

# Steel: the proven performer for a new Christchurch





The 12-storey HSBC Tower on the banks of the Avon River has been described as the safest multi-level building in Christchurch, having incurred no structural damage during the earthquakes. Reoccupation began just three months after the February 22<sup>nd</sup> earthquake and the building now features none other than CERA itself on its tenant directory.

## Introduction

**Historically, Christchurch's commercial buildings have been dominated by concrete construction. However, the recent earthquakes have decimated the city's building stock - CERA estimates that 1,200 of a total of 2,800 buildings in the CBD will eventually be demolished.**

Notably, heightened awareness of seismic performance and the significant scale of the rebuild will likely change the rules of construction that apply, both in Christchurch and nationally.

The new CBD will look different than it did before the earthquakes. Buildings will be built from different materials and using new construction methods that can meet the new seismic performance and commercial drivers of the rebuild.

Based on the proven seismic performance of steel buildings in the earthquakes, and its recognised speed of construction, structural steel has much to offer the reconstruction of Christchurch.

Steel: the proven performer for a new Christchurch aims to educate key players in Christchurch's building and construction industry about the benefits of structural steel solutions in the city's rebuild, particularly in relation to:

1. Technical merits: new low-damage, seismic-resisting technology
2. Commercial case: structural steel solutions for new builds are a good investment
3. Design vision: structural steel's potential in terms of architecture and design

Indeed, steel-framed buildings, on the whole, have performed very well in the

earthquakes. The two tallest examples in Christchurch, the 12-storey HSBC Tower and the 22-storey Pacific Tower, suffered only minor damage. This demonstrates both the resilience and economic value of steel-framed buildings – any damaged components can simply be removed and replaced, meaning tenants can be back in their buildings paying rent earlier than might otherwise be possible with buildings of alternative construction materials and methods.

The exemplary performance of these buildings is a credit to the expertise of the structural engineers involved, and to the quality workmanship of both local and national steel fabricators.

Importantly, speed and resources will be crucial elements of a successful rebuild – elements which the structural steel industry is well placed to address. Over the past decade the capacity of New Zealand's structural steel sector has doubled thanks to significant investment in new fabrication technology and workshops. This technology has increased not only productivity, but also the quality and precision of the fabricated product.

Moreover, prefabricated steel construction will make better use of the national capability of the construction sector, thereby reducing the pressure on Christchurch's local construction industry.

SCNZ, representing New Zealand's structural steel industry, looks forward to helping you play a part in rebuilding a new, resilient Christchurch.



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## Safety and seismic resilience - the technical case for structural steel

The Canterbury earthquakes have highlighted the importance of seismically-resilient building construction. Apart from several notable exceptions, buildings have generally met the Building Code's structural performance requirement for life safety. However, the cost of repairs and the time to regain building function have resulted in significant economic loss.

For the most part, steel buildings in Christchurch have performed well, with either minimal or no structural repairs required to return them to service. In this section we review this performance and present the latest developments in seismic-resisting systems.

### Steel's performance in Christchurch

Even though the shaking was significantly greater than the design level, steel buildings, on the whole, bore the earthquakes very well – they not only satisfied their life safety mandate, but were also back in service shortly after the earthquakes. Minor yielding did occur in most structures: there was some gypsum board damage, and some elevators needed to be realigned, but the buildings either continued to be used or were reoccupied following minor repair.

There were isolated examples of more significant damage, but these could be specifically traced back to poor detailing or construction, leading to compromised load paths. There were no examples of

unexpected poor behaviour from a detail or structural system. This performance is a tribute to the modern design of well-detailed steel structures. There were no deaths or major injuries reported from these buildings. (For an exemplary building, refer to the case study on page 16.)

Despite this good performance, however, the New Zealand steel industry is working to develop these solutions even further. It is exploring options to reduce significant damage to major steel members, or designing and detailing these members for rapid replacement. For example, the Heavy Engineering Research Association Structural Research Panel has been considering the possibility of designing all multi-level steel buildings as low-damage in the next decade.

are not expected to be large after an earthquake.

#### • 2008: New Zealand's first full low-damage building

The Victoria University Te Puni Village project featured a world-first rocking steel frame which used pre-stressed Ringfeder springs (figure 3). This spring detail, which allows the frames to dissipate seismic energy by controlled rocking, was used in conjunction with sliding hinge joints.

In 2009 the project won the prestigious Institute of Structural Engineers (UK) award in the Education and Healthcare category. The judges commented it was "a worthy project bringing true innovation in the field of seismic design and economy to what could have otherwise been a very expensive building". Please refer to the case study on page 14.

The secret to this behaviour is slotted holes in the bottom flange and the bottom row of the web plate connections that allow significant rotation of the beam end relative to the column face (figure 2). Fully tensioned bolts generate sufficient friction resistance to ensure the joint is rigid up to the design level earthquake actions. Once these are exceeded the slotted joints slide, allowing energy dissipation due to friction.

The joint is designed and detailed such that there is negligible damage to the frame or slabs. The joint has a similar cost to conventional construction.

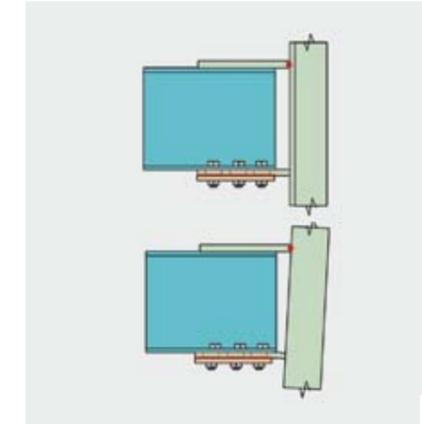
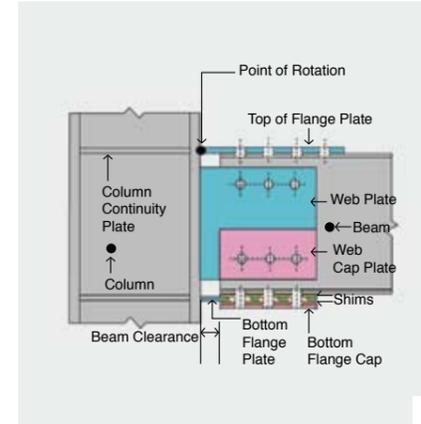
A feature of this type of connection is that it possesses a dynamic self-centring characteristic which means the permanent displacements of steel frames using this detail

### The development of structural steel seismic design in New Zealand

New Zealand structural steel design has been based on a combination of international design practice, particularly from the United States and Canada, and local research. This research was jointly funded by industry and government and focused on confirming the adequacy of existing design and fabrication practice, and also the development of new low-damage seismic-resisting systems.

Some key milestones in the development of local steel seismic design practice in New Zealand include:

- **2005: Sliding hinge joint**  
This joint can remain rigid under in-service conditions or ultimate state wind loading, and can rotate under severe earthquake loadings, returning to the rigid state when the severe earthquake stops (figure 1).



1 Sliding hinge joint detail  
2 Sliding hinge joint at rest and under loading  
3 Rocking frame holding down detail (photo courtesy of Aurecon)

### Why did multi-level steel structures perform better than expected?

Many people have asked why so many modern buildings were damaged beyond economic repair in the Canterbury earthquakes of 2010/11. In simple terms, the reasons are:

1. the prevailing design philosophy behind the Building Code, known as ductile design, emphasises the protection of life rather than damage avoidance;
2. the ground shaking in Christchurch on 22 February was significantly more severe than allowed for in the Building Code, and led to unprecedented soil liquefaction, lateral spreading and foundation failure.

This begs the question, why did steel structures perform better than buildings made of other materials? Steel researchers have proposed various explanations for this outcome, some of which are the subject of current research. The following are possible explanations:

1. **Technical robustness of seismic design provisions:** New Zealand design procedures take robust account of the overall building response and are conservative compared with many overseas' practices. The same applies for the connections between steel members. It means we have not had panel zone and connection failures in well-designed and detailed buildings because of the high damage threshold.
2. **Elastic stiffness and self-centring capability:** in seismic-resisting systems steel columns remain elastic, which assists in drift control and self-centring. The gravity system, where columns are spliced to remain continuous through the height of the building, provide an additional elastic stiffness and also assist with self-centring.

3. **Mechanical properties of steel:** steel has a clearly defined point at which the behaviour changes from elastic to damaged. With concrete, this change occurs at a relatively low level of loading and gradually gets more pronounced. This meant that most steel buildings only became inelastic in the February 22<sup>nd</sup> earthquake. They have not suffered continuing damage in the other events, unlike damaged concrete buildings.

4. **Excellent performance of composite floor systems:** these floors have proved to be very robust in fire (from the time of the Broadgate fire in London in 1991) and the earthquakes showed they are equally robust in severe shaking events. They imparted considerable extra strength and stiffness to the buildings and helped them to effectively return to their pre-earthquake position following the shaking. Initial results from research underway at the University of Auckland show that composite floor systems increase the stiffness of the building by a factor of at least two.

