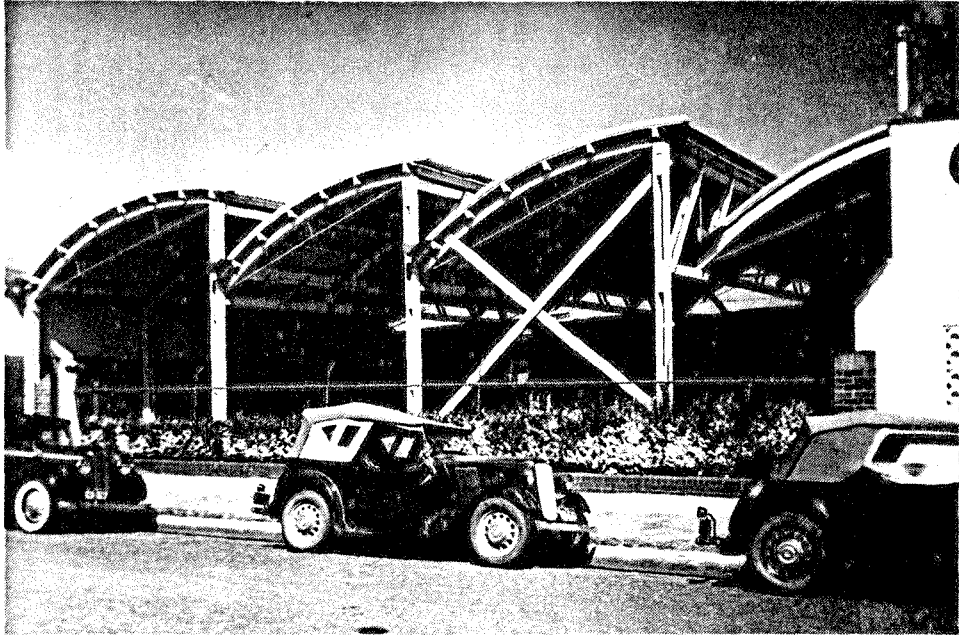


The Forgotten Long Span Timber Structures of Australia.

A Thesis for the Degree of Master of Architecture,



by

Bernard

Gregory Nolan

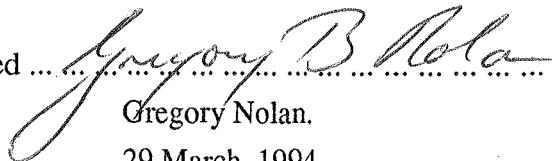
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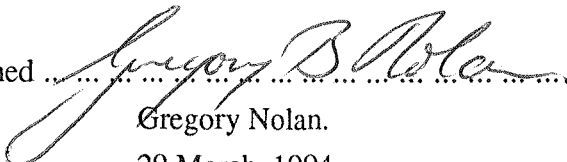
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October 1994

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29 March, 1994

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Though timber is a material of such fundamental importance in construction, and though it has been recognised since the earliest history of mankind, there is no material about which so little is generally known, and about which so many fallacies are widely and tenaciously held.

I. H. Boas 1936, September, p. 360

Synopsis

This research begins to gauge the extent and quality of long span or structurally unique timber building in Australia and to evaluate the conditions that lead to that building. Before this research, professional knowledge about Australian experience with timber construction had been limited to historic wooden structures built before 1915 and to the personal knowledge of individual practitioners. Sixty years of experience and development in building with timber in Australia seem unrecognised or unknown. This ignorance necessarily restricts current professional practice in timber construction as Australian designers can only draw inspiration from their immediate experience, their knowledge of local heritage structures or from international publications.

This paper identifies five separate construction cycles of long span or structural unique timber structures in Australia, establishes the main practitioners of each cycle, explores the reasons for each cycle's rise and decline and outlines the architectural and technical advances made. These cycles are:

- the Timber Bridge Cycle that began in 1860 and ended 1915. This cycle saw extensive timber bridge and building construction throughout Australia. The cycle is named after the network of timber bridges built throughout inland Australia.
- the Pacific War Cycle. This began in 1942 and ran to that war's end in 1945. It was a period of national reliance on wood and probably the most intense period of practical engineering and architectural experimentation in timber in Australian history. The longest span, the most varied and the most diverse timber structures in Australian history were built during this period.
- the Postwar Reconstruction Cycle. This cycle began in 1950 and ended in 1961. It coincided with the major industrial expansion of the 1950's and saw detailed experimentation with plywood and with the glue laminated arch form.
- the Australian Regionalist Cycle. Led by architects, this cycle began in 1962 and ended in 1975. It saw timber accepted as a desirable aesthetic and structural alternative to man made materials such as steel and concrete. The designers of this period experimented with a wide range of structural forms and techniques in timber.

- the Portal Frame Cycle. This cycle began in 1984 and came to a close in 1992. Exploiting the volume of industrial and commercial construction of the time, initially engineers embraced timber construction, refining the structural technologies of timber portal frame buildings. Subsequently the cycle broadened to include architects.

As each of these cycles contains its own key long span structures (or exemplars), this paper examines twenty four of these in detail.

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Introduction

Origins of the Research

Often, the questions that arise from professional practice cannot be answered without examining the underlying assumptions that govern a practitioner's actions. This research is one such examination and its main questions arose from specific experiences during the design and construction of a forest interpretation complex in the Southern Forests of Tasmania near Geeveston.

The first experience raised questions about the way society uses the resources it draws from the forest. At the Tasmanian Forestry Commission's Geeveston log yard, stockpiled craft logs were sold to the public. A few species did not sell well as the timber was regarded as unsatisfactory for building or unfashionable for craft use. Eventually, these logs were sent to the chip mill. As these logs were technically suitable for both building and craft uses, this raised the question of why this particular resource was not used to its optimum? In turn, this led to a more general question. If we discard these logs so easily and chip them, do we extract the greatest benefit from the logs that we retain? Is timber a resource we use with efficiency or one we use carelessly because it is an easy material to obtain and work?

The second experience raised questions about how design professionals (architects and engineers) view building in timber. While timber solutions were designed for a majority of sites in the Geeveston project, the immediate decision where a clear 27 metre (m) clear span was required was to design a steel structure. The design professionals involved believed from their personal practical knowledge that a timber solution was not a feasible option for this span given the design, production and technical capability that was available to them. Why was this? Was timber technically capable of high performance solutions such a 27 m clear span? If it was, why was it not available as a realistic option in this situation? As it wasn't, can professionals claim that they are using timber to its optimum in building applications under their control?

To combine the issues raised by these sets of questions, for Australian society to derive the maximum benefit from the materials it extracts from the forests, it must begin to ensure that forest products are used in the most highly valued applications available. As a large proportion of all forest products and the majority of timber in Australia are used in building, it is therefore necessary for design professionals to

use timber confidently in the high valued and long lasting building applications under their control. If they are not, as this example suggests, it is important to find out why.

Timber as a building material in Australia

Timber is an important building material in Australia and building in Australia is the dominant use of sawn and high value timber products. Of Australia's sawn hardwood and softwood production in 1990-91, valued at \$852 m (Industry Commission 1993, Table 3. 1, p. 49), and its imported sawn hardwood and softwood, estimated at 10.5% and 43% respectively of Australian consumption in 1990-91 (RAC 1992, p. 353), the building industry used 72% (BIS Shrapnel 1991, Table 2. 7, p. 11). In addition, a significant portion of Australia's veneer and panel production, valued at \$307m (Industry Commission 1993, Table 3. 1, p. 49), and its imports of plywood, 36. 8% of Australian consumption in 1990-91 (RAC 1992, p. 354), was also used in building of all kinds. Together, the sawn timber and board sectors represent 39% by value of all Australian forest products. So, in the absence of accurate statistics, it is reasonable to estimate that 25% by value of all forest products produced in Australia are used in the building industry and that the total value of sawn timber, veneer and timber panel consumed by the Australian building industry in 1990-91 was at least \$1, 000 m.

Timber construction dominates specific areas of building, especially in housing. Due to its workability and economy, 85% of wall frames, 40% of floors and virtually 100% of roof frames constructed in 1986 in Australia were made of timber (National Timber Marketing Committee 1987). Timber and timber products were then used in joinery, doors and personalised aesthetic fittings, such as polished timber floors, panelled doors, solid timber bench tops and timber panel lining. The perception of the brick and tile Australian home is in reality a timber building clad in a brick skin. Non domestic construction also uses significant quantities of timber and employs 10% of all Australian consumption for sawn timber products (BIS Shrapnel 1991, Table 2. 7, p. 11).

Timber is an important material to architects and to all designers and makers of artefacts. George Earle (1969, p. 223) described its attraction as:

The infinite shape plasticity of modern technology's production, made of materials and forms that deny any self identification in their total commitment to their function, is not easily related to man's experience with living. Instead the knotty, splintery, irregularly dimensioned, warping, shrinking, swelling, directionally grained, uneven strengthened piece of wood expresses better man's grasp on the imperfect realities of life.

Sydney architect, Stewart Whitelaw (1990, p. 16) observed:

Architects love timber. They love the feeling of scale, humanity and the tangible warmth that the use of timber brings to a space. Apart from the effect of natural light, it is difficult to imagine any other design decisions that can so radically alter the feeling of a space.

Timber has the potential to be a socially and environmentally sustainable building material. Judged by the seven criteria employed by the Resource Assessment Commission (RAC 1991, Vol. 1, p. 298), timber was the only material of the six major building material examined that was either renewable or biodegradable. It had the lowest process energy in its manufacture, using only 20% of the energy required to manufacture a similar weight of steel. It also had the most benign air emissions of the materials examined. More importantly for sustainability, the raw material for timber can be grown either in plantations or in conjunction with holistic agricultural practice near where it is to be use, the timber can be processed without major capital investment while producing useful by-products and little or no waste or pollutants, can be used without special equipment or skill and has strength and capacity that encourages efficiency of use.

Logically, there is a relationship between the potential economic, social and environmental sustainability of timber and its use as a building material because the building industry, and by inference the design professions that design the buildings and specify the use of materials in that industry, consumes or direct the consumption of 72% of all sawn timber and probably a similar proportion of other high value timber products. If timber is used intelligently and efficiently by the design professions and the building industry as a whole in long life, highly valued and intelligently designed applications then the potential for sustainable technologies to develop is likely to be greater than if the material is wasted in short life span, low value or poorly designed ones.

Given all these reasons, one would expect that Australia's design professions would maintain a developed understanding of timber and its use as building material in Australia. However, there is considerable evidence, set out in detail below, that the knowledge of the use of timber as a building material in Australia is restricted and that this limits the capacity of design professionals to use timber to the maximum benefit to society.

The loss of Australian repertoire in timber construction

In his exploration of professional practice, Schon (1983, p. 49) observed that:

... the workaday life of the professional depends on tacit knowing-in-action... In his day-to-day practice he makes innumerable judgements of quality for which he cannot state adequate criteria, and he displays skills for which he cannot state the rules and procedures. Even when he makes conscious use of research based theories and techniques, he is dependant on tacit recognitions (and) judgements...

Schon maintains that these tacit recognitions and judgements are based on reflection on past practice and experience.

The practitioner has built up a *repertoire* of examples, images, understanding and actions. (The architect's) repertoire ranges across the design domains. It includes sites he has seen, buildings he has known, design problems he has encountered and solutions he has designed for them... A practitioner's repertoire includes the whole of his experience insofar as it is accessible to him for understanding and action (p. 138).

This last point could apply equally for an entire profession as for a single practitioner: a profession and its constituent members can only reflect and bring experience to bear if they are aware of that experience and it is accessible to them. So, with the use of timber as a building material, if practitioners are to design in timber and use the material to its architectural, structural, economic and environmental potential then they must have a repertoire of timber solutions available to them on which to reflect and draw understanding. If that repertoire does not exist or is not accessible, then it is probable that the quality of Australian design in timber by design professionals is restricted.

It is a central premise of this thesis that the repertoire of Australian practice in timber available to design professionals is restricted to the timber buildings and bridges of which they have had personal experience or to those built before 1915. Cox, Freeland and Stacy (1980, p. 66) established the 1915 limit.

By the time it had been reduced to a few vertical brackets . . . at the outbreak of World War I, the last anaemic drop of vitality had drained out of timber construction in Australia. For the next fifty years, timber was ignored. Its virtues were forgotten and only in such ignominious and unseen places as wharves, mine heads and storage sheds, and as sleepers for railway tracks, were the Australian hardwoods used.

They then identified a new resurgence of timber construction in 1965 as 'a new generation rediscovered... the spirit and qualities of the legacy of the rude timber buildings (and) injected (it) into the twentieth century bloodstream'. However, the knowledge of this generation was lost by 1989 when Baker (1989) in a major report on the factors behind the acceptance of timber as a building material for

large public structure in Europe described Australia's tradition of timber architecture as:

There have been some fine examples of timber bridges, wharfs, woolsheds and houses. These examples are relatively isolated.

Beckett (1987, p. 40) held a similar opinion to Baker. In an article extolling the need to reach a Australian style of timber construction, his example of Australian repertoire was Percy Allan's timber approach spans of the Pymont Bridge in Sydney built in 1902. He added that:

... in New Zealand, Scandinavia... and France, timber engineered structures compete with steel and concrete, but not... until now in Australia.

Carrol (1988), in his work on 200 years of engineering in Australia, cites timber structures only twice; once for the first structures of white colonisation and then for Percy Allan's Pymont Bridge. Ward (1992, pers. comm., April) put it bluntly when he said that advanced timber building or architecture in Australia before 1970 was 'a black hole' as there was not enough structurally acceptable information to allow structures to be built effectively. Crews (1990), in his overview of research into the non residential building market for timber, called timber 'the forgotten material' of Australian structural design.

In 1992, a survey undertaken as part of this research program asked 120 Australian design practitioners and professionals and timber industry members to nominate three timber buildings in Australia they thought were important structures. Forty eight replies were received, yet only three respondents nominated buildings that were constructed between 1925 and 1975. Only one of these was an active design professional and only five buildings from this period of any type were nominated. None were buildings of Cox's new generation. Further, in an analysis of all replies, no single timber structure stood out as being generally recognised as important. Most respondents nominated structures they had designed or for which they had supplied materials. This suggests that Australia's design professionals are only drawing from their own work for reflection and not from a wider pool of professionally accepted and recognised solutions.

Though unrecognised, there is evidence that a wide pool of experience may exist. As stated above, Cox, Freeland and Stacy (1980, p. 66) identify valuable work in timber in the 1960's by a 'generation' of Australian architects with Cox (1982) maintaining that timber emerged as one of the most important building materials. Leicester (1988, p. 320) identified further important work, stating that:

Many remarkable timber structures were designed and constructed during the war (the Pacific War). These included 60 metre span timber arches for aircraft hangers, and 30 m glue laminated arches for storage buildings.

Even though Leicester continued that a major structural report carried out by the Dept. of Works and Construction into the condition of these wartime structures had a major impact on subsequent timber engineering technology, this report has not provided the basis for a repertoire of timber building as it is generally inaccessible.

In summary, therefore, there is significant evidence that there may be considerable Australian experience in timber but that that experience, if it exists, is not recognised by either the authors quoted or by the professionals and academics surveyed. For them, it is unknown and consequently inaccessible. However, as Schon pointed out, for professionals to advance the quality of their practice in timber design and construction that experience and the potential repertoire that it offers must be made accessible for reflection.

Research aims and limitations.

The aims of this research are to begin to establish a repertoire of Australian timber construction by:

- exploring the factors that have influenced the use of timber and timber products as building materials by the design professions in Australia; and
- documenting the extent of practice in long span or structurally unique timber structures in Australia.

Schon (1983) described research of this type as repertoire building research:

When practice situations do not fit available theories of action, model of phenomena, or techniques of control, they may nevertheless be seen as familiar situations, cases, or precedents. Repertoire building research serves the function of accumulating and describing exemplars in ways useful to reflection in action... In architecture, the idea of precedent has been associated with particular buildings,... with collections of buildings,... or with devices particular to a particular architect... Repertoire building research in architecture may go on to analyse how an architect thought of a problem he posed, the solution he found, the domains from which he drew the language of designing.

The research program followed two streams of systematic investigation. The first was an investigation of the practice situation that led to particular patterns or types of construction. This included the interrelationship between:

- the nature of the material;
- the industry that manufactured products from timber;
- the professions that used or could have used timber; and
- society itself.

The second stream was an investigation of Australian timber structures. As this was a richer field than originally anticipated, only structures unique to a structural type or with spans over 100 ft (30.5 m) were considered in detail. Differentiating structures by span and by structural type allowed for a manageable number of relevant structures to be identified and investigated. Long span or unique structures demand: technical sophistication by the professionals involved; confidence by those professionals in their own skill and the material they are using; a developed material supply industry; and a confidence by clients in both the material used in their structures and in the technical capabilities of the professionals that use them. One would expect to find this confidence during times when the design professions were using timber regularly with skill.

The methodology of the research was tuned to produce the repertoire or precedent Schon identified as necessary for reflective architectural practice. It was not conducted to produce an historical study of buildings as defined by Bell (1984, p.6).

Research Method

Information Collection and Storage

An initial literature research indicated that no complete work on Australian experience with timber as a building material was available. Therefore, the research method was developed on the assumption that one did not exist and that the information necessary to compile one would have to be first collected from original sources then collated. The primary information sources identified were practitioners: members of the design professions and the timber industry; and publications: books, reports and serials. It was anticipated that large quantities of information would need to be initially collected and stored before any synthesis was possible. To facilitate this, three computer databases were established. The first included information on individual timber structures and contained the name, location and designers of each building, descriptions of its construction, the names

of the owners and other contacts and literature references. The second database included information on timber practitioners and included address, area of practice, buildings constructed and literature references. The third database was more general and contained literature references on the influences of timber use, notes on practitioner knowledge and interview notes. A listing of entries in the structures and practitioner databases is included in Appendix 1. A sample entry for each of these two databases is also included.

Practitioner Survey.

As no literature collection of Australian experience of timber building appeared to exist, a survey of practitioners was undertaken. This had two main aims. First it would provide a collection of buildings and practitioners that were recognised as important by those active within the field. Second, it would test the depth and subtlety of current knowledge about the use of timber as a building material in Australia. Two questionnaires were sent to each of 120 Australian architectural and engineering practitioners; timber industry representatives; timber industry members; academics and researchers in all architectural and most engineering faculties in Australia; all State National Trust organisations; and all State Forestry Commissions. The first questionnaire asked each recipient to nominate 3 buildings they thought were important timber structures constructed in Australia at any time since white colonisation. It specified that domestic buildings were not to be included unless they were considered exceptional. The second requested each recipient to nominate one important timber practitioner in Australia during the same period. Within one month of the questionnaires being sent, follow up phone calls were made to each of the recipients encouraging their participation. A copy of the questionnaires and covering correspondence is included in Appendix 2.

48 replies were received. Of these, 7 replied that they were unable to contribute due to lack of expertise. The contributions of the other 41 responses were included in the building and practitioner databases. The only structures that were nominated and not included into the databases were several repetitive domestic structures and 3 structures that could not be identified from the information supplied. As outlined above, only three respondents nominated buildings that were constructed between 1920 and 1975. These nominations included a generic reference to wartime buildings in Queensland, two office buildings constructed in Canberra, notable for their internal timber paneling, the Sydney Opera House and Symonds' Homebush Bay factory.

All the practitioners nominated by the respondents were current practitioners.

Published Information.

As stated above, an initial literature search indicated that comprehensive Australian works on the topic did not exist or were not readily available. Those works that were available and whose title or subject area indicated that they may have been of use provided little information. Most dealt with housing and house construction, wood and silviculture technology, or the history of particular timber companies, personalities or regions.

The recognised works that dealt with aspects of the topic fell into two groups; the first were historic works that looked back at timber structures. These included:

- *Rude Timber Buildings* by Cox, Freeland and Stacy;
- *Warehouses and Woolstores of Victorian Sydney* by Balint, Howells and Smyth; and
- *Spanning Two Centuries: Historic bridges of Australia* and its companion works by Colin O'Connor.

The second group was current works prepared from immediate experience. They included:

- *A report on the structural soundness of unseasoned timbers used in structures erected for war purposes* by the Dept of Works and Housing 1946; and
- *Timber Manual* by the National Association of Forest Industries.

A search of Post Graduate theses' titles and synopses revealed that the majority of works on timber were technical pieces for Masters of Materials or Building Science of little apparent value to this research. In all, only 10 titles deal with timber between 1955 and 1987. A national listing of undergraduate theses was unavailable.

The principal source of documentation on the topic was serials. The key publications were: *The Australian Timber Journal*, published between 1935 and 1973; *The Australian Forest Industries Journal (AFIJ)*, which succeeded the *Australian Timber Journal* in 1973 and has recently closed; the original *Wood World*, published between 1967 and about 1976; the current *Wood World*,

published quarterly since 1982; and *Timber Facts*, currently published by TRADAC. Design profession serials such as the RAIA's *Architecture Australia*, or the Institution of Engineers' *Journal* tended to treat timber usage as a sideline to either the building or the practitioner. They provided additional detail on particular structures if they have been identified from other sources. Inspection of serials published before 1935 proved unrewarding. Journals such as *Australian Builders and Contractors News* and the *Building, Engineering and Mining Journal of Australia* were examined in part but did not provide sufficient additional information to justify a continued effort.

The Results of the Search

The practitioner survey and the detailed literature search provided considerable base information that was entered into the prepared databases. The quality of the information collected was not uniform and some periods were not well covered. Most of the publications were regionally produced and even national publications had definite regional biases. Therefore while it was reasonably easy to establish if something did happen in one state, it was very difficult to be certain that it did not happen in another state at the same time. The largest gap in information was for commercial timber buildings constructed from the end of 1860 to the beginning of 1935. Unfortunately this is almost 75 years. While commentary on prominent public structures of this period was available, evidence of the less prominent was unavailable. In contrast, bridges constructed during this period are very well documented. Smaller gaps in the literature existed for all types of timber structures between 1945 and 1950 and between 1976 and 1984. The collected information fell into two distinct but interdependent types. The first dealt with specific aspects of timber usage in Australia. It included notes and articles on the level of use, the factors that influenced that level and the main personalities involved. The second dealt with the specific structures.

The available information was synthesised to establish patterns of use and groupings of buildings and practitioners to be investigated in more detail. At this stage, it became obvious that the available resources were insufficient to investigate all areas adequately. Subsequently, further research on the patterns of usage was restricted to cross checking the main streams already established. The primary research effort was then directed at the structures. The quality of information available on each structure varied. In some cases the designers of the building were still practicing and full information was available on request. In other cases, buildings were known only by a caption and a photo. These structures had

to be researched, positively identified and then located. In the extreme cases, this involved looking up the phone book for the particular city in the right year, obtaining an address and visiting the site to see if the structure still existed.

Site Inspections and Interviews

After detailed preparation, a 30 day field trip was undertaken to all State capital cities, Canberra and country areas in NSW, Victoria, Queensland and South Australia. During this journey over forty sites and structures were visited and photographed. If documentation for a structure did not exist, it was measured. Ten reference libraries or archives were visited. Over twenty interviews were undertaken with practitioners or timber industry representatives. The information originally collected from the journals in Tasmania was confirmed and enhanced. No new streams of information were uncovered.

These library searches and interviews confirmed that no other comprehensive research on timber architecture in Australia has been previously undertaken. Perhaps most indicative was an interview with Mr. Henry Llewellyn of Sydney. Mr. Llewellyn was the junior partner of Stanley and Llewellyn, consulting engineers very active in timber construction in the early 1950's. Now in his late eighties and retired, Mr. Llewellyn has not been approached about the firm's timber buildings by any other researcher. He was very generous in explaining the construction techniques employed and the technical and economic influences that determined the forms they used. Unfortunately, all records and drawings of these buildings were destroyed several years ago.

Chapter One

The Cycles of Timber Structures in Australia

1.1 Identifying the cycles.

In Australia since European Colonisation, it appears that long span or structurally unique timber structures have been constructed in cycles. Rising from a period of very little apparent activity, each cycle has waxed as key practitioners or practitioner groups exploited the economic, social and technical conditions of their times with a particular set of structural and aesthetic timber solutions. Then, as these conditions changed, the cycle waned until the practitioners working within that cycle, their expertise and their structures were apparently lost to professional memory. After a further period of apparent inactivity, a new cycle appears with new practitioners using a different set of structural and aesthetic timber forms. This rise and fall of activity defines a cycle yet each cycle has unique characteristics. The length of each cycle and the period between the waning of one cycle and waxing of the next were not regular. They varied as the economic, social and technical conditions dominant in Australia varied. As explained in detail below, the dominant structural and aesthetic forms of each cycle were unique and there is no evidence that the forms developed during one cycle were investigated and reapplied during a later cycle. Also, there is no evidence that any major practitioner in timber was active in the dominant construction forms of more than one cycle.

This research has identified five cycles of long span or structurally unique timber construction. These are:

- the Timber Bridge Cycle. 1860 to 1915
- the Pacific War Cycle. 1942 to 1945
- the Postwar Reconstruction Cycle. 1950 to 1961
- the Australian Regionalist Cycle. 1962 to 1975
- the Portal Frame Cycle. 1984 to 1992

The Rude Timber Building Cycle, which ran from 1788 to 1860, is identified here for completeness as its structures were obviously the first of their type in Australia but it is not investigated in detail as its structures are predominantly short span.

Each of the five cycles after 1860 is analysed in detail below. It must be noted however that this document includes only the first layers of information on each cycle. Each cycle requires further research.

1. 2 The Rude Timber Building Cycle 1788 - 1860.

This cycle of Australian timber structures began with the arrival of the First Fleet in Sydney in 1788 and is named from the title of Cox, Freeland and Stacy's (1980) publication documenting many of the buildings of this cycle. These were generally simple post and beam structures roofed with pitched rafters or rudimentary trusses. Spans were generally short, less than 15 m. The longest span structures of the period were bridges. Though the majority of bridges were simple girder structures, bolt laminated arch structures were built using British/European design technology (Fraser, 1985). The 1855 Denison bridge over the Macquarie River at Bathurst had five spans, with the largest three being of 27 m. This cycle ended in 1860.

1. 3 The Timber Bridge Cycle 1860 to 1915.

This was the period of great timber infrastructure works in every state in Australia. Of the cycle, bridges were the most recognised symbols of achievement in timber and the majority of long span timber applications. The cycle began in 1860 when William Bennet, Chief Engineer of the NSW Public Works Department (PWD) designed the first of NSW's five major timber truss bridge types, known as the old PWD type (Fraser, 1985). Leicester (1988, p. 318) described the period up to 1900 as:

... the most exciting era for timber engineering in Australia. Armed with the imported technology of structural mechanics and urged on by the railways to span wide rivers, the engineers of the time designed and built numerous remarkable bridges... Other remarkable structural uses of timber during the period were to be found in the development of power and communication networks, wharves and jetties, and of course, public buildings.

The dominant timber joint technology of this time used mortice and tenon or housed joints or simple timber compression seat. This limited design solutions as: these joints generally demanded oversized members since loads had to be taken by a member weakened by a mortice or a rod; mortice and tenon or housed joints had to be strapped to ensure that they did not open up due to movement in the timber or in the structure; and as it was not possible to achieve a reliable tension joint, steel rods had to be used as tension members. This technology was complicated by the numerous and varied qualities of Australian timbers as it was impossible at the beginning of the cycle to predict their characteristics accurately.

Two pin bolt laminated arch bridges continued to be built in several states before the 1880's and spans up to 27 m were achieved (O'Connor 1985, Nov). The originally imported design technology was adapted to suit Australian conditions and timbers and vertically laminated arches constructed from local hardwoods replaced the horizontally laminated arch originally employed and constructed from both hardwood and imported softwood. One example of the adapted type was constructed in 1876 at Angle Vale in South Australia (see Exemplar 14). It spanned 82 ft (25.0 m) and remains standing (Hawes, Legoe, Stacy and Young 1988).

Bennet pioneered the long span timber truss bridge and this was the most used and recognised timber bridge form of the cycle. His old PWD type timber truss was an adapted Queen post truss form. It was originally designed for spans up to 15 m but was later adapted to achieve a 100 ft (30.5 m) span. A 100 ft (30.5 m) old PWD bridge was built at Clarence Town in NSW in 1878 and remains standing. However, it was not the first timber structure in Australia to span 100 ft (30.5 m). In 1870, an American McCallum truss bridge was used to span 130 ft (40 m) over the Lachlan River at Cowra (Fraser, 1985). One further bridge of this type was built over the Richmond River at Casino in 1874. The first known Australian designed long span bridge was a unique 40.5 m span cable trussed bridge constructed over the Alligator Creek Bridge near the Fitzroy River in Queensland (Qld) (see Plate 1 and Exemplar 2). It was constructed in 1873 and remained in service as late as 1960 (Cameron). In 1880, the 100 ft (30.5 m) cable stayed girder Maclean Bridge over the Logan River in Queensland was completed.

In 1884, J. A. McDonald designed the second NSW timber truss bridge type. This had standard spans of 65 ft (19.8 m), 75 ft (22.9 m) and 90 ft (27.4 m) and was constructed up to 1894. In 1893 he adapted this standard design for the composite timber and steel Cowra Road Bridge over the Lachlan River (see Exemplar 6). This bridge had three 161 ft (49.1 m) mansard trusses. In 1893, Percy Allan designed the third NSW timber truss type with a standard span of 90 ft (27.4 m). In 1895, he extended this sophisticated design to span 110 ft (33.5 m) and used it for the bridge over the Murrumbidgee at Wagga Wagga (see Exemplar 5) and for bridges at Morpeth and Inverell, all in NSW (O'Connor 1985). With a wider carriageway than its predecessors, the Wagga Wagga bridge was the biggest timber structure in the Colonies at that time. Numerous Allan truss bridges were built until as late as 1929 and in 1984 about 80 were still in service (Dept. of Main Roads NSW, 1987*). Besides these three timber truss bridge types, two composite

steel and timber truss bridge types were developed in NSW. These were the De Burgh truss built from 1899 and the Dare truss built from 1903 (See Plate 2).

By Federation, the timber truss bridge form was fully developed and it was used for long span applications until 1934. Many of these truss bridges remain standing. It was the peak form of the period and was refined more extensively in NSW than in any other state. Only in Queensland were the engineers more adventurous in form. Most other states abandoned timber earlier or did not have the number of bridges to build.

The first known 100 ft (30.5 m) span building in Australia was the Garden Pavilion built in Sydney for the International Exhibition of 1879. Designed by James Barnet the building was built predominantly of oregon and was crowned by a 100 ft (30.5 m) span dome. This was a 36 sided polygon dome supported by 12 main arch ribs and 24 minor ribs, all in timber. It was 154 ft (47 m) high at the apex and sprang off a semi-circular drum. When built, it was the largest dome in the Southern Hemisphere and the sixth largest in the world (Latta 1986, p. 136). It was an exceptional structure however and the bulk of timber structures of the period were more restrained post and beam type factory, commercial or storage buildings

Knowledge of Australian timbers increased during the cycle. In 1894, the Professor of Engineering at the University of Sydney, William Henry Warren (1894) systematically tested the characteristics of about 60 species of Australian hardwoods. He tabulated the results and set out expected performance for them in engineering uses. He also advised on practical timber technology,

Generally the best timber is that which has been grown slowly upon a soil rather dry than moist, and it is compact and heavy, the annual growth rings being narrow and uniform. Timber should show a hard clear surface when cut and should be free from clefts, radial cracks, cupshakes, or cracks between the annual rings. The timber should be felled either in mid-summer or in midwinter, when the sap is quiet, the latter is preferable.

From this auspicious beginning, Leicester (1988, p. 319) maintains that:

About the turn of the century, timber lost its pre-eminent position as a structural material. This was partly due to the fashionable attraction of the new structural materials such as wrought iron and reinforced concrete and partly due to the problems related to the maintenance and durability of timber structures sited in exposed locations.

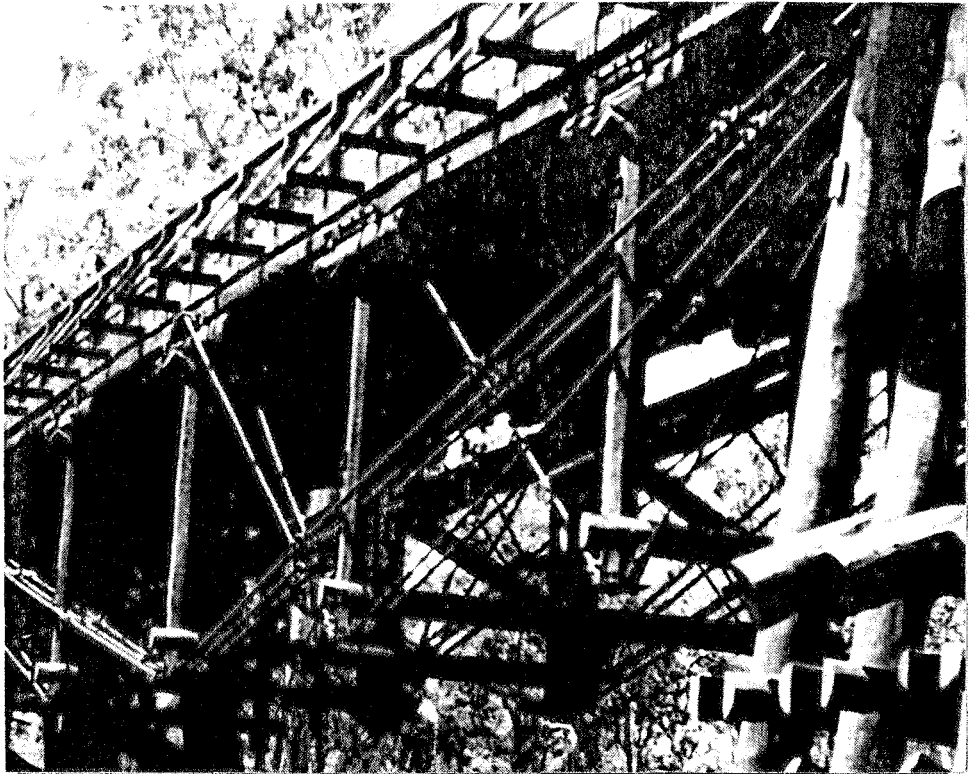


Plate 1. The Alligator Creek Bridge near Yaamba, built in 1873. Photo: Courtesy of Transport Queensland.



Plate 2. The 31.7 m composite timber and steel Dare truss bridge across the Murray River at Howlong in NSW, built in 1908.

In many Australian States after 1900, iron, steel and concrete bridges were generally constructed in preference to timber ones but timber was still relied upon for economic bridge construction. Doak (1935, p. 187) noted:

In Queensland the availability of large quantities of first class hardwoods has had a very important bearing upon the choice of timber for railway bridges in preference to such materials as steel and concrete... It was probable that the majority of engineers did not fully appreciate the great durability of Australian hardwoods... It did appear not unreasonable to anticipate an average life of 40 years for girders and piles in railway bridges... The life (of road bridges) must have been 80 years or more. Although it is customary to speak of these decrepit old structures with contempt there is no doubt that they have been an excellent investment.

Little documentation has been found for timber buildings constructed between 1900 and 1930 although it is known that large timber structures such as wool stores, warehouses and wharf buildings were built all over the country. The available technology generally restricted the main forms to post and beam structures with King and Queen Post trusses, etc. (See Plates 3 to 6). Of these buildings, Perry House in Brisbane is notable in that at nine stories high and built in 1912, it was reported to be the tallest timber framed building in Brisbane. It has been renovated and is still in use as an office building. Besides these heavy industrial buildings, several architects were using timber in fine and considered ways at this time. Notable was R. S. Dods with his All Saints Church at Tambrookum, constructed in 1915 and his numerous houses.

As Cox, Freeland and Stacy (1980) and Fraser (1985) described, the timber bridge cycle ended in 1915 though the last long span timber truss bridges were not constructed in NSW till 1934 when the Depression forced a short revival of timber bridge building. A period of apparent stagnation in timber construction followed, even though significant technical developments were introduced and considerable research into timber engineering was carried out in Australia (Leicester 1988 p.319).

When the *Australian Timber Journal* (ATJ) was first published in 1935, a forum opened for discussion of the development of timber structures, the evolution of timber technology and the cultural acceptance of the material.

Let us make more propaganda for the use of timber. The necessity for an intensive propaganda for the use of timber is apparent when one sees how steel, concrete and other materials are ousting gradually timber in every direction. (ATJ 1935, p. 3)



Plate 3. Heavy green hardwood posts and struts on the ground floor of the IXL Jam Factory in Hobart which is the University of Tasmania's Centre for the Arts.

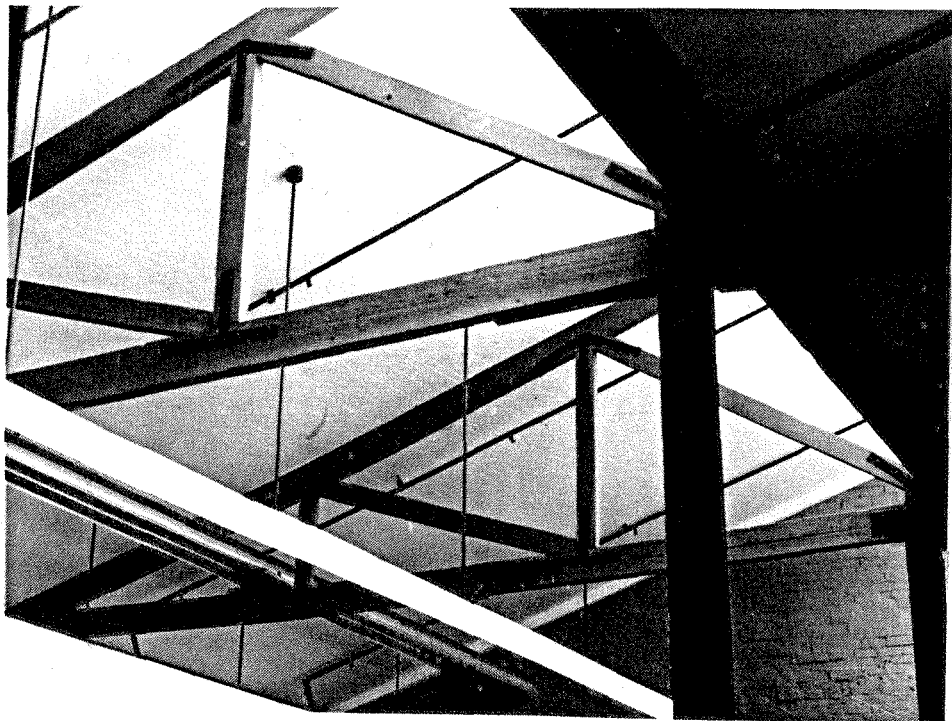


Plate 4. Oregon mortice and tenon trusses held together with steel brackets form this saw tooth roof, IXL Jam Factory.

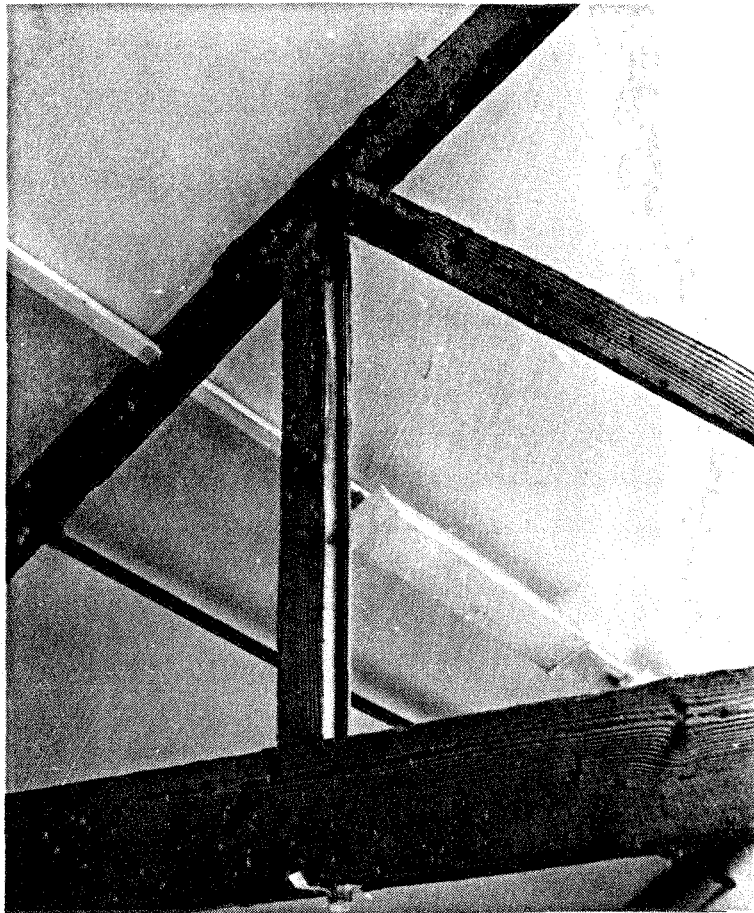


Plate 5. Oregon trusses with steel strap joints and tension rods. IXL Jam Factory.



Plate 6. A cast iron corbel serves to cap the green hardwood post and support the bearers and posts above. IXL Jam Factory.

In this first of many articles on the need for concerted action within the timber industry, a pattern of debate that ran through till the present day began to be established. Though mainly conducted as editorial statement, it concerned three active groups; the timber industry; the design professions; and the research bodies, predominantly the Commonwealth Scientific and Industrial Research Organisation (CSIRO), its predecessor, the Council of Scientific and Industrial Research (CSIR) and the State Forestry Commissions. In its various guises, the debate concentrated on factors influencing the technical acceptance of timber in construction. The main two were established quickly as quality control and the structural uncertainty associated with using timber products. Discussion of the aesthetic or constructionally desirable characteristics of timber rarely occurred.

In 1935, Australia was still struggling out of Depression. Besides the general malaise, timber researchers in the CSIR had specific problems to face resulting from timber's long traditional acceptance. Boas (1936, September, p. 370) noted:

There is no material about which so little is generally known, and about which so many fallacies are widely and tenaciously held (than timber). That this is so is by no means entirely the fault of timber users. They have inherited the fallacies from earlier generations, and the timber industry themselves held most of them until quite recently. The fact is both producers and users of timber had no alternative material to use and accepted it with all its supposed inherent disadvantages without much consideration... Many Architects and builders still have a fear of kiln dried timber which is entirely unjustified... Little use is made of the inherent qualities of the native hardwoods and they are used in sections far larger than is necessary, thus creating a fallacy that they are too heavy and considerably increasing the difficulty of drying. In this consideration designers are greatly hampered by building regulations based upon old practice using softwoods, and one of the outstanding problems is the modifications of these regulations to suit our own materials.

The forest products industry's major focus at the time was the perceived need to maintain and increase timber usage in the construction of the Australian house. As the effects of the Depression receded, Governments undertook large slum clearance and housing reconstruction programs. Unfortunately, timber houses were regarded as both unhealthy and fire traps.

The question of the wooden house is ... one on which I think many Municipal Councils generally have the wrong ideas. Firstly there is the widely held idea that wooden houses form slums. This is entirely erroneous. (Boas 1936, October, p. 390)

While of obvious importance, the prominence given by the timber industry to the material's use in housing at this time was repeated with monotonous regularity throughout the following years. This could have been a natural response by the industry as design professionals moved increasingly towards iron, steel and

concrete for large scale construction. However, it could also be that the industry's reluctance to address the problems perceived with timber as a major engineering material and its decision to take the easy course encouraged this move. Whichever the case, while advances in timber technology outside Australia made large timber structures more feasible, steel and concrete dominated the Australian construction market.

Leicester (1988, p. 319) noted:

The years 1920 - 1940 saw a period of intense development in research towards timber engineering technology... Several independent research studies were undertaken by various universities, state forestry commissions and railway authorities until 1930 when the CSIR decided to commit a major effort towards research in timber engineering through its newly formed Division of Forest Products.

The *Australian Timber Journal* reported much of this local and international research in extensive articles. In February 1937 the first of these outlined the development of shear connector technology.

During the latter part of the World War (I) and the ensuing reconstruction, many European engineers... developed a wide variety of timber joint connectors, which found an immediate application in wood structures, designed on a strict engineering basis. (ATJ 1937, p. 44-48)

The first structure erected in Australia using split ring connectors was the 112 ft (34.1 m) high forest lookout tower constructed in 1935 at Kirup in Western Australia. It was also the first known usage of split ring connectors in hardwood in the world.

The tower was designed and its construction supervised by Mr. Ian Langlands, Timber Mechanics Officer of the Div. of Forest Products, CSIR... It is a self supporting structure in a 20 ft (6.1 m) square base with concrete footings. The corner posts range from 8 ins x 8 ins (200 x 200 mm) at the bottom to 4 ins x 4 ins (100 x 100 mm) at the top. The tower has been designed to stand a 100 miles per hour gale... With the exception of the stairways, cabin and splice cover plates for which seasoned jarrah was used, the whole of the structure was built with absolutely green timber. Jarrah being used throughout. (Forests Department WA 1939, p. 694)

In March 1937 a second article (Morath 1937, March) outlined the development in glue technology while in April 1937 a further major article (Morath 1937, April) outlined the history and development of plywood and its use in construction. Plywood manufacture was already well established in Australia by this time. In 1929 Ralph Symonds of Sydney built a varnished waterproof plywood speed boat. It was supposedly the first attempt to use plywood for marine purposes (Hochroth 1987, p. 2). By the mid 1930's Symonds had set up a formed plywood division

producing 4. 6 m long curved plywood panels that were used as ceilings for trains and trams.

In April 1938, the newly formed Timber Development Council reported on its activities. Recognising the need for professional support of timber, the Council approached the Royal Australian Institute of Architects...

on the general question of timber framed construction... It was suggested that members of the Institute should enrol as members and even accept office on our Council. The Council of the Institute decided, however, that its members should be free of any implied entanglement, as the architect's profession demanded that he should always maintain complete freedom of outlook and an aloofness from personal advocacy of any particular building material. (ATJ 1938, p. 144)

This is one of the few times recorded where architects as a profession were asked to contribute to the problems of timber construction. After this brief flirtation and rejection, architects appear very rarely in the debates conducted between the members and associates of the timber industry. The Council also commented on the most persistent problem for timber suppliers and a consistent worry for design professionals.

Members should also especially note that there was general complaint against supply of timber improperly graded and in many instances not seasoned as required and stated... Incalculable harm generally will be done, and much of the valuable propaganda work of your Council nullified, unless more attention is given to production and marketing of timber fully up to the standards and degrees of seasoning now determined for the trade by the Standard Association of Australia. (ATJ 1938, p. 144)

Additional major articles on timber engineering were to appear in the *Australian Timber Journal* before the end of 1939. The most notable, written by the Division of Forest Products of the CSIR, was published in November 1938. This article concluded:

Another outstanding development in the last decade is the development of gluing as a means of building up timber structures. Tests have shown that glued up beams, columns, arches, etc., develop the full strength of a solid member, and at the same time permit the use of smaller timber. Other advantages are that more effective seasoning is possible, lower grade material may be used in the more lightly stressed portion, and the structural members of practically any size or shape can be built up... The use of plywood for structural purposes is also rapidly increasing, particularly in housing construction... It will thus be seen that, contrary to the opinion one often hears that timber as a structural material is doomed, the evidence points to a greater use of timber in the future but perhaps not in the ways as we know it today. (CSIR 1938, p. 607)

In early 1939, the CSIR published its Technical Publication No. 32; Handbook of Structural Timber Design by J. Langlands and A. J. Thomas. This was the first set of comprehensive design recommendations for building with Australian timber

(Leicester 1982) and was the culmination of the CSIR's research effort into timber engineering. The handbook simplified the problems associated with the variety of hardwood timbers by grouping species into strength groups.

By September 1939, Australia was at war. Originally, timber was not seen as a vital war material. Though Australia was a primary source of physical resources to Empire forces, the reality of the destruction of this war appeared as removed from the suppliers and designers of Australia in 1939 and 1940 as it had been during the first War. While many things happened overseas, very little of social substance changed at home.

(In 1939) the building industry was by far the largest consumer of timber... Instead of falling off during the early stages of the war as anticipated, civilian building activity was maintained during this period and in some States even showed a considerable increase due to the growing public interest in real estate as a war time investment. (Controller of Timber 1944, p. 357)

Not everyone was engaged in real estate speculation, however. In 1940, the NSW branch of the Timber Development Association (TDA):

working in close collaboration with the Div. of Forest products of the CSIR and the Forestry Commission of NSW have prepared designs for a transportable Bellman type hangar (a British developed steel hangar) made entirely from structural timber in commercial use in Australia and had submitted them to the authorities for consideration. These plans have been prepared by Messrs. Haskins, Davey and Gutteridge, Consulting Engineers, and provide for a building equal in size and strength to the steel type. (ATJ 1940, p. 478)

The building design was for an 85 ft (25.9 m) span portal frame constructed out of sawn hardwood, bolted with shear connectors. Though there are reports of Bellman hangars on several sites, all those inspected were steel buildings. No evidence has been found that the timber variant of the Bellman hangar was built.

During the first stage of mobilisation, civilian construction of industrial buildings was still without major restriction. In November 1941, a Sydney company launched a patented timber construction technique in a major article in the ATJ. Titled *The Lamella Roof* by R. M. Fletcher, this very thorough article outlined the possibilities, history and technical considerations of this form of construction. It also stated that,

All Lamella designs are prepared by the Lamella Roof Company in Sydney, in accordance with the architect's requirements. (Fletcher 1941, p. 473)

Langlands (1942, p. 155) lists lamellas as a new development in timber construction in Australia but no other records of the company or examples of their work have yet been found.

1. 4 The Pacific War Cycle 1942 - 1945.

On 7 December 1941, the Japanese Navy launched its surprise attack on the American Pacific Fleet in Pearl Harbour and on 22 December 1941, the first American forces arrived in Australia. As the Government began to order the resources of the Commonwealth for the nation's defence, it recognised that timber was now an essential war material. As a consequence, it established an office of the Controller of Timber and placed all the timber resources of the nation under its control. In his report of 1943, the Controller of Timber (1944, p. 345) detailed the scale of the use of timber for war purposes.

During the year immediately preceding the war, 1938/39, Australian consumption of sawn timber (native and imported) totalled 975 million super feet. Heavy wartime requirements superimposed on civilian needs would have meant a demand far in excess of supplies. Accordingly, civilian uses of timber were dramatically curtailed soon after the outbreak of hostilities, mainly by gradually tightening control of civilian building activities, total prohibition of which, without Government consent, were imposed as from the middle of 1942. By this means, the authorities were successful in keeping wartime consumption of sawn timber at about the same level as that pre-war... Wartime demand for construction timber has been exceedingly heavy.

As the numbers of Allied troops in Australia increased, the defence building program that had begun to wind down in late 1941 was revitalised and efforts redoubled to house personnel and equipment. To co-ordinate this mass of construction work, the government established the Allied Works Council (AWC) and from 26 February 1942, it assumed control for all defence projects for the Allied Armies. Centred in Melbourne, the AWC consisted of E. G. Theodore, the Director General of Allied Works, C. A. Hoy, the Director General of Works from the (Australian) Department of the Interior and Lieutenant - Colonel E. H. Heiberg of the US Corp of Engineers. Staff for the Council were drawn from the Works and Services branch of the Department of the Interior (Australian Archives).

In its 1942 - 43 report, the AWC (1944, p. 354) stated:

Confronted with a huge building programme to meet the requirements of war, and realising the necessity to conserve steel, the Allied Works Council's Directorate of Works quickly recognised the advantages of the use of Australian timber as a building material for large engineering structures... Allied Works Council Engineers quickly adapted themselves to the designing of all types of timber framed buildings and overcame associated difficulties... With the ever increasing demand for supplies of Australian hardwoods, came the difficulty of allowing sufficient time for seasoning. Finally the use of green timber became unavoidable. Green timber had not previously been employed in a major structural role, and its behaviour was a subject of experiment.

The AWC made other departures from accepted design practices in timber. They assumed that the structures would be temporary and to conserve materials, adopted wartime working stresses for the timber at least 33% greater than those recommended by the CSIR (Dept. of Works and Housing 1946, p. 6).

The war removed every major factor that had restricted design and construction in timber in this country during the preceding two decades. It severely curtailed steel supply for building. A single agency coordinated timber supply. Timber design technology and experience became available (from the Americans as well as from local professionals). Most importantly, an urgent demand existed for large structures. As a result, largely untried timber technologies became the foundation of most major building construction in Australia for more than three years. From its establishment in 1942 till its dissolution in February 1945, the AWC built thousands of structures all over Australia. Many of them were in timber (see Plates 7 and 8). The value of the projects it undertook was roughly equal to that of pre-war civil construction. Besides major structures, whole hospitals and military complexes were prefabrication and transported from the southern states to Queensland, the NT and to theatres of war in the Pacific Islands (Controller of Timber 1944, p. 357).

In 1946, the Department of Works and Housing undertook a major structural review of the AWC's work and reported on a detailed engineering survey of 327 timber structures constructed in 1942 and 1943 in all states except SA and the NT. The building categories reported were:

1. Wool Store Buildings (single storey buildings having simple rafters supported on columns at 16 ft (4.9 m) and 20 ft (6.1 m) centres.
 - a. Heavy Construction
 - b. Light Construction
2. Saw tooth roofed workshops and stores.
 - a. Buildings which include 75 ft (22.9 m) span Pratt roof trusses with split ring connected joints
 - b. Buildings with roof trusses of 60 ft (18.3 m) span or less
3. Aircraft Hangars.
 - a. 130 ft (39.6 m) span roof trusses with shear plates
 - b. 96 ft (29.3 m) span roof trusses with shallow and deep types with shear plates
 - c. Cantilever Workshop hangars

4. Arched stores and workshops.
 - a. 104 ft (31.7 m) span nailed arches (US Army design)
 - b. 170 ft (51.8 m) span nailed arches (US Army Design)
 - c. 170 ft (51.8 m) span nailed arches (AWC Design)
 - d. 95 ft (29 m) span glue laminated arches
 - e. 66 ft (20.1 m) span bolted arch ribs (Australian Army Design).
5. Curved-roof Inland Store Buildings.
6. Workshops with quadrangular roof trusses.

It is probable the AWC and other defence organisations constructed other major timber building types during the war. At least two other types of nail arch building were constructed. Of the 327 buildings inspected in 1946, the report classed 250 as sound, 48 as needing light repair, and 29 as needing extensive repair. Of the twenty nine needing extensive repair, seventeen were repairs required to Pratt truss types and eight of the remaining twelve were 130 ft (39.6 m) hangars. Excluding these two types, only four other buildings needed extensive repair.

The examination of the known long span structure types begins with the type 3a. 130 ft (39.6 m) span and type 3b. 96 ft (29.3 m) span truss roof aircraft hangars. The structural layout of these buildings was probably derived from a 1941 U. S. Army Air Corps design for a steel hangar spanning 122 ft (37.2 m).^{*} This was adapted for construction as a segmented curved roof structure built from unseasoned Australian hardwood instead of steel. By late 1941, the Works and Services Branch produced two variants, the 96 ft (29.3 m) and the 130 ft (39.6 m) hangar. Construction drawings for the Werribee buildings are dated from as early as 24/12/41. Six 130 ft (39.6 m) hangars and two 96 ft (29.3 m) hangars were built at Tocumwal in NSW (see Plates 9 to 12). One 130 ft (39.6 m) hangar and four 96 ft (29.3 m) hangars were built at Charleville and two 96 ft (29.3 m) hangars were built at Garbutt Airport at Townsville, both in Qld. One 96 ft (29.3 m) hangar was built at Maylands in WA and one 130 ft (39.6 m) hangar and four 96 ft (29.3 m) hangars were built at Werribee in Victoria (see Exemplar 3). (Dept. of Works and Housing 1946). Four of the 130 ft (39.6 m) hangars at Tocumwal, the 130 ft (39.6 m) hangar at Charleville and all the buildings at Werribee still exist. The fate of the other buildings is unknown.

