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Densification Strategy: Sustainability Analysis of Co-Housing Typology

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Abstract: Densification strategy through co-living typology seems to be a sustainable solution to current global issues: increasing in human population, housing crisis and inflated prices. However, the characteristic of the typology that able to house high significant number of people on a piece of land create a dispute, especially on the dwellers' comfort. Thus, the aim of the research is to identify the performance of the typology to the inhabitants. Components such as floor plan area, daylighting and ventilation aspects are employed in the research to justify the sustainability of the typology to the inhabitants. The components were based on the space standard, Average Daylighting Factor (ADF) and sDA (Spatial Daylight Autonomy) through Sefaira analysis and simulation, and guidelines from Manchester City Council (2017) through Manchester Residential Quality Guidelines (MRQG) and Sinha (2014) respectively. The research was focusing on ongoing construction of the Echo Street Co-Living in Manchester, UK. From the analysis, the finding generally shows the typology manages to achieve a sustainable-performance unit through area and dimension, as well as ventilation aspects, even though there is a minor flaw, especially in providing an adequate level of daylighting. The result from the research could be used as a reference to design a high performance co-living unit in the future.

Keywords: Densification strategy, co-living typology, building sustainability, space standard, Manchester

1. Introduction

Manchester has been recognized as the busiest city in the northwest of England, especially in the late 18th century during Industrial Revolution (Kidd and Wyke, 2016). The capability of the town on vast production of cotton wool products such as textiles and clothes had attracted people outside Britain to come and work here. It was reported that there was more than sixfold increase in the number of populations between 1801 and 1891 (Manchester City Council, 2016). The population of Manchester is growing, and it is expected to continue to grow (Manchester City Council, 2017). The graph on Figure 1 below shows two distinct forecasts on future population in Manchester: Subnational Population Projection (SNPP) and Manchester City Council Forecasting Model (MCCFM), and it is projected that the population of Manchester will continue to grow.

Manchester City Council (2018) has devised a policy dubbed 'Manchester Northern Gateway: Strategic Regeneration Framework' in response to the issue. The council believes that the policy will not only enhance the current city centre area but will also address the housing crisis and future population growth (Manchester City Council, 2018). By planning an efficient route map and empowering Rochdale Road as a main road connecting Manchester

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Northern Gateway to the City Centre, this Strategic Regeneration Framework focuses on providing new residential and commercial buildings, increasing the connectivity of urban dwellers to other places.

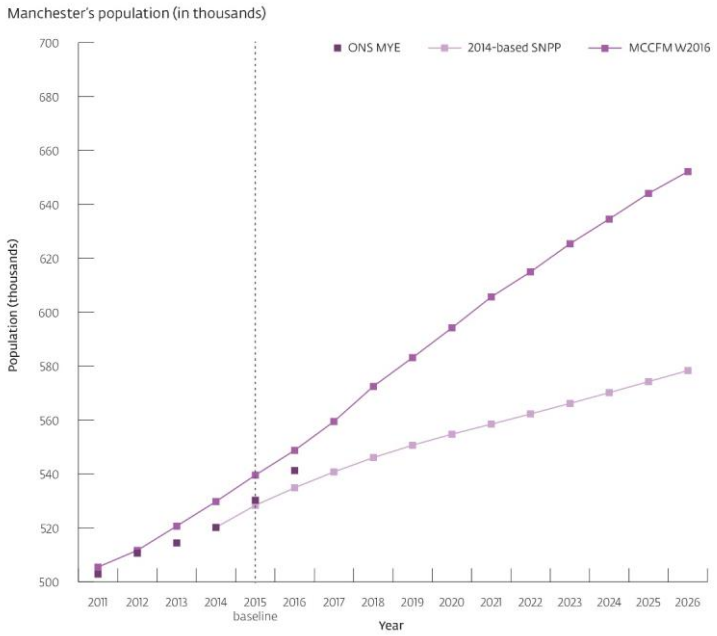


Fig. 1 - Number of populations in Manchester from 2011 to 2016 and a projection to 2026 (source: Manchester City Council, 2018)

According to Figure 2 below, the strategy will specify 131 blocks, with 83 blocks (64%) earmarked solely for residential spaces and another 18 blocks (14%) will accommodate mixed development of residential and commercial areas. Developers are encouraged to build a medium to high-rise construction to densify areas and ensure that the maximum number of people can live on a single piece of land under the policy (Manchester City Council, 2018).

