

# Urban Sustainability: Comparative Value of Building-Top Apartments

Gordon Holden, Morten Gjerde\*

Victoria University of Wellington, New Zealand

## ABSTRACT

This paper discusses the ecological performance of constructing new apartments on top of existing buildings. The emerging architectural typology of 'building-top apartments' in Wellington is discussed as a more 'sustainable' solution to urban apartments compared with conventional 'demolished-site' development.

Apartments built on top of existing buildings are a typology that averts demolishing the host building thereby avoiding waste and improving life-cycle performance. It can be built more economically because it does not require excavation and footings. It contributes to urban population intensification thereby supporting city social and cultural vitality and economic development. It accommodates many people who walk to work thereby reducing motor vehicle congestion and pollution as well as potentially contributing to public health through better fitness. It supports higher numbers of people in the city as casual observers and thereby potentially contributes to reduction in crime. By accommodating a significant proportion of the city's population growth building-top apartments comparatively help reduce land subdivision on the city's boundaries which consume energy and resources at a higher rate.

Wellington has an emerging urban architectural typology that can be shown to be contributing to city sustainability in terms of having less impact on the environment than conventional development while also contributing to better economic performance and to social and cultural endeavours. The paper scopes across a range of matters while focusing on building sustainability, specifically site development, life cycle assessment, cost of demolition, cost of footings and foundations, construction waste and embodied energy and CO2 emissions.

Building-top apartments in Wellington are a breeding ground for new ideas and are seen as an important vehicle for city renewal with lessons that may be transferable to other cities.

**Key words:** building-top apartment typology; comparative urban sustainability.

## **COMPARATIVE ANALYSIS IN ECOLOGICAL PERFORMANCE**

Characterisation of the meaning of sustainable design is vexing there being no commonly agreed definition currently available (Gann, 2003). Notwithstanding this there are many endeavours driven by both governments and by industry to give guidance to improving the ecological performance of buildings, prominent amongst which are rating systems. Environmental performance criteria scoping across user needs, embodied energy and energy use, life cycle costs, waste minimisation, CO<sub>2</sub> emissions and construction materials and methods that are widely understood has been established. The calculation methods for these criteria are largely agreed and now they are arguably the most visible aspect of appreciating and informing sustainable design (Green Building Council of Australia, 2005; Leadership in Energy and Environmental Design, 2005).

Most sustainable design rating systems are conceptually underpinned by comparative analysis within each of the criteria mentioned above. Typically designing decisions can be made about materials, construction methods and environmental and energy performance at conceptual and developmental phases. The data used to inform decisions, while independently related to the element under discussion, is understood comparatively with alternatives generally located in a value scale from better to worse. Alternative solutions for both proposed and existing buildings can be evaluated comparatively. Decisions about the final design inevitably are influenced by relative analysis that compares alternatives. Ideally over time through comparative analysis being adopted as a communication tool, users, clients, regulators and the public at large will change their values to appreciate both immediate and long term advantages of improved ecological performance of buildings.

This paper adopts and adapts the idea of comparative analysis when evaluating apartments built on top of existing buildings. Building-top apartments are presented as more sustainable solutions for apartment buildings than the common city re-building process of new construction on demolished sites.

## **PHENOMENON of BUILDING-TOP APARTMENTS**

New Zealand's capital city Wellington is experiencing an unusual building phenomenon which when studied shows evidence of a contribution to city sustainability that is worthy of note. Apartments are being constructed on the top of established buildings and because of the increasing number of examples, over seventy to date, there is a sense that a new layer is adding to the city's already distinctive character. Compared with the conventional redevelopment cycle of demolition and building anew, constructing on top of existing buildings is shown to be more sustainable in terms of building construction. This new layer is also contributing to greater liveability and vibrancy as well as adding other desirable attributes to the city. It is suggested that there are potentially transferable lessons for other cities of the world from studying this emerging typology. Holden, 2003 presents a case for building-top apartments to be considered an emerging typology.