^{*} Copies of this steel design are held at the works office of the Werribee Sewerage Farm, which now controls the five hangars at the site.

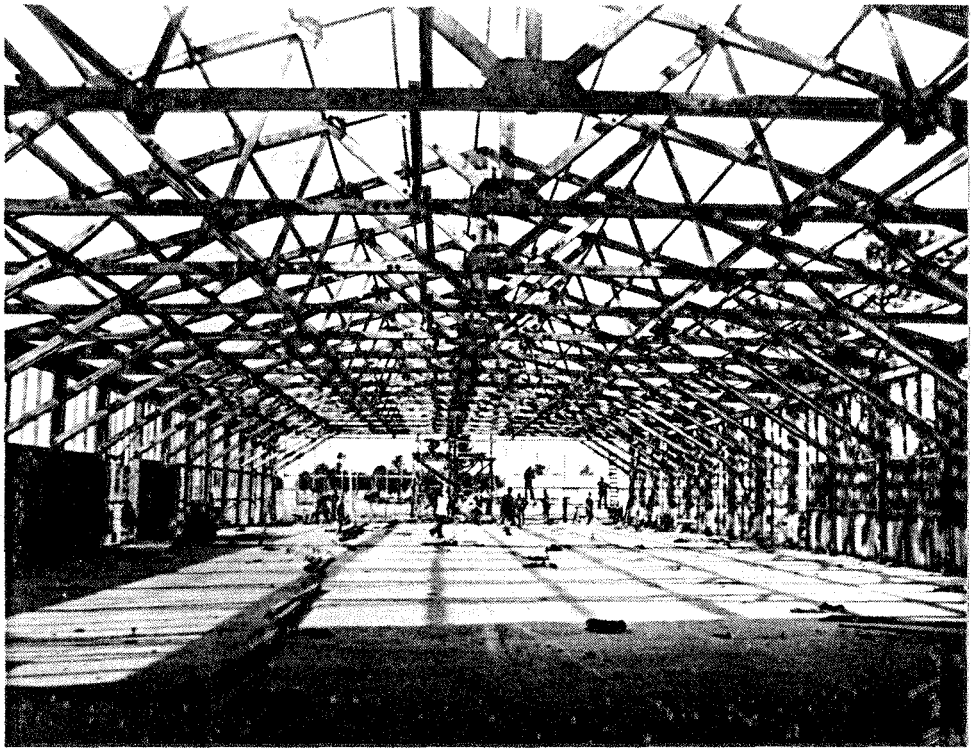


Plate 7. Barracks building under construction. Tocumwal, NSW 1942. Photo: Australian Archives



Plate 8. Store Building, Hobart, Tasmania, 1942.

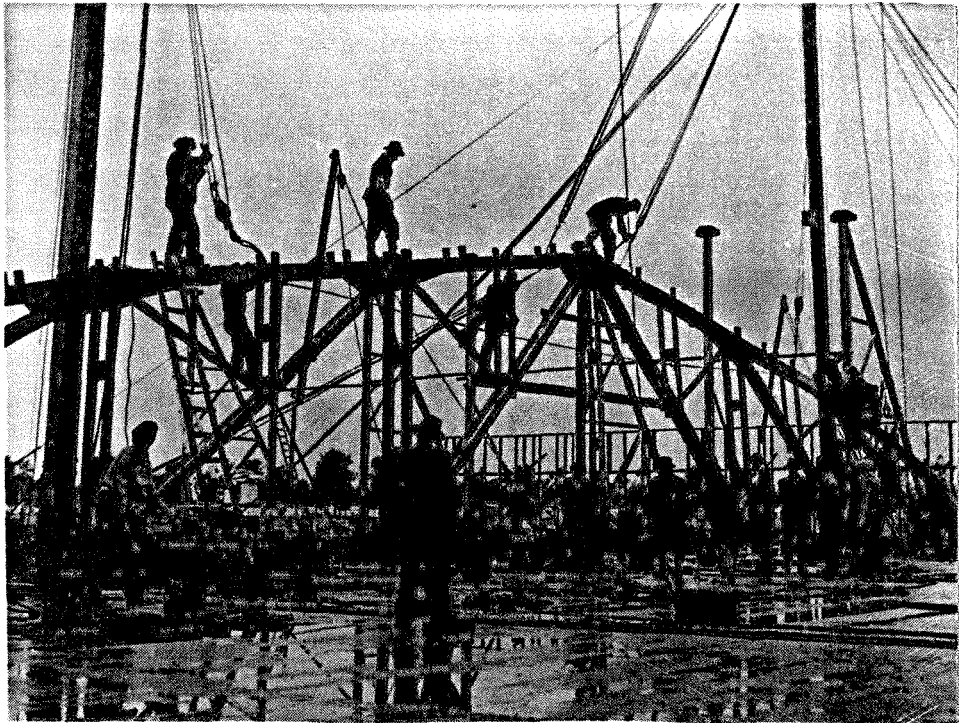


Plate 9. 130 ft (39.6 m) trusses ready to be raised for hangar roof. Tocumwal, NSW. 1942. Photo: Australian Archives.

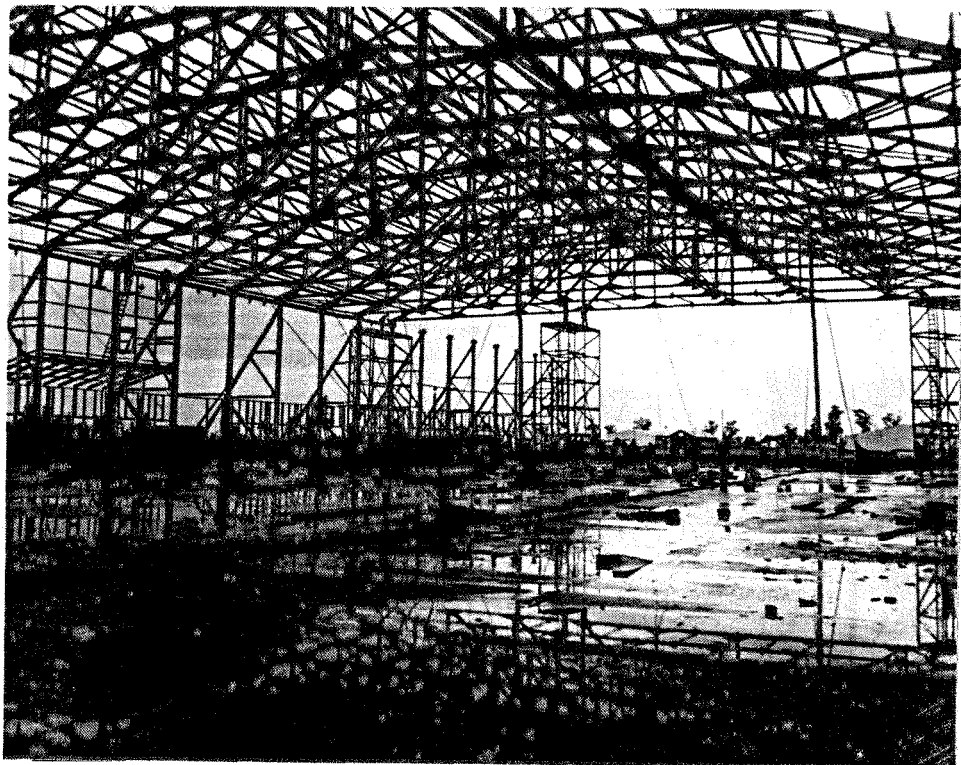


Plate 10. 130 ft (39.6 m) hangar under construction. Tocumwal, NSW. 1942. Photo: Australian Archives.

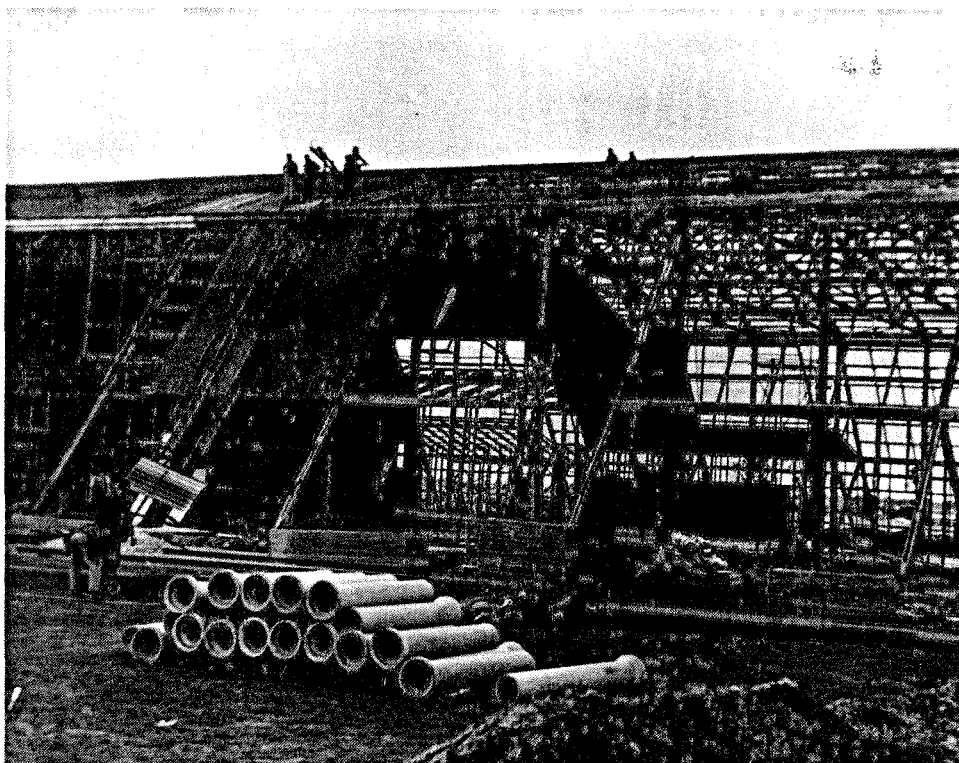


Plate 11. Buttress and roofing of 130 ft (39.6 m) hangar. Tocumwal, NSW. 1942.
Photo: Australian Archives.

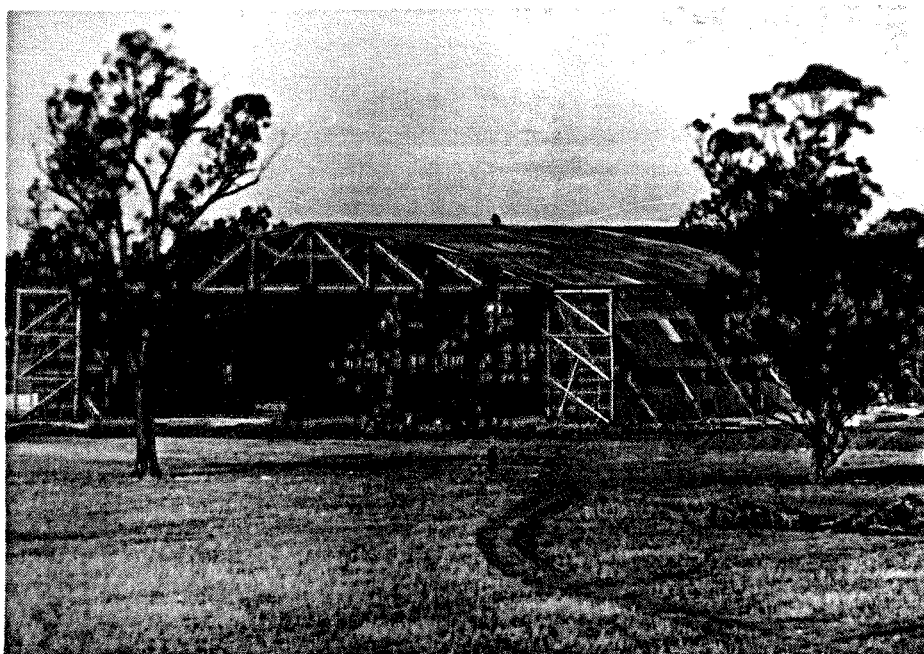


Plate 12. One of the six 130 ft (39.6 m) hangars under construction at Tocumwal, NSW. 1943. Photo: Australian Archives.

The 130 ft (39.6 m) variant suffered considerable problems initially. It is probable that the stresses allowed were just too great for satisfactory performance with green hardwood.

At Tocumwal and Werribee, 130 ft (39.6 m) span hog back trusses were constructed with a camber of 8 ins (200 mm) at the centre of the span. Deflections from the cambered position ranged from 184 mm to 238 mm and were measured nine months after erection... (Also these) trusses were constructed with a straight line camber to the centre span, with the result that after deflection, roughly the quarter points of the span were the lowest, giving a double festooned appearance. (Dept. of Works and Housing 1946, p. 26)

Many of these structures had to be propped and recambered. With the seasoning of the timbers, these trusses stabilised and those inspected in August 1992 were performing satisfactorily. The problems of the 130 ft (39.6 m) variant are not recorded as occurring in the 96 ft (29.3 m) version and those inspected in 1992 were performing satisfactorily. Architecturally these structures are unique as they are the first long span trusses recorded that use timber as tension web members. They are the longest clear span gable shaped timber truss buildings known in Australia.

The next construction type listed is the arched store and workshop buildings. Construction type 4a is the 104 ft (31.7 m) span three pin nailed arches. In these structures, light hand nailed boxed trussed arches were constructed from green hardwood. Though boxed curved timber trusses were used to form arches in Victorian times, this was the first time numerous nailed boxed trussed arches were used to form large structures. They were built to several American designs of 104 ft 3 ins (31.7 m) span and one adapted AWC design of 105 ft (32 m) span. All were three pin arches. The arch rise varied between 26 ft 3 ins (8.0 m) and 27 ft 6 ins (8.4 m). The main arch chords were 3 x 2 ins (76 x 50 mm) or 3 x 1.5 ins (76 x 38 mm) for the American designs and 4 x 2 ins (100 x 50 mm) for the AWC design. Arch bracing varied between 2 x 1 ins (50 x 25 mm) and 4 x 1 ins (100 x 25 mm). These buildings were constructed extensively. Seven were constructed at Rydalmere in NSW (see Exemplar 21). Twenty two were constructed at Garbutt Airport at Townsville (see Plates 13 to 16), ten were constructed at Stewart, three were constructed in Cairns, five were constructed at Tolga, near Cairns, one was built at Rockhampton, at least one was built in Eagle Farm, and several were constructed at Coopers Plains army base near Archerfield, all in Queensland. Additional buildings may have been built at other locations. The buildings at Garbutt and at Coopers Plains have been demolished. Those at Rydalmere exist in their original condition, while the single building at Eagle Farm exists though it has been significantly varied. The fate of the other buildings is unknown.

Construction type 4b is the 170 ft (51.8 m) span three pin nailed arches to a US Army design. They were designed to be temporary and to carry camouflage netting only, though some were later roofed with sheet metal. The arches had a rise of 35 ft 9 ins (10.9 m) and a 170 ft (51.8 m) span, yet the main arch chords were only 2/3 x 2 ins (17 x 50 mm). Eight of these structures were constructed at Garbutt Airport at Townsville, three were constructed at Charters Towers and two were constructed at Amberley, all in Queensland. Additional buildings may have been built at other locations. None of the buildings and no photographs or drawings of these structures is known to have survived.

The type 4c. 170 ft (51.8 m) span nailed arch buildings constructed to an Allied Works Council design were more durable. The AWC developed this three pin arch design in 1943 from the lighter U. S. Army version. The arches of these buildings rise 34 ft (10.4 m) from their supports and were fabricated with 5 x 2.5 ins (125 x 63 mm) arch chords and 3 x 1.5 ins (75 x 38 mm) braces. Five buildings were constructed and still exist at Archerfield in Queensland (see Plates 17 and 18 and Exemplar 22). Three are 170 ft (51.8 m) wide and 356 ft (108.5 m) long. Two more have their arches constructed on top of nom. 8 ft (2.4 m) high buttress supports and are over 190 ft (58 m) wide. These are also 356 ft (108.5 m) long. Four were constructed of green hardwood and one was constructed of oregon. Light, graceful and hand nailed, these buildings are the longest clear span timber structures existing in Australia. One further class of igloo arch building is known. In 1944, the US. Army Air Corps designed and constructed a 181 ft (55.2 m) class igloo to house B 29 bomber aircraft at their base in Darwin. Constructed on top of concrete buttresses, the timber arches were 171 ft 6 ins (52.3 m) between the pins. They had a rise of 41 ft 2 ins (12.6 m) from their supports and were fabricated with 5 x 2.5 ins (125 x 62 mm) arch chords and 4 x 1.5 ins (100 x 38 mm) web braces. It was designed for Group A or B standard grade hardwood (see Plates 19 to 21). Only one of these buildings is known to have been built and it stood until 1974 when Cyclone Tracy destroyed it. (Foster, Wing Commander 1992, pers. comm., October). Known as Hangar 172 at RAAF Darwin, it was the longest known clear span structure ever constructed in timber in Australia.

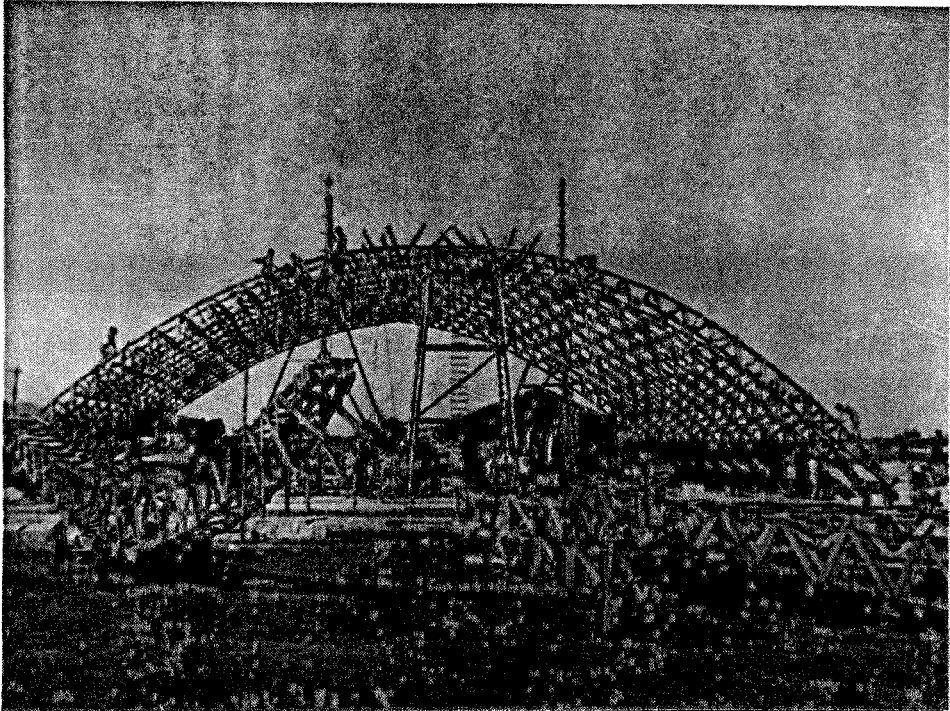


Plate 13. 104 ft (31.7 m) RAAF store under construction at Garbutt Airport, Townsville, 1943. Photo: Australian Archives.

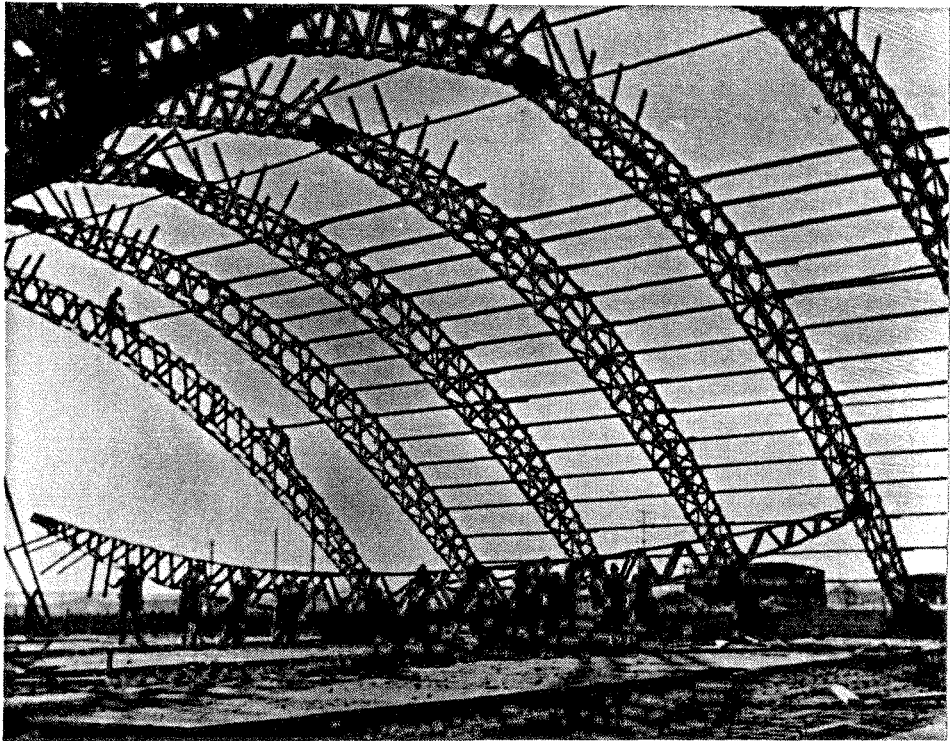


Plate 14. Manoeuvring the arches for erection of a 104 ft (31.7 m) store. Garbutt Airport, Townsville, 1943. Photo: Australian Archives.

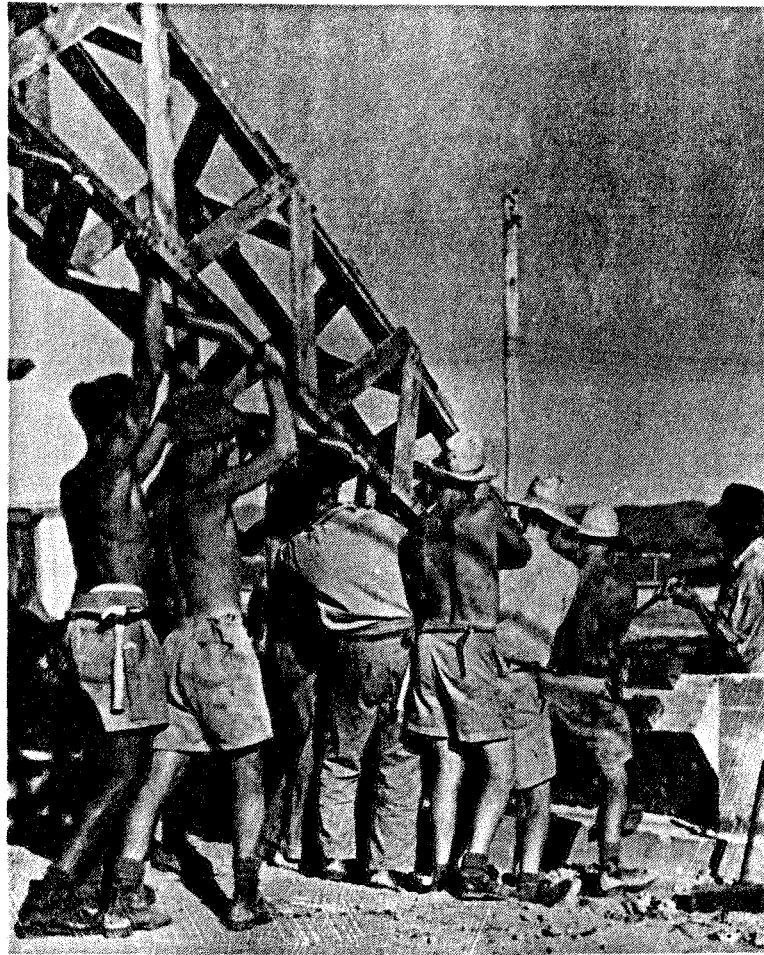


Plate 15. Carpenters locate an arch onto its support pin. Garbutt Airport, Townsville, 1943. Photo: Australian Archives.

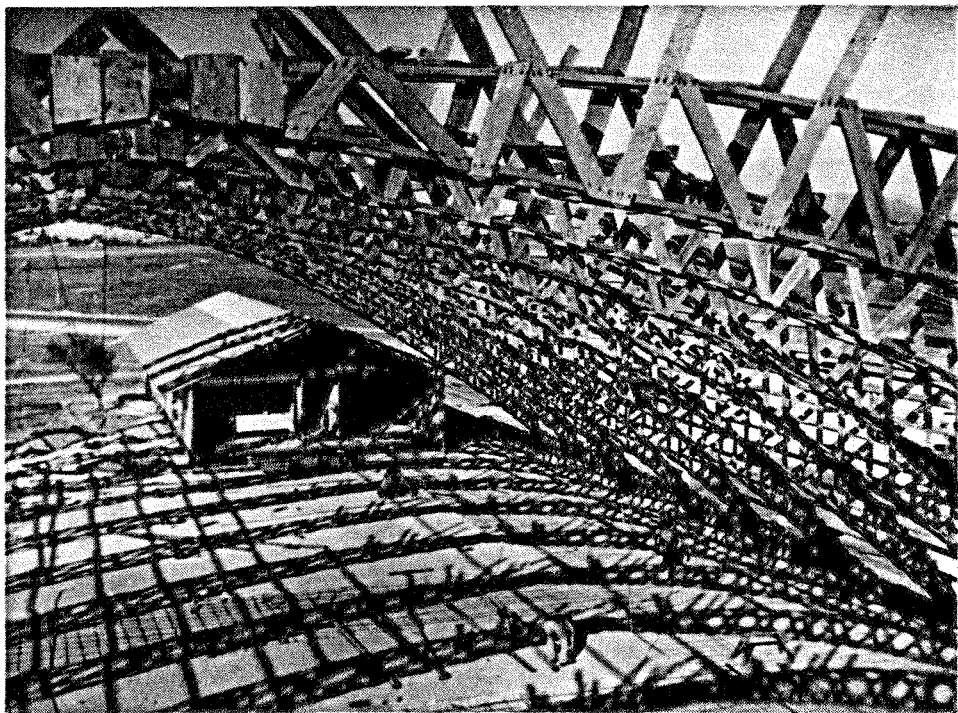


Plate 16. A 104 ft (31.7 m) store before roofing. Garbutt Airport, Townsville, 1943. Photo: Australian Archives.

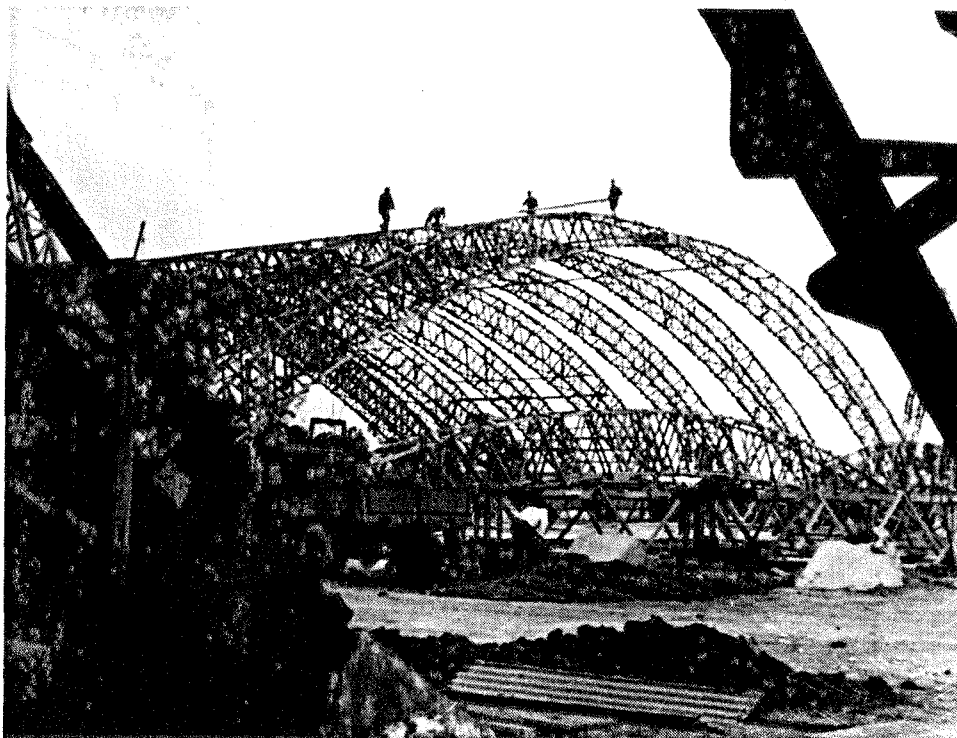


Plate 17. 170 ft (51.8 m) green hardwood hangars under construction at Archerfield, Queensland. 1943. Photo: Australian Archives.

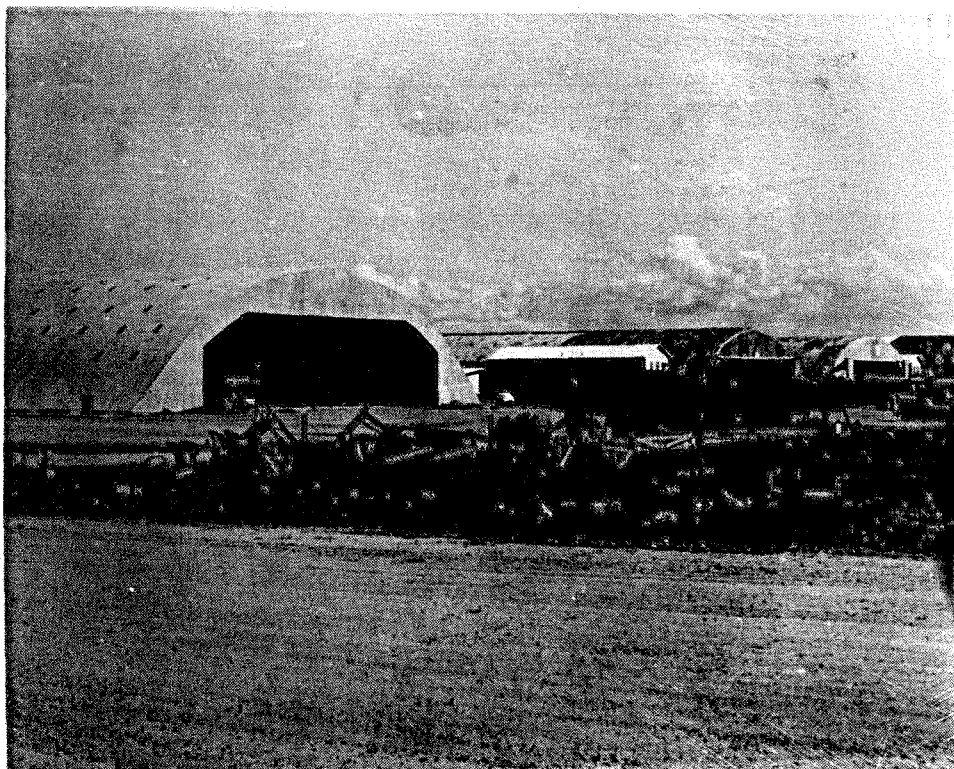


Plate 18. Three 170 ft (51.8 m) hangars complete with the fourth under construction, Archerfield, Queensland. 1943. Photo: Australian Archives

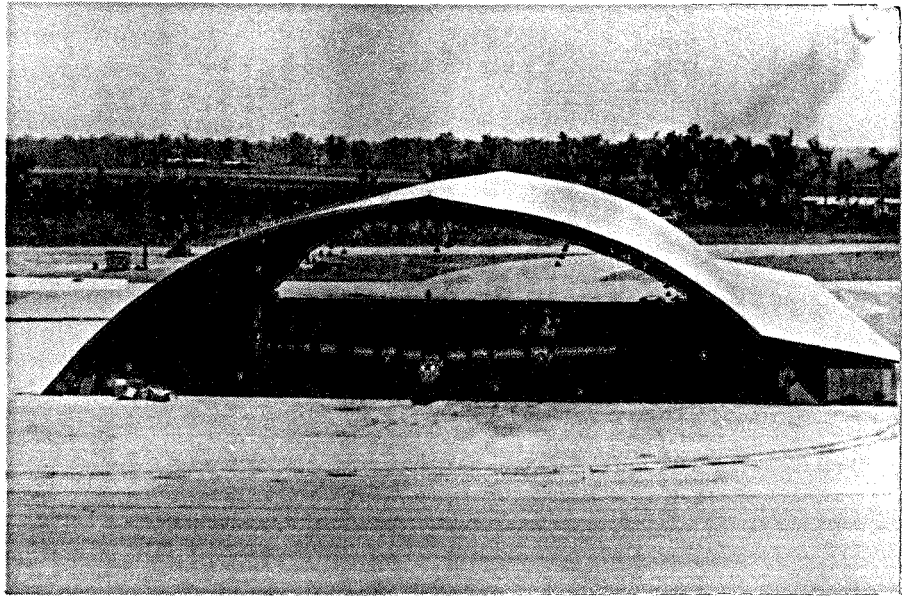


Plate 19. The 181 ft (55.2 m) igloo at the K40 Air Repair Depot, Darwin, 1944. Photo: Australian Archives)

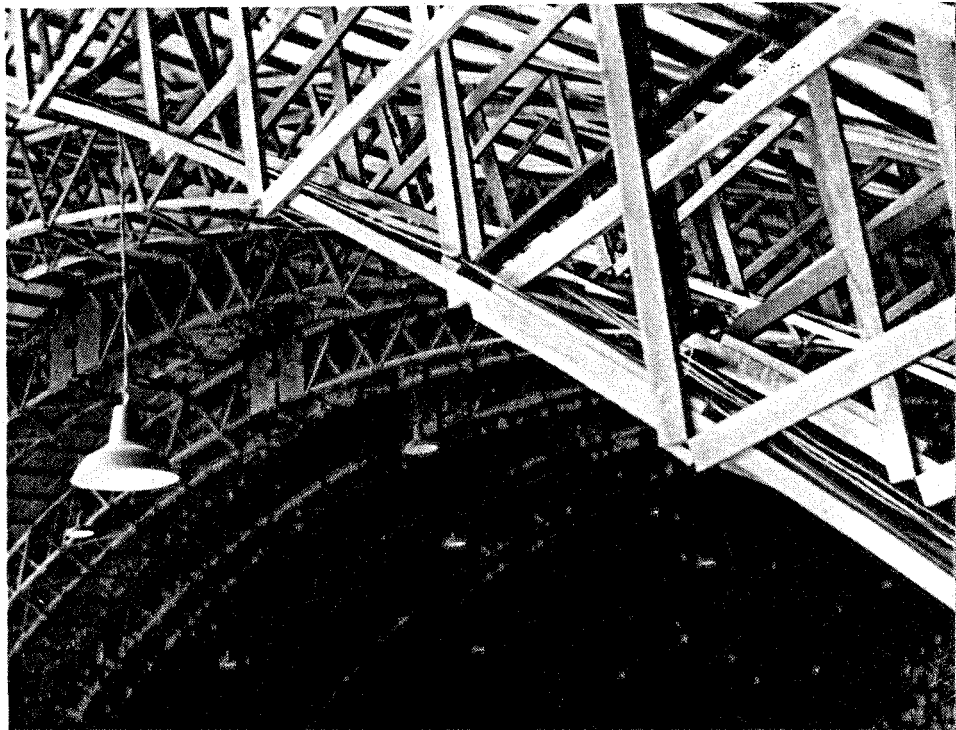


Plate 20. The truss chord and plywood reinforced top pins to the 181 ft (55.2 m) class igloo, Darwin, 1944. Photo: Australian Archives

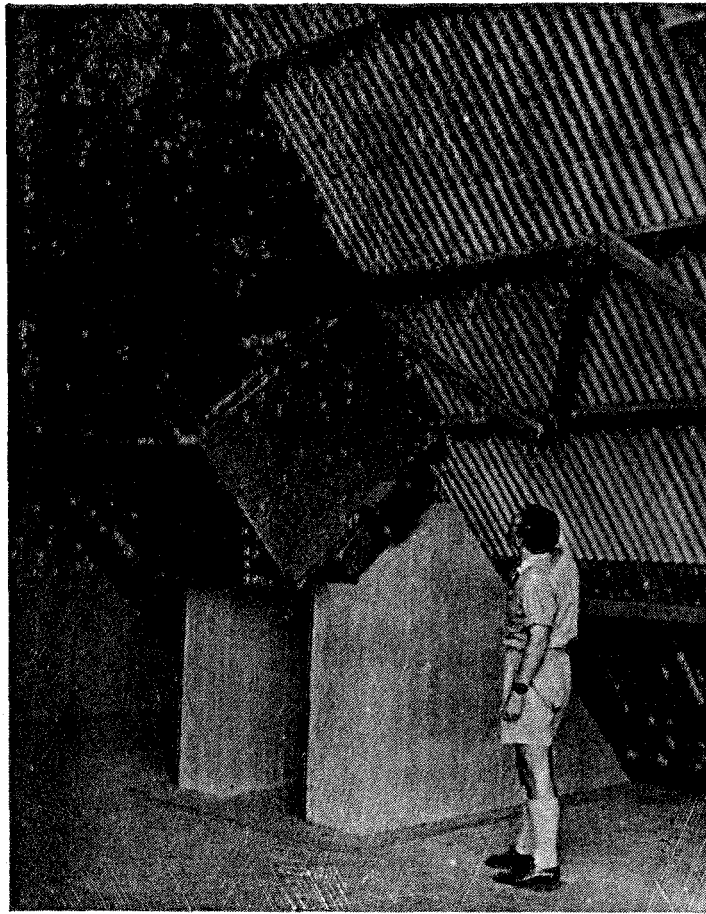


Plate 21. Concrete buttresses to the 181 ft (55. 2 m) class igloo were designed to reduced the chance of termite attack. Darwin. 1944. Photo: Australian Archives

Though not a 100 ft (30. 5 m) clear span, the construction type 4d. 95 ft (29 m) span glue laminated arches is included here. Although this was not the first use of glue laminated material in a building in this country,* this is the first glue laminated building constructed in Australia (Forestry Commission of NSW 1942, p. 825). The building is a three pin parabolic arch structure. Ralph Symonds Ltd constructed it for National Springs Ltd in O'Riordan Rd, Alexandria in 1942 (Moss 1992, pers. comm., May 3) (see Exemplar 16). Symonds fabricated the arches from 26 laminations of low grade rimu and they still stand without apparent deflection or decay (see Plates 22 and 23).

* The first documented application using glue laminated rafters was a store building designed by H. Garnet Alsop, Architect. It used 325 x 90 mm beams laid up from 105 x 18 floor boards to span 6 m with a 3 m cantilever. (Building 1941, p. 80)

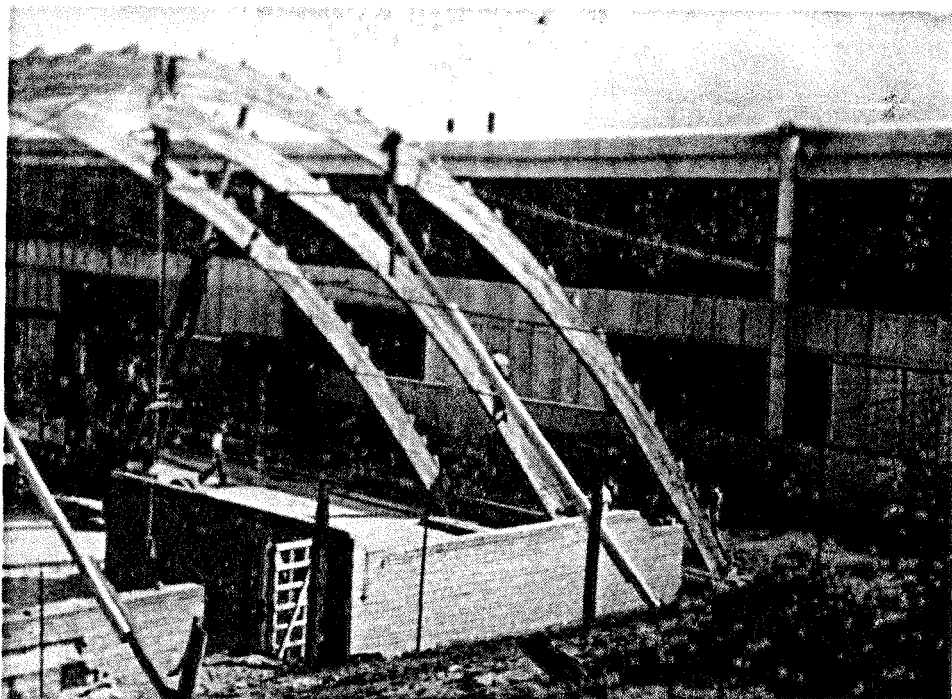


Plate 22. Arches under construction at National Springs Ltd in Alexandria, NSW.
1942. Photo: Institution of Engineers Australia Library, Canberra.



Plate 23. As with the nailed arches, manpower played a large part in the
construction of laminated arch structures. National Springs Ltd, Alexandria, NSW.
1942. Photo: Institution of Engineers Australia Library, Canberra

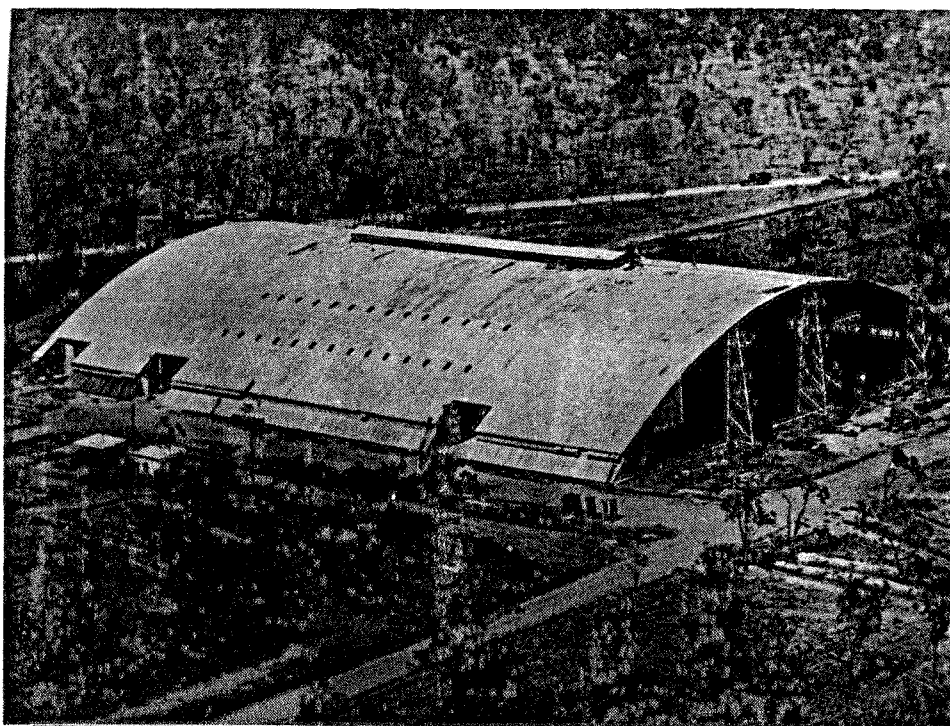


Plate 24. One of the two inland store buildings under construction for the RAAF at Macrossan, Queensland. 1944. Photo: Australian Archives



Plate 25. End wall bracing and construction. RAAF Stores, Macrossan, Queensland. 1944. Photo: Australian Archives

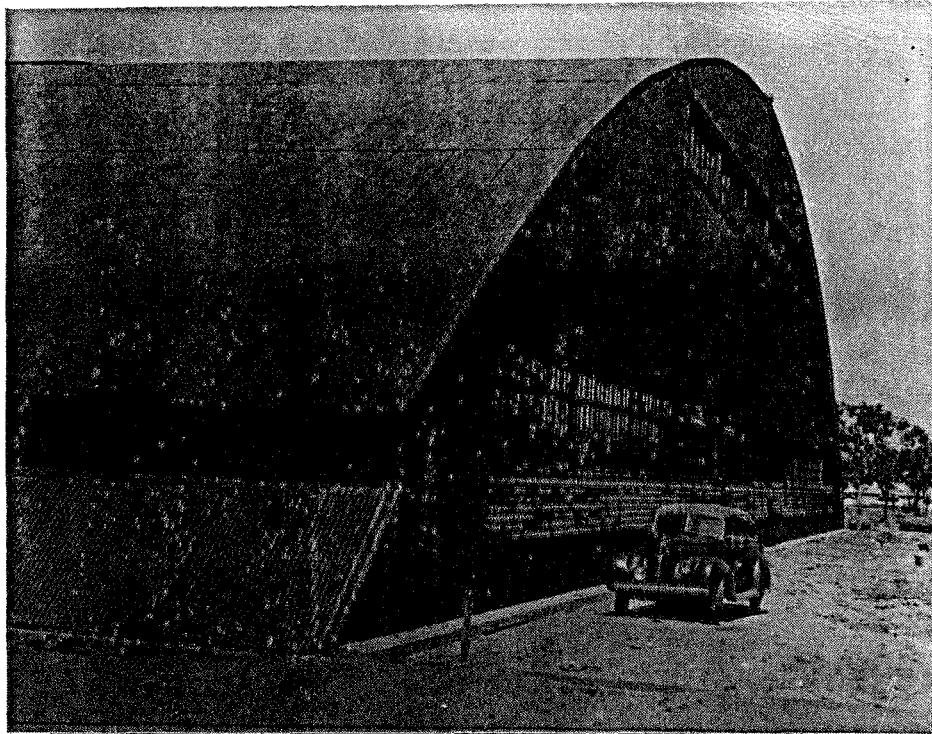


Plate 26. End wall. RAAF Stores, Macrossan, Queensland. 1944. Photo: Australian Archives

The last of the buildings to be considered in detail here is the type 5 construction curved roof inland store buildings. Though with a clear span of only 15.5 m, these structures are the largest stores building constructed during the war and demonstrate the significant technological advances that were used widely in the hundreds of other small timber structures built during the cycle. They represent the assured confidence and skill that their designers had developed in timber construction since the beginning of the Pacific War. These buildings are curved roof structures with five support lines of posts at nom. 15.5 m centres. The central three lines of posts support gantry cranes which serve the central two aisles. One measured example at Drayton in Queensland has 15 bays of trusses at centres of 6.1 m. The whole building is over 60 m wide and 95 m long. When one examines these war time general store buildings, a different design aesthetic in timber can be perceived to that normally seen. It is not one that would normally be regarded as Australian. These buildings owe nothing to the farmhouse building techniques and aesthetics that have tended to dominate later Australian literature and myth in timber. They introduce new form, new combinations and new possibilities. At least five of these structures were built at Dubbo in NSW. Three were built at Drayton in Toowoomba in Queensland (see Exemplar 8), two were built at Macrossan in Queensland (see Plates 24 to 26) and two were built at Merredin in Western

Australia. Several buildings at Dubbo and the three Drayton buildings are still operational RAAF stores. The fate of the other buildings is unknown.

Consulting architects and engineers undertook a secondary stream of construction during this period with commissions for essential factory work. Given that steel was almost unobtainable, any of these buildings could represent further experiments in timber structures. Structures known to be built of timber but unidentified include a large complex of aircraft factories thought to be in Victoria and at least three glue laminated arch buildings constructed by Ralph Symonds. At least one of these was built in Melbourne (Cooper 1946, p. 641). The only identified building is a saw tooth glue laminated tied arch structure that Malcolm Stanley designed in early 1943 for A. Crook Electrical in St Leonards, NSW (see Plate 27)

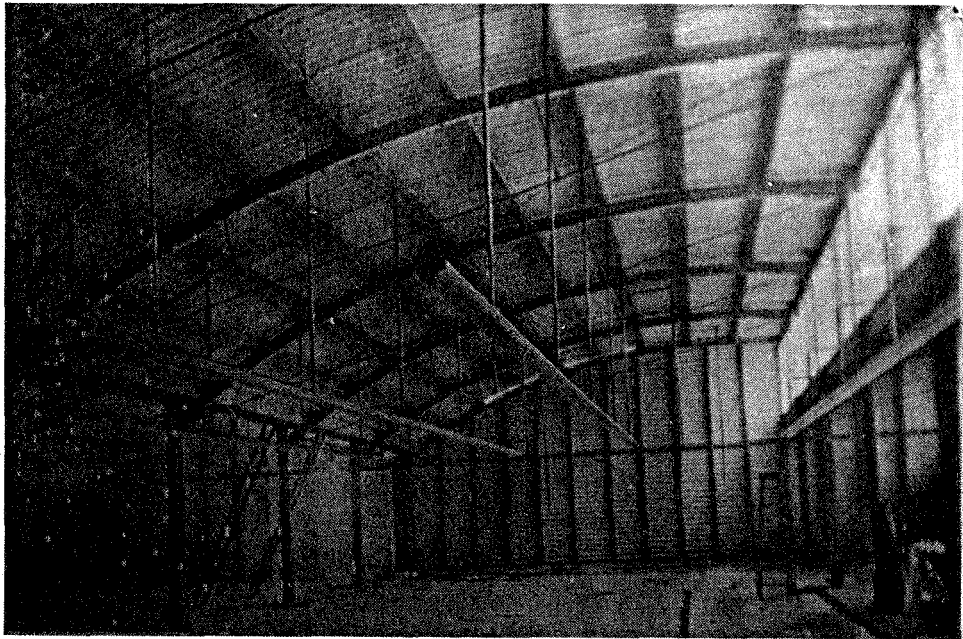


Plate 27. The graceful tied arches of A. Crook Electrical in St Leonards, NSW. 1943. Photo: Australian Timber Journal.

As the war progressed, the Timber Development Association of Australia (TDAA) realised that the credibility achieved by timber construction during this period was due to extraordinary circumstances. Believing that without full industry support the prewar preference for timber substitutes (steel and concrete) would return, they lobbied hard for the industry to prepare for the a long fight ahead.



Plate 28. This advertisement showed a recognition of the success of timber during the war as well as the danger of 'Substitutes' after the war. Image: Australian Timber Journal

The Pacific War Cycle of timber construction ended with the end of the war in 1945. It is not easy to summarise this cycle as reliable information is unavailable. My research into the period indicate that; due to wartime censorship, magazine reports from the period are not specific about the location and extent of building; the Department of Defence has not kept co-ordinated records on the timber buildings that it once owned or on those it still owns (Pritchard, G. 1992, pers. comm., June 1); the Australian Heritage Commission knows of only isolated structures, such as the single igloo at Eagle Farm in Queensland; and no research has been undertaken to gauge the performance of any of the materials or forms since 1946.

However, the available evidence indicates that the Pacific War Cycle was a period of great national dependence on timber as a building material and probably the greatest period of concentrated experimentation with timber structures in Australian history. For three years, every major technology in large scale timber construction available was successfully employed all over Australia. Besides the technologies foreshadowed in 1938: shear connector joints; plywood; and glue lamination; multiple nail technology was introduced and used for the longest clear span timber structures built in this country. The longest span, most numerous, most diverse and most widely spread examples of timber buildings seen in Australia were

all built at this time. Equally important, every major group of native structural timber was put into extreme field test in every part of the country.

However, professional memory of the work of this period appears to be lost. There are several hypotheses why this happened. One is that as the Pacific war ended the demand for steel for munitions was greatly reduced while demobilisation led to a vastly increased demand for housing. The Government had severely curtailed construction of housing for all save essential purposes in 1942 and even before this an unmet demand existed from the great Depression. If the timber industry needed a market after the constraints of war then housing was an old and reliable friend. It seemed they did not need to face the uphill path to success that the TDAA had predicted just yet. If steel needed a market then industrial reconstruction and pent up consumer demand probably consumed all that could be produced. Another hypothesis is that as a result of war time censorship, little knowledge of wartime timber construction became public. Anecdotal evidence suggests that many people assumed the largest timber buildings of the war were built of steel. A further hypothesis is that as housing drew in all timber supplies and as imports of timbers were reduced to a trickle (Architecture 1946), the new found confidence in wooden structures was lost. Little evidence has been found that the designers and engineers who built the hundreds of war-time timber structures took much of their acquired skill in timber with them into peace-time practice. As these buildings were only designed as temporary structures, these designers may not have expected them to last or simply were not interested as timber was regarded as only a poor substitute to be used in a rough way when nothing else was available. It is probable that the majority of private design professionals had so little experience with timber during the war that with its end they resumed the pre-war patterns of preference for steel over timber. This was understandable as the United States military introduced much of the timber technology employed. In 1945, it was probably still completely alien to the bulk of Australian design professionals. Further, even though Loder (1946, p. 2) concluded that:

the similar use of green Australian hardwood in further structures (similar to those built during the war) can be attended with an assured confidence that a satisfactory standard of performance will result.

He felt it necessary to preface this with:

No attempt is made in this report to compare the relative merits of timber and steel for the structural purposes, as although it is recognised that some of the buildings surveyed could have been more satisfactorily constructed in steelwork ... the use of substitute materials was imperative to conserve steel...

Finally, timber structure may just have ceased to fit the latest in architectural and building styles. Whatever the combination of causes, the serial literature on timber building after the war returned to the issues common before it; housing, supply and quality control. At the same time, any compiled information on war time construction in timber was filed and apparently forgotten. This process was so thorough that in 1992, only one complete library copy of the Department of Works and Housing's 1946 report was available in Australia. Even the CSIRO did not hold the complete work.

As a result, the mammoth green hardwood structures of 1942 and 1943 left no legacy on the aesthetic development of architecture in Australia or on the design professions' regard for timber structures. It was as if the timber buildings of the war had never been built.

1.5 The Postwar Reconstruction Cycle 1950 - 1961.

Physically untouched by war except in the far north, Australia now proved a store of raw materials for Postwar reconstruction. Industry retooled and expanded. By 1950, a major cycle of industrial building was underway and all building materials, especially steel, were in short supply (Llewellyn 1992, pers. comm., 19 August). Timber design and engineering re-emerged to take advantage of this opportunity with a major flowering of long span industrial timber structures. The two major practitioners were the engineer, Malcolm Stanley and the manufacturer, Ralph Symonds, both of Sydney.

Symonds was renowned as a master of plywood who specialised in doing things that most people said could not be done (Hochroth 1987, p. 20). During the war, he made plywood landing craft for the Army and decoy Kittyhawk aircraft for the Air Force. He went bankrupt more than once and built a series of one-off timber and plywood structures. He regarded these projects as essential aspects of product development and company promotion. Symonds' first known major Postwar structure was his own factory at the corner of Burrows Rd and Campbell St in St Peters, NSW (see Exemplar 20). This building consists of two pavilions of 31 m span three pin glue laminated arches. The arch pairs are at 6.1 m centres. Symonds began the first pavilion in 1946 and extended it progressively until it consisted of 32 bays, making a building over 195 m long (see Plates 29 and 30). He built the second pavilion perpendicular to the first, beginning in 1950. It has 24 bays of 31 m span arches and is over 148 m long. Both buildings still exist and are in reasonable condition.