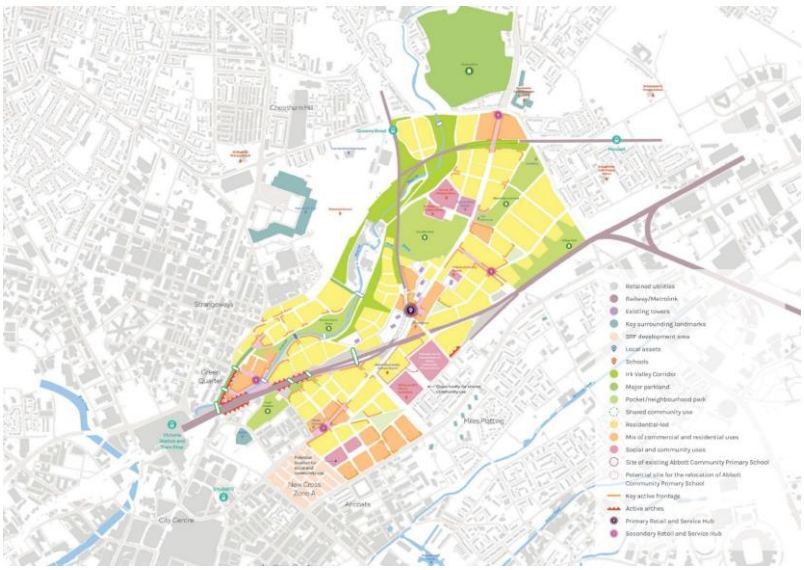


Fig. 2 - Master plan of Manchester Northern Gateway (source: Manchester City Council, 2018)

2. Methodology

Case study is conducted where Echo Street Co-Living which located inside the Manchester Northern Gateway is selected for the research. The project is currently in the construction phase, and it was expected to complete in the year 2022 (Sheppard Robson, 2018). The building plans are obtained from the Planning Application Documents, provided by the Manchester City Council (2018). The indicator used to justify the acceptable dimension and floor area is the space standard: Nationally Described Space Standard (NDSS). 3-dimensional model also designed based on the plans given to analyse the building performance through Sefaira software. The software has run a simulation on energy used,

daylighting and thermal comfort aspects that allow us to understand how the building performs and how the building affects the inhabitants. Qualitative approach is adopted for the daylighting aspect where the Average Daylighting Factor (ADF) and Spatial Daylight Autonomy (sDA) are recorded from the simulation. The value obtained from the simulation was then reflected to the BREEAM Guidelines and Building Research Establishment (BRE) Guide to identify the building performance, specifically on the daylighting aspect. On the other hand, Manchester Residential Quality Guidelines (MRQG) by Manchester City Council (2017) and Sinha (2014) were referred to identify the ventilation aspect of the building. From the analysis of these three aspects, the performance of this co-housing building to the inhabitants can be identified.

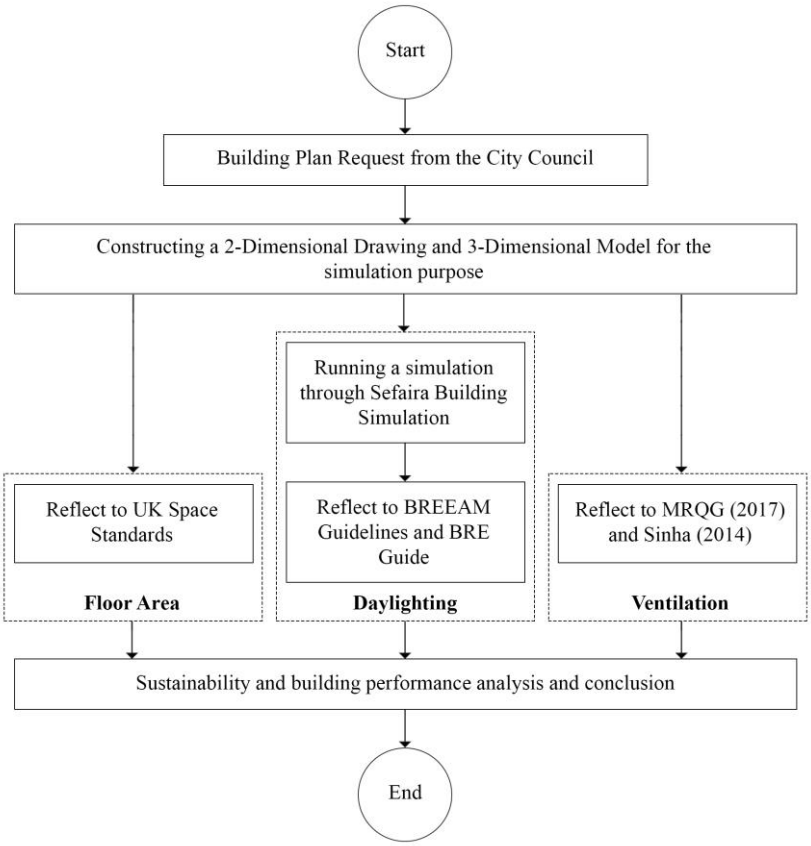


Fig. 3 - Diagram of research methodology on co-housing typology in Manchester (source: Author's diagram)

3. Background Study

Manchester City Council is implying a densification strategy in the future development planning. It raises a concern on whether the strategy consider the standard and minimum space dimension, natural daylighting, and natural ventilation. Even though it was reported that co-housing typology can be a sustainable solution on the high number of populations, housing crisis and inflated price (RIBA, 2018), the dispute especially towards the individual and the comfort of the urban dwellers still need to be discussed.

Co-housing is defined by four 'lenses': (1) common aim, (2) spatial arrangement or design, (3) design and delivery process, and (4) lifestyle and behaviour expectations (Ahn, et al., 2018). It is frequently established by people who share similar interests and live communally on it (Robinson, 2017). The typology is characterized as "intentional communities" that are built and managed by residents (Ahn, Tusinski and Treger, 2018). It is a typology in which residents share some spaces to carry out communal activities. Residents will, however, be given a private space in which to carry out their personal needs. Different co-living may illustrate varying appetite based on degree of space sharing level among the co-living inhabitants (Ahn, et al., 2018).

