Where Planning Regulations and Development Practice Collide: The Multi-Storey Apartment Building in Subtropical Brisbane Australia

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ABSTRACT

Brisbane Australia has been undergoing a growth cycle since 2011, with many new apartment buildings on the skyline. Brisbane City Council's e-Plan Multiple Dwelling Code unequivocally links the city's character and identity, and residents' way of life, to the local subtropical climate and landscape. Performance outcomes for code assessable apartment developments promote cross-ventilation and well-designed private outdoor spaces (for example, balconies) to be achieved by correctly designed fundamental structural controls - orientation, spatial configuration, and shading.

A sample of recently-approved 5 – 30 storeys apartment buildings in Brisbane's inner urban renewal areas was studied for performance under the Code. Spatial-structural architectural data were collected from documents submitted for development approval to Council's online system. A 65-year-old apartment building recognised as an Australian significant building of the 20th Century was also analysed.

The research identified performance gaps between planning policy and actual design. The older building out-performed the new under all criteria. Little diversity in building configurations, spatial characteristics and basic floor layouts was observed. Overall, the approach utilised by developers is producing formulaic apartments that cannot be effectively cross-ventilated and that have extremely limited or no private open space.

Developers' primary interests are to maximise yield and 'the view'. This paper provides evidence that the planning code is having little effect on key items driven by these aims. These are: compact form (large building volume enclosed by a small façade area) that reduces the extent of external walls available for effective openings; and extensively glazed, unshaded external walls that are compensated for with air-conditioning technology. The quest for views is also compromising the utility of balconies with glazed balustrades diminishing usable, comfortable, private outdoor area. These products are unlikely to meet future market preferences for more authentic innovative place-based buildings and make long-term liveability and sustainability aims difficult to achieve.

Keywords: *policy and regulation, subtropical, apartments*

1. INTRODUCTION

Brisbane Australia has been undergoing a growth cycle since 2011, with many new apartment buildings appearing on the skyline. Performance outcomes for code assessable apartment developments under Brisbane City Council's *e-Plan Multiple Dwelling Code* (2014) promote cross-ventilation and well-designed private outdoor spaces (for example, balconies) to be achieved by correctly designed fundamental structural controls - orientation, spatial configuration, and shading. The structural (architectural) approach to thermal comfort design aligns most closely with Brisbane residents' preferences for occupant control over indoor environments, and occasional energy use (Kennedy, Buys, & Miller, 2015).

Developers' primary interests are to maximise yield and 'the view'. Generic design strategies that are applied to achieve these aims have an effect on the factors that residents consider important for liveability in the subtropics such as availability of natural ventilation to control thermal comfort, access to private outdoor space for everyday home-based activities (Kennedy et al., 2015). Developers favour compact form, where large building volume is enclosed by a small façade area (Barton & Watts, 2013) and extensive external glazing for views. The former reduces the extent of external walls available for effective openings, while the heat gain associated with the latter is compensated for by mechanical controls (air-conditioning technology) often without shading to mitigate glare, and reflectance problems.

The purpose of this paper is to present data and discussion on how recently-approved buildings measure up to the objectives of the Multiple Dwelling Code (MDC) unequivocally links the city's character and identity, and residents' way of life, to the local subtropical climate and landscape.

2. CLIMATIC DESIGN APPROACHES AND BUILDING CONFIGURATION

Brisbane is located in Queensland Australia at 27.5°S and 153°E. The natural conditions of the mild subtropical climate fall within the "comfort zone" (Ballinger, Prasad, & Rudder, 1992) 80% of the year, and continuous air-conditioning as a function of dwellings is rarely desired by residents. Nevertheless, cooler temperate or hot humid tropical climatic conditions are experienced annually, each requiring specific design responses. It is important to admit the sun's energy and store using thermal mass when it is required during winter (Givoni, 1998); and exclude direct sun by orientation and shading strategies and remove heat by in summer (Hollo, 1995). Ventilation to provide air movement reduces the effects of humidity (Emmanuel, 2005).

