Design Research Towards Improving Liveability and Sustainability in Medium Density Infill Housing in South East Queensland

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Abstract: South East Queensland (SEQ) is Australia's fastest growing region. The Council of Mayors (SEQ) has identified the strategic potential of medium density development in creating greater diversity and affordability in housing markets, as well as promoting a more compact and sustainable urban form. However, the construction of infill buildings at 4-8 storey scale can present significant challenges in terms of achieving sustainable, liveable outcomes within existing site and financial constraints, as well as integration into extant surrounding neighbourhoods.

This paper reports on a design research project commissioned by the Council of Mayors (SEQ) that investigated design strategies for improving the liveability and sustainability of medium density infill development, and sought to provide an evidence base for the benefits and costs of incorporating such strategies. Current market developments representative of a status quo were analysed to provide a benchmark and ensure the strategies are feasible within the constraints of market-led delivery.

A series of alternative design models were formulated employing simple but effective changes to current market development approaches to improve liveability and sustainability. Cost-benefit evaluation of construction and life-cycle expenditure against a benchmark was undertaken, revealing the increase in construction costs was negligible, and a reduction in energy consumption of nearly 15% was possible. Further design benefits included enhanced quality of space/liveability, alongside improved shared spaces and impact on the public realm and neighbours.

Potential adjustments to current planning and building codes are proposed to provide necessary flexibility. More broadly, the research shows the value of a holistic, design-led process of testing, refining and reinventing development parameters.

Background

South East Queensland (SEQ) had a population of 4.6 million in 2011 projected to increase to 6.6 million in 2031, a rate of growth higher than that of Melbourne and Sydney[1]. The SEQ Regional Plan forecasts demand for an additional 754,000 new dwellings between 2006 and 2031, and anticipates at least 374,000 will be delivered through infill development (DIP 2009). This is a total increase on 2006 housing stock of almost 70%, with almost 50% is to be delivered as infill development.

To address this significant population increase and change in housing delivery, the Council of Mayors (SEQ), an independent organisation representing the interests of 12 local governments in SEQ, established the Liveable Compact Cities Project (LCCP) as a research and advocacy initiative. The LCCP investigated the impact of state and local government policy settings on the cost and supply of medium density dwellings, how government processes interacting with medium density delivery could be made more efficient while improving the quality of urban outcomes, and how the market might be influenced to increase housing choice and affordability (Council of Mayors SEQ 2011).

The LCCP found that "…there is a mismatch between demand and supply in South East Queensland, with significant supply side reform needed to meet the increase in underlying demand and to provide the diversity of housing types required." (Council of Mayors SEQ 2011) An increasing proportion of the population is now seeking semi-detached, attached or apartment dwellings due to affordability pressures and the prioritising of locational and amenity advantages over living in a free standing house. Demographic trends in SEQ (particularly ageing of the population and an increase in couple households with no children) are also likely to increase demand for smaller housing options. However, the development industry identifies investors as the primary target market for medium density development, and pursuing the emerging market sector of owner-occupiers is still perceived as risky.

[1] Author's calculation based on Queensland Treasury (2011), DTPLI (2014), DPI (2013)

Research context

Affordable apartment development operates within tight financial constraints due to higher square metre construction costs for medium density dwellings than detached dwellings. Balancing project viability with the aspiration for highly sustainable and liveable outcomes is a difficult challenge. This is well appreciated by local council planning departments in SEQ, who have expressed concern at the quality of many applications they receive, and echoed by consumer concerns. Community forums undertaken by the LLCP suggested that the primary detractions of medium density housing are perceived proximity to neighbours, reduced living space and body corporate costs (Council of Mayors SEQ 2011).

In the context of increasing medium density infill supply, the quality of development outcomes will have a huge impact on the ongoing liveability and sustainability of our cities through the nature of dwelling uses and the cost of operation. For instance, in Queensland, electricity consumption by the residential sector is growing twice as fast as overall consumption, and carbon emissions from residential buildings are projected to increase by 78% by 2050 under business as usual conditions (DERM 2009).

The life cycle cost benefits of sustainable design, and its link to occupant comfort and wellbeing, are now well established amongst the research community (Milligan 2010, QUT 2009-15, Kennedy 2015, Rowe 1996). The advantages of sustainable design are also recognised by housing consumers in SEQ. The LCCP community forums found that natural light and ventilation are highly valued and most prospective purchasers were prepared to pay an up-front premium for sustainability features. However, there is a prevalent view in the SEQ development industry that sustainable design adds 5% to the construction costs, which most consumers are unwilling to pay despite their stated preferences (Council of Mayors SEQ 2011).

Research aims and method

In response to these differing views around affordable development and the financial challenges involved, this research sought to evaluate the costs and benefits of improving the sustainability and liveability of typical medium-density infill outcomes in SEQ, while still maintaining project viability. It seeks to identify simple but effective design strategies that can be readily adopted by government and industry as general guidelines for future affordable medium-density infill supply.

The project uses the integrative processes of design research as the theoretical basis for its enquiry. This speculative mode of inquiry involves ‘investigations in which architects use the creation of projects … as the central constituent in a process’ (Fraser 2013). Through a projective and spatial engagement with ‘real world’ issues and sites, design research provides unique insights for affecting transformative change in response into the urban challenges we face.

