SUSTAINABLE
HIGHER DENSITY RESIDENTIAL DEVELOPMENT

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ABSTRACT

This paper discusses the potential of improving the sustainability of existing cities and towns through residential use of roof-top additions to buildings.

The phenomenon of extending existing buildings by adding floors is not especially novel, there being many examples throughout history. However judging by the limited number of recent cases in most cities, this design typology appears to not have received much attention. Building on top can be shown to provide good ecological performance of individual buildings but also improved performance of the wider built environment.

The aim of the paper is to show city authorities and the property development industry through scholarly argument and international case studies the key benefits of building on top of suitable existing building stock.

A hypothetical case study is presented wherein building on top is compared with demolishing the existing building and building anew. Attention is given to sustainability in terms of: life-cycle assessment; embodied energy; energy in use; CO2 emissions; building materials and technologies; reduction/avoidance of demolition waste; and, footings/foundations. Wider implications of building-on-top are explored in terms of city infrastructure; city services - water, waste, power, transport; city regulations; and, city expansion. Social, cultural and economic enhancement of the city is discussed in terms of cultural heritage and activity; social behaviour, economic performance; and, public health.

The hypothetical case study together with the example of Wellington City building-top apartments provides transferable ideas for sustainable higher density residential development.

Key words: building-top apartments; urban sustainability; higher density residential development.
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INTRODUCTION

The context of the term ‘higher-density residential development’ in this discussion is that of roof-top additions to existing buildings which will be addressed with selective reference to several broad discourses. Discussion on density will range from single apartments to medium-high density, but will mostly focus on medium density. Examples in the city of Wellington, New Zealand will receive detailed attention but a wider view will also be taken.

The phenomenon of extending existing buildings by adding floors for a range of purposes is not especially novel, there being examples throughout history. However the specific design typology of roof-top apartment additions appears to not have received much attention in architectural and urban design discourse nor in more recent sustainability literature. This paper seeks to go some way toward addressing this deficiency by presenting exploratory research which suggests that city sustainability can be improved through encouraging building-top apartment development.

The paper brings new material to light but also builds on previously presented and published work (see: Holden, 2003; Holden, 2004; Holden & Gjerde, 2007).

VISUAL TYPES OF BUILDING-TOP APARTMENT

Building-top apartments are relatively recent in western cities, the earliest coming to notice from the 1970’s. The famous American architect Paul Rudloph was at the vanguard with his own experimental penthouse (1977) built on top of a traditional five-story row house in Manhattan (Fig 1). Early examples tended to be additions to single ownership buildings helped by simplified legal and approval processes. Not surprisingly single ownership buildings continue to be popular hosts for upward additions because of easier project management (Fig 2). It is this category that has produced the most experimental if not eccentric examples (Fig 3, Fig 5). But single ownership also has produced ‘dumb’ projects, for example those that appropriate ubiquitous suburban or rural detached house models that are unrelated to city centre built form (Fig 7). However from observation most building-top apartments appear to fall into one of two visual types. Type one are those that are in contrast with the host building generally of a contemporary pragmatic form or individualistic. Alternatively are those that attempt visual compatibility with the host through adaptation of elements (Fig 8, Fig 9, Fig 10).

Contemporary pragmatic building-top apartments appear to be mostly driven by market forces. While there have been some that sit atop multi ownership buildings many are the product of developer single ownership buildings using development air-rights. This type is usually strata-titled on completion for sale (Fig 4, Fig 6).

As with any building project typically the developer or building owner investigates the economic feasibility for the design and city authorities test the proposal against regulations. However to date no examples have been identified where either developer or authority have investigated the sustainability impact for the project let alone the collective potential impact of this typology for the whole city. If individual projects were more closely studied within sustainability informed city-wide vision then from the indicators explored in this paper it is suggested that there is a place for policy that encourages a new layer to be built on top of the city’s existing building stock.

An individual hypothetical example is discussed next and the collective impact for the City of Wellington, New Zealand follows.
APARTMENTS ON TOP IN CONTRAST WITH HOST BUILDING

Fig. 1. Paul Rudolph, *Penthouse Beekman Place*, New York, 1977. The architects personal laboratory for ideas.

Fig. 2. Tonkin Liu & Richard Rogers, Shoreditch, London, 2007. Contemporary pragmatic contrasting form.

Fig. 3. MVRDV: *Didden Village*, Rotterdam, 2007. An individualistic eccentric addition within a conservative urban area.

Fig. 4. Anonymous Apartments 36 Av Marceau, Paris. Pragmatically driven design in contrast with the host building.

Fig. 5. Korteknie Stuhlmacher Architecten, *Parasite*, Rotterdam 2001. Experimental eccentricity attached to a lift tower.