5. **Low-ductility:** the steel structures were designed for relatively low ductility (or yielding). This is because the sizing of frame members is often governed by wind or gravity loading, or the requirement to control seismic drifts.

### New developments: low-damage seismic-resisting systems

The high cost of building damage in Canterbury will drive widespread uptake of new low-damage seismic-resisting technology. These systems can withstand major earthquakes and require no major post-earthquake repair. What is required is a paradigm shift in building design philosophy. Ductility will always be a desirable attribute of modern building design, but this must be combined with new design methods that reduce the residual damage, even after the building has been subjected to large deformations.

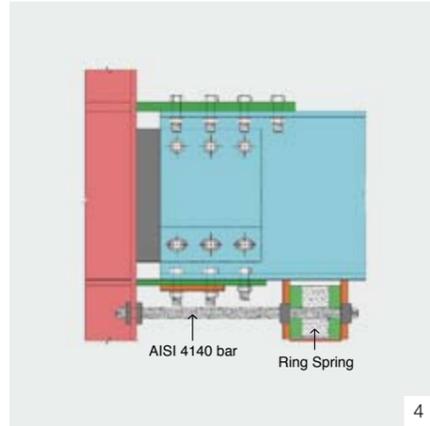
There are two alternative ways of designing buildings to avoid permanent damage in severe earthquakes:

1. **Base isolation** requires the building to be separated from the ground by isolation devices which can dissipate energy. This is proven technology but adds 8-10% to the total construction costs and is limited in terms of its applicability to building form. This solution is best suited to short, stiff, heavy buildings with low periods of vibration.
2. **Low-damage design** is developing rapidly, in several different forms. In steel buildings the principal low-damage solutions to date have utilised sliding friction connections and rocking braced frames. Current low-damage research in New Zealand has focused on refining and extending applications for existing low-damage steel seismic load-resisting technology.

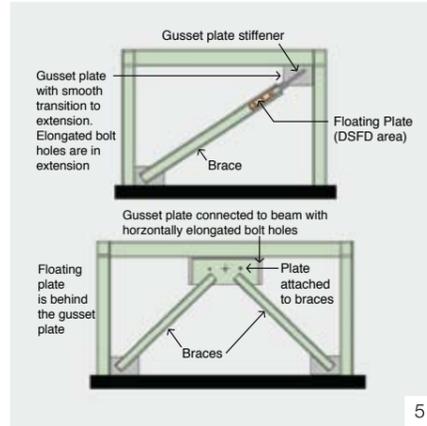
Since the original development of sliding hinge technology there has been a change in terminology: sliding connections are now known as asymmetric friction connections.

### Asymmetric friction connections

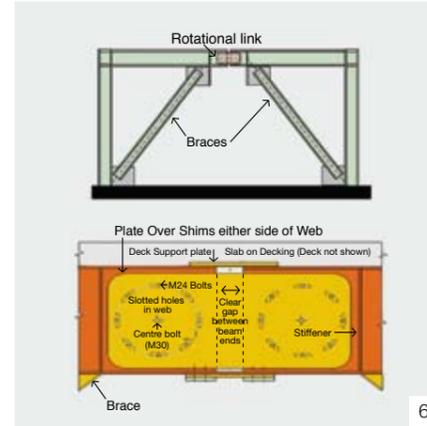
One refinement under consideration at the University of Auckland is the introduction of friction ring springs to the original sliding hinge joint to produce a true self-centring joint that restores the vertical alignment of the structure to post-construction tolerances at the end of the earthquake (figure 4). Studies on the durability aspects of sliding hinge technology are being undertaken by Associate Professor Greg MacRae at the University of Canterbury, where researchers are investigating corrosion lock-up and the performance of these types of joints at



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elevated temperatures in fire, as well as cold welding.

The extension of the asymmetric connections concept to concentrically braced frames is the brainchild of MacRae (figure 5). Examining the advantages that these systems have over ordinary buckling braces, buckling restrained braces, or eccentrically braced frames, he concluded that:

- there is no significant damage to the frame (except perhaps to some bolts that may require tightening or replacement)
- the system will have almost the same behaviour in both directions of loading
- the joints have significant post-elastic

stiffness which encourages re-centring of the structure after an earthquake

- the technology developed does not require patents for use

Researchers under Associate Professor Charles Clifton at the University of Auckland are also studying the use of rotational sliding hinge joint technology for low-damage eccentrically braced frames. These will use wear-resistant plates for the shear link between the two groups of bolts (figure 6).

Further research is also planned on the rocking frame system and on different low-damage connections at the column base.

Researchers are motivated by the possibility that these innovative structures could become standard designs that could not only save lives but also avoid severe economic damage to buildings. Notably, low-damage seismic-resisting technology does not come at a significant cost premium. In a recent project, the additional cost of applying low-damage systems in lieu of a conventional approach was just over 0.5% of the total building cost for the Victoria University Te Puni Village project.

To date over \$3 billion of steel building construction has been undertaken in New Zealand featuring low-damage steel seismic load-resisting systems.

### Anatomy of multi-level steel construction

The two main components of multi-level steel buildings are the composite steel floor system and the lateral load-resisting system. As a general rule of thumb the most cost-effective solutions are produced when the steel framing supporting the flooring and the lateral load-resisting system are kept separate. This allows expensive complex connections to be limited to the lateral load-resisting system and simple cost-effective connections to be utilised for the remainder of the structure.

#### Flooring systems

Steel-concrete composite floor construction will generally produce the most efficient floor system as it combines the benefits of both materials. Designing the floor slab to act compositely with the steel beams can increase the bending strength of the beam by a factor of 1.5-2 and increase its stiffness by a factor of

3-4.5. This results in lightweight floor solutions with good spanning capability. In New Zealand there are three common forms of steel-concrete composite construction:

1. precast flooring on steel framing
2. rolled steel joist on steel framing
3. metal deck slab on steel framing (figure 7).

The advantages of the latter two options are that they result in a lighter superstructure and, subject to appropriate span limits, the concrete slab can be poured without needing to prop the floor. This has speed advantages in buildings with significant follow-on trades such as heating and ventilation.

In recent years there has been greater demand for buildings with large uninterrupted floor areas, providing flexibility in their end use. An increase in the number of companies in New Zealand manufacturing customised cellular or welded beams has seen an increase in long-span composite beam

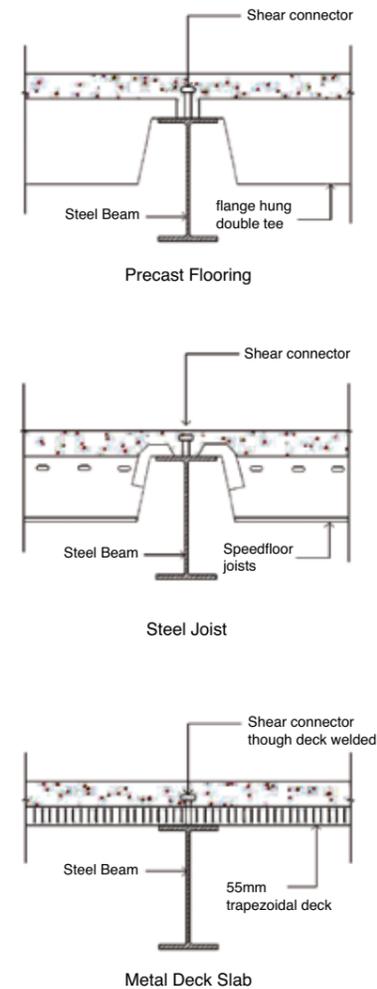
solutions for multi-level commercial projects such as car parks and offices. These beam spans are typically in the range of 12-25m.

#### Lateral load systems

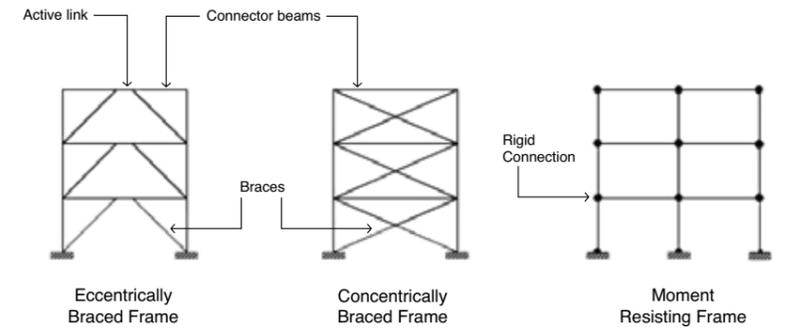
Steel-framed buildings are typically braced against lateral loading such as wind or earthquakes by braced (concentric or eccentric), or moment-resisting frames (figure 8). Eccentrically braced frames are the most popular form of braced steel frame used in New Zealand, and this will likely continue due to their very good performance during the earthquakes.