The focus of this research was to investigate the influence of passive design elements (such as natural lighting, orientation and cross-ventilation) which cannot be quantified as readily as ‘active’ design add-ons (such as insulation, advanced glazing and renewable energy generation) and have been less studied in the specific context of medium density housing. The design research specifically examines developments of 4-8 stories, which was identified by The Council of Mayors (SEQ) as an under-researched development category that has the greatest need for design guidance in the development market. This scale of development also occupies a type of ‘sweet-spot’ in current building regulations: it is above the scale required to have fire-isolated stairs, but below a height where stair pressurisation and full sprinkler systems are needed. Fire services can attract significant construction costs and impact heavily on project viability.

The research was undertaken in three stages, which are reflected in the structure of this paper. The first section briefly summarises the findings of case study analysis of typical market infill redevelopment in SEQ. A ‘benchmark’ project was selected against which the cost and benefits of proposed design enhancements could be compared. The second section outlines two alternative design models produced for the same site and location as the benchmark project. This ensured that the proposals operated within the same basic planning restrictions and yield expectations. The designs were developed in sufficient detail to show that the approach was workable and enable construction costing and environmental assessments to be carried out. The third section examines the costs and benefits of the design alternatives compared to the benchmark project. The paper concludes with a discussion of current planning and building controls that support or impede the viability of delivering more sustainable and liveable infill outcomes.

Case study analysis of status quo market development

Location

To give the research contextual focus and 'real-world' conditions, a case study area was adopted and analysed. The suburb of Cleveland, roughly 25km southeast of Brisbane, was chosen for a number of reasons including:

- its rapid population growth
- recent master-planning and re-zoning for allotments to change to medium-density zoning (Redland City Council 2010)
- a significant amount of development activity occurring at a fast pace
- its direct train line to Brisbane but location on the periphery
- its transition from seaside town into Regional Activity Centre
- being indicative of many medium density development areas in SEQ.

Design characteristics of status quo developments

The research team reviewed a broad range of medium density infill developments in Cleveland. Based on this preliminary examination, and in consultation with The Council of Mayors (SEQ), three representative case studies were selected for detailed analysis. All three projects were between 4-8 storeys, had recently received planning approval and demonstrated limited design quality outcomes recurring in market-led infill development. Key design issues include:

- Dwelling densities are often high – between 165 and 330 dwellings per hectare (net)
- High dwelling yields combined with current setbacks and open space requirements encourage large building masses to be centred on the site resulting in awkward and underutilised peripheral spaces (Figure 1)
- Basement car parking extends over much if not the full extent of site, leaving limited permeable ground for vegetation and water sensitive design strategies (Figure 2)
- Apartments are usually located around a fully internalised central core limiting passive design opportunities (Figure 3)
- Standardised internal apartment plans repeated over floor levels inhibit dwelling diversity.

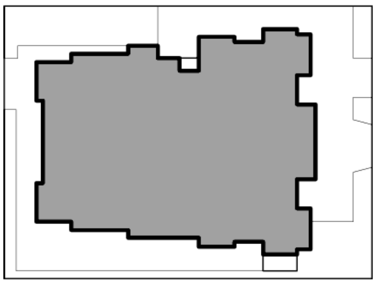

Figure 1: Large building mass centred on the site with little consideration of 'leftover' spaces

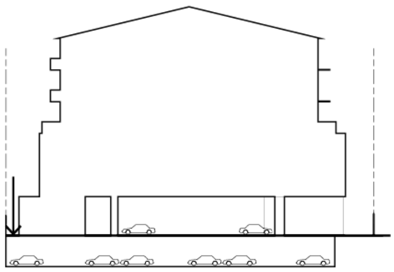

Figure 2: Basement parking across the full site extent results in limited permeable ground

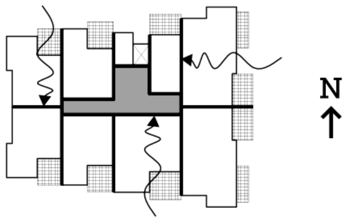

Figure 3: Internalised core prevents natural ventilation

Urban impact

Areas experiencing pressure to intensify in SEQ but which are presently underdeveloped, like Cleveland, are characterised by low-density building forms, large lot sizes and ample vegetation. The 'green' environment provides relief to the scale and form of status quo medium density developments, and this is often the context chosen for marketing images (Figure 4). But if these status quo types are multiplied over many sites to become the dominant form as current zoning allows (Figure 5), the collective impact of the design issues outlined above becomes readily apparent (*Figure 6*).

While provocative these visualisations are spatially accurate and thus feasible. Large building masses and ill-considered siting would result in limited outlook from one building to the next, and a lack of visual permeability from the street. Vehicle movement would dominate the ground level of this urban environment, with little room for vegetation. The consequent lack of shade canopy would negatively impact on neighbourhood quality and the walkability of the area (QUT 2009-15), a serious consequence as walkability has been found to be a key enabler of consumer choice for higher-density inner city living (Council of Mayors SEQ 2011).