Co-housings and thriving communities are a result of the typology's encouragement of a 'collaborative' lifestyle and greater reliance between residents (Williams, 2006). Even though the typology's original goal was to promote residents' physical and mental health, the typology has since been able to accommodate a larger number of people through a space densification method (Williams, 2006).

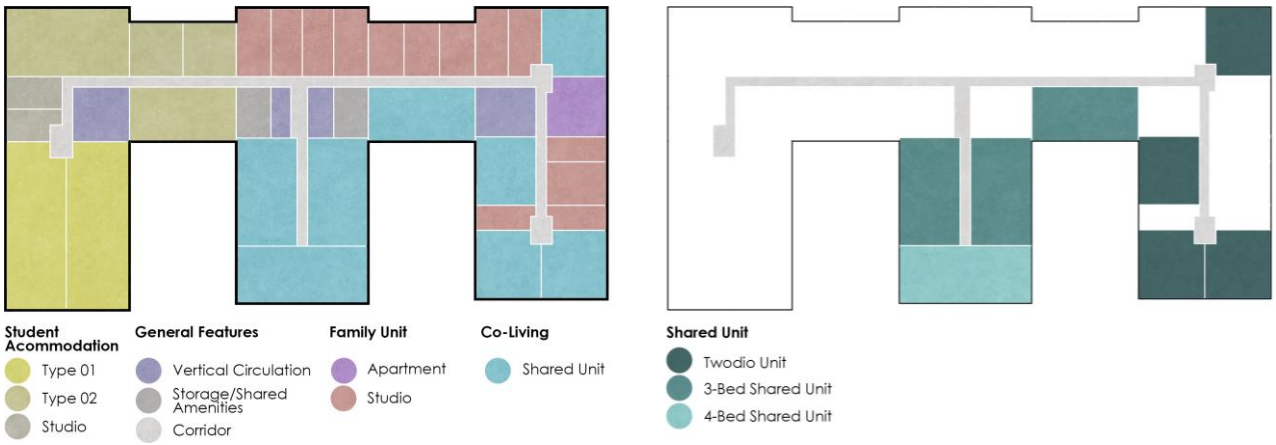
4. The Case Study

Echo Street Co-Living was designed by Sheppard Robson, and the project is being developed by iQ Student Accommodation (iQSA), a recognized operator and developer of city centre buildings, built exclusively for young

people across the UK. The site covers 32,800 m² (3.28 hectares), with the building's total development area of 21,976 m² accounting for 67 percent of the overall land area (Echo Street Consultation, 2017). The building comprises three towers with different heights and number of floors (14, 20 and 26 storeys). It is located next to the gateway of Picadilly and the North Campus of the University of Manchester. The building comprises mixed-use development including co-living residential accommodation, student accommodation and commercial area. The building is designed to provide 242 student bedrooms, grouped over 86 units and 621 co-living bedrooms grouped over 406 units (Sheppard Robson, n.d.). From the Figure 5, typical floor plans are divided into 2 building typologies: west tower accommodates student accommodation and the east tower designated for co-living typology.

(a) **(b)**

Fig. 4 - (a) Ground floor plan of the Echo Street Co-Living. The drawing is not to scale (source: Manchester City Council, 2018); (b) typical floor plan (source: Manchester City Council, 2018)



(a) **(b)**

Fig. 5 - (a) Typical floor plan. The drawing is not to scale (source: Author's diagram based on data from Manchester City Council, 2018); (b) shared unit on a single floor plan (source: Author's diagram based on data from Manchester City Council, 2018)

The focus point for the research is the co-living typology which also considered as shared unit. Inside the unit, spaces such as kitchen, dining area and living area are shared among the inhabitants but they still have their own bedrooms and toilets. The building provides three types of co-living unit which are Twodio, 3-Bed and 4-Bed. **Table 1** below summarizes the shared units on a single typical floor.

Table 1 - Summary of co-living typology on a single floor (source: Manchester City Council, 2018)

Typology	Type	Number of Bedrooms	Number of Bed Spaces (Persons)	Number of Toilet	Number of Units	Total Floor Area (m²)
Shared Unit	Twodio	2b	2p	1	4	49.2
	3-Bed	3b	3p	3	3	82.6
	4-Bed	4b	4p	4	1	94.13

Figure 6 below also shows the plan of every co-living unit. The plan was used to evaluate the sustainability of the units including space standards, daylighting, and ventilation.