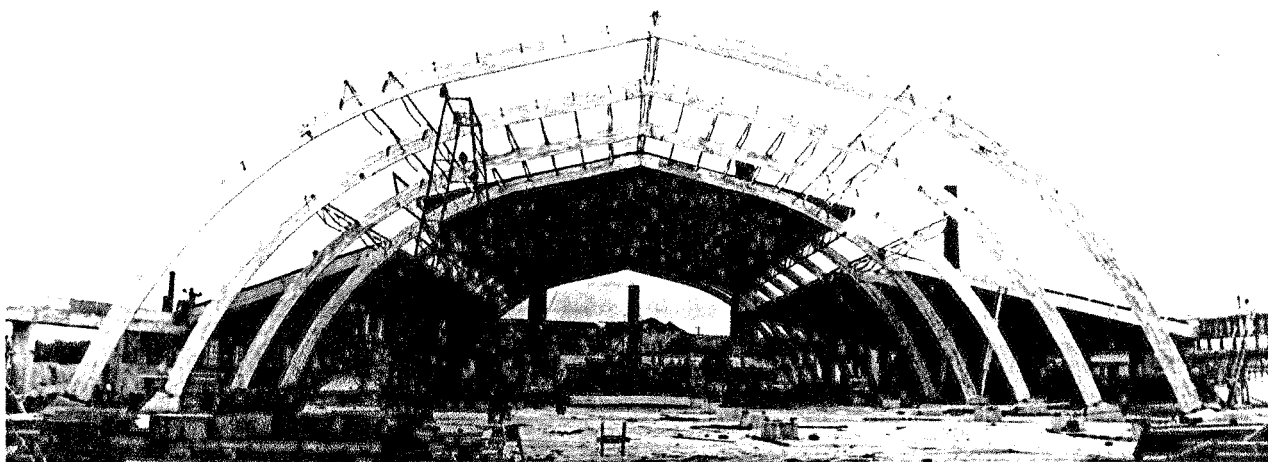


Plate 29. Arches under construction in the original pavilion at Ralph Symonds' Factory, St Peters, circa 1946. Photo: Donated by Mr. H. Llewellyn.

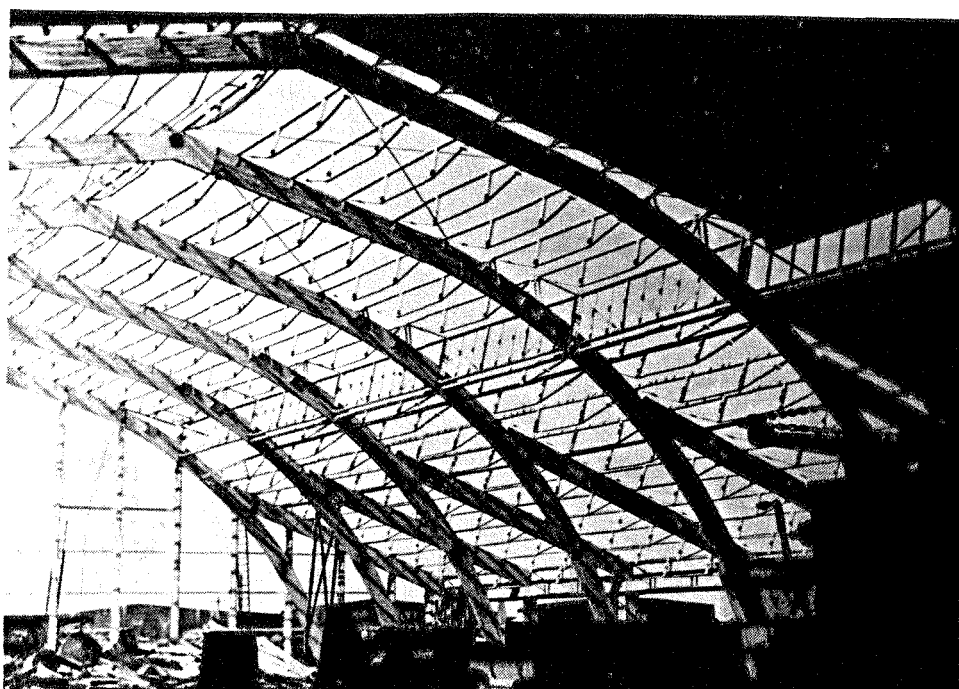


Plate 30. The south end of the original pavilion ready for sheeting, Ralph Symonds' St Peters works. circa 1946. Photo: Donated by Mr. H. Llewellyn.

Symonds' next known works are possibly his most idiosyncratic. These were the Ceremonial Arches built for Queen Elizabeth II's visit to Sydney in 1954. They included;

1. The Timber Development Association's Log Arch:

A 72 ft (21.9 m) long, 8 ft (2.4 m) diameter rotating log constructed of 5/16 ins (8 mm) ply which spanned 65 ft (19.8 m) across Macquarie St, Sydney.

2. The City Council Boomerang Arch:

A 'boomerang' shaped portal that was a 10 ins thick and up to 70 ins wide (250 x 1770 mm) hollow rectangular cell structure spanning 96 ft (29.3 m). Built across Park Street where it intersects with the central path of Hyde Park, Beauvais Associates Pty. Ltd. of Sydney designed it.

3. The Insurance Companies' Arch:

A pair of intersecting parabolic arches of glue laminated 24 ins x 4 ins (610 x 100 mm) timber members sheathed in plywood. They were 30 ft (9.15 m) apart at the bases, spanned 72 ft (21.9 m) across Macquarie St, Sydney and were designed by Stephenson and Turner, Architects.

4. The Bankers' Arch:

A pair of tapering parabolic plywood arches that spanned 120 ft (36.6 m) over the intersection of Pitt St and Martin Place in Sydney designed by Mr. G. G. G. Neave of the Commonwealth Bank's Architects Branch (see Plates 31 to 33).

5. The Retail Traders' Arch:

This was a triangular plywood box girder spanning 65 ft (19.8 m) across Macquarie St, Sydney. 30 ft (9.1 m) wide across the top of the girder, perpendicular to the span and with a depth of 6 ft 6 ins (2 m), murals were painted on its lower surfaces. Mr. C. Garth ARAIA, Director for Parks for the Sydney City Council, designed it.

6. The Agricultural Society's Arch:

Constructed over Bridge St, Sydney, this was portal frame gate resembling two pylons with a spanning arch designed by Mr. R. Tennant of the Royal Agricultural Society. It was 71 ft (21.65 m) from outside of pylon to outside of pylon.

At least one other arch was constructed for the Queen's visit, a boomerang style arch erected in Melbourne (see Plate 34) which was apparently a copy of the City Council Arch in Sydney.



Plate 31. Conceptual Drawing of the Bankers' Arch prepared by G. G. G. Neave.
Image: Architect's Branch of the Commonwealth Bank.

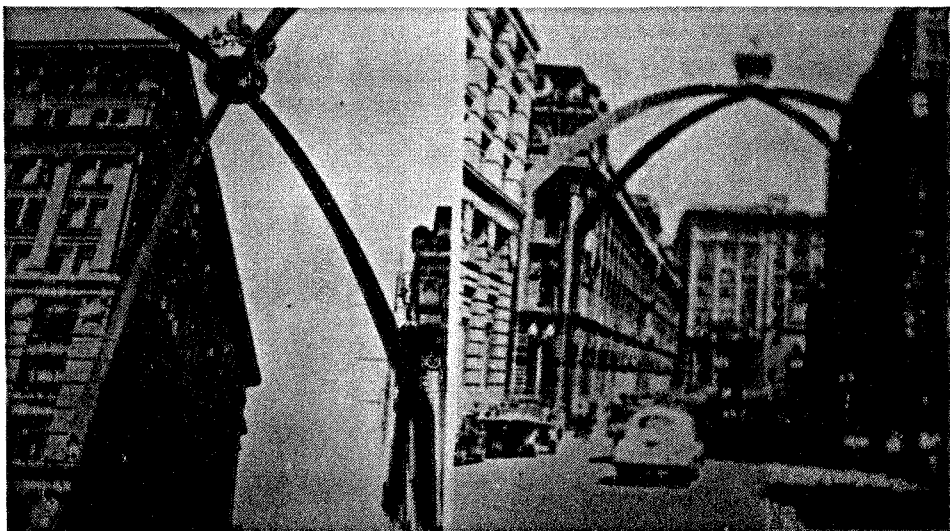


Plate 32. The Bankers' Arch from Pitt St, Sydney, NSW. Photo: Australian Timber Journal.

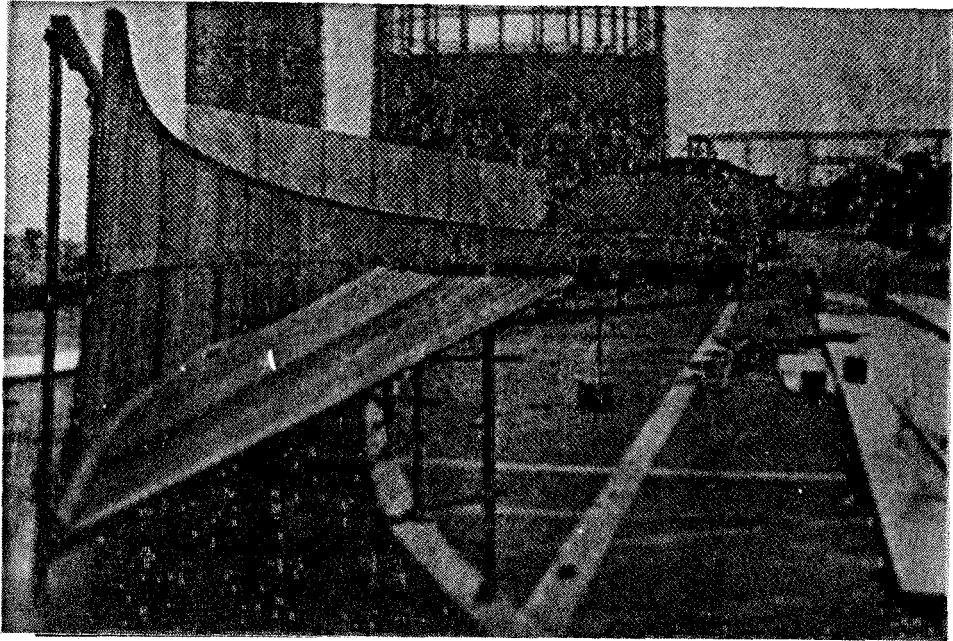


Plate 33. The Bankers Arch under construction at Ralph Symonds' St Peters yard, NSW. Photo: Australian Timber Journal.

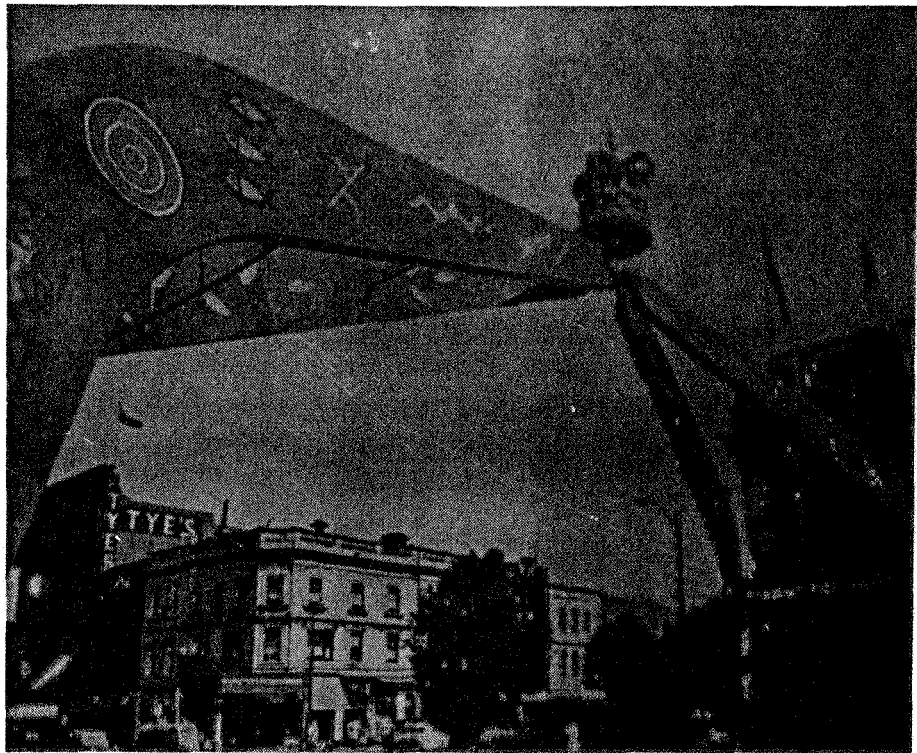


Plate 34. The Boomerang Arch in Melbourne, Vic. Photo: Australian Timber Journal.

Three of these structures are particularly interesting. The City Council Boomerang Arch and its partner in Melbourne were three pin portals and as such were the first large span portal frames in ply recorded. The Bankers Arch was unique. It was the only truly graceful arch of the six. Its light parabolic arches, constructed of 8 mm plywood, spanned 120 ft (36.6 m) between the heavy Victorian buildings of Martin Place.

Symonds produced at least one other major arch building before 1958. This was a 120 ft (36.6 m) span factory for Neon Industries in Melbourne. The architects were Stephenson and Turner and the engineer was Mr Hudspeth (Building: Lighting: Engineering: Magazine, 1955, P. 33). The arches for this building appear very similar to those used in Symonds St Peters factory. They were 28 x 4 ins (710 x 100 mm) members glue laminated from oregon. Symonds shipped them from St Peters to Melbourne on a special truck and bogey (see Plate 35).

Symonds last major work was his own factory built in 1958 and 1959 (see Plates 36 to 38 and Exemplar 23). This building is immense. It consists of three parallel rows of tied three pin glue laminated arches. Each row of arches is at 52 m centres while each arch spans 43 m. Glue laminated rafters span between. There are 46 arch bays in each row at 7.6 m centres. This gives a building over 156 m wide and 350 m long. The arches were glue laminated on the ground slab of the building and erected by Symonds' own work force. The whole work took only 18 months (Hochroth 1987, p. 16). This is the single largest timber building ever constructed in Australia. It still stands.

Symonds died in 1961 in a boating accident. Of the buildings listed above, the St Peters and the Homebush Factory still stand, both in reasonable condition. The only records of the Ceremonial Arches are archival photos and articles. The fate of the other buildings is unknown. It is probable that Symonds constructed many other glue laminated arch buildings in Sydney and other cities between 1942 and his death. Unidentified photos of at least three occur in various library collections. Ralph Symonds Limited continues to manufacture plywood but has not maintained any records of the period.

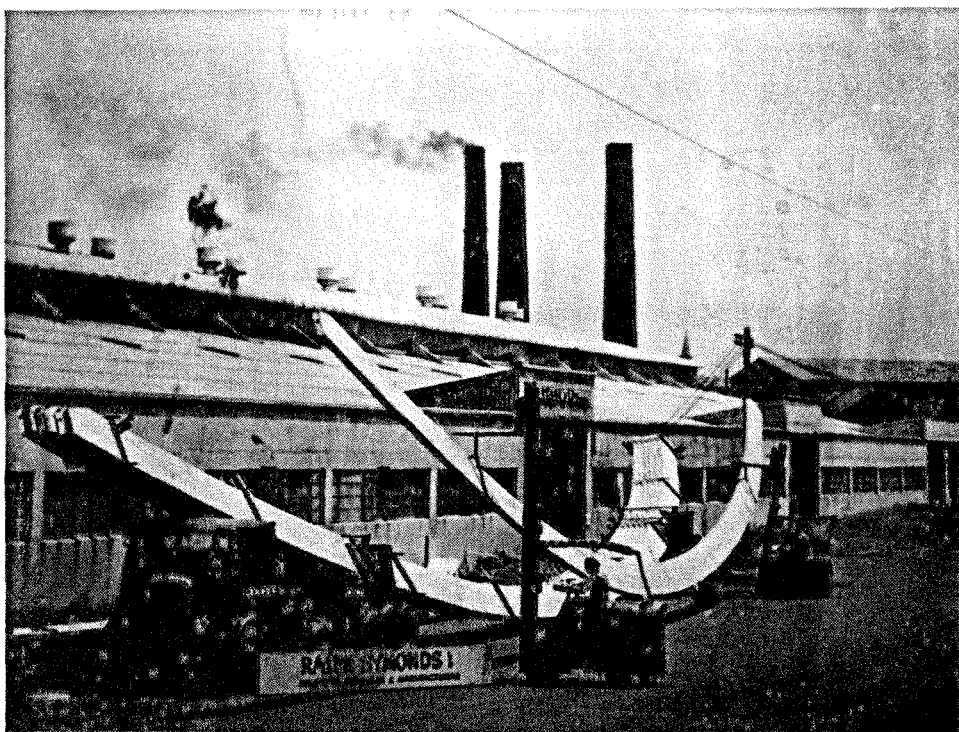


Plate 35. Arches being loaded at Ralph Symonds' St Peters factory before being transported to Melbourne, circa 1955. Photo: uncatalogued collection, Mitchell Library, NSW.

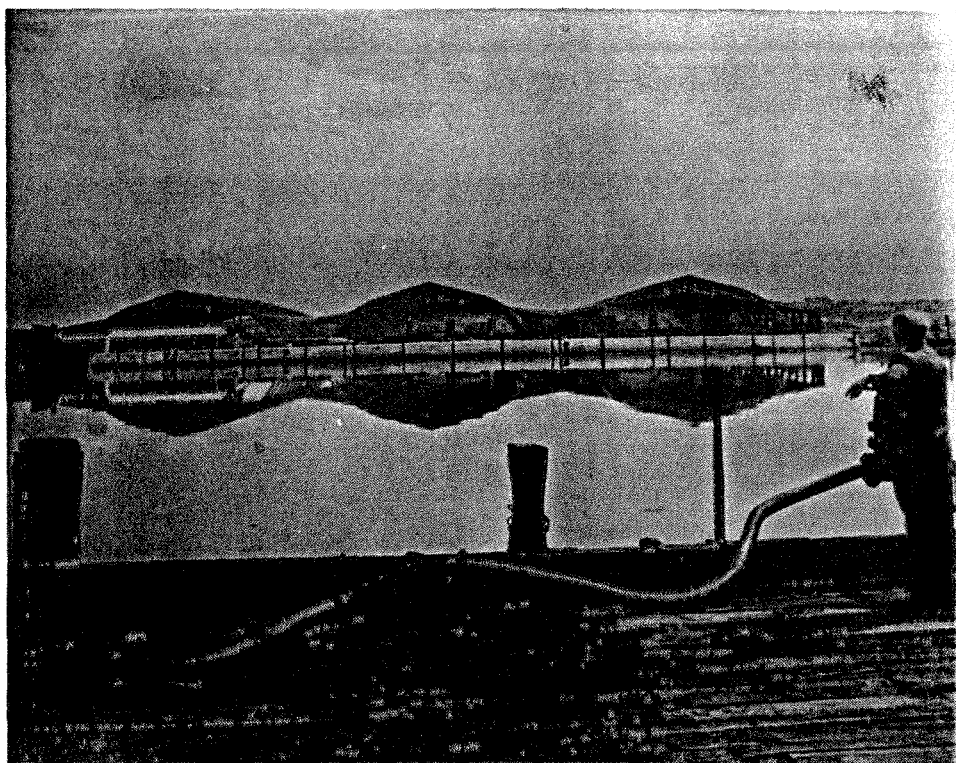


Plate 36. Ralph Symonds' factory at Homebush Bay, NSW. Photo: uncatalogued collection, Mitchell Library, NSW.

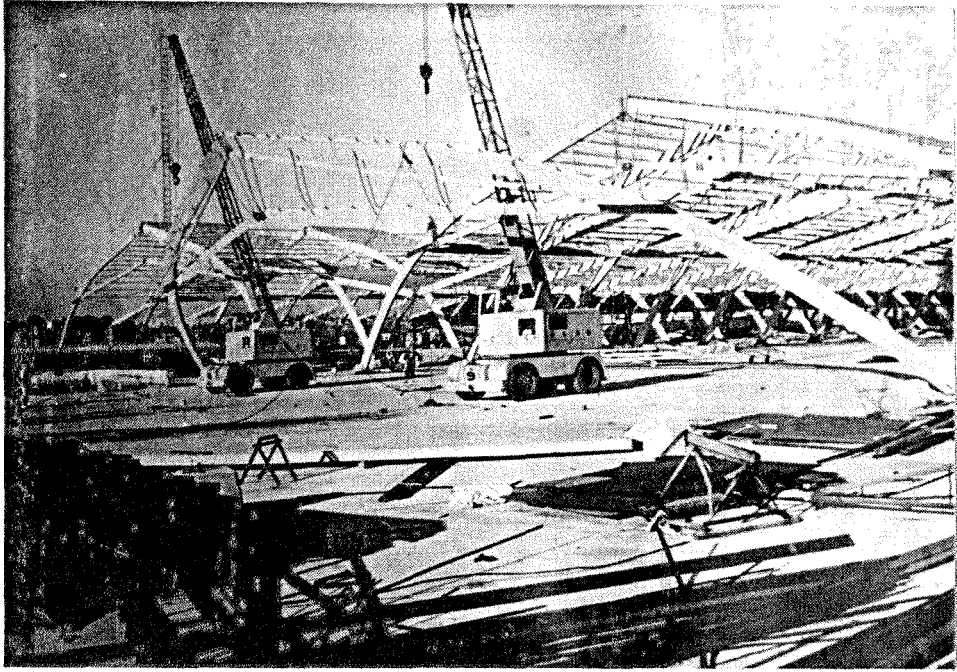


Plate 37. Arch sets being erected: Ralph Symonds' factory, Homebush Bay, NSW. 1959. Photo: uncatalogued collection, Mitchell Library, NSW.

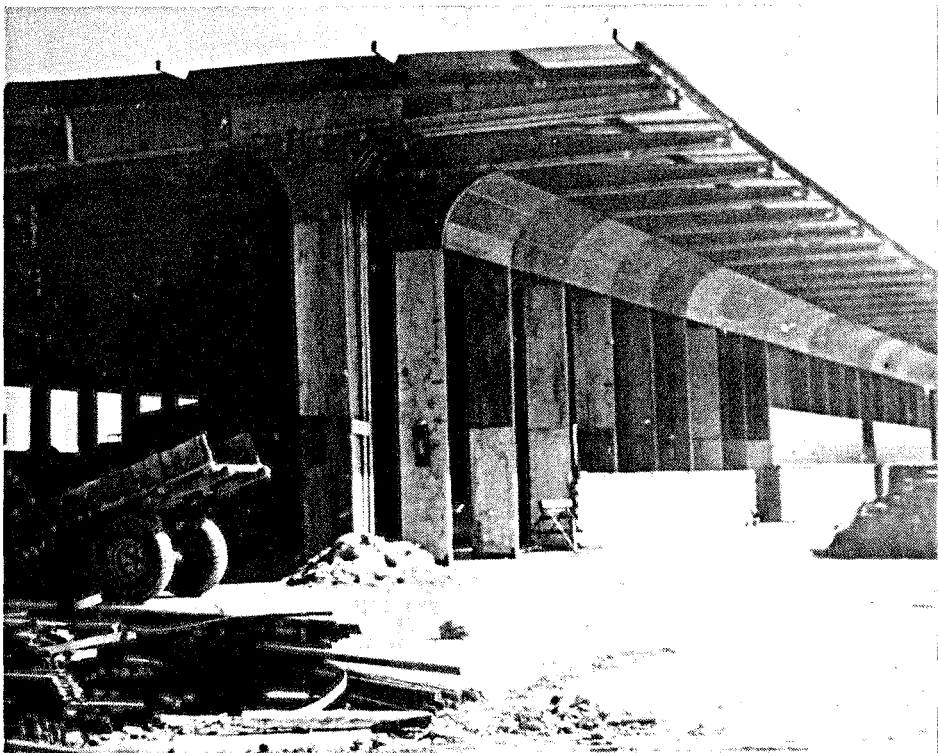


Plate 38. A plywood framed portal building at Ralph Symonds' factory, Homebush Bay, NSW, 1959. This building was next to the main structure and no longer exists. Photo: uncatalogued collection, Mitchell Library, NSW.

Symonds' friend, Malcolm Stanley, was a respected professional consulting engineer. He had at least four papers on different topics printed in the *Institution of Engineers' Journal*. In 1951, Stanley (1951, p. 154) wrote:

During and since the last War, failure of steel supplies in Australia concentrated the attention of Australian engineers to the alternate use of glued timber sandwich construction. Ground to ground arch ribs were pioneered by Ralph Symonds and flat arch construction, pier to pier type, was designed and used by the writer. Latest inspection of all such glued laminated timber constructions, some over ten years old show no deterioration, it being a recognised fact that in many cases, weight by weight, wood is stronger than steel, with the added advantage of being much stiffer...

Stanley was an active practitioner in timber in every sense. He was involved with glue laminated arch structures from at least 1943. Then as senior partner of the consulting engineering firm of Stanley and Llewellyn, he designed a steady stream of long span industrial structures in timber from 1950 to 1955. He and his office developed the flat pier to pier two pin tied arch form to such an extent that by 1952, they had patented a stiffened tied arch. Using this form, Stanley produced satisfactory and economic timber solutions (he had repeat commissions). The arches became known as 'Stanley' arches. They were site laminated from a variety of timbers using casein based glues (see Plates 39 and 40). Unlike Symonds' practice of relying solely on the glues to laminate his foundation arches, Stanley used stitch bolts through the arches at about 900 mm centres to guarantee adhesion (Stanley 1954, September, p. 585).

Stanley's first known project was a glue-laminated tied arch saw tooth roof for A. Crook Electrical at St Leonard, NSW, in 1943 (see Plate 27). It was a popular solution and Wunderlich used it for their roofing advertisements. The next building was of the same type for B and S Electrical in Alexandria, NSW (see Plate 41). This employed a steeper, shorter span arch than the St Leonard building yet it is a building of considerable beauty. The location and date of construction are unknown. In early 1950, Stanley and Llewellyn designed a 131 ft 6 ins (40 m) conventional timber bowstring truss building for Larke Hoskins's works at Riley Street, Surrey Hills, NSW. The architects for the project were David King and Associates. The parabolic arch trusses had laminated oregon timber top chords 18 ins x 6 ins (456 x 152 mm) and a lower chord of two 6 x 1/2 ins (152 x 12.5 mm) flat steel members (Architecture 1950, p. 95). In 1952, Stanley and Llewellyn designed a factory for C and C Engineering at Ferndell St, Granville. It had two 130 ft (39.6 m) tied arch wings around a 45 ft (13.7 m) central bay. This factory is the first known use of Stanley's patented stiffened tied arches. It was also a very graceful building.

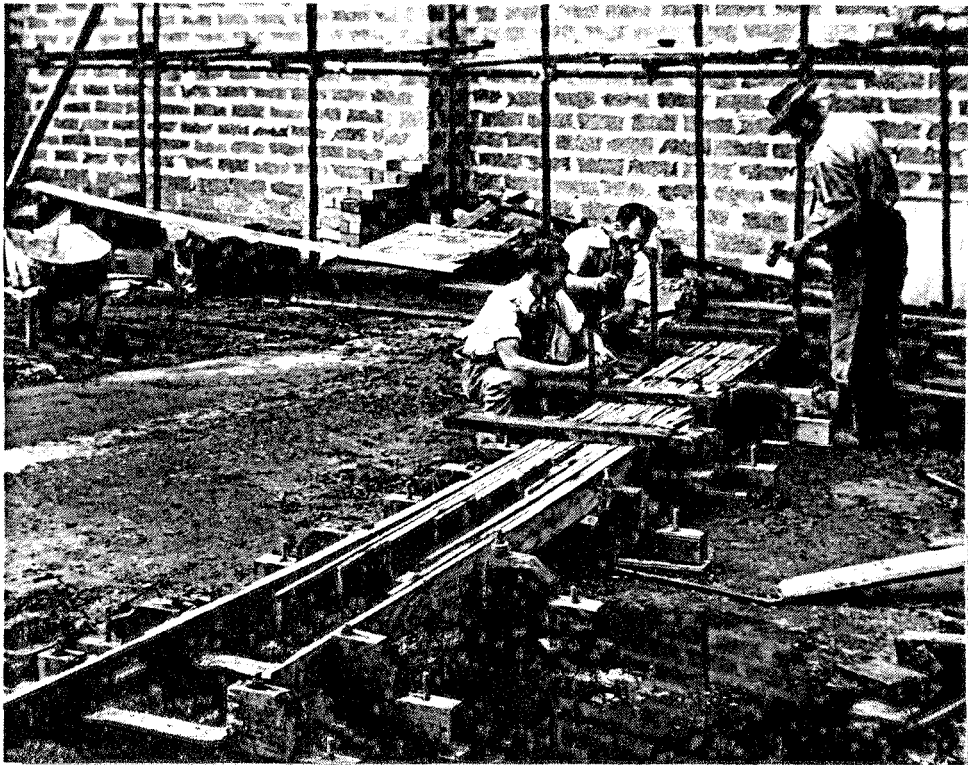


Plate 39. Arches being laid up in site moulds. Photo: Donated by Mr. H. Llewellyn



Plate 40. Cutting the end of the arch to fit the steel seat and drilling it to take the tension rod were the most exacting tasks in constructing the tied arches. The stitch bolts can be clearly seen. Photo: Donated by Mr. H. Llewellyn.

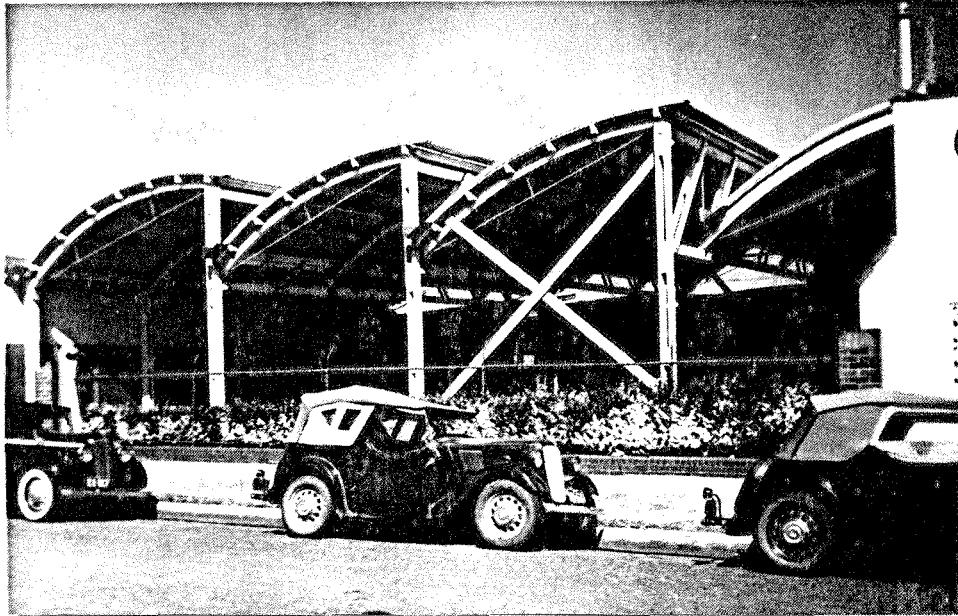


Plate 41. B and S Electrical in Alexandria. Constructed by A. Marr and Sons.
Photo: Donated by Mr. H. Llewellyn

In 1953, Stanley and Llewellyn designed a second plant for Larke Hoskins. This is a factory of two rows of 120 ft (36.6 m) stiffened tied arches (see Exemplar 15). It has 13 bays of 4.55 m. Widely reported, the building featured on the cover of the *Australian Timber Journal* in April 1953 and Pearson et al. (1962) included it in Chapter Eleven of the CSIRO's Timber Engineering Design Handbook. It still stands and acts as a motor showroom. When inspected in 1992, it was in good condition. In May 1953, the *Australian Timber Journal* reported another Stanley and Llewellyn structure. This was a 188 ft x 188 ft (57.3 x 57.3 m) factory constructed for Clark Kilns (NSW) Pty Ltd. With a covered floor area of 34,000 sq. ft (3,159 m²), it was hailed as the largest laminated timber arch and braced girder structure in Australia (see Plates 42 and 43). The roof was supported by sixteen 15 ft (4.6 m) high perimeter lattice braced steel columns at 46 ft (14 m) centres. Braced girders of laminated hardwoods rested on the columns, supporting the ends of the arches. These girders measured 6 ft x 2 ft 6 ins (1.8 x 0.76 m) and were cambered 6 ins (152 mm). The sole internal structural support was a 2 ft (600 mm) diameter concrete filled column in the centre of the building. Two half arches spanned 92 ft (28 m) each and joined on a central ridge girder at the crown of the roof 45 ft (13.7 m) above the ground. These trussed arches used 15 x 6 ins (381 x 152 mm) members. They were laminated on site from 6 x 1 ins (151 x 25 mm) hardwood and glued with a casein based glue. The arches had patented inverted A braces and 1 1/4 ins tie rods (ATJ 1953, May, p. 254).

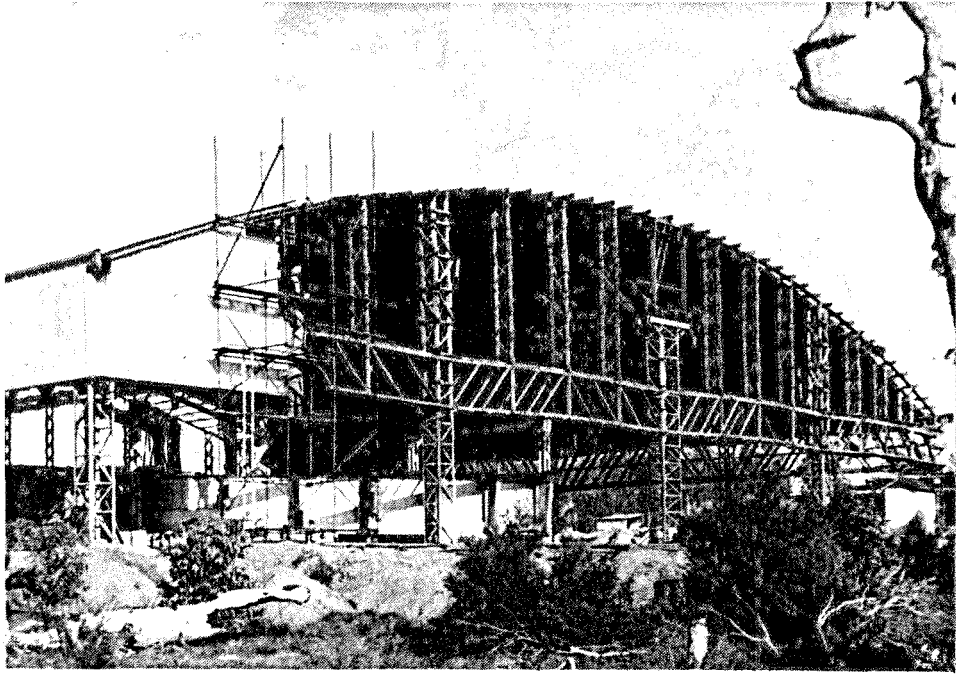


Plate 42. The factory for Clark Brick at Moorebank, NSW under construction, 1953. Photo: Donated by Mr. H. Llewellyn

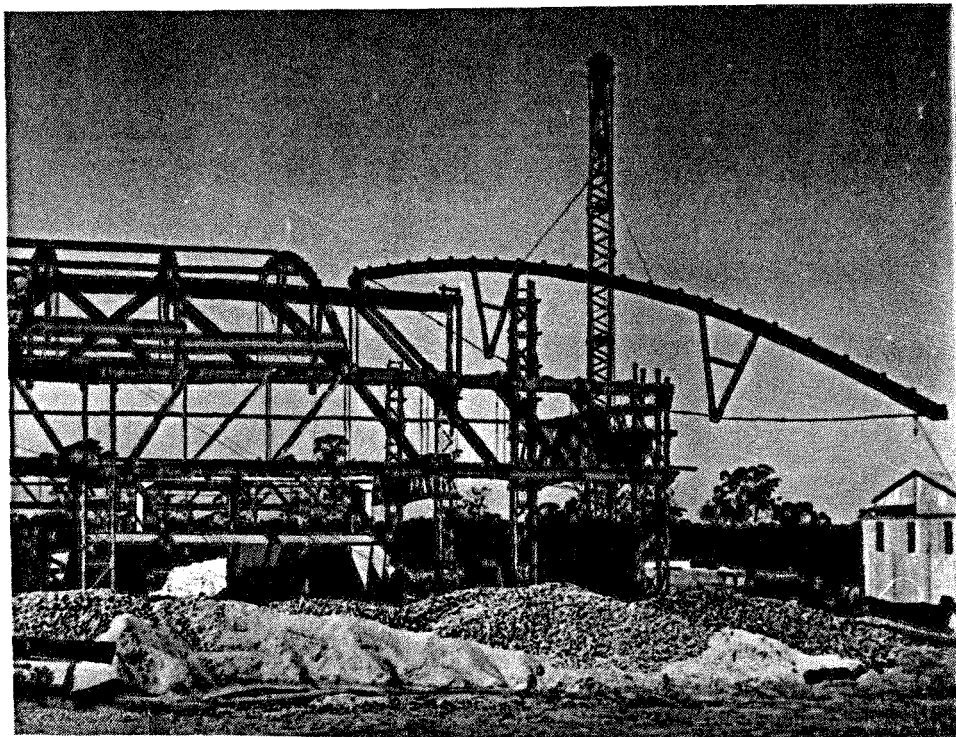


Plate 43. A half arch being installed. Clark Brick, Moorebank, NSW, 1953. Photo: Donated by Mr. H. Llewellyn.



Plate 44. The 100 ft (30.5 m) span factory at Canturbury, NSW. Photo: Donated by Mr. H. Llewellyn.

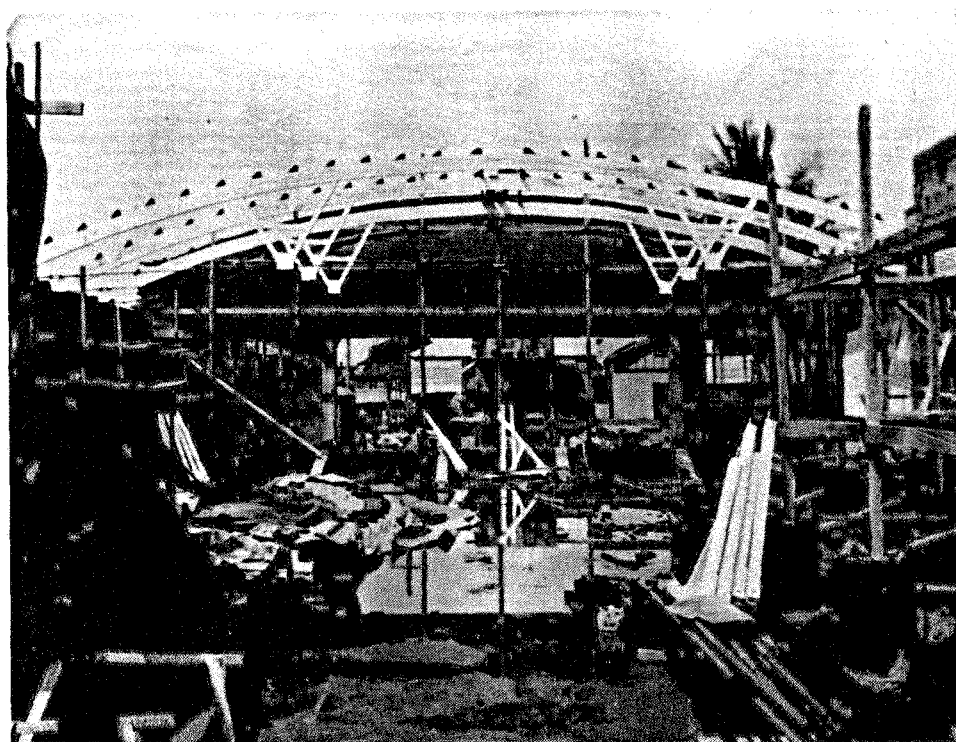


Plate 45. The 70 ft (21.3 m) span factory under construction for Thomas Brown, Cairns, Queensland. Photo: Donated by Mr. H. Llewellyn

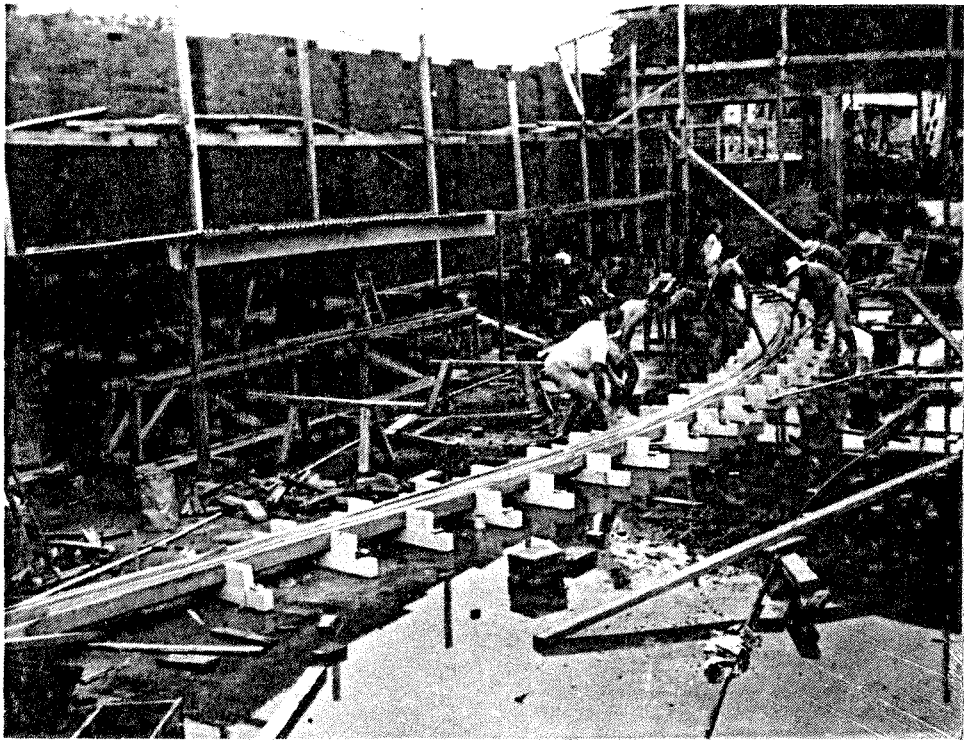


Plate 46. Laminated arches being laid up on site. Thomas Brown Factory, Cairns, Queensland. Photo: Donated by Mr. H. Llewellyn.

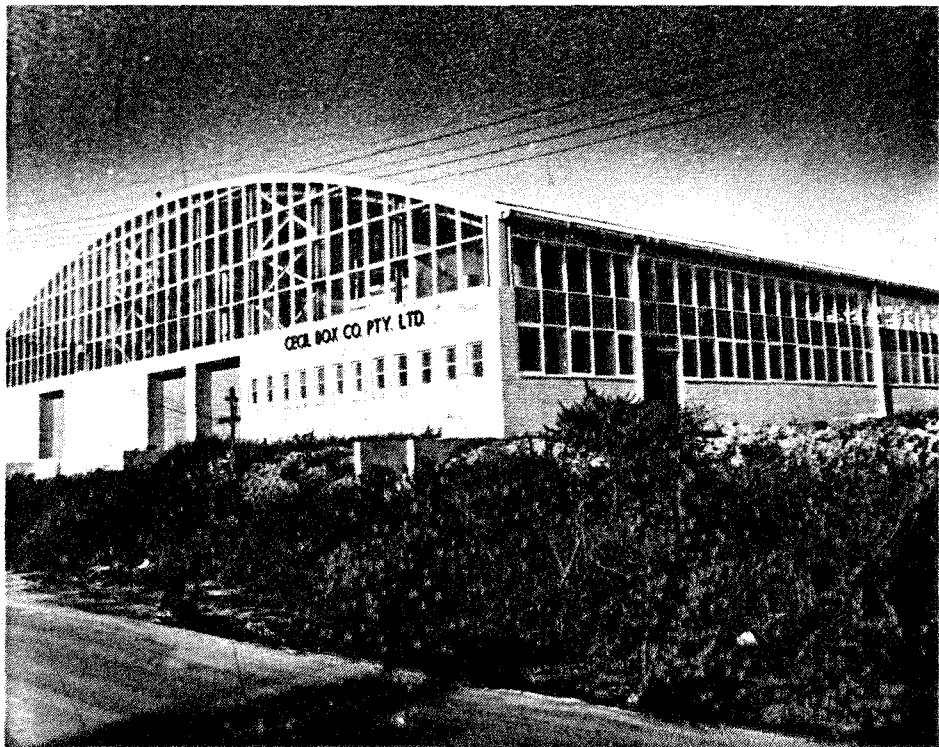


Plate 47. A factory for Cecil Box Limited, Rhodes, NSW. Photo: Donated by Mr. H. Llewellyn

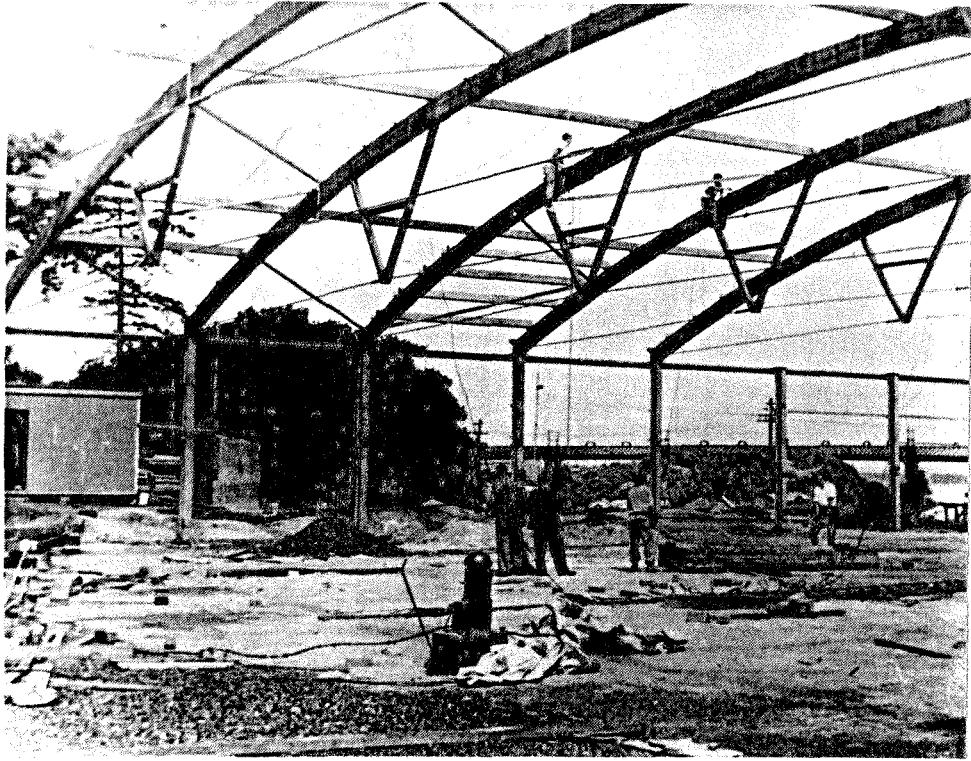


Plate 48. Cecil Box Limited factory under construction, Rhodes, NSW. Photo: Donated by Mr. H. Llewellyn.

Other known Stanley and Llewellyn (Llewellyn 1992, pers. comm. 19 August) projects include:

- a 100 ft (30.5 m) span tied arch structure at Canterbury in NSW (see Plate 44);
- a factory for Thomas Brown at Cairns in Queensland. It was of 13 trusses with spans of 70 ft (21.3 m). It had a 12 ins x 4 ins (300 x 100 mm) top arch section (see Plates 45 and 46);
- a factory for Cellucotton Ltd in Sydney;
- a factory for Cecil Box Limited in Rhodes NSW (see Plates 47 and 48);
- a plant for the Newcastle Wool Pressing Co. in NSW; and
- a factory for Elder Smith and Co. at St Peters, Sydney. This factory had a span of 100 ft (30.5 m) with a rise of 12 ft (3.6 m) in the arch. The main arch chord was a 14 ins x 6 ins (355 x 100 mm) glue laminated member. In 1954, these arches were tested with a load of 7,000 lbs (3,175 kg) at the quarter point. The maximum deflection was 1 1/8 ins (28 mm) and the load was applied and removed three times without noticeable set. The design load of the truss was for dead weight of the arch itself, an asbestos roofing cover and wind (Stanley 1954, September, p. 606).

Finally, Stanley designed the Rothman's Pavilion at the Sydney Showgrounds, which features a folded plate timber roof on steel columns and radial valley rafters.

Malcolm Stanley died in 1955. After his death, the only known timber project undertaken by his firm was a 65 ft (19.8 m) diameter shallow dome constructed at the Revesby Pacific hotel in Sydney. It was constructed in 1957 from prefabricated laminated timber ribs and sheeted in 16 mm ply with a bonded aluminium external skin. Of all these structures, the Granville and Surrey Hills buildings have been demolished while the Cellucotton building was destroyed by fire in the 1960's. The Enfield building still stands and is in good condition, as is the Rothman's Pavilion. The fate of the other structures is unknown.

Beside this major flowering in Sydney, there is evidence that there was activity in other centres. In late 1954, several major South Australian timber merchants, including Geddes, Lloyds and Wadlows, established a new company called Laminated Timber Products Limited with an aim to capture some of the industrial and commercial contracts of the early 1950's in South Australia.

The object of the company is to provide a service to builders and architects in the manufacture of glulam arches and to initially make arches to any specification required, including large buildings and churches. (ATJ 1955, p. 283)

By 1955, the firm had constructed:

- their own factory building: a 130 ft (39.6 m) span foundation semi-circular laminated arch structure at Hanson Rd, Adelaide in SA (see Plates 49 and 50);
- a 150 ft (45.7 m) span arch structures of similar type that is now part of Seas Saphor's Mill at Kalangadoo, near Mt. Gambier in SA (see Exemplar 17); and
- two church buildings, one of which was at Kurralta Park, the other at Meddons, South Australia.

Both factories still exist and are in reasonable condition. The simple Kalangadoo building is the longest known clear span glue laminated arch building in Australia. Though the company was reported to have further orders for 1956, it went out of business before 1963. After Stanley's death in 1955, evidence of further long span timber structures reduces considerably. Though Symonds and other practitioners continued to design or produce glue laminated structures, the concentrated construction of successful timber structures seen in Sydney in the early 1950's was not repeated. The cycle that began with Symonds' St Peters Factory in 1946 ended with his death in 1961.



Plate 49. The 130 ft (39. 6 m) factory at Hanson Rd, Adelaide. 1955.

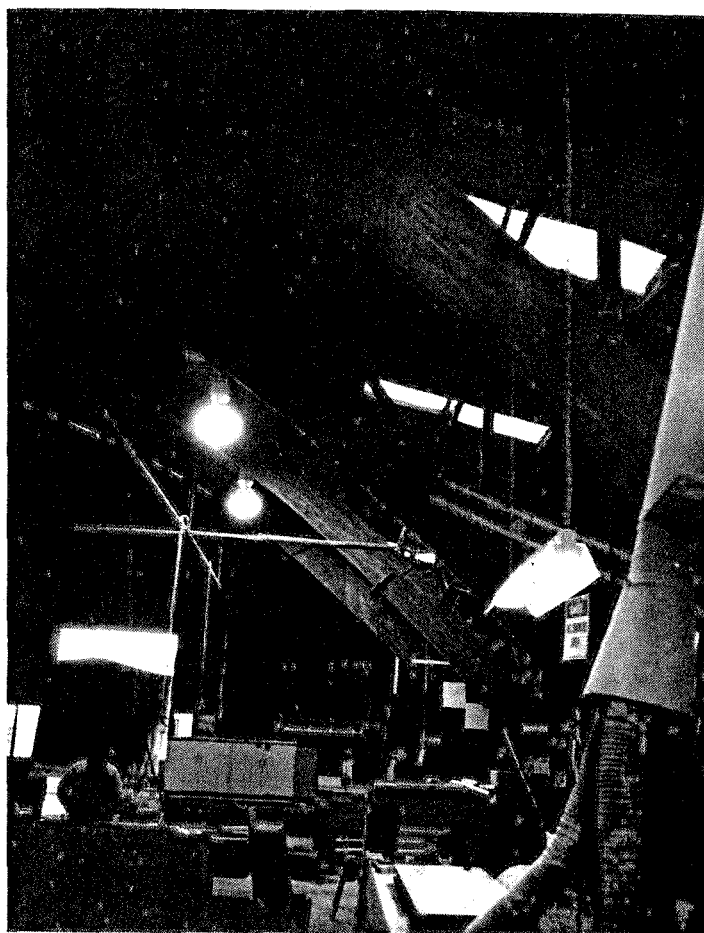


Plate 50. Site laminated oregon arches. Hanson Rd, Adelaide. 1955.

During this time, timber had been used as a comparable alternative to steel by several dedicated engineering practitioners. However, while it held economic advantages *, it was not seen as a favoured choice by the dominant professional groups. At the worst reading of the situation, it could be that the Symonds' and Stanley's timber structures were constructed only because there was so much work available and alternative materials were in short supply.

Buildings of significant size and beauty were constructed and several are known to still stand. However, like the war time buildings, they seem to have made little or no impact on the aesthetic or structural development of architecture or on the appreciation of timber structures. Symonds' Homebush Bay factory is the only timber building of the period that is commonly known to current design professionals. It is a favourite site visit for professional courses at several of Sydney's universities. All the other buildings are unknown to professional groups and to timber industry representatives in Sydney.

This loss of professional memory is more confounding than the disappearance of the war time buildings. Unlike the war buildings, information on Stanley's and Symonds' buildings was not censored. Stanley's work was widely reported in the building and timber literature of the day. It greatly interested the CSIRO and, as the research and standards agent of the timber industry, they struggled to keep up with his developments. The clients for Stanley's timber buildings were major companies. At least one was so satisfied with their timber product that they had a second larger building constructed. Also being a respected engineer, Stanley had credence in intellectual and professional circles. Despite this, it took 30 years from his death for another long span tied arch timber building to be constructed in this country and it was designed in ignorance of his methods. Symonds, on the other hand, was considered a larrikin. He reportedly clashed with the dominant engineering establishment yet built in a very public way. Premiers attend his openings and Earls were his business partners (Hochroth 1987, p. 17). Nonetheless, Symonds' eighteen years of work in timber structures was as good as forgotten within professional circles when Cox, Freeland and Stacy wrote their work on timber construction less than eight years after his death.

* Symonds maintained "that glue laminated factories were most economic for spans greater than 90 ft (27.4 m). Anything less than that and it was cheaper to build in steel."; from an address entitled Facts & Fallacies of Timber Design; Reported in Australian Timber Journal; January, 1957; p. 103

The architects of the time built in the International Style and it appears that timber was held to be incompatible with its requirements. Not one major commercial (as against industrial) building in timber was recorded from this period. Interestingly, one of Australia's original modernist buildings, Seidler's Turrumurra House of 1950 was a timber building and won that year's timber house award.

1. 6 The Australian Regionalist Cycle 1962 - 1975.

This cycle began in 1962 with an inspirational basis that Cox, Freeland and Stacy (1980, p. 66) described in 1968 as:

... a new generation rediscovered in the countryside and the old industrial areas the (timber) buildings whose strength, honesty and rightness were qualities largely missing from our world. The stability and permanence, the unaffectedness and confidence, the personalness and warmth that they had were new and delightful. Avoiding copying, the spirit and the qualities of the legacy of the rude timber buildings of a century before had been injected into the twentieth century blood stream - and Australian architecture is the richer and better for it.