Figure 4: Marketing image for a recent Cleveland development

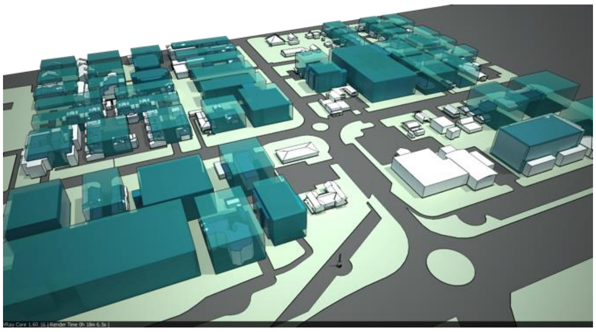

Figure 5: Projection of current planning envelopes in a Medium Density Zoned area

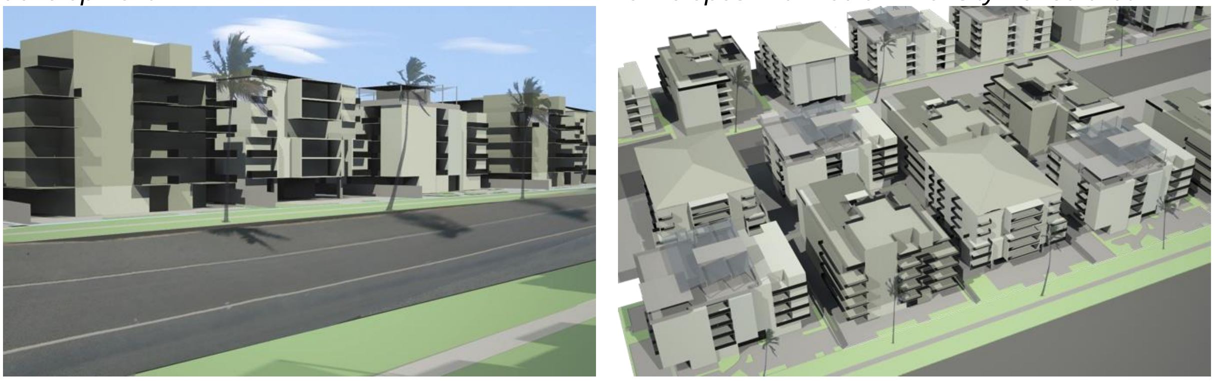

Figure 6: Visualisation of streetscape & suburban block if real, approved case studies were replicated

Medium-density design alternatives

The case study analysis identified a range of areas where design enhancements could improve the sustainability and liveability of status quo medium-density development at building and urban scales. Drawing on these observations, the research developed two alternative design models to examine how a series of relatively modest re-configurations of building typology could address the limitations in current infill outcomes. Through an iterative design process and in consultation with leading local architects, the strategies developed sought to improve orientation, ventilation, site and context responsiveness, adaptable internal plans and quality open and shared spaces. The two alternative models are:

Ventilated Core Model

The Ventilated Core Model consists of a 6-storey block with penetrations running north-south and east-west throughout the entire building, capturing prevailing sea breezes that cool and circulate air (Figure 7). The L-shaped configuration of the maisonette unit type (Figure 11) allows for circulation corridors on every second level, increasing efficiency and the ability to provide dual-aspect apartments (Figure 8). The design takes into account the sub-tropical climate by providing deep balconies that are an extension of bedroom and living areas, essentially acting as a series of 'outdoor rooms'.

The building is sited towards the southwest corner of the site, though without significantly overshadowing the adjacent block. It sits just above ground on stilts over a semi-submerged car park with heavily planted battered walls that increase natural ventilation, aesthetics and improve the microclimate. All services and car park entry are located to the south, freeing the northern side for private yards and providing apartments with a pleasant outlook and access to northern light (Figure 10).

