APPROPRIATE USE OF STRUCTURAL TIMBER

Warwick Banks, Holmes Consulting,
Auckland, New Zealand

Many criteria are assessed by a Structural Engineer, when choosing the appropriate material to perform a particular task.

Ideally these criteria should be centred around economics, aesthetics, performance, ease of construction, client preference. Sometimes the designers expertise and familiarity with certain materials play a significant roll in the choice of material.

Unfortunately the latter criteria limit the use of structural timber within New Zealand.

Why Use Timber?

Firstly, New Zealand has plenty of it. Unfortunately most of it leaves our shores in the form of logs or chips. In order to remain competitive for the long term, value must be added to this resource, such as the manufacture of structural timber products. We should see more structural timber products becoming available for use in New Zealand over the next decade, such as glue laminated timber, plywood, medium density fibre board, laminated veneer lumber, orientated strand board, densified veneer lumber. Some of these products are not manufactured in New Zealand as yet, we can only hope that they will, and with them bring a vastly increased scope for structural timber usage.

To use timber, just because its there, is not reason enough. There are however many other global fundamental reasons for the use of timber as a structural building material.

It is a sustainable, renewable resource. It requires less energy to produce than many other materials. It has fewer detrimental global effects than many other materials.

There are also regional reasons such as the recreational/Eco tourism spin off from plantation forestry, and the employment opportunities provided by the Forestry Industry.

As a Structural designer, these reasons should have considerable weight in our choice of material.

However ultimately it is our client whom we must convince that timber is the appropriate material to use, and in most cases we would be hard pressed to convince a client based on these reasons alone.

In many cases timber may not be the appropriate material to use, but for the global and regional reasons listed above, the timber option should always at least be considered.

Typical Structural Timber Usage

There is plenty of scope for the use of timber beyond where it is 'usually' used in the Building Industry in New Zealand today.

Timber is typically used in New Zealand for the domestic construction industry and in smaller, low rise commercial or Industrial Building where the spans are relatively small.

There is nothing wrong with the usage. It should, and is activity promoted as an appropriate use of structural timber, in these areas.

Designers should remember that in some instances large clear spans are not everything. In some cases a client may wish to compromise a building layout with internal posts, for a significant saving in construction costs. Situations have arisen in the past where large clear spans have been provided within a new factory building, only to have the client erect numerous internal posts under rafters to run cabling down to machines situated on the floor.

How Can Structural Timber be Utilised More Effectively

Efficient design utilises the best materials for the job by exploiting the materials best properties. The use of structural timber in conjunction with other materials, expands the areas where structural timber can be used effectively, beyond the areas of domestic and low rise, small span commercial and industrial structures.

Timber has very good compressive strength properties if adequately restrained against buckling. The characteristic compressive strength

for visually graded No. 1 framing Radiata Pine is 20.9 MPa. This is bordering on the compressive strength of concrete!

Of course, timber is not concrete, and never will be. There are many other aspects to consider in design, but the compressive strength of timber parallel to the grain is certainly one aspect of the material which can be effectively exploited in design.

The tensile strength however is only half of the compressive strength value and connection design for high levels of load is difficult.

Steel however has excellent tensile strength properties and connection design is simple and economical.

The utilisation of timber in compression and steel in tension, much in the same way as is done in reinforced concrete design, can result in timber/steel component structural members carrying loads far in excess of a timber only structural member.

The concept is not new but is certainly under utilised in the construction industry in New Zealand.

Some recent examples of where this concept has been put into practice, are the Centennial Swimming Pool building in Papatoetoe, Auckland, the Gulf View Towers Apartment Building, Auckland Central, the Fox Street Apartment Building in Parnell, Auckland and the Picton Street Apartment building, Ponsonby, Auckland.

All of these structures used tensile steel members with compression timber members.

Centennial Swimming Pool Building - Papatoetoe

The pool enclosure required a clear space of approximately 32m. This span would ordinarily be outside the range of economic timber design, if timber were to be used in isolation.

A bowstring truss configuration was adopted using a glue-laminated timber top compression chord with steel rod tension chord and steel tube vertical king pin members.

The end result was a rafter which not only demonstrated the required structural performance, but also proved to be economical and aesthetic.

Gulf View Towers Apartment Building

This building is a five storey apartment building which was constructed on top of an existing reinforced concrete carparking building.

Timber construction was the obvious choice due to its light weight nature, and as a result the need for structural strengthening of the existing reinforced concrete carparking building was negated. The primary lateral load resisting system utilised a combination of plywood clad shearwalls and a structural timber moment resisting frame.