APARTMENTS ON TOP COMPATIBLE WITH HOST BUILDING

Fig 8 Wellington. Contemporary form but compatible with host

Fig 9. Wellington. Contemporary form but compatible with host.

Fig 10. Wellington. Addition compatible with host
HYPOTHETICAL EXAMPLE

The following hypothetical example explores quantifiable aspects of sustainability pertaining to new apartments on top of an existing building. Many design initiatives, technologies, construction methods and materials selection can be incorporated in a building design to significantly contribute to sustainability however the focus here is not on such measures but rather on the typology in a broad context. The example consists of six building-top apartments on three levels sitting on a three-level existing reinforced concrete and brick base building which is 32m long x 16m wide x 13m high. Ground floor is designated retail use with the two existing floors above used for offices (fig 11).

SITE DEVELOPMENT

There are three main development approaches with indicative costs for each as follows in Fig 12.

Demolish existing and build anew
Complete demolition is generally the only feasible option where a building is well below structural performance requirement for additional floors on top or where its functional adaptability renders it redundant. Premium land value and development potential may also encourage demolition.

Build on top and continue use of existing
A building can be retained as a ‘foundation’ or base for additions on top provided there is structural capacity and available air-space above the roof within the planning regulations. A financial advantage of this approach is that the base building remains available for continued use.

Build on top and renovate existing
Renovation of the existing building as well as building on top can re-position the marketability of the total building better through enabling an income stream throughout the project by staging the renovations and new work.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Site demolition +clearance</th>
<th>Reconstruct base building</th>
<th>Renovate existing building</th>
<th>Construct new rooftop addition</th>
<th>Total estimated cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 storeys, medium quality, rate based on rates incl lifts HVAC + fire protection</td>
<td>3 storeys, basic standard including new HVAC</td>
<td>3 storeys, medium quality, rates based on multiple units, (greater than 3 storeys)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Area 512 (x3) m$^3$ 1536 m$^2$ 1536 m$^2$ 1152 m$^2$

Rate (Gidden,2008) $70.00 /m$^3$ * $145 for foundations $2400.00/ m for remainder $700.00 / m$^2$ $2600.00 / m^2$

Completely new $107,000$ $3,770,000$ N/A $3,000,000$ $6,877,000$

Build on top & no renovation N/A N/A N/A $3,000,000$ $3,000,000$

Build on top and renovate N/A N/A $1,075,000$ $3,000,000$ $4,075,000$

Fig.12. Indicative development costs (after Holden and Gjerde, 2007)

* Square metre floor plan area approximates for cubic metre volume of demolition waste.

LIFE CYCLE ASSESSMENT

While recognising that building material extraction, manufacture and transport takes time, by far the longest phase in the life cycle of a building is the period of occupation. Costs associated with occupation include maintenance as well as energy consumed. Unfortunately, many buildings have been demolished without giving adequate consideration to options including renovation wherein most of the building is retained, or de-construction, where building components are salvaged.

COST OF DEMOLITION

Demolition where none of the materials are salvaged causes dust, noise, vehicle movements and disturbance in the immediate area. This carries a loss of amenity which is difficult to quantify. Demolition costs that can be quantified are shown in Fig 12. This assessment is based on the likely volume of waste material that would be generated and transported from site in the demolition process.

COST OF FOOTINGS AND FOUNDATIONS

Complete demolition of the host building, removal of waste and construction of a new foundation amounts to approximately $181,000.00 (512m2 x $145/m2 + $107,000). This could represent a cost saving if the building is retained plus approximately 4-6 weeks of construction time. Consequently it can be argued that retention of the host building, where it is structurally viable, can improve the financial sustainability of a development project that just builds apartments on top. An approximate 6% saving is available through avoiding the direct cost of demolition and of new foundations.

LANDFILL and CONSTRUCTION AND DEMOLITION WASTE

Construction and demolition waste comprises a significant amount of the waste that goes to landfills, estimated at 17% although this would be higher when private landfill is counted. The New Zealand Waste Strategy declares that reducing waste is a cornerstone of the Government’s commitment to sustainable development (Ministry for the Environment, 2002). It can be argued that any project that reduces the quantity of waste going to landfill would be seen to improve national sustainability objectives.
EMBODIED ENERGY AND CO₂ EMISSIONS

Embodied energy is used as a de-facto measure to assess environmental impact of human activity (Alcorn 2003). Embodied energy is the energy consumed in all activities necessary to establish a building, including direct and indirect energy. Direct energy includes that required to assemble the building while indirect energy includes energy embodied in the materials and products brought in from off-site (Alcorn 1998, 2003). Quantifying the energy embodied in any building project is very complex and the variables can be almost limitless. Embodied energy figures are sensitive to location of the project, mainly due to the energy required for transport of materials and workers to and from the site. A project that includes many imported products can have a considerably higher embodied energy than a similar one employing locally produced materials. Another significant factor is the source of energy. The following table shows the embodied energy for the hypothetical example, based on Treloar data (2001).