Figure 7: Ventilated Core Plan: lobby levels 2 & 4

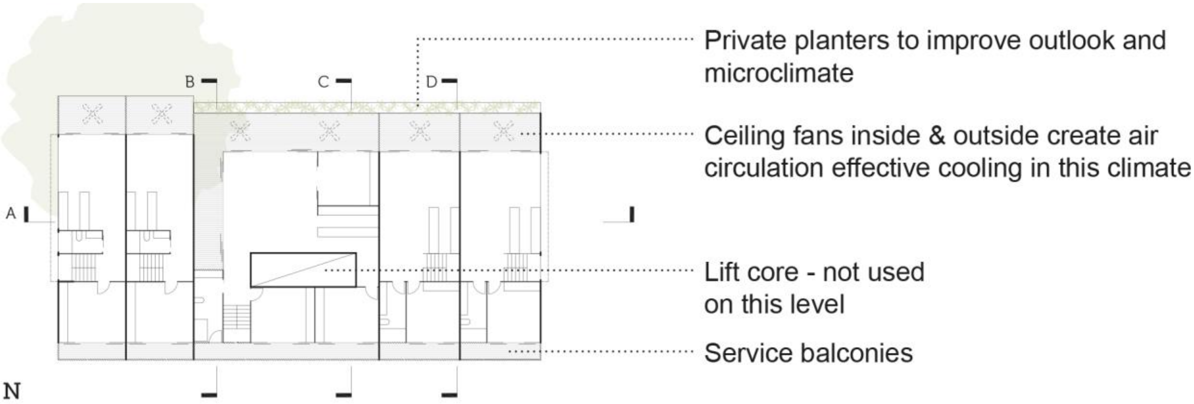

Figure 8: Ventilated Core Plan: dwelling levels 1, 3 & 5

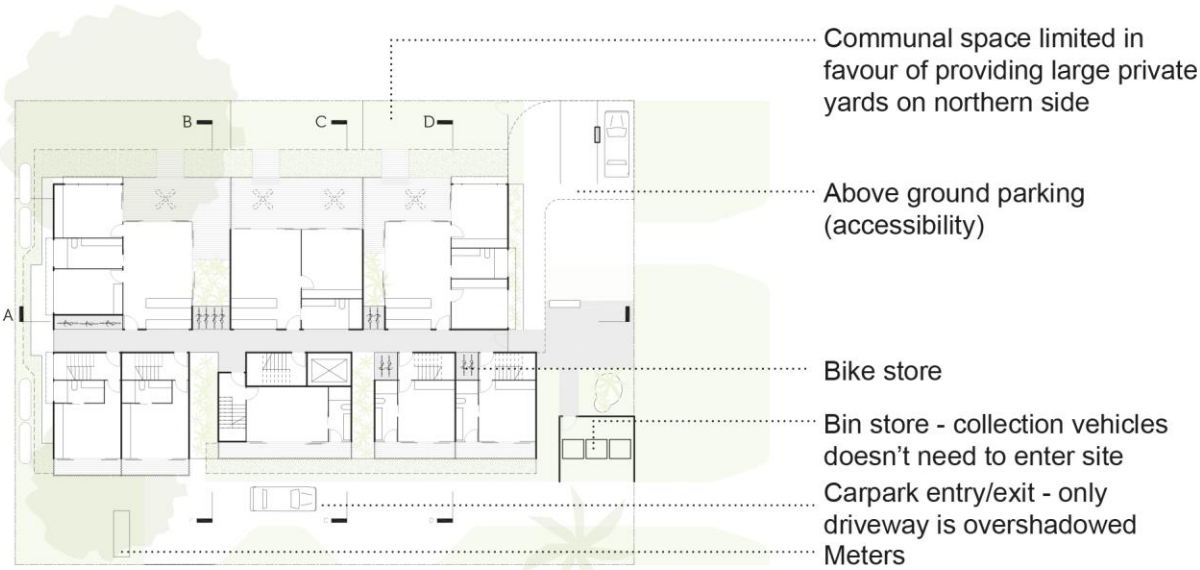

Figure 9: Ventilated Core Plan: ground floor

Figure 10: View from north-east

Figure 11: Section D

Multiple Core Model

The Multiple Core Model (Figure 12) provides full dual aspect, with all apartments extending from one side of the building to the other. Having only two apartments straddle a vertical circulation lobby on each floor allows all apartments to have optimal solar orientation and enables highly effective cross-ventilation. This requires two more lifts than would generally be the case, however these lifts could all be smaller and less costly. The configuration of the circulation core can be varied in response to fire servicing requirements (Figure 14). An exhaust vent at the top of the circulation lobby acts as a thermal chimney, making use of the thermal stack effect to purge stagnant air and naturally ventilate (Figure 15). Combined with its natural lighting, this increases the appeal of the lobby as an alternative to taking the lift.

Having multiple circulation cores breaks the plan into three relatively independent modules that can be slipped relative to each other. This enables the overall building mass to be tailored to site conditions such as existing mature trees or attractive views (Figure 13). In this case, stepping the overall footprint southwest to northeast allows a large beautiful tree to be retained.

The building is sited towards the south boundary, without significantly overshadowing the adjacent block. All services and car park entry are located to the south, freeing the northern side for private yards and providing apartments with a pleasant outlook and access to northern light (Figure 16 & 17). The basement car park is semi-submerged and open at the sides to enable natural ventilation and improved microclimate.