Both of these systems took advantage of the compressive strength properties of timber and the tensile strength properties of steel.

The plywood shearwalls utilised timber compression chords with steel tension tie rods placed adjacent. The compression connections in the timber chords were a simple butt joint while the tensile connections in the tie rods used coupling nuts and anchor plates. The shear transfer was accommodated in the plywood panels of the shearwall.

The five storey timber moment resisting frame used the same material strength utilisation philosophy. A solid glue-laminated horizontal beam passing continuously through the beam column joints, with splices at mid span was utilised. Plybox type construction columns were used with timber compression chord members and steel tie rod tension members inside the compression chords. Shear transfer was once again achieved with plywood cladding to these columns.

The use of timber in conjunction with steel resulted in a building of a size which would not have been possible in timber alone.

Fox Street and Picton Street Apartment Buildings

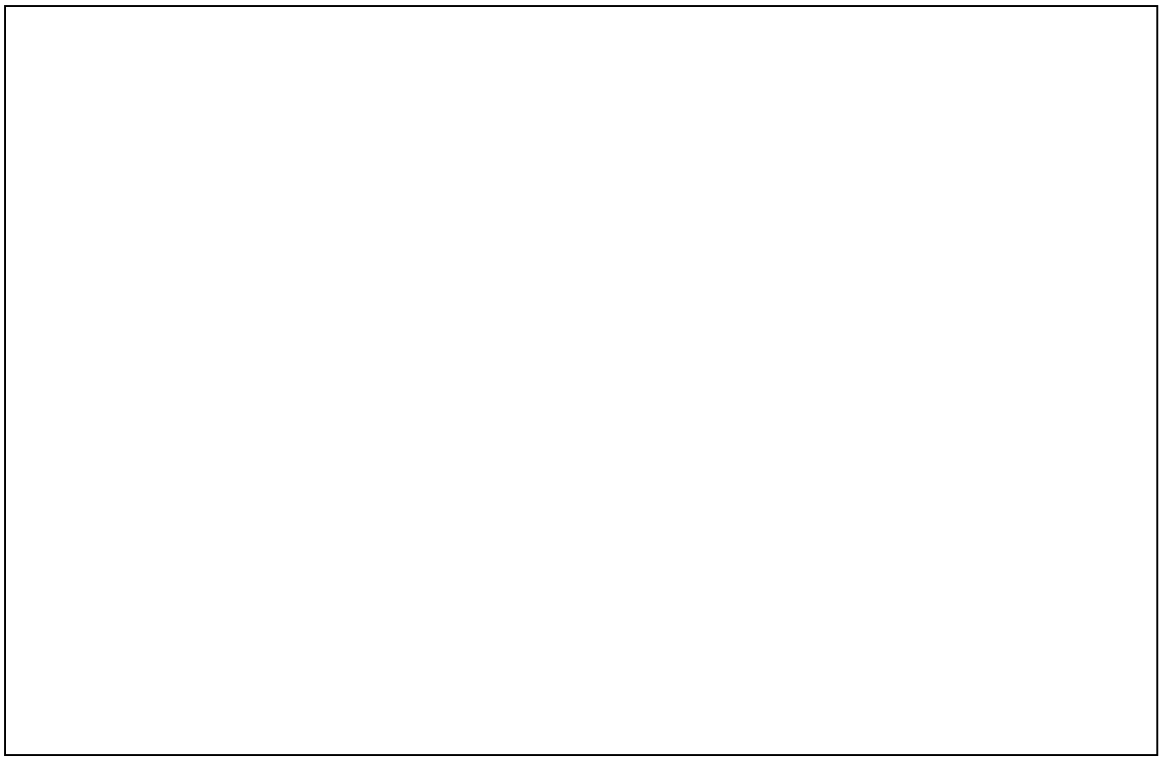
The Fox Street and Picton Street Apartments are new buildings on clean sites. These buildings are in the four to five storey range, and utilise the same principles outlined in the first two cases. The first storeys in general are constructed from reinforced concrete, and house the carparking areas while the upper three to four storeys are constructed in timber utilising the timber compression/steel tension member system outlined above.

These are all examples where the usages of structural timber in conjunction with other materials has resulted in a composite system which exceeds the capabilities of timber on its own. While these composite systems utilise the best properties of timber, we must also consider the other, not so advantageous properties such as shrinkage with moisture content change, cumulative perpendicular to the grain compressive strains (in multi storey construction), and brittle perpendicular to the grain failure. Just as we exploit the positive properties we can also use load paths which avoid the negative properties or at least reduce the effects of such properties.

