Project Ethos

Aesthetic Refinement of Pres-lam Structure.

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I. ACKNOWLEDGEMENTS

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II. ABSTRACT

Research Question: How might the Pres-lam structural system be aesthetically refined in order to both impart a sense of safety to the users of such a building as well as express its structural function?

The Pres-lam structural system has been applied in a mere few buildings currently, fewer still express the structural system in any meaningful way. If this relatively new system is to be more widely acknowledged and revered, we must explore ways in which a built example may effectively communicate the structural actions of the system as well as express the safety its inhabitants would be granted with regards to seismic activity and post-disaster habitability. It is this industry attitude towards structural expression, specifically in that of Pres-lam, that is expressed in the working title, Project Ethos.

Analysis of the structural function of Pres-lam reveals the most feasible aspects of the system for expression to the user. Rocking and re-centering motion of the engineered timber shear walls are made possible by the internal post-tensioning cables as well as external mild steel dissipaters that may be replaced after acting sacrificially in a seismic event. Further to this, historical influence is taken from the architectural styles of High-Tech Architecture as well as Deconstructivism.

The first two mid-rise buildings in New Zealand to explore this system in a wider sense give precedence for the attitudes taken towards the structural expression of Pres-lam. The first example, NMIT's Arts and Media building, shows a level of internal structural expression aimed at communicating the raw detailing technicalities to industry professionals, while the second example, the Carterton Events Centre, makes critical use of Pres-lam to ensure post-disaster habitability but makes little attempt to express the structural system in any meaningful way.

This designed outcome proposes a multi-use mid-rise building in the earthquake affected town of Kaiapoi, and explores various methods of direct as well as indirect expression of the Pres-lam structural system in order to communicate the inherent structural actions while imparting an aura of safety to the users.
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1.0 PART ONE - RESEARCH

1.1 INTRODUCTION

While there have been projects undertaken, such as the Arts and Media building at the Nelson Marlborough Institute of Technology (NMIT), with the express purpose of showcasing Pres-lam as a suitable structural system as well as the viability of multi-story timber construction in general, there may still be room for development with regards to the way in which such a system is expressed and the way that this affects the user’s perception of space as well as the built form, both structural and architectural.

The expression and perception of architecture, however subjective, can have a profound effect on the mind of the user. It is this interaction that this project aims to leverage through the aesthetic refinement of the Pres-lam structural system. Following through with the recently observed trend in commercial architecture within the Christchurch/Canterbury rebuild of simple structural exposure in the visual sense, of columns, beams and diagonal bracing members, one could postulate further and more meaningful structural expression is possible when the structural elements themselves are made the focus of a design.

The following research elements have been aimed at increasing the legitimacy and relevance of the final outcome by providing an external point of reference against which the designed building may be assessed. Firstly, an exploration of the Pres-lam structural system as it exists now will provide the base for aesthetic refinement, followed by a rigid set of aims and intent. The historical styles of High-tech architecture and Deconstructivism are then explored to provide the needed external reference points. Finally, case studies of the Arts and Media building at NMIT as well as the Carterton Events Centre have been made to establish the current state of Pres-lam structure in architecture.
1.2 PRES-LAM STRUCTURAL SYSTEM

History/Origin in PRESSS

The precursor to the Pres-lam structural system was the Precast Seismic Structural system (PRESSS), a similar system of post-tensioned columns, beams and externally mounted shear walls, though in concrete. Developed by the University of California in San Diego, the PRESSS system was tested with a five storey building with the intention of providing a more practical concrete construction solution for commercial applications.

It is upon the principles and ideas of this post-tensioned concrete structural research that the newer timber Pres-lam system would be developed, as suggested by the objectives of the original PRESSS testing; “To develop new materials, concepts, and technologies for precast concrete construction in different seismic zones.”

The ideology and structural actions of the PRESSS system are quite similar to those of the Pres-lam system with the exception of sustainability, with timber providing a much more environmentally friendly building material. The ideology of the Pres-lam system will be discussed in the following paragraphs.

Another point to consider is that while this post-tensioned concrete frame system is a vast improvement over conventional concrete design, this research project is primarily concerned with the potential for aesthetic refinement, a point on which the timber Pres-lam system shows more promise.

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2 Nigel Priestley, “Preliminary Results and Conclusions from the PRESSS Five-Story Precast Concrete Test Building” PCI Journal, Nov-Dec (1999): 43.
Ideology and Technicalities of Pres-Lam

Earthquake Damage seen in the more common monolithic concrete construction as existing in Christchurch brought about a shift in ideology with regards to damage resistance in commercial buildings. While the status-quo was to simply avoid catastrophic collapse, allowing the occupants to safely evacuate, the financial as well as socio-economic losses intrinsic in the business downtime caused by repairs or relocation brought about an ideological shift moving closer toward damage mitigation. As Pampanin puts it, our societal expectations of seismic building performance and the reality we have been confronted with by the Canterbury earthquakes are quite mismatched³.