Braced frames will generally result in a cheaper overall structural cost but will not always be architecturally acceptable. Both types of steel lateral load systems feature low-damage technology, further enhancing their seismic performance. The design of such systems is well established in New Zealand, with good seismic design resources available for structural engineers.

- 4 Moment frame with sliding hinge joint and ring spring
- 5 Braced frames with sliding hinge joint
- 6 Eccentrically braced frame with active link and detail of rotational sliding hinge
- 7 Common steel-concrete composite floor systems
- 8 Lateral load-resisting systems for steel buildings
- 9 Te Puni Village, Victoria University



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# The commercial case for steel construction

Ask any developer or investor about the most important part of a building project, and they'll tell you it's the return on investment. In this section we set out the commercial case for steel construction in Christchurch, breaking it down into five key financial considerations. To bring it to life, the commercial case is based on a model project for a four-storey office building.

Our analysis concludes that, compared to alternative materials, developers and owners can procure a seismically-resilient steel building solution with the additional commercial benefits of a faster build, earlier rental streams and lower financing costs, without paying a cost premium.

## 1. Competitive building costs

Cost estimates, including foundations and superstructure, were prepared for the model project (table 1). Note that miscellaneous structural items such as stairs and lift pits, which are common to all options, have been excluded from the cost estimates.

| Option      | Total estimated structural cost |
|-------------|---------------------------------|
| 1: Steel    | \$1.96m*                        |
| 2: Timber   | \$1.95m                         |
| 3: Concrete | \$2.00m                         |

**Table 1: Model project - cost estimates for construction options**

\* Two steel options were costed:  
 1. K-frame steel with Comflor \$1.96m;  
 2. Hybrid: Steel framing and precast flooring \$1.90m.  
 For the purposes of this exercise we have taken the first option

Investment in fabrication technology and workshops, and the modern approach of simple bolted connections, has improved productivity in the industry, resulting in lower costs. This is reflected in the competitive

cost for structural steel solutions, which are comparable to timber and slightly lower (2%) than concrete.

## 2. Prefabrication

One key attribute of steel construction which will add real value to the rebuilding of Christchurch is that much of the work, particularly critical operations such as welding and painting, can be undertaken off site – and some of it in other cities. This will have a number of advantages:

### Faster construction programmes

A faster rebuild will offer significant benefits to Christchurch and the wider Canterbury region. Recent news articles have highlighted the importance of quickly developing CBD accommodation, conference, events and sporting facilities to restore the economic well-being of Christchurch.

There will also be an initial demand for office space in the CBD for those companies who have a preference for a central location – as evidenced by the 'anchor group' of 30 firms seeking to become anchor tenants on a series of new office projects in a western precinct of the CBD.

Relocating businesses to new modern offices will also increase productivity. Many Christchurch businesses are currently operating in less than ideal buildings for optimal productivity. UK research<sup>1</sup> has shown that modern features such as good lighting contribute to an increase in productivity of 3-20% and a reduction in absenteeism of 15%. Therefore it is in the interests of the local economy to get businesses into new, well-designed premises as soon as possible.

Our model project shows modern steel construction, featuring simple on-site bolted connections, results in faster overall construction programmes.

Steel's superior construction speed is graphically illustrated in figure 1 (page 8), with the concrete option's final floor and roof not started by the time the steel structure is ready to be made weathertight (150 days). The speed difference is not so pronounced for the timber option (175 days), but it will still take another 75 working days once the steel structure is finished to complete construction of the concrete option's final floor and roof structure.

Importantly, as shown in table 2, the model project found steel's speed advantage is maintained to the end of the contract. This allows construction plant, equipment and personnel to be released sooner for other projects, and for building owners to have an earlier income stream through tenants taking earlier occupation of their premises.

| Option      | Total programme (days) | Difference in construction programme (days) |
|-------------|------------------------|---|
| 1: Steel    | 304                    | -   |
| 2: Timber   | 319                    | 15  |
| 3: Concrete | 343                    | 39  |

**Table 2: Model project – construction programme comparison**

### Significant local and national capacity

The Canterbury steel construction sector, supplemented by the wider national supply chain as required, is well placed to provide significant construction capacity to the Christchurch rebuild. In fact, the current spare capacity of the country's steel construction sector could easily absorb all of the expected office rebuilding in Christchurch – a job expected to take at least a decade.

<sup>1</sup> The Impact of Office Design on Business Performance: The Commission for Architecture & The Built Environment and the British Council for Offices, 2005



## Model project

The model project consists of a four-storey office building with a footprint of approximately 1,300m<sup>2</sup>. These dimensions are consistent with the low-rise vision contained in the Christchurch City Council's Central City Plan.

Within this framework, we modelled three different construction options, representing the three most common building materials – steel, concrete and timber (see table 3).

All three buildings were supported on 10-12m-long screw piles and each has a concrete slab. The costs for the foundation elements were included in the total structure cost estimates.

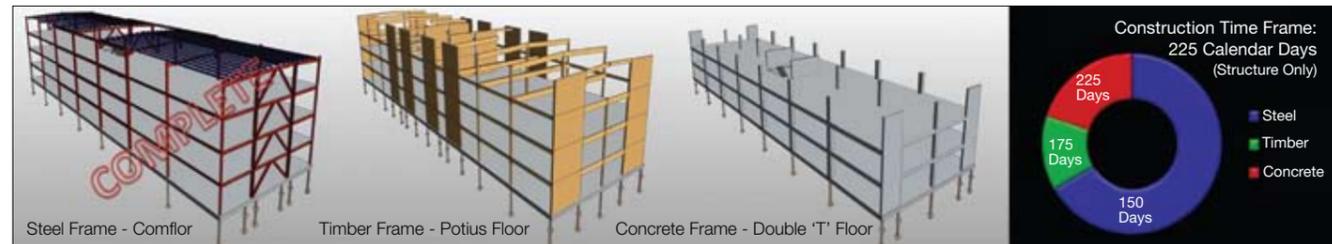
| Option  | Floor system  | Framing                    | Lateral load-resisting system  |
|---|---|----------------------------|--|
| 1: Steel framing and metal deck slab flooring                         | 130mm-thick slab, 60mm trapezoidal metal deck profile | Hot-rolled steel sections  | Eccentrically braced frames in cross direction. Moment-resisting frame in longitudinal direction |
| 2: Timber-framed floor, in situ concrete topping, plywood shear walls | Potius panels and 65mm in situ concrete topping       | LVL sections               | Plywood shear walls in both directions   |
| 3: Precast concrete flooring, concrete framing and shear walls        | Double-tee flooring and in situ concrete topping      | Concrete beams and columns | Moment frames in longitudinal direction. Concrete shear walls in transverse direction            |

**Table 3: Model project - summary of construction options**

SCNZ would like to acknowledge the contributions of the following for the model project: structural engineers Aurecon; architects Architectus; quantity surveyors Capital Projects; and builders Mainzeal.

As a general rule of thumb, steel options result in a 10-15% reduction in the construction programme for multi-level commercial building projects, compared to other materials.

1 Our model project shows modern steel construction results in faster overall construction times



Estimates have put the volume of office construction over this period at approximately 300,000m<sup>2</sup> based on 60% of the office space between the Four Avenues being rebuilt. If a ratio of 50kg of steel per m<sup>2</sup> is used, this equates to about 15,000 tonnes of fabricated steelwork. The country's largest fabrication company currently produces this tonnage each year on its own.

To put this into further perspective, the drop in annual steelwork tonnage fabricated by the New Zealand steel construction sector alone since the 2008 Global Financial Crisis is 25,000 tonnes (excludes plate and pipe sections).

**High quality product**

Prefabrication also brings quality control advantages to building projects. It is much easier to produce quality workmanship in the controlled environment of a workshop rather than on site, where adverse weather can

have an impact. It is also easier to undertake quality assurance work off site.

**3. Earlier rental returns and reduced financing costs**

Faster construction translates to earlier tenancing and therefore earlier income streams for the building owner. To quantify this, rental income calculations have been made based on the model project and shown in tables 4 and 5. The difference in construction programmes in table 3 have been combined with the market rates applicable to a Christchurch CBD building to give the additional income associated with earlier occupation by the tenant.