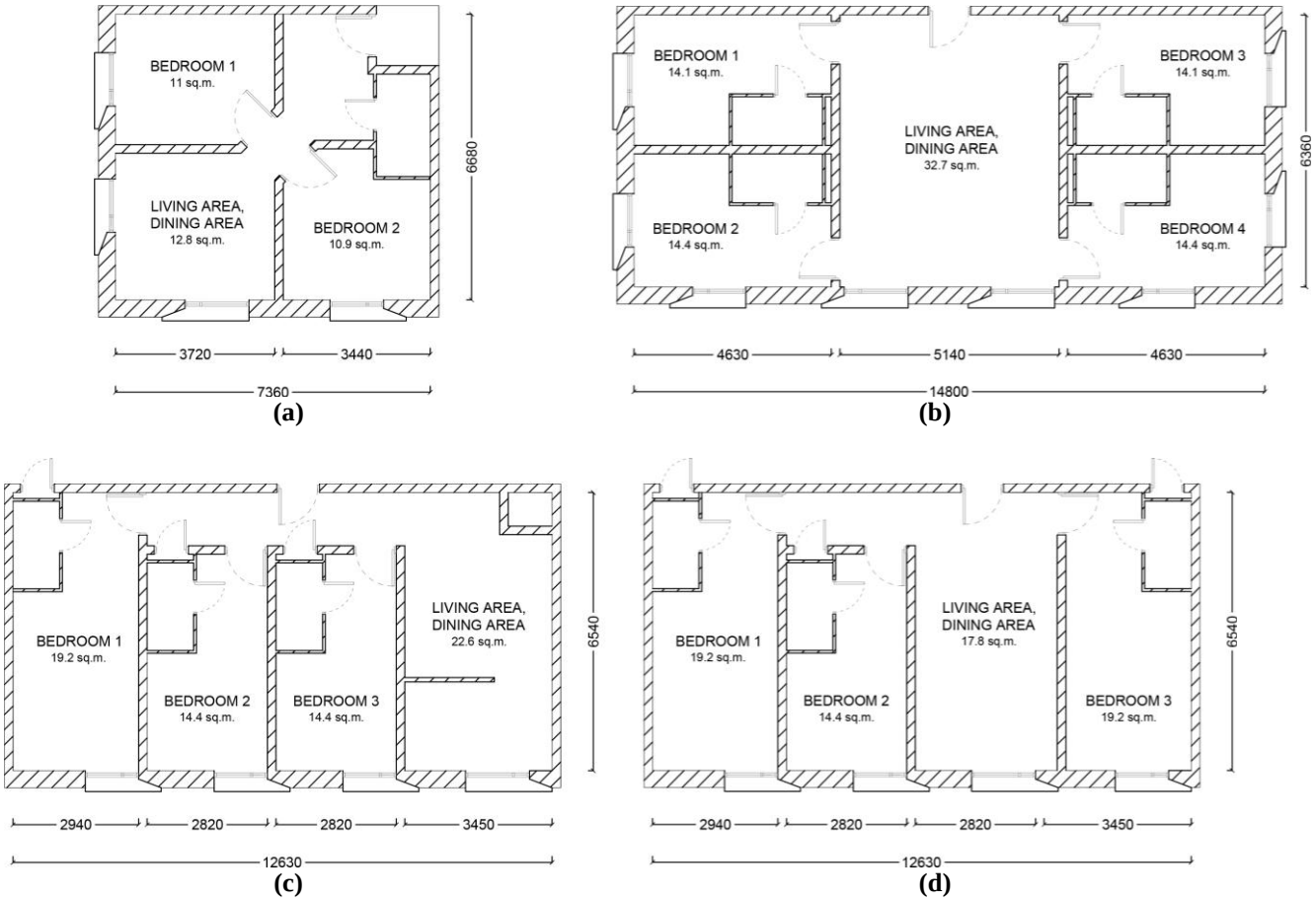


Fig. 6 - Floor plan of the co-living units (source: Manchester City Council, 2018) (a) twodio type; (b) 4-bed type; (c) 3-bed type 1; (d) 3-bed type 2

Table 2 - Summary of floor plan areas of co-living typology (source: Manchester City Council, 2018)

Type	Bedroom Floor Area GIA (m^2)				Toilet Floor Area GIA (m^2)	Living Area, Dining Area & Kitchen Floor Area GIA (m^2)	Gross Internal Floor Area (m^2)
	B1	B2	B3	B4			
Twodio	11	10.9	-	-	4.1	12.8	57.9
3-Bed Type 1	19.2	14.4	14.4	-	4.2	22.6	72.6
3-Bed Type 2	19.2	14.4	19.2	-	4.2	17.8	72.6
4-Bed	14.1	14.4	14.1	14.4	4.1	32.7	85.4

5. Sustainability Analysis

From the building plans obtained, sustainability analysis is done based on aspects as follows:

- **Space Dimension.** UK has undergone progressive changes and development on the building space standards since 1667 through London Building Act (Park, 2017). Throughout the history, there were six space standards suggested by six expert groups: Parker Morris (1961 – 1980), English Partnerships (2005 – 2007), Homes & Communities Agency (HCA) (2007 – 2014), National Housing Federation (NHF) (2008 – 2015), Greater London Authority (GLA) (2010 – 2015) and Nationally Described Space Standard (NDSS) (2015 – Now) (Park, 2017) as shown in the **Table 3** below. In the UK, there are huge debates between space standards and regulations. The term 'standard' allows greater flexibility and increase the viability of the development. The recipient has also more scope to negotiate and less cause to panic. In contrast with regulation, it is non-negotiable. Even though the purpose of

regulations is to protect occupants, but to make space standard into regulation is not easy. Building regulations require mandatory space standards and additional development cost would become 'inevitable' in land purchases. In other words, it can threaten the viability of the development and reducing the affordability of the homes (Park, 2017). According to The Building Regulation 2010: Approved Document M (2015), there is no specific regulation for rooms in a dwelling. However, according to the same regulation, under M4 (3) Category 3, there is minimum requirement outlined for disabled people. In the UK, the standard is based on 'Number of Bedrooms' (b) and 'Number of Bed Spaces' which also referred to as 'Number of People' (p).