The deformation of internal reinforcing steel seen in figure 2 illustrates one of the main issues that Pres-Lam addresses. While the bars inside traditional plastic hinge deformation regions is a sacrificial effort to prevent complete building failure, this kind of damage is not seen as reasonably practicable or financially feasible to repair, thus either lengthy replacements must be undertaken or a relocation of the operations within the building must be made, referred to as “socio-economic loss⁴”.

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³ Pampanin, Reality-Check, 137.
⁴ Ibid., 137.
To combat the irreversible nature of damage to internal sacrificial elements, the wall base to foundation junction is redesigned to allow a certain amount of movement and, with the internal post tensioning tendons providing the re-centering action after lateral forces have been applied\(^5\).

The same logic has been applied at the column to beam junction, where rocking and re-centering motion has been allowed in order to minimise permanent structural damage and by extension socio-economic loss is also made negligible.

\(^5\) Pampanin, *Reality-Check*, 145.
The second element of the Pres-lam system is the externally mounted rocking shear walls, also developed from a similar component in the original PRESSS concrete system. Here, coupled timber walls of various kinds of engineered timber such as LVL, Glulam, or Xlam, are allowed to rock in a similar way to the columns. Internal post-tensioned tendons, along with further reinforcement into the foundations at the base of the wall act to re-center the structure after rocking movement\(^6\).

Further external dissipation to rocking movement is provided by the flexural plates by which the timber wall components are coupled. Due to that fact that these elements are acting as fuses absorbing seismic forces, they further reduce permanent damage to the building\(^7\). Also, to the relatively external placement of these plates, they are more easily replaced than internal reinforcing.

A tertiary aspect of the Pres-lam system, adapted from the original PRESSS concrete system, is the external mild steel dissipaters. Following through with the ideology of low socio-economic loss, the external dissipaters, also referred to as ‘plug and play dissipaters’, act as fuse link fixings where the necked zone in the center is sacrificed under seismic movement in the control of rocking motion. The external dissipaters were adopted as an alternative to the internal grouted mild steel bars due to the ease of replacement after the fuse fixing had done its job.  

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8 Pampanin, *Reality-Check*, 147.
Conclusion

The Pres-lam system was chosen to be the basis of this aesthetic refinement research project for a number of reasons. Firstly, the structural actions of rocking, dissipation, and re-centering provide a viable source of evocative motifs from which to form expressive mutations of the Pres-lam system. Secondly, while this research project is not directly concerned with sustainable design, more wide-spread adoption of timber structures in multi-storey commercial applications would provide a positive influence on the environmental impact of the construction industry. Thirdly, public perception of timber construction could be said to be more positive than that of concrete or steel with regards to aesthetics.

Further to this, the damage reduction/socio-economic loss mitigation ideology is perfectly suited to the chosen North Canterbury location for the designed project building, with regards to the psychological aspect of the Cantabrians who experienced the powerful earthquakes of 4th September 2010 and 22nd February 2011.
1.3 AIMS & INTENT

In order to tie the previously mentioned research elements into the design project, it is necessary to formulate a rigid set of criteria against which the final outcome may be analysed so that an objective judgement may be made of whether the design has been successful in implementing the goals of the research question. It is also critical that these criteria be tied into, and informed by, the external research elements in order to avoid the issue of circular logic or self-justification. Therefore, the following exploration of the research question in the form of success criteria has been made.

Research question: How might the Pres-lam structural system be aesthetically refined in order to both impart a sense of safety to the users of such a building as well as express it’s structural function?

To achieve the primary objectives of the research question, I have developed design parameters to define the project and how it will be resolved. Note that the hierarchy of the parameters is indicated by the associated letter, ranked in descending order of importance per aim.

Aim One: To impart a sense of safety to the user through the aesthetic refinement of Pres-lam structure.

Objective 1A: The overall/wider scale composition of the designed building should complement the sense of safety observed by the user.

Objective 1B: Where possible, the new ‘low socio-economic loss’ ideology should be imparted to compound the perceived sense of safety and security.

Aim Two: To visually express the structural function of Pres-lam through aesthetic refinement.

Objective 2A: The engineered timber shear walls should be altered in such a way that the rocking and re-centering actions can be expressed while retaining the physical core composition that allows said action.

Objective 2B: The external plug and play dissipaters should be visually redesigned in order to express both the rocking/re-centering action of the device as well as its sacrificial/replaceable nature.
1.4 INFLUENCE: High Tech Architecture

High Tech Architecture is the primary stylistic influence for this research project for the simple reason that it focuses on the honest expression of structure and technological influence.