The relationship between external wall area and enclosed floor area (WTF) is critical in the success of these strategies. Using the structural approach, increasing the extent of external walls is beneficial in terms of opportunities for openings for cross-ventilation, and daylight availability (Ratti, Baker, & Steemers, 2005). The natural ventilation strategy (integrating structural form, and sizes and locations of openings) can have more of an impact on comfort than thermal mass, both in summer and winter. On the other hand, if the mechanical approach is adopted, reducing the extent of external walls in apartment buildings is beneficial for restricting heat gain or loss through the façade.

Expressing this relationship as Surface Area to Volume (SAm^2/Vol m^3) ratio provides an indicator of whether the overall building form is fundamentally appropriate to the local climate conditions. The higher the ratio, the greater extent of external wall area indicated. The lower the ratio, the more 'compact' the structural form is, with greater volume being enclosed by least surface area. Thus, reducing the extent of external walls is essentially a strategy for heating conservation (Oldfield, Trabucco, & Wood, 2009) and is not suitable for tropical and subtropical conditions.

The relationship between external wall area and enclosed floor area (WTF) is also a critical measure of cost effectiveness in the value profile of a multi-storey building (Barton & Watts, 2013). From a construction cost perspective, the lower the cost of enclosing a unit of floor area with external walls, the better. The greater the number of dwellings on an individual floor plate of an apartment building means that the developer can increase profit by recouping the cost of constructing the external wall from a greater number of purchasers.

The metric is also an indicator of the spatial properties of dwellings: a high WTF ratio implies that dwellings have a greater extent of façade available to the interior spaces, while a low WTF ratio tends to indicate a "deeper" plan shape with less external façade available. In multi-storey buildings with several dwellings on each level, the lower the WTF ratio, the more the building form precludes passive forms of control over moderating the internal dwelling environment, and the more air-conditioning is needed.

The MDC Performance Outcomes (POs) and associated Acceptable Outcomes (AOs) exemplify the passive climatic structural approach to design rather than the technological approach (see Table 1 for a sample).

PERFORMANCE OUTCOME	ACCEPTABLE OUTCOME METRICS
PO 20 Development includes buildings that exhibit subtropical design character and subtropical living	• 1 of: Dual aspect / greater than 2.4m ceilings / Habitable rooms with 2 windows or openings; • Weather and sun protected external doors and windows to habitable rooms; • Sun-shading or deep recesses on North; • Sun-protection on West.
PO 28 Development must provide attractive and functional private open space for residents	• 12m^2 minimum balcony area • 3.0m minimum dimension

PO 29 Development provides a resident with functional outdoor living space that receives natural light but is shaded to protect the resident from direct sunlight	• Solar access (form, materials, orientation) • 75% of a dwelling's outdoor living area N or NE (taking into account desired street interface and privacy outcomes)

Table 1: The MDC's Performance Outcomes and Acceptable Outcomes for Assessable Development

3. METHODOLOGY

This research focuses on a sample of recently-approved multi-storey residential buildings (MSRBs) from five to 30 storeys tall in Brisbane's medium and high-density zones in inner urban renewal areas. Projects with Development Approval (DA) post-2011 were identified by searching Council's online planning application system. A sample of 15 projects was purposively selected to take into account a range of scales of development and spatial configurations. Building usage was primarily Class 2 (Apartments) as defined by National Construction Code (Building Code of Australia) Volume 1(2013) but could also be mixed-use with multiple classifications, for example Hotel (Class 3), Commercial or Professional offices (Class 5), Retail (Class 6). Relevant DA documents were accessed from the online system, and a content analysis of architectural drawings (plans, sections and elevations) was conducted.

In addition, the Torbreck Apartment building completed in 1960, situated at 182 Dornoch Terrace, Highgate Hill was selected as a benchmark case. This building is an Australian Institute of Architects 'Significant Building of the 20th Century' (2010). The researchers accessed documents from a case study (Centre for Subtropical Design, 2006).

The research was conducted as a desk-top study during the period December 2015 to February 2016. Field observations to assess any differences between approved designs and built outcomes, or to identify resident modifications were not undertaken because not all of the building construction was complete at the time.

The following spatial-structural metrics were used to gain an understanding of the extent of opportunities for cross-ventilation and daylight availability: Building form and spatial configuration - (for example: tower, podium, core location and single or double loaded corridor, and number of storeys); typical private dwelling unit size, calculated as fully enclosed covered area (FECA) measured to line of 'weather-tightness'; external wall-to-internal floor area (WTF) ratio of typical dwellings; Surface Area to Volume (SA m^2/Vol m^3) ratio of overall building.