Wellington, as with other New Zealand cities, underwent a strong building phase from the early 1970's until the global economic 'collapse' in the late 1980's. During this period demolition of older building stock prevailed leaving many sites vacant in anticipation of new development potential encouraged by

artificially high land values. The economic viability of many older buildings was undermined and numerous of them were left un-occupied with deteriorating fabric. At the time the city was strictly planned into permitted and prohibited land use zones. Also during this period many businesses relocated out of Wellington thereby reducing the pool of tenants and owners. Several areas of Wellington, especially the south low-city area of Te Aro became ghost-town like with very few residential inhabitants and many vacant buildings and bare sites.

National and regional economic restructuring in the late 1980's and early 1990's coupled with a revised regulatory environment and philosophical shifts in the approach to city planning 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.

A Wellington city plan was established in the early 1990's that contained the city's growth by re-zoning land on the perimeter from future urban to rural, thereby restricting growth at the edges. City buildings were required to be strengthened for earthquake conditions 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 a similar time a new national performance-based building code was introduced permitting light-weight, including timber-frame, construction for apartment buildings. Also global economic difficulties 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. Together these circumstances contributed to a climate where new construction on top of existing buildings became profitable for developers (Holden, 2004).

## **SCOPE of BUILDING-TOP APARTMENTS**

As mentioned, there are over seventy examples of new apartments built on top of existing buildings in Wellington city. Most of these are within about 1.5 square kilometres in the South-City area of Te Aro essentially within about ten minutes walk of each other.

The examples range from a single apartment on three levels, named the 'sky-box' (Fig. 1), designed and lived-in by architect Gerald Melling and perched over the top of an old brick warehouse that is used as an office. The largest complex is a group of thirty apartments called 'Galleria' (Fig. 2) designed by the firm 'Archaus' on top of a two level 1970's service and retail building. While there are a few other large complexes, for example the twenty six apartments on top in 'The Lofts' (Fig. 3) by Perry Architects, most of the examples fall within the range from four to eight apartments. Four hundred and twenty six individual apartments on top of buildings have been identified across seventy six examples, giving an average of 5.6 apartments per complex.

The host buildings range from that of a single storey to a medium-rise building 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. The configuration and character of apartments on top varies considerably influenced by site conditions, adjoining buildings and activities and the design approach taken.