Honesty of material expression (and by extension structural expression) is said to be one of the defining aspects of High-tech architecture. Exploration by Davies of works by Richard Rogers and Norman Foster uncovers a value placed on the ‘play of light and shade’ with regards to externally exposed and expressed elements of building technology as well as the specifically expressive potential of exposed structure\(^9\). Similarly, Hopkins observes that the exposed steel space frame of Rogers’ Centre for Visual Arts in Norfolk acts to ‘enliven an otherwise plain cuboidal form’ all while having the practical function of housing the building’s services\(^10\).

An exciting avenue for imbuing more refined meaning into this project building is the utilisation of influence from other industries. The example made for this point by Davies is the Oxford Ice Rink by Nicholas Grimshaw. The tensioned mast-like structure utilised to overcome the issue of low sub-soil bearing capacity was chosen for the suggested symbolism of power due to its visual ambiguity to that of a sailing ship\(^11\).

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However, it is also worth considering that an overt expression of building technology may also be overbearing. Hopkins makes reference to Richard Rogers’ Lloyd’s Building in London, using the phrase ‘Technophilia’ to describe the way in which the building’s technology is expressed in his opinion ‘bluntly’, drawing comparisons to that of an oil rig\(^\text{12}\).

In conclusion, these ideas from High Tech Architecture could influence the expression of this research design in a few ways. First, if a relevant industrial influence could be drawn from either the context of earthquake engineering and design or that of the proposed site itself, this could be incorporated into a range of expressive mutations of the Pres-lam system as long as this does not affect its primary structural duties. Furthermore, simple and honest exposure of Pres-lam structural elements is a given if it is to be expressed, however there will be enclosure detailing issues to resolve if the Pres-lam elements are to be expressed from both internal and external perspectives.

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1.5 INFLUENCE: Deconstructivism

Another source of historic guidance can be found in Deconstructivism, though seemingly to a lesser extent.

Firstly, one of the more common and widespread architectural tools that could be applied to this project is the metaphor. Abstracted meanings and iconography may be imparted through careful design of architectural geometry. The example made by Hopkins is that of Daniel Libeskind's Jewish History Museum in Berlin. Referring to the geometry representing a stylized Star of David as well as the axes of the building making physical reference to the places where Holocaust victims once lived.\(^{13}\)

Also, tying into the previously discussed High-tech Architecture idea of Influence from external industries, there is the Deconstructivist concept of Intertextuality. Conceived by architectural theorist Julia Kristeva, the idea refers quite simply to the way that the meaning of one text may be influenced by another.\(^ {14}\)

In conclusion, these few ideas from the post-modernist thought school of Deconstructivism may be applied to this research project in a few ways. If the purely structural elements of Pres-lam are able to be visually altered with the influence of external sources, a more meaningful aesthetic refinement may be made than would be achieved by simply exposing them. Further to this, such refinement could easily inform any amount of different metaphors, the challenge will be to guide this instillation in such a way that the meanings will not be lost on the general public.

\(^{14}\) Ibid., 340.
1.6 CASE STUDY: NMIT Arts & Media Building

The first building in New Zealand, as well as the world, to utilise the newly formulated Pres-lam system was the Arts and Media Building at the Nelson Marlborough Institute of Technology, acting as the first full-scale practical proof of concept that more sustainable timber construction practices could be applied to multistory architecture.

The new complex was constructed with three structurally separate parts as illustrated in figures 13 and 14 but the main focus regarding Pres-lam, and therefore this research project, is the ‘Arts’ segment. The vertical load is taken by the LVL frame, though they do not employ the external mild steel dissipaters developed by the University of Canterbury. Engineered timber shear walls are placed at each end along with perpendicular shear walls within the building.

To function as described in chapter 1.2 of this document, the engineered timber shear walls require a full length void internally to house the post-tensioning cables which anchor into the concrete foundations. In this application however, openings were left to provide access for monitoring equipment in order to carry this project’s demonstrative purpose\(^\text{15}\).

From the outside of the arts building the expression of the new Pres-lam system seems to be limited to direct observation of external exposure through the curtain walls, or the suggested geometry of the paired shear walls on the east and west ends.

However, this is not the fault of the designers as the intention is for the building to act as a technical example of structural technology. In an attempt to ensure that the building did not become purely an engineering project, Andrew Irving of Irving Smith Jack Architects explains that an aesthetic approach of reductive design and an appearance of effortlessness was utilised in order to communicate the fact that this building represents new cutting edge construction technology, as well as the fact that it is more sustainable in its use of timber sourced from within 80km of Nelson.

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16 Irving, Andrew, and Jeremy Smith, “Irving Smith Architects - the work | NMIT arts and media” YouTube Video, 3:10, Posted by “The Descriptor”, December 5, 2015. https://www.youtube.com/watch?v=URk9xErAaWI
With the exception of the ability to directly observe the Pres-lam frame through the glazed façade, there is little to no tangible expression of the new structural system observed from the exterior of the building, the internal expression however is much more noticeable.

