual photoreceptors is referred to as equivalent melanopic lux (EML) as they absorb light using pigment melanopsin (Solemma 2022). This research evaluated healthy lighting using EML as a measurement without making assumptions about artificial lighting. Therefore, even though the WELL Circadian Lighting Credit can be achieved by using both natural and artificial lighting (IWBI 2022), due to the uncertainties of how people use electric lighting at home, this study focused on daylight as the sole lighting source for meeting the WELL Circadian Lighting credit. To meet the requirements of the WELL Circadian Lighting credit, at 75 percent or more of the workstation area, at least 200 EML must be available. The 200 EML may be daylight and must be present for at least hours between 9AM and 1PM for every day of the year (IWBI 2022).

Tables 4 & 5 summarize the properties of the selected materials chosen from the Radiance material library and also used in the ClimateStudio simulations.

Table 4: Properties of the selected materials chosen from the Radiance material library in ALFA.

Layers	**Materials From Library**	**Specularity**	**R(P)**	**R(M)**	**M/P**
Interior Walls	White painted walls	0.40%	81.20%	76.80%	0.95
Floor	Light gray floor tiles	0.20%	41.80%	37.60%	0.9
Ceiling	White room ceiling	0.40%	82.20%	77.40%	0.94
Exterior Cladding	Aluminum gray Cladding	2.40%	47.60%	46.60%	0.98

Table 5: Properties of the selected glazing materials chosen from the Radiance material library in ALFA.

Layers	**Materials From Library**	**Rf (pho)**	**Rf (mel)**	**Rb (pho)**	**Rb (mel)**	**T (pho)**	**T (mel)**	**M/P**
Glazing for Windows and Glass enclosed balconies	Double IGU Clear Tvis 63%	10.80%	10.90%	11.20%	11.10%	63.30%	61.70%	0.98
Glazing for Balustrade	Single Pane Clear Tvis 88%	8%	8.20%	8%	8.20%	88.30%	89.09%	1.01

In ALFA, rather than an annual measurement, for WELL the simulations are point-in-time analysis. The dates for simulations were March 21st (spring equinox), June 21st (summer solstice), September 21st (fall equinox) and December 21st (winter solstice) under clear sky conditions. To run the simulations, the time 9AM and 1PM was selected. This was selected because this time period is specifically identified in the WELL Building Standard and significant for circadian entrainment (Dijk and Lockley 2002).

Table 6: Summarized table of ALFA simulation set-up details.

Grid Setup	**Weather File**	**Orientation**	**Sky Conditions**
Spacing: 1,277 mm Directions: 8 Rotation: 0.0 Radius: 250 mm View plane Offset: 1,200 mm Work plane Offset: 400 mm	Toronto, ON	N, S, W, E	Clear sky conditions

4 RESULTS

The results presented in this section test (1) open-air and (2) glass-enclosed balconies, and (3) larger balconies for living and dining space, in relation to daylight availability and healthy daylighting.

4.1 Impact of Enclosing the Balcony on Daylight in Apartment Unit Space

This section shows the impacts of enclosing the balconies. Table 7 summarizes the impacts of fully enclosing the balconies on the daylight in the units relating to the LEED Daylighting Credit. Table 8 summarizes the impacts of fully enclosing the balconies on the healthy lighting in the units relating to the WELL standard's Circadian Lighting feature (only accounting for daylight). In Tables 7 & 8, results are presented as reduction compared to non-enclosed balconies as an average of all orientations rather than actual values due to the large number of results.

Table 7: Simulation results showing the changes to sDA, ASE, and LEED credit in the unit space when the balconies are enclosed.

Unit Type	Size (m)	sDA	ASE	LEED Credit
Enclosed Studio	7 x 4m	sDA reduced by 14% average of all orientations	ASE increased minimally	LEED credit dropped from 1 to 0
Enclosed One Bedroom	11.5 x 4.3m	sDA reduced by 9% average of all orientations	ASE remains the same, except in the east orientation reduced by 1.5%	LEED Credit remained 0

Table 8: Simulation results showing the changes to healthy daylighting levels in the unit space when the balconies are enclosed.

Unit Type	Size (m)	% Floor Area 200 EML at 9AM	% Floor Area 200 EML at 1PM
Enclosed Studio	7 x 4m	12.4% reduction average of all orientations	18.8% reduction average of all orientations
Enclosed One Bedroom	11.5 x 4.3m	11.6% reduction average of all orientations	13.4% reduction average of all orientations

The simulation results are shown in the four orientations for March 21st in Table 9 to compare against the WELL Circadian Lighting Credit. The pass and fail chart referred to the orientations that passed or failed Feature 54 Precondition in the WELL Standard when balconies were enclosed compared to when they were opened. All orientations were studied but only the March 21st date was shown in detail here.

The one-bedroom apartment, regardless of open or enclosed balcony, failed to meet the WELL Standard Feature 54 requirements. The studio apartment, on the other hand, met the WELL requirements in some conditions. At 9 am, the studio apartment with an open balcony passed the WELL Standard at the south and east orientation. For the enclosed studio apartment, the WELL Standard was only met at the east orientation. At 1 pm, the studio apartment with an open balcony fulfilled the requirements at the south and west orientation. For the enclosed studio apartment, the WELL Standard was achieved only at the south orientation.