This cycle was principally driven by architects and timber emerged as one of the most important building materials (Cox 1982). Though a philosophical connection was established with the Rude Timber Building Cycle, this did not restrict the breadth of solutions. The buildings produced were most diverse. As foretold by Stanley in 1954, plywood was adopted widely as a construction material. In 1962, Clarke, Gazzard and Yeomans, Architects, won the James F. Brett Plywood Prize for the clubhouse of the Forbes Golf Club. It was described as:

The upper floor consists of one large space 50 ft (15. 2 m) wide and 110 ft (33. 5 m) long, surrounded by an open terrace... The box plywood trusses support the roof in a clear span over the upper floor 51 ft (15. 5 m) centre to centre of columns, cantilever 10 ft 6 ins (3. 2 m) in on each end and are 12 ft (3. 6 m) apart. (Architecture in Australia 1963, p. 110 - 111)

At about the same time, plywood portals spanning 40 ft (12. 2 m) were constructed for Wilkinson's Timber in Mt. Gravatt, Brisbane. A plywood portal structure was constructed at Dobroyd Point Aquatic Club, Sydney in 1964. A standard school building design using a 36 ft (11 m) plywood beam on a 6 ins x 6 ins (152 x 152 mm) post as the primary structural element was adopted by the NSW Education Dept, the first one being built at Gateshead Public School in Newcastle in 1965. A 50 ft (15. 2 m) span portal assembly hall was designed by Alan Eedy, ARAIA, and constructed for the Oatley West Primary School. Alan Robertson ARAIA, designed a 50 ft (15. 2 m) span church with plywood gothic arches at Lorne, Victoria and Lloyd Wynn ARAIA of Sydney designed a 36 ft (11

m) span 26 ft (7.9 m) high church at West Pymble, utilising plywood portal arches fabricated by Automated Building Components.

Pearson, Kloot and Boyd's Timber Engineering Design Handbook assisted this resurgence. Released by the CSIRO in 1958, this revised Langlands and Thomas's work and codified many of the technical developments made since the Pacific War. With this revived interest and confidence, other forms were explored. The world's first commercial multiple hyperbolic paraboloid (hypar) roof was constructed in the U. K. in 1957. In Australia, the first hypar roof was built as the South Parklands Restaurant in Adelaide in 1962.

(It) incorporates a roof to the dining area composed of three contiguous timber shells. Each shell consists of three layers of 5 ins by 13/16 ins (125 x 20.6 mm) nailed and glued Oregon boards... Contractor for the supply and construction of the shell was Wadlow Timber Industries Ltd., Port Adelaide (Copley 1964, p. 239 - 243)

Another three hypar shell building was constructed by Beechams for the Aboriginal Advancement League Recreation Centre in Melbourne to cover a floor area of 40 ft (12.2 m) x 50 ft (15.2 m). In more conventional and historically inspired construction, Ian McKay and Phillip Cox designed the St Andrews Presbyterian Agricultural College, Leppington in 1962 and followed it with the 1965 Sulman and Blackett Award winning, C. B. Alexander Presbyterian Agricultural College, Near Tocal Homestead, Paterson. The Tocal building was described as:

The major rafters are of tallowwood and ironbark, and blackbutt serves as minor rafters and linings. All roof timbers were exposed and stained. Parallel chord trusses in the entrance hall state the strong theme of heavy timber roof systems throughout. The assembly hall/gymnasium off the main entrances is 108 ft (33 m) in length and a fink truss system spans it's 63 ft (19.2 m) width. Bolsters supporting the truss systems were hand hewn with an adze. The series of trusses has bottom bracing chords of 10 ins x 4 ins (250 x 100 mm) section with 8 ins x 4 ins (200 x 100 mm) diagonal bracing and mid-span purlin strutting of NSW hardwood in the dining room. The king post truss system is visually complemented by the solid plank furniture of Tasmanian Oak... The focal point of the complex is the magnificent chapel. It is 50 ft (15.24 m) square. Rising from the brickwork the roof becomes a 100 ft (30.5 m) spire, made up of four major trusses joined up with a central common chord. This spire withstands tremendous wind loadings and incorporates one of the most complex joints known, using 210 split ring connectors... This is a timeless character. It rates with the world's best contemporary building projects (Wood World 1968, p. 1).

McKay continued his work with timber structures throughout the 1960's, firstly with the Presbyterian Church at Manilla, NSW

The trusses were prefabricated from 3/16 ins (4.7 mm) plywood in a 4 ins x 2 ins (100 x 50 mm) ladder frame and proved economical and light for erection.

They are connected by plywood sheets linking inside chord to outside and are thus triangulated by the tiled roofing battens. Thus every element performs a structural and finishing function and the building is extremely light, flexible and economical. It was completed in 1968. Area 1988 sq ft (184. 7 m2). (Architecture in Australia 1970, p. 777 - 718)

He followed this experience with a stressed skin beam roof for the Food Services Hall, Woden, ACT. Engineers for this building were Ove Arup and Partners.

The Woden building owes very little to tradition. Simply, the Food Services Building is 28 plywood beams spanning between glazed three dimensional verindal trusses... This provides a clear 80 ft (24. 4 m) span square area for people to sit at tables and eat. The beams are 81 ft (24. 7 m) long. They are the largest stressed skin plywood beams ever made in Australia. Framing is radiata pine and the skins are 3/8 ins (9. 5 mm) marine plywood with a sapele face veneer. Each beam has a five inch camber (125 mm). The beams were fabricated in Sydney... The overall effect in situ is of a continuous folded plate oiled timber ceiling (Wood World 1970).

Industrial buildings in timber were also constructed. Unlike the stream of confident buildings constructed in Sydney and elsewhere in the 1950's for disparate clients, these were single groups of buildings built for companies with an interest in timber. In 1962 Beechams in Melbourne constructed their own works as a display for their developing timber engineering section. The largest structure, the resawing plant, is 364 ft (110. 9 m) long and has a 100 ft (30. 5 m) clear span oregon bowstring truss roof (see Plates 51 and 52). It still stands and is in good condition.

In 1963 Lloyds Timber built a propped portal truss structure for their new mill building at Port Adelaide. It still stands in good condition (see Exemplar 13):

(It) is an excellent example of the advanced use of timber as a structural engineering product... The 240 ft (73. 2 m) wide section is spanned by two sets of 120 ft (36. 6 m) long trusses at 16 ft (4. 9 m) centres. All told approx. 80,000 super ft of undressed timber was used in the wall framework and trusses. (ATJ 1964, p. 244)

The timber industry and the CSIRO clearly recognised the importance of this work and the value of increased professional competence in timber construction. In 1962, the TDA hosted a Timber Engineering Conference in Melbourne to establish an Australian Institute of Timber Engineering. Mr. J. D. Boyd of the Division of Forest Products of the CSIRO was the principal speaker at the conference:

(In his speech) he pointed out that unfortunately engineering, as taught in most technical schools and universities in Australia, gives scant attention to timber, and its special qualities, good and bad, which must be understood if it is to be efficiently used... it must be faced that very few engineers in Australia at present could be regarded as efficient designers. Furthermore, most engineers in Australia cannot be tempted at present to design in timber, because of their lack of knowledge on one hand and perhaps more importantly because of the lack of adequate fabricating facilities. (ATJ 1962, p. 51)

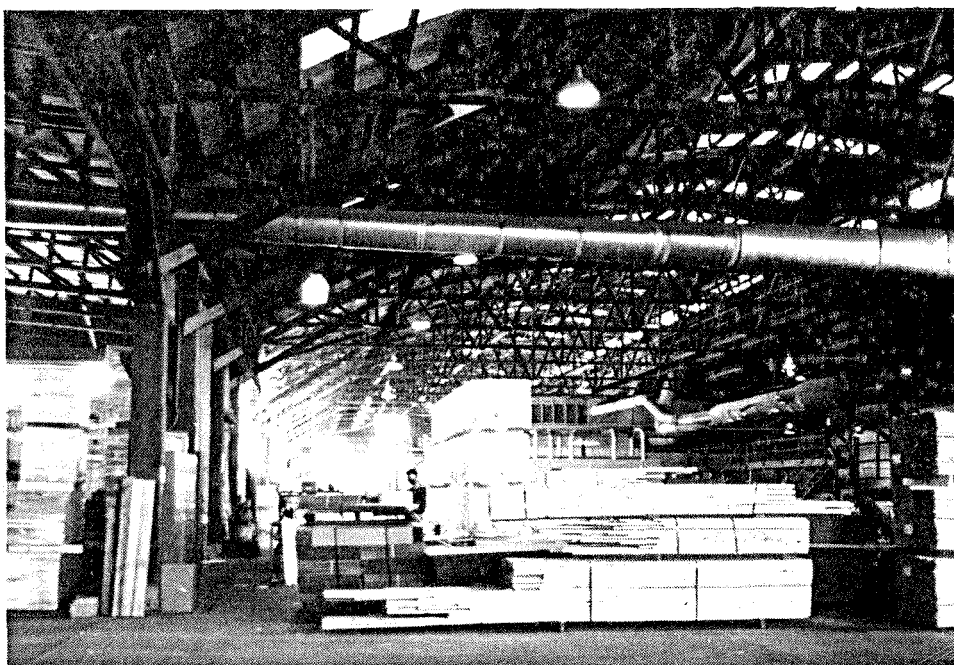


Plate 51. The resawing mill at the Beecham-Wright plant at Altona North, Victoria. 1962.

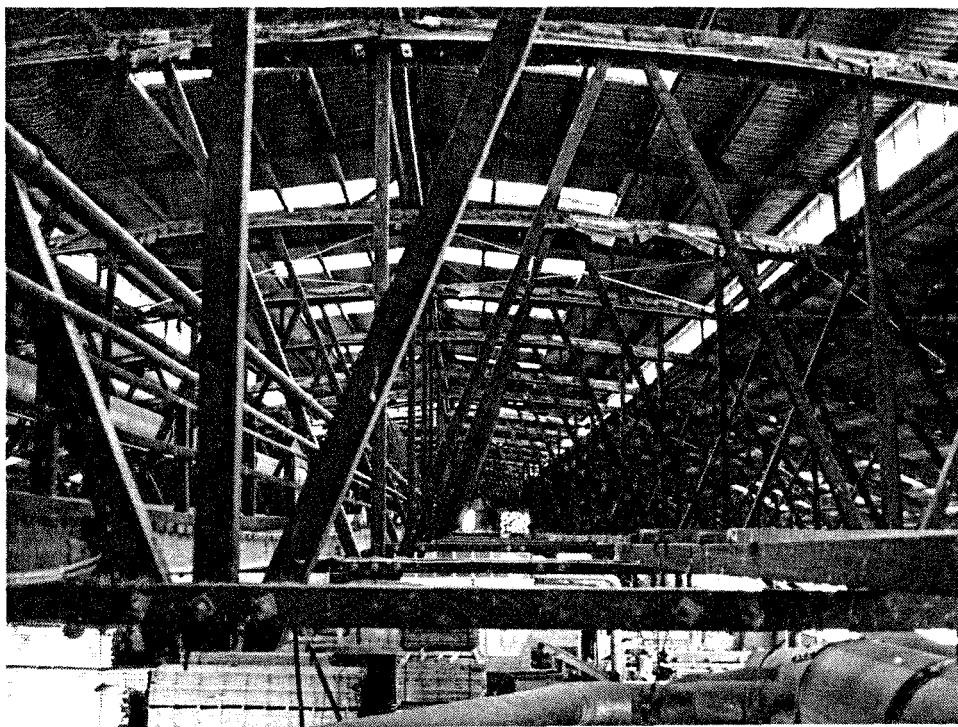


Plate 52. Bowstring trusses at the Beecham - Wright plant at Altona North, Victoria. 1962.

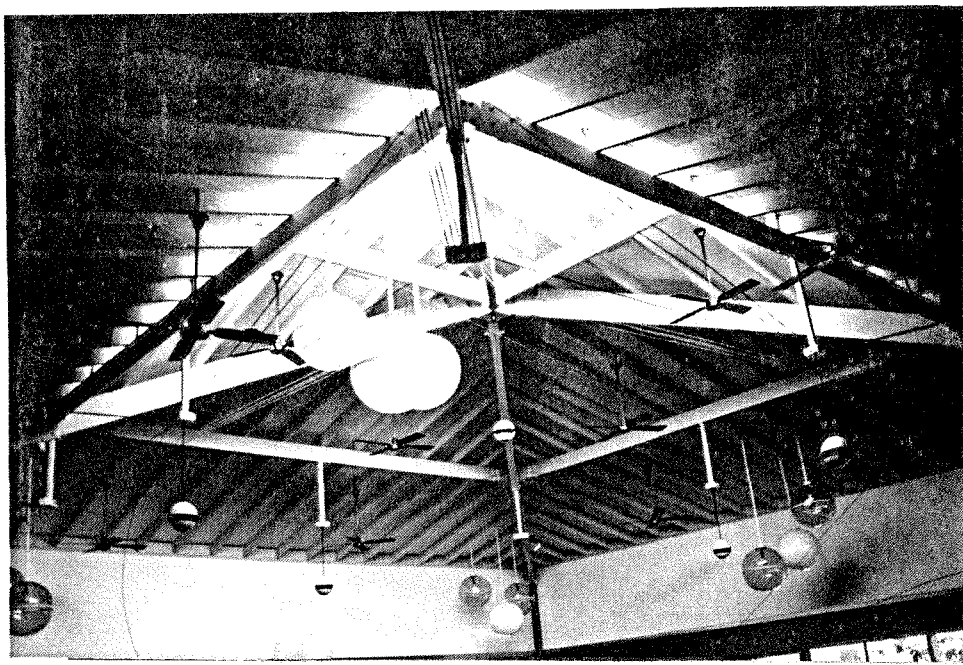


Plate 53. A pinned frame roof of trussed beams over the Dining Room of the Crippled Children's Centre, Perth, WA, 1972.

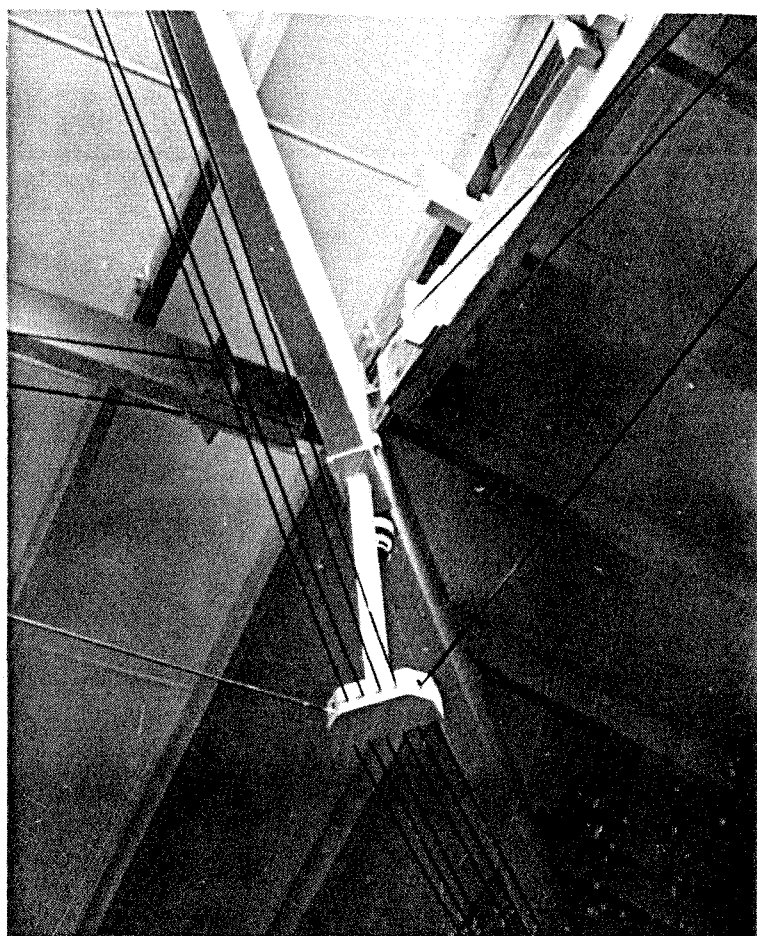


Plate 54. Detail of trussed roof beams, the Dining Room of the Crippled Children's Centre, Perth, WA, 1972.

Mr. D. Barnes of the NSW TDA commented on quality control. He said:

There is a wide difference of approach on the question of control between the North American and U. K. Industries. In North America, through the Canadian Institute of Timber Construction (CITC) and the U. S. American Institute of Timber Construction (AITC), strict standards have been developed. CITC and AITC were formed by interested member companies of the industry to establish standards for both design and manufacture, to produce basic technical data and to develop and operate quality control. (This system was also successfully introduced in New Zealand and for the Australian Plywood industry in 1963). This reflects the emphasis placed on standards and quality throughout the whole organised industry (there). In the U. K. the TDA 'approved manufacturer' scheme, in practice, operates rather as a listing of firms interested in and capable of manufacturing engineering members, than a guarantee of quality to a standard. Each manufacturer sets his own standards and, as one of them put it, the companies that sustain the quality of their production must in the long run get the business. (ATJ 1962, p. 51)

Occurring at the beginning of a major upward cycle in timber engineering, there are several important points to note from this conference. First, neither the Royal Australian Institute of Architects, the Association of Consulting Engineers Australia, the Institution of Engineers nor any tertiary education body appear to be represented. The only participants were the timber industry and its major research arm, the CSIRO. Second, it appears that the question of concerted quality control procedures became too difficult and the U. K. model of quality control was adopted. Interestingly, of the five English speaking countries mentioned, the three that adopted externally verifiable quality control programs developed significant glue laminated timber sectors. Australia did not. Third, the conference concentrated on the need to educate engineers in timber. This was superficially logical but it was architects who were driving the rise of timber design that was under way and demanding timber construction from their professional associates. Finally, the Australian Institute of Timber Engineering was formed at the Conference with CSIRO and industry support with the stated aim of promoting engineering education. It existed until at least 1966. However, no publication or document from this organisation has yet been found.

In 1963, the Gang-Nail truss system was introduced to Australia, and with it came American marketing techniques. Stokes (1966, p. 212) outlined the history of its introduction. The names in parentheses are supplementary information drawn from a previous article (ATJ 1964, February, p. 253):

Lightweight timber trusses as such are not new. Considerable research and development on lightweight nailed trusses were carried out in the 1940's by the Commonwealth Experimental Building Station and the CSIRO... In 1960, a large Melbourne based timber company, (Kauri Timber) applied for patents for a steel multi nail connector plate with triangular teeth, and after a considerable testing program... plants were installed to manufacture these trusses in four states...

Little expansion of the truss industry took place however and it was not until 1963 that the truss explosion took place.

At this time a group of major Australian timber Companies (Kauri Timber, Melbourne; Lloyd's Timber, Adelaide; Australian Lumber Co, Perth; George Hudsons, Sydney) joined forces with the leading American nail plate company (Automatic Building Components Inc of Florida) and established offices and manufacturing facilities in Melbourne. This company then took over the original Australian connector... A comprehensive engineering design department was set up led by a talented young engineer (Stokes himself)... (and) measures were adopted which enabled the connectors and the designs to be to be unconditionally guaranteed so that in turn, the fabricators could unconditionally guarantee the trusses... Fabricators were appointed in every capital city after careful evaluation of each Company's technical ability, its marketing history, its general history and its industry status... This group, through the successful programme outlined above, now supplies over 90% of Australia's trusses and truss usage is rising

Gang-Nail trusses have been one of the few successful long term timber engineering systems in Australia. Marketing was originally targeted at industrial building and significant structures were built. One of the largest was the building materials centre constructed for Brandon's Timbers in 1968. It featured 100 ft (30.5 m) span bowstring trusses fabricated with Gang-Nail plates (ATJ 1968, p. 53). Built near Archerfield Qld, it still stands. In Perth, Bunnings Limited, one of West Australia's largest timber producers also embraced timber engineering. In 1961, Tom Bunning interviewed and employed a highly qualified timber engineer from London, Dimitri Chess. Soon after glue laminated beams and engineered roof trusses were introduced to Western Australian buildings (Mills 1986, p. 201).

As the decade turned, two consistent concerns returned for the timber industry. This was the lack of quality control by general producers and a lack of trained timber professionals. Huddleston (1969, p. 45) outlined the former:

It is known that some timber merchants and some small manufacturers without proper workshop facilities are manufacturing glulam members. Quality control in most is unsatisfactory and the Division of Wood Technology has been called upon to investigate difficulties arising from the unsatisfactory manufacture. Each failure which occurs, even though it may not be disastrous and only require immediate measures to rectify it, comes under notice and is widely discussed.

Stokes (1969, p. 308) commented that:

The future of timber engineering in Australia hinges on the availability of timber engineers orientated towards the need of the market... It is a matter of concern to find an almost abysmal lack of confidence in timber and the lack of a 'feel' for timber as a structural material in the very heart of our industry and I now believe that this confidence can only be widely developed by conceiving, designing and then seeing, and living with slender safe timber structures.

Even given these difficulties, numerous short and medium span domestic and commercial buildings were constructed using timber as a primary structural

material (see Plates 53 and 54). In contrast to the experience of the 1950's, architects embraced timber and this was the first cycle since Federation where the leaders of a major design profession willingly adopted timber as a desirable aesthetic and structural alternative for day to day practice. In 1969, Alan Williams and Associates designed the Gosford Municipal Library with engineers, Ove Arup and Partners. Also in 1969, what was probably the first timber structure enclosing a swimming pool in Australia was constructed at Malvern in Victoria:

Timber used structurally is the basis of design... The fully enclosed pool (is) one of two in a complex of five pools in the 'Harold Holt Memorial Swimming Centre'. The columns were glue laminated by the Woods and Forest Dept. of the South Australia. They support trusses with a 70 ft (21. 3 m) span. Stress grading of all timbers was carried out to ensure that they satisfied the design requirements for strength and stiffness. (Wood World 1969)

Architects were Kevin Borland and Daryl Jackson. It proved a forerunner of many such structures. The genre continued with the pool enclosures at Devonport, Tasmania in 1973 (Wood World 1974), at Auburn, NSW in 1975 and further complexes by Daryl Jackson at Collingwood and Frankston, Victoria. Other building types that favoured timber as a construction material in the 1960's and 1970's were hotels and restaurants. New hotel buildings provide possibly the greatest variety of timber structures of the period. The pub designers of this time realised and exploited the psychological associations of wood with relaxation and informality.

In 1973, two of the largest glue laminated structures ever built in this country were completed. The first was a giant storage building built by Bunnings Limited for Texada Mines Pty. Ltd. at Cape Cuvier, 995 km. north of Perth (see Plate 55 and Exemplar 19). The building is a three pin gothic arch structure of 23 bays of arches at 4. 88 m centre. Each arch had a rise of 23 m and a span of 41 m. The building had a total storage capacity of 66,040 tonnes but was never used. The industrial process for which it was constructed failed. The second, and perhaps the single most technically demanding timber structure ever attempted in Australia, was the Sydney Opera House. Inside what is commonly regarded as a monument of concrete construction, architects Hall, Todd and Littlemore designed two timber theatres of plywood and glue laminated hardwood.

Seventy thousand sq. ft (6,500 m²) of white birch have been cut for the job and all have been kept to strict standards of colour and quality for this building... The eighty separate sections of the crown, when assembled, span an area 40 ft (12. 2 m) in diameter and the outside dimensions of the total assembly are accurate to a thirty second of an inch... (while in the theatre seating and stages) over 134,000 sq. ft (12,500 m²) of laminated brush box hardwood panels was used. (Wood World 1971)

In 1972, the Standards Association of Australia published CA 65, its first timber engineering design standard. In 1975, this standard was revised slightly, metricised and renumbered AS 1720 - 1975a (Leicester 1982). Also in 1975, a new generation of timber bridges appeared with the 50 m span pedestrian bridge over the Plenty River at Greensborough in Victoria (see Plate 56 and Exemplar 18). A graceful three pin foundation arch, this is the longest clear span timber bridge (as against a composite timber and steel bridge) ever constructed in Australia. It was designed by BSC Consulting of Melbourne. The arches were solid members laminated from CCA treated radiata pine. Bunnings fabricated them in Perth.

By the time this bridge was built however, the diverse construction of timber buildings begun to wind back and the Australian Regionalist Cycle ended by 1976. This could have come about because the architects and engineers who designed with timber in the 1960's matured, growing away from the material or as architectural style had introduced the cycle, a change in that style now helped to bring about its close. There is evidence that professionals found that the lack of quality and supply control from a fragmented timber industry was not worth the trouble in administration and detailing. At the 1978 Timber Conference, Phillip Cox or Don Gazzard commented:

Just recently we documented a very large school in timber for the PWD... (and) it's been a very difficult process to get sufficient timber in sufficient sizes and sufficient consistency to get that building built. I think a lot of the trouble goes back to the industry where you must co-ordinate your efforts. (AFIJ 1978, p. 38)

In 1976, the dedicated timber construction magazine, *Wood World*, folded from lack of subscriber and advertising support. The only other national timber periodical, the *Australian Forest Industries Journal (AFIJ)*, had reduced its timber structures coverage in 1967 when *Wood World* was introduced and now showed little interest in reviving it. No building constructed between 1974 and 1984 was nominated in the replies to the building survey carried out for this research. While undoubtedly timber structures continued to be built through this period, the chance to establish a diverse and confident commercial and industrial timber construction sector in Australia that had appeared so promising when Ian McKay's plywood beams were installed at Woden, ACT, had slipped away.

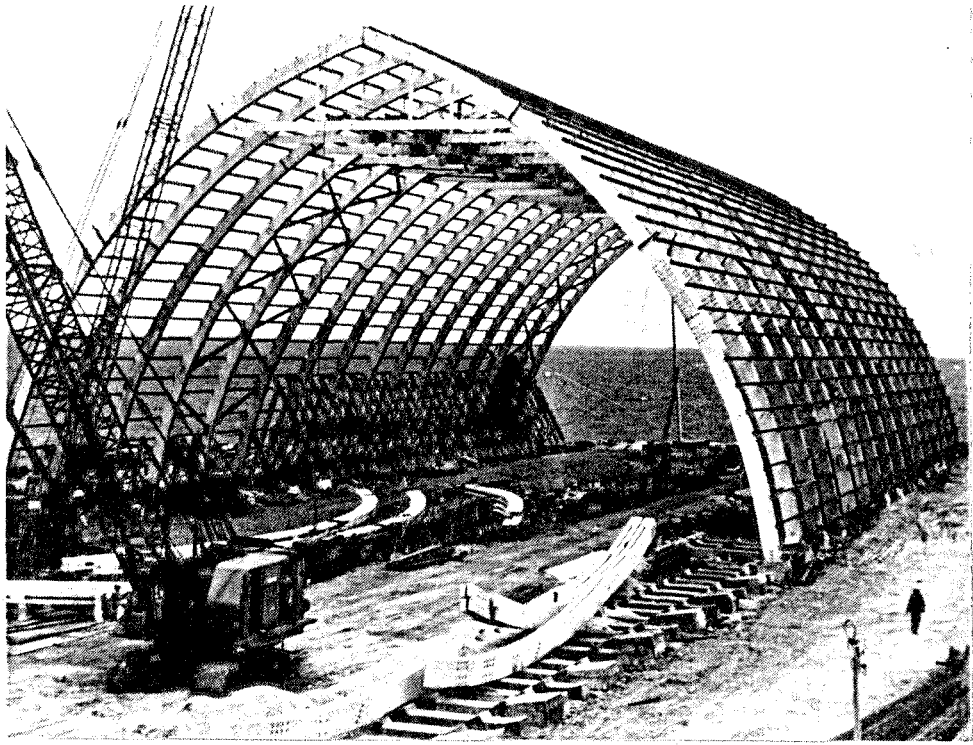


Plate 55. The 41m span jarrah arches at Texada Mines Pty. Ltd. Plant, Cape Cuvier. WA. Photo: Donated by Bunnings Limited

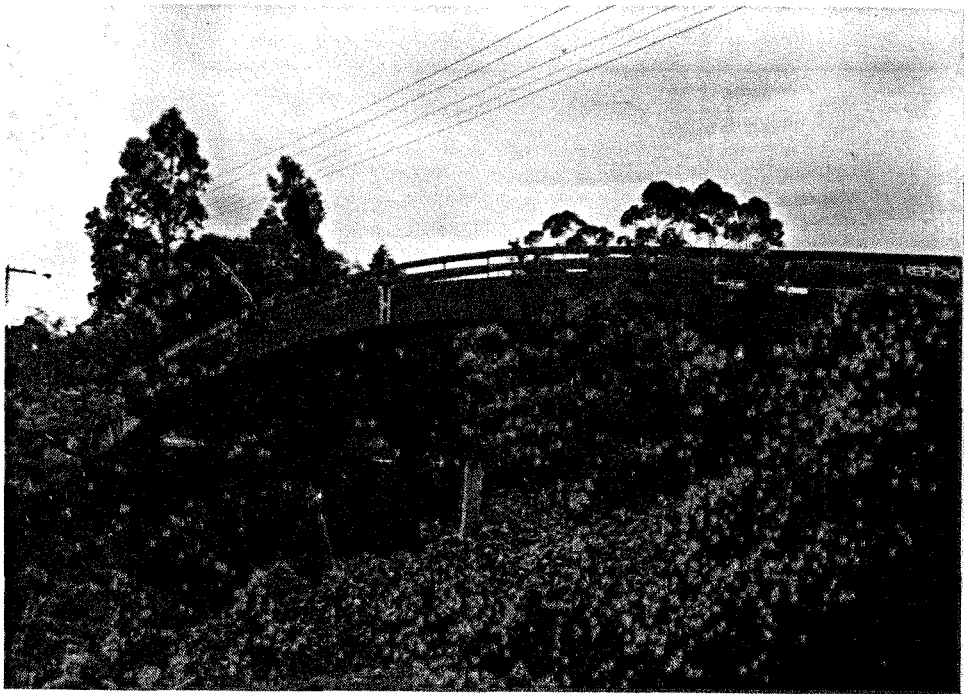


Plate 56. The 50 m. span Plenty River bridge at Greensborough, Victoria.

Again, as with the green hardwood buildings of the Pacific War Cycle and the arches of the Postwar Reconstruction Cycle, the diverse timber structures of the Australian Regionalist Cycle appear to have slipped first from the memory of the timber industry and then from professional memory. Documentation of this period from a timber perspective has not been carried out even though many of the practitioners of this period are still alive. In spite of the stated concentration of the timber industry on engineering education, the major works, literature and legacies of the cycle were all architect inspired or produced. The most enduring aspect was Cox, Freeland and Stacy's identification of the farmhouse and the heavy timber factory as the archetypal Australian timber structure. This association pervaded the popular perception of built timber forms of the time and now appears to have passed into the accepted culture of the design professions and the public.

In 1982, the combined Timber Development Associations relaunched a much changed *Wood World*. However, Colin MacKenzie (1983, p. 35), engineer at TRADAC in Queensland, stated:

The following initiatives and research require immediate consideration to ensure the credibility of structural timber.

- a. The enforced and controlled use by Industry of existing stress grading techniques.
- b. Continued rationalisation of visual stress grading rules...
- d. Implementation of an Industry Quality Control programme for proof graded timber...
- f. Implementation of in-grade assessment programmes for all species...
- g. Determination of the "real" joint properties of all species.

On the truss fabrication industry, he commented:

The Industry, in general, has no recognised parameters that are required to be met to set up a (truss) plant, no established or enforced industry quality control programmes for truss manufacture and no single recognised training scheme for the staff that are in control of these plants... The same story is also applicable to laminated beams, wall frames and other engineered timber products.

Unfortunately, these comments were similar to those of the first Timber Development Council in 1938.

1. 7 The Portal Frame Cycle

1984 - 1992.

The Portal Frame Cycle was established in 1984 as Australia again entered a resurgence of commercial and industrial building. Unlike the Australian Regionalist Cycle, this cycle identified no historical inspiration. Its dominant form was the portal frame and the structural design technologies employed were international. They were made possible by the use of glue laminated, the introduction of

laminated veneer lumber (LVL) to Australia and the refinement of multiple nail technology. Pine and oregon were the base materials. Only glue laminated used native Australian hardwoods and then only occasionally. In 1984, the cycle began when timber engineering gained several converts at the Pacific Engineering Conference in New Zealand. Lyngcoln reported that;

It fired up and motivated a number of Australian engineers such as Peter Law and Bruce Hutchins. We were extremely impressed by the timber engineering techniques we were shown and our attitude was: 'If the Kiwis can do it, why can't we?' What's more, they were using a lot of our basic research to do it. The immediate result of that conference was a couple of timber structures were built. (Gough 1988, p. 30)

In 1985, the South Australian Timber Corporation (SATCO) introduced LVL to the Australian market. In the same year, Bruce Jordan, an engineer with SATCO, designed the first LVL portal building in Australia for their plant at Mt. Gambier, South Australia. (Jordan 1992, pers. comm., 11 September). Though a relatively small 15 m span portal, it established many of the design characteristics of its much larger successors. In 1986, The National Association of Forest Industries (NAFI) was formed as a peak national body for the timber industry. In 1987, the *Australian Forest Industries Journal* relaunched with it's *AFIJ* format and reintroduced timber engineering to its editorial policy. This increased the profile of practitioners and material alike. Finally in 1988, the new Australian Standard Timber Engineering Code was released.

Engineers founded the new timber movement producing timber industrial structures. In conditions of industrial expansion similar to the early 1950's when Stanley made his mark, Law in Queensland and NSW, Hutchins and Yttrup in Victoria, Dan Jepsen in Queensland and others around the country began to produce a series of confident industrial timber portal structures in glue laminated and LVL. A short list of these structures includes:

Timber Industry Training Centre, Creswick. Victoria.

Designers: Timberbuilt Pty. Ltd., Arch. Consultant Ross Henry;
Engineers: Timberbuilt Pty. Ltd., Bruce Hutchins;
Structure: beam grids;
Material : LVL - box beams;
Span : 12 m.

Timber Component Merchandising Centre, Bayswater. Victoria. 1987.

Engineers: Mark Bachelor, Bruce Hutchins, Dan Jepsen, Ross Proud, Ian Windle;

Structure: two pin portal frames;
Material : glue laminated softwood - oregon;
Span : 24 m.

Olympic Sportsfield, Adelaide. South Australia. 1987.

Engineers: Don Phillips of Connell Wagner;
Structure: tied arch;
Material : mechanically laminated softwood ;
Max span : 25 m.

Tradesman's Entrance Hardware Store, Tullamarine. Victoria. 1987

(see Exemplar 1).

Architect: S. Sokolski Co;
Engineers: P. J. Yttrup and Associates;
Structure: straight solid beams; two pin continuous portal frames;
Material : LVL;
Span : 30 m.

Contract Development Buildings, Campbellfield, Victoria. 1987.

Engineer: Peter Law of Gore Law and Associates;
Structure: 2 pin frame portal;
Material : glue laminated softwood;
Span : 40. 5 m.

Scrimber International Warehouse, Mt. Gambier, South Australia. 1988.

(see Exemplar 9).

Architects: Ross Henry;
Engineers: P. J. Yttrup and Associate;
Structure: two pin portal frames;
Material : LVL;
Span : 30 m.

CSR Wood Panel store, Tumut, NSW.

(see Exemplar 10)

Engineers: Don Phillips of Connell Wagner Pty Ltd;
Structure: two pin portal frames;
Material : glue laminated softwood;
Span : 40. 6 m.

Dale Glass Industries Factory, Melbourne, Victoria. 1989 (see Plate 58).

Engineers: Law, Matheson, Yttrup Pty. Ltd., Sydney;
Structure: straight simply supported beams;
Material : LVL - box beams;
Span : 26 m.

**Carpentry Training Room, Dandenong TAFE Campus, Dandenong, Victoria.
1990 (see Plates 59 and 60)**

Engineer: P. J. Yttrup and Associates;
Structure: two pin portal frames;
Material : LVL - box section;
Span : 34 m.

CSR Softwood Factory, Caboolture, Queensland. 1990.

Engineers: Dan Jepsen and Associates, Brisbane;
Structure: two pin portal frames;
Material : glue laminated softwood;
Span : 11 m.

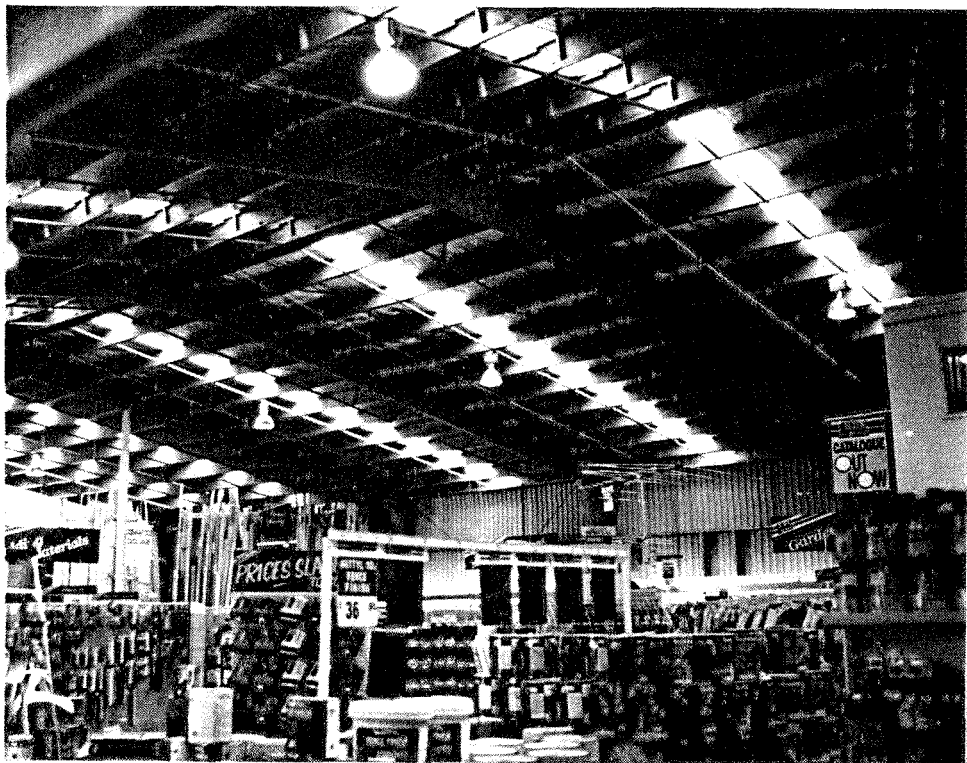


Plate 57. Peter Law's Bowen Timber City Store at Seven Hills in NSW



Plate 58. 26 m span LVL box beams of the Dale Glass Industries factory in Melbourne span between tilt up concrete side walls.

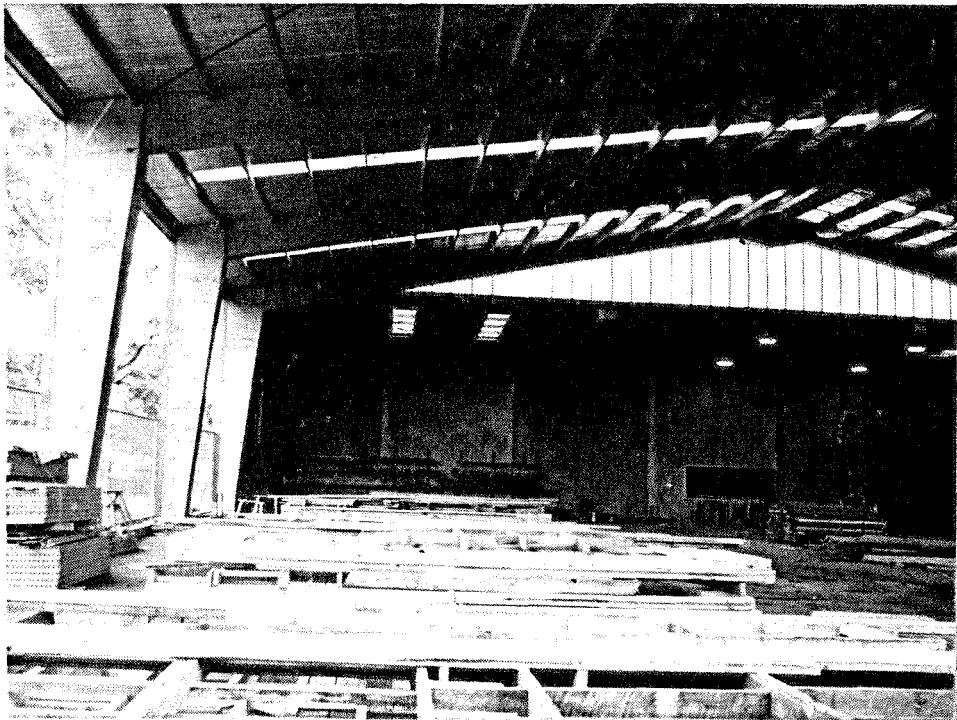


Plate 59. The 34 m span Carpentry Training Room, Dandenong TAFE Campus, Dandenong.

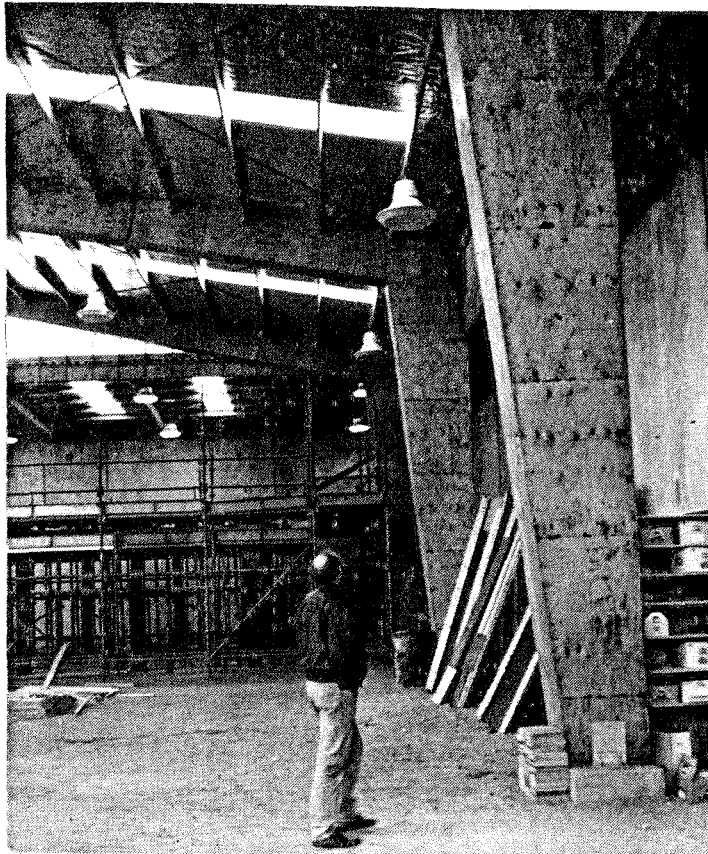


Plate 60. Engineer Peter Ytrup in front of the LVL box columns at Dandenong.

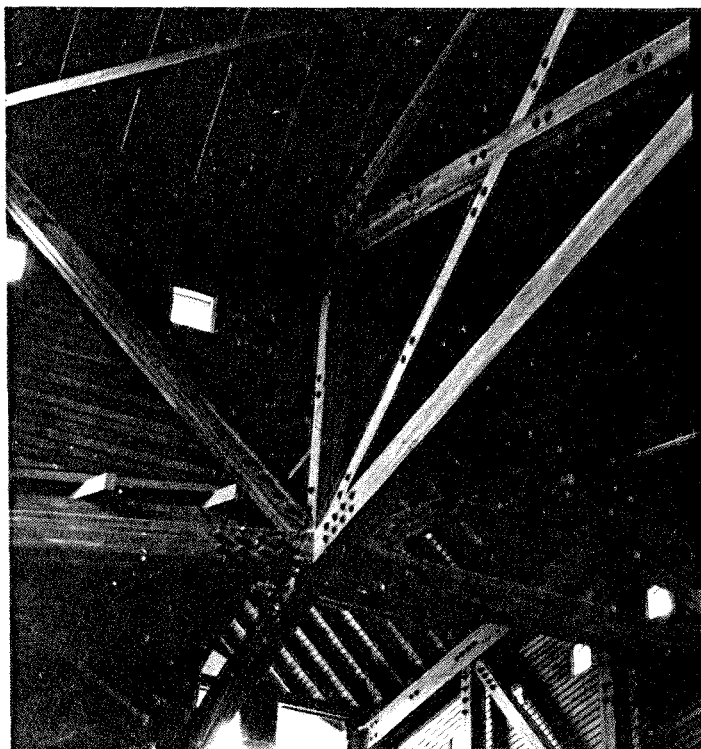


Plate 61. The laminated jarrah beam grid designed by Brand Deykin and Hay for the John 23rd Chapel, Perth

Timber bridge building revived. In 1982, the 26 m long Elwood Canal Bridge was constructed of two parabolic arched 1100 x 150 mm glue laminated jarrah beams. Bunnings fabricated the arches in Perth before shipping them to Melbourne. By 1986 this form was well established and bridges were constructed in both jarrah and treated radiata. Examples are in several States.

Unlike the 1950's, where it appears that few architects took great interest in the industrial timber building being constructed around them, architects became involved in this latest resurgence. This was due to a lingering inspiration of the Australian Regionalist period as well as a result of the absolute volume of commercial building during the 1980's. It also reflected the association of timber with nature and the environment. Reporting on their work is limited, however. The first building of this cycle nominated in the Building Survey also dates from 1984. This was the new library for the Forestry Commission of NSW offices at Pennant Hill, designed by Phillip Baker of the NSW Public Works. It is a small, well detailed post and beam building. Other architects whose work was nominated in the Building Survey include:

- **Greg Burgess** for his Box Hill Arts Centre and Brambuk Cultural Centre
- **Peter McIntyre** for his Diner Plain Resort in Victoria,
- **Whitelaw and Chrystal** for their Clydesdale Building and Dalgety Pavilion in Sydney.
- **Guymer Bailey** for their Kingfisher Resort Village, **Addison Yeates** and **Lindsay Clare** in Queensland.
- **Parry and Rosenthal** for their Karri Valley Resort and **Brand Deykin and Hay** for their John 23rd Chapel (see Plate 61 and Exemplar 24) in Western Australia.

In 1990, the winner of the Sulman Prize was again a timber building. It was architect Greg Burgess's and engineer Peter Yttrup's Brambuk Cultural Centre.

The building design suggests the form of the widespread wings of a white cockatoo and the roof form also dips and peaks echoing the surrounding mountain ranges. The organic form of the structure required the use of natural materials such as timber and stone that predominate. These have been manipulated with technologically advanced construction techniques bringing Brambuk to life... This unique timber building has become a regional focal point for aboriginal communities and through exhibitions and other activities will illustrate the richness of aboriginal culture to Australian and overseas visitors. (Wood World 1990)

It is necessary to put this period of timber usage in perspective. While no reliable statistics exist, the percentage of commercial buildings constructed in timber appears to have been low. Also, there were very few recognised timber practitioners in either profession. The most encouraging factor from this cycle was that research and education of professionals by professionals was recognised as an important factor in the development of timber structures.

Anecdotal evidence suggests that this cycle has fallen victim to the economic recession of 1992.

Chapter 2

Exemplars of Australian Timber Construction.

While the previous chronological examination demonstrates the cycles of construction, an understanding of the development of technical and professional skill can only come from a detailed investigation of important timber structures, the exemplars. This chapter contains documentation of 24 such Australian structures. They were chosen because each satisfied one or more of the following conditions in that it:

- signals an advancement in Australian technical expertise in timber;
- was a technically demanding structure for its time;
- is structurally unique;
- uses a unique or unusual joint or detail type;
- is a key example of a current practitioner's work in timber;
- is one of the only known existing examples of a past practitioner's work;
- represents a key or climax solution in the technical or architectural development of a cycle;
- is historically relevant as it is the first, largest or longest span of a particular type; or
- is a more refined or particularly representative example of a whole series of structures.

Short or medium span structures were chosen only where they were structurally unique or particularly representative. Existing structures were given preference over those demolished. Structures planned but not constructed were not considered. The documentation for each exemplar is designed to be self contained and includes: a physical description of the structure in text, photos and original drawings; an evaluation of the structure's importance in the development of timber technology and architectural form; a brief history of the structure and its construction; a condition report; and a list of literature references particular to that structure. These literature references are also included in the List of References for the whole document. The entry headings for each structures may vary or be left out dependant on the information available. For example, some structures have no known literature references.

The buildings are sorted by structural form in the format established by Goetz et al. (1989). The simplest structures, simply supported beams and frames, lead followed by portals, arches and more complicated forms.

While this list of 24 buildings does not intend to be exclusive and could have been extended if resources allowed, it represents a starting point for professional investigation and the beginning of a repertoire of Australian timber structures.

Exemplar 2. 1

Name of Structure:

Tradesman's Entrance Hardware Store

Operators:

BBC Hardware Chain

Address:

Mickleham Road, Tullamarine, Vic.

Architects:

S. Sokolski Co-design.

Structural Engineers:

P. J. Yttrup and Associates.

Builders:

S. C. Project Management

Date Constructed:

1987

Structural System:

Simply supported beams

Description:

The complex has two wings. The first is a timber warehouse of 30 m span LVL box beams supported on double oregon columns. These are braced off the roof beams to reduce their effective height (see Plate 62 and 63). The hardware wing uses a variety of structural techniques and materials, including glue laminated columns and ply and LVL bolted and nailed parallel chord trusses. The principal form used is twin bay portal frames. These span 15 m in each bay. They feature a 4. 8 m deep parallel chord truss running perpendicular to the frames through their centre line. (See Plate 65). These trusses brace the frames while running through and over them to form a rooflight above.

Development:

Designed to demonstrate the suitability of timber as a construction material, AFIJ described the building as a "structural timber smorgasbord". It includes most of the materials and forms that are common in timber practice today.

Condition:

Glue laminated columns to the exterior of the hardware wing have required stitch bolts and additional weather protection. All interior work appears in satisfactory condition.

References:

Australian Forest Industries Journal, 1987, *Structural Timber Smorgasbord*, July, p. 36 - 38

Australian Forest Industries Journal - Cover Supplement, 1987, *Tradesman's Entrance Showpiece Sales Centre*, July.

Wood World, 1988, *Confidence in Timber*, August.

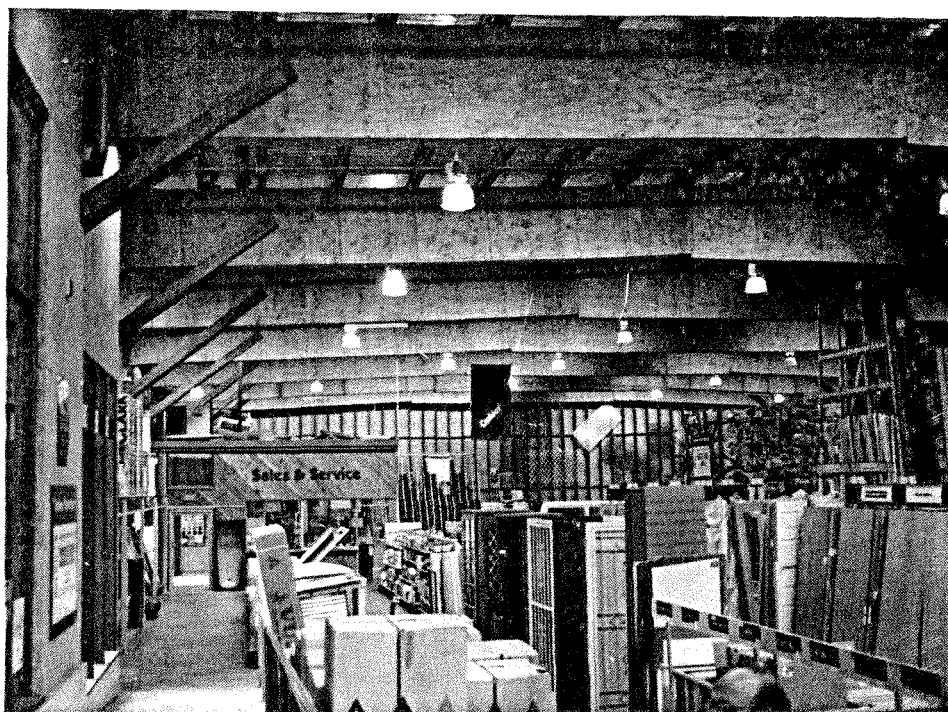


Plate 62. The 1200 x 260 simply supported plywood box beams in the timber warehouse, Tradesman's Entrance, Tullamarine, Vic.

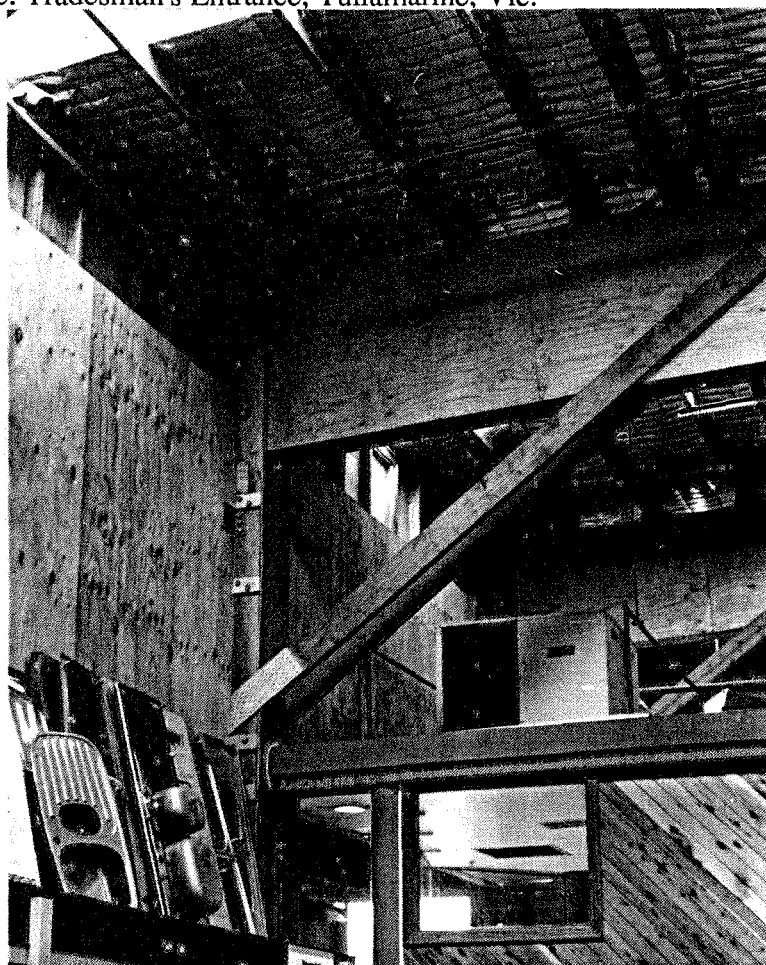


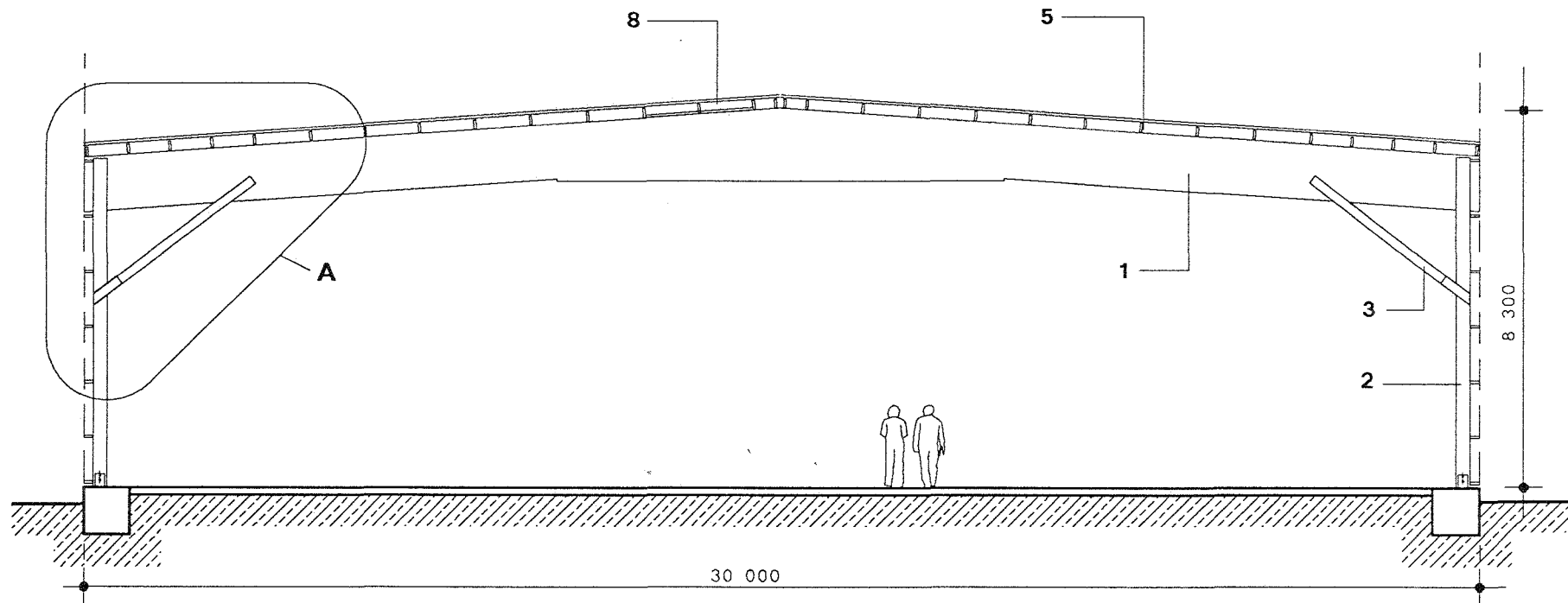
Plate 63. 200 x 75 F7 knee braces stiffening the spaced twin 300 x 75 columns. Tradesman's Entrance, Tullamarine, Vic.