Jeremy Smith explains that the building was designed to be legible, putting the detailing and technology on show, furthering the project’s demonstrative goal.

“We’re going to make this building incredibly legible, so that the New Zealand timber industry can go through it and can understand how it works.”

Considerations were also made from the perspective of the user, and how they will perceive the space in a non-technical way. Smith argues that the space needs to feel homely whether the user is there for the completion of a tertiary qualification or simply an evening class. He argues that the familiarity and warmth of exposed timber fulfills this goal.

Another viewpoint is taken on the matter of exposed timber structure in the Architizer project summary, arguing that these methods have acted to de-institutionalise the spaces, in addition to the aforementioned qualities of warmth and legibility.

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17 Irving, Irving Smith Architects, 1:50.
18 Ibid., 5:50.
In his explanation of the design and detailing, Smith also reiterates the ideology of the Pres-lam system, where rocking is controlled within replaceable dissipative elements\textsuperscript{20}.

In conclusion, the aesthetic and expressive outcomes of the NMIT Arts and Media Building could be seen as a product of the design ideology, which while being tied into the damage mitigation concepts of Pres-lam itself, was more focused on technical expression of joints, materials, and industry practices through direct exposure. While entirely valid, there would seem to be some room for development regarding external expression, ensuring that not only the users but also passersby will be able to read the building.

The designed building of this research project holds different contexts, sub-texts, as well as use cases, which will provide an interesting point of comparison in the way that this affects the visual expression of Pres-lam.

\textsuperscript{20} Irving, \textit{Irving Smith Architects}, 8:10.
1.7 CASE STUDY: Carterton Events Centre

The second building, both nationally and globally, to utilise the Pres-lam system was the Events Centre in Carterton, near Wellington. The design of this building offers an interesting juxtaposition on structural expression when compared to the NMIT Arts and Media Building.

The use of Pres-lam in the Carterton Events Centre came about as a practical resolution in regards to performance and cost requirements for the project; the rocking dissipative timber shear walls were able to provide the required building performance as well as the ability to rely on more sustainable local materials and expertise\(^{21}\).

Figure 20: Carterton Events Centre Northern Façade (Opus, 2011)

Figure 21: Pres-lam wall placement in Carterton Events Centre (Dekker, 2012)

A further practical consideration for the use of Pres-lam in this context was the use of the building as a civil defence point. While this was not the intention of the project, the client wanted the space to be available as a safe post-disaster building in case of a civil emergency. The rocking and re-centering nature of Pres-lam structure allowed this proposed use to be viable.

Finally, the interesting point of difference on the matter of structural expression with this building is that LVL shear walls are seen as a potential mismatch rather than an element to incorporate.

“The walls are within the architectural lines of the building and are non-intrusive to the architectural finishes of the building.”

This would of course align with the subjective nature of aesthetics in architecture, but would also suggest that the accompanying structural elements, finishes, and linings greatly inform the expression of the Pres-lam structure itself.

23 Curtain, Design of Carterton Event Centre, 3.
2.0 PART TWO - DESIGN
2.1 STRUCTURAL EXPRESSION

We often see structure and enclosure as completely insular components of architectural design and for the most part only see exposed structure because we do not deem it reasonably practicable to enclose, for example, a single column. So beyond the occasional example of exposed structural elements, how might we utilise the aesthetic effects of a system such as Pres-lam to enhance the human experience of a building in conjunction with the other design elements, rather than in isolation?

The first aspect to understand here is the currently understood differentiation of structural and architectural form. In the interest of exploring this difference, Charleson defines architectural form as “enveloping form or shape” specifically to preclude and separate the concept of structural form. This is in slight contrast to Ching’s somewhat vague description of architectural form as the external outline which governs unity for the whole. Structural form is then defined by Charleson as the “building’s primary or most visually dominant structural system” but also concedes that these structural elements are often out of sight or unceremoniously exposed.

The apparent hierarchy of enclosure or architectural form over that of structural form is reinforced in the views of Erikson, stating that structure is the dominant form-altering element, which unless decided on later in the project, will unduly affect other elements of the design. This research project on the other hand specifically aims to have the structural system express influence on other aspects of the design, affirming that the inversion of this suggested hierarchy would reap the most reward for expression of the primary structural system.

27 Ibid., 1.
Another aspect to consider is how the intended meanings or metaphors regarding structural action and safety are instilled into the design.

Perhaps instead of the easily misinterpreted author’s intended metaphor instilled in the design, one would utilise the structure to create something akin to an open book, something that is open to interpretation and holds the possibility of spawning any number of subjective interpretations as the user manifests their own meaning and their own story of what the building and/or structure means to them.