**4. Potential for better insurance outcomes**

There have been major insurance consequences resulting from the ongoing

earthquakes which, so far, have hindered the CBD rebuild from commencing:

- an unwillingness by the insurance industry to take on new risk in Christchurch
- the significant rise in the cost of building insurance premiums nationally

**Grey Star – a seismic rating system**

Following the earthquakes there has been greater awareness that the Building Code minimum structural performance requirements do not address the cost of repair and the time needed to re-occupy

- Table 4 and 5 assumptions:
1. Rental rates taken from Colliers International's Feasibility of Building Development in the Christchurch CBD report contained in appendix G of the Christchurch City Council's Central City Plan
  2. Net lettable area - office 1,170m<sup>2</sup>
  3. Net lettable area - retail 1,170m<sup>2</sup>
  4. Office rental per annum \$420/m<sup>2</sup>
  5. Retail rental per annum \$650/m<sup>2</sup>
  6. Total rental income per annum \$2.2m (\$43,000 per week)
  7. Ratio of net lettable area to gross area of 0.9
  8. Bridging finance cost per annum \$13,600

| Option    | Construction duration (days) | Time difference (days) | Time difference (weeks) | Savings in financing costs | Additional rental income | Total value of time saved |
|-----------|------------------------------|------------------------|-------------------------|----------------------------|--------------------------|---------------------------|
| 1: Steel  | 304                          | -15                    | -3                      | \$40,832                   | \$129,925                | \$169,757                 |
| 2: Timber | 319                          | 0                      | 0                       | \$0                        | \$0                      | \$0                       |

Table 4: Model project - additional rental income for steel option compared to a timber alternative

| Option      | Construction duration (days) | Time difference (days) | Time difference (weeks) | Savings in financing costs | Additional rental income | Total value of time saved |
|-------------|------------------------------|------------------------|-------------------------|----------------------------|--------------------------|---------------------------|
| 1: Steel    | 304                          | -39                    | -7.8                    | \$106,162                  | \$335,205                | \$441,367                 |
| 2: Concrete | 343                          | 0                      | 0                       | \$0                        | \$0                      | \$0                       |

Table 5: Model project - additional rental income for steel option compared to a concrete alternative

- 2 Waikato Emergency Department Building: Precast flooring lowered onto site-attached corbels
- 3 Waikato Emergency Department Building: Strengthened column base



buildings. As a result, organisations such as the Construction Industry Council have been giving serious consideration to the adoption of a seismic rating tool – Grey Star. This would likely see buildings with seismic qualities which exceed Building Code thresholds recognised with lower insurance premiums, and allow investors, tenants and insurers to make more informed decisions.

The need for such a tool has been recognised internationally, with the Structural Engineers Association of Northern California (SEAONC) developing an earthquake performance rating system. The SEAONC rating tool, which focuses on three key seismic performance indicators – safety, repair, and cost and time to regain function – is intended to communicate information about the seismic risk of buildings to the general public. Each performance indicator is ranked from 1-5 stars with 1 representing the lowest rating and 5 the highest.

The insurance industry already appears to be making decisions based on the likely seismic performance of commercial buildings, with one news report<sup>2</sup> suggesting the premium increases for buildings built prior to 1979 were substantially more than newer buildings, and buildings built prior to 1936 were proving difficult to insure at all.

Steel-framed buildings performed very well in the earthquakes and new low-damage technology now exists to improve the seismic resilience of buildings even further. The adoption of such technology typically increases the total building cost by 8-10% for base isolation and 1-2% for low-damage technology<sup>3</sup>.

The development of a local Grey Star system will allow owners of steel-framed buildings utilising low-damage systems to derive commercial benefit from having a building that is a lower insurance risk and more desirable to safety-conscious tenants.

On this basis, it is likely these buildings would be cheaper to insure, command a rental premium and be worth more as an

investment than a building that only meets the Building Code's minimum standards.

**5. A future-proof investment**

Future-proofing your investment is an important consideration in maintaining the value and returns of commercial buildings. In recent years there has been demand for buildings with large uninterrupted floor space, which are flexible in their final use. This demand has seen an increase in long-span welded steel beam solutions up to 25m long.

Colliers International has noted the repercussions from the Christchurch earthquakes have spread to other parts of the country. In centres such as Wellington, building surveys are being undertaken to ascertain Building Code compliance. Buildings with deficiencies must be upgraded to maintain their current value and rental return, while those that are not economic to upgrade may no longer be tenatable. Steel-framed buildings are easier to seismically upgrade than other materials – strengthening elements such as additional braces are relatively easily incorporated into the existing structure.

Future changes in building use may require portions of the floor to carry greater imposed loading than was originally envisaged. Floor support elements such as beams and columns may be readily strengthened. Increases in the number of floors to a building may also be accommodated more easily in a steel-framed building compared with other materials. A good example of this is the Waikato Hospital Emergency Department building constructed in 2009. During the course of the steelwork erection a decision was made to add additional storeys to the building. As the building erection was well advanced, what couldn't be returned to the workshop was strengthened on site by the addition of platemwork.

<sup>2</sup> www.stuff.co.nz/business/small-business/4992169/Insurance-goes-through-roof  
<sup>3</sup> Source: Aurecon

**A track record of industry collaboration**

Recent examples of successful joint venture projects between Christchurch and North Island-based fabricators include the Forsyth Barr Stadium in Dunedin, where Christchurch-based fabricator Pegasus Engineering and Auckland's Grayson Engineering undertook the contract to supply and erect 3,900 tonnes of steelwork for the roof structure. The large fabricated components were trucked down to Dunedin. A total of 128 and 124 truck loads of fabricated steelwork left Christchurch and Auckland respectively.

Another example closer to home is the 22-storey Pacific Tower in Christchurch. This 800-tonne contract was also delivered by Pegasus Engineering together with Tauranga-based Jensen Engineering. The North Island-fabricated component of the steelwork was trucked to Christchurch and erected by the local fabricator.



## Designing a resilient city

By Richard McGowan and Dean MacKenzie Warren and Mahoney

### Central City Plan - the blueprint

Following the devastating earthquake of February 22, 2011, the rebuilding task ahead is immense. The Christchurch City Council's recovery plan for the city, the Central City Plan, was informed by tens of thousands of public submissions along with input from the business community and the design profession.

The Central City Plan draws out five key elements that go on to inform the entire document:

1. Green city – an upgraded and wider Avon river / Otakaro corridor, more tree-lined streets and a new network of neighbourhood parks;
2. Stronger built identity – a lower rise city with strengthened urban design controls;
3. Compact CBD;
4. Ability to live, work, play, learn and visit;
5. An accessible city for all.

The plan also proposes setting stricter urban design parameters, including building height limits (allowing for some existing-use rights), minimum and maximum building street edge heights, minimum allowable ground floor heights and visual transparency.

In addition, the plan prohibits setbacks for car parking and encourages discreet side entrances for vehicles with concealed parking.

### 10 x 10: Warren and Mahoney's contribution

In March 2011, while too early to propose specific solutions, Warren and Mahoney developed its Ten Thoughts for Christchurch – key insights to inform the redesign and reconstruction of the city:

1. Forget buildings, it's all about the streets – focuses attention on the public realm;
2. Cities are about people – proposes mixed

occupancy of the CBD;

3. Back to the future – suggests the historical legacy is what will help drive it forward;
4. Icons are not the answer;
5. Consistent density, high intensity – proposes a low-rise, dense CBD;
6. The future is green – suggests sustainability is a bottom line;
7. Infrastructure and the city – proposes a holistic, cohesive and design-led view of infrastructure;
8. Safe investments – new buildings must be commercially sustainable;
9. High quality, high return – proposes long-term, strategic thinking;
10. Think global and local – proposes lifestyle choice as the primary strategic driver and fundamental point of difference for the city.

We put these insights to 10 leading figures from Christchurch's business, professional and cultural sectors in a book called 10 x 10. These included Jenny Harper – director of the Christchurch Art Gallery, Dr Rod Carr – Vice-Chancellor of the University of Canterbury, Jim Boulton – CEO of Christchurch International Airport and Sir Miles Warren, among others. The publication can be read at our website [www.warrenandmahoney.com](http://www.warrenandmahoney.com)

### Why steel for Christchurch?

There are many reasons architects might use steel. These could be for reasons of efficiency – both structural and commercial – but also for purely architectural reasons, such as lightness.

#### Precision

Steel has a precision not found in other primary structural materials – both a dimensional precision and precision in terms of the material finish. This is a result of the way it is formed and shaped, which in turn imparts a technical sophistication.

#### Prefabrication

The prefabrication of steel – the potential to

pre-make components in a controlled and remote location – gives increased quality control and accuracy while decreasing on-site installation time.

#### Efficiency

Steel is an efficient structural solution, requiring only a minimum structural depth to achieve maximum spans. This structural efficiency gives steel a versatility and allows it to be used in a variety of projects – from the minimal column intrusions of modern commercial, education and public buildings to the much longer spans required in stadiums and auditoriums.

#### Lightness

An efficient structural system also gives a lightness of structure and an increase in visual transparency. Cantilever depths appear minimal and column slenderness ratios are maximised.