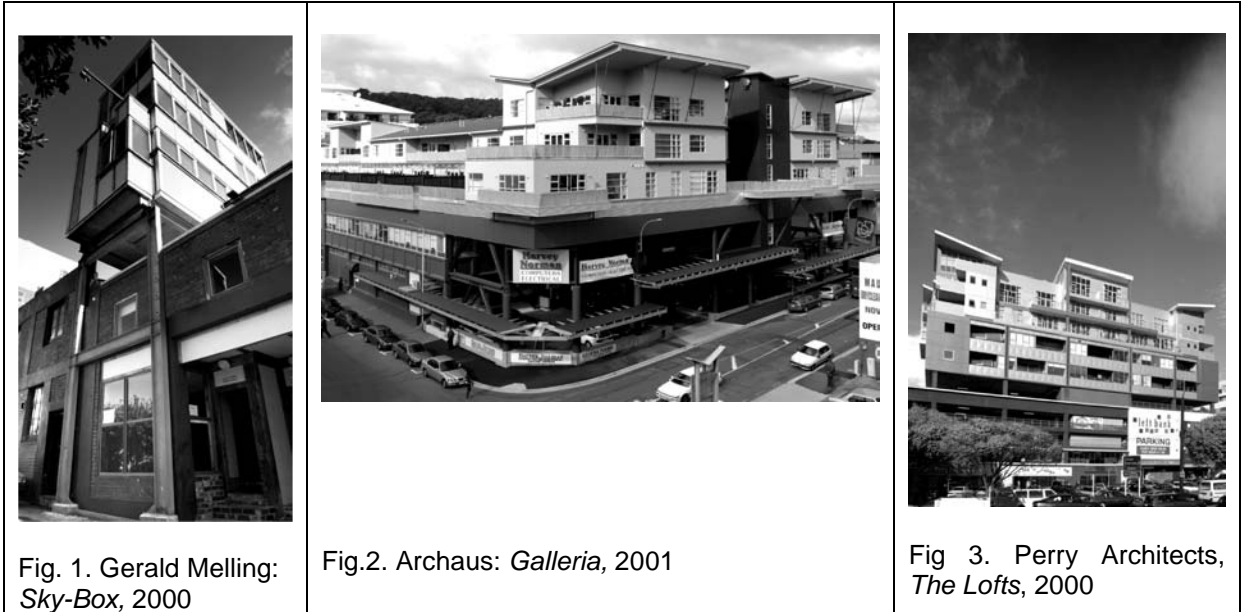


Fig. 1. Gerald Melling: *Sky-Box*, 2000

Fig.2. Archaus: *Galleria*, 2001

Fig 3. Perry Architects, *The Lofts*, 2000

## HYPOTHETICAL CASE STUDY

In order to explore sustainability aspects a hypothetical case-study has been sketched that adopts characteristics that may be regarded as typical in Wellington. In this hypothetical case the base building is about eighty years old of three storeys height. It is 13m high of brick and reinforced concrete construction with a long side of 32m on a street frontage and a short side of 16m. The six apartments on top are across three floors totalling 7.5m height in all, set a little back from the long side street side and set back from the other long side sufficiently to provide stair and lift access, giving a width for the top of 12m. The hypothetical case proposes ground floor retail use with the two existing floors above used for offices. This hypothetical case is used for the calculations and discussion that follows.

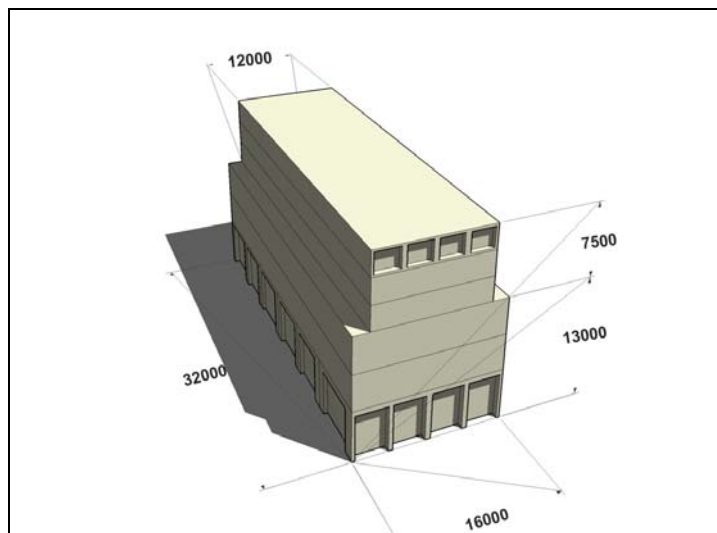


Fig. 4. Hypothetical case study building

## **SITE DEVELOPMENT OPTIONS**

In the hypothetical case we first consider site (re)development. Generally a site development strategy is adopted that aims to provide the developer with the best financial return on investment. In respect of a site that contains a building that has additional development potential, the owner has three main approaches to select from.

### **Completely new**

This strategy requires that the existing building be removed from the site before a new building can be constructed. Complete demolition is the most common manner by which buildings are removed, although other methods employed less frequently are the complete relocation or sequential demolition allowing for recovery of building elements for recycling. Complete demolition is often the only feasible option where a building is substantially below the required structural performance requirement and the cost/effort to upgrade is deemed excessively high in relation to potential economic returns. Demolition is often undertaken to minimise risk, both during the construction phase and after, where the financial returns from an older building may be less certain.

### **Build on top**

In structural terms a building can be retained as a 'foundation' or base for an addition on top provided there is structural capacity and available air-space above the roof within the planning regulations. The straight rooftop addition represents the minimum intervention on the site, depending on access arrangements during the project. A significant financial advantage of this approach, regardless of how the building is owned, is that the base building remains available for use, helping to ease the financial burden of redevelopment.