Plate 64. 200 x 50 F7 purlins run over the ply box beams in the timber warehouse. Tradesman's Entrance, Tullamarine, Vic.



Plate 65. 4. 8 m high LVL trusses running through glue laminated twin portal frames in the hardware wing. Tradesman's Entrance, Tullamarine, Vic.

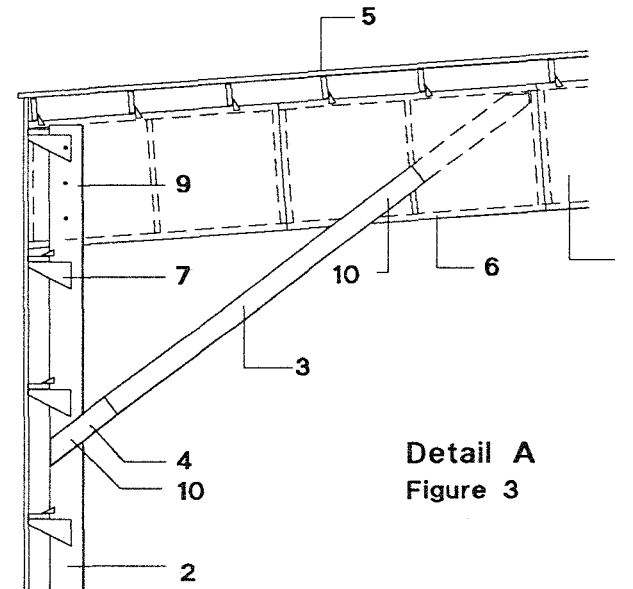
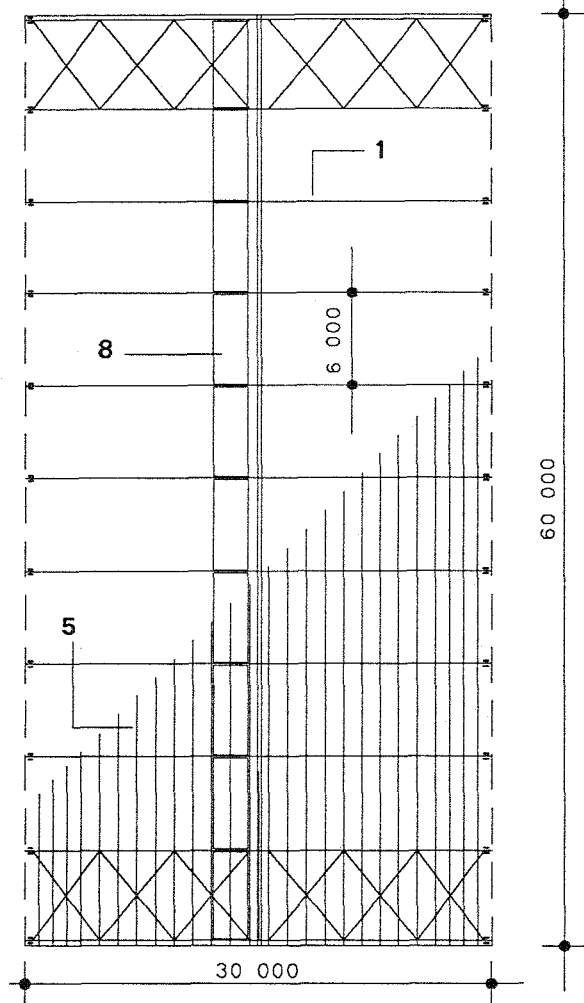


**Transverse Section
Timber warehouse
Figure 1**

Tradesman's Entrance Hardware Store.

1. 1 200 x 270 plywood box beam
2. 2 x 300 x 75 F7 columns
3. 2 x 200 x 75 F7 knee brace
5. 200 x 50 F7 purlin at 1200 centres
8. 15 ply shear skin bracing

Tradesman's Entrance Hardware Store.



1. 1200 x 270 Plywood box beam
2. 2 x 300 x 75 F7 columns
3. 2 x 200 x 75 F7 knee brace
4. 15 plywood nail gussets
5. 200 x 50 F7 purlin at 1200 centres
6. 240 x 63 LVL frame
7. 15 ply girt cleat
8. 15 ply shear skin bracing
9. 3 M20 bolts
10. Nail group

Exemplar 2. 2

Name of Structure:

Alligator Creek Bridge

Address:

Rockhampton Road at the Alligator Creek, near the Fitzroy River, Qld.

Bullder:

W. H. Standish as Superintendent of Works.

Date Constructed:

1873

Structural System:

Simply supported trussed beam.

Description:

The bridge was a single 40.5 m undertrussed span, supported by triple trestle piers at either side of the creek. It had simple girder and trestle approaches. The main span consisted of three parallel ironbark compression chords. These were supported at sixth points by vertical ironbark compression posts (see Plates 66 to 68). These posts were trussed under the bridge by groups of wrought iron tension bars and were braced transversely. The tension bar suspension system for the main span was complex. The centre posts were supported by three bars running from the trestle support to the base of the post and then to the other trestle. The two posts outside the centre were supported by two bars which ran from the top of the centre post, to the base of the second post and then to the trestles. The outside posts were supported by one bar. These ran from the top of the second post to the base of this outside post and then to the

trestle. Where necessary, the iron bars passed through the posts.

Development:

This was a unique and remarkable bridge. It is the oldest Australian designed structure spanning over 100 ft (30.5 m) found in this study.

Though simpler trussed beams were used widely in industrial buildings till Federation, especially in floor beams, this is the only major external application known. It was the longest under floor tension bar supported timber structure built in Australia.

History:

The bridge was built in 1873 using selected ironbark for the girders and compression frames of the principle span. The highest quality timber was necessary as the design of the bridge meant that these members could not be replaced. Designed as a single lane bridge to carry horse drawn vehicles, the bridge served for 80 years. In its latter years, strict load and speed limits for vehicles were imposed.

Condition:

The bridge was demolished about 1960.

References:

Beckett, R. S. , 1987, *Bridging the Gap - the Percy Allan Precedent*, *AFIJ*, August, p. 34 -35.

Cameron, I. G. , *125 Years of State Public Service in Queensland*, Queensland Government Printer,

O'Connor, Colin, 1985, *Spanning Two Centuries: Historic bridges of Australia*, University of Queensland Press.

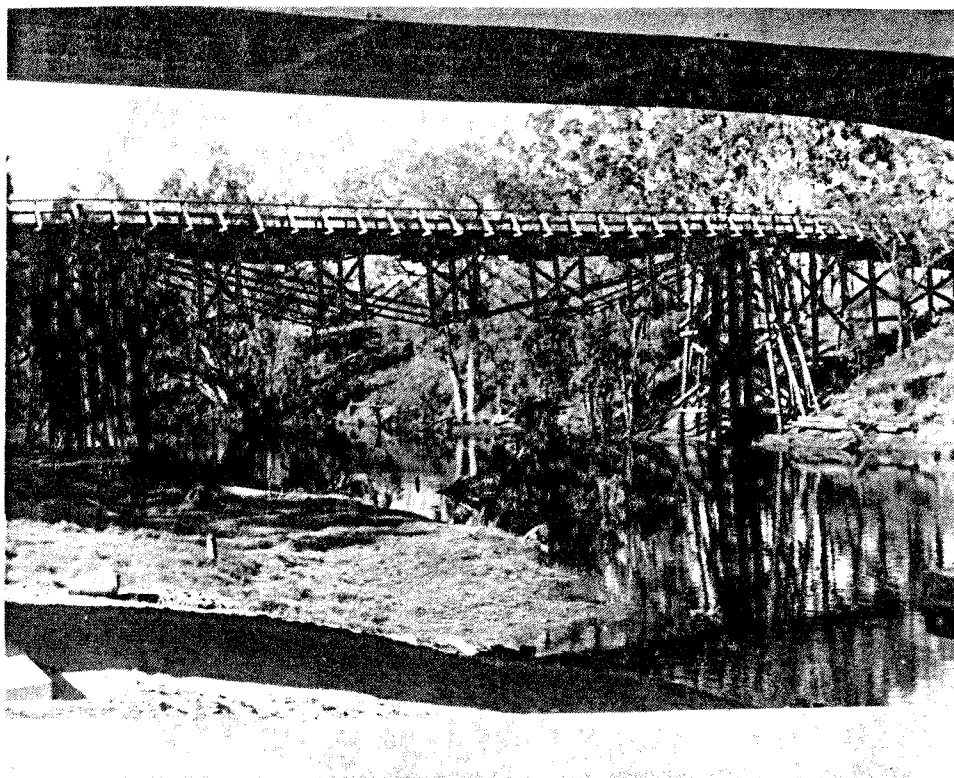


Plate 66. The 40.5 m undertrussed span of the Alligator Creek Bridge seen underneath its modern replacement. The support posts at sixth points were trussed longitudinally with steel rod and transversely by round section timber. Photo: Courtesy of Transport Queensland

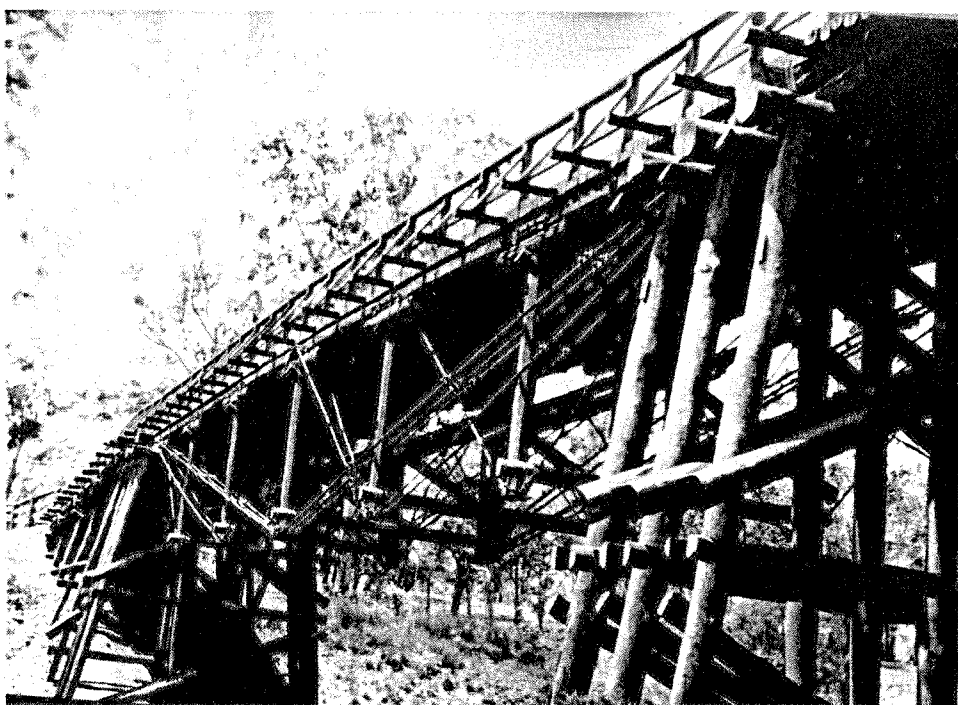


Plate 67 The tension rods supported the base of each support post beneath the bridge. Alligator Creek Bridge, Qld. Photo: Courtesy of Transport Queensland

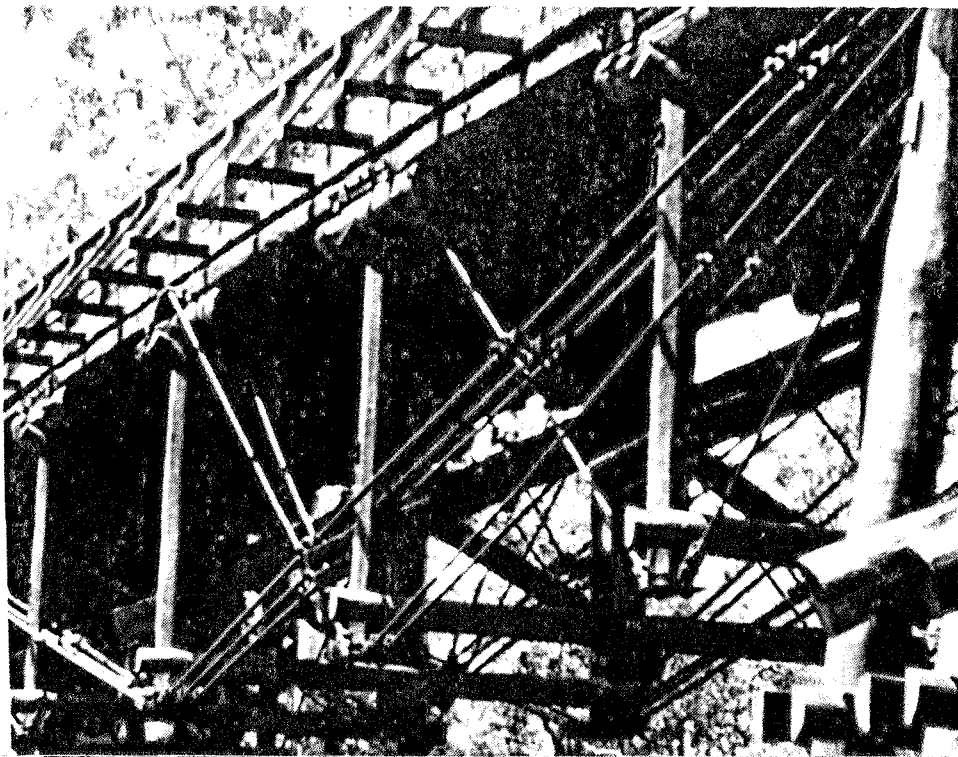


Plate 68. Where necessary, the tension cables passed through the support posts. This made replacement of these members impossible. Alligator Creek Bridge, Qld. Photo: Courtesy of Transport Queensland.

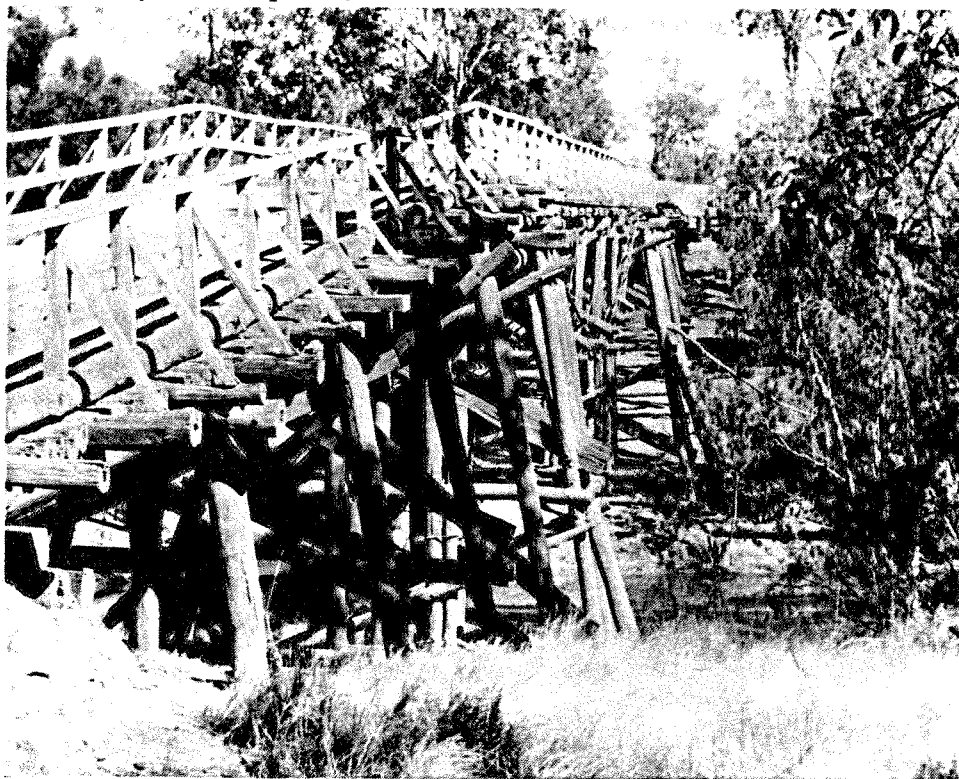


Plate 69. While significant problems occurred with the bridge approaches, the line of the main span showed little sag. Alligator Creek Bridge, Qld. Photo: Courtesy of Transport Queensland.

Exemplar 2. 3

Name of Structure:

Werribee Treatment Complex

Owners:

Melbourne Water

Address:

New Farm Road, Werribee, Vic.

Architects and Engineers:

Works Director, Air Services of the
Dept. of the Interior.

Date Constructed:

1942

Structural System:

Simply supported triangular trusses on
buttressed columns.

Description:

The Werribee complex consists of
four 96 ft (29. 3 m) and one 130 ft
(39. 6 m) hangar buildings. The form
of both building types is similar.

The 96 ft (29. 3 m) hangars consists
of eight bays of "hog back" triangular
trusses on hardwood columns on a 14
ft (4. 3 m) grid. This gives a building
112 ft (34. 1 m) long. The columns
are 23 ft (7. 0 m) high to the
underside of the trusses. They are
buttressed to the ground in the line of
the trusses and braced along the line
of the columns. This leaves the
building open internally and at both
ends. The trusses span 96 ft (29. 3 m)
and are 12 ft (3. 6 m) from the line of
the springing to the peak. They were
originally built with a 6 ins (150 mm)
camber. They have a spaced pair of 8
x 3 ins (200 x 75 mm) hardwoods as
the top chord, a spaced pair of 6 x 3
ins (150 x 75 mm) as the bottom
chord, a spaced pair of 4 x 2 ins (100

x 50 mm) vertical webs and the
diagonal webs vary from pairs of 6 x 3
ins (150 x 75 mm) in the centre of the
truss to 4 x 2 ins (100 x 50 mm) at the
outside. The trusses are strutted in the
plane of the bottom chord in line with
each vertical truss web. The outside
bay formed by this strutting is braced
along both sides and each strut bay in
the end truss bays is also braced. Two
lines of sway bracing run the length of
the building.

The 130 ft (39. 6 m) hangar is a much
more substantial building. It consists
of 12 bays of trusses at 14 ft 6 ins (4.
4 m) centres. This gives a building 176
ft (53. 6 m) long. The columns are 33
ft (10 m) high to the underside of the
trusses. The trusses are 16 ft (4. 9 m)
high from the springing to the apex
and each weighed about 5 tonnes
when erected. They were originally
built with a 6 ins (150 mm) camber
and are strutted in the plane of the
bottom chord in line with each truss
vertical. Sway bracing runs the length
of the building at the five central
vertical truss webs. Wind bracing ties
the end truss bays through the six
subsequent bays in the line of the truss
bottom chord and runs down both
sides of the building.

Both buildings are constructed from
green hardwood and use bolted steel
plates and shear connectors at each of
the major truss joints.

Development:

While the aisles of the side buttresses
of these buildings are reminiscent of
rude rural timber buildings, the
technology used and span of these
structures is striking. They owe
nothing to previous timber forms
employed in this country. The

buildings are the first known long span structures using shear connectors and the first known use of timber as the tension member in a long span truss. The 130 ft (39.6 m) hangar remains one of the largest clear span timber triangular timber trussed buildings in Australia.

History:

With the onset of the Pacific War, construction of infrastructure for the air defence of Australia became an urgent priority. Within weeks of Japan entering the war, the Works and Services Branch of the Australian Dept. of the Interior converted the structural layout to a US Army Air Force design for a 122 ft (37.2 m) span steel hangar into designs for 96 ft (29.3 m) and 130 ft (39.6 m) span timber hangars.

The plans for the Werribee complex were completed by the end of January 1942 and construction of the buildings and accompanying landing strips began almost immediately. The

complex served as an aircraft repair and maintenance depot for aircraft from nearby RAAF Williams for the duration of the war. The 96 ft (29.3 m) variant performed well but the 130 ft (39.6 m) buildings experienced considerable difficulties. As the green hardwood used in their construction seasoned and shrank, noticeable deformation occurred. Additional bracing and recambering was required as early as 1943. After the war, the complex was subsequently handed over to Melbourne Water.

Condition:

All the buildings still exist and those inspected were in a satisfactory condition.

References:

Dept of Works and Housing, 1946, *A report on the structural soundness of unseasoned timbers used in structures erected for war purposes*, Dept of Works and Housing, Melbourne

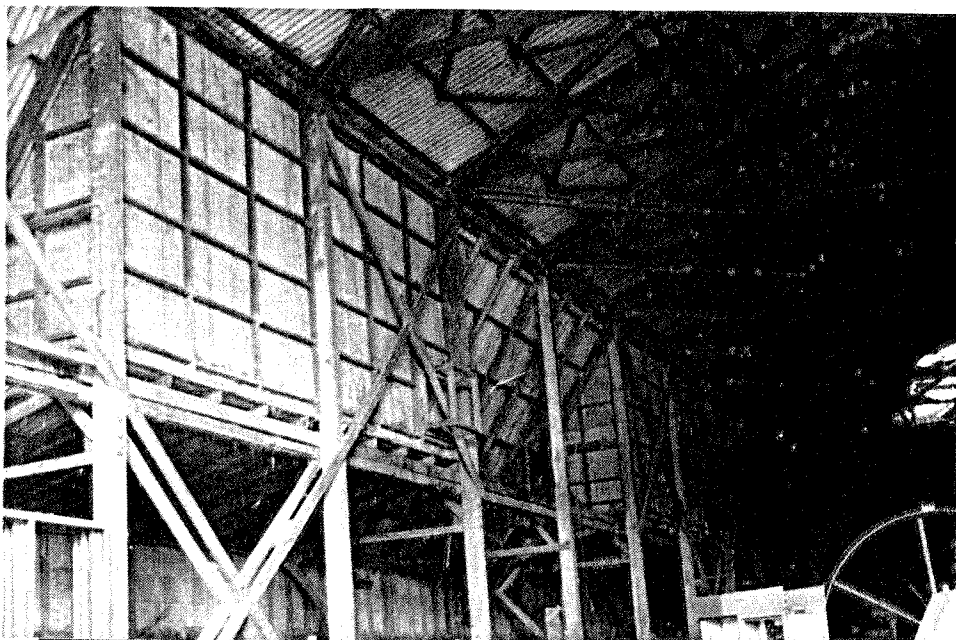


Plate 70. The buttressed and braced post supporting the 130 ft (39.6m) trusses. Werribee Treatment Complex, Vic.



Plate 71. The 130 ft (39.6 m) trusses with struts and sway braces in the roof of the large hangar at the Werribee Treatment Complex, Vic.



Plate 72. A typical truss joint in the Werribee hangars.

Exemplar 2. 4

Name of Structure:

Perm-a-log drying area.

Owners:

CSR Softwoods.

Address:

Potassium St, Narangba, Qld.

Structural Engineers:

Dan Jepsen & Associates.

Date Constructed:

1992

Structural System:

Simply supported triangular trusses

Description:

The building is a simple pitched roof shelter on cantilevered poles. The CCA treated slash pine poles are at

13. 5 m spacing down both sides of the building. These carry plywood box beams which run the length of the building and support 26 m span, glue laminated slash pine, triangular trusses at 6. 7 m centres. All truss joints are effected by 12 and 16 mm steel dowels.

Architectural Development:

While the building is architecturally unremarkable, the dowel joints used in the trusses are rare in Australian timber structures. They are common in European practice and reminiscent of the hand nailed trusses used extensively in Australia.

Condition:

The building is in satisfactory condition.



Plate 73. The roof to the drying area showing cantilevered post, plywood box beam and dowel jointed roof trusses. Photo: Courtesy of Dan Jepsen.

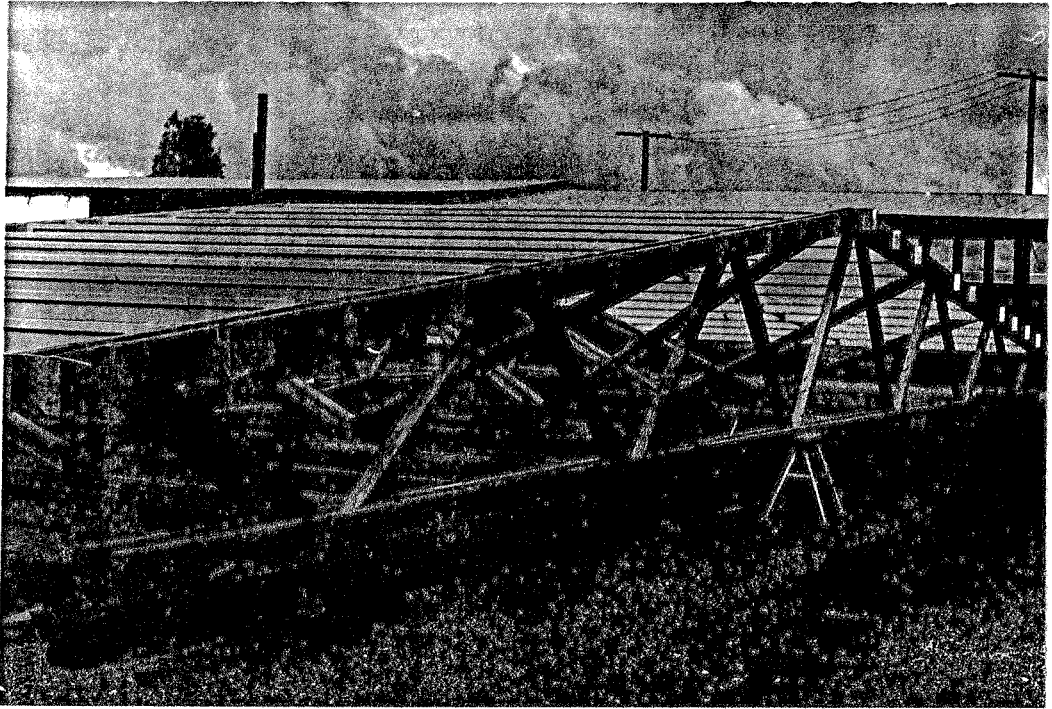
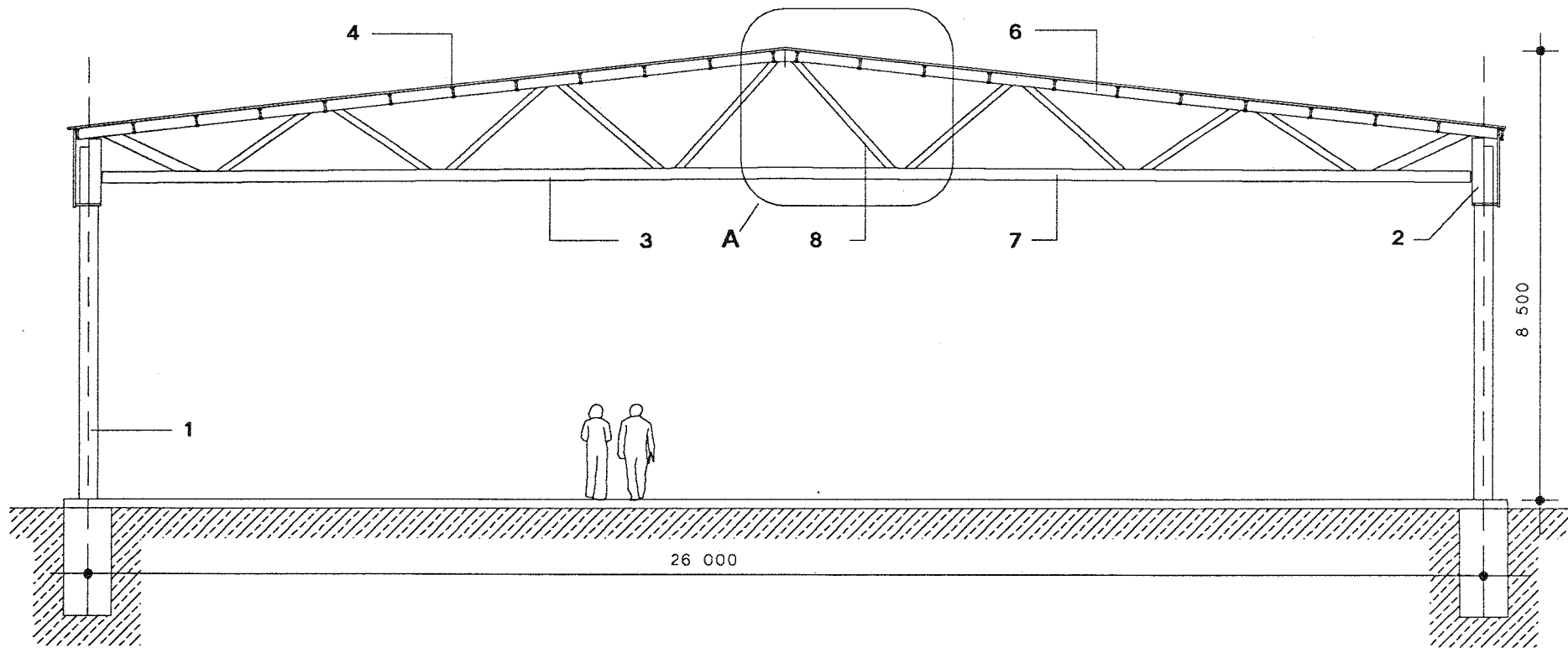


Plate 74. Modules of trusses complete with purlins ready for erection. Perm-a-log drying area, Narangba, Qld. Photo: Courtesy of Dan Jepsen.



Plate 75. Truss joint showing the steel dowel connectors and the glue laminated material. Perm-a-log drying area, Narangba, Qld. Photo: Courtesy of Dan Jepsen.

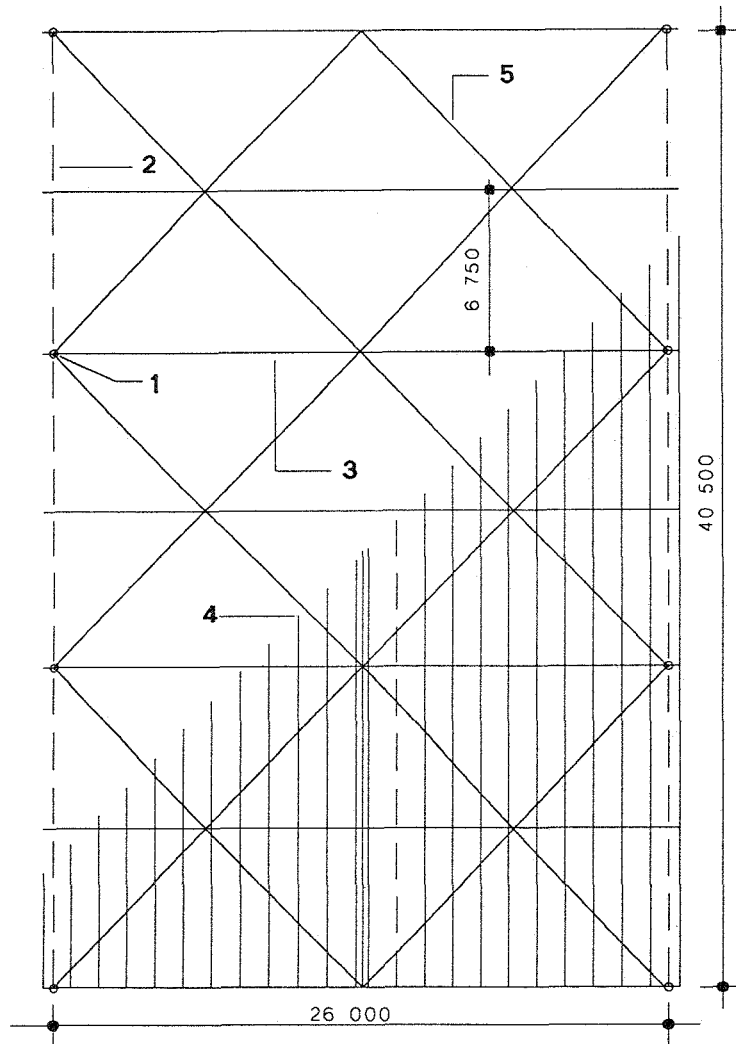


Transverse Section

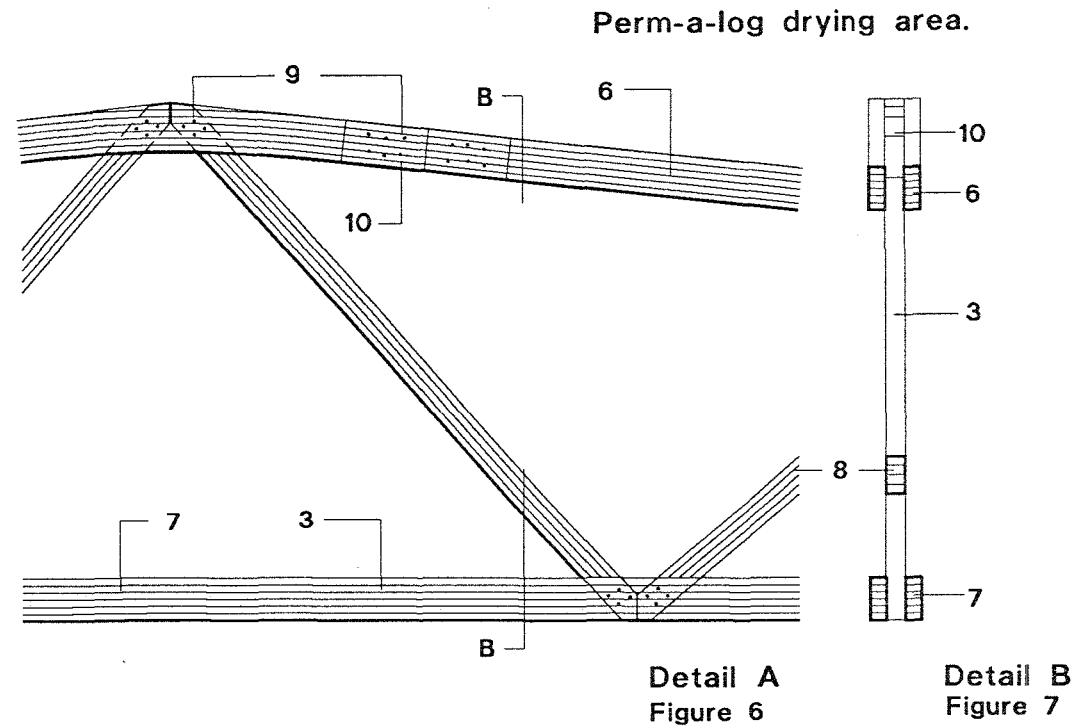
Figure 4

Perma-a-log drying area

1. 350 F14 slash pine CCA treated poles
2. 1 200 plywood box beam
3. glue laminated timber trusses
4. 210 I purlins at 1 200 centres
6. 2 x 200 x 70 glue laminated F17 top chord
7. 2 x 200 x 70 glue laminated F17 bottom chord
8. 135 x 90 glue laminated F17 web



Plan
Figure 5



Detail A
Figure 6

Detail B
Figure 7

1. 350 F14 slash pine CCA treated poles
2. 1 200 plywood box beam
3. glue laminated timber trusses
4. 210 I purlins at 1 200 centres
5. 5 x 50 galvanised flatbar bracing
6. 2 x 200 x 70 glue laminated F17 top chord
7. 2 x 200 x 70 glue laminated F17 bottom chord
8. 135 x 90 glue laminated F17 web
9. M12 & M16 steel dowels
10. Top chord splice

Exemplar 2. 5

Name of Structure:

Hampden Bridge

Owners:

Road Transit Authority of NSW

Address:

Across the Murrumbidgee River at
Wagga Wagga, NSW

Structural Engineer:

Percy Allan

Date Constructed:

1895

Structural System:

Simply supported parallel chord
trusses

Description:

The bridge is a Howe truss structure with timber top & bottom chords, diagonal timber compression webs and vertical steel tension rods. It has three 110 ft (33.5 m) spans and simple trestle and girder approaches. To allow easy maintenance and replacement, all the timber elements in the main spans are spaced double members. Timber to timber joints are simple cast iron compression shoes.

Member sizes reduce towards the centre of the truss spans. The tie rods reduce from three rods at the panels closest to the supports to two at the intermediary panels and a single rod each side of the centre panel. Timber sizes also reduce. The top and bottom chords are spaced pairs of hardwood members with steel splice plate joints. The bottom tension chord plates incorporate square bar ribs vertically to transfer tension more efficiently.

The top compression chord plates are simple spacing and locating plates.

Development:

Allan bridges were the peak timber truss form of the Timber Bridge Cycle. Substantially simpler than their predecessors, they were designed with a developed understanding of wood and its long term performance in exposed locations. The designs used less material, were easier to repair and maintain and enjoyed long operational lives. The original Allan truss design had a 90 ft (27.4 m) span with a 15 ft (4.6 m) carriageway. Designed in 1893, it proved highly successful and bridges of this type were constructed as late as 1929. In 1895, this basic design was upgraded to a span of 110 ft (33.5 m) with a carriageway of 23 ft 8 ins (7.3 m). The Wagga Wagga bridge was the first example of this larger design.

The longest timber truss vehicular bridge in Australia was an Allan bridge built at Kempsey in NSW in 1900. It had four spans of 153 ft (46.6 m).

Substantial numbers of the Allan truss bridges are still in use.

History:

When the Hampden Bridge was constructed in 1895, it was the largest timber structure erected in the Australian colonies. Designed originally as a steel structure, tenders were unacceptably high and so a timber alternative was developed. With an intended economic life of about thirty years, it is still operational. Major repairs have been carried out regularly, the latest in 1985 and 1990.

Several other bridges were constructed to the same design. The 1898 bridge at Morpeth is still in use while the 1896 Inverell bridge has been demolished.

Condition:

The bridge is in satisfactory condition.

References:

Dept. of Main Roads NSW, 1987, *Timber Truss Bridge Maintenance Manual*, Dept. of Main Roads NSW.

O'Connor, Colin, 1983, *Register of Australian Historic Bridges*, Institution of Engineers, Australia.

O'Connor, Colin, 1985, *Spanning Two Centuries: Historic bridges of Australia*, University of Queensland Press.



Plate 76. The three 110 ft (33.5 m) parallel chord truss spans of the Hampden Bridge at Wagga Wagga, NSW. Note the reduction in member sizes towards the centre.

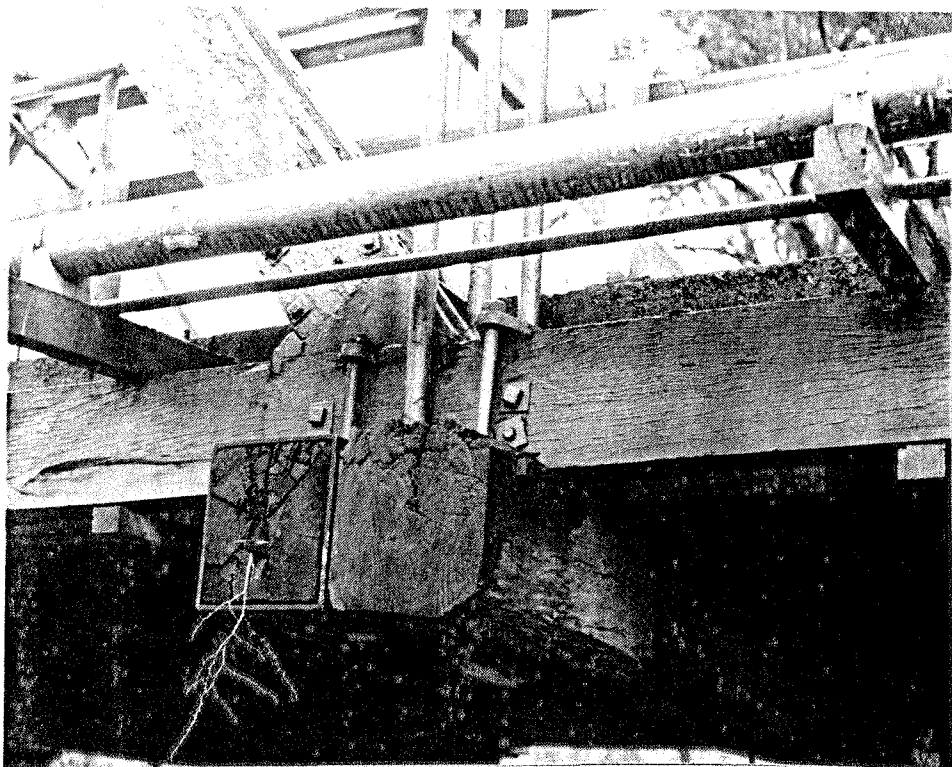


Plate 77. One of the base joints. The compression shoe to the diagonals, the main tension rods, the bottom truss chords and the deck support beams can all be seen. Hampden Bridge at Wagga Wagga, NSW.

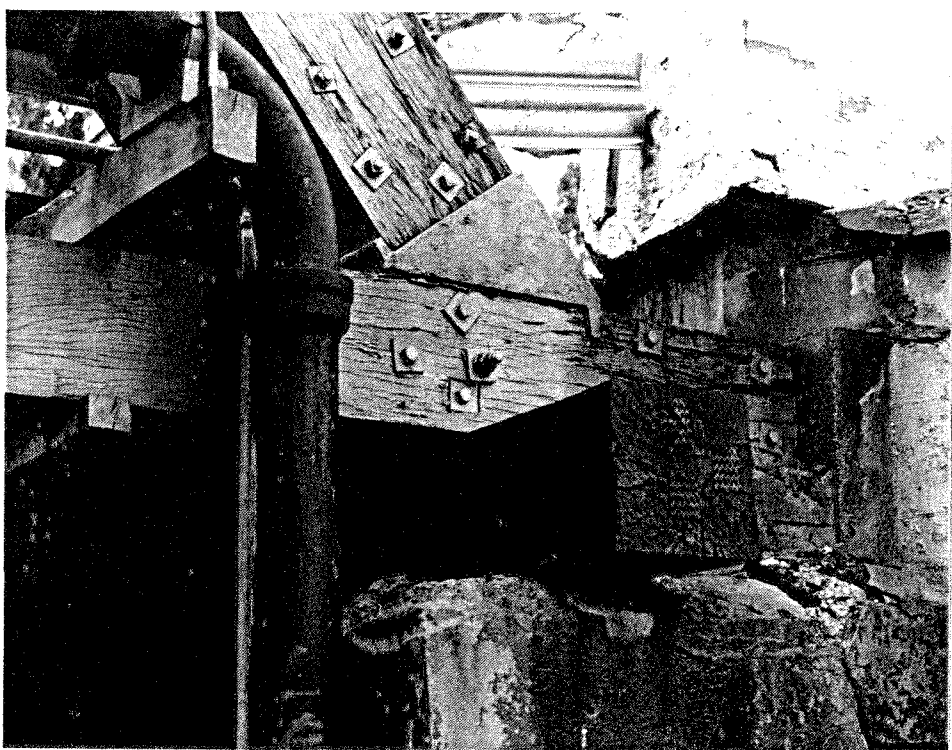
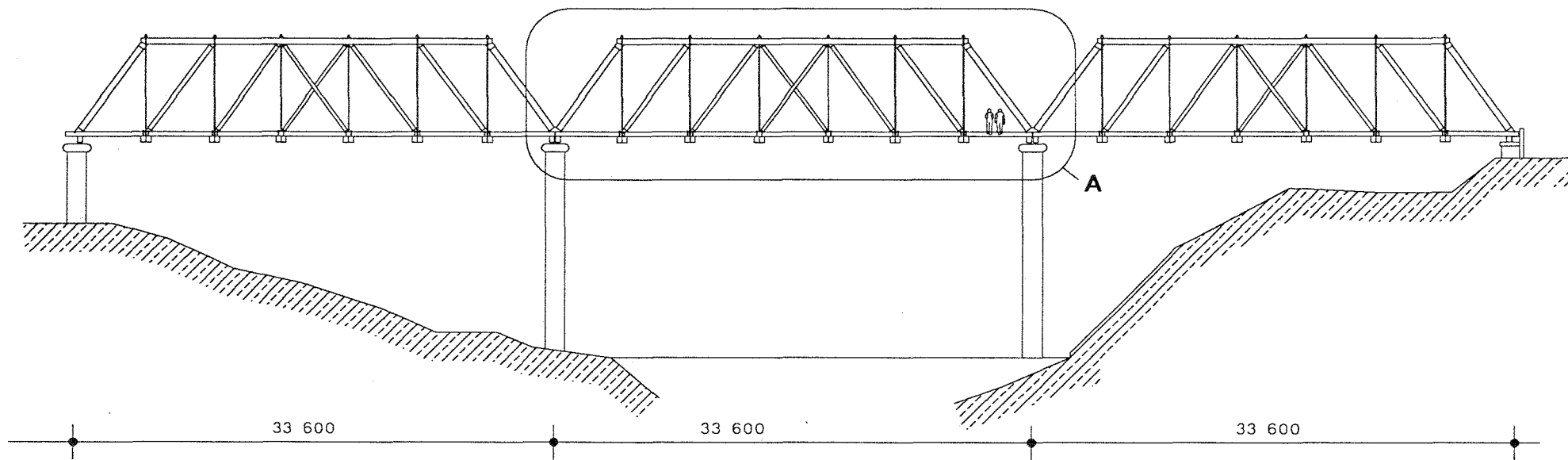


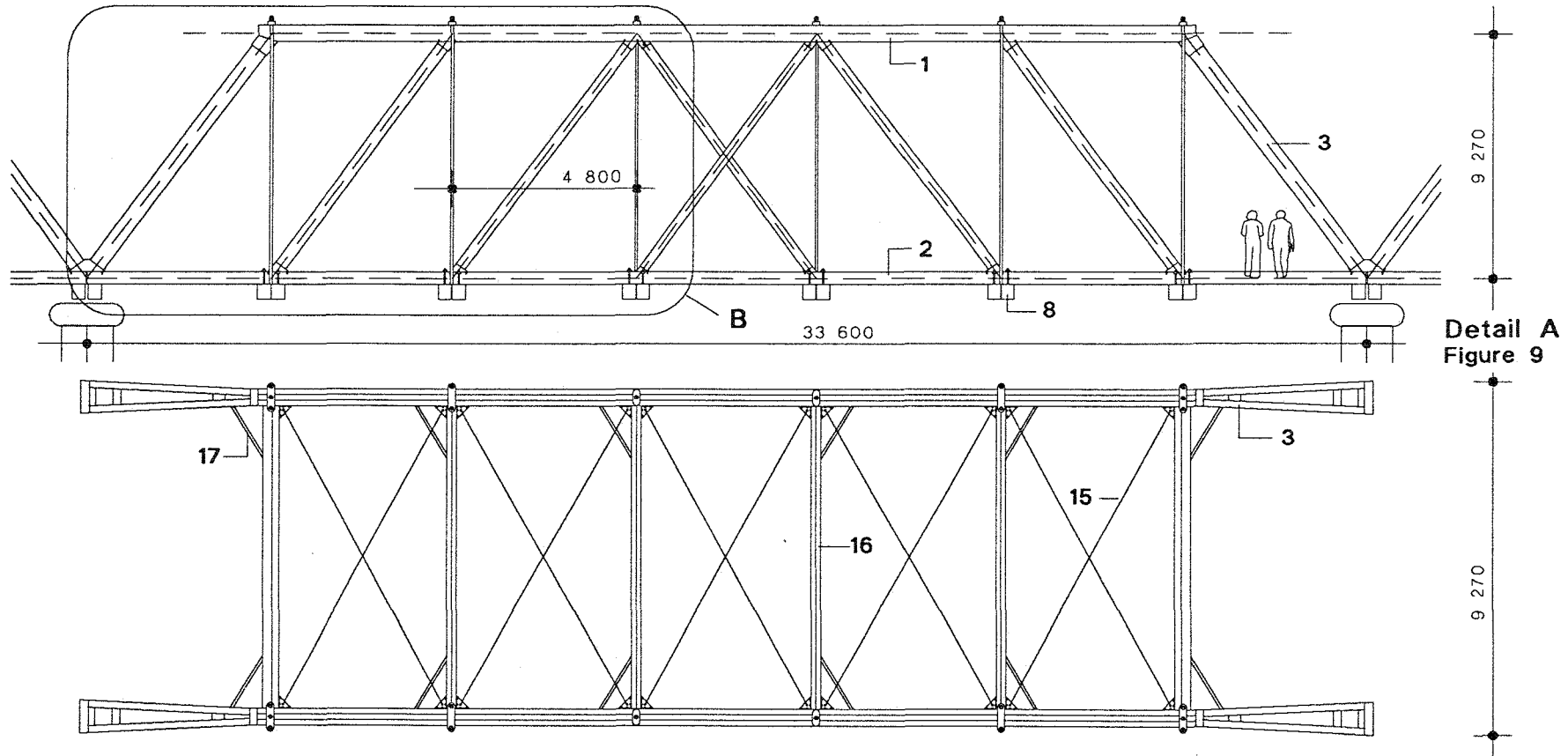
Plate 78. The end bearing plate to the truss. Hampden Bridge at Wagga Wagga, NSW.



Northern Elevation

Figure 8

Hampden Bridge, Wagga Wagga

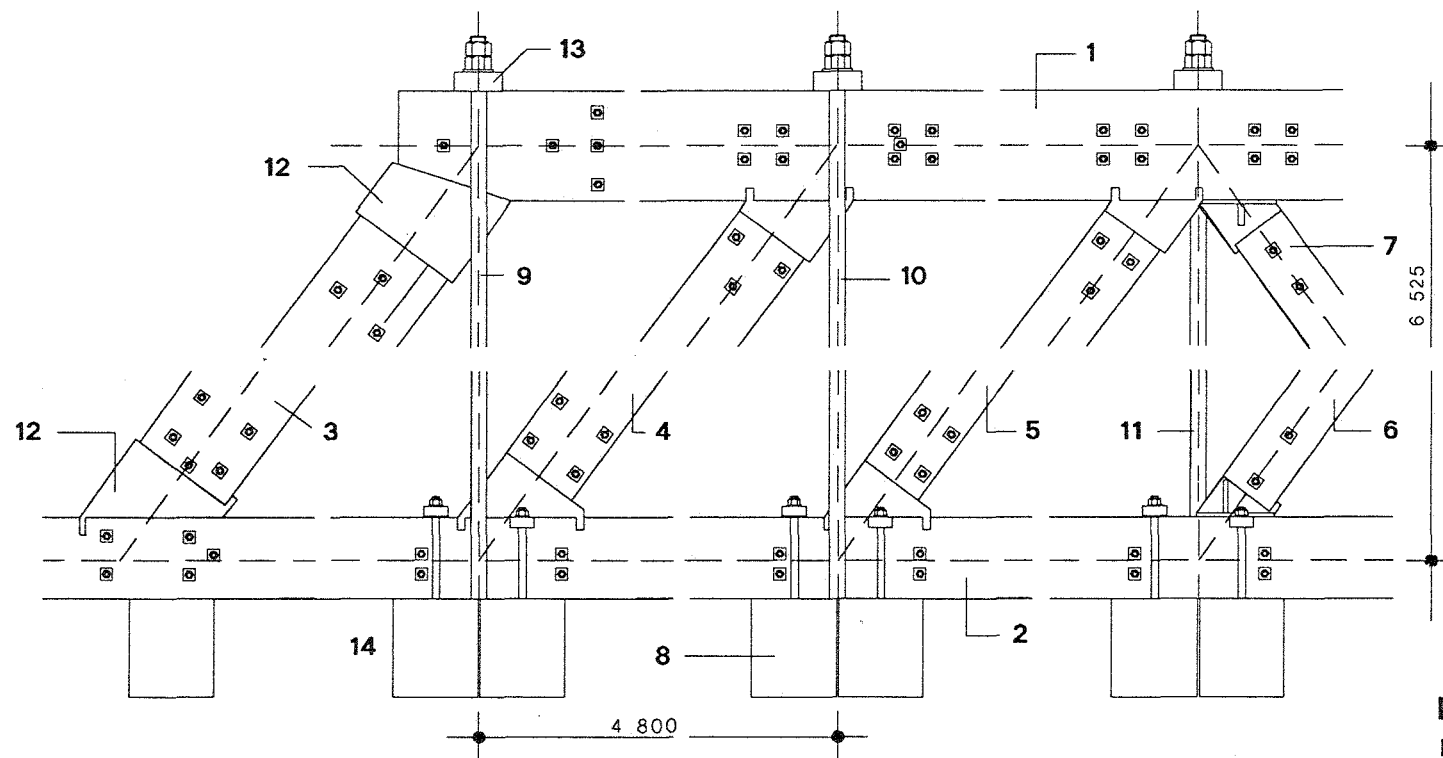


Detail A
Figure 9

Roof Plan
Figure 10
Hampden Bridge,
Wagga Wagga

- 1. 2 x 450 x 150 h/w top chord
- 2. 2 x 330 x 175 h/w bottom chord
- 3. 2 x 435 x 170 h/w web

- 8. 400 x 350 under bearers
- 15. steel wire bracing
- 16. 2 x 300 x 100 struts
- 17. angle sway bracing



1. 2 x 450 x 150 h/w top chord
2. 2 x 330 x 175 h/w bottom chord
3. 2 x 435 x 170 h/w web
4. 2 x 330 x 170 h/w web
5. 2 x 285 x 150 h/w web
6. 2 x 240 x 100 h/w web
7. 2 x 240 x 100 h/w web

8. 400 x 350 under bearers
9. triple 65 dia. tension rods
10. double 65 dia. tension rods
11. single 65 dia. tension rod
12. compression shoes
13. cast iron spacing plates
14. suspension plates and bolts

Detail B
Figure 11

Hampden Bridge
Wagga Wagga

Exemplar 2. 6

Name of Structure:

Cowra road bridge.