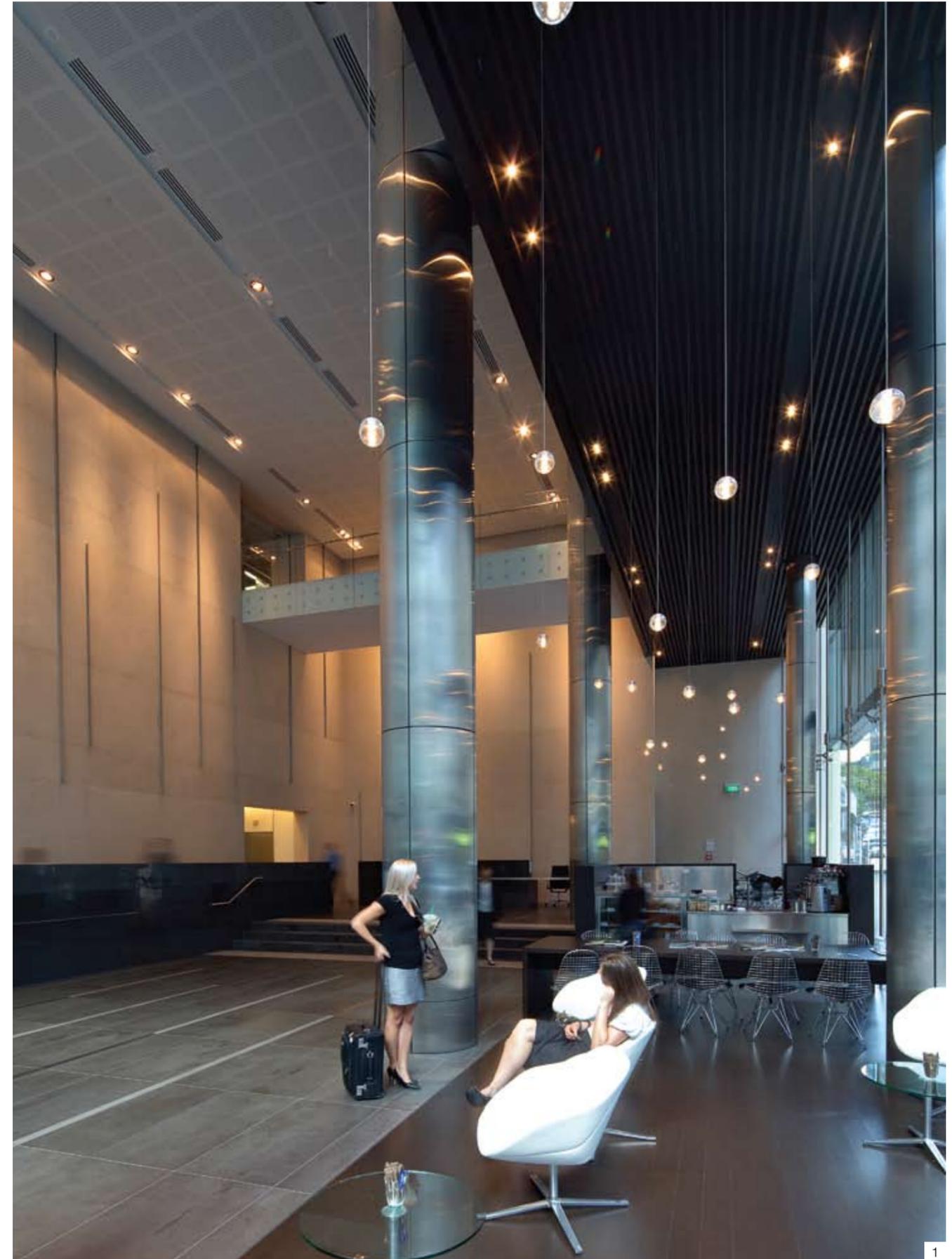
#### Dynamism

Steel allows for increased structural expressiveness. It's more able to express dynamic load paths, and performs well in tension and compression, unlike other traditional primary structural materials. This in turn allows steel to be integrated into the external expression and façades of buildings.

Clearly, the many merits of steel have much to offer the rebuild of Christchurch – for architectural, structural and commercial reasons. Precision, efficiency and architectural appeal create a compelling case worth strong consideration for any building project.

### Warren and Mahoney steel precedents

Warren and Mahoney have recently completed several significant buildings that use steel structures, though all for differing reasons, which highlight the multiple benefits of using steel.





2

There are many reasons architects might use steel. These could be for reasons of efficiency – both structural and commercial – but also for purely architectural reasons, such as lightness.

#### **Deloitte Centre**

The Deloitte Centre is a 21-level tower in Auckland with over 21,000m<sup>2</sup> of premium-grade net lettable space. Facing onto Auckland's Queen Street, the structure covers an entire city block and incorporates the sensitively-restored, heritage-listed Jean Batten Building.

The structure was steel-framed columns and beams with a composite metal-concrete floor slab tying back to a concrete core.

A steel structure was selected primarily for commercial reasons – a steel structure increases the net-to-gross ratio as the structural sizes of steel are much less than concrete; it was faster to erect because of the possibility of off-site prefabrication of elements and its reduced mass allows for smaller foundations due to the lower total gravity load.

The triple-height lobby employs slender steel columns in conjunction with a cantilever of the office floors above to achieve a visually transparent lobby without the weight of a massive structure.

#### **Novotel**

The Novotel Auckland Airport is a 4-star, 12-level, 263-key hotel adjacent to Auckland's international airport. The conceptual design of the hotel was based on four principles – creating an international presence, expressing an openness and diversity of New Zealand's people, building an experience and making a memory.

The structural solution was steel-framed columns and beams with a composite metal-concrete floor slab tying back to a primary concrete shear core.

A steel structure was selected for time constraints – the hotel operators insisted the hotel be operating prior to the Rugby World Cup 2011. While the foundations were built – in situ – the steel work was prefabricated in parallel off site and brought to the site when the foundations were complete.

The columns at the lower floors are highly expressive and reveal the structural logic and story of the building while allowing a highly transparent and legible reading of the lobby inside.

#### **NZi3**

The NZi3 Innovation Institute is a 2,300m<sup>2</sup> research centre for Information and Communications Technology at the University of Canterbury. Its mission is to take innovative ideas from the lab and transform them into solutions for industry.

The lower level acts as an arrival space – facilitating public display and interaction. Above this area is a large, flexible workspace for post-graduate students, staff and private sector research personnel.

The upper floor of the building is considerably larger than the lower floor. This provided an opportunity for a structurally

exciting response and, after an exploration of 'hands-free' technology, resulted in a building of cantilevers rather than columns.

Steel was used on the NZi3 Innovation Institute for two reasons. Firstly, it was exploited to create a significant cantilever of the top floor over the second. The top floor is essentially formed through large trusses that run along either longitudinal length of the building and are then tied back to the core. Secondly, however, and in keeping with an Innovation Institute, the steel trusses were rendered explicitly visual to highlight the expressive and dramatic structural solution.

This solution would not have been possible without the use of steel members.

- 1 Deloitte Centre, Auckland
- 2 Novotel Auckland Airport
- 3 NZi3 Innovation Institute

Images courtesy of Warren and Mahoney



3

## Te Puni Village

### Case Study

**When the Victoria University of Wellington (VUW) decided that additional student accommodation and facilities were needed, the site available was steep and exposed, at the southern end of Kelburn Campus. The brief given to the architects, Architectus, envisaged 348 dormitory rooms, 298 studio rooms and three two-bed apartments.**

Architectus' Auckland partner Michael Thomson describes the design concept: "Three separate accommodation buildings are linked by an amenities level. The Terrace is a low-rise development of four levels; it is linked to the second building, the Tower, by an entry courtyard and administration wing. A bridge at the common amenity level, which contains the dining area, links to the third building, the Edge, which runs on a north/south axis along the steep contours at the edge of the site. The project was to be known as the Te Puni Village."

Hawkins Construction was engaged to construct the Architectus design. VUW

as the client made a significant request right at the outset, stipulating that Aurecon (then known as the consulting engineers Connell Wagner) was to incorporate in the design the latest advances in damage avoidance, as applicable to structural steel-framed buildings under severe earthquake attack. Aurecon's Sean Gledhill explains: "In the philosophy of damage-avoidance design, the bracing structure is designed to withstand a major earthquake with minimal and readily repairable damage. This typically involves incorporating mechanisms in the structure that can control loads and sustain large deformations. VUW's objective was to ensure that, after a large earthquake, the student accommodation buildings could be utilised as an administration facility while other university buildings were under repair. In short, the university would be functional."

To complement the architecture, Aurecon engineers developed a seismic-resisting system that included perimeter longitudinal moment-resisting frames with transverse concentrically braced frames, or CBFs.

To develop a damage-avoidance solution, they pursued the idea of using a tension fuse at the junction of the CBF frames and the foundations. Adapting research done at the University of Auckland, they coupled the CBFs with stepping bases controlled through pre-stressed Ringfeder springs. The system allows the building to lift off the ground and rock, using railing buffer technology to control the movement. The system also incorporates sliding hinge joints between the columns and the foundation, as well as in the steel beams.