### **Build on top and renovate existing**

A rooftop addition project can also present the developer with an opportunity to renovate and refit the existing building. Interventions may be necessary in the existing building to upgrade structural or services systems and this could be a catalyst for renovation and upgrading. Coordination of building work in the existing and for the rooftop addition may allow for efficiencies that would reflect in a lower overall cost than if the two projects were undertaken separately. The refit and renovation work is often staged to enable existing tenants / owners to remain in the building throughout or to relocate for short periods. Where renovation is well planned it can enable an income stream throughout the project and for commercial tenancies continuity of serviced is important to avoid losing customers.

Indicative costs associated with developing the site following each of the three scenarios listed above in relation to the hypothetical case study shown in Figure 4 are set out below in Figure 5.

Activity	Site demolition +clearance	Reconstruct Base	Renovate existing building	Construct new rooftop addition	Total estimated cost
		3 storeys, medium quality, rate based on 'high rise' rates include lifts, HVAC + fireprotection	3 storeys, basic standard including new HVAC	3 storeys, medium quality, rates based on multiple units, high rise (greater than 3 storeys)	
<b>Area</b>	512 (x 3) m <sup>3</sup>	1536 m <sup>2</sup>	1536 m <sup>2</sup>	1152 m <sup>2</sup>	
<b>Rate (Gidden,2004)</b>	\$53.00 /m <sup>3</sup>	1925.00 / m <sup>2</sup>	*385.00 / m <sup>2</sup>	1850.00 / m <sup>2</sup>	
<b>Completely new</b>	\$81,000	\$3,000,000	N/A	\$2,100,000	\$5,100,000
<b>Build on top</b>	N/A	N/A	N/A	\$2,100,000	\$2,100,000
<b>Build on top and renovate</b>	N/A	N/A	\$590,000	\$2,100,000	\$2,690,000

Fig. 5. Indicative costs for site development

\*While this figure is drawn from the standard data it is recognised that the degree of renovation would affect the cost.

## LIFE CYCLE ASSESSMENT

Evaluation of sustainable development practices must take an holistic view (Kibert, 2005). Such a view considers the full life cycle of the investment represented by a building development. The period considered therefore includes the construction phase, incorporating the extraction of materials, their refinement and change into building materials, transport to the prefabrication factory and eventual delivery to the building site. An analysis would also reference all activity necessary to assemble the building on site. The longest phase in the life cycle of a building is the period of occupation and use. Costs associated with this phase include maintenance, both planned and extraordinary as well as easily the most significant cost in the entire life of a building, energy consumed. Once a building ceases to be economically or functionally viable decisions are needed regarding renovation or disposal. Unfortunately, many buildings have been demolished without giving adequate consideration to the options which include complete renovation, perhaps for a new use, or de-construction, where building components are salvaged.

## COST OF DEMOLITION

An existing building represents an asset in terms of enabling the rooftop addition but if the building is to be removed prior to full site redevelopment it must be seen as a financial liability. Removing the building would consume financial and time resources of the redevelopment project, both of which must be taken into account by investors. Disruption to the surrounding areas from the demolition activity is generally considerable yet often not adequately considered by developers. Demolition as it is carried out where none of the materials are to be salvaged causes dust, noise, vehicle movements and what could only be described as chaos in the area immediately surrounding the site. This carries an associated cost, as a loss of amenity value, and which is difficult

to quantify. Demolition costs that can be quantified are shown in Figure 5. This assessment is based on the likely volume of waste material that would be generated and transported from site in the demolition process. It would not allow for any salvage operations, which would extend the likely two week period of demolition based on recent observations of demolition processes in the Wellington area.

## **COST OF FOOTINGS AND FOUNDATIONS**

At the most basic level of consideration, the host building provides a foundation base on which the new rooftop addition can be built. The value of existing foundations can also be calculated and compared using the case study example and cost information from the Rawlinson's Handbook (Giddens, 2004), see figure 6.

It can be seen that the complete demolition of the host building and establishment of a foundation system to suit the volume of the case study example of the three storey 'roof top addition' placed on the cleared site would incur a direct cost of some \$125,000.00 (demolish cost plus footings cost) This represents a potential savings of approximately 6% of the estimated construction cost for the addition of \$2,100,000.00 (estimate of the case study example using figures presented in Giddens, 2004) as well as more than 4 weeks of construction time. It can therefore be argued that retention of the host building, where it is structurally viable, can improve the financial sustainability of a development project by avoiding the direct cost of demolition and of a new foundation system. The potential saving of 4 to 6 weeks where these activities are not undertaken can also improve the financial viability of such a project.