The Floor Area Ratio (FAR) of typical apartment building floor plates were calculated to determine potential for developer's yield. The metrics for FAR included net saleable area (all dwellings areas exclusively allocated to private dwelling units including balconies or similar) and common areas (shared by the residents of each floor including lifts, corridors and lobbies, stairs, ducts, plant rooms, electrical rooms, indoor garbage storage, lift motor rooms, administration areas and any gymnasiums, indoor swimming pools, common laundries, common bathrooms, common changing facilities, business centres, community/lounge/activity rooms and so on).

Utility of private outdoor space was measured according to the metrics for minimum dimensions and screening in the MDC.

4. RESULTS AND DISCUSSION

The research identified performance gaps between planning policy and actual design. Table 2 (see over) summarises the results. Overall, the approach utilised by developers is producing formulaic apartments that cannot be effectively cross-ventilated and that have extremely limited or no private open space. Little diversity in building configurations, spatial characteristics and basic floor layouts was observed.

The older building (Case 16) out-performed the new under all criteria. The benchmark Case 16 SA/Vol metric reflects the slender forms of its two towers, and associated cooling natural ventilation strategy. Half of the buildings represented by the sample have similar or higher SA/Vol ratios, and half have lower. All three towers in Case 15, a multi-tower project, have very low SA/Vol ratios, indicating a 'compact' building form unsuited to the structural approach desired in the subtropics. Another multi-tower project (Case 14) demonstrates both the highest and one of the lowest ratios. Surprisingly one low-rise building (Case 5) also exhibits the compact characteristic that is more suitable to heating conservation, rather than cooling by cross-ventilation.

Table 3 below summarises the findings of wall-to-floor ratio investigations for typical dwellings within the buildings, showing the benchmark Case 16, and the maximum and minimum cases. Case 16 has larger more spacious apartments and high WTF ratio indicating high potential for a successful ventilation strategy. The area of glazing compared to the overall external wall area indicates that walls are solid mass material compared to Case 15 where the external wall area is fully glazed. It is also worth mentioning that the primary functional requirements of windows under the BCA are admission of daylight and ventilation. View out of the window is a secondary function that has been given primacy by developers' imperatives.

The greater external façade area of the older building provides both thermal mass and opportunities for strategic openings, balancing daylighting and cross-ventilation appropriate for warm climates in accordance with recommended climate-responsive design strategies (Ratti et al., 2005). Glazed walls in MSRBs may be desirable for views and daylight (J. Lee, Je, & Byun, 2011), but unless a holistic architectural logic that serves the occupants' needs is employed, they can become the greatest source of glare and heat transfer and thermal discomfort in both temperate (Hofer, 2008) and tropical (Lam, 2000) climates.

ID	**Ht Storeys**	**Building Form**	**Spatial Config-uration**	**No of dwell - ings**	**Typi-cal Floor Area Ratio**	**SA/Vol (m^2/m^3)**	**Balcony Area ≥12m²**	**BalconyMin dim ≥ 3m**	**Solar Design**	**Balustrade transparency**
1	5	Tower	Edge-core DL	19	8:1	0.167	N/Y	Y	Y	0
2	5	Tower	Edge-core DL	17	9:1	0.174	N	N	Part	50
3	5	Tower	Edge-core DL	14	12:1	0.210	Y	Y	part	0
4	5	2 Towers	T1 Central-core DL T2 Edge-core DL	21 22 **43**	15:1 7:1	T1 0.139 T2 0.136	Y	Y	part	80
5	5	Tower	Central Core DL	20	17.1	0.107	Y	Y	Y	80
6	5	Tower	Edge-core DL	16	13:1	0.195	Y	Y	part	100
7	7	Tower & Podium	Central Core DL	18	9:1	0.194	Y	Y	part	100
8	7	Tower	Central-core DL	38	8:1	0.185	N	N	N	NA
9	7	Tower	Edge-core	17	14:1	0.168	Y	Y	part	80
10	7	Tower	Edge-core DL	18	10:1	**0.242**	Y	Y	N	100
11	20	Tower & Podium	Central Core DL	140	7:1	0.125	N	N	N	90
12	10	Tower	Central core DL	48	7:1	0.166	Y	Y	Y	50
13	15	Tower	Central core DL	135	7:1	**0.082**	N	N	part	100
14	30	3 Towers (25 st) 5 storey Podium	Central-core DL	352 296 267 **915**	10:1 7:1 11:1	**T1 0.090** **T2 0.265** T3 0.237	N	N	N	100