Further to this, consider that there might be a base instilled meaning of lesser complexity that would hopefully be more easily and consistently interpreted by the user, on top of which they would subjectively manifest the finer points of the narrative for themselves. For example, the narrative arcs of more interactive media such as story driven games provide the setting and context to the player, on top of which they make their own subjectively informed decisions about how they act in response to various situations. In this way a partial design narrative could be seen as the comparison to standard architectural metaphor in the same way that a game’s story could be compared to a linear story provided in more traditional paper media.
Figure 24: “Developed Vitruvian Matrix” (own sketch diagram)
Another area of exploration made here to further understand the developing aesthetic theory is a rethinking of the Vitruvian values of architecture not only in isolation but in relation to each other, especially in this project where the relationships of structure, aesthetics, and function are more closely related with regards to the project aims.

Here, the direct relationship of each element to its neighbour is considered as well as the way that those connections relate to the remaining third element, forming a full matrix through which to consider concept designs.

The most notable connection formed here is the one marked in green, where the connection of structure to aesthetics denotes the visual expression of structure while the perpendicular relationship of this connection to function denotes the way in which this expression is informed by the use or context of the building.

In applied terms, this reiterates the importance of deepening the meaning of the expression of Pres-lam in this design by tapping into the contexts of the locality as well as earthquake resistance.
Various elements of aesthetic design and structural detailing will influence the design of this research building and require some analysis and discussion of methods of application.

Firstly, **structural scale** refers to the comparison and contrast of small or fine structural elements with larger monolithic members; whether this is between primary and secondary structural system elements or between the structure and other architectural aspects such as the enclosure\(^2^9\). Ching builds on this idea with the concept of **structural proportions**, where the relative dimensions of a structural member can suggest the nature of the system or the size of the spaces within, due to the intrinsic relationship of greater size with greater resistances in some systems\(^3^0\). Charleson also adds that if structural scale is not properly considered, unintended readings may present themselves to the user, such as frailty of fine elements when contrasted to bulky ones.

> “Designers must decide whether or not to expose structure in these situations. If the scale of structure as compared to that of adjacent architectural elements or spaces might lead to unintended readings, such as the flimsiness mentioned above, perhaps the structure should be either enlarged or concealed if this reading is to be suppressed."\(^{3^1}\)

The potential application of this theory within the current research project would be to ensure that the exposed Pres-lam shear walls were the most dominant element, both of structural and architectural form, on the outside of the building and also possibly inside if expressed throughout an internal void. Also, the external dissipaters would be seen in this regard as a tertiary or perhaps auxiliary structural element, which is worth considering to ensure that there is a clear hierarchy of elements within the building so as to avoid clutter or contradiction.

These considerations are important if the design objective of structural expression is to be met. For instance, if the Pres-lam shear walls are not the dominant focused architectural element, it would be a challenge to ensure that expressive meanings within were effectively communicated.

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\(^2^9\) Charleson, *Structure as Architecture*, 63.

\(^3^0\) Ching, *Architecture: Form, Space, and Order*, 296.

\(^3^1\) Charleson, *Structure as Architecture*, 64.
Another interesting avenue for expression is the **connection of the external to the internal**. This connection is not necessarily literal or physical, but can allow the outside face of a building to suggest the structural system that repeats within. This would be a way for a structural element to be expressed externally that is not able to be physically exposed to external conditions. Charleson suggests however that this relationship may have manifested as an active opposition to the idea of facadism where the external face is a misrepresentation of a building's interior\(^\text{32}\).

This idea could be applied in the current project by linking multiple instances of the Pres-lam shear walls together in a visual manner on either side of the building enclosure. Further to this, simple external exposure of these timber shear walls would present multiple enclosure and weathering issues, and this method of implying the system externally without physically exposing it to the elements will prove very useful.

This is important to consider as, again, the design objective of structural expression of the Pres-lam shear walls would be much more effectively addressed if they could be accurately portrayed externally as well as exposed internally.

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Expressive roles will of course be a critical part of this design project but nonetheless Charleson’s exploration of the idea proves quite useful. He draws reference to Gothic cathedrals in the way that the structural load paths are made legible via the layout, scale and shape; referring to the buttresses and arch formations. The expressive roles carried out by structural elements would seem to be only limited by the skill of the designer and are therefore able to be misread and convey the wrong meaning just as easily as a more well-developed and intentional expression of stability could be.

The expressive roles of the Pres-lam for this project are already defined as they relate directly to the purpose of the structural system as well as the context of its development. This aspect does however tie in very closely with the next aspect of structural action, due to the nature of this project.