Table 9: Summary of orientations that passed or failed the ALFA simulations on March 21st at 9 AM and 1 PM.

	MARCH 21st AT 9AM				**MARCH 21st AT 1PM**			
MODEL TYPE	SOUTH	EAST	NORTH	WEST	SOUTH	EAST	NORTH	WEST
Studio Apartment with Open Balcony	*PASS*	*PASS*	FAIL	FAIL	*PASS*	FAIL	FAIL	*PASS*
Studio Apartment with Enclosed Balcony	FAIL	*PASS*	FAIL	FAIL	*PASS*	FAIL	FAIL	FAIL
One Bedroom Apartment with Open Balcony	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
One Bedroom Apartment with Enclosed Balcony	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL

4.2 Testing Larger Balcony Designs to provide Dining and Living Spaces

This section summarizes results of how larger balconies impacted daylight availability and healthy daylighting.

4.2.1 Simulation Results for Daylight Availability

Table 10: Daylight availability comparison chart for the unit space of original, dining and living balcony. The percentage in these tables referred to the percentage of space meeting sDA 300, 50.

	Original Enclosed Balcony (Figure 3)	**Larger Enclosed Balcony as Dining Space**	**Larger Enclosed Balcony as Living Space**
sDA	N: 23 % E: 29 % S: 35 % W: 27 %	N: 9 % E: 16 % S: 23 % W:14 %	N: 6 % E: 15 % S: 24 % W: 14 %
ASE	N: 0 % E: 2 % S: 2 % W: 0 %	N: 0 % E: 0 % S: 0 % W: 0 %	N: 0 % E: 0 % S: 0 % W: 0 %

The simulation results show the original size inset open-air balcony and larger balcony options. Table 10 above summarizes the daylight simulation results for the daylight conditions in the one-bedroom apartment (Figure 3). The sDA percentage of the one-bedroom apartment is low and the increase in depth of the balcony to make it into a dining and living space made it significantly lower. When the balcony was enlarged to accommodate a living space, the sDA for the unit space became inadequate as it was reduced to 0% in all orientations. The ASE percentage was insignificant because there was not enough daylight to cause glaring or over lighting. It's important to note that none of the balcony types, including the original enclosed balcony met the LEED Daylighting Credit.

4.2.2 Simulation Results for Healthy Lighting

The healthy lighting simulations using ALFA produced findings about healthy lighting and larger balcony options. Table 11 below summarized the healthy lighting simulation results for March equinox. Other dates as discussed earlier were studied, but only March 21st is shown in detail for this report because the simulation results of the other dates followed the same trend as identified in March 21st.

Table 11: Healthy daylighting comparison chart for original, outside and living balcony on March 21st. The amount of healthy lighting is reduced as the balcony increases.

MODEL TYPE	**SOUTH**	**EAST**	**NORTH**	**WEST**
One Bedroom Apartment with Enclosed Balcony	9 am: 38 % 1 pm: 49 %	9 am: 53 % 1 pm: 39 %	9 am: 32 % 1 pm: 40 %	9 am: 20 % 1 pm: 27 %
One Bedroom Apartment with larger balcony, Enclosed Balcony as a Dining Space	9 am: 17 % 1 pm: 25 %	9 am: 30 % 1 pm: 22 %	9 am: 22 % 1 pm: 28 %	9 am: 18 % 1 pm: 28 %
One Bedroom Apartment with larger balcony, with Enclosed Balcony as a Living Space	9 am: 11 % 1 pm: 21 %	9 am: 26 % 1 pm: 13 %	9 am: 20 % 1 pm: 25 %	9 am: 14 % 1 pm: 20 %

The results show that the east orientation is the best orientation for circadian stimulus at 9 am and the south orientation is the best orientation for circadian stimulus at 1 pm. Similar to daylight availability, the percentage of floor area to meet EML requirements decreases as the depth of the balcony increases. This was indicated by the decrease in the percentage of floor area to meet the EML requirements. Therefore, when discussing only healthy daylighting, the original one-bedroom balcony has the best circadian lighting performance. However, it is important to note that none of the units have healthy daylighting as all of the units failed to meet the WELL Standard in every orientation.

5 DISCUSSION

5.1.1 Performance of Open and Enclosed Balconies

The daylight in both unit sizes, for both open and enclosed balconies were inadequate when evaluated using the LEED daylighting and WELL circadian lighting requirements. Enclosing the balcony further reduced the sDA for both sizes of units. This was more pronounced in the smaller, studio apartment. The sDA of the studio apartment was reduced by an average of 14 percent, whereas the one-bedroom apartment was reduced by 9 percent. This was consistent with the findings identified in other studies where glazed balconies contribute to the light barrier effect. Relating to the LEED daylighting requirements, the open-air balcony in the studio apartment had the best daylight qualities and the next best was the glass-enclosed balcony on the studio apartment. This was an expected finding as the studio apartment had a smaller aspect ratio and needed less light penetration. Therefore, even enclosed in glazing, the daylight in the studio apartment was still better than the one-bedroom apartment.