<table>
<thead>
<tr>
<th>Building area (M²)</th>
<th>Embodied energy (GJ/M²)</th>
<th>Total embodied energy(GJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1536</td>
<td>10.7</td>
<td>16,435</td>
</tr>
</tbody>
</table>

Fig. 13. Energy embodied in the host building

Alcorn (2003) identifies a direct correlation between embodied energy and CO₂ emissions although no explicit data is yet available. This link is also implied in the ‘Green Star’ rating system that awards credit points for retention of structure to reduce material consumption (Green Building Council of Australia, 2005). It can be confidently concluded that a significant volume of greenhouse gas will be avoided with any strategy to reuse an existing building rather than demolish.

OVERALL POTENTIAL

Compared with demolishing and building anew, to renovate the existing hypothetical case-study building and build new apartments on top represents a potential cost saving of $2,802,000 or 40% of the outlay. This could only be potentially off-set through attracting higher rental or higher sales for new premises compared with renovated ones. Sustainability improvements derived from landfill, materials and embodied energy savings, with consequential reduced CO₂ emissions, additionally contribute to this typology’s higher economic performance and sustainability than conventional redevelopment.

WELLINGTON’S CONTEXT

The economic viability of many older buildings in Wellington was undermined during the 1970’s to 1980’s due to national economic restructuring and relocating businesses. Numerous older buildings were left un-occupied with deteriorating fabric. At the time the city was strictly planned into permitted and prohibited land use zones and there were very few residential inhabitants in the city. A revised regulatory environment and philosophical shifts in the approach to city planning during the late 1980’s and early 1990’s helped to set the scene for rejuvenation of the city. Although unanticipated by the changes that were taking place, conditions were set for the commencement of the phenomenon of apartments being built on top of existing buildings.

Wellington’s early 1990’s plan restrained physical growth by re-zoning land on the perimeter from future urban to rural, thereby restricting expansion at the edges. This encouraged developers to look for opportunities within the existing city. City buildings were required to be earthquake strengthened and many were given an extended life
through assistance funding for reinforcement. A new district plan created the potential for development in the air space above most buildings to a datum height and the plan encouraged multiple uses of buildings and sites. At about the same time a new national performance-based building code was introduced permitting light-weight construction, including timber-framing, for apartment buildings, provided fire prevention measures were incorporated. Global economic difficulties at the time encouraged many New Zealanders to return from overseas and with their urban-living experiences they, together with immigrants from urban cultures, contributed to creating a demand for living in the city (Murray, 1998).

Together these circumstances contributed to a climate where new construction on top of existing buildings became profitable for developers and attractive to buyers. Over one hundred projects have been completed to date (Holden & Gjerde, 2007).

**WELLINGTON BUILDING-TOP APARTMENTS**

Building-top apartment examples in Wellington range from a single apartment on three levels, named the ‘sky-box’ (Fig. 1). The largest complex is a group of thirty apartments on top of a two level 1970’s service and retail building. Most of the examples fall within the range from six to eight apartments, what may be classified as medium-density residential development. Host buildings range from single storey to medium-rise buildings of eight floors while most are from two to four floors. The host buildings tend to be redundant offices, retail and warehouse buildings that have been renovated for on-going productive use. Many have retail and service activities at street level with offices above and with the upper floors converted into apartments, then with the new apartments on top. Some of the base buildings are heritage listed and this coupled with district controls can influence the design character of additions on top. Configuration and character of apartments on top varies considerably and may be influenced by site conditions, adjoining buildings and activities and the design approach taken.

**WELLINGTON BUILDING-TOP APARTMENTS**

Fig. 1. Gerald Melling: Sky-Box, 2000. A single apartment above a warehouse converted for office use.

Fig. 2. Architecture Workshop: Blair Apartments 2001. 3 apartments on top of offices & retail.

Fig 4. Three building-top apartments on Egmont St, TeAro, Wellington

INFRASTRUCTURE and CITY EXPANSION

By constraining growth at the edge of the city and by encouraging intensification in the centre Wellington is creating circumstances that are conducive to improved performance of the transport and services infrastructure. City centre dwellers utilise public transport less and they have fewer vehicles than for the rest of Wellington (Wellington City Council 2009). Generally water supply, effluent system, gas and electricity supply were designed many decades earlier for up to double the current residential household occupancy levels resulting in surplus capacity in the city centre.