Owners:

Cowra Shire Council

Address:

Adjacent to the Lachlan River, Cowra, NSW

Structural Engineer:

J. A. McDonald

Date Constructed:

1893

Structural System:

Simply supported composite timber and steel mansard trusses.

Description:

The bridge consisted of six girder spans followed by two 90 ft (27. 4 m) timber trusses, two 91 ft 2 ins (27. 8 m) timber trusses and three 161 ft 11 ins (49. 4 m) composite truss spans.

These three principal spans were composite mansard trusses with timber top chords and webs, steel bottom chords and steel tension rods. Steel bearers running across the bottom chords carried timber carriage joists and decking.

The steel compression shoe at the base of each timber member incorporates opposing wedges. These allowed the ready packing of the green timber member as it seasoned and shrank along its length.

Development:

The Cowra bridge is the largest remaining example of a composite steel and timber vehicular bridge in Australia. Its span was exceeded only

by the composite timber truss bridge over the Lane Cove River in Sydney. The design furthered McDonald's development of economical truss forms and was a variation on the principal forms of trusses used in the NSW road system. In an effort to increase the working life of the bridge, short strips of corrugated iron roofing were included over the principal timber members.

History:

McDonald's composite bridge was the second of three bridge built across the Lachlan at Cowra.. In 1870, an American McCallum truss bridge with 40 m spans was constructed across the river. Built from Australian hardwood, the bridge was narrow was hard to maintain and plans to replace it commenced in 1886. Construction of the McDonald bridge commenced in 1891 and it remained in service till 1986.

Condition:

The bridge has been removed. One 162 ft (49. 2 m) truss span has been restored by the Institution of Engineers Australia and stands in a park adjacent to the river.

References:

Dept. Of Main Roads NSW, 1987, *Timber Truss Bridge Maintenance Manual*, Dept. Of Main Roads NSW.

Fraser, D. J., 1992, *Preservation of a Unique Structure*, paper to Sixth National Conference on Engineering Heritage, Hobart, 5-7 October.

O'Connor, Colin, 1985, *Spanning Two Centuries: Historic bridges of Australia*, University of Queensland Press.



Plate 79. The restored 162 ft (49.4 m) span from the original bridge in the park adjacent to the Lachlan River at Cowra, NSW.



Plate 80. The steel bottom chord and compression seats at the springing of the trusses. Opposing wedges can be seen above the two main bolts. Cowra road bridge, NSW.

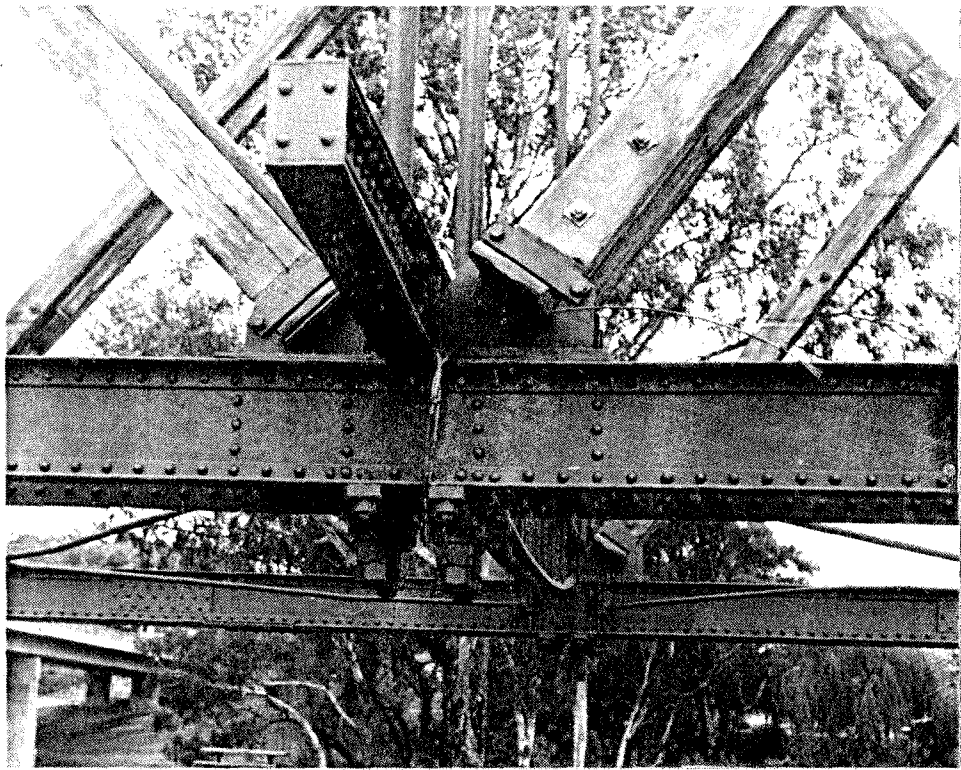


Plate 81. A typical base connection. The compression shoes, packing wedges, steel bottom chords and bearers and the steel tension rods and fixings are visible. Cowra road bridge, NSW.

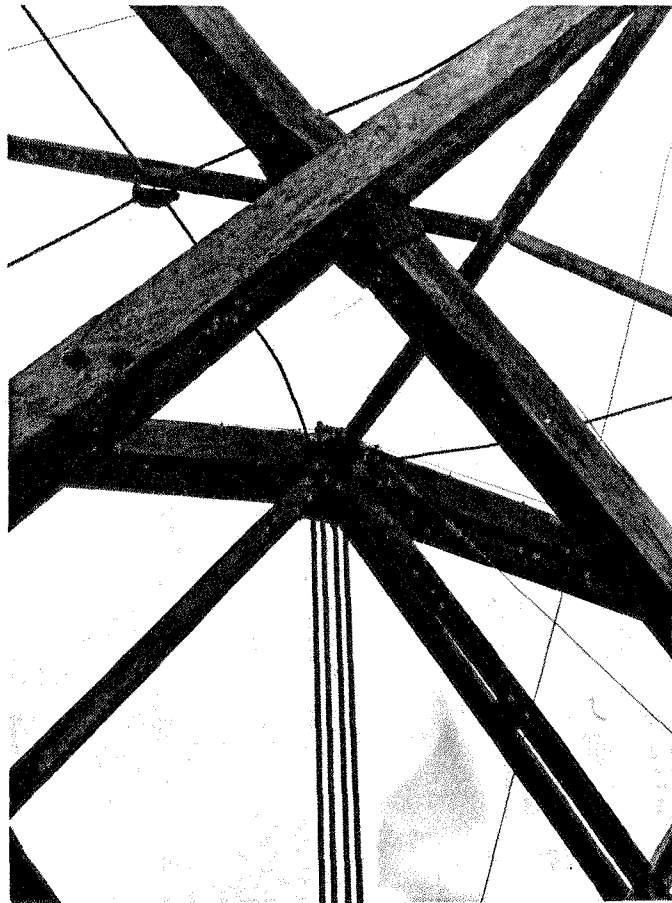
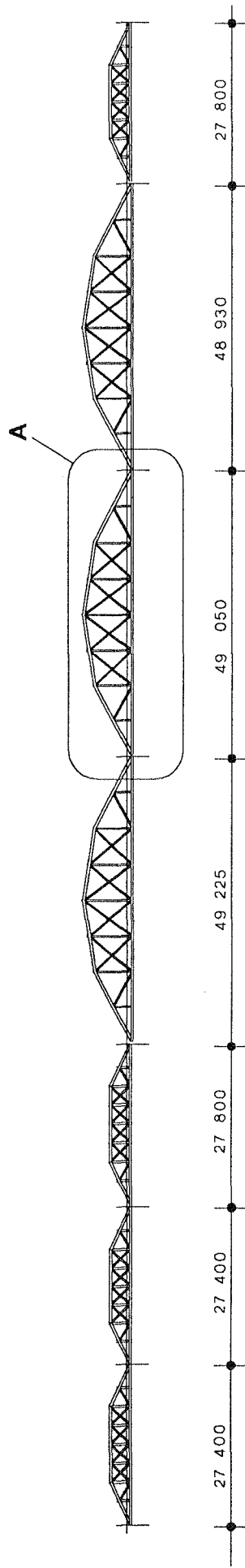
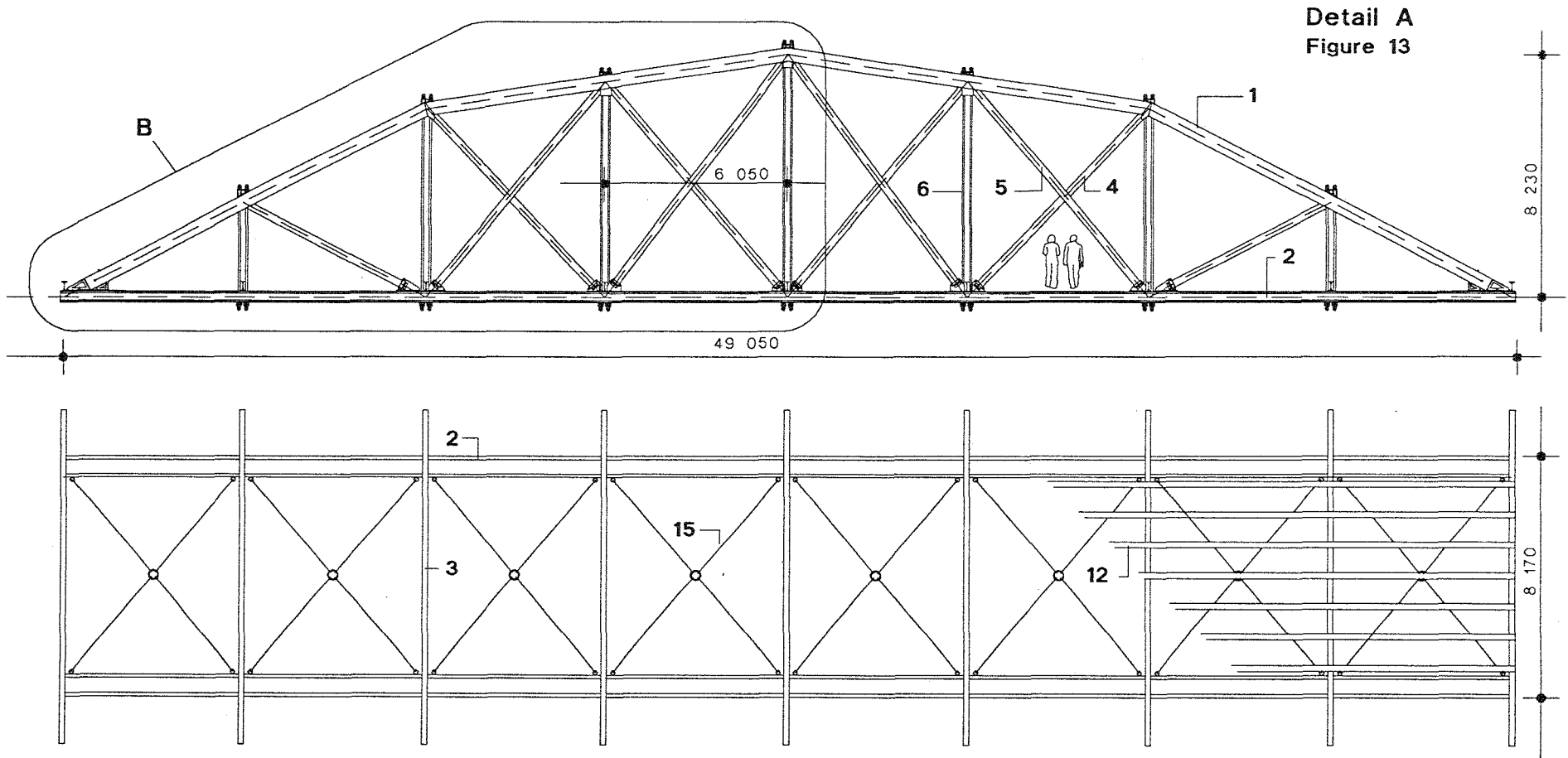


Plate 82. The joint at the apex of the truss showing packing blocks, bracing and struts. Cowra road bridge, NSW.



Elevation
Figure 12

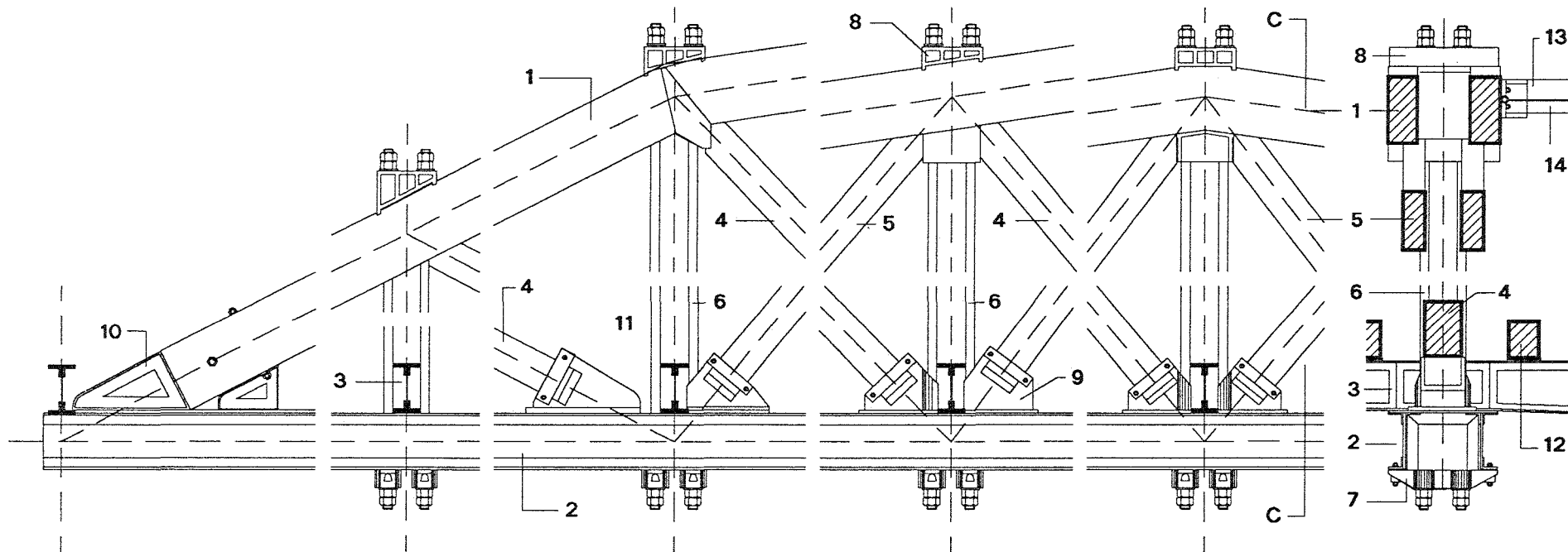
Cowra road bridge



1. 2 x 450 x 230 h/w top chord
2. 2 x 330 x 115 riveted steel bottom chord
3. tapering main floor joist
4. 240 x 260 h/w web

5. 2 x 240 x 150 web
6. 4 x 60 dia. steel tension rods
12. 400 x 200 h/w floor joists
15. deck bracing rods

Deck Plan
Figure 14
Cowra road bridge



Detail B

Figure 15

Detail C

Figure 16

Cowra road bridge

1. 2 x 450 x 230 h/w top chord
2. 2 x 330 x 115 riveted steel bottom chord
3. tapering main floor joist
4. 240 x 260 h/w web
5. 2 x 240 x 150 web
6. 4 x 60 dia. steel tension rods
7. cast iron washer plates

8. cast iron couplers
9. cast iron compression shoes
10. rivetted compression end
11. shrinkage wedges
12. 400 x 200 h/w floor joists
13. h/w struts
14. bracing ties

Exemplar 2. 7

Name of Structure:

Board shed

Owners:

Hyne and Son Pty Ltd

Address:

Tuan, east of Maryborough, Qld.

Structural Engineers:

Holmes McLeod Pty Ltd.

Date Constructed:

1992

Structural System:

Grid of trussed beams

Description:

The building is 61.5 m wide and 162.4 m long and is roofed by a beam grid of nail plate trusses supported by cantilevered CCA treated poles. Four lines of these poles run the length of the building at 20.45 m centres. The poles in the two perimeter lines are at 6.3 m centres while those in the centre lines are at 12.6 m centres. They support modules of primary and secondary nail plate trusses. The primary trusses of the modules run longitudinally on each side of the cantilevered columns and support transverse secondary trusses running between the primary truss at either end of the module. These secondary trusses span 20.45 m at 3.1 m centres. They support nail plated softwood purlins running in continuous spans over each module.

Development:

The building is notable for its size and its developed use of nail plate trusses. Though commonly associated with domestic construction, nail plate

trusses have been used for industrial applications since the technology was first introduced into Australia in 1960. Spans up to 30 m were achieved. This modern application demonstrates that nail plate technology is still capable of producing highly efficient and economical industrial buildings.

As with the Narangba building (see Exemplar 4), this structure exploits timber's ease of construction. The 12.6 x 20.45 m truss modules were fabricated on the ground and services installed before being lifted into position.

History:

This shed is adjacent to an existing steel portal shed of the same profile. In the planning stages, three alternative solutions were costed. They were:

1. a glue laminated building;
2. a steel building matching the existing shed; and
3. the nail plate building.

While pricing was highly competitive, the nail plate solution proved most economic. The client (Hyne and Son) provided the timber and fabricated the trusses.

Condition:

The building is in a satisfactory condition.

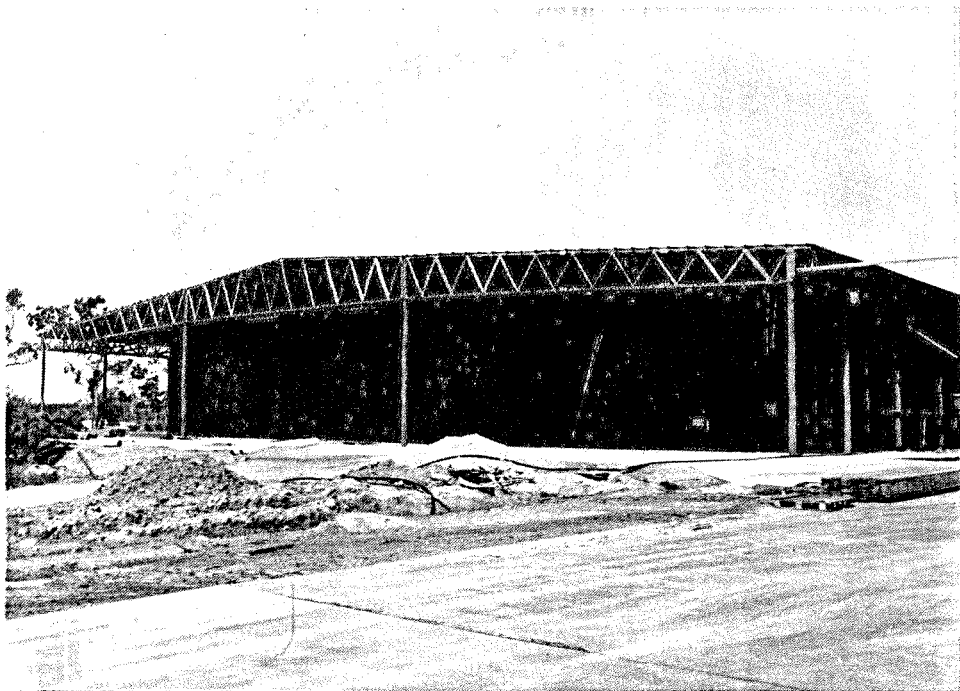


Plate 83. The front elevation of the board shed at Tuan in Queensland.

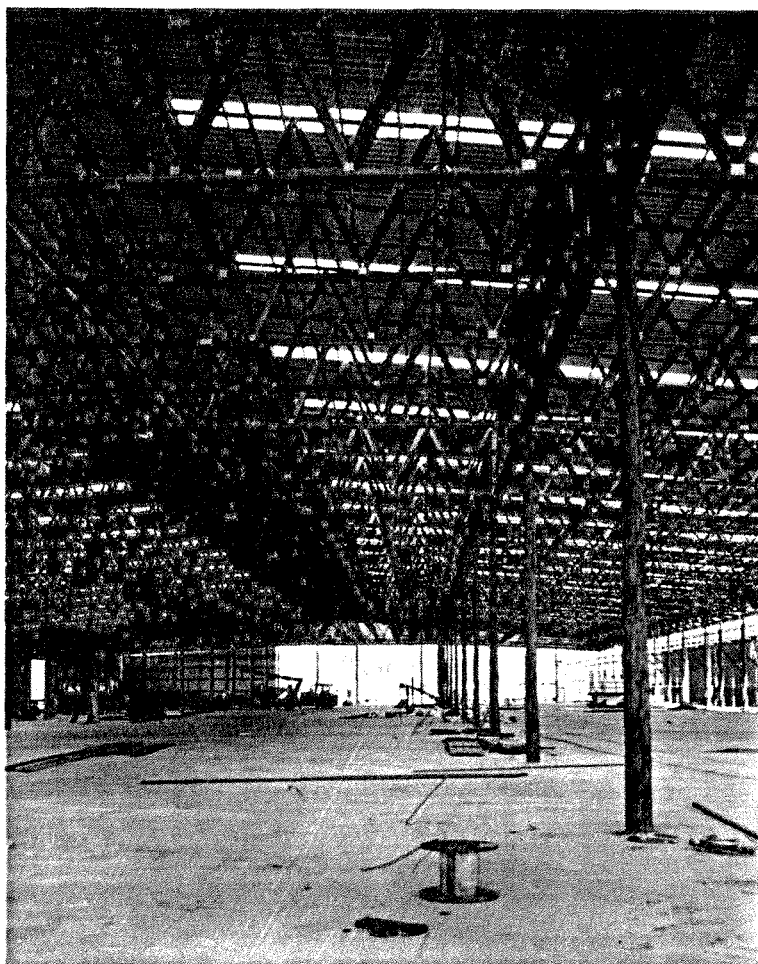


Plate 84. Looking along the line of primary trusses which run either side of the cantilevered columns. The building is 162 m long and 62 m wide. Hyne's board shed, Tuan, Qld.

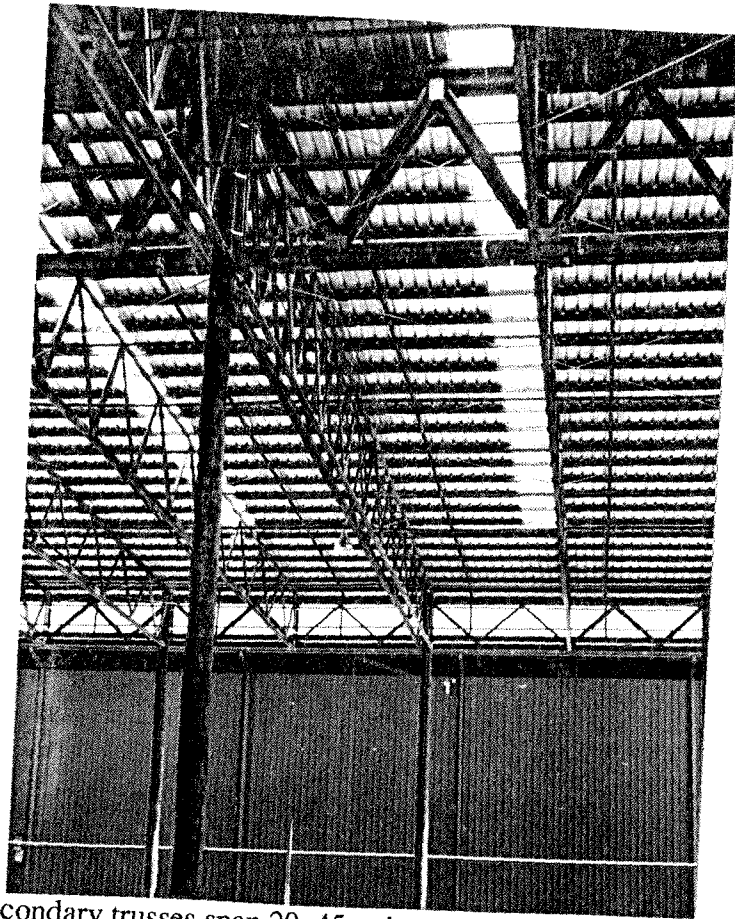
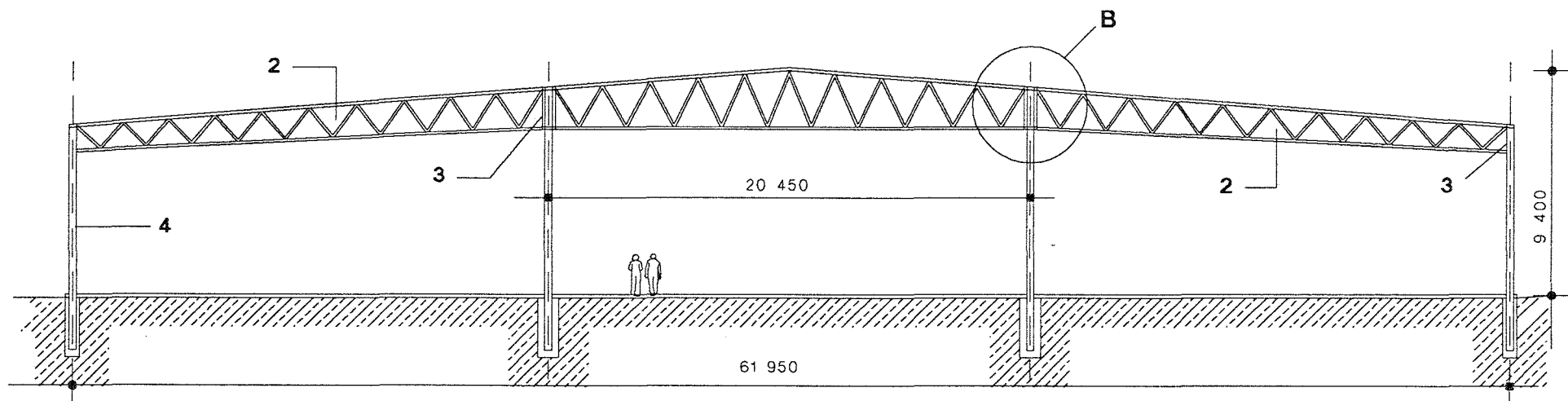


Plate 85. The secondary trusses span 20.45 m between the primary trusses and are double where two modules join. Hyne's board shed, Tuan, Qld.



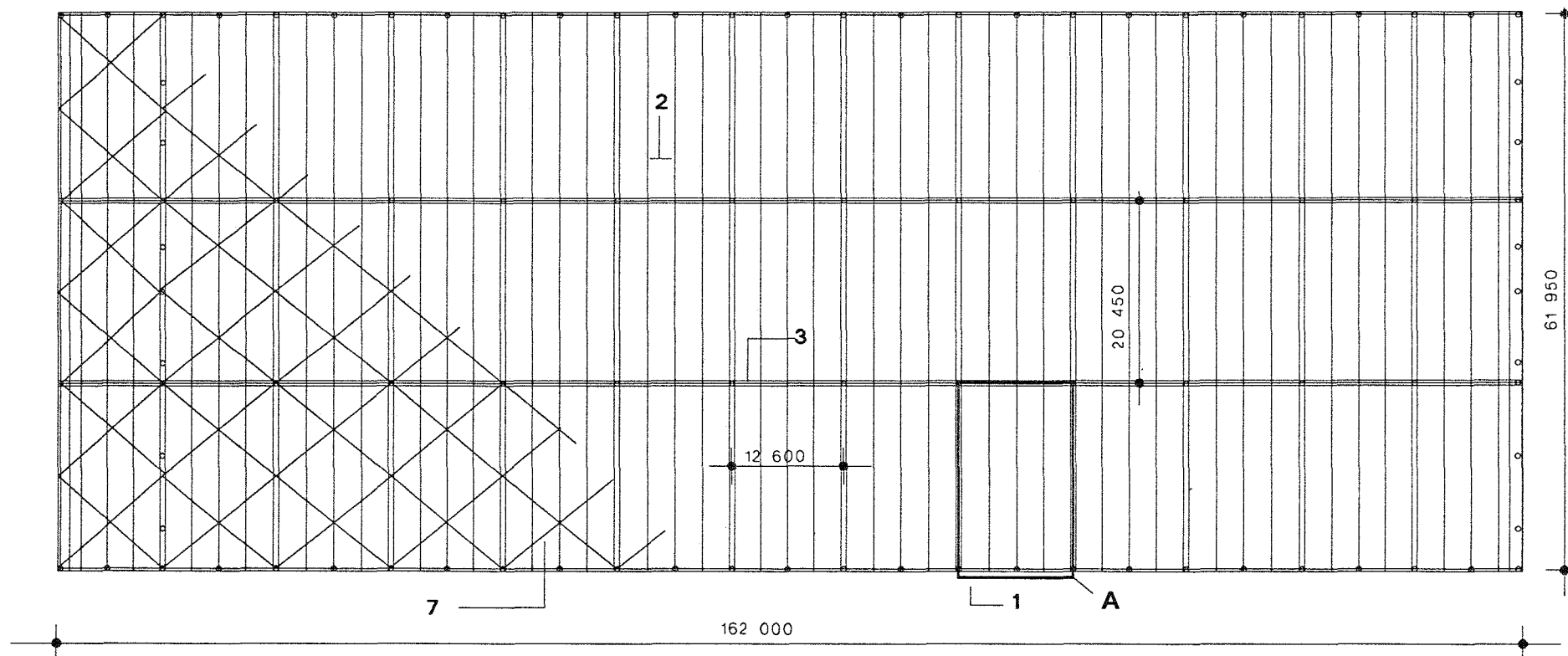
Plate 86. The primary trusses are bolted directly to the top of the columns. Note the T members used as webs, top and bottom chords. Hyne's board shed, Tuan, Qld.



Transverse Section
Figure 17

Hyne and Sons' board shed

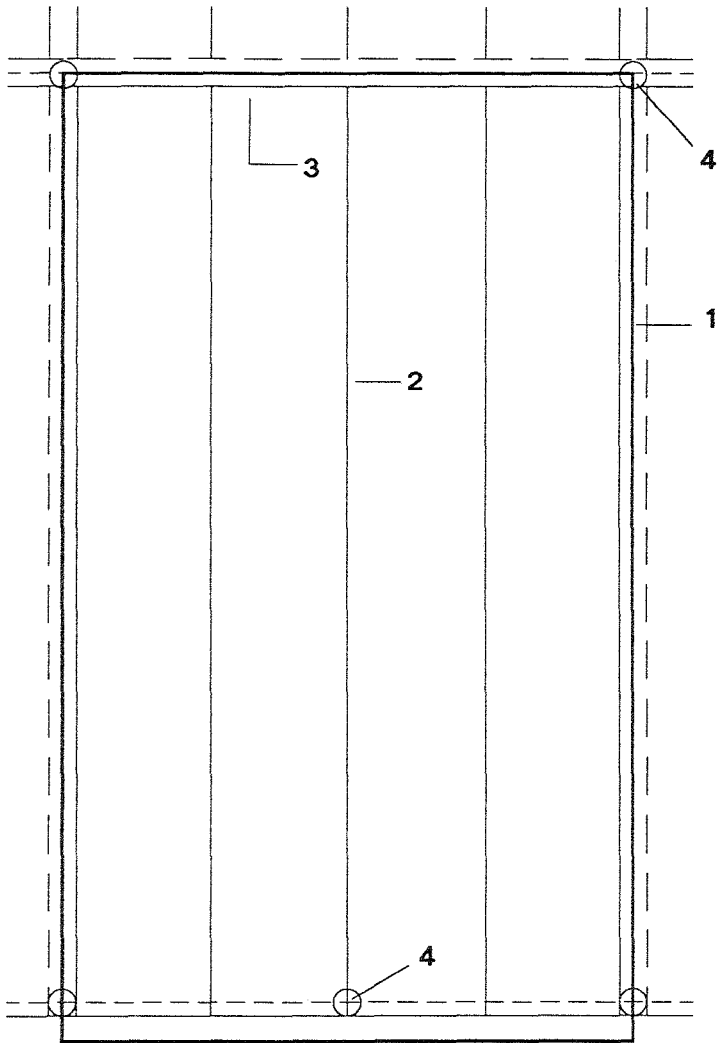
- 2. Secondary gang nail truss
- 3. primary gang nail truss
- 4. 300 dia. cantilevered pole



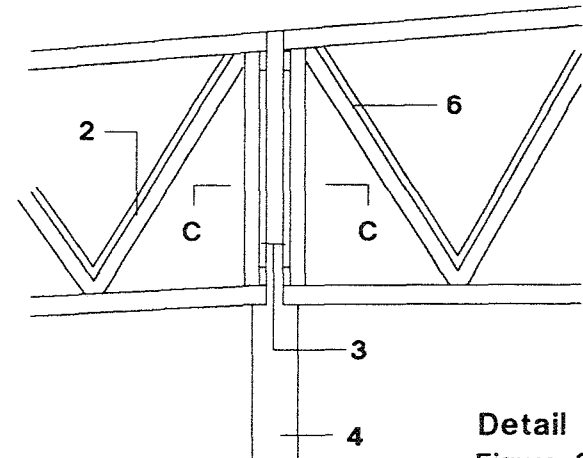
Plan
Figure 18

Hyne and Sons' board shed

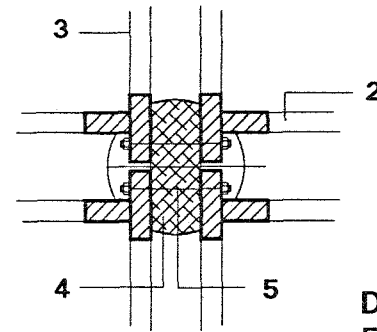
- 1. truss module
- 2. Secondary gang nail truss
- 3. primary gang nail truss
- 7. strap bracing



Detail A
Figure 19
Hyne and Sons'
board shed



Detail B
Figure 20



Detail C
Figure 21

1. truss module
2. Secondary gang nail truss
3. primary gang nail truss
4. 300 dia. cantilevered pole
5. M12 through bolts
6. T - stiffener to web

Exemplar 2. 8

Name of Structure:

Store Buildings, No. 7 Stores Depot

Owners:

Royal Australian Air Force

Address:

Drayton Rd, North Drayton,
Toowoomba, Qld.

Architects and Engineers:

Allied Works Council

Builders:

Civil Construction Corp.

Date Constructed:

1943

Structural System:

Continuous curved trusses on solid
hardwood columns

Description:

This building is a very large curved roof truss structure. It has 15 bays at 6.1 m centres and five longitudinal lines of columns at 15.8 m centres. The columns are solid hardwood. Segmented curved trusses run transversely between these columns to form the roof. The roof trusses have double top and bottom chords, with single vertical compression members and double diagonal tension members. They are fabricated with bolts and shear connector joints. Steel bolting plates are used only at the change of pitch joints on the top chords. The building is braced by a series of longitudinal bracing trusses, formed around the main transverse truss members and by four fully braced truss and column bays. The end wall wind posts are laced trussed columns.

Gantry cranes run down the central two aisles of the building.

The whole of the building was constructed from unseasoned hardwoods.

Development:

One of the major developments in timber engineering during the war was the large scale introduction of bolt and shear connector technology. This allowed more efficient truss forms and permitted the design of dependable tension joints in timber. It also allowed a different truss aesthetic to be employed.

Hundreds of structures were constructed using this technology during the Pacific War but none were as large or as representative as the RAAF inland stores buildings. Though the 15.8 metre span is unremarkable when compared to other AWC & RAAF designs of the period, the practical success of the solution is notable and the RAAF maintains many of these buildings as operational stores.

History:

With the continuing military build-up throughout the country in 1942, it was essential for large aircraft stores facilities to be constructed so the RAAF selected sites far enough inland to be free from possible carrier based air attack. Buildings to this design were built at Dubbo in NSW, at Drayton (near Toowoomba) and Macrossan in Queensland and Merredin in Western Australia.

Condition:

The building is in satisfactory condition.

References:

Dept of Works & Housing, 1946, *A report on the structural soundness of unseasoned timbers used in structures erected for war purposes*, Dept of Works & Housing, Melbourne.

RAAF Supply, 1991, *No 2 Stores Depot Detachment 'D'*, Number 31, December.



Plate 87. Looking along a row of internal columns with the bolt & shear connector trusses above.

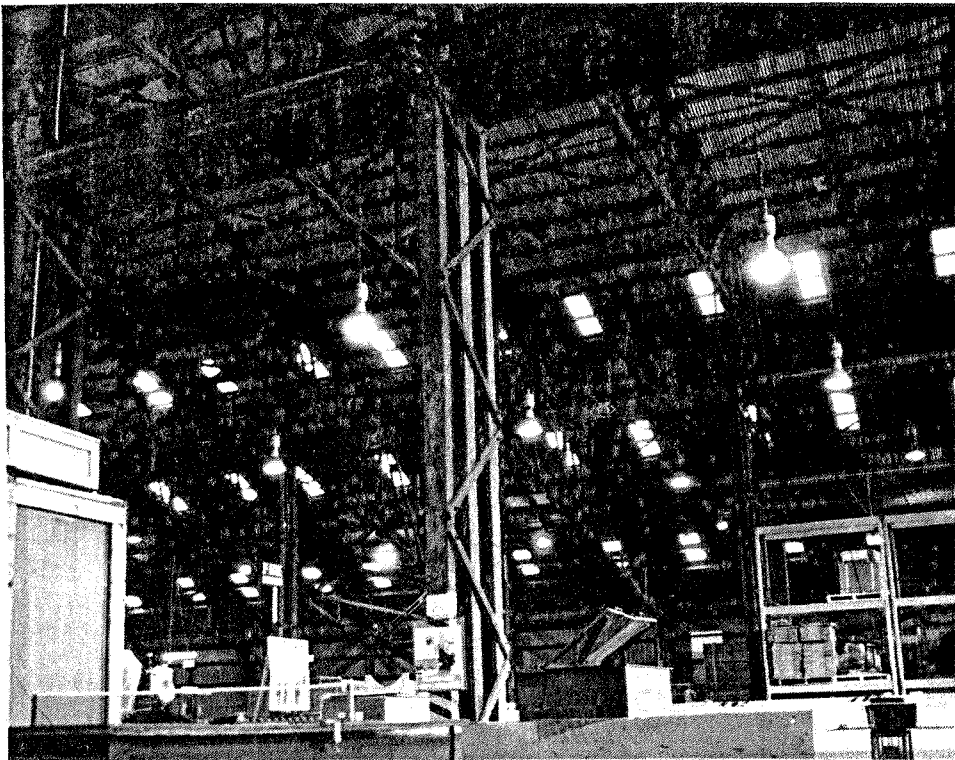


Plate 88. A laced triple hardwood column of the central row. These support the roof and a gantry crane rail on each side. RAAF No. 7 Stores Depot, Drayton, Qld.

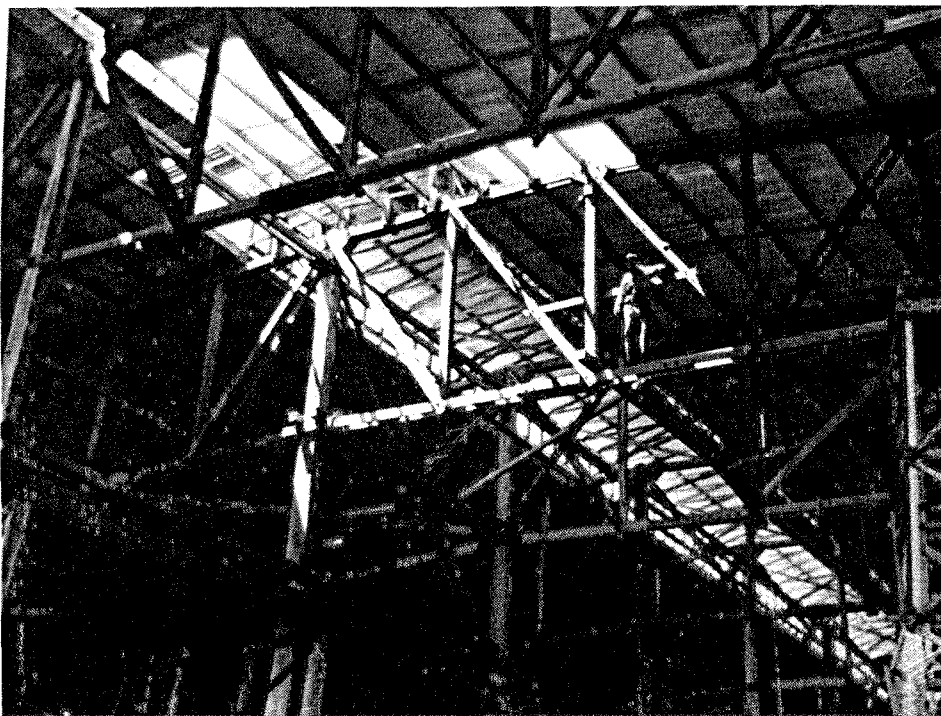


Plate 89. One of the construction workers standing on the central truss section of the roof. RAAF Macrossan, Qld. Photo: Australian Archives.

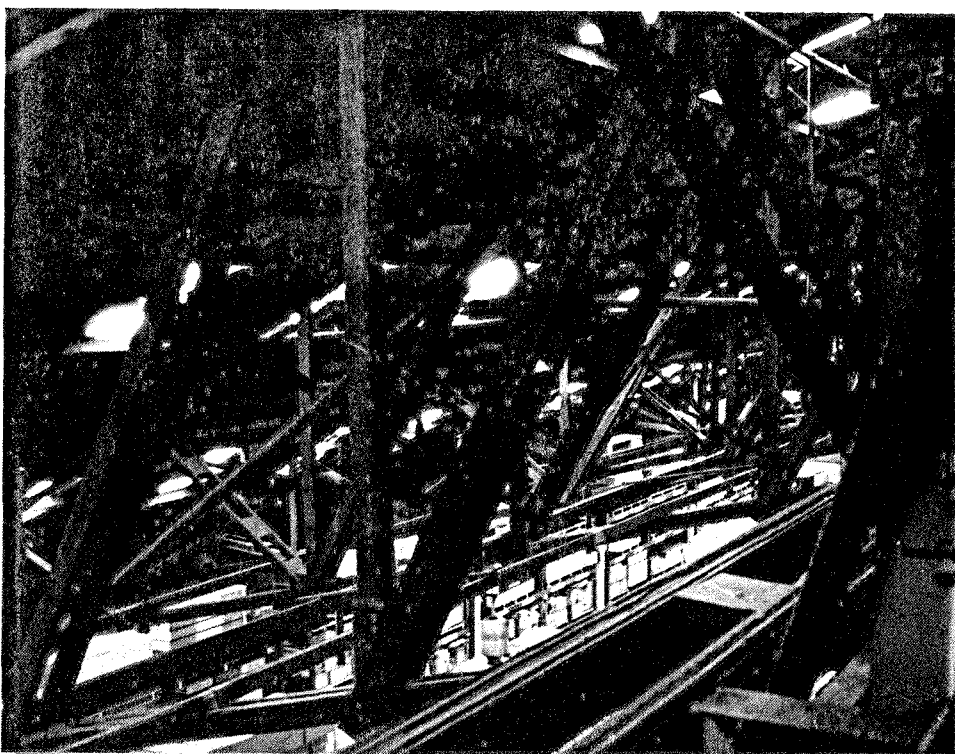


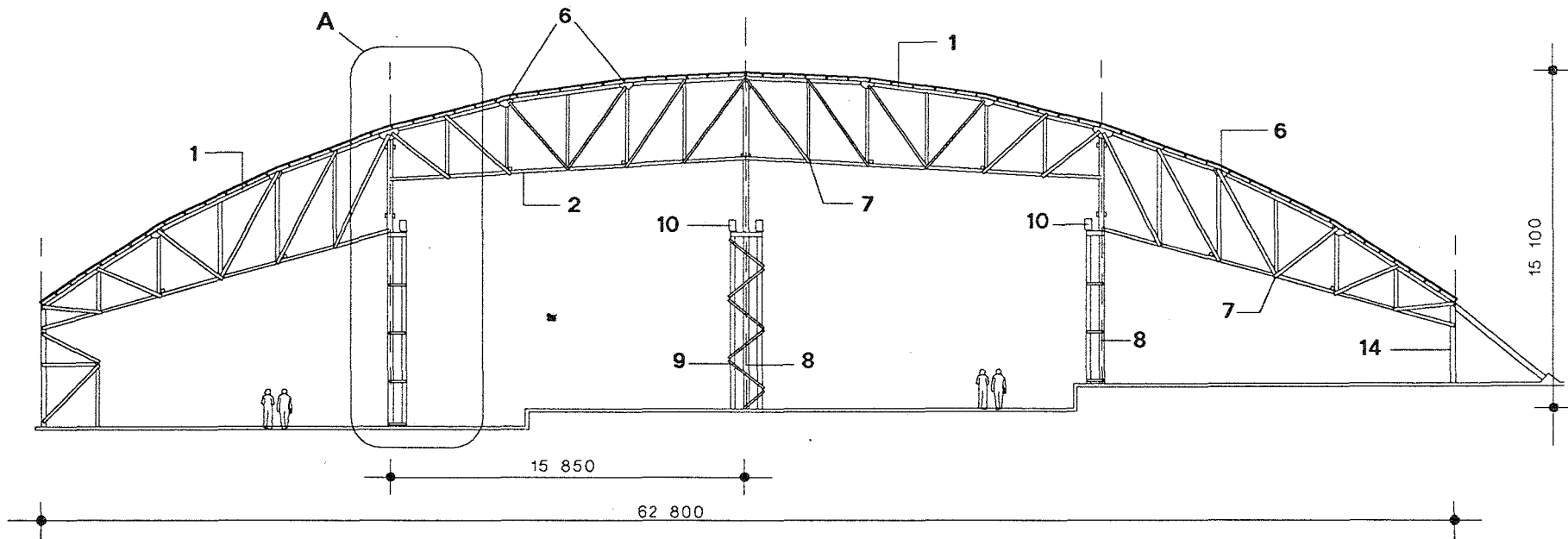
Plate 90. Looking through the trusses from one of the gantry cranes, the packed double compressions chords and single tension chords can be seen. RAAF No. 7 Stores Depot, Drayton, Qld.



Plate 91. The end wall of the building under construction with the laced wind posts and main longitudinal bracing visible. RAAF Macrossan, Qld. Photo: Australian Archives.



Plate 92. The base connection detail of the main longitudinal bracing and the columns. RAAF No. 7 Stores Depot, Drayton, Qld.



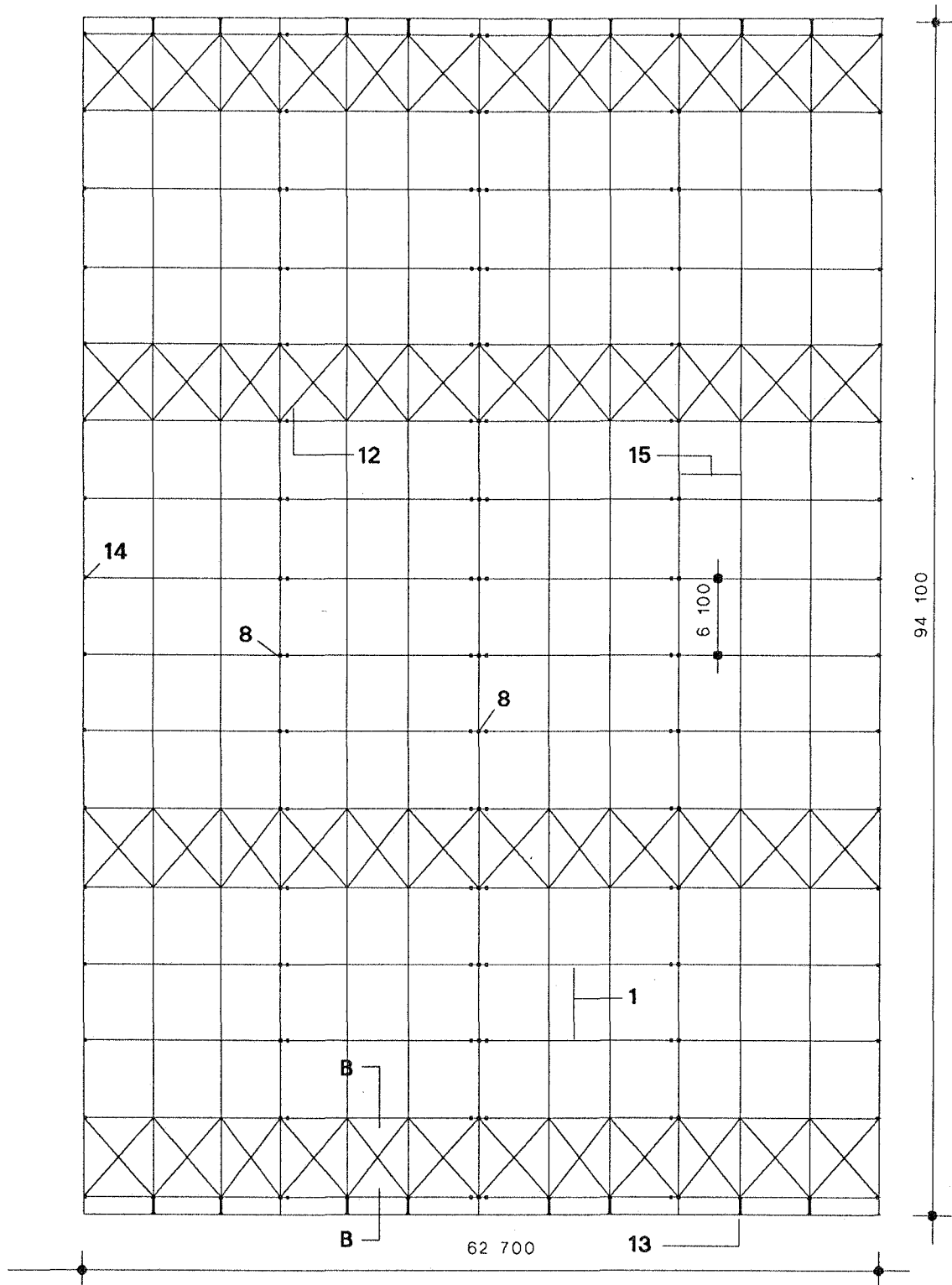
Transverse Section

Figure 22

Store building, RAAF Drayton

- 1. 2 x 165 x 70 h/w top chord
- 2. 2 x 150 x 50 h/w bottom chord
- 6. steel joint plates
- 7. bolt and shear connector joint

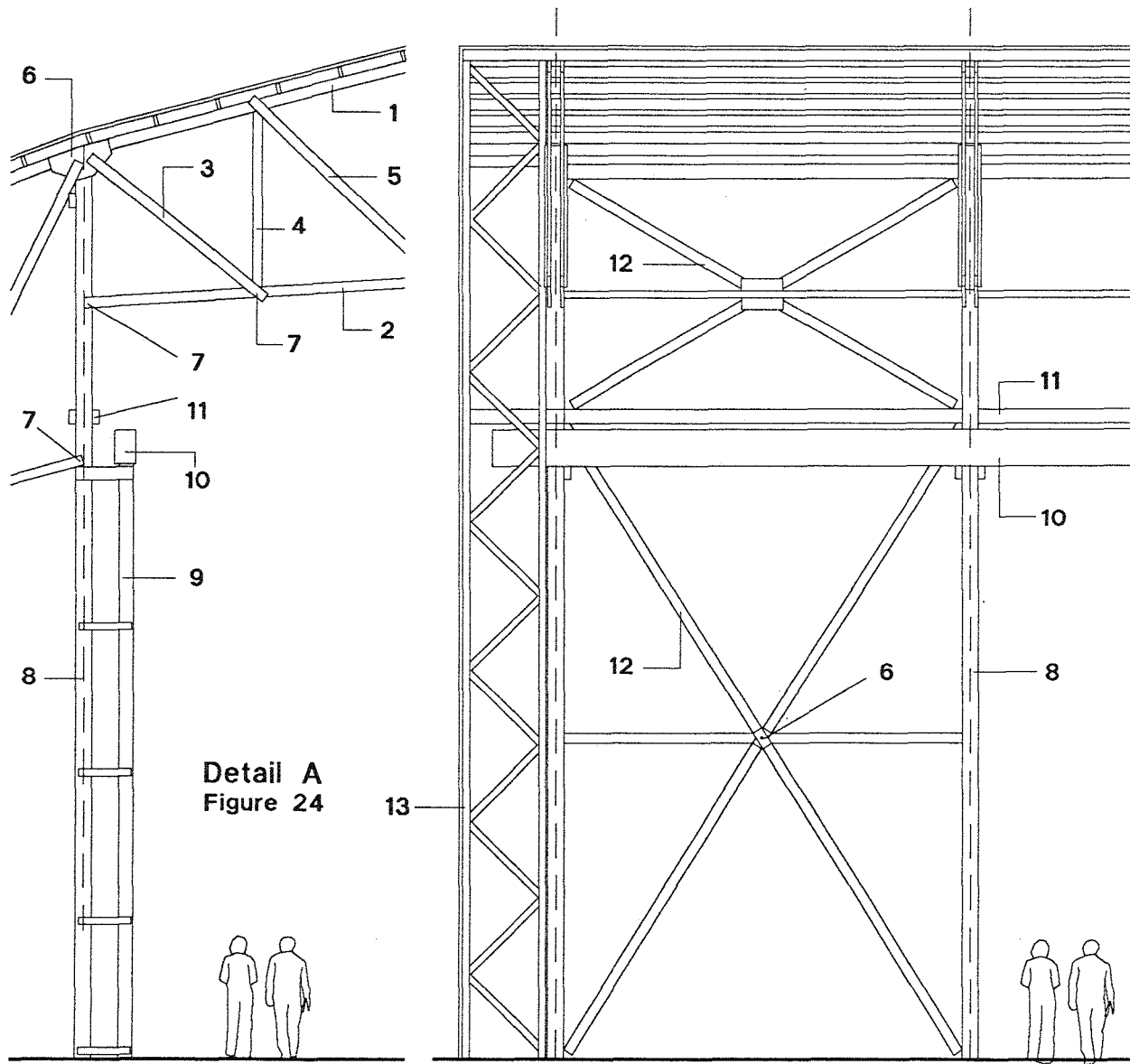
- 8. 240 x 240 h/w column
- 9. 240 x 200 h/w gantry post
- 10. gantry beam and rail
- 14. 220 x 220 h/w columns



Plan
Figure 23

Store building
RAAF Drayton

1. h/w truss line
8. 240 x 240 h/w column
9. 240 x 200 h/w gantry post
12. 2 x 150 x 50 h/w braces
13. 1200 wind post nailed together from 100 x 75 & 100 x 50 h/w
14. 220 x 220 h/w column
15. 150 x 150 h/w ties



Detail B
Figure 25
Store building, RAAF Drayton

1. 2 x 165 x 70 h/w top chord
2. 2 x 150 x 50 h/w bottom chord
3. 2 x 150 x 50 h/w web
4. 150 x 125 h/w web
5. 2 x 100 x 50 h/w web
6. steel joint plates
7. bolt and shear connector joint
8. 240 x 240 h/w column
9. 240 x 200 h/w gantry post
10. gantry beam and rail
11. 2 x 200 x 100 h/w ties
12. 2 x 150 x 50 h/w braces
13. 1200 wind post nailed together from 100 x 75 & 100 x 50 h/w

Exemplar 2. 9

Name of Structure:

Warehouse

Owners:

Forwoods Products Limited

Address:

Jubilee Highway, Mt. Gambier, SA.