Table 3 - Comparison of GIA standards in m² (Park, 2017)

	1 Storey							
	1p	**1b2p**	**2b3p**	**2b4p**	**3b4p**	**3b5p**	**3b6p**	**4b5p**
NDSS (2015 – Now)	*37 39	50	61	70	74	86	95	90
GLA (2010 – 2015)	*37 39	50	61	70	74	86	95	90
NHF (2008 – 2015)	-	50	61	70	-	86	95	-
HCA (2007 – 2014)	-	45	57	67	-	75	85	75
English Partnerships (2005 – 2007)	-	51	66	77	-	93	-	-
Parker Morris (1961 – 1980)	30	45	57	70	-	79	86	79

*Where a 1b1p has a shower room instead of a bathroom, the floor area may be reduced from 39m² to 37m².

The information in the table below reflects the Echo Street Co-Living units to the space standard criteria in Table 3, specifically to the NDSS:

Table 4 - Comparison of echo street co-living units to space standard compliance in m²

Type	Gross Internal Floor Area	Space Standard	Compliance
Twodio	57.9	50 – 61	Yes
3-Bed Type 1	72.6	61 – 74	Yes
3-Bed Type 2	72.6	61 – 74	Yes
4-Bed	85.4	74 – 90	Yes

- **Daylighting.** There are nine components outlined by Manchester City Council (2017) to deliver high-quality residential development: one of them is 'providing sufficient daylight to the house'. There are several guidelines outlined: one main window wall facing within 90º of due south, larger windows, floor to ceiling at a minimum 2.4m in living area and bedroom spaces, north facing accommodation, and avoiding 45º orientation either side of North (Manchester City Council, 2017).

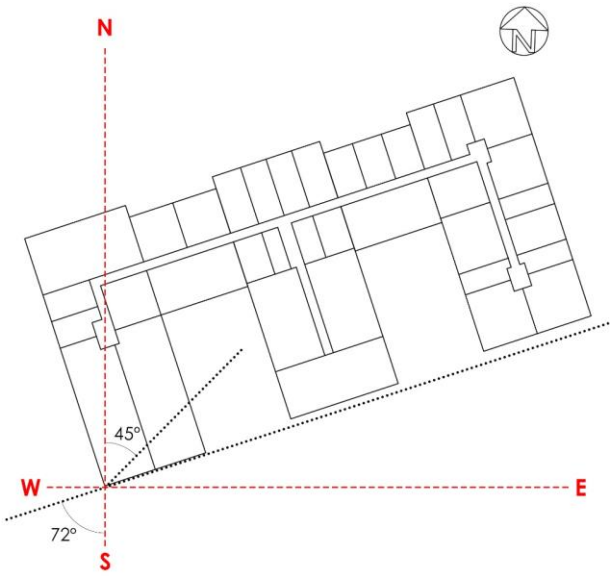


Fig. 7 - Building orientation: main façade facing within 90º due South and avoiding 45º due North as suggested in the BRE Guide (source: Author's diagram)