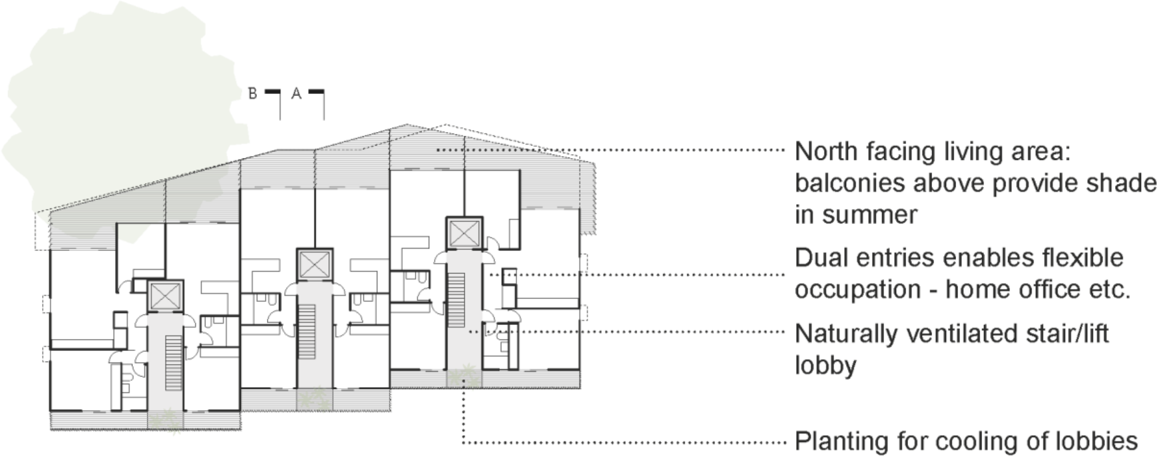

Figure 12: Multiple Core Plan: typical

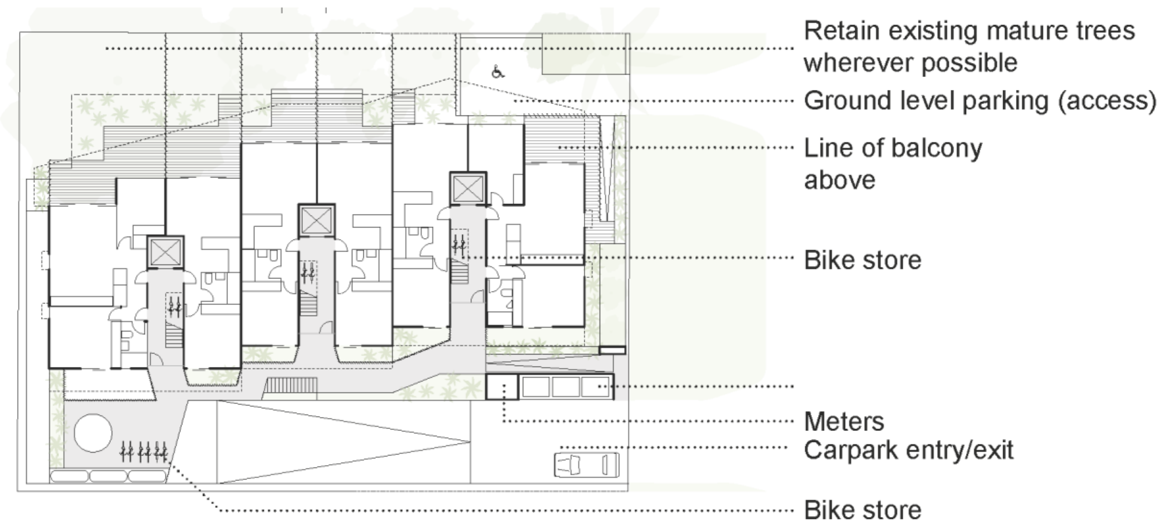

Figure 13: Multiple Core Plan: ground floor

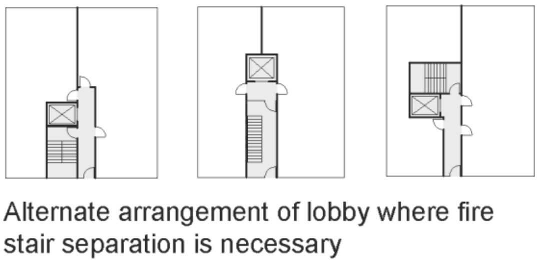

Figure 14: Stair variations

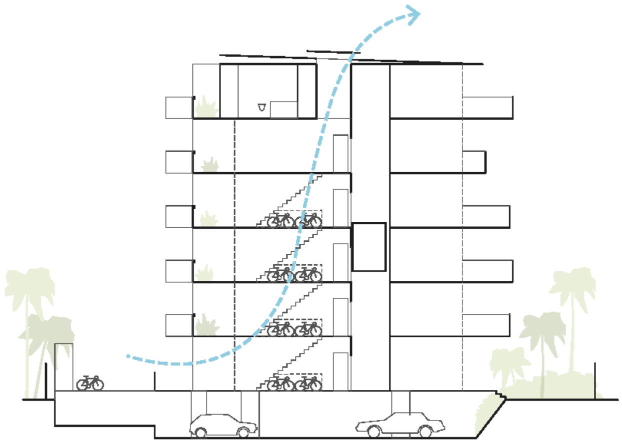

Figure 15: Section A

Figure 16: View from north-east

Figure 17: View from south-east

Findings from the Cost-Benefit Comparisons

The following section discusses the benefits of the alternative design models compared with the market benchmark and the additional construction costs needed to achieve higher quality outcomes.

Environmental Performance

The internalised core configuration of the benchmark design results in the majority of apartments being unable to effectively cross-ventilate. This configuration also results in half the dwellings having poor solar orientation; apartments enclosing the southern side of the core have no access to northern sunlight. By contrast, the two alternative designs are structured such that apartments have dual aspect, enabling through ventilation and northern aspect for all dwellings.

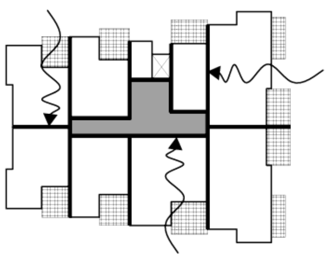

Figure 18: Benchmark project, internalised core

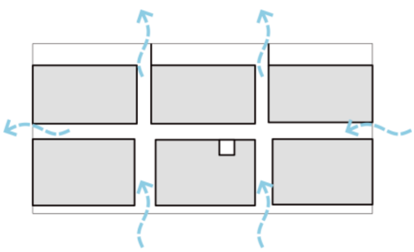

Figure 19: Alternative design: Ventilated Core

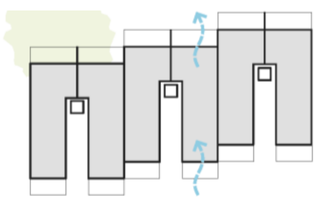

Figure 20: Alternative design: Multiple Core

To analyse and isolate the affect of these different physical configurations on internal ambient temperature and energy used for heating and cooling, thermal modelling was undertaken with glazing and insulation specifications standardised across the three projects as far as possible[2]. To enable valid comparison of thermal performance and energy use of the development benchmark and two alternative designs, a similar apartment from each scheme was chosen, which was a north facing, mid-block, single-bedroom apartment approximately 45m^2 in area on a mid-level floor.