33 Charleson, Structure as Architecture, 70.
34 Ibid., 72.
Intrinsic to the aesthetic and expressive nature of this project is **structural action**. Defined as the adaptation of structural form in order to express its function, such detailing stands in contrast to standard unrefined detailing in that elaborations are made to better communicate the way the structure works\(^\text{35}\). Charleson makes the example of a portal frame base connection that tapers at the ends and connects to a steel baseplate rather than simply arriving at the foundation and being bolted in place. It is the use of this base plate and the angle that aligns with the structural stresses that express the structural action of the portal frame\(^\text{36}\). Another interesting way of approaching this aspect is in the deliberately expressed non-structural or weak nature of one element in order to emphasise the strength of another\(^\text{37}\).

In this research project, the expression of a non-structural lift ‘core’, which would conventionally be part of a concrete shear core, could help to suggest that the Pres-lam shear wall elements and the external steel dissipaters are the primary source of stability, and could help to emphasise the importance of this role.

This aspect could serve both the objective of overall perceived building safety and that of structural action expression by implementing differing levels of expressed strength or dissipative ability throughout the different Pres-lam structural elements as well as the other non-structural systems.

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36 Ibid., 147.
37 Ibid., 145.
Finally, the relationship of **lightness to heaviness** holds the potential to enhance the expression of Pres-lam in this design project by managing the perceived ‘visual weight’ of a structural element. One technique to lighten an otherwise heavy element to manage perceived intrusiveness is to chamfer or curve the element near its base. Furthermore, multiplicity of elements while also providing more basic benefits such as rhythm, can reduce the visual weight of the structure and render it less intense.\(^38\)

This could be applied to this research project by extending the shear-wall elements in an aesthetic, non-structural, curved manner which could potentially coincide with the applied theory from the earlier ‘internal to external’ aspect. Another way to manage the visual weight of the Pres-lam shear walls, possibly to increase the weight if deemed desirable, would be to place a perceptibly lighter element such as glazing adjacent to the shear walls. Proper management of this visual weight would ensure that the intended meaning of stability and structural action is not misinterpreted as overly intense or foreboding.

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Figure 28: Early concept for architectural expression applied additively to Pres-lam shear walls (own sketch)
2.2 SITE – KAIAPOI

In order for the specific design choices made regarding the aesthetic refinement of the Pres-lam system in this particular project to be properly understood, a brief exploration of the site and context must be made.

The chosen site sits at the intersection of the main road of Kaiapoi and the Kaiapoi River, which is a tributary of the Waimakariri River. Kaiapoi is advertised as an historic river town.

Kaiapoi was also one of the worst affected areas of North Canterbury during the earthquakes of 2010 and 2011, notably in the east Kaiapoi area along the river bank\(^{39}\). As a sort of ground zero for much of the seismic destruction in North Canterbury, including 35 other intermediary shakes over 5.0 on the Richter scale\(^{40}\), the chosen site works perfectly as a place to express structural stability and impart the idea of safety.


Figure 29: Site satellite image as at June 2009 (Google Earth, 2016)
Figure 30: Site satellite image as at January 2016 (Google Earth, 2016)
The site, formerly home to a selection of small shops as well as a tavern up at the river bank level, is now empty after the demolition of the aforementioned quake-damaged buildings, currently used as a temporary public car park as many such sites in the region have been.

The surrounding amenities include the local post-shop and a realtor’s office to the east with a New World Supermarket across the road. Directly across the road to the north is the Heritage Brick Bank of New Zealand building, now closed off due to earthquake subsidence damage and currently undergoing repairs. To the north across the roundabout, a new low-rise complex of shops and cafes has been erected as well as the new home of the local information center. Across the road to the west is a Christian fellowship church, with the Kaiapoi river bordering to the south. Across the river on the east side of the bridge is the newly complete Kaiapoi Public Library designed by Warren and Mahoney and finally to the west across the river is the newly refurbished Blackwell’s Department store.

Overall, the site and locality was chosen to provide the most suitable context for the expression of the Pres-lam system, due to its focus on earthquake energy dissipation and post-disaster usability. The residents of this area, including myself, were some of the most affected by the earthquakes and would therefore be the most appropriate users for this research project’s designed outcome.

Also, a brief note on the programme of the building to be designed. In the interests of having a realistic internal context for the building to be designed around, a programme of mixed use including retail, offices, hospitality, and an art gallery that doubles as a post-disaster civil defence point has been developed. It is important to note however that the aim of the research project is to explore the expression of the Pres-lam structural system and its effect on the users, not the effect on the programme.
2.3 ASPECT 1: Extension of Pres-lam shear wall elements externally

Over the course of researching both current examples of Pres-lam architecture and the wider context of structural expressiveness, one major shortcoming of current Pres-lam designs becomes clear. While in some small ways the engineered timber shear walls are exposed internally, little to no expression is made externally, likely due to enclosure and weatherproofing challenges.

The primary method taken for more effectively expressing Pres-lam structure in this project has been to ensure that the structural system is perceptible from the outside of the building just as much, if not more than, from the inside.