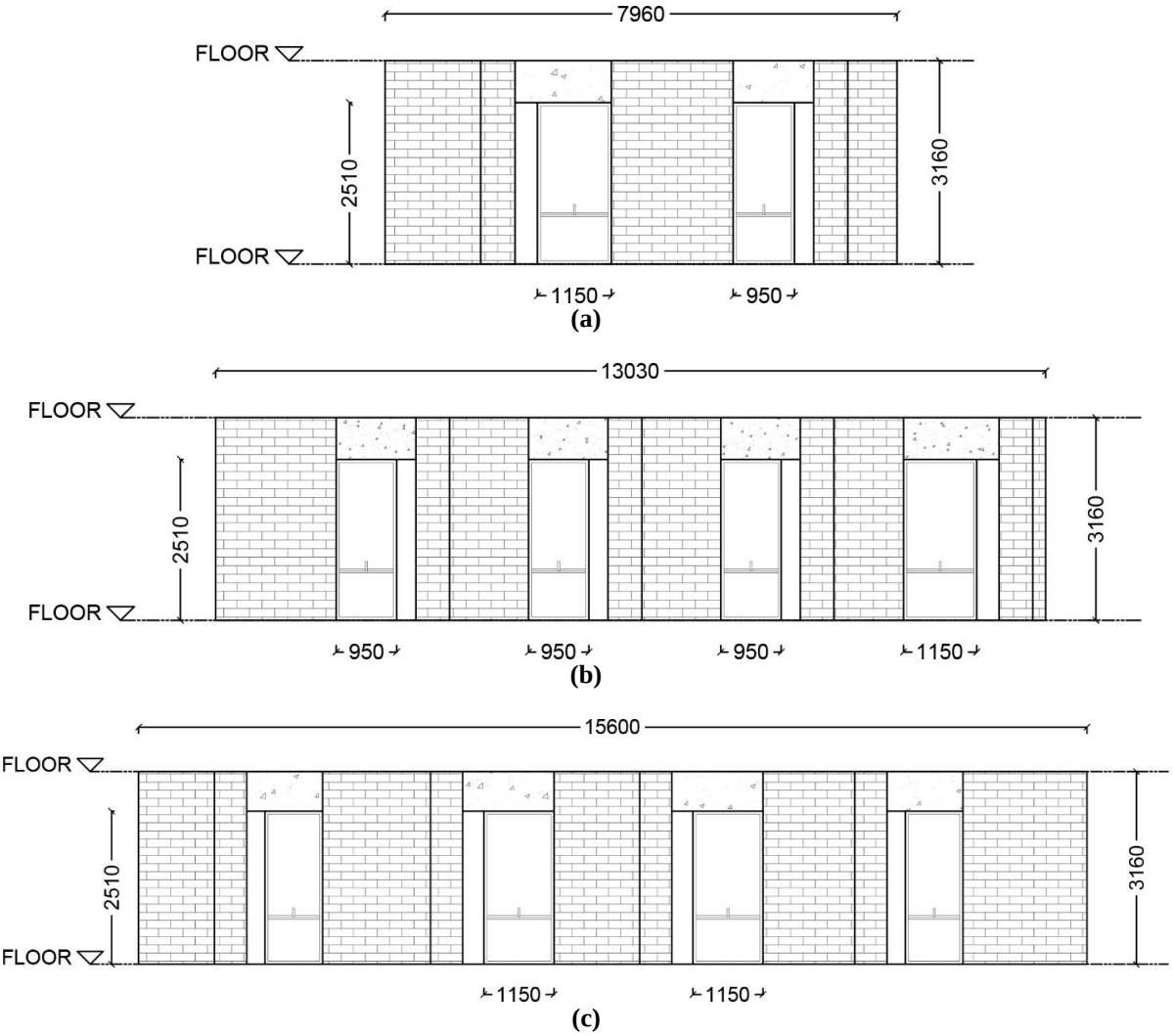


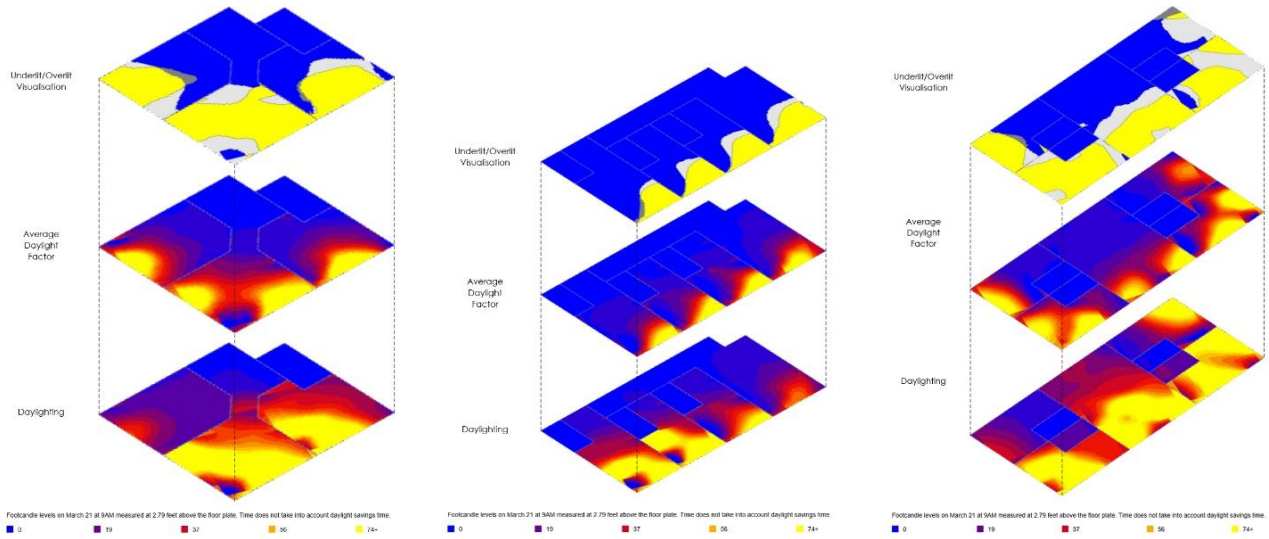
Fig. 8 - Co-living units elevation view (source: Manchester City Council, 2018) (a) twodio unit; (b) three-bed unit; (c) four-bed unit

From Figure 8 above, every room inside the co-living units are designed with large windows. All bedrooms are equipped with windows with the dimension of approximately 2.5 m height with 0.95 m width. On the other hand, the main area: living area, dining area and kitchen are designed with approximately 2.5 m height with 1.15 m width. Window to wall ratio can be calculated from the glazing size data obtained. **Table 5** summarizes the compliance of Window-to-Wall ratio to the BREEAM Guidelines (2020).