Table 1: Overheating and overcooling (24/7)

	# of hours p.a. temp >25 °C	% of year	# of hours p.a. temp <16 °C	% of year
Benchmark	2,466	28.15	232	2.65
Ventilated core	1,991	22.73	407	4.65
Multiple core	2,056	23.47	299	3.41

Table 2: Overheating and overcooling during hours 17:00-8:00 every day of the week

	# of hours p.a. temp >25 °C	% of year	# of hours p.a. temp <16 °C	% of year
Benchmark	1,200	13.70	195	2.23
Ventilated core	614	7.01	349	3.98
Multiple core	672	7.67	255	2.91

The results showed that the alternative designs outperformed the benchmark in maintaining a comfortable internal temperature (**Table 1**). The Benchmark would be overheated 5% more of the year, but the alternative models would be colder for 1-2% more of the year. Examining internal temperature only during hours of occupancy resulted in slightly better percentages for the alternative models (**Table 2**). When comparing the energy needed to maintain comfortable temperatures, the advantage of the alternatives was more pronounced (**Table 3**), with 16-23% savings for cooling and 2-9% savings for heating. Although the Ventilated Core Design fluctuates more with the outdoor temperature, it is significantly cooler in summer and uses 14.5% less energy overall than the Benchmark. The Multiple Core Design performs nearly as well during summer, with slightly improved performance mid winter due to the higher proportion of shared walls and less glazing than the Ventilated core model.[3]

Table 3: *Heating and Cooling energy (KwH)*

Month	Benchmark Heating	Benchmark Cooling	Ventilated Heating	Ventilated Cooling	Multiple Heating	Multiple Cooling
Jan	77.1	209.6	67.5	192.9	79.7	209.9
Feb	68.8	180.7	60.2	160.3	71.1	176.1
Mar	75.4	104	65.9	67	78	76
Apr	79.1	52.3	71.5	29.8	80.2	31.5
May	98.2	11.5	89.4	1.8	94.7	1
Jun	130.5	0.4	121.4	0.2	117.5	0.1
Jul	163	0.1	154.2	0	144.8	0
Aug	143.6	1.4	140.1	0	132.9	0
Sep	86.4	2.8	80	0.1	88.1	0
Oct	81.2	27.6	72.7	12.6	84.5	10.7
Nov	73.3	89.8	64.1	57.1	75.7	62.6
Dec	73.2	140.1	64.1	111.9	75.7	117.6
Summed total	**1149.7**	**820.4**	**1051.1**	**633.7**	**1122.9**	**685.4**

[2] Report by Greensphere Consulting contains a full description modelled parameters and outcomes is available upon request. The Ventilated core design has an additional R1.0 added to external wall insulation owing to the apartment being bounded by breezeways (this variation has been accounted for in the costings).

[3] All temperature analysis was based on dry-bulb measurement. Analysis of apparent temperature was outside the scope of study, but if included would likely have a favourable impact on results for the alternative models. This is because these have superior levels of cross-ventilation which enables through breezes to lower the apparent temperature during periods of overheating.

Liveability: relationship to passive design

The improved passive performance of the alternate designs offers immediate liveability benefits within the dwelling, namely the improved access to light and air that comes with dual aspect. While all units of the Ventilated Core and Multiple Core designs enjoy a northern orientation, the Benchmark example has apartments facing in all directions. Analysis of a south-facing unit's thermal performance showed its energy consumption for heating and cooling to be of negligible difference to the identical north-facing unit. However, the south-facing unit would lack the benefit of direct sunlight and receive much lower levels of indirect natural light. Dual aspect also allows for a secondary outdoor space on the southern side. This provides the flexibility of having a cooler outside space in the heat of summer, and a place for laundry/services that avoids compromising the main outdoor living space. Furthermore, the alternate models enable natural lighting and ventilation of shared lift lobby and semi-basement car park, improving the experience of arriving at one's apartment.

Site and landscape

The review of market case studies indicated that the maximisation of dwelling yields within rigid setback provisions frequently results in broad building masses centred on the site. This has the effect of producing a series of leftover, under-productive edge-spaces in the setback zones, with little consideration of amenity impacts and characteristics of surrounding sites. When combined with the construction of full-site basement car parks, the potential to retain existing mature trees or establish new large-scale vegetation is also severely limited.

Sub-tropical vegetation plays a significant role in ensuring climate-responsive, comfortable microclimates, as well as shaping the character of existing neighbourhoods (Centre for Subtropical Design 2010, QUT 2009-15). The other vital contribution it makes to liveable medium-density outcomes is to reduce residents' perceptions of crowding (Kearney 2006). Both of the alternative designs allow for considerable vegetation with generous setbacks provided on the north side of the building, and the location of basement parking to enable deep-root planting. Densely planted, sizeable private yards provide enjoyable open space amenity for ground level apartments and a 'green' outlook for all upper level dwellings (Figure 21).

The stark quality and arresting scale of many standardised infill developments is ameliorated in the alternative designs through their narrower footprints, considered siting, ground floor landscape treatments and the location of openings/balconies on the facade. Vegetation can improve the aesthetic appearance of larger-scale development, enhances the urban microclimate, and provides an means for sympathetically integrating with existing neighbourhoods (Figure 22).

Figure 21: Densely planted north facing private yards

Figure 22: Street frontage, showing visual permeability and allowance for substantial vegetation

Diversity

Where the benchmark examples each tended to comprise dwellings of a similar type and size (with the primary benchmark heavily weighted towards smaller dwellings to maximise yield), the alternative models demonstrate how a broader range of dwellings can be efficiently included through the use of maisonette and L-section apartment types (**Table 4**). Moreover, avoiding the common practice of devoting the ground level to vehicle circulation and parking allows some apartments at ground level to have large private yards, increasing their suitability for families.