Firstly, the shear walls have been distributed throughout the building across the transverse and longitudinal faces as well as throughout the interior, providing the primary structural resistance to lateral earthquake forces in either direction. Note that while there are more shear walls on the west face than the east face, the engineered tolerances of the internal tensioning rods would be designed so as to provide equal dissipation on each of the opposite faces and avoid twisting issues.

Next, a few approaches have been taken to further express the shear walls externally. Due to the full height with which many of the shear walls are expressed, the potential for an overly intense or overbearing reading of the structure becomes possible; to combat this the theory of lightness to heaviness discussed earlier is applied. Curves at the base are applied in a non-structural but visually continuous fashion. The segments of the shear wall are then suggested to continue across the ground on the north side and on top of the stop bank on the south. This visually extends the shear wall elements, altering the perceived structural proportions, making the wall elements suggest the structural action of the tensioning cables within, which facilitate the rocking and re-centering motion.

Figure 37 (opposite): Pres-lam shear walls extended/curved on north face (own digital model)
To further embed this notion of tensioned cabling communicated by the tall slender segments of the Pres-lam shear walls, the visually continuous timber extension elements are continued up and over the roof, traveling back down through each side of the full height atrium, terminating in a loop on top of the stop bank. Practically, this provides sun shading to the outdoor areas on the roof, and lends visual continuity to the entire design. Metaphorically however, this further applies the expressive role of the shear walls partly due to the suggestion that these elements are ‘tied in’ to all parts of the building but also due to the symbolic formation of a seismograph reading, linking the design to both the recent local history and the context of Pres-lam’s development.

Also note that the shear walls on the east and west faces have been concealed externally with panel cladding to ensure the focus from the outside is on the ‘waveform’ travelling along the north to south axis.

The weatherproofing issue discussed at the beginning of this section has also been considered. While the gaps between the coupled elements of the Pres-lam shear walls, which allow for the flexural plate connections, are exposed on the interior face, the external side could not be, due to the need for enclosure. Conversely, effective expression of the structural system required external perspectives to also show the structure. Drawing from the concepts of the aforementioned ‘internal to external’ theory, the shear walls themselves are not directly exposed but rather suggested from the outside by timber facings and translucent paneling, forming a weatherproof detail that also allows further expression of the structure at night as light shines through the gaps.
2.4 ASPECT 2: Extension of Pres-lam shear wall elements internally

While the fully structural instances of the engineered timber shear walls are exposed to the internal spaces, further expressive devices are needed to impart any meaning further to simple structural exposure. In a similar manner to the way the external expression has been aided by the aesthetic continuation of the shear wall panels, the interior expression is developed through visually continuous elements running across the floor and along the ceiling at certain intervals. These internal aesthetic continuations are only extended out from fully structural instances of the Pres-lam shear walls so as to not appear as independent expressive elements. They are also curved upward at the atrium edge to form balustrades. Also, the components are made to coincide with the grid formed by the primary Pres-lam structure of post-tensioned columns and beams. The use of the same visual language to form parts of floors, ceilings, and particularly the balustrades ensures the expression of Pres-lam structure in this building is the main focus, while reducing visual clutter of elements that might have otherwise filled those roles.

Figure 39 (opposite): Bottom right: Structural Pres-lam shear walls. Top right: structural + external aesthetic. Left: Structural + internal extensions (own digital model)
Further to the previously mentioned effect of curving these visual elements to manage visual weight, the meeting of upturned timber balustrades on opposite sides of the full height atrium in the center of the building also references the local context of the building. The nautical theme of Kaiapoi as an historic river town is woven into the language of the building this way.

The final part of this internal continuation of the Pres-lam system is seen in the connection of the two tall shear walls at either side of the atrium, affectionately referred to as ‘the half pipe’ due to an earlier iteration of the concept with a much larger curve radius. Firstly, this connects the two continuous paths of expressed timber material as per the discussion in Aspect One ensuring the meaningful connection of inside to outside, but further to this acts to present the two tall shear walls as one folded element. This is an intentional inversion of the previously explored concept of ‘lightness to heaviness’. While the intention of ensuring multiplicity of structural elements would have been to lower the overall perceived visual weight or intensity of the structure, the intention of this project is to express the strength and safety of the Pres-lam structural system. Therefore, these two atrium shear walls have been allowed to appear as massive powerful elements, or rather one visually intense folded element suggestive of strength and safety, all while being tempered by the softening curved connection at the base.