Table 5 - Window-to-Wall ratio of co-living units and compliance to BREEAM Guidelines (2020)

Unit	X - GIA (m^2)	Y - Total Glazing Area (m^2)	BREEAM Guidelines (2020)	Window Wall Ratio (Y/X)	Compliance
Twodio	57.9	10.54	5%	18%	Yes
3-Bed	72.6	10.04	5%	14%	Yes
4-Bed	85.4	20.09	5%	24%	Yes

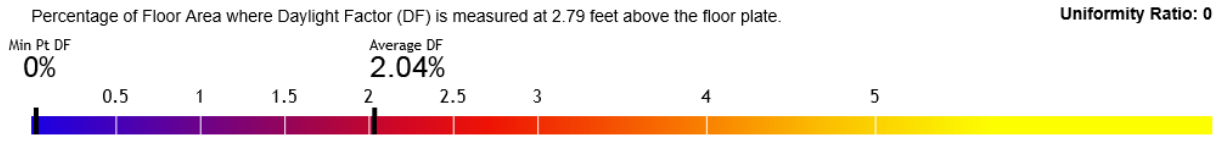
However, according to the same guideline, there are other criteria under the daylighting aspect that could be considered which are Average Daylighting Factor (ADF) (BREEAM, 2020) and Spatial Daylight Autonomy (sDA) (Jacubiec, 2014). Sefaira software has been employed to assess those aspects and evaluate the sustainability of the co-living units. The software provided a simulation on the ADF and sDA and the values then can be reflected to the BREEAM Guidelines (2020) and the Building Research Establishment (BRE) Guide, 'Site Layout Planning for Sunlight and Daylight: A Guide to Good Practice' by P. Littlefair (2011).



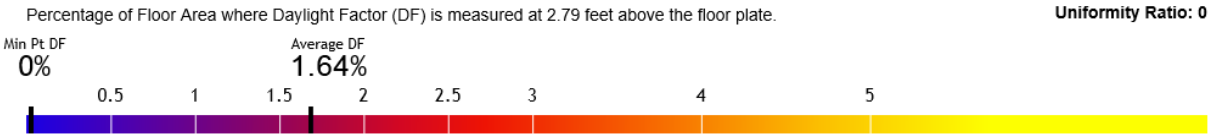
(a) **(b)** **(c)**

Fig. 9 - Sefaira Visualization on the co-living units (a) twodio unit; (b) three-bed unit; (c) four-bed unit

From the simulation above, daylighting visualization can be assessed on the co-living units through footcandle level. Overall, Three-Bed unit is mostly unilluminated due to floor plan design and room arrangement, while Four-Bed unit is mostly illuminated due to the same reasons. Average Daylighting Factor (ADF) is an indicator of how well-lit the indoor spaces. From the Sefaira visualization on **Figure 9** and ADF on **Figure 10**, it can consider that Four-Bed unit possess the highest ADF, followed by Twodio unit and Three-Bed unit. According to BREEAM Guidelines (2020), average daylight factor required is at least 2% and Three-Bed unit failed to achieve the minimum requirement.



(a)



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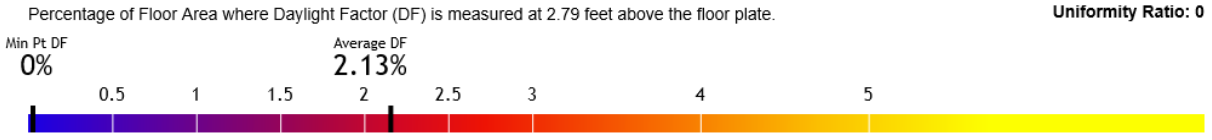
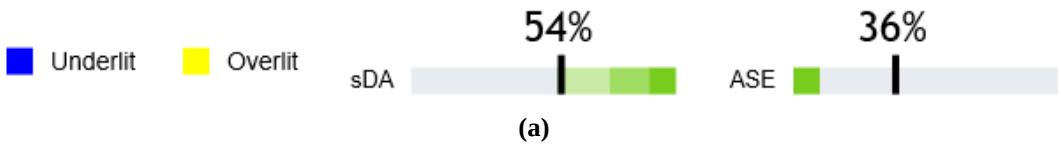


(c)

Fig. 10 - Average Daylighting Factor (ADF) of the units (a) twodio unit; (b) three-bed unit; (c) four-bed unit

On the other hand, Spatial Daylight Autonomy (sDA) is defined as the percentage of floor area, that meets specified illuminance level (Tsagrassoulis et al., 2015). The assessment from the **Figure 11** below indicates that Four-Bed unit possess the highest sDA compared to the other two. Based on the guidelines from LEED v4 Dynamic Daylight Performance Metrics, minimum threshold required for accommodation unit is 50% (Jacubiec, 2014). This indicates that Three-Bed unit is unable to meet the minimum value of sDA.