Table 4: Comparison of development yields for Benchmarks and Alternative Designs

	Benchmark examples			Alternative designs	
	Standard	Affordable (Primary)	Luxury	Ventilated core	Multiple core
Site area (m2)	1,214	1,214	1,214	1,214	1,214
Studio	0	5	0	0	0
1 Bed	9	25	0	7	16
2 Bed	20	10	4	14	8
3 Bed	0	0	16	0	6
4 Bed	0	0	0	3	0
Total no. of apartments	29	40	20	24	30
Total no. of beds	49	50	56	47	50
Net saleable area (m2)	2,380	1,989	2,807	1,879	2,275
Balcony/private outdoor area (m2)	567	491	1,351	1,659	953
Lobby area (inc. stairs, lifts) (m2)	378	465	238.8	318	400
Parking area (inc. stairs, lifts, store, bikes, waste) (m2)	1327	1530	1327	943	1143
Residence carparks (no.)	29	40	25 (5 tandem)	24	30
Visitor carparks (no.)	7	8	4	1	0
Number of elevators	1	1	1	1	3

The alternative models offer greater flexibility in their occupation. The lower bedroom that can be accessed without entering the rest of the home in the L-section apartment of the Ventilated Core, and the second lobby entry of apartments in the Multiple Core (Figure 23) both create opportunities such as having a home office or semi-independent resident. These features allow the dwelling to adapt to change occupant needs over the course of its lifecycle, and are less likely to be achievable when using a standard internalised core.

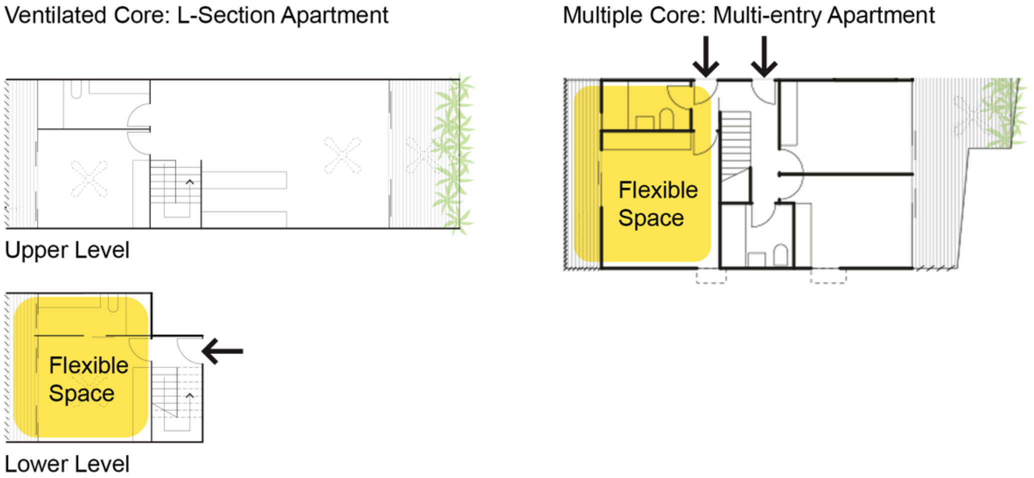

Figure 23: Adaptable dwelling plans

Construction Costs

Schematic costings were undertaken to enable comparison of construction costs between the Benchmark example, Ventilated Core Design and Multiple Core Design. The figures are not a precise indication of what it would actually cost to build each project; rather, through using a comparative method, they highlight the relative cost position of each design scheme.

Overall, the Ventilated Core and Multiple Core would cost approximately 6.0% and 2.3% more respectively than the Benchmark (**Table *5***). The dollars per bed and per square metre of net saleable area (NET - internal areas only) are very similar across all three schemes. On dollars per square metre of NSA including outdoor space, the alternative models are actually 20% cheaper than the Benchmark, reflecting the limited provision of external private open space in the Benchmark.

When liveability and sustainability factors are considered over the lifecycle of the developments, the alternative designs offer more value for the initial construction cost. Similarly, the adverse impact on the broader urban environment, resulting from poor quality design outcomes, might be considered a ‘public cost’ that is not considered at the scale of individual buildings. The potential expense of rectifying the unintended consequences of collective development impacts, for example deterioration of a walkable neighbourhood, requires further research.

Table 5: Construction cost comparison

	Benchmark	Ventilated core	Multiple core
Gross floor area (m2)	4,475	4,799	4,771
Net saleable area (m2)	1,989	1,879	2,275
$ per apartment	$226,750	$400,417	$309,333
$ per bed	$181,400	$204,468	$185,600
$ per m2 (GFA)	$2,027	$2,003	$1,945
$ per m2 (NSA)	$4,560	$5,114	$4,079
$ per m2 (NSA inc. outdoor space)	$3,657	$2,716	$2,875
Total precinct cost	**9,070,000**	**9,610,000**	**9,280,000**
Total precinct cost $/m^2	**2,027**	**2,003**	**1,945**

Regulatory barriers for improved infill outcomes

The process of background research, benchmark analysis and applied design research enabled the project to examine and test the impact of current planning and building controls on delivering good quality and viable infill development in SEQ. The final section of this paper discusses potential adjustments to current regulations that could facilitate more liveable and sustainable outcomes.

Setbacks from site boundaries

Current uniform setback provisions are adversely affecting open space quality as previously described. Assuming unchanged site coverage, current large street setback requirements could be reviewed as they fail to take into account the existing amenity provided by wide streets and large nature-strip reserves. Setback requirements could be made more performance-based to allow and encourage customised site-specific responses. Front setbacks could be reduced, and side/rear setbacks increased to protect amenity on adjoining sites. Retention of existing mature vegetation could trigger flexibility or trade-offs in siting and building envelope controls.