15	30	3 Towers (12, 27, 28) Podium (5 storey	Central-core DL	40 257 97 206 **601**	 7:1 7:1 6:1	T1 0.097 T2 0.089 T3 0.063	N*	N	N	100
16	22	2 Towers Podium	Central-core DL & Ext-core SL	91 49 **140**	8:1 9:1	T1 0.150 T2 0.164	N*	N	Y	50

Doubled Loaded (DL); Single Loaded (SL); *Some POSs meets this requirement; ^Balustrade transparency used as a proxy for screening to private outdoor space

Table 2: Summary of Case Study Building Characteristics

Case	Building height Storeys	Typical dwelling	FECA m^2	External wall area m^2	WTF ratio	Glazing area m^2	Total openable area m^2
Benchmark Case 16	22	1B/1Ba 2B/1Ba	92 107	37.8 53.7	0.41 0.50	7 26	5 13
Maximum Case 6	5	1B/1Ba 2B/2Ba	52 74	49 58	**0.94** 0.78	10 18	5 5
Minimum Case 15	30	1B/1Ba 2B/2Ba	50 81	6.9 8.7	0.13 **0.10**	6.9 8.7	6 6

Table 3: External Wall-to Floor Ratio for typical dwelling units

Untreated glazing can be the main avenue for unwanted heat gain throughout the year in the subtropics (ABCB, 2010). The desk-top study could not determine whether low emissivity and spectral selective glazing technology which is of benefit to reduce heat gain (D. H. Lee, 2000) was intended. It is important to note that low-E glazing does not automatically translate into a high performance façade, and it is associated with unshaded buildings. In the subtropics, the structural approach to window design is associated with controlling thermal comfort in summer through shading to control overheating and with generating air movement to counter humidity (Szokolay, 2008). Shading devices also reduce glare and the intensity of daylight entering habitable areas (Edmonds & Greenup, 2002).

Private outdoor living spaces varied quite widely in terms of space and form. Very few dwellings in the sample had primary outdoor living spaces that exceeded 12m^2 despite outdoor living being one of the hallmarks of Brisbane's subtropical lifestyle. While the width of balconies varied across the cases, depths varied widely and many were extremely shallow (460mm, Case 15) or non-existent (Case 8). Most cases incorporated glass balustrades to balconies which offered no sun protection and inhibited air flow. Only 25% of cases had well-resolved designs that complied with the MDC.

The sample analysis demonstrates the tensions between developer's quest for yield and the planning policy's desire to promote climate-responsive building form for MSRBs to play a valuable part of the sustainable subtropical city of the 21st Century. BCC has established that 'structural' design approaches are suitable for multi-residential development Brisbane. But evidently, the current 'passing standard' is too low to achieve acceptable sustainable design. Code Assessable pathways to Development Approval are preferred by developers in order to accelerate the process and thus save money. Ironically, generic solutions are not necessarily the most cost efficient outcomes.

5. CONCLUSIONS

Successful design of private apartment dwellings depends on the overall building form and configurations that require less energy. A major challenge for planning codes is to reconcile the environmental drivers of building form (light and ventilation to dwellings) versus economic drivers (wall-to-floor area) and net-to-gross saleable floor area. This paper has revealed the tensions between the MDC and generic MSRB solutions. It provides evidence that key items driven by developers' aims to maximise yield and privilege 'views' above other important design considerations make it difficult for apartment dwellers to fully embrace climate-responsive high density subtropical living.

Next steps in this research is to investigate the root problems in the current system that results in generic design in order to propose what can be done to enhance the lived experience for Brisbane residents and neighbours (including surrounding community) using effective planning to achieve design approaches suitable for the local subtropical humid climate.

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