The sliding hinge joint was developed by Charles Clifton, Associate Professor of Civil Engineering at the University of Auckland. Incorporating slotted bolt holes, the joints between the beams and the columns are allowed to slide, dissipating seismic energy.

Clifton says: "At the end of the earthquake, the preload in the springs brings the frames back to rest in their pre-earthquake position. As far as I am aware, this is a world-first for a multi-storey steel-framed building."

MJH Engineering was the steel constructor on this project. Managing director Malcolm Hammond says the damage-avoidance solution was simple to fabricate and easy to install. "The sliding hinge joints presented the challenge of establishing a suitable bolt-tightening sequence, but we met this with a detailed construction methodology to ensure the tolerances were achieved. An excellent speed of construction was maintained. This enabled the main contractor Hawkins Construction and MJH Engineering to maximise shared craneage for the erection of the steelwork and the placement of precast flooring."

A prestigious international award recognising Aurecon's innovation in the Te Puni Village project was made by the Institute of Structural Engineers (UK) in 2009.

- 1 The Edge is a long form running along the north/south axis of the steep eastern contours
- 2 A typical sliding hinge joint connected to a concentrically braced frame
- 3 A sliding hinge joint with the cantilever brackets that will support the façade
- 4 The Terrace, a low-rise on Fairlie Terrace linked to the Tower by an entry courtyard and administration wing



## Pacific Tower

### Case Study

**Ernest Duval of Equity Trust Pacific, the owner of the 22-level Pacific Tower on Gloucester Street, likes to think of Christchurch's tallest building as the 'poster boy' for the city following the massive destruction of the 2010/11 earthquake series. And he's probably justified in his thinking.**

Completed in 2010 and comprising eccentrically braced steel frames cast integrally with composite metal deck slabs, the building also incorporates several innovative features. These include carstackers, cranked braces and 'super' moment-resisting frames at ground floor level. The latter remove the need for braces from the front elevations of the building, allowing unobstructed views.

Pacific Tower bore the earthquakes very well – just one active link required replacing. This demonstrates the resilience and economic value of steel-framed buildings – any damaged components can be removed and replaced, meaning tenants can be back in their buildings paying rent faster than might otherwise be possible with buildings of alternative construction materials and methods.

#### Commercial considerations

Duval says concrete has historically dominated Christchurch's building scene thanks to the plentiful local supply of quality aggregate and the industrial disputes of the 1970s. But the earthquakes will change all this: "We simply can't afford to have 'throwaway cities' in New Zealand. The extensive concrete cracking and spalling throughout the city shows that it's too expensive to repair and rebuild everytime there is an earthquake. We need better engineering and better materials, and steel is the logical solution."

For Duval the benefits of building in steel are compelling:

- financial – fast speed of erection and reduced foundation costs;

- it's easier to build with – prefabricated sections are simply craned in and bolted together;
- it's strong – steel's ductility gives it resilience and its low mass reduces the forces the building is required to resist in an earthquake;
- and it's safe – steel has proven seismic performance.

The height of the Pacific Tower was heavily criticised during the planning phase, but Duval says he simply wanted to exploit the site's best asset: its magnificent mountain-to-sea views. He needed a solution that would give him the height he wanted from a small 700m<sup>2</sup> site.

#### Design considerations

Importantly, the steel-framing system provided a lightweight structure for the confined site. This feature led to a more cost-effective below-ground design – smaller foundations, fewer piles – and a smaller lateral load-resisting system. The steel framing was also easier to transport, crane and erect in a confined site with limited access.

Its engineering design also allowed the Pacific Tower to perform well during the earthquakes.

"The Pacific Tower performed better than expected," says CPG structural engineer Sean Gardiner. "There was an increased ground response in Christchurch for buildings of this height, likely due to the depth of soils below the CBD. Given the intensity of shaking, significantly more damage could have been expected."

A number of design features aided the Tower's good seismic performance. To begin, the building was piled to mitigate against settlement and liquefaction and, to address the seismic and wind-loading issues inherent in such a tall building, a mix of eccentric K-braced and D-braced frames, orientated in a tube shape, was located up along the centre of the building. The

predominantly tubular geometry increased the building's stiffness and limited its torsional response.

Transfer diaphragms are situated at levels six and 11 where braced frame lines change. Crucially, the active links were well detailed: polystyrene packers were installed adjacent to the columns to prevent the slab contributing to braced frame strength and potentially overloading other structural elements, there were also drag ties in diaphragms, and careful design of transfer diaphragms.

Gardiner, who was an engineer with Structex when the Pacific Tower was designed five years ago, says seismic-resisting technology has advanced in that time.

"There has been a shift to damage avoidance, whereby structural elements are even more easily and cheaply inspected, repaired or replaced," he says. "For example, where the Pacific Tower has welded active links, an option would be to bolt them instead, allowing their replacement to be simpler and cheaper."

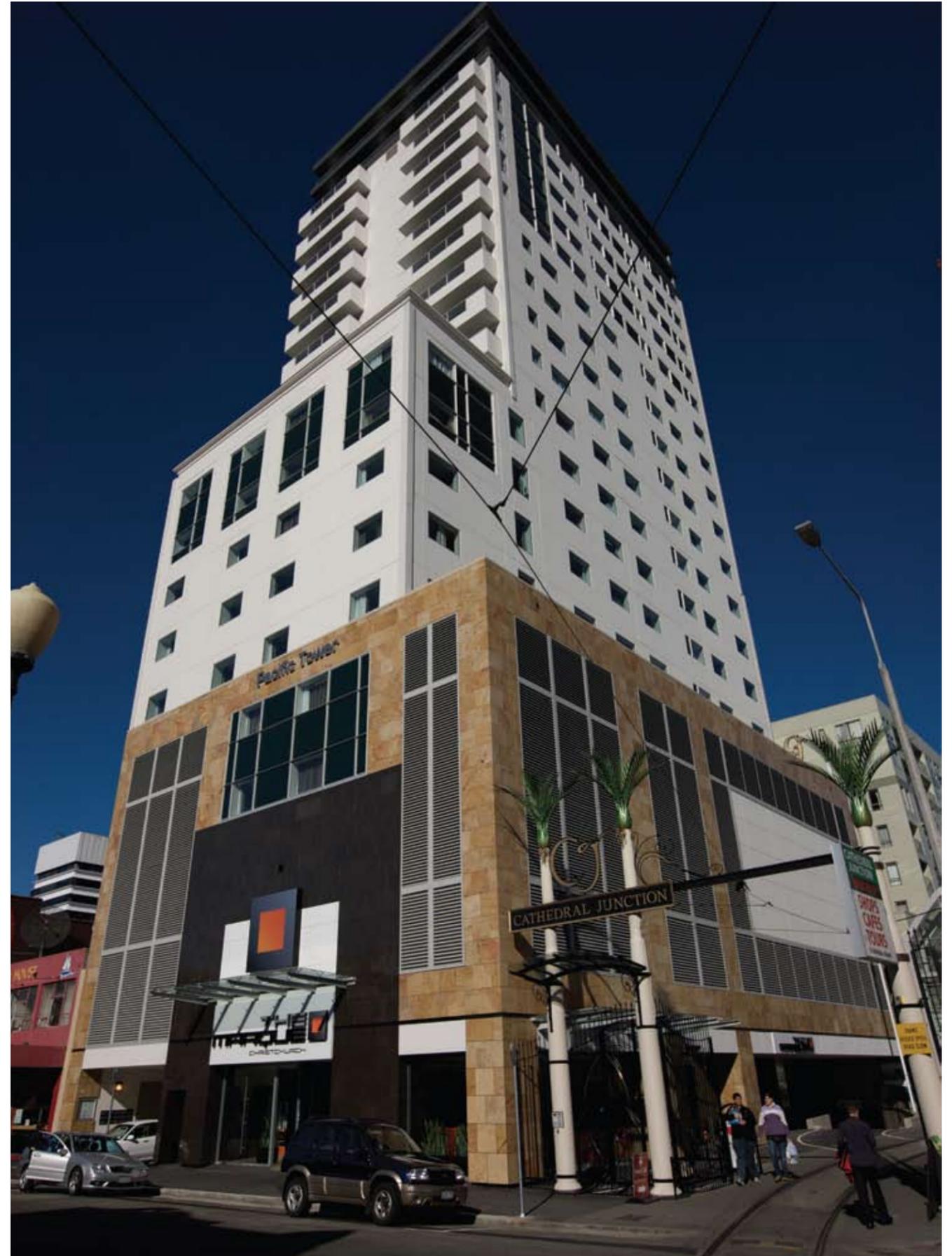
Pacific Tower architect Rob Campbell of Foley Design sees steel buildings being a major force in the rebuilding of Christchurch, for the many reasons mentioned above, and more.