All of the examples given, use the timber/steel composite system as the primary gravity and lateral load resisting systems. We should not however exclude the possibilities of using timber for the gravity systems only in multi-storey construction, while utilising reinforced concrete or steel construction for the lateral load resisting systems. This approach could see timber used economically in large multi-storey construction where the size of the projects would exceed the capabilities of timber/steel composite lateral load resisting systems. It this good to see a number of buildings being constructed around Auckland City at present, using this concept.

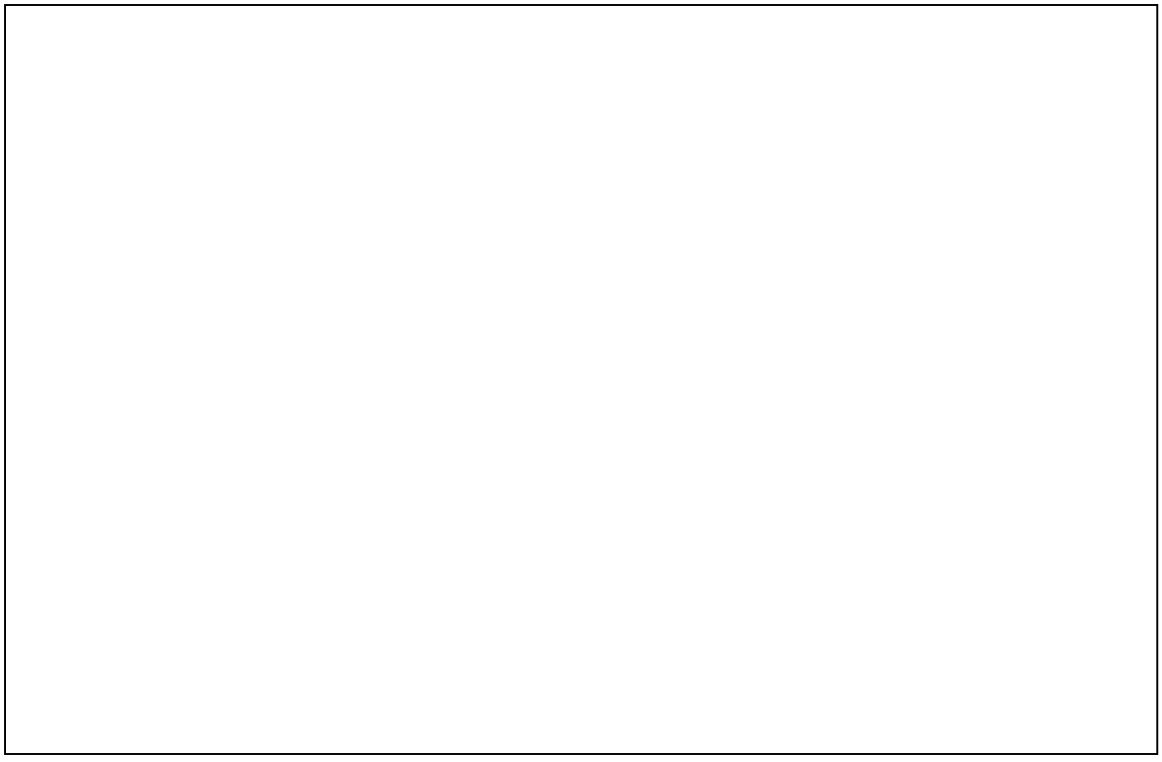
The widespread application of these concepts would see a growth in the appropriate use of structural timber. The appropriate use of structural timber would see economic benefit to building owners, structural timber product manufacturers, the New Zealand economy in general due to the contributions of the Forestry Industry, and ultimately environmental benefit both regionally and globally.

Timber, its got to be good for you !



Photograph 1. Gulf View Towers Apartment Building

Photograph 2. Centennial Swimming Pool Building - Papatoetoe



Photograph 3. Fox Street and Picton Street Apartment Buildings

CASE STUDY

Andrew Charleson School of Architecture, Victoria University of Wellington, Wellington, New Zealand

Small and beautiful - timber structure at domestic scale by Andrew Charleson, Senior Lecturer, School of Architecture, Victoria University of Wellington.