<b>Item</b>	<b>Area</b>	<b>Rate</b>	<b>Total</b>
<b>site clearance</b>	384	\$ 3.45	\$ 1,324.80
<b>substructure</b>	384	\$ 112.50	\$43,200.00
<b>total</b>			<b>\$44,524.80</b>

Source: (Giddens, 2004)

Fig. 6. Costs for Foundations

## **CONSTRUCTION AND DEMOLITION WASTE**

Construction and demolition (C&D) waste comprises a significant amount of the waste that goes to landfills in New Zealand each year. Storey, et.al. (2005) argues that the actual volume is much greater than the 17 % figure that is most often quoted on the basis that much of the C&D waste goes to private or illegal landfills. The New Zealand Waste Strategy declares in its opening paragraph that reducing waste is a cornerstone of government's commitment to sustainable development (Ministry for the Environment, 2002). Without citing figures, the document goes on to suggest that construction and demolition waste is a greater problem than it needs to be and so, after requiring that the amount of C&D waste is quantified by weight by the end of 2005, that the current amount is reduced by 50% by the end of 2008. It can therefore be argued that any project that reduces the quantity of waste going to landfill would be seen to improve the sustainability outcomes.

Rooftop apartment additions adopt the development strategy of retaining and reusing or refitting the host building for further use. It is possible to speculate on

the quantity of waste from the demolition that would have occurred if the building were razed completely in favour of a completely new building (Figure 7)

Building area (M <sup>2</sup> )	Rate of Solid Waste generated (m <sup>3</sup> /m <sup>2</sup> ) [k]	Total demolition waste (m <sup>3</sup> )
1536	1	1536

Fig. 7. Demolition Waste

The unit of measure cited in this table is different – volume – to the figures referred to in the waste strategy and it is arguably the more relevant unit of measure. Figure 7 sets, quantifies and places into perspective the amount of C&D waste that can be prevented going to landfill – because it isn't being generated. The average 8 wheel truck used in demolition operations can transport 10 m<sup>3</sup> of waste, therefore the saving in waste by retaining the use of this three storey building represents about 150 truckloads.

Another 'reduction' of waste generation comes through not having to reconstruct a building of similar proportions to the one taken away. There is no reliable data to suggest an average waste generation of the type of building that would be constructed to replace the demolished structure, however it is clear that this too would be a saving over normal practice as the waste isn't being generated in the first place. The reuse and addition strategy clearly represents a win-win situation in terms of C&D waste generation.

## EMBODIED ENERGY AND CO<sub>2</sub> EMISSIONS

Embodied energy has been used as a defacto scale to assess environmental impact of human activity (Alcorn 2003). In the context of this paper, embodied energy is the energy consumed in all activities necessary to establish a building on site and includes the direct and indirect energy components. The direct energy includes that required to assemble the building while the indirect energy includes the 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 because of the energy required for transport of materials and workers to and from the site. For this reason a project in New Zealand that includes many imported products can have a considerably higher embodied energy than a similar one employing locally produced materials. Another significant factor is source of the energy.

Alcorn (1998) has published embodied energy values for an extensive list of New Zealand building materials and any detailed analysis of the energy bound up in a building should use those figures. The scope of this study has not allowed a detailed analysis, nor is it warranted as the researchers have set out to identify a wide range of sustainability indicators for a typical rooftop addition project in Wellington. Further in depth studies will enable examination of embodied energy values in more detail. To enable a high level comparison, it is considered appropriate to use the values published by Treloar (2001) for office buildings in Melbourne, Australia. Treloar identified that taller buildings embody a higher energy value per m<sup>2</sup>, which he attributed to greater structural demand. It could therefore be assumed that the values for all building types would be



proportionally higher in New Zealand due to seismic design requirements. Figure 8 sets out the relative values per m<sup>2</sup> for office buildings of varying height and Figure 9 quantifies the energy embodied in the case study building.