"Steel offers architects and designers the ability to 'free' up the design somewhat. Structural steel is lightweight, and this can be used to a design's advantage; the superstructure can be visually 'light'."

And, with today's seismic design technology, structural steel is simply more reliable.

"Nature itself has provided the ultimate testing ground in the earthquake series we have had (and are still having)," says Campbell, "and the structural steel in the Pacific Tower has performed admirably."

Image courtesy of Foley Design



## Let Kiwis rebuild Christchurch with local content

**The common view is that Christchurch's reconstruction will take place over a 10-year period. This reflects the realities of a limited local construction resource and a desire to avoid the usual boom-and-bust cycle with accompanying cost volatility.**

It is vital that New Zealand companies play a leading role in the rebuild. This will contribute to the city's, and indeed New Zealand's, return to economic prosperity, and help ensure the long-term integrity of the city's buildings and infrastructure.

An emerging and worrying trend, however, has been to source prefabricated structural steelwork from lower-cost economies, predominantly in South-East Asia.

SCNZ has been working with the likes of the Canterbury Development Corporation (CDC) and NZTE's Industry Capability Network New Zealand to encourage infrastructure and building procurers - such as local government and developers - to consider whole-of-life and service costs, rather than just initial capital cost, when making purchasing decisions.

### Cost considerations

All purchasing decisions should be based on a whole-of-life approach in which the true costs of procurement decisions are

considered over the planned life of the product or service. According to a recent CDC report<sup>1</sup>, New Zealand companies are competitive on this basis.

Lowest-cost purchasing decisions are invariably shown to be the most expensive when whole-of-life criteria are applied. An effective procurement policy should ensure that domestic suppliers are given a fair opportunity to supply. All too often there is not a level playing field: foreign competitors don't always comply with locally recognised standards of safety; many have never heard of sustainability; and often their governments offer subsidies and special procurement incentives that lead to dumping.

Procurers who turn a blind eye to this only serve to prolong it. Meanwhile our New Zealand fabricators lose the business and our government loses tax revenue, to the detriment of our economy.

### Employment considerations

Purchasing locally has significant downstream benefits to the economy. The CDC report references 2009 findings from Berl concluding that every \$1 million spent in domestic manufacturing activity in New Zealand (instead of imports) results in an additional \$0.93 million in value added and 8.87 FTEs.

Similar research undertaken by the Heavy Engineering Research Association looked at the cost of not purchasing steel locally. Over the past five years, imports of fabricated steel into New Zealand have tripled - from 2008-2009 alone, the value of imported steelwork increased by \$43 million, or more than 50%. The economic impact was the loss of more than 150 jobs in the steel construction sector.

### Building Code considerations

The earthquakes have highlighted the importance of Code compliant buildings. The New Zealand Steel Structures Standard includes world-leading material and welding requirements to ensure steel structures are seismically resilient. The very good seismic performance of steel structures in the earthquakes also demonstrates the quality of workmanship of local steel constructors.

Importing low-cost structural steelwork to international standards not recognised in NZS 3404 places greater onus both on the designer and the local authority: the designer must demonstrate Code compliance has been achieved; the local authority, in this instance the Christchurch City Council, must be convinced that adequate evidence of compliance has been provided. All of this adds up to greater risk to all parties.

Quite simply, sourcing steelwork through the local supply chain, fabricated from structural steel grades and in accordance with manufacturing standards recognised in the New Zealand Steel Structures Standard, is the easiest route to show compliance with the Building Code.

<sup>1</sup>Six Months On: Issues, challenges and opportunities facing the Christchurch reconstruction by Phillip Ridge, Project Manager, Canterbury Development Corporation, sourced from [www.manufacturingnz.org.nz](http://www.manufacturingnz.org.nz)

Independent inspection of critical welded components is much easier to undertake in a local fabrication shop



## Contributing to a sustainable Christchurch

**Sustainability is a common thread running throughout the Christchurch rebuild conversation. Steel possesses very strong sustainability credentials, key amongst which is its recyclability: steel can be recycled and reused endlessly without compromising its properties.**

**Steel's other sustainable characteristics include:**

### Extending building life

Extending the life of a structure enables more value to be extracted from the resources invested to build, operate and maintain it. Steel's inherent flexibility makes it the material of choice for renovating and refurbishing buildings, for example:

- Long-span beams allow large column-free spaces, providing flexibility in the floor plan
- Major alterations are readily made - due to steel's light weight, extra floors can often be added without overloading existing foundations

### Build faster with less disruption

Overall construction programmes are shorter using steel thanks to:

- Efficient and precision off-site manufacture and prefabrication
- 'Just-in-time' deliveries
- Steel's superior strength-to-weight ratio
- Rapid installation by fewer people, in any weather
- Reduced disruption and disturbance around the site

### Minimal waste

Steel construction's low-waste credentials benefit all stages of the construction lifecycle:

- By-products of the steel-making process can be usefully employed elsewhere. Slag, for example, is used as lightweight aggregate for roading
- Any waste generated during steel manufacture and fabrication is recovered and recycled in the steel-making process
- Automated, computer-controlled production lines turn out high precision

steel components, minimising defects and waste

- Steel can be easily recovered at the deconstruction phase and reused or recycled

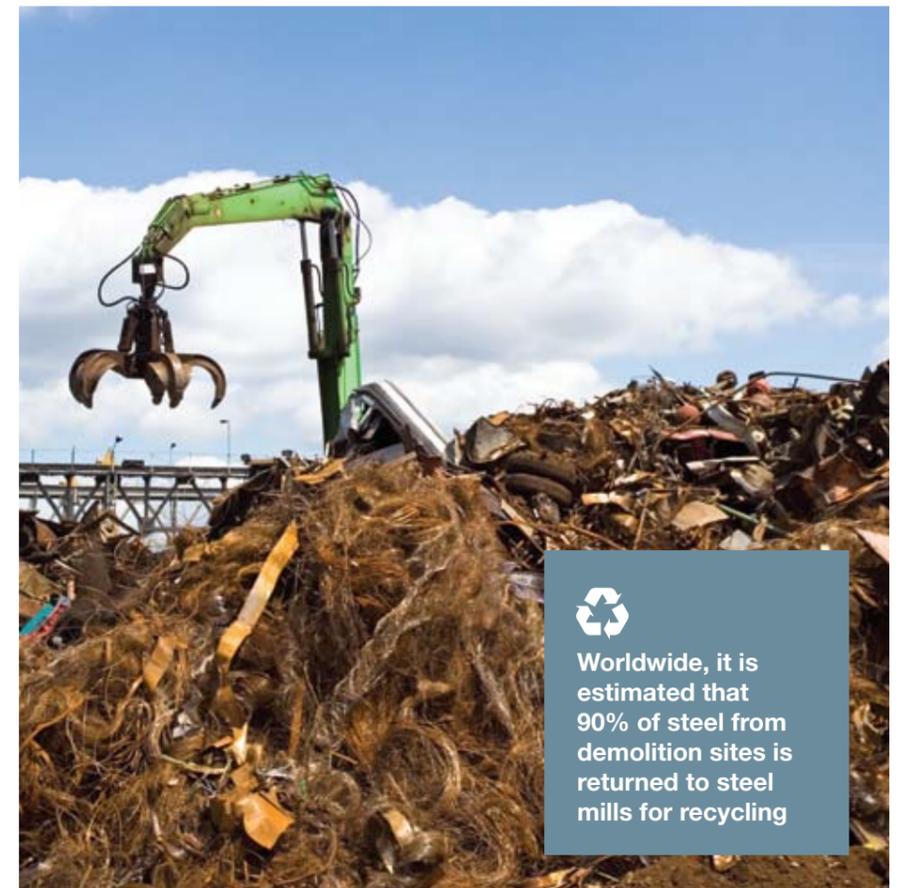
### Competitive emissions profile

Carbon emissions are an important factor in measuring sustainable performance, and steel stacks up.

- A Ministry of Agriculture and Forestry-commissioned report<sup>1</sup> demonstrated that, on a whole-of-life basis, steel's environmental performance compares favourably to other materials such as concrete and timber

- Thermal mass acts as a heat sink, tempering a building's internal environment by reducing and delaying the onset of peak temperatures. Put simply, it keeps the building cooler in summer and warmer in winter and reduces reliance on air-conditioning. Optimal thermal performance over a 24-hour period is achieved using only a 100mm-thick floor slab. All forms of steel-concrete composite construction meet this requirement

<sup>1</sup>Research report 2008-02, University of Canterbury: Environmental Impacts of Multi-storey Buildings Using Different Construction Materials



Worldwide, it is estimated that 90% of steel from demolition sites is returned to steel mills for recycling

# Facts about steel buildings

In recent years the performance of structural steel buildings has made significant advances in the areas of fire resistance, thermal mass and floor vibration. This section outlines the latest innovations in these areas.