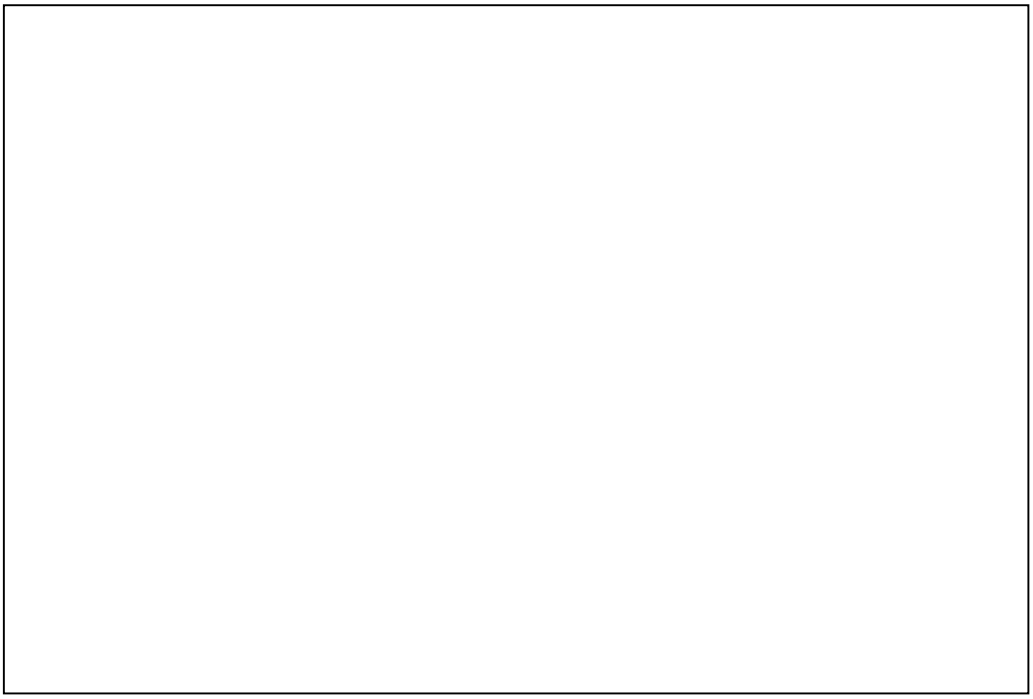
The architectural brief was challenging: a steep narrow site, admittedly with a northern aspect, a restricted budget, a high stud height and no gibboard! The client also needed a spacious area in which to play her violin, and was keen to use natural materials wherever possible. After years of living in a house at various stages of completion she could not bear to paint another wall. The solution, an exquisite timber house that treats the senses.

Upon entry, the distinctive fragrance of macrocarpa reinforces the visual delight of the main space. In plan, only 3.9 m wide by 10 m long, the space is subdivided into central four equal bays of 2.7 m by vertical trusses rising from the concrete slab floor to the ply roof diaphragm above the second storey. Although the space is subdivided, the openness of the timber trusses allows the whole space to be experienced from anywhere inside. The structure contributes architecturally in several ways. As well as cantilevering to resist lateral transverse loads, trusses modulate or subdivide the ground floor plan. Bays between trusses have been put to specific uses; an area for lounge furniture, the dinning room table, a kitchen, bookshelves, and so on. Along the northern wall the trusses support the double glazing, while opposite, they project out from the macrocarpa diagonally sarked wall to carry a mezzanine walkway above. To allow for circulation the top half of the trusses are transformed to function as portal frames. The trusses are interesting and attractive elements in their own right given the geometry of their structural form, the golden mellowness of the timber, and attention to detail.

Construction details have been carefully attended to. With no internal linings and all studs exposed, detailing is all important. The trusses have bolted connections, and to achieve the required refinement, concealed nail-plates have allowed a single bolt per chord-web member connection. Elsewhere, detailing is to a similarly high standard. Some delightful touches are afforded by the exposed studs. Consider for example the towel rails and shelving set between studs. In such a narrow house not one millimetre of width is wasted.

Essentially the house is box-like in form. However, front and back doors at each end are signified by recesses in plan and two freestanding trusses at right angles to each other. Again, trusses are doing far more than load bearing. Not only do they provide a visual link between exterior form and interior space, add visual richness to the exterior composition, they also function as latticework for climbing plants.

This house is an example of excellent timber design. With a combination of innovative conceptual design, and considerable refinement of details, Melling:Morse Architects with Martin Meyers Structural Engineer, have exceeded the expectations of a delighted client. In so doing the designers have shown the potential for structure to make a significant architectural contribution in a domestic context.



Photograph 1. View along the house with the glazed wall to the left and two vertical trusses in the foreground.

Photograph 2. Interior view showing how the vertical trusses modulate the interior space