Architects:

Ross Henry

Structural Engineers:

P. J. Yttrup & Associates Pty Ltd

Builders:

Boulderstone Pty Ltd

Date Constructed:

1988

Structural System:

Fixed Portal Frame

Description:

This warehouse is the largest building at the Scrimber International Complex. It is a 32 metre span fixed portal frame structure with 9 bays at 8.5 m centres and one at 5 metres centres. The portals are constructed from 900 x 426 LVL box members and stand 13.5 m high at the eaves, rising to 16 m at the apex. They support a 48 tonne capacity travelling crane running on LVL support beams. The primary bracing for the crane is two LVL T shaped braces while 50 x 2 mm galvanised steel straps brace four complete bays. The end wall wind posts are 600 x 63 LVL.

Development:

This building displays a strength and scale uncommon in an industrial building. Its 1:2 height to width

proportion combines with the simple form and confident detailing to create a strong and assured structure that carries its heavy industrial crane with ease.

History:

The building was constructed as part of the main production facility for Scrimber, a reconstructed timber product. After technical and production difficulties, production of Scrimber was halted and the complex is currently idle.

Condition:

The building is in a satisfactory condition.

References:

Australian Forest Industries Journal, 1988, *Scrimber plant is timber framed*, August, p. 18.

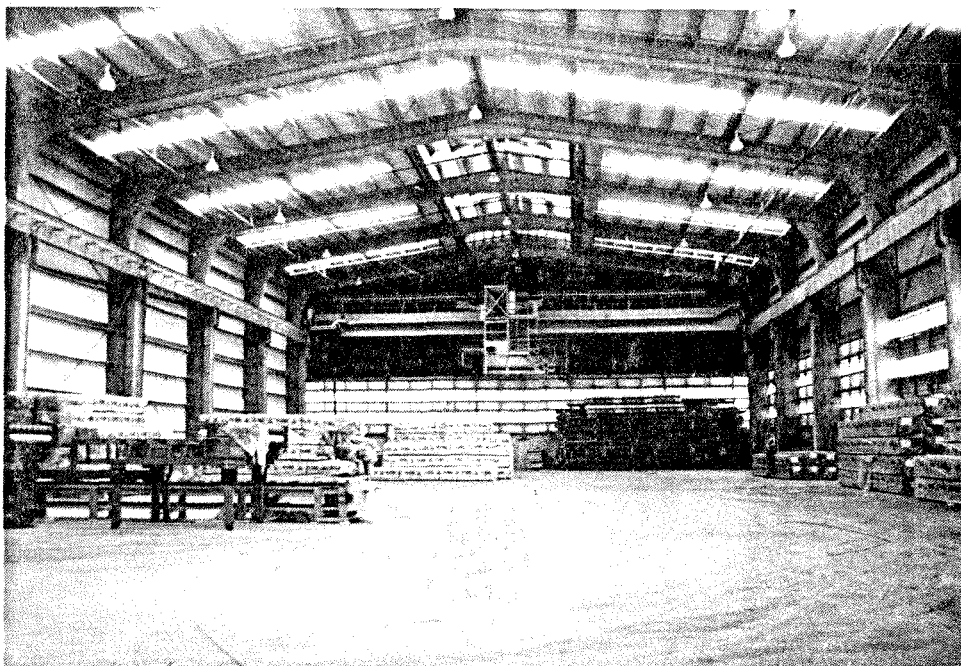


Plate 93. The 32 m. portal frames of the Scrimber International warehouse. The gantry crane runs the full length of the building on the LVL columns & support beams.

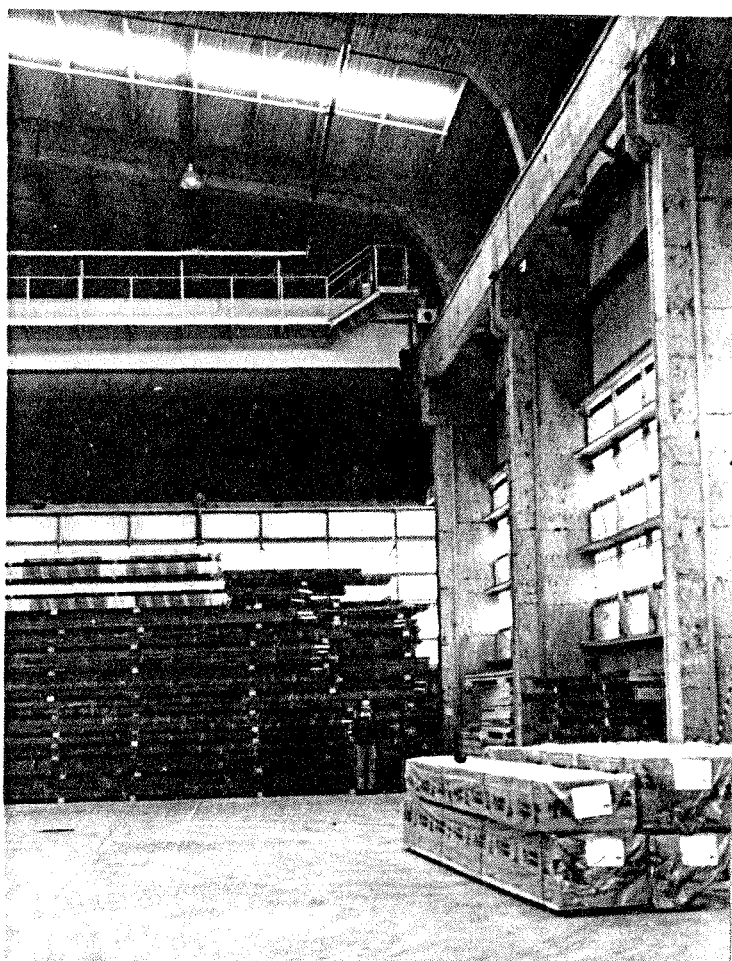


Plate 94. A visitor, seen bottom centre, is dwarfed by the scale of the structure. Scrimber International warehouse, Mt. Gambier, SA.

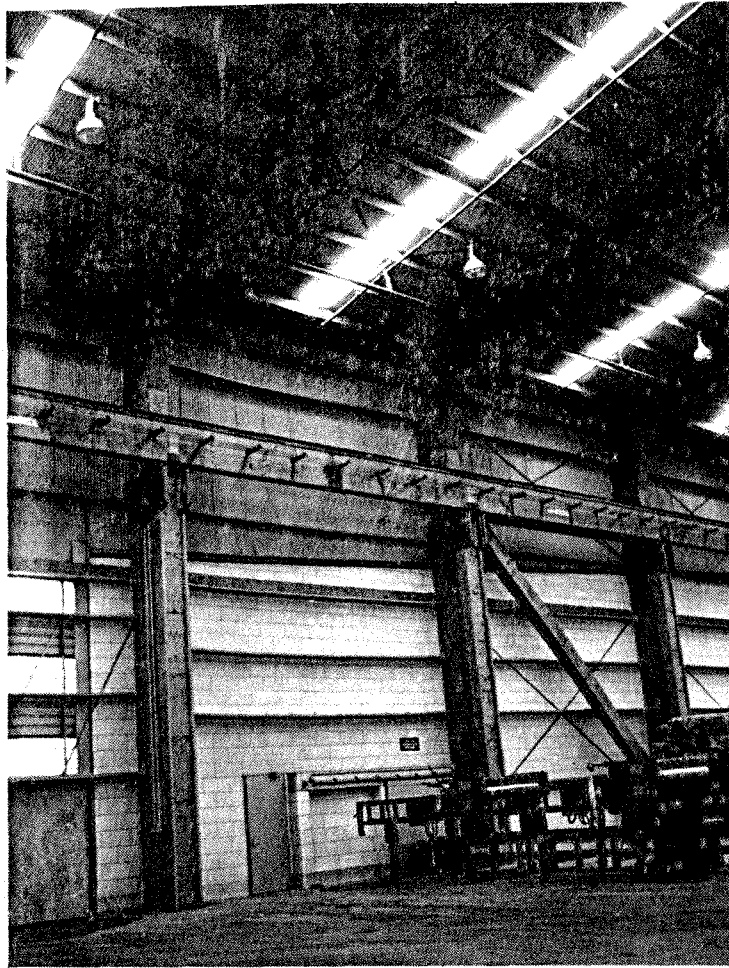


Plate 95. The gantry running beams, main structure brace, purlins and girts are LVL. Scrimber International warehouse, Mt. Gambier, SA.



Plate 96. Ridge ventilators and nailed gusset joint at the apex of the portal frame. Scrimber International warehouse, Mt. Gambier, SA.

Exemplar 2. 10

Name of Structure:

Board store

Owners:

CSR Timber Products

Address:

Jepsen Avenue, Tumut, NSW.

Structural Engineers:

Connell Wagner Pty. Ltd.

Bullders:

I. G. Wallace and Sons

Date Constructed:

1989

Structural System:

Two pin portal frames

Description:

The building is a two pin portal frame building constructed from glue laminated radiata pine. It has 10 bays at 9 metre centres and each portal frame spans 40.5 m. The principal moment connections are nailed, 25.4 mm thick, LVL gusset plates. The main portal rafters taper at their springing and are in three sections across the span. These are spliced by nailed LVL gusset plates. Purlins and girts are glue laminated softwood.

Development:

This is one of the largest nail gusset plate portal frame buildings constructed from glue laminated softwood in Australia.

Condition:

The building is in satisfactory condition except for one portal leg that was struck by a fork lift. The

impact caused a split in the lamination and has had to be reinforced.

References:

Australian Forest Industries Journal, 1990, *CSR backs glulam in giant Tumut project*, January/February, p. 33



Plate 97. The portal rafters taper after springing from the glue laminated columns. CSR board store, Tumut, NSW.

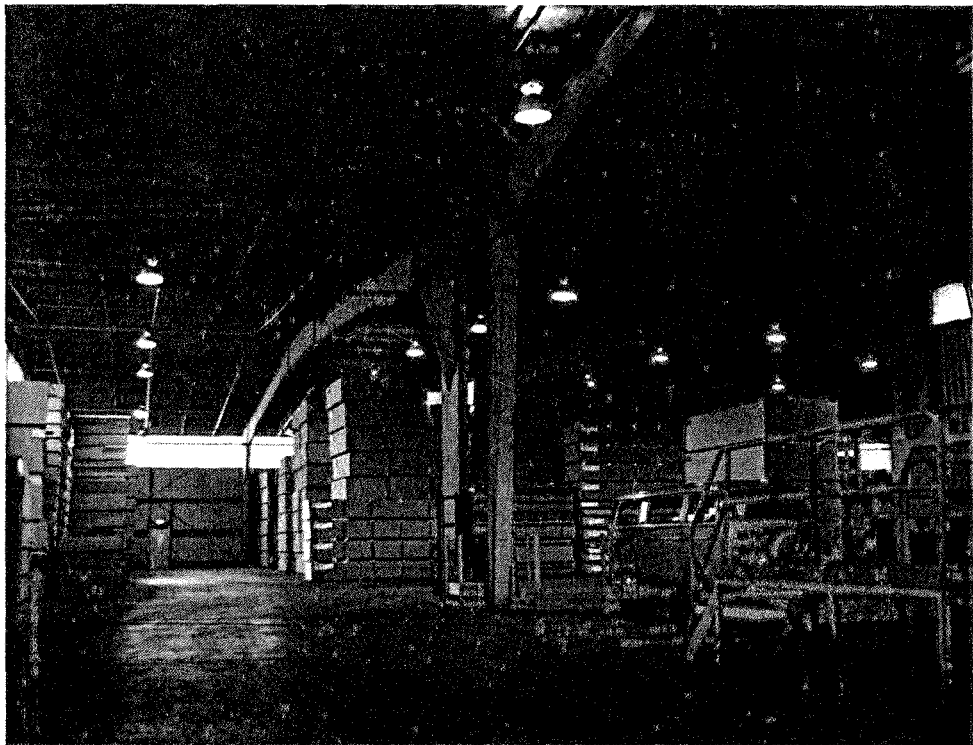


Plate 98. The timber portals were built adjacent to a similar steel portal building. The full width of the timber span is visible. CSR board store, Tumut, NSW.

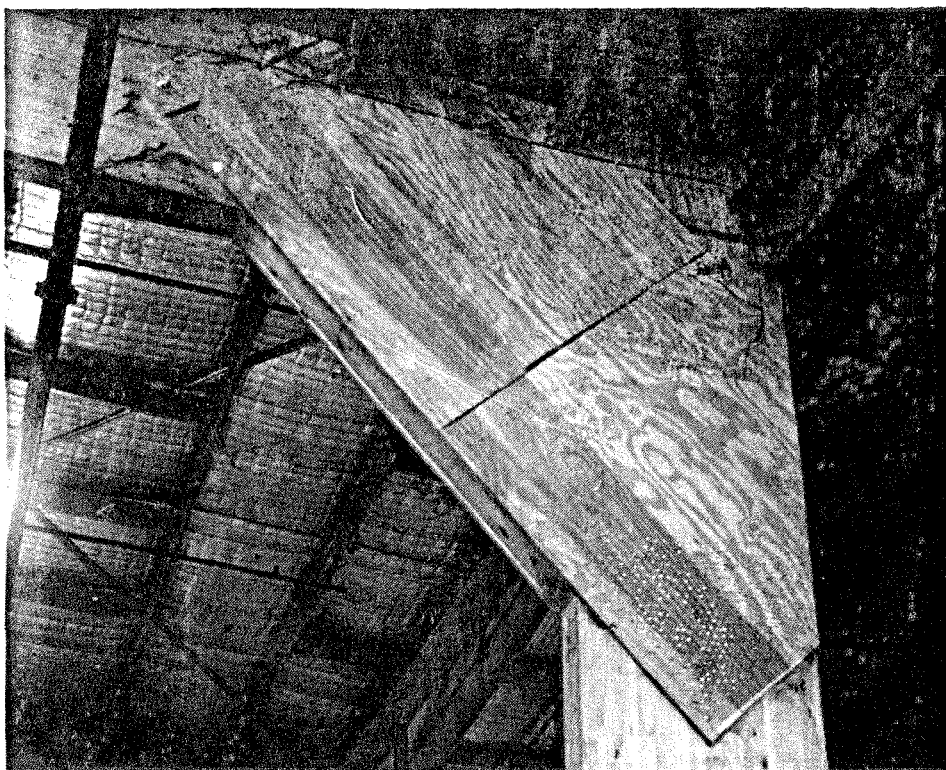
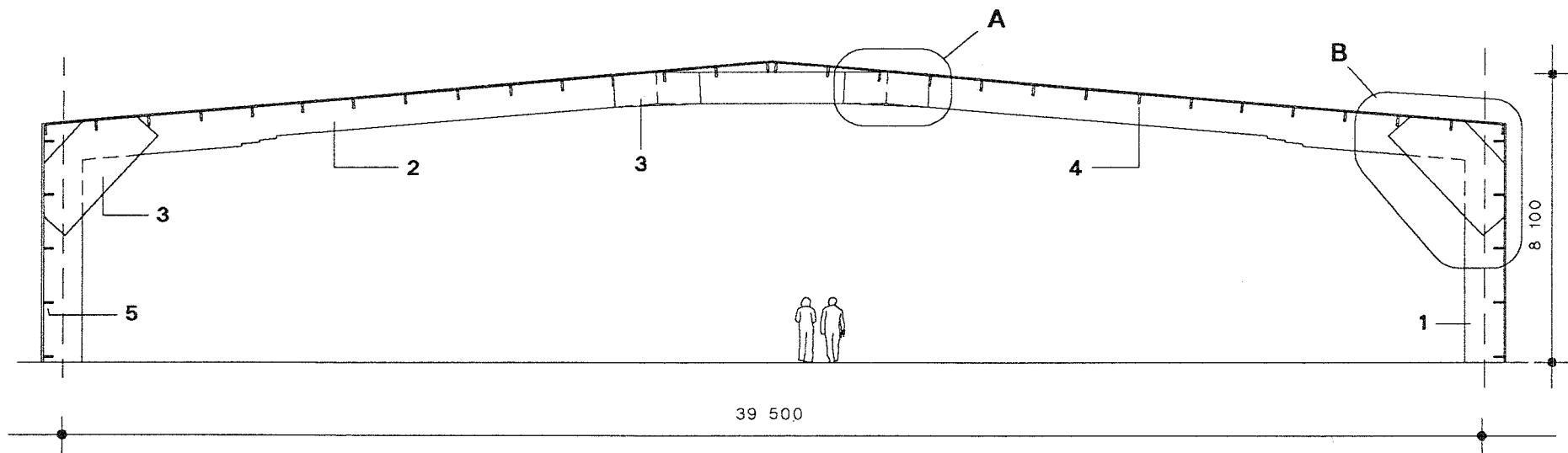


Plate 99. The nailed gusset plate at the moment joint between the rafters and columns. CSR board store, Tumut, NSW.



Plate 100. The base detail of the glue laminated columns. CSR board store, Tumut, NSW.

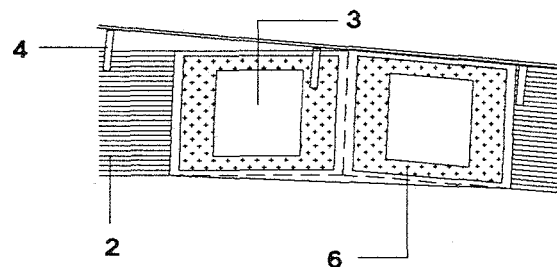
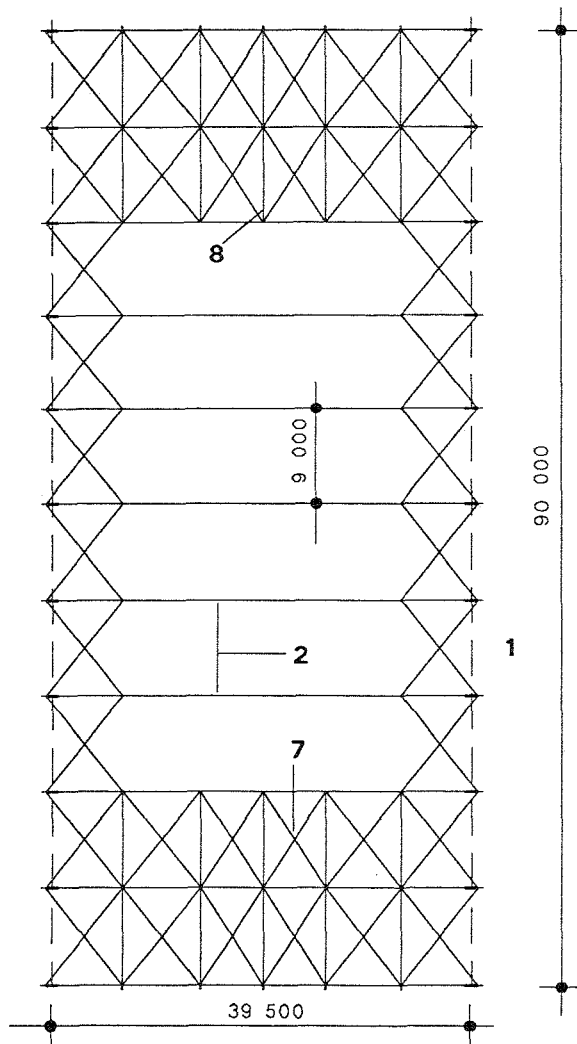


Transverse Section

Figure 26

CSR board store, Tumut

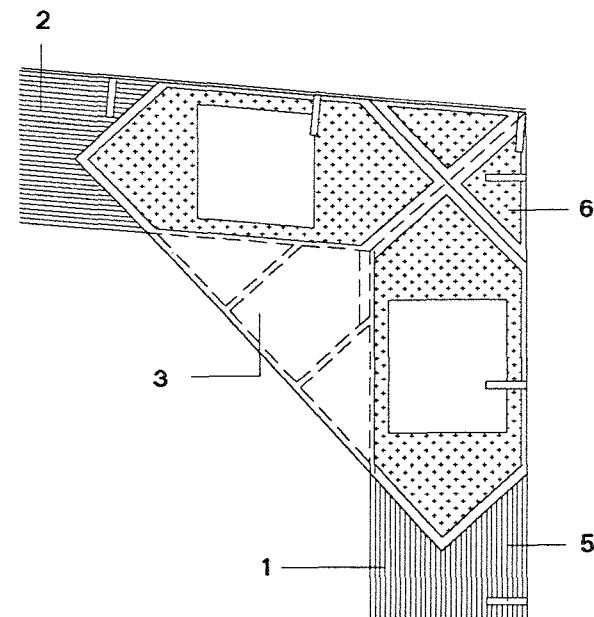
1. 1080 x 180 glulam radiata columns
2. 1080 - 870 x 180 glulam rafters
3. LVL gusset plates
4. 275 x 40 glulam purlins
5. 275 x 40 glulam girts



Detail A
Figure 28

Plan
Figure 27

CSR board store, Tumut



Detail B
Figure 29

1. 1080 x 180 glulam radiata columns
2. 1080 - 870 x 180 glulam rafters
3. LVL gusset plates
4. 275 x 40 glulam purlins
5. 275 x 40 glulam girts
6. nailing pattern
7. "Speedbrace" roof bracing
8. std purlin with 140 x 35 T stiffener

Exemplar 2. 11

Name of Structure:

Factory Building

Owners:

CSR

Address:

Mitchell Crescent, Cardiff, NSW

Structural Engineers:

Timberbuilt Pty Ltd; Principal: Bruce Hutchins

Date Constructed:

1991

Structural System:

Two pin portal frame

Description:

The factory is a two pin LVL portal frame structure. It has 7 bays, ranging in width from 12 m to 8.5 m, giving a building 72.6 m overall. Each portal frame spans 43 m and has LVL box section columns and rafters. The rafters have an internal splice plate and the columns taper to their base. All moment joints are nailed LVL gusset connections. The purlins are LVL "I" beams set between the portal frames and fixed with LVL connection blocks. These blocks are connected to the portals with Type 17 Tek screws and nailed to the purlins. Girts and wind posts are all LVL.

Development:

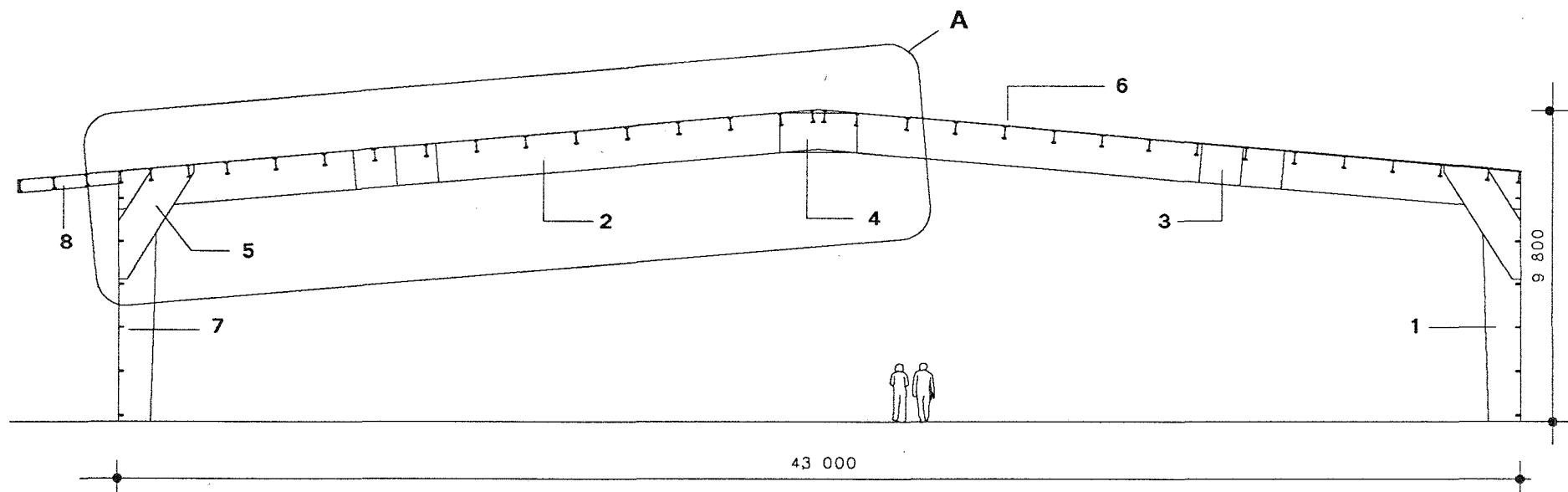
While similar to many other buildings of this period, this factory and Scrimber International's Warehouse represent the pinnacle of industrial building during the Portal Frame Cycle. From Jordan's first Australian LVL portal in 1985, the form developed to Yttrup's strong 32 m

portal by 1988 and Hutchins' 43 m building by 1991. Both these later two used an LVL box section as the principal column and rafter member.

The Cardiff building is the longest clean span portal building known in Australia.

Condition:

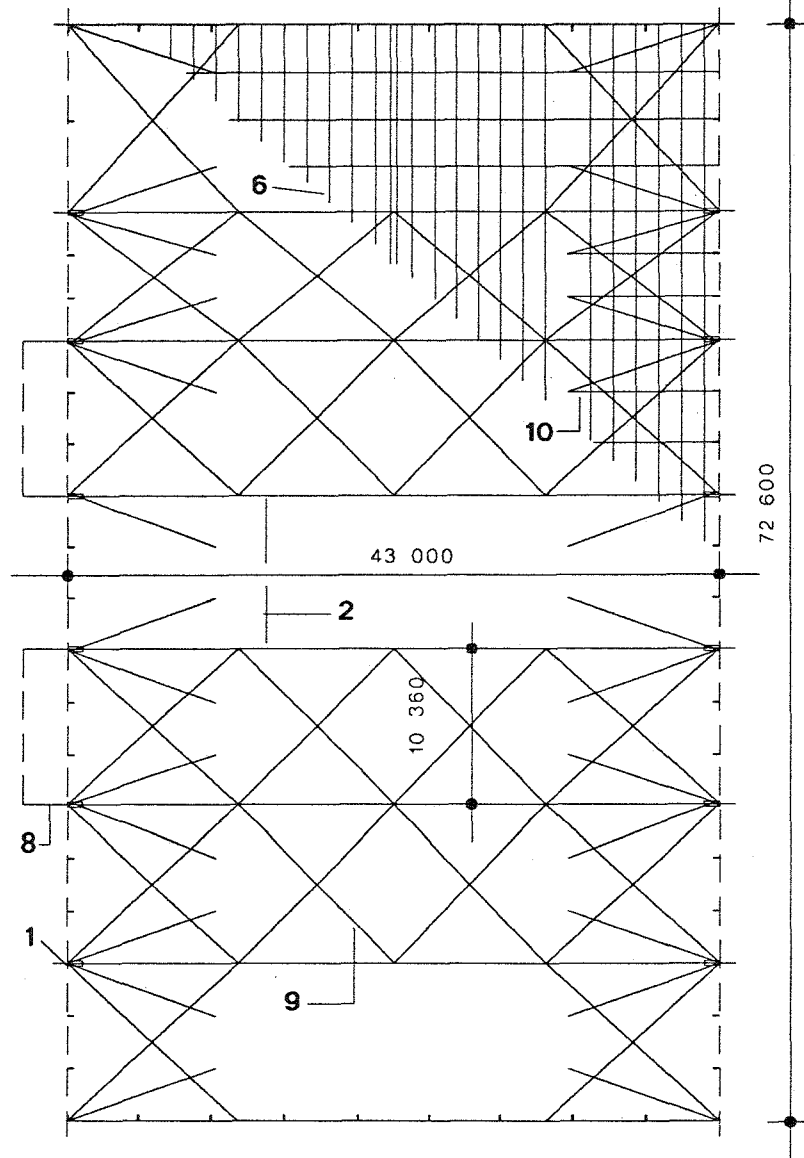
The building is in a satisfactory condition.



Transverse Section
Figure 30

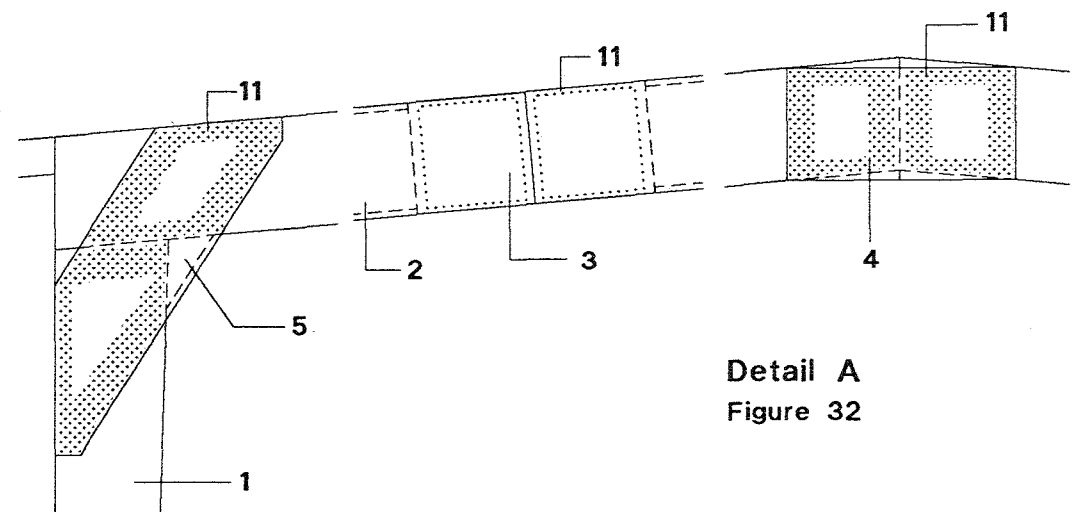
CSR board store, Cardiff

1. tapering 1200-1000 x 330 LVL box column
2. 1200 x 330 LVL box rafters
3. internal LVL splice plate to rafters
4. 54 LVL ridge gusset
5. 63 LVL knee gusset
6. nom 400 hyspan I purlins at max 1 560
7. LVL girts
8. 400 x 240 LVL box awning rafter



Plan
Figure 31

CSR board
store, Cardiff



Detail A
Figure 32

1. tapering 1200-1000 x 330 LVL box column
2. 1200 x 330 LVL box rafters
3. internal LVL splice plate to rafters
4. 54 LVL ridge gusset
5. 63 LVL knee gusset
6. nom 400 hypan I purlins
8. 400 x 240 LVL box awning rafter
9. 50 x 2 galvanised strap bracing
10. LVL purlin restraint
11. nailing area

Exemplar 2. 12

Name:

Store building

Owners:

Le Messurier's Timber Company

Address:

McNaughtons Rd, Clayton, Vic.

Architects:

KMH Neighbour Lapsys Architects.

Structural Engineers:

Timberbuilt Pty Ltd.

Date Constructed:

1990

Structural System:

Propped portal frames

Description:

The building is a simple factory building with attached offices. The storage area consists of six bays of 72 m span propped portal frames at 12.67 m centres. The frames are constructed of LVL box sections and support LVL "I" beam purlins at a maximum of 1.58 m centres. The purlins support a sheet metal roof. The girts are LVL square section and fixed to the frames and LVL wind posts with sheet metal connectors. The storage area is separated from the office accommodation with tilt up concrete panels. These are propped off the LVL portal frames. The roof is braced with galvanised strap steel.

Development:

The building represents a variation on the strength of the LVL and glue laminated portal buildings seen at Scrimber International and at Cardiff. Using the same technology, this

structure uses the propped portal form to span 72 m with simple and graceful members.

Interestingly, this timber building is indistinguishable from the contemporary steel framed factory buildings that surround it.

Condition:

The building is in a satisfactory condition

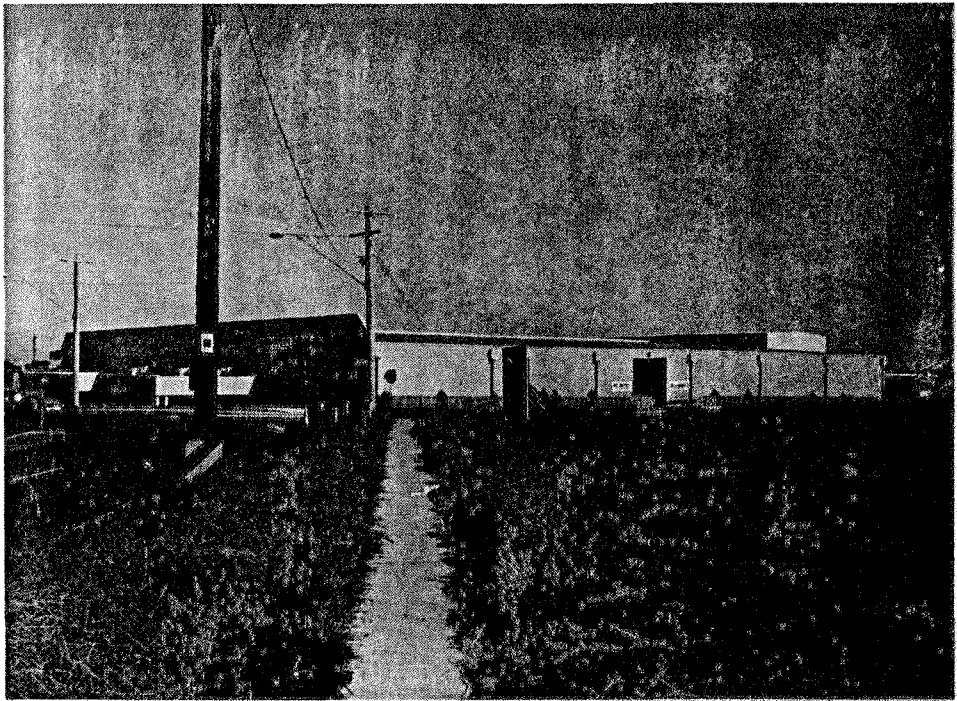


Plate 101. Exterior view of the Le Messurier's store, Clayton, Vic.

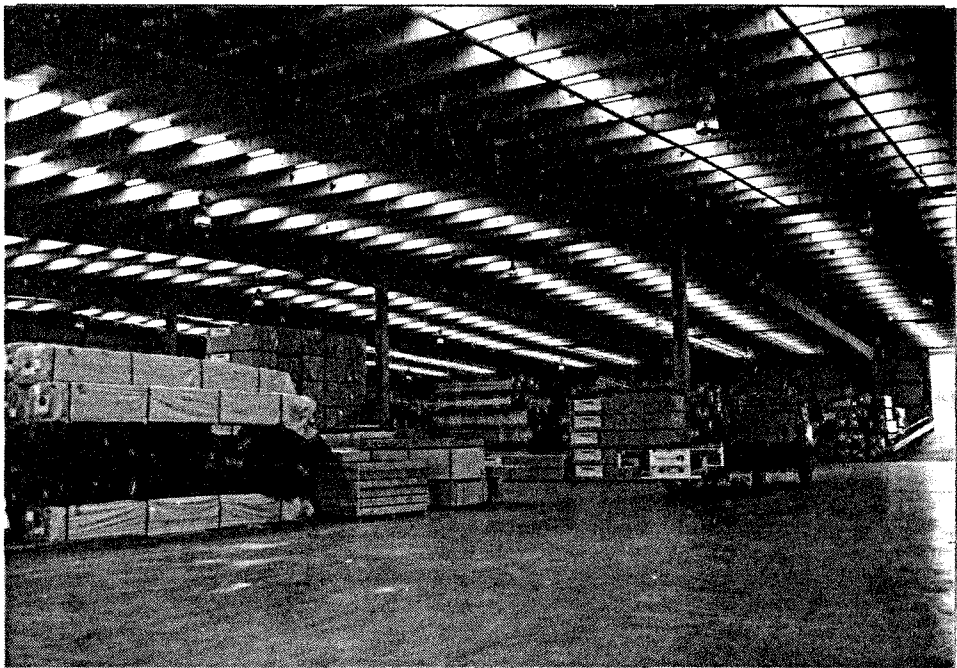


Plate 102. The 72 m span propped portal frames are LVL box sections. The building serves as a drive in board store. Le Messurier's store, Clayton, Vic.



Plate 103 The portal rafters house inside the box sections of the column at the supports. The moment joint is effected with a concentrated pattern of machine driven nails. Le Messurier's store, Clayton, Vic.

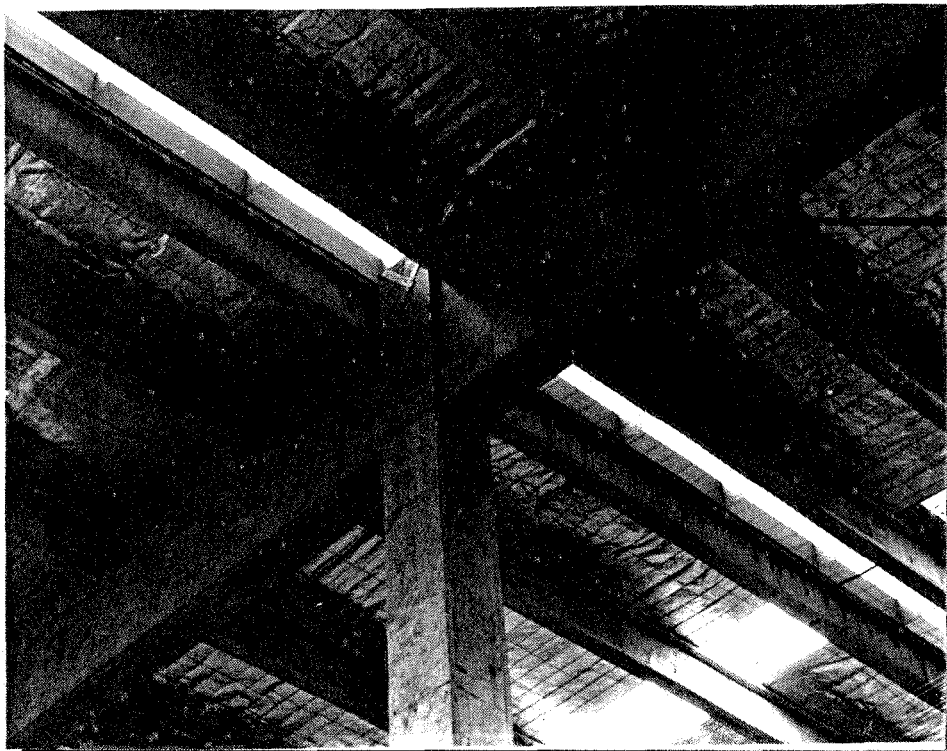
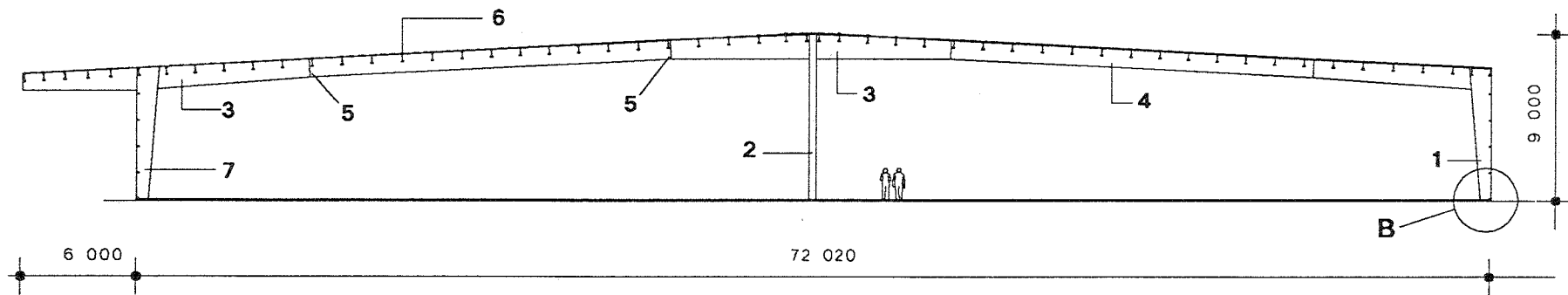


Plate 104. The central prop supports the portal rafters. Purlins are LVL "I" beams. Le Messurier's store, Clayton, Vic.

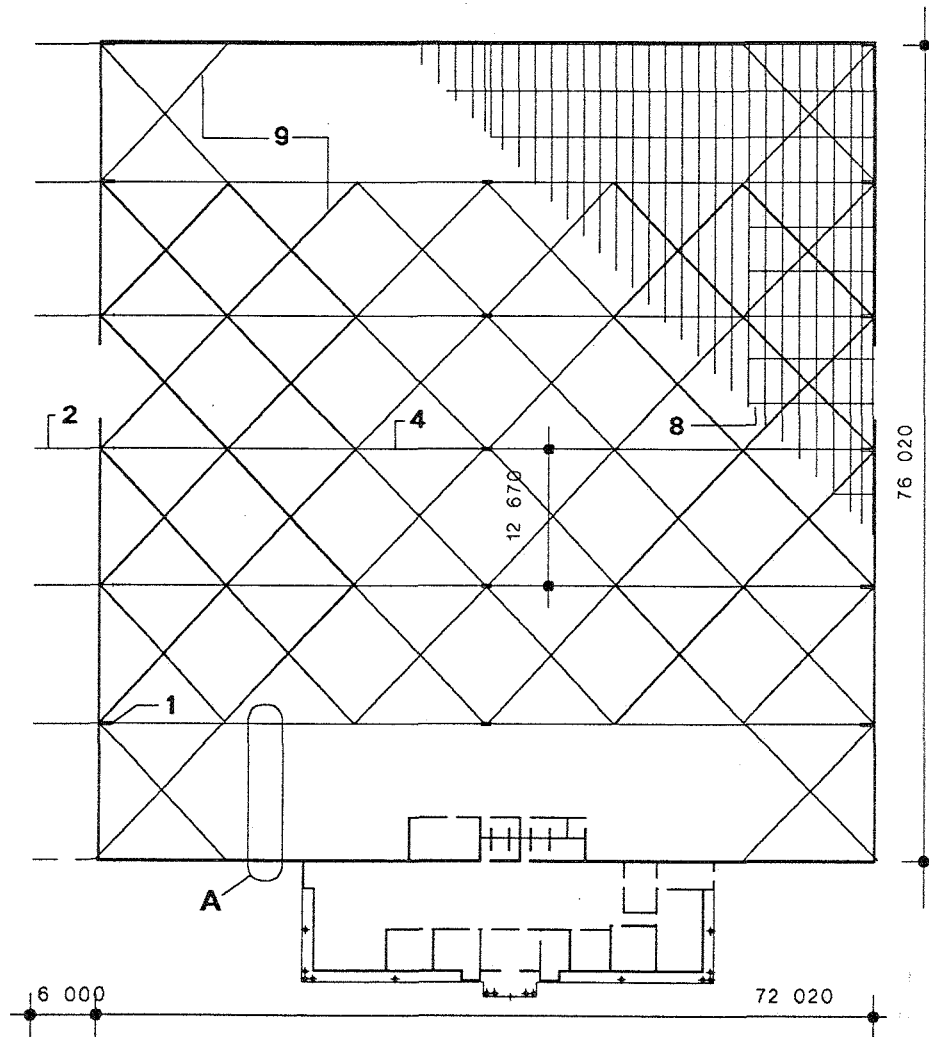


Transverse Section

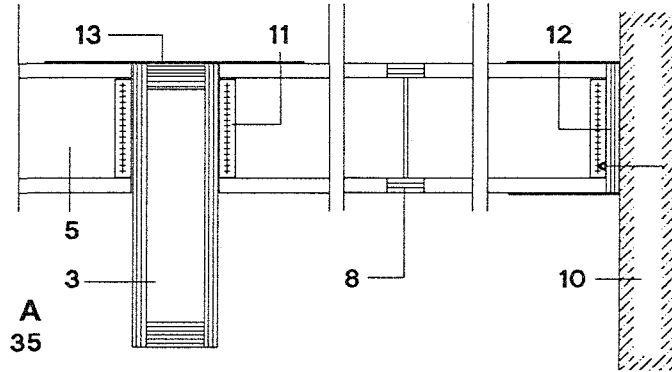
Figure 33

Le Messurier's store building, Clayton

1. tapering 1200-600 x 430 LVL box column
2. 400 x 430 box column
3. tapering 1200-1000 x 300 LVL box rafter section
4. 1000 x 300 LVL box rafter section
5. splice with internal LVL box splice plate
6. 450 hyspan I purlins at 1 580 centres
7. 130 x 45 LVL girts

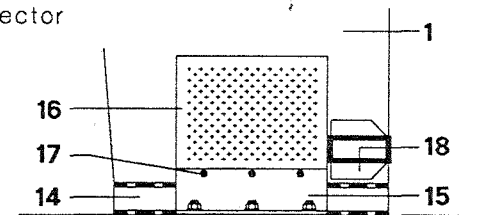


Detail A
Figure 35



1. tapering 1200-600 x 430 LVL box column
3. tapering 1200-1000 x 300 LVL box rafter section
4. 1000 x 300 LVL box rafter section
6. 450 hyspan I purlins at 1 580 centres
8. purlin blocking
9. 25 x 1.2 galvanised strap bracing
10. tilt slab concret wall
11. 63 x 55 x 365 plywood connection block
12. 450 x 45 LVL raker plate
13. 25 x 1.2 continuity strap
14. 50 treated block between malthoid layers
15. 100 x 100 x 12 angle with 3 x M16 bolts
16. 2 nail plate with 113 nails
17. 3 type 17 teks
18. sheet metal girt connector

Detail B
Figure 36



Plan
Figure 34

**Le Messurier's
store building**

Exemplar 2. 13

Name of Structure:

Store

Owners:

M. S. McCloud Holdings

Address:

Francis St, Port Adelaide, South Australia

Architects:

Hassell Pty Ltd.

Structural Engineers:

Kinnaird Hill & Associates

Date Constructed:

1962 - 1963

Structural System:

Propped trussed portal

Description:

The building is a simple industrial store building of 10 bays of 240 ft (73.2 m) span propped portal frames at 16 ft (4.9 m) centres. The portal frame rafters are pairs of parallel chord trusses with a gabled top chord supported by a spaced timber post at the centre and strutted columns at the perimeter. The trusses were constructed of solid oregon members connected with bolts and steel connection plates. The columns are kauri. The building is fully braced in the bottom chord of the two outside bays and the top chord of the centre bay. Each truss weighed about 4 tonnes when erected.

Development:

This building was one of the few large scale industrial buildings constructed in wood at the beginning of the Australian Regionalist Cycle. This

cycle was dominated by architects and it seems the designers of industrial buildings regarded wood as a structural alternative for long span buildings only when their client was associated with timber.

The form of this building demonstrates the move away from the glue laminated arch solutions dominant in the preceding decade towards the more linear solutions of the Australian Regionalists.

History:

The building was constructed for Lloyds Timber Mill Ltd reportedly to show their faith in timber as a structural material.

Lloyds had been a founding partner in Laminated Timber Products Limited when it was established in 1955.

However, by 1962, that company had folded and Lloyds' interest in glue laminated materials and solutions had disappeared.

Condition:

The building appears in satisfactory condition

References:

Australian Timber Journal - 1963
Editorial Annual, 1964, *Timber is an Economic Structural Medium*, February, p. 244.

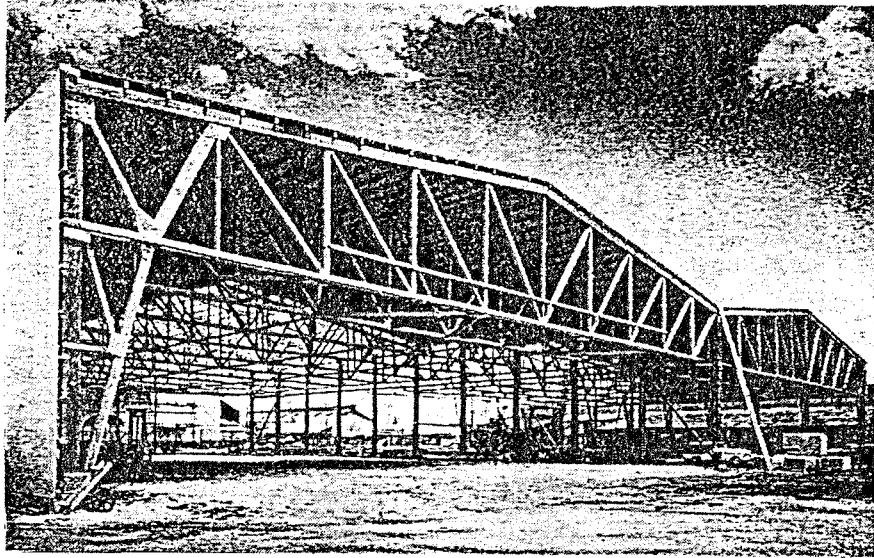


Plate 105. The two 120 ft (36. 6m) propped portal spans under construction for Lloyd's timber store at Port Adelaide, SA. Photo: Courtesy of the Australian Timber Journal.

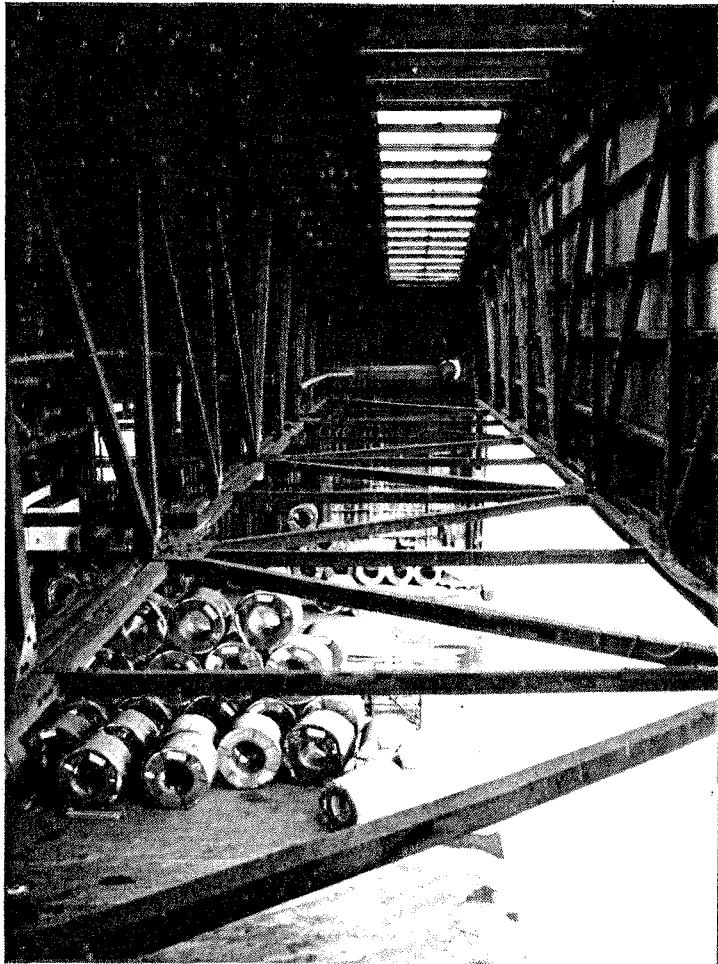


Plate 106. Looking between two of the trussed portal rafters. The perimeter bays of the building at both ends are fully braced in the line of the bottom chord. Lloyd's timber store, Port Adelaide, SA.

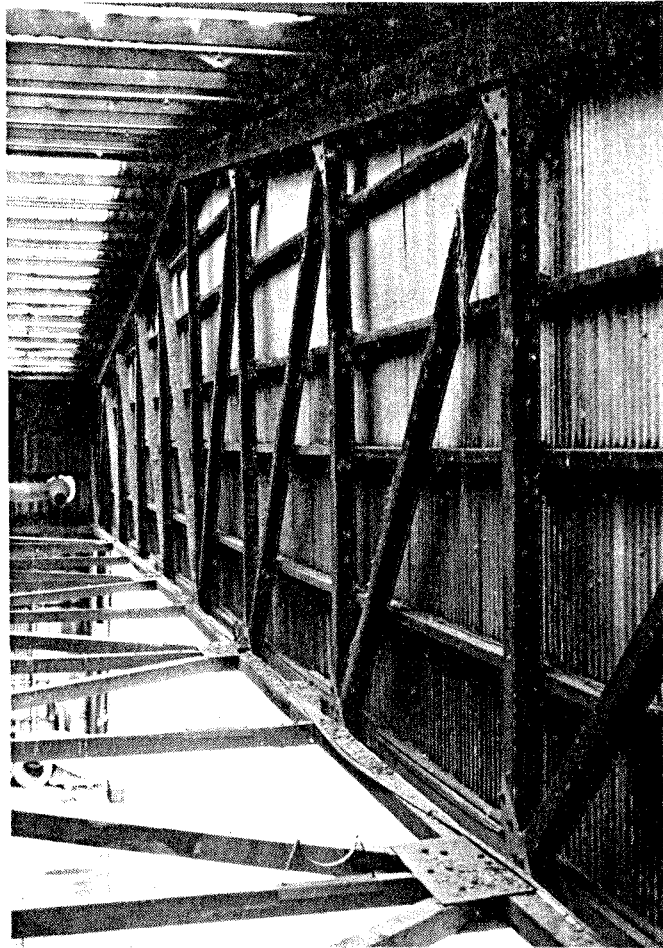


Plate 107. Cladding to the end truss. The portal trusses have spaced double top and bottom chords with single webs. Lloyd's timber store, Port Adelaide, SA.