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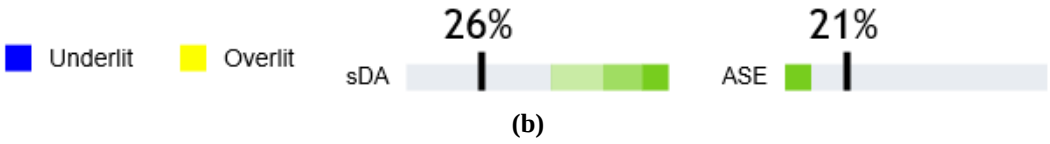

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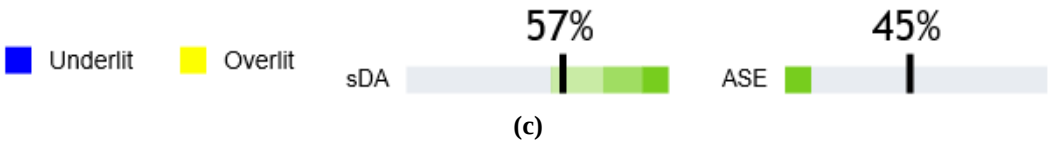

(c)

Fig. 11 - Spatial Daylight Autonomy (sDA) of the units (a) twodio unit; (b) three-bed unit; (c) four-bed unit

- **Ventilation.** Ventilation may be used for several reasons: (1) controlling indoor air quality; (2) replacing warm indoor air with outside cool air; and (3) comforting building inhabitants (Emmerich, Dols and Axley, 2001). Inside a building, there are three different forms of ventilation: cross ventilation, single-sided ventilation, and stack effect. The direction and speed of the wind are the most important factors in ventilation. The orientation and materials of a structure need to be carefully considered to allow optimal natural ventilation. Figure 12 depicts a graph of typical wind speed and direction distribution in Manchester. Based on the statistics, it can be considered that the wind blows primarily from the East and South-East (Meteoblue, 2019). The heaviest winds are from the East, with the greatest wind speeds of 20 to 25 mph recorded in the South-East. According to the Masterplan in Figure 7, the site is oriented 72º to the South and facing directly to the South-East, allowing it for optimal ventilation inside the units.

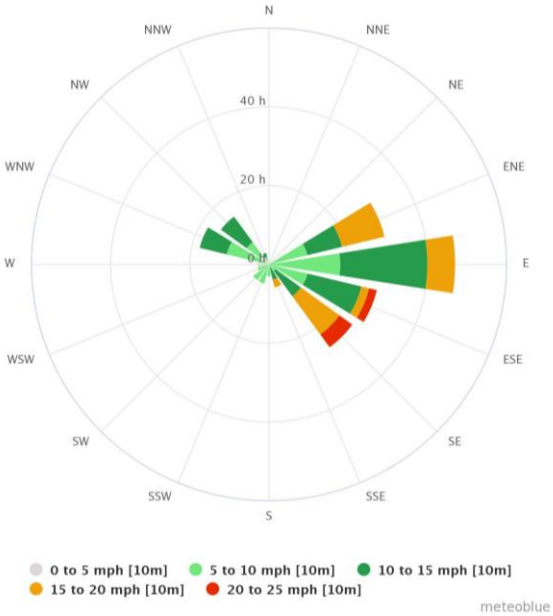

Fig. 12 - Distribution of wind speed and direction in Manchester (source: Meteoblue, 2019)

Generally, all units can provide single-sided ventilation as they possess big and long window, which approximately 2.5 m, more than minimum requirement for this type of ventilation (1.5 m). Other than that, single-sided ventilation is effective to the depth of the dwelling that less or equal to 2.5 times the height of the dwelling (Sinha, 2014). The height of the units is the same which is 2.6 m and by referring the guidance, single-sided ventilation can be effective up to 6.5 m. Twodio unit, 3-Bed unit and 4-Bed unit have a depth of 3.4 m, 5.1 m to 6.5 m and 4.6 m, respectively. Hence, the ventilation can take place inside the units successfully. Furthermore, these residences include apertures on both opposing sides of the area, such as windows or doors, allowing for cross ventilation.

However, the toilet is the sole drawback to these floor plans. There isn't single window in the area, thus the toilet isn't exposed to any natural ventilation. However, the problem can be alleviated by installing an extraction fan within the ceiling or wall and hence, removing the warm and wet air from the toilet to the outside through a ventilating pipe.

According to The Building Regulation 2010: Approved Document F (2010), if a space is not accessible to any natural ventilation, the space shall be linked to mechanical extract ventilation. For instance, a toilet requires an 8 liter per second (l/s) minimum ventilation rate extractor/fan and a kitchen is 13 l/s, which is located inside the hoods. In these units, a minimum rate of ventilation of 21 l/s is usually required. If the developer of the building can provide such frequency for the mechanical ventilation system, the unit can operate efficiently and could be recognized as sustainable unit to the dwellers.

6. Conclusion

Space densification strategy which considered as ‘desperately needed’ is a manifestation on the current global issues: rising in human populations and housing crisis. However, the strategy should not be taken for granted especially for the architects and developers. Even though the concept of the typology can be regarded as the solution to those problems, the comfort of inhabitants, sustainability and building performance should not be jeopardized. Consideration on space standards, daylighting and ventilation aspects should not be neglected to allow dwellers to experience sustainable and liveable life. From the case study, it can be concluded that:

- Every co-living unit in the Echo Street Co-Living building provide an acceptable area and dimension, in respect to NDSS.
- Three-bed unit is unable to exhibit a good daylighting aspect reflecting to the low value obtained on the ADF and sDA. However, this can be argued that the underlit space is predominantly a circulation space. Important spaces such as bedrooms and living room are still equipped with adequate daylighting. Mechanical lighting such as lamp and LED bulb can be used to enlighten the underlit space.
- Every co-living unit provide a high ventilation level because the orientation of the building, dimension of the window and floor-to-ceiling height allow cross ventilation and single-sided ventilation to take place in the units.

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