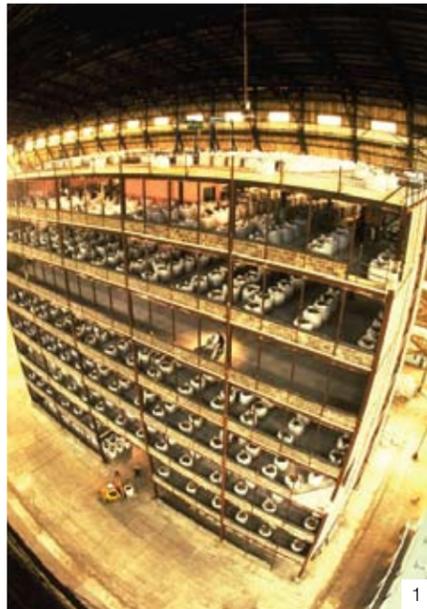
## Performance of steel buildings in fire

Traditionally, multi-storey steel buildings were considered vulnerable to collapse in severe fires if any of the structural members were uninsulated; multi-storey concrete buildings, on the other hand, were considered inherently robust. Detailed investigation of whole building performance has shown that the reality is quite different – the performance of steel-framed buildings in severe fires is, in fact, more dependable and predictable than reinforced concrete buildings.

The step change in understanding multi-storey steel-framed buildings' behaviour in fire began in 1991 with a severe fire on an unprotected office building in Central London. Rather than collapsing as conventional wisdom would have expected, the Broadgate building (figures 2 and 3) sustained only localised structural damage and was rapidly returned to service. Two decades of research following this have greatly increased our understanding of whole steel building behaviour in severe fire and led to these buildings being the most understood system now in terms of overall fire behaviour.

New Zealand has been involved in this research, through a programme led principally by Charles Clifton, first at the Heavy Engineering Research Association (HERA) and now as Associate Professor at the University of Auckland.

The results show that for steel-framed structures with composite floors comprising in situ concrete on steel deck supported on a network of steel beams, the fire resistance of the floor system is much higher than that of the individual slab or beam elements.



Even with mostly uninsulated supporting beams, these floors will develop a fire resistance many times higher than that of the individual uninsulated elements.

The same does not apply for columns, however, which typically need protection.

Research from the University of Canterbury has also highlighted the benefit of fitting sprinkler systems to suppress full fire development.

Today, design procedures to calculate the fire resistance of composite floor systems with some unprotected supporting beams are becoming available. The most advanced of these is the Slab Panel Method, first published in 2006 by HERA and currently undergoing a major upgrade.

Steel structures combining sprinklers and a floor system designed using the Slab Panel Method are a very cost-effective and fire-safe option. Indeed, they are becoming standard practice for multi-storey steel-framed buildings in New Zealand.

1 Cardington Test Facility: full-scale eight-storey building ready for fire test  
 2 Fire broke out on a floor of the Broadgate building during construction; the steelwork was unprotected  
 3 In the Broadgate building fire, the temperature of the unprotected steelwork reached over 1,000°C. Not only did the structure not collapse, it was repaired in 30 days

## Thermal mass

As the importance of sustainability has increased, attention has focused on ways that a design can reduce the carbon emissions of buildings. For framing and flooring systems, the choice between steel and concrete solutions has provided limited opportunities to influence operational carbon. There is, however, one exception – thermal mass.

Thermal mass acts as a heat sink, tempering the internal environment by reducing and delaying the onset of peak temperatures (figure 4). Put simply, it keeps the building cooler in summer and warmer in winter. Used effectively, it can help avoid the use of air conditioning, leading to significant reductions in carbon emissions.

But how much mass is required for the best result? Research has proven that, for a 24-hour cycle of heating and cooling, only 100mm of mass is needed to absorb excess heat – providing additional concrete mass over 100mm will not increase the amount of excess heat that the floor is able to absorb. It may, however, result in larger foundations and additional building costs.

Composite floors are generally 130-150mm thick with 70-90mm of concrete above the

ribs – precast concrete units, on the other hand, are generally 200-250mm thick. As such, composite flooring solutions provide optimum thermal mass for lightweight construction.

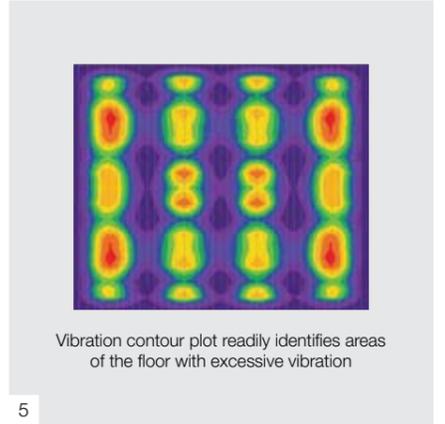
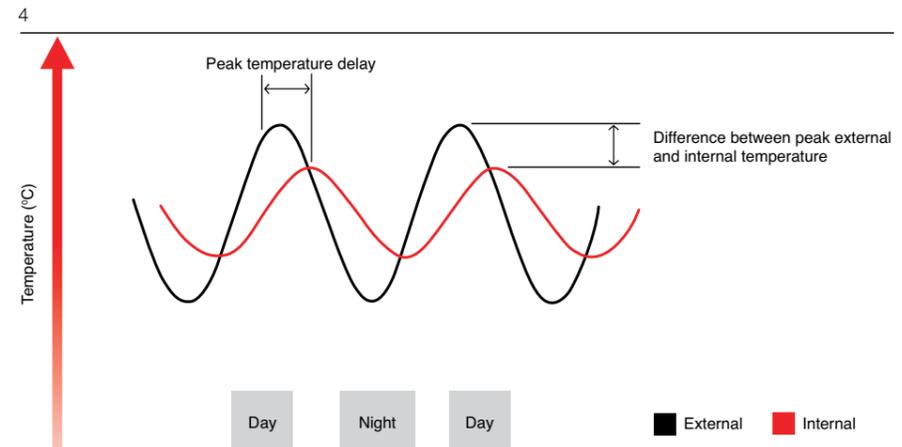
Clearly, the choice of structural system will make a difference to the weight of the floor, the size of foundations and the overall building costs.

## Floor vibration

In recent years there has been increased demand for office buildings that are fast to construct, have large uninterrupted floor spans and offer flexibility in their final use. This, along with the obvious benefits of lighter superstructures in a seismically active country, has made the dynamic performance of floors an important consideration in building design.

While there is a subjective element to perceptions of flooring vibration induced by human activity, there are now internationally recognised performance criteria included in standards.

Until recently a lack of robust methods for assessing the vibration performance of floors has made it difficult to accurately predict



Vibration contour plot readily identifies areas of the floor with excessive vibration

their dynamic performance. A new method – based on extensive European research that includes both in situ measurements of the vibration performance of a number of buildings and computer simulations – is now available.

Developed by the UK's Steel Construction Institute (SCI), *Design of Floor for Vibration: A New Approach* uses a finite element approach to determine the accelerations at various points on the floor due to walking activity. These accelerations are then compared with the limits cited in the international standard ISO 10137 to determine if the response of the entire floor is acceptable. Commercially available software is available to implement this procedure; it produces contour plots of floor response to allow designers to easily identify areas of the floor with excessive vibration (figure 5). Designers can easily modify the structure locally to reduce the floor vibration to acceptable limits.

This approach, which has been used in the UK since 2004, has been used on a number of international and local projects, including some very exacting applications.

Previously there was a perception that only very heavy floors could guarantee adequate vibration performance of suspended floors. In the UK this perception was limiting the use of structural steel-concrete floor solutions in vibration-sensitive areas such as hospital operating theatres and test laboratories. With the advent of a reliable design method, structural steel now enjoys a high market share in the health sector.

In New Zealand, SCNZ has assisted a number of consulting engineers assess the vibration performance of local projects using the SCI's methodology.

Illustration of beneficial effect of thermal mass on internal temperatures.

## Steel Construction New Zealand



**Steel Construction New Zealand (SCNZ) aims to educate the country's construction sector – from developers to architects, engineers, quantity surveyors, builders and tenants – about the benefits of building in steel and, in doing so, increase its use in the commercial buildings and infrastructure of today and tomorrow.**

### Design Support Service

SCNZ offers a free design support service to all building specifiers such as architects and engineers. This service includes preparing one or more preliminary costed structural design options that involve the efficient and cost-effective use of structural steel. For more information please visit [www.scnz.org](http://www.scnz.org)

### Why join SCNZ?

For members, SCNZ offers industry advocacy services and provides technical advice on the latest in steel design trends and standards. SCNZ's membership of over 220 companies represents New Zealand's entire steel construction industry, including manufacturers of structural steel and steel products, distributors, fabricators, erectors, designers, detailers, galvanisers, and paint and building supply companies.

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