CULTURAL HERITAGE

Building on top may generate less disruption to adjoining sites and to the urban fabric of the neighbourhood. By building on top the sense of place and built environment heritage of the immediate area is largely maintained at street level through the retained building, though the presence of new construction on top is likely to be obvious.

SOCIAL and CULTURAL ENHANCEMENT

Wellington has very high growth in the number of people living in the central area compared with the city as a whole. Between the 1991 and 2006 census Wellington’s population grew about 9% overall compared with about 2000% in the central area to over 12,000 (Wellington City Council 2009). This central area population live in purpose built apartment buildings as well as in converted buildings, including an estimated 17% in building-top apartments.

City centre residents create a demand for mixed use services and activities that previously did not exist or were under-provided and this has generated improved economy and a high level of vitality. All central city functions for work, entertainment, shopping and commerce are comfortably accessible for pedestrians. Wellington as a whole has the highest percentage across Australasian cities of workers who walk to and from work at approximately 19% (Statistics New Zealand 2008). Of central city residents approximately 73% walk to work (Wellington City Council 2009). Increased pedestrian activity in the centre has prompted city authorities to improve the quality of urban environments through re-designing and building new and better pedestrian areas and parks, which in turn contribute to cultural enhancement for the whole city.

Another aspect of having an increased residential population in the city centre is the contribution this makes to reduction in crime and to a greater sense of personal security. International literature reveals significant linkage between intensive mixed land use and reduced crime and an increased sense of personal security (Petersen, 1998; Research Solutions, 2001). Of relevance is that having more ‘eyes on the street’ over longer periods provides ‘natural’ surveillance that contributes to greater safety.

PUBLIC HEALTH

It is speculated that the health of city-centre residents compared with the general population is likely to improve above national standards through greater pedestrian generated physical exercise, with positive implications on public health costs (McIndoe etal, 2005; Litman, 2003). Woodward (2002) observes that for Australia and New Zealand “perhaps the most serious public health implication of car-dependent societies is the unprecedented level of sedentariness that this lifestyle encourages”. Woodward discusses the implications of declining physical activity including increased bodyweight leading to higher risks of cardiovascular disease and diabetes and also links between inadequate physical activity and certain cancers. Sedentary behaviour is linked to a projected 25% increase in deaths from Type 2 or lifestyle diabetes (World Health Organisation, 2005).
It is not suggested that building-top apartments alone are likely to make a highly significant improvement to public health but rather that through accommodating additional city residents most of whom walk rather than use energy consuming transport, they make a contribution to sustainability that is worth encouraging.

OVERALL POTENTIAL

The Wellington city area of TeAro is highly conducive to building-top apartment development opportunities and most of the city’s examples of building-top apartments are located here. TeAro is approximately 1000m x 800m in size and by extrapolating from a two block analysis of the land area, approximately 75% is considered to either have existing buildings or be available for building, the remainder accommodates roads, footpaths, parks and other public spaces. Approximately 5% of the buildings are evaluated by visual survey as capable of supporting additions on top with minimal strengthening required provided the additions are of light-weight construction and of two or three floors. This approximates to 900 apartments and with an occupancy average of 2.2 people per apartment (the average for Wellington City apartments) about 2000 additional people can be accommodated in TeAro. A further approximately 2000 additional people are estimated to be able to be accommodated in the remainder of the Wellington central area.

Overall approximately 4000 additional people could be accommodated in central Wellington at lower cost and more economically, socially and environmentally sustainable than through conventional development processes of demolish and build anew.

CONCLUSION

The hypothetical case study and the Wellington example show that even without accounting for individual building sustainable-design detail solutions, building on top of the existing is a strategy that the brings sustainability benefits compared with conventional demolished-site redevelopment.

This paper raises matters that obviously require further research and investigation both in broad terms and explicitly for individual cities. However there are clear indicators that building-top apartments contribute to city sustainability; specifically in terms of having less impact on the environment embracing, waste, life-cycle cost and embodied energy; while they also contribute to better economic performance of higher density residential development and to a city’s social and cultural endeavours.

Wellington’s building-top apartment phenomenon is largely accidental, the outcome of developers with their architects ceasing on opportunities to generate higher economic returns than by demolish and build anew process. Studying the phenomenon has teased out several factors beyond economic returns that if included in city planning and policy development will predictably contribute to cities performing more sustainably.

The challenge for any city is a shared one across city authorities, developers and design professionals, to identify the opportunities and constraints that pertain to the particular place. This can lead to quantifying the sustainability benefits that constructing new apartments on top of existing buildings may bring. Leadership by city authorities is needed to initiate progress.
REFERENCES