Building height	3 Storeys	7 Storeys	15 Storeys	42 Storeys
Embodied Energy GJ/M <sup>2</sup>	10.7	11.9	16.1	18.0
Source: Treloar (2001)				

Fig. 8. Relative embodied energy values for different height buildings

Building area (M <sup>2</sup> )	Embodied Energy (GJ/M <sup>2</sup> )	Total embodied energy (GJ)
1536	10.7	16,435

Fig. 9. Energy embodied in the host building

This brief analysis of the energy embodied in the case study building reveals that the decision to reuse and redevelop a three storey building would result in a saving of 16,435 GJ of energy. Converting this figure to more commonly understood terms reveals that the energy embodied in this case study building is in the order of 4.57 x 10<sup>6</sup>kWh.

Significant environmental impact is caused by CO<sub>2</sub> emissions. Research has identified CO<sub>2</sub> as a principal greenhouse gas, one which New Zealand plans to reduce emissions of as part of its obligations, having ratified the 1997 Kyoto Protocol. Alcorn (2003) identifies a direct correlation between embodied energy and CO<sub>2</sub> emissions establishing a link between CO<sub>2</sub> emissions and energy source. As noted earlier, the scope of this paper does not allow a detailed analysis of the embodied energy in the case study building, referring instead to rates established in relation to floor areas. Unfortunately no similar studies exist for CO<sub>2</sub> emissions, suggesting that evaluation is warranted. Based on an analysis of the embodied energy of the host building and in consideration of the link between embodied energy and CO<sub>2</sub> it can be concluded that a significant volume of greenhouse gas will be avoided with any strategy to reuse an existing building in connection with a rooftop apartment development.

In concluding this part of the paper that has focused on environmental and building matters it is noted that the Australian 'Green Star' rating system for Office Design v2 awards credit points for retaining the façade and structure of existing buildings during development as an encouragement to reduce new material consumption (Green Building Council of Australia, 2005).

## INFRASTRUCTURE and CITY EXPANSION

As well as the sustainability aspects that have been discussed in quantifiable terms above, by comparison with demolishing buildings to make way for new construction, creating new parts on top potentially improves the efficiency of existing city infrastructure and services. For example a study of urban intensification in Brisbane showed that the water supply and effluent system was designed many decades earlier for about double the residential household occupancy than is currently the case, thereby being able to accommodate

additional residences on the same system (Loder & Bayley, 1988). This is also the case with power and gas supplies.

Roads and transport infrastructure including train networks and their impact on residential intensification would be the subject of a separate study but it is confidently speculated that people living in building-top apartments together with those in renovated buildings and new buildings would contribute to greater efficiency and sustainability of systems (Newton, 2004).

By constraining growth at the edge of the city and encouraging intensification in the centre Wellington is creating circumstances that are conducive to improved performance of the infrastructure which in turn is leading to comparatively enhanced sustainability.

## **CULTURAL HERITAGE**

As previously mentioned, in some cases during construction on the top of existing buildings parts of the base building can remain occupied, thereby causing less disruption to existing building users than with vacant site new building construction. Building on top may also generate less disruption to adjoining sites and to the urban fabric of the general neighbourhood. By building on top the sense of place and built environment heritage of the immediate area is largely maintained at street level because of the retained building, though the presence of new construction on top is likely to be obvious. In heritage precincts, such as that of the Cuba Street area, new additions on top are required to be compatible with the host building and where possible set back from parapets thereby maintaining the visual integrity of the existing building as seen from the street. Design compatibility between the new additions and the existing building is attempted by many examples but few can be considered to be aesthetically successful. A very successful hidden building-top addition is 'Little Havana Street' on the third level of a Cuba Street building which leaves the casual pedestrian observer completely un-aware of its existence.