Figure 40 (opposite): Internal continuation of shear walls at atrium base (own digital model)
2.5 ASPECT 3: Emphasis on External Dissipation

The external mild steel dissipaters at the floor to column junctions acting as sacrificial fuse links are one of the better sources of context for expressing the intention of Pres-lam. The sacrificial ‘plug and play’ nature of the dissipaters as well as the structural action of rocking and re-centering are the intended message to be communicated by the new design. Even if the user’s interpretation of the dissipater detailing does not relate to the actions it carries out, the high-tech aesthetic should also instill feelings of safety. Further to this, the local context can be woven into the building once again, via the utilisation of implied nautical materials to refer to the river town aspect of Kaiapoi’s identity. At the point of writing this document, the dissipater concept utilises intentionally severe geometries and materials reminiscent of a modern ship to both express the context of the locality as well as enhance the users’ perception of the detail as providing strength to the building and safety to themselves.

It is also worth noting that similar to the cables within the shear walls, the engineered resistances of each external dissipater can be modified to equalize overall resistance across the plan to avoid unequal forces during seismic activity; this also allows a degree of flexibility in the placement of dissipaters to achieve aesthetic goals.

The most dominant consideration by far for the redesign of the dissipaters was the way the rods can be removed and replaced with relative ease after performing during a seismic event. This has been suggested, firstly by the base connection point of the dissipaters being set into the foundation rather than connecting directly to it; the offset of the floor plane also mimics the direction that the dissipaters act during movement, further expressing the structural action. Moreover, the steel cover plate over the base connection rebate, as well as the industrial style lever handle on the column connection plate are by no means physically necessary, however these elements express the replaceable nature of the dissipaters to the users by drawing attention to the way in which they are removed and replaced.
2.6 MISCELLANEOUS DESIGN CONSIDERATIONS

A few further considerations for the overall plausibility of this concept have been made with respect to building movement under seismic loading. Firstly, the lift ‘core’ was initially designed as a concrete shaft tied into the primary structural columns and beams, however after speaking to a Joe Muller, a structural engineer colleague, it was made clear that this would be counter-intuitive to the structural purpose of the Pres-lam system. Due to the rigidity of a concrete core, lateral forces would first be resisted by this lift core instead of the engineered timber shear walls throughout the building, which would only begin to carry out their dissipative roles to the fullest once the concrete core had failed. This is of course opposite to the low socio-economic loss ideology of Pres-lam and thus the lift shaft has been redesigned to be non-structural as well as independent to a degree, being secured to the primary structure by slotted plate connections allowing a degree of movement. Similarly, the curtain wall glazing has been allowed a certain degree of flexibility through slotted channel fixing, once more reducing potential earthquake damage, and ensuring the building would be suitable for habitation directly after a civil emergency.

While the primary concern of this project is earthquake forces and the expression of the Pres-lam structure, a secondary consideration was flooding. In the event that the stop bank is breached and low level flooding were to occur, the second floor which would normally be art gallery space would become the primary post-disaster response space accessible from an entry located at the level on the south façade, above the top of the stop bank.

The incorporation of base isolation systems was also considered at an early stage. However, it was later discovered that the combination of two separate dissipative systems held the potential for the lateral forces caused by earthquakes to be amplified rather than dissipated. While both the Pres-lam system and the base isolation system would act to dissipate lateral movement on their own, it is possible for the two instances of movement to become unsynchronized and cause constructive interference. Though not a concern for the current project, this issue can be avoided through the use of expensive and time-consuming force modeling software.
3.0 PART 3 – CONCLUSION

The Pres-lam structural system is a relatively young one and will undoubtedly become more widely utilised as industry awareness grows. Important aspects of this process will include the public and professional perception of the system, its safety, stability and the way it resists or dissipates lateral forces. It has become clear from this research project that the extension of structural technology into expressive architectural elements is not simply a stylistic product of the 1970’s late modernist movement of high-tech, but also a valid means of communicating the actions of the structure and generating more general implications of safety.

The application of these theories in the industry at large could be applied to any structural system deemed worthy of expression by the designer, through careful analysis of the critical structural actions and conversion of these actions into visually legible metaphors. Furthermore, a differentiation of visually legible metaphor and simple structural exposure must be made. While many new buildings, especially in Christchurch, make simple honest reference to some aspect of their structural systems via direct visual exposure, many would not consider this to be architecture, but a product of engineering design. The primary examples of the extension/elongation of the shear wall elements and emphasis placed on the external mild steel dissipaters in this design aim to deepen the readings a user may make into the building, implying the structural actions of the post-tensioned timber products and instilling an aura of safety through emphasised critical detailing.

The design response to this research question has intentionally explored a more overt series of structural expressions, forming a combination of honest material exposure as well as modified detailing to allow potentially more meaningful perceived metaphors. Connections to the local context and the background of Pres-lam’s development are also made in the interest of ensuring the structural system is not being communicated in isolation but rather with a more inclusive recognition of its surroundings.


Irving, Andrew, and Jeremy Smith, “Irving Smith Architects - the work | NMIT arts and media” *YouTube Video*, 10:20, Posted by “The Describer”, December 5, 2015, https://www.youtube.com/watch?v=URk9xErAaWI


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