Feasibility of Multi-Storey Pres-Lam Timber Buildings: Design, Construction and Cost.

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By

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ABSTRACT

The aim of this dissertation appraises the feasibility, in terms of constructibility and cost, of the new patented Pres-Lam timber system developed at the University of Canterbury, New Zealand in collaboration with the timber industry. Engineered wood products (laminated veneer lumber) and a post-tensioned ductile connection are the key components of this technology. Pres-Lam can successfully be used in quality buildings with large open spaces, offering excellent performance against hazards such as earthquakes, extreme weather conditions or fire.

This feasibility study has been conducted by re-designing the concrete – steel structure of a 5-storey hotel in Pres-Lam. The timber design includes a detailed selection of structural drawings and some alternatives to the connections selected.

The results show that the Pres-Lam design is more environmentally friendly, faster to be erected and also cost competitive.

Keywords: Timber buildings, Multi-storey, LVL, Pres-Lam, Hotel, Post-tensioning

7. CONCLUSIONS.

The main objective of the research was to figure out if Pres-Lam as structural system is feasible for regular commercial buildings in terms of constructibility and cost.

The conclusions show that the new patented Pres-Lam system is competitive with other building materials such as concrete or steel. The following bullet points highlight the conclusions of this research.

- Constructibility of Pres-Lam is completely feasible with a high level of prefabrication off site. That fact entails several advantages such as: faster erection time, less amount of wasted material, meticulous tolerances achieved and improvements on health and safety. At the moment, the fabrication of LVL members is not developed and consequently, long procurement time and higher fabrication cost can penalise Pres-Lam.

- Faster erection by spending a little extra time re-designing and optimising the sequence of the construction, valuable on-site time can be saved. This case study shows that Pres-Lam erected by multi-bay frame system at ground level is three times faster than concrete frames and fifty percent faster than steel frames, both erected by platform method. Also, the erection of Pres-Lam requires less scaffolding, propping and crane- haulage.

- Cost effective. At the moment, the Pres-Lam structure costs only 5% more than the actual concrete-steel structure. The overall cost of the building by choosing Pres-Lam as structural system is practically negligible. Nevertheless, improvements in the wood industry will reduce the cost of fabrication significantly and this Pres-Lam technique can be a more economical alternative within a short period of time.

- Versatile system. Pres-Lam presents multiple alternatives at both, the design and the construction stages, making Pres-Lam as a very flexible construction material. In case of an unexpected issue during construction, a quick economical solution can be achieved. In this case study, once the multi-bay frame method was chosen, the Pres-Lam erection becomes a rigid system.

- Lighter material. Less weight of the structure means, in most cases, less foundations required but also, it implies less transportation and faster erection. This fact reduces possible disturbance like noise, traffic-issues, CO_2 emissions, logistic problems, etc. This case study shows that the Pres-Lam alternative is 40% lighter than the concrete-steel structure.

- Post-tensioning. The elements utilised for post-tensioning are products well known in the construction sector: Macalloy (or Dywydag) steel bars, tension strands and cables, couplers or high capacity hangers are universal standardised products. As well, standards like Eurocode 2 or NZS3101:1996 can be followed for this particular design. Nevertheless, a design guideline by STIC Ltd will be published in 2011.

- Composite materials. This case study is a valid example of good construction practise by combining different materials. In this case, concrete was perfectly compatible with timber for structural purposes. Although the design could have entirely been designed in timber, a sensible, best possible and effective design was reached by using concrete at underground levels and erecting the timber frame above ground level to avoid moisture issues.

In the Chapter 1, some questions to the research were listed. The answers to these questions can now be given:

Q1. How will the optimum Pres-Lam system be designed?

Gravity loads: floors, beams and columns.

Lateral loads: Frames in one direction and walls in the other direction.

Q2. What type of connections will be used?

The main frame and wall connections use post-tensioned steel strands. Secondary connections are joist hangers and other conventional timber connections.

Q3. How will all of the loads be transferred to the foundations?

The main path of load transfer from the roof is to the columns to the concrete box and into the foundations. Load from the floors is transferred to the frames and to the walls, then to the concrete box and into the foundations. For further info: appendix D.

Q4. Is Pres-Lam a flexible structural system?

Yes. Flexible in design and flexible in construction.

Q5. Are the constructibility of Pres-Lam systems feasible for multi-storey commercial buildings?

Yes. Feasible in terms of constructibility, erection time and cost.

Q6. Is the cost of Pres-Lam systems competitive against concrete or steel?

Yes, in this case study, the cost of structural Pres-Lam is similar to the concrete-steel version. This design indicates that Pres-Lam may be more economical than concrete or steel for structural purposes in the future, depending on the particular building design.

Q7. Is the erection of a Pres-Lam system faster than other traditional material for a five storey commercial building?

Yes. In this case, the Pres-Lam system is three times faster than a concrete frame and 50% faster than steel frames.

Q8. What standard of pre-fabrication can be achieved by using Pres-Lam?

The members can be totally prefabricated and partially assembled off site with little time needed for on-site works.

A complete set of 2D and 3D drawings of the proposed building is available on request.

8. FUTURE RESEARCH.

The develop of any new technology, independently of its nature, represents an almost endless source of research. The Pres-Lam system is not an exception and a large number of possible projects are defined in this chapter.

One of the most convenient improvement to the system is the industrialization in the fabrication of the timber members. The timber industry sector must focus in new automatized process and machinery to delivery the requested LVL members in shorter time and with a more competitive price.

Although flooring systems and cladding are being studied at the moment, the best possible solution for each singular design is not known yet. Research could be done in order to clarify all the different flooring systems available in the market, with its information about feasible span, depth of members and loads. Descriptive span tables and joist spacing for given loads would help the designer to chose between the different floor alternatives (TCC's, prefabricated double-T's, stressed skin panels, etc.). As well, a deep review of cladding opportunities could be listed.

According to the National Standards, the friction between column and beam is not considered when applying Pres-Lam (statement defined by its equivalent in concrete). This is a very conservative approach that increase the material needed to carry gravity

loads. Research can be done in order to determine a friction coefficient to empirically enhance the structural performance of the Pres-Lam connections.

Other possible research is the study of the Pres-Lam elements in other timber products like Glue laminated timber (Glulam), Parallel Strand Lumber (PSL), Cross-Laminated timber (CLT) or I-joists. This could increase the use of Pres-Lam in new markets and also it could increase the overall use of timber in construction.

The post-tensioned system could as well be utilized in other structural elements like roofing or flooring, for a larger, column-free, spaces (like swimming pools, sport complex, auditoriums, etc.).

Nevertheless, the Pres-Lam principles applied to multi-storey buildings for frames and walls are established and the main priority must be commercialise the use of Pres-Lam. Architects, engineers and public in general should know about this promising method of construction and the significant advantages of timber as construction material. Institutions are a well sector to start with.

The author also suggests to link and involve the patented Pres-Lam system with new Building Information Modelling technologies (BIM) to supply industry and customers with a large amount of information like, cost, erection time, drawings or sustainable data in a short period of time.