For healthy lighting, the aspect ratios of both units are large, and do not achieve deep daylight penetration. Therefore, neither unit size studied met the WELL circadian lighting requirements using daylight alone. Effective electric lighting is needed in both unit types, especially in winter months, to achieve healthy levels of EML. The simulation results showed that the studio apartment had the best performance among all other model types due to its dimensions and aspect ratio. Another expected finding was that the percentage of floor area achieving 200 EML decreased when the balcony is enclosed and deepened. The simulation results confirmed that the south orientation is the best for circadian stimulus followed by the east orientation.

5.1.2 The Impacts of Larger Balconies for Living and Dining Spaces

The enclosed balcony for the one-bedroom unit was enlarged to be able to provide a year-round dining and living space. It was found that the sDA percentage was reduced by 13 percent in the dining space and 14 percent on average in the living space. The ASE percentage showed minimal changes as there was not enough daylight to cause glaring or over lighting. Therefore, the effects of modifying balcony sizes to accommodate a dining space and living space reduced the amount of daylight availability in the unit. However, the difference between the dining and living space balconies was minimal on the daylight availability in the unit. Larger balconies could be incorporated carefully with minimal tradeoffs.

Relating to healthy lighting, the simulation results showed that there was less reduction in the total floor area to reach 200 EML when the balcony was used as a dining space. The finding was expected as the balcony of the living space was deeper and required more quantity of daylight.

Overall, the daylight availability of both balcony types was affected and the difference between a dining and living space balcony was minimal. This implies that future balcony designs could consider different design options such as increasing the size of the balcony to accommodate more functional spaces. Therefore, future MURB designs can incorporate different types of balcony designs to meet the needs of the occupants.

6 STUDY LIMITATIONS AND RECOMMENDATIONS FOR FURTHER WORK

This focused study had several limitations. A limitation of the study is that the building context was not taken into account in the simulations of the apartment units. This is significant because the quality and quantity of daylight entering a unit may be reduced or limited by the shadows of neighbouring buildings, and units may also be exposed to building surfaces' reflectivity. Toronto is a dense city with numerous tall structures close to one another. Another limitation is that this project did no examine other aspects of comfort such as thermal comfort, or ventilation. Thermal comfort and energy performance can be another issue with balconies and should therefore be studied to extend this study.

The findings from this research led to the following recommendations:

1. Simulation findings about aspect ratio in apartment units and unit sizes
    a. This research showed that deep aspect ratio apartments, such as the two floor plan types identified in this study had poor daylight availability and circadian stimulus in the unit. The tested units were 1:1.8 and 1:2.6 which is too high to be properly daylit. There is no way to compensate for deep units so a main recommendation of this study is to stop designing deep units like this.
    b. This study tested small one-bedroom units. Other unit sizes and types, including larger family apartments or two level suites, should be studied in future MURB studies to understand the impacts of balcony design in these dwellings.

2. Field work for validation in simulation results
    a. Occupant surveys and on-site measurements would be important next steps to understand the impacts and relevance of the simulation results. Comparing different kinds of data will advance work in this area because new findings could then be integrated into further research and recommendations. Future work should also test different scenarios for electric lighting although it would be difficult to make assumptions about resident lighting choices in MURB.

7 CONCLUSIONS

The main conclusions from this research were that in typical small, relatively deep apartment floor plans, there is insufficient lighting and a deeper balcony has minimal impact. These types of dwellings are being built in large number in Toronto and with or without balconies, they do not have acceptable levels of daylight. None of the unit types evaluated met the LEED and WELL requirements for daylighting. These dwellings are normally built with a balcony and this study showed that it is not the balcony that caused the lack of daylight penetration, it is the aspect ratio and unit size, orientation and layout. If an outdoor space is desirable, even if the interior of the apartment cannot be well lit, at least there could be a provision for outdoor space. The type of small units evaluated in this study have light from only one side, which is typical in the design priorities of typical MURB floorplans. The goal is to provide as many units as possible per floor. However, this study showed that small, deep apartments cannot provide well-lit interiors. Findings in this study highlight the need for MURB specific guidelines and standards relating to the provision of daylight and that would limit aspect ratios. Significantly, these specific metrics should be made suitable for living environments. Designing for daylight availability and healthy daylighting should be prioritized in MURB designs. Given the many benefits of daylight, the findings in this research would help to benefit the occupant's well-being.

The question of whether or not to enclose balconies needs further investigation and it depends on multiple factors such as privacy, thermal comfort, view, and desired uses. As this research is a case study that looked at one building typology in Toronto, these important aspects were not examined in this paper. This paper identified the need for more research into MURB design for daylight availability and healthy daylighting, two design parameters are not often prioritized in typical MURB designs. In order to promote the liveability of multi-unit residential buildings, especially smaller suites, building codes and/or municipal planning standards may include minimum requirements for daylighting with trade-offs for larger balconies. Otherwise the forecast growth in MURB housing will likely result in a stock of dwellings with unhealthy daylighting levels and dysfunctional balconies that will adversely impact quality of life.

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