## **SOCIAL and CULTURAL ENHANCEMENT**

Wellington has experienced extremely high growth in the number of people living in the central area compared with the city as a whole. In the decade between census in 1991 and 2001 overall Wellington's population grew about 9% compare with about 700% in the central area of Te Aro to over 3000 (Statistics new Zealand, 2001). It is in this area that most of the building-top apartments exist. This population live in purpose built apartment buildings as well as in converted buildings and it is estimated that about one third live in building-top apartments. Altogether city residents create a demand for mixed use services and activities that previously did not exist and this has generated a high level of vitality at pedestrian level throughout the district.

All central city functions for work, entertainment, shopping and commerce are comfortably accessible for pedestrians and it is not surprising that Wellington has the highest percentage in Australasian cities of workers who walk to and from work (approximately 13% indicated by Statistics New Zealand). Increased pedestrian activity in the centre is sparking city authorities to improve the quality and connectivity of urban environments by re-designing and building new and better pedestrian areas, which in turn contributes to cultural enhancement.

Another aspect of having an increased residential population in the city centre, with accompanying mixed uses and improved public spaces, is the contribution this potentially 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; Space Syntax, 2001). Of relevance is that having more 'eyes on the street' over longer periods provides 'natural' surveillance that contributes to greater safety (Llewelyn-Davies, 2004).

It is worth noting that overall recorded crime offences in Wellington (per-capita) have fallen approximately 22% in the decade to 2006, compared with approximately 19% for the whole of New Zealand (Police National Headquarters, 2006). In the same period Wellington South - City centre experienced the greatest population growth percentage in New Zealand. The approximately 700% growth in South-City derived mostly from apartment dwellers and over one third of the dwellings are building-top apartments (Statistics New Zealand, 2001). While without detailed research a correlation between reduced crime and increased city dwelling cannot be authenticated, the early data suggests that further investigation may be fruitful.

## **PUBLIC HEALTH**

It is confidently 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 et al, 2005). Woodward (2002) observes that for Australia and New Zealand "disease attributable to traffic pollution may be at least as great as that caused by road accidents" and that "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 many of whom walk rather than use energy consuming transport, they make a contribution that is worth considering.

## **CONCLUSION**

Building-top apartments in Wellington may be regarded as something of an accidental development. While the regulatory relaxations and changed economic and social circumstances of the late 1980's and early 1990's can be seen as underpinning the initiation and expansion of the phenomenon, constructing-on-top of existing buildings was not explicitly envisaged as an outcome. Nevertheless we now have an innovative movement that overall is an important vehicle for urban renewal from which lessons can be learned, both as

to negative (mainly of a detailed design nature) and positive attributes (as discussed in this paper), that can possibly be transferred elsewhere.

This paper discusses the environmental, economic, social and cultural benefits of constructing apartments on top of existing buildings comparatively with demolishing the old and constructing the same volume of conventional building on a vacant site. It shows that building on top of the existing is a strategy that cities should encourage. This should at least be seen as a coping mechanism to constrain less sustainable building practice and one that reduces environmental impact compared with conventional demolished-site redevelopment. The strategy may be seen as being of an incremental-change nature moving toward a comparatively higher sustainability of the urban environment.

This pilot study implies the challenge of a further incremental change being that focused attention to ecological design principles is required in order to achieve higher performance. Within this focus the new construction on top of existing buildings could be required to be of very high sustainability standards ideally approaching six stars in the 'Green Building Council' rating system. An example of what is possible is suggested by the Robert L. Preger Intelligent Workplace (IW) project at Carnegie Mellon University. This is a building-top extension completed in 1997 to accommodate parts of the School of Architecture that operates as a laboratory to test performance of sustainable design systems in an integrated occupied setting (Hartkopf, 2005). If Wellington established building-top design guidelines that set high-rating sustainable design performance requirements then the city could proudly claim world leadership in innovative environmentally friendly urban development. The expert knowledge surrounding the city's achievements could be a highly prized export service.

While this paper raises matters that require further research and investigation it is concluded that Wellington's building-top apartments are contributing to city sustainability in terms of having less impact on the environment embracing waste, life-cycle cost and embodied energy, while also contributing to better economic performance and to social and cultural endeavours.

## REFERENCES

Alcorn A, (1998) *Embodied Energy Coefficients for NZ Building Materials (3<sup>d</sup> ed)*, Centre for Building Performance Research – Victoria University, Wellington.