Requirements for on-site visitor parking

In the case study area of Cleveland, development require 1 car space per unit, plus 1 visitor car space for every 4 units. This requirement is typically met by a full level of basement parking below grade, plus additional parking at ground level. Whilst provision of adequate parking is important for medium-density residential development, the requirement for on-site visitor parking (approximately 7-8 spaces per development site) is impacting on overall site usage and limiting the inclusion of deep-root trees, either new or existing. Cleveland is characterised by generous streets with wide nature-strips and very little on-street parking demand. The capacity for public streets to accommodate (at least some) visitor parking should be considered. Intermittent parking could be naturally shared across frontages within a 200-300 metre walking distance. Street parking could also be metered to provide revenue for public realm and streetscape improvements. Development contributions could also be negotiated to facilitate on-street visitor parking with associated landscape works.

Retention of existing trees and mature vegetation

Given the important role of vegetation for creating sustainable and liveable environments in the SEQ climate, appropriate policies and regulations should be developed to protect existing ‘green assets’ or require the re-planting of equivalent trees of indigenous species. This has occurred through vegetation protection zones in other municipalities.

Requirements for communal open space

The provision of communal open space is in some cases mandatory, however it is often delivered to a low level of quality, or relegated to the awkward ‘leftover’ spaces typical in standardised developments. In the case studies reviewed by this research, common areas were rarely integrated into the overall design concepts, nor did they contribute to the quality of development in a meaningful way. A recent study of high-density housing in SEQ found that the shared nature of communal spaces is generally not attractive to residents, while utilitarian spaces such as corridors and lifts were viewed more positively as social spaces for chance encounter (QUT 2009-15). In subtropical climates where year round “outdoor living” is valued, private outdoor space plays an important role in resident perceptions of liveability (Kennedy 2015). Ground level spaces might thus be better utilised for high-quality private courtyards, which if properly arranged and landscaped can also contribute to the amenity of upper level apartments and the overall quality of the surrounding urban context. The mandatory nature of this provision should be reconsidered, particularly in conjunction with stricter controls on retention of existing vegetation.

Requirements for off-street rubbish collection vehicles

Current regulations in the case study area require large rubbish collection vehicles to be able to enter and exit the site in a forward gear. This is an onerous requirement that results in large areas of ground surface being given over to vehicle circulation, and also requires high vertical clearances. This reduces the ability of developments at this scale to provide quality ground-level useable space that contributes to both private and public urban amenity. These are good reasons to enable street-based centralised collection options, with appropriate screening and landscape amelioration. Alternatively, experience in other municipalities suggests that options for private collection of waste may offer greater flexibility and better urban outcomes, and the provision of such services could be included as a condition of permit.

Deemed to Comply vs Performance Based approaches to building regulations

The recurrence of centralised lift lobbies and shared corridors without ventilation at this particular development scale (4-8 storeys) is driven by two factors. First, developer interest in maximising yield while minimising spending on unsellable common space, and second, restrictions of a 'deemed to comply' approach to building codes, particularly in relation to travel distances and fire separation of various building elements. Across the study area there was an overall lack of building variety and very little design innovation observed, to which the 'deemed to comply' restrictions may be a contributing factor.

The two alternative designs were developed in consultation with a building surveyor and work on a "performance-based" approach to building compliance. Performance-based compliance is widely used in other municipalities and can allow more innovative design solutions based on actual, rather than theoretical or standardised, situations. For this project, it enabled greater spatial and passive design advantages to be achieved in the flexible location, improved use and ventilation of the proposed circulation cores. This would not have been possible without considering alternative fire containment strategies and their impact on travel distances to escape stairs. Their delivery would require the engagement of a fire-engineer to undertake specific modelling as part of the consultant team. For this to be a viable option in the affordable infill market, a degree of certainty that fire-engineered solutions will be accepted by relevant authorities is needed. The experience of performance-based approaches in other states should be reviewed and benchmarked. For example residential sprinkler systems to certain parts of buildings have been found to increase design flexibility[4] and could be considered as part of a cost-benefit analysis[5].

Conclusion

The viability of improving the quality, liveability and sustainability of affordable medium-density developments in SEQ requires multiple design and delivery concerns to be considered in an integrated fashion. This design-led research project has enabled the competing priorities of affordable costs & liveable/sustainable benefits to be examined and synthesised through the development of alternative infill design models. It has demonstrated how a series of modest changes to typical building design typologies can lead to measureable improvements in environmental performance, provide significant benefits with regard to quality of space/liveability suitable to SEQ's climate, and increase housing diversity and flexibility.

The extension of these strategies to enhance the public realm and increase the amenity for neighbouring buildings was pronounced when compared to the collective impact of standardised development outcomes. The ongoing benefits offered to prospective residents, the broader community and urban environment in SEQ are considerable and would appear to justify the very marginal cost difference involved.

Rigorous spatial analysis through design and construction costing indicates that the alternative design strategies are viable in the current medium density infill market but could be better facilitated with cooperation from planning and building authorities. Furthermore, the proposed design strategies begin to address existing consumer concerns around the liveability and appeal of apartment living. More detailed research into demand-side drivers and 'willingness to pay' for enhanced design outcomes would be valuable.

[4] The Commons, an apartment building designed by Breathe Architects in Victoria, demonstrates how fire sprinkling can reduce requirements for the fire separation of escape stairs, enabling them to be naturally lit and ventilated and thus more attractive as an alternative to taking the lift.

[5] Report from PLP Building Surveyors available upon request.

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