Alcorn A, (2003) *Embodied Energy and CO<sub>2</sub> Coefficients for NZ Building Materials*, Centre for Building Performance Research – Victoria University, Wellington.

Criscillo, v., Tong, H. (1999) *Wellington City Apartments : The Survey*, Moore Warburton, Wellington.

Gann, D., (2003) *Trading Places – Sharing Knowledge about Environmental Building Techniques*, in, Cole, R., and Lorch, R., *Building, Culture and Environment*, Blackwell Publishing, Oxford.

Giddens C, ed. (2004) *Rawlinsons New Zealand Construction Handbook*, Rawlinsons Media Ltd., Auckland.

Green Building Council of Australia, (2005), *Green Star – Office Design Technical Manual*.

Gjerde M, (2003) *Thick Skin – The Performance of Concrete in Residential Construction in New Zealand*, Proceedings of the Concrete Institute of Australia Biennial Conference 2003, CIA, Brisbane.

Hartkopf, V., Archer, D., Loftness, V., (2005) *Building as Power Plant – BAPP*, in Yang, J., Brandon. P.S., Sidwell, A.C. eds, *Smart & Sustainable Built Environments*.

Holden, G., (2003) *Building-Top Apartments : an Emerging Typology*. The Planned City, Petruccioli, A. et al (eds), Uniongrafica Corcelli Editrice, Bari, pp135-140.

Holden, G., (2004) *Residential Palimpsest : A Novel Dimension to City Sustainability*, paper presented at Sustainable Cities conference, Siena.

Kibert C, *Sustainable Construction: Green Building Design and Delivery*, John Wiley and Sons, Hoboken New Jersey USA.

Leadership in Energy and Environmental design, (2005) *LEED for New Construction and Major Renovations*.

Litman, T. (2003) *Economic Value of Walkability*, Walk21-IV Conference, Portland, Oregon.

Llewelyn-Davies. (2004) *Safer Places: The planning system and crime prevention*. London, Office of Deputy Prime Minister and the Home Office.

McIndoe, G., et al, (2005) *The Value of Urban Design*, Ministry for the Environment, Wellington.

Ministry for the Environment, (2002) *The New Zealand Waste Strategy*, Ministry for the Environment, Wellington.

Murray, S.A., (1996) *The Demand for Inner City Apartments: A Case Study of Wellington*, New Zealand. Master of Arts, Victoria University of Wellington.

Newton, P. (2004) *Reshaping the Future of Cities*, in *Ecos*, Jan-Mar, 2004.

Petersen, D. (1988) *Smart Growth for City Centres*. In; Urban Land Institute, ULI on the Future Smart Growth: Economy, community, environment. Washington Urban Land Institute.

Police National Headquarters (2006) *New Zealand Crime Statistics*.

Research Solutions (2001) *Mixed Use Developments Perception Survey*. Auckland Auckland Council.

Statistics New Zealand, *2001 Census : Population and Dwellings Statistics : Territorial Authority and Area Unit by Census Usually Resident Population Count, 1991, 1996 and 2001; Territorial Authority and Area Unit by Private Occupied Dwellings, 1991, 1996, 200*, Statistics New Zealand, Wellington.

Storey J, Gjerde M, Charleson A, Petersen M, (2005) *The State of Deconstruction in New Zealand, in Deconstruction and Materials Reuse – an International Overview*, Chini A (ed.), CIB, International Council for Research and Innovation in Building Construction and University of Florida.

Treloar G, Fay R, Ilozor B, Love PED, (2001) *An Analysis of the Embodied Energy of Office Buildings by Height*, in *Facilities*, May/June 2001.

Wellington City Council, (1994) *Wellington City District Plan : Central Area Design Guide; Courtney Character Area Design Guide; Cuba Character Area*, Wellington City Council.

Woodward, A.J., (2002) *The motor car and public health : are we exhausting the environment?* in, *The Medical Journal of Australia*, Vol 177, No 11/12, pp592-593.

World Health Organisation, (2005) *Preventing Chronic Diseases: A Vital Investment*, World Health Organisation, Geneva.