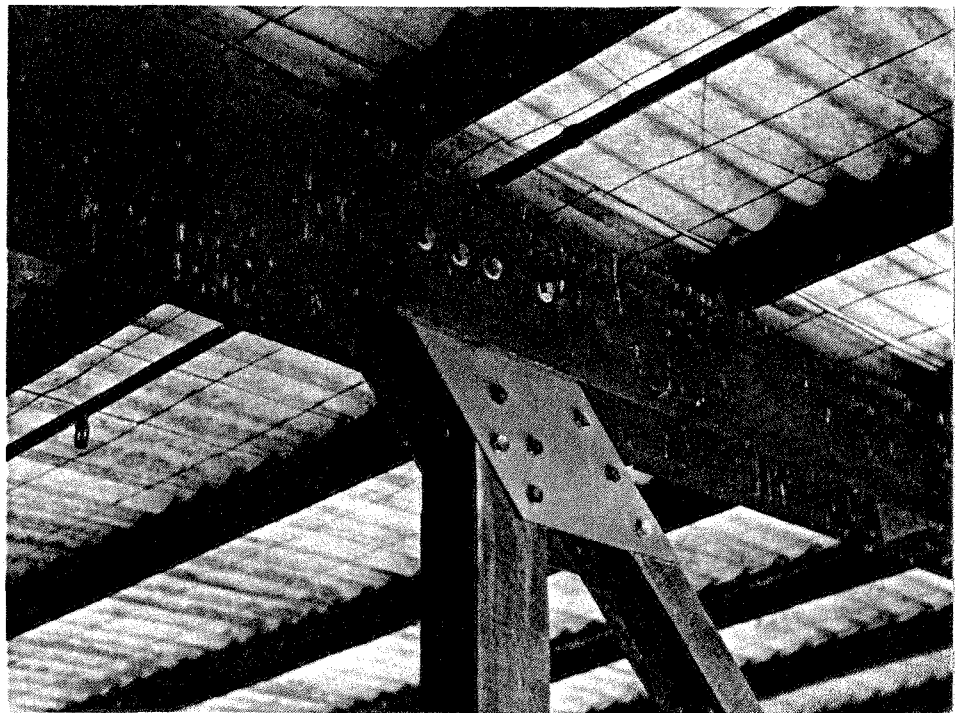
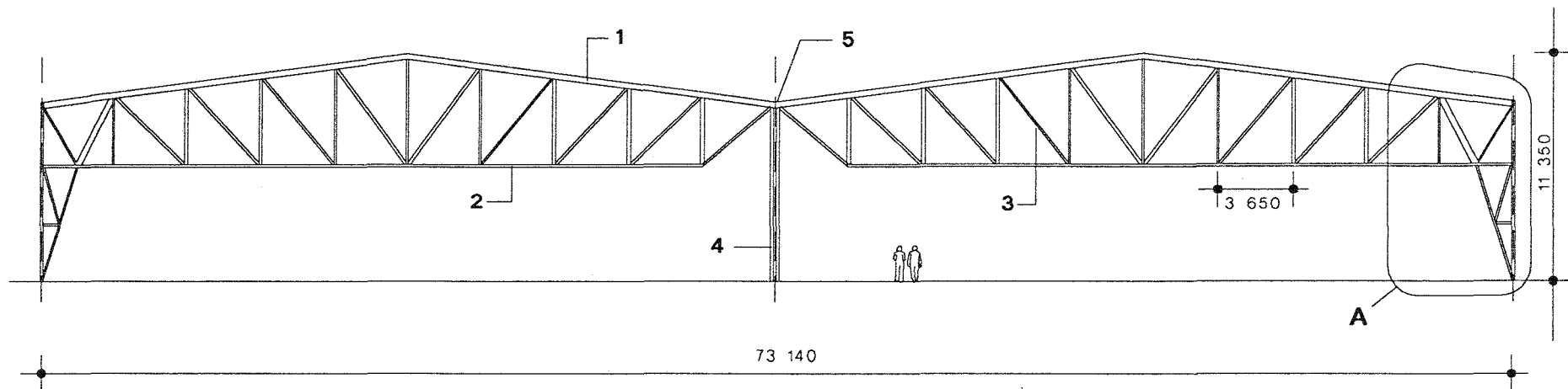


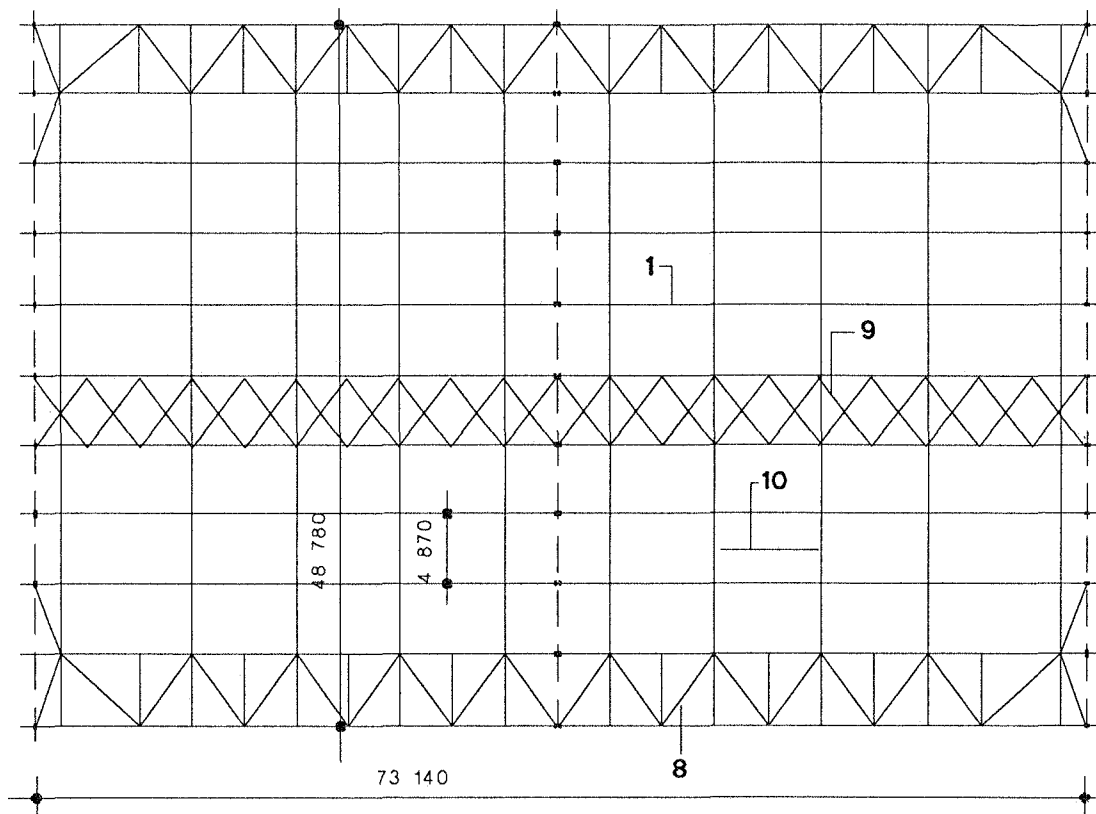
Plate 108. All the joints in the portals are bolted with exposed steel plates. Purlins are fixed with sheet metal connectors. Lloyd's timber store, Port Adelaide, SA.



Transverse Section
Figure 37

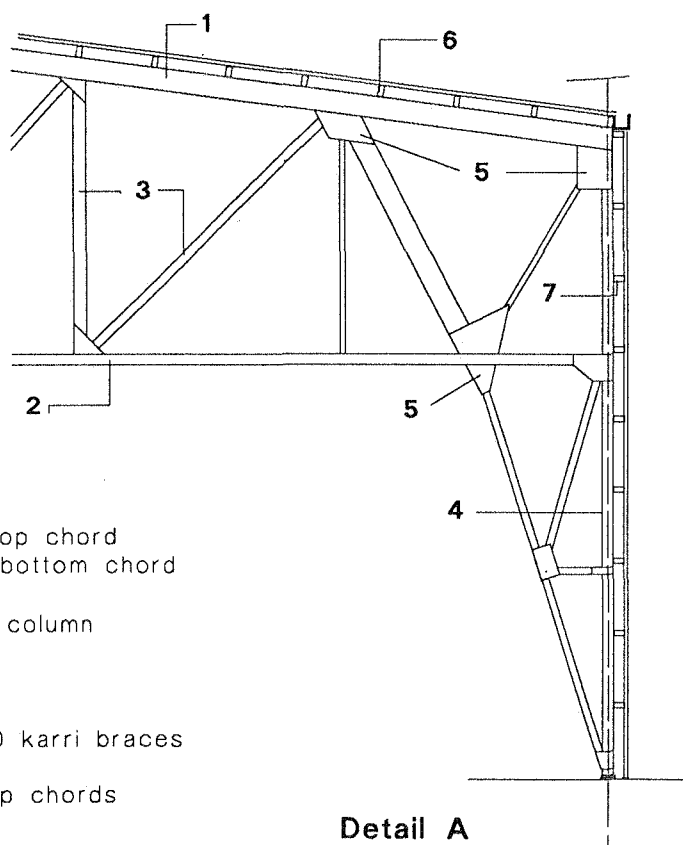
Lloyd's timber store

1. 2 x 300 x 75 oregon top chord
2. 2 x 150 x 100 oregon bottom chord
3. oregon webs
4. 2 x 300 x 150 oregon column
5. steel fixing plate



Plan
Figure 38

Lloyd's timber store



Detail A
Figure 39

1. 2 x 300 x 75 oregon top chord
2. 2 x 150 x 100 oregon bottom chord
3. oregon webs
4. 2 x 200 x 150 oregon column
5. steel jointing plates
6. 150 x 75 purlins
7. 150 x 75 girts
8. 150 x 150 & 150 x 100 karri braces
to line of bottom chords
9. 150 x 50 bracing to top chords
10. 150 x 50 struts

Exemplar 2. 14

Name of Structure:

Angle Vale Bridge

Owners:

The City of Munno Para

Address:

On the Heaslip Rd., across the Gawler River. Approx. 35 km. north of Adelaide, SA.

Structural Engineer:

C. F. G. Ashwin of the Central Roads Board.

Builders:

Hack & Parker

Date Constructed:

1876

Structural System:

Two pin foundation arches

Description:

The bridge is a single span two pin parabolic arch structure. It has four primary arches, each consisting of three vertical laminates of solid red gum. These pieces were shaped to the arch curve, laid out with staggered butt joints in each laminate, then joined together with pegs and bolts to form the primary arches.

Each arch sits in a cast iron shoe built into the stone abutments and the outside arches are protected by a sheet metal cap. The four arches are tied together horizontally with threaded rods which run through steel spacing pipes. The structure is then braced with timber sway bracing running across the curve at the top of the arches.

Red gum deck bearers are propped off each arch by posts and tied down with steel tension ties. The posts are blocked and cross braced fully in the line of the arches and have one line of torsion bracing perpendicular to the arches. The blocks and post bracing have half housed joints. Fixings are generally bolts with square washers. The deck is now PEC treated spotted gum.

Development:

Using technology imported from Europe and America, laminated arch bridges were designed and built in most Australian colonies. In South Australia, the first was built in 1856. Originally bolt laminated horizontally and constructed mainly of imported softwood, the arches were cheap but had a service life of only 12 to 16 years. By 1873, an improved working knowledge of Australian hardwoods and reflection on the causes of failure of previous bridges saw subsequent arches vertically laminated out of the most durable local timbers. Further, the most exposed outside arches were protected with sheet metal caps. These improvements increased the service life of arch bridges to 40 years.

After 1880, the arch form was superseded by iron bridges in South Australia and by parallel chord timber trussed bridges in other states. It was not used regularly again in bridges until 1975.

History:

The Angle Vale bridge is the largest and best example of the three historic laminated arch bridges still in existence in Australia (All are in South Australia). It was constructed between February and November, 1876.

Though there were plans to replace it in 1938, it remained in service to 1966 when it was converted into a footbridge. In 1987, The City of Munno Para received grants from the Community Employment Program and the Bicentennial Authority for the conservation of the bridge and the landscaping of its surrounds. They undertook the work with Maunsell & Partners as consulting engineers. It was completed in 1988.

Condition:

The bridge has been restored and appears in a satisfactory condition.

References:

Hawes, J., Legoe, D., Stacy, W. Young, D., 1988, *The Conservation of Angle Vale Laminated Timber Arch Bridge*, Fourth National Conference on Engineering Heritage, Sydney, December 5 - 8.

Llewellyn, Peter, 1988, *Timber Bridges Keep On Truckin'*, Australia Forest Industries Journal, May, p. 49 - 51.

O'Connor, Colin, 1985, *Spanning Two Centuries: Historic bridges of Australia*, University of Queensland Press.

O'Connor, Colin, 1985, *History of Timber Bridges in Australia*, Paper to Timber Bridges Seminar, Monash University, November 6 - 8.



Plate 109. The two pin vertically laminated arches of the Angle Vale Bridge. The outside arch was fitted with a sheet metal cap to protect it from the weather.



Plate 110. The Angle vale bridge seen from its concrete and steel replacement. The timber arches and deck supports are original. The deck timbers have been replaced.



Plate 111. The arch laminates are bolted and pegged while the arches are spaced with steel pipes and a tie rod. Rods also tie the deck bearers to the arches. Angle Vale Bridge, Gawler, SA.

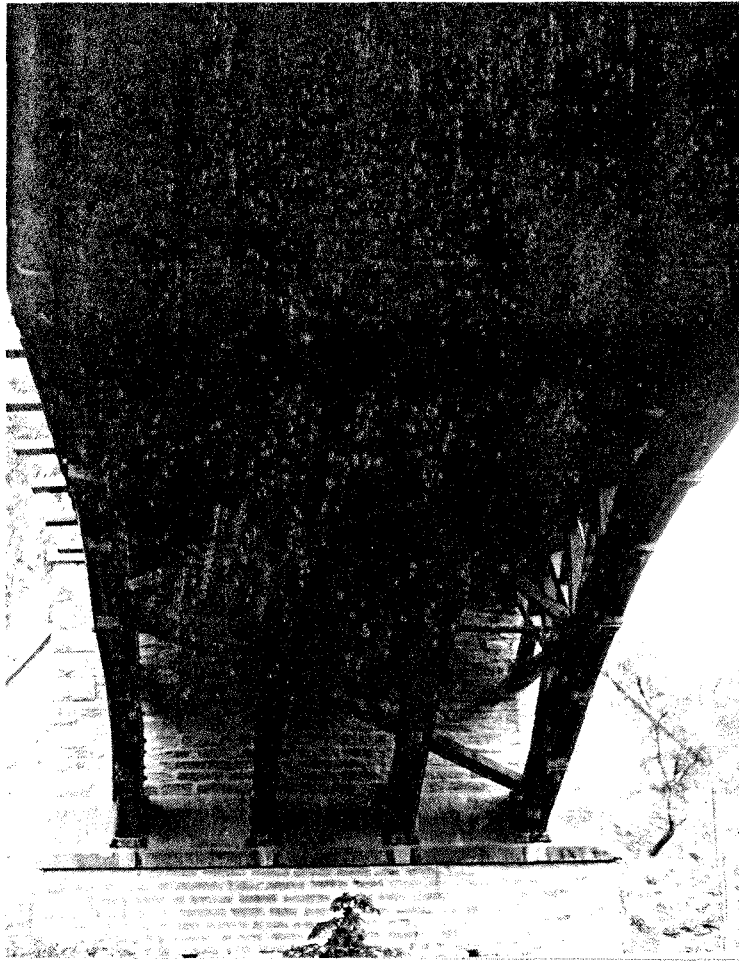


Plate 112. The arches have sway bracing running across the top of the arches and the deck support braces are braced between each arch row. Angle Vale Bridge, Gawler, SA.

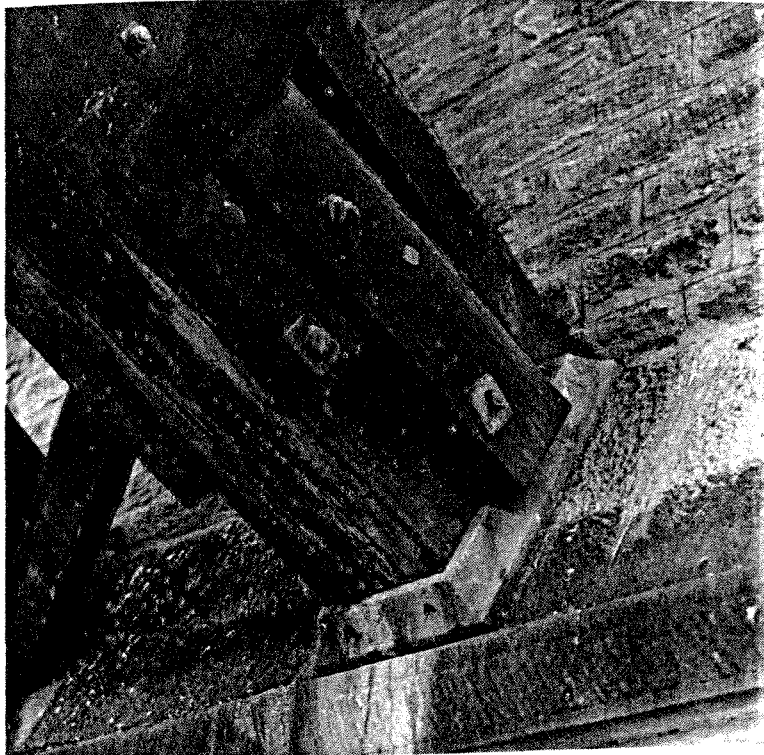
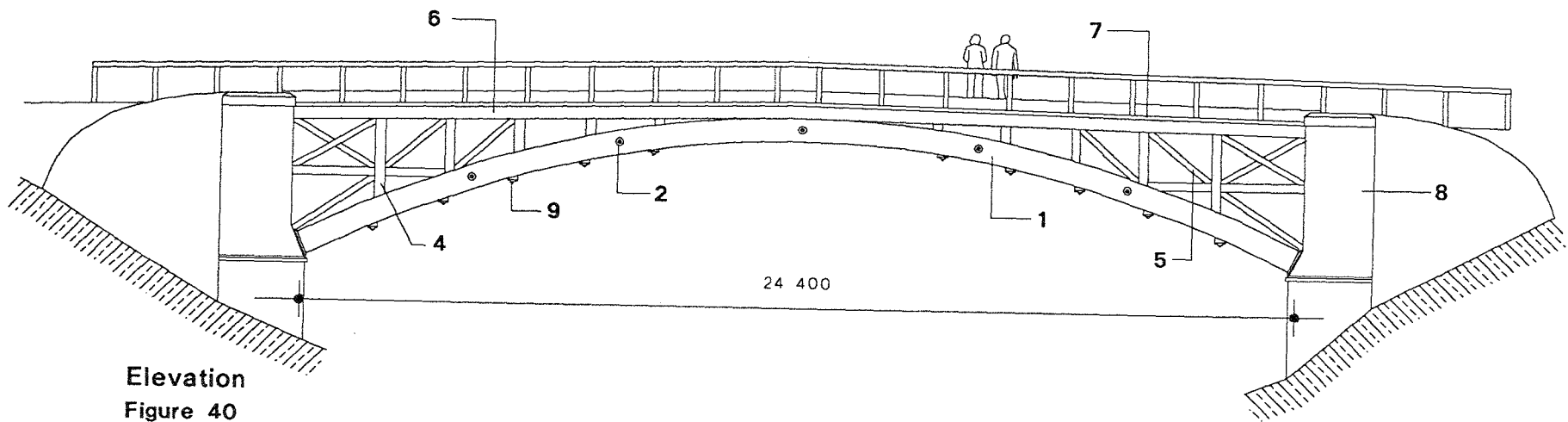


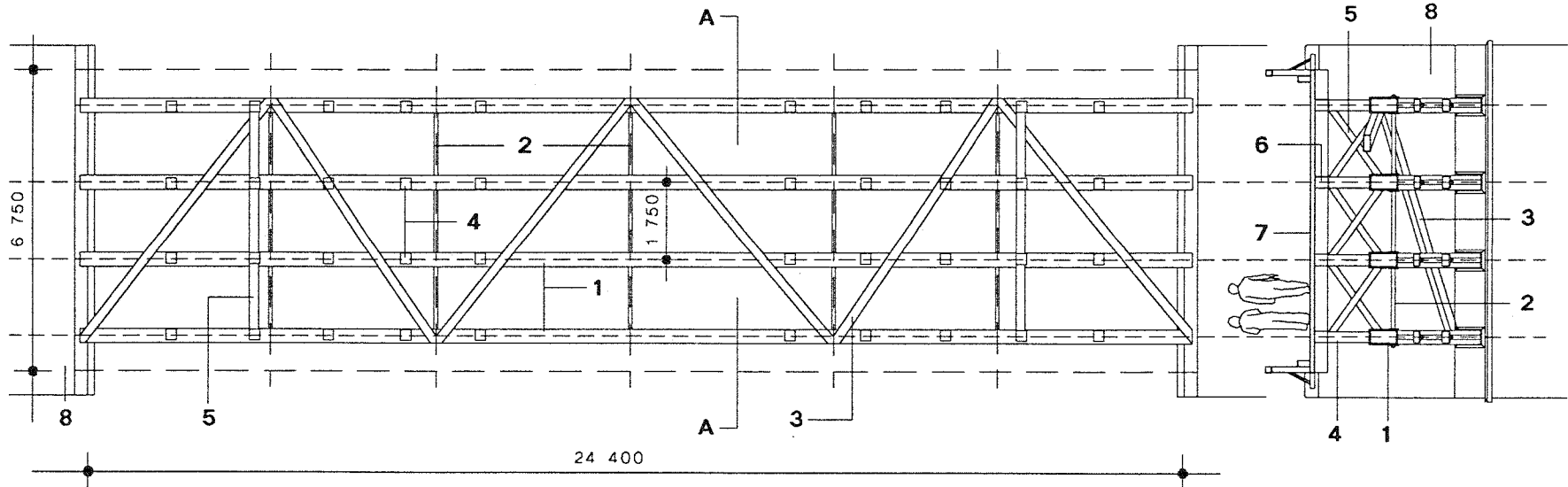
Plate 113. The arches sit in iron shoes against the stone buttress. Angle Vale Bridge, Gawler, SA.



Elevation
Figure 40

Angle Vale Bridge

- | | |
|------------------------------------|------------------------|
| 1. 590 x 320 bolt laminated arches | 6. 300 x 250 stringers |
| 2. 75 dia. tie bolts and spacers | 7. 100 decking |
| 4. 240 x 230 posts | 8. stone abutments |
| 5. 200 x 150 braces | 9. 24 dia. tie rods |



Plan
Figure 41

Section A
Figure 42

Angle Vale Bridge

- | | |
|------------------------------------|------------------------------|
| 1. 590 x 320 bolt laminated arches | 5. 200 x 150 torsion bracing |
| 2. 75 dia. tie bolt and spacers | 6. 300 x 250 stringers |
| 3. 200 x 150 sway bracing | 7. 100 decking |
| 4. 240 x 230 posts | 8. stone abutments |

Exemplar 2. 15

Name of Structure:

Enfield Motor Auction

Owners:

TNT Properties Pty Ltd

Address:

Cosgrove Rd. Enfield, NSW

Engineers:

Stanley & Llewellyn.

Builders:

Structural Services Pty. Ltd.

Date Constructed:

1953

Structural System:

Two pin tied arches

Description:

The building has a roof of two lines of 120 ft (36. 6 m) span two pin tied arches, supported on steel columns and beams internally and tapered concrete columns on the perimeter. Each line of arches consists of 13 bays at 4. 55 m centres. The building has a monitor roof. Every second roof bay is set down between the arch pairs as a simple pitched roof. This allows a south light to be included in the wall of the higher curved roof section.

The main arch chords have 24 oregon laminates glued together on site with casein glues. They have stitch bolts at 550 mm centres. The arch chords are stiffened by Stanley's patented inverted A braces and tied with light steel channel. The A-braces also support the secondary rafters and the pitched roof.

Development:

The tied arches of this building represent the culmination of over ten years of development of the pier to pier, two pin tied arch form by Malcolm Stanley and his firm Stanley & Llewellyn. Malcolm Stanley first used a two pin tied arch to form saw tooth factory roofs in 1943. By 1950, he had used 131 ft 6 ins (40. 1 m) span bowstring trusses to form a monitor roof for a Sydney factory. These had a glue laminated top chord, solid hardwood webs and steel tension plates. The monitor roof provided a natural south light and eliminated the undesirable box gutter required by the saw tooth form.

By 1952, Stanley & Llewellyn had developed the tied arch form further and introduced patented stiffening frames to their arches. These kept the size of the main arch chord to a minimum and saved on the number of joints and members required for true bowstring trusses. These stiffened arches became known as Stanley arches and were used extensively in industrial buildings in Sydney during the early 1950's. They were also used in Newcastle in NSW and Cairns in Qld. Spans varied from 70 ft (21. 3 m) to at least 130 ft (39. 6 m).

Though visually complicated in photographs, this building is a simple and graceful solution. The roof form, with its even light and exposed timber is an attractive and effective structure.

History:

The building at Cosgrove Rd, Enfield, was the second timber industrial building Stanley & Llewellyn designed for Larke Hoskins and Co. Ltd. The first was a 131 ft 6 ins (40. 1 m) span

conventional bowstring truss building constructed at Riley St, Surrey Hills in 1950. David King & Associates were the architects.

Larke Hoskins & Co. Ltd built the Enfield building as a vehicle assembly plant. It now forms the showrooms for Enfield Motor Auctions

Condition:

The building and roof trusses have been cleaned and appear in satisfactory condition.

References:

Architecture, 1950, July.

Australian Timber Journal, 1953, cover photo and caption, April.

Australian Timber Journal, 1957, May

Building: Lighting: Engineering; 1952, October 24.

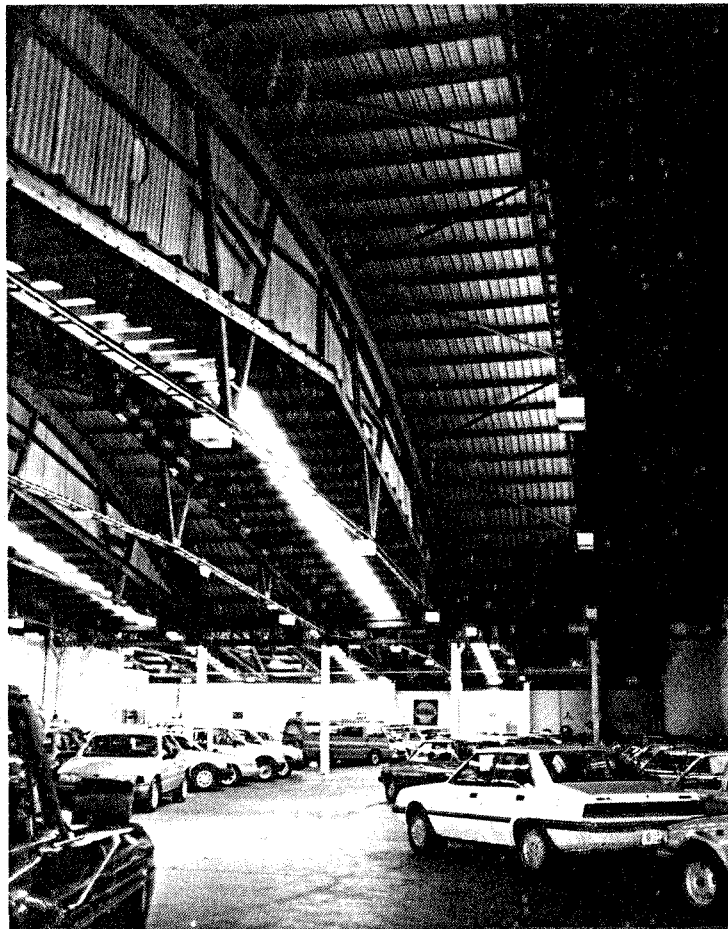


Plate 114. Stanley & Llewellyn's stiffened tied arches span 120 ft. (36.6 m) with an 18 x 6 ins (450 x 150 mm) site laminated arch chord. The form of the monitor roof, one bay high, one bay low, can be clearly seen. Enfield Motor Auctions, Enfield, NSW.

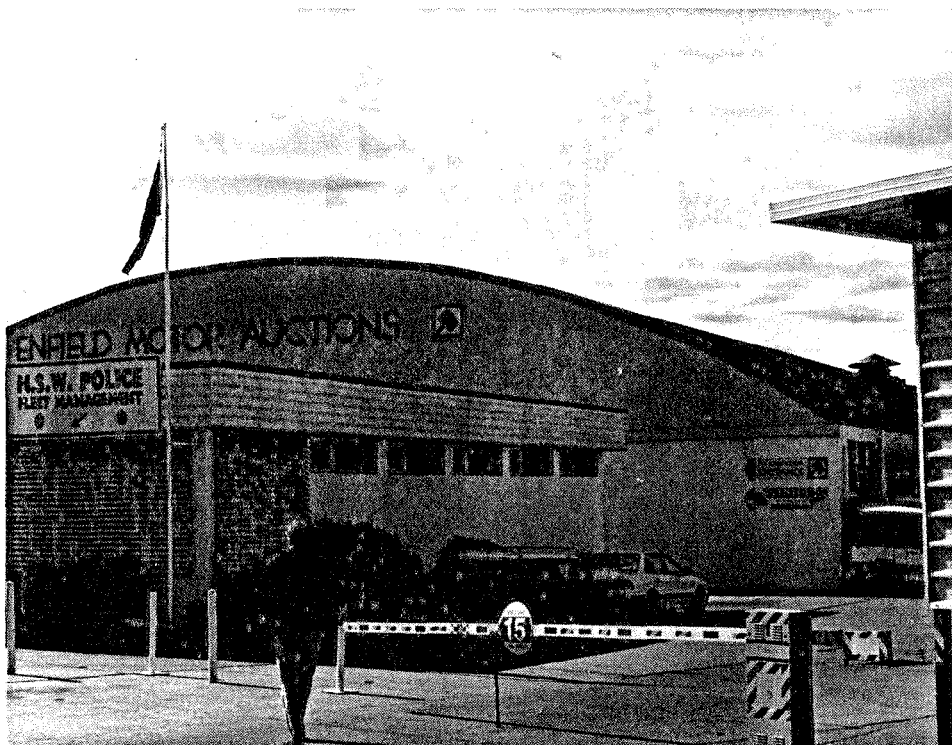
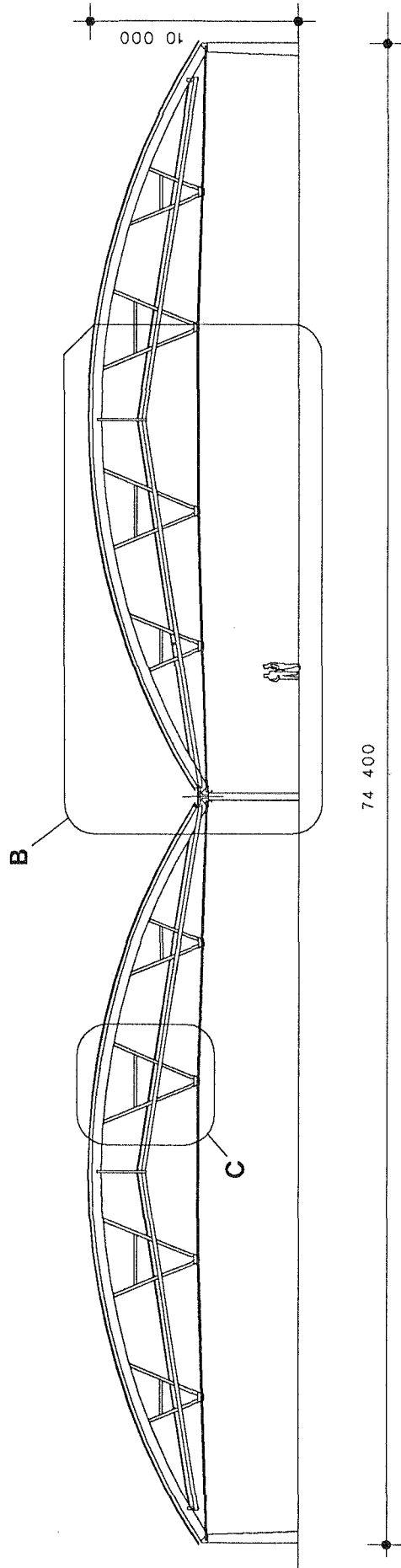


Plate 115. Enfield Motor Auctions was built as a vehicle assembly plant for Larke Hoskins in 1953.



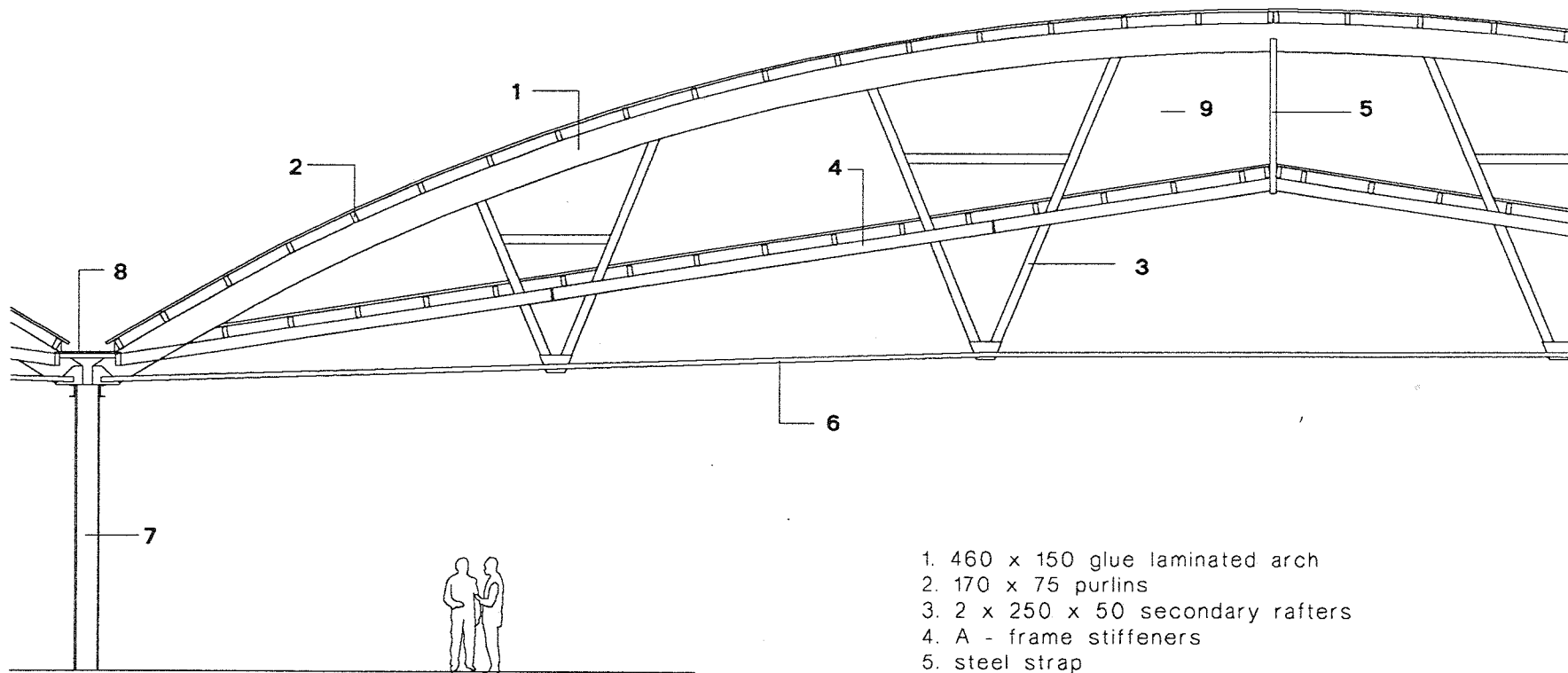
Plate 116. One of the stiffening frames of the arch. The secondary rafters were cut at the frames and provided no support for the arch. Enfield Motor Auctions, Enfield, NSW.



Transverse Section

Figure 43

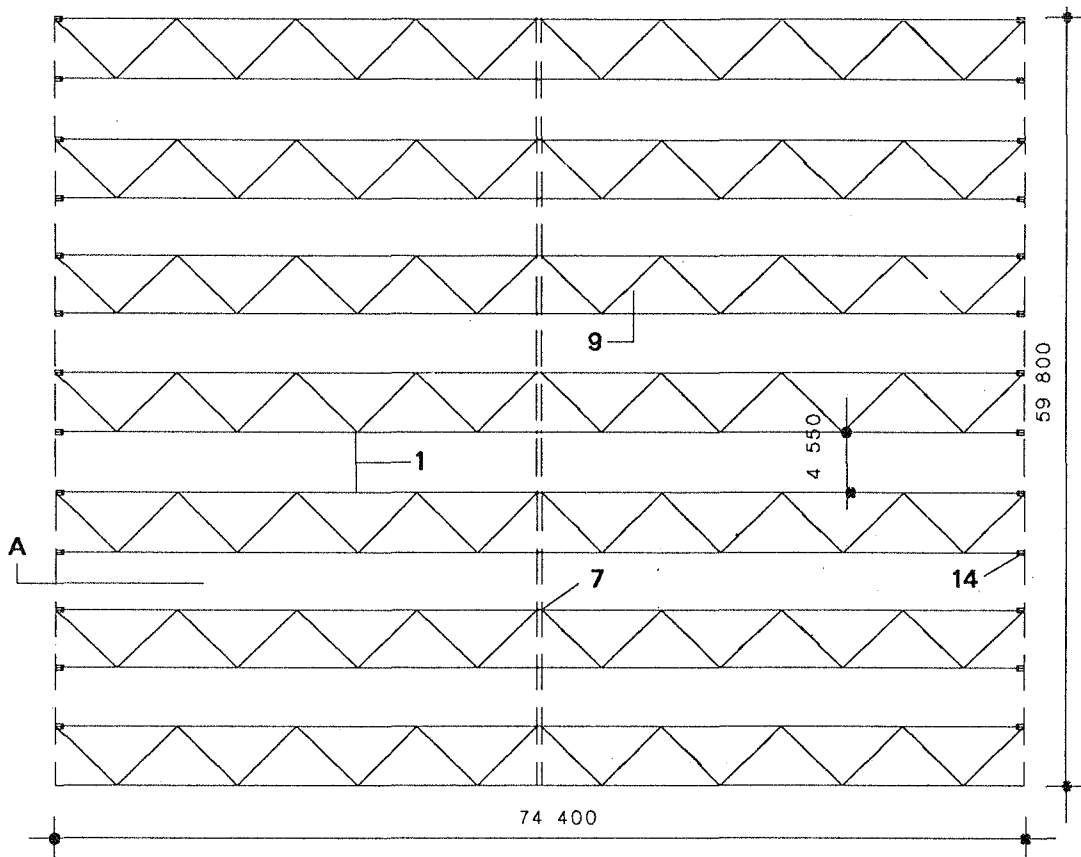
Enfield Motor Auctions, Enfield



Detail A
Figure 44

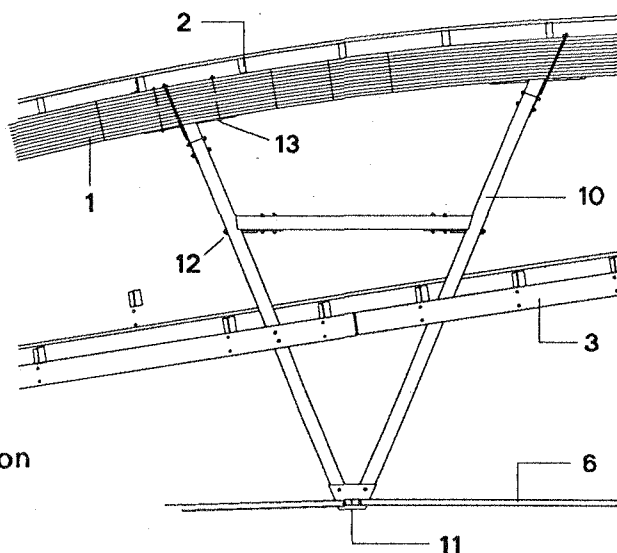
Enfield Motor Auctions, Enfield

1. 460 x 150 glue laminated arch
2. 170 x 75 purlins
3. 2 x 250 x 50 secondary rafters
4. A - frame stiffeners
5. steel strap
6. 2 x 75 x 50 C section tension tie
7. 2 x 375 x 100 channel column
8. box gutter
9. south light



Plan

Figure 45



Detail B

Figure 46

**Enfield Motor Auction
Enfield**

1. 460 x 150 glue laminated arch
2. 170 x 75 purlins
3. 2 x 250 x 50 secondary rafters
6. 2 x 75 x 50 C section tension tie
7. 2 x 375 x 100 channel column
9. 65 x 35 roof bracing to arched bays
10. 150 x 150 h/w braces
11. steel base shoe
12. bolt and plate connectors
13. stitch bolts at 550 centres
14. tapering 600 - 450 x 380 concrete column

Exemplar 2. 16

Name of Structure:

Factory

Owners:

National Springs Pty. Ltd.

Address:

52 O'Riordan Rd. , Alexandria, NSW

Architects and Engineers:

The Allied Works Council.

Builders:

Ralph Symonds Limited

Date Constructed:

1942

Structural System:

Three pin foundation arches

Description:

The building is a regular three pin parabolic arch structure of 17 bays at 14 ft (4.3 m) centres. Each arch spans 95 ft (29 m). The ribs were butt joint laminated on site from 29 layers of low grade rimu (a New Zealand timber) using casein glues. The detailing in the remainder of the building is very simple. The purlins run simply supported over the arches and are fixed with nail blocks. Bracing is also nailed hardwood. The building has a curved sheet metal roof with a ventilator line along the length of the ridge. The end walls are framed with 10 x 3 ins (240 x 75 mm) solid hardwood at 9 ft (2.7 m) centres.

Development:

The concept of glue laminating timber to form heavy structural members had been introduced to Australia by the CSIR as early as November, 1938. However, its first recorded use was

not until 1941 when short span glue laminated beams were used in a store building designed by H. Garnet Alsop, Architect. By 1942, the shortage of materials and the demand for military related industrial construction forced the AWC to experiment with new building solutions in timber. The National Springs building was the result. It is the first large scale building in Australia to use glue laminated timber as its principal structural members. It reintroduced the arch form to Australian building to take maximum advantage of the new technology and minimise the materials required.

While economic and quick to build, this appears to be the AWC's only glue laminated arch building. Their subsequent arch stores were all hand nailed igloo structures.

History:

Ralph Symonds was probably involved in the National Spring's building as he was an experienced manufacturer of plywood. It was his first glue laminated building and he developed air driven jacks to press the arch laminates together. His work team could manufacture one rib every two hours. Quality control was poor and the butt joints often opened up during pressing to leave gaps up to 10 mm. Fortunately, this does not appear to have affected the performance of the building as it still stands with minimal maintenance.

While the AWC abandoned glue laminated arches, Symonds' successful experience here opened up a whole series of developments in arched industrial forms. He constructed at least three more foundation arch

buildings prior to the war's end with one known in Melbourne.

True foundation arch industrial buildings proved impractical as large areas at the sides were too low to be used effectively. They were also very difficult to light and heat. These problems were resolved with the introduction of the pier to pier, two pin tied arch form in 1943 and the use of secondary rafters with the foundation arch form in 1946.

Condition:

The building is in good condition.

References:

Building, Timber Development, Building Research, Laminated Timber Beams, 1941, October 24, p. 80

CSIR, Division of Forest Products, 1938, *Research Notes, Australian Timber Journal*, November.

Dept of Works & Housing, 1946, *A report on the structural soundness of unseasoned timbers used in structures erected for war purposes*, Dept of Works & Housing, Melbourne, p. 63

Forestry Commission of NSW, Division of Wood Technology, 1942, *The Glue Laminated Wooden Arch*, *Australian Timber Journal*, July, P. 824.

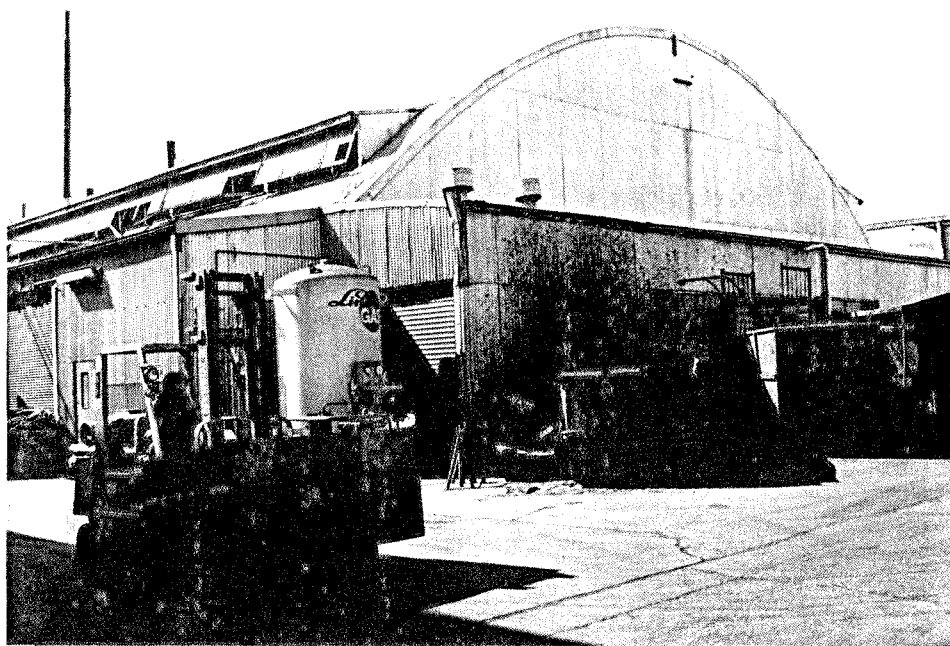


Plate 117. The foundry & workshop building at the National Springs' plant at Alexandria, NSW.



Plate 118. The glue laminated parabolic arches inside the plant. They were laminated on site using low grade timber and casein glues. National Springs' factory, Alexandria, NSW.

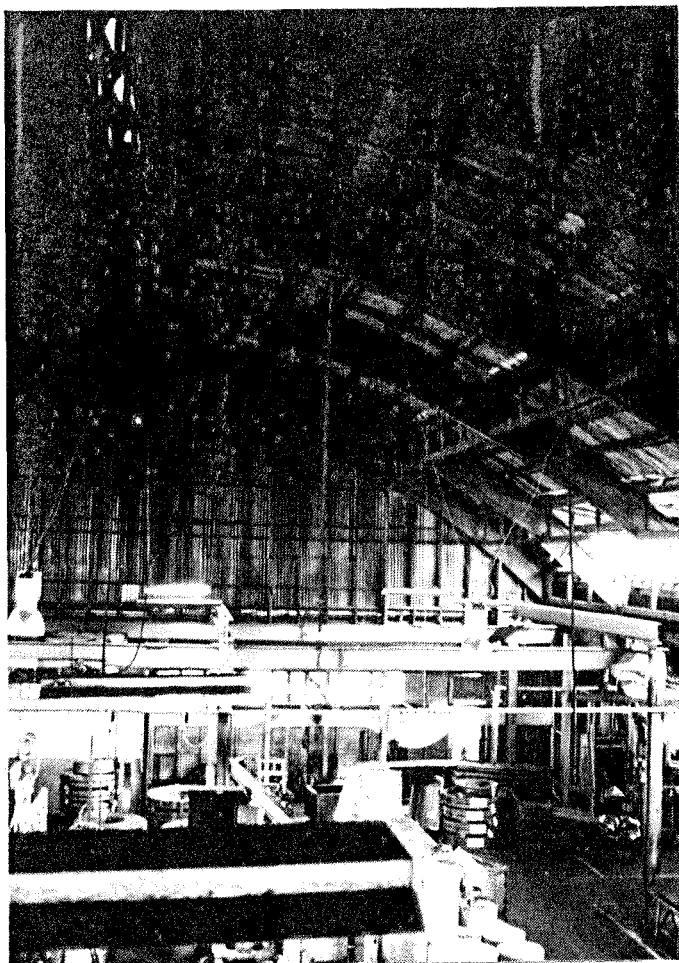
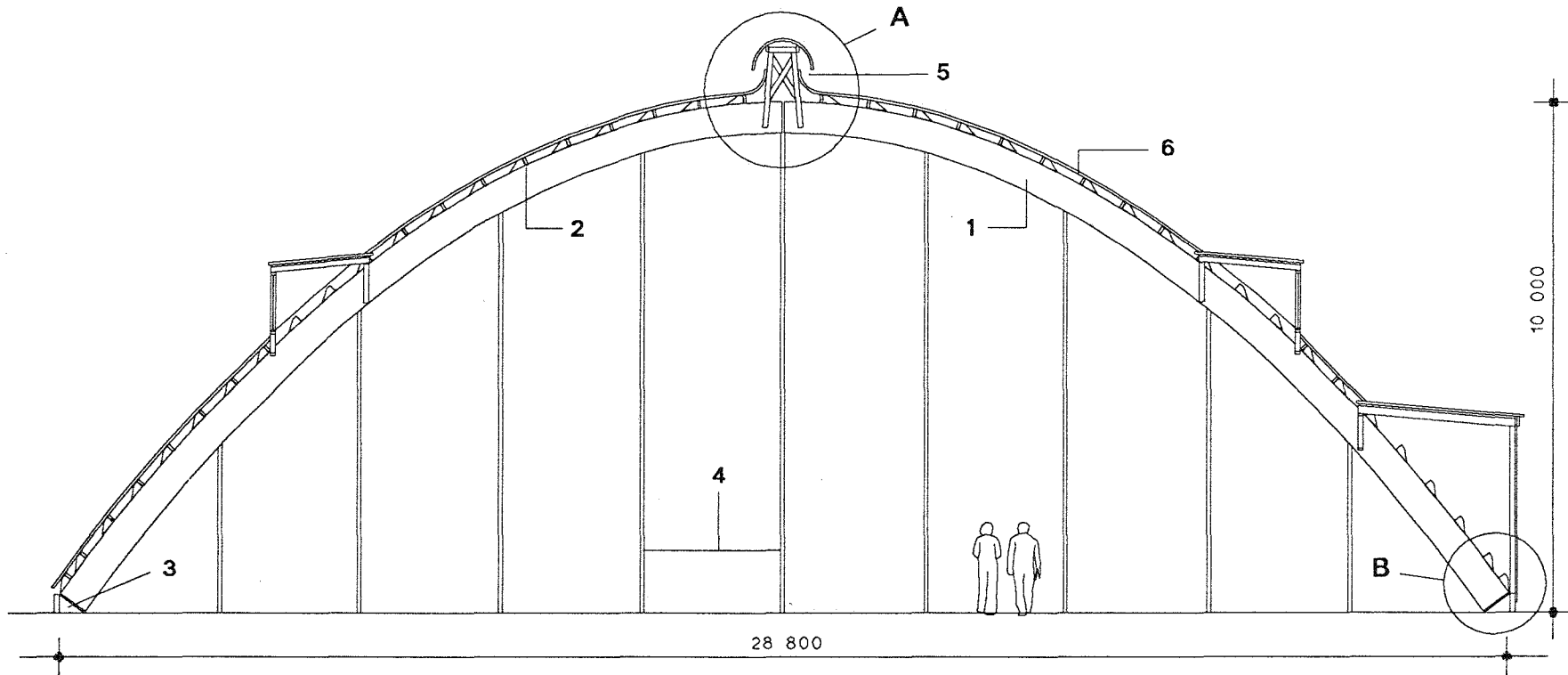


Plate 119. Though fifty years old, the arches appear in satisfactory condition. Maintenance has been minimal. National Springs' factory, Alexandria, NSW.



Plate 120. The concrete footing and steel pin plate at the base of the arches. National Springs' factory, Alexandria, NSW.

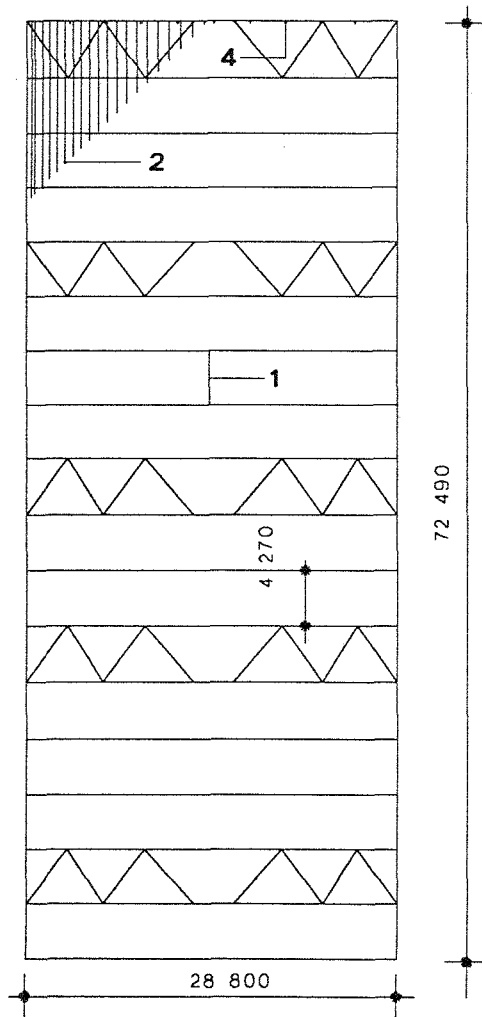


Transverse Section

Figure 47

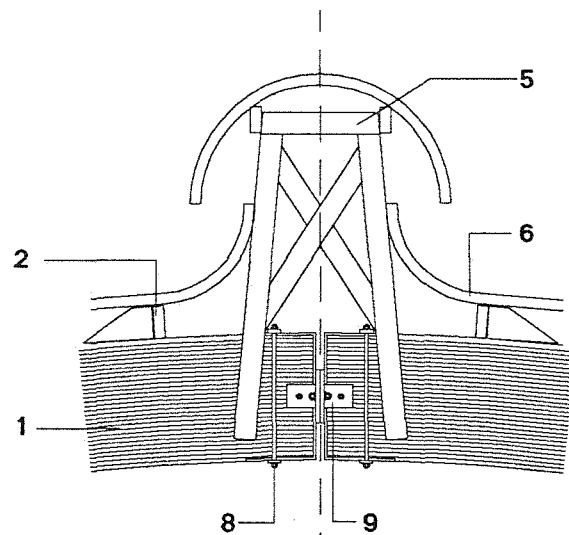
Factory, National Springs, Alexandria

1. 595 x 100 glue laminated parabolic arch
2. 150 x 50 h/w purlins at 750 centres
3. concrete arch foundation
4. 240 x 75 h/w end wall wind posts
5. ventilator
6. sheet metal roofing

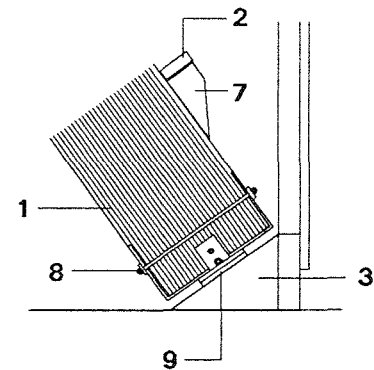


Plan
Figure 48

**Factory, National Springs
Alexandria**



Detail A
Figure 49



Detail B
Figure 50

1. 595 x 100 glue laminated parabolic arch
2. 150 x 50 h/w purlins at 750 centres
3. concrete arch foundation
4. 240 x 75 h/w end wall wind posts
5. h/w ventilator frame
6. sheet metal roofing
7. h/w purlin nailing block
8. arch end strap bolts
9. pin plates

Exemplar 2. 17

Name of Structure:

Storage building

Owners:

SEAS Saphor Timber

Address:

Kalangadoo, SA, about 40 km north of Mt. Gambier.

Builders:

Laminated Timber Products Ltd.

Date Constructed:

1955

Structural System:

Three pin foundation arches

Description:

The building has 9 semi-circular, three pin glue laminated foundation arches at 4.6 m centres. They span 46.2 m. The arch members were generally butt joint laminated and were fabricated with a resorcinol glue. Bracing consists of solid oregon members set between the arches and fixed with steel plates, bolts and shear connectors. They form a lattice pattern through the length of the building. Purlins run simply supported over the top of the arches and are fixed by bevelled support blocks nailed directly to the arch. They support a simple corrugated iron roof.

Development:

Arches laid up on the arc of a circle were probably the easiest arch form to fabricate. However, as seen from the NSW experience, these simple arch buildings had a limited use. They had restricted height at the sides and their volume made them very hard to light and heat.

With a clear span of 46.2 m, this is the longest clear span glue laminated arch building known in Australia.

History:

Laminated Timber Products Ltd. was formed in late 1954 as a joint venture between several major timber supply firms in Adelaide to exploit the developments in glue laminated technology. During 1955, they constructed at least four major glue laminated buildings: a 32 ft (9.75 m) span steep three pin portal church, a 32 ft (9.75 m) span three pin gothic arch church at Kurralta Park, a 130 ft (39.6 m) semi-circular three pin foundation arch factory in Hanson Rd. Adelaide, and the factory at Kalangadoo. While they were reported to have further work and Pearson, Kloot & Boyd listed them in 1958, the firm was dissolved before 1962. The arches for the Kalangadoo building were fabricated at the company's factory in Adelaide before shipment to Kalangadoo for erection.

Condition:

The base of one arches has been replaced. The rest of the building appears in satisfactory condition.

References:

Australian Timber Journal, 1955, May, p. 283

Australian Timber Journal, 1956, *Can Timber Hold Its Own?*, March, p. 132.

Pearson, R. G., Kloot, N. H., and Boyd, J. D., 1962, *Timber Engineering Design Handbook*, 2nd edn, CSIRO and Jacaranda Press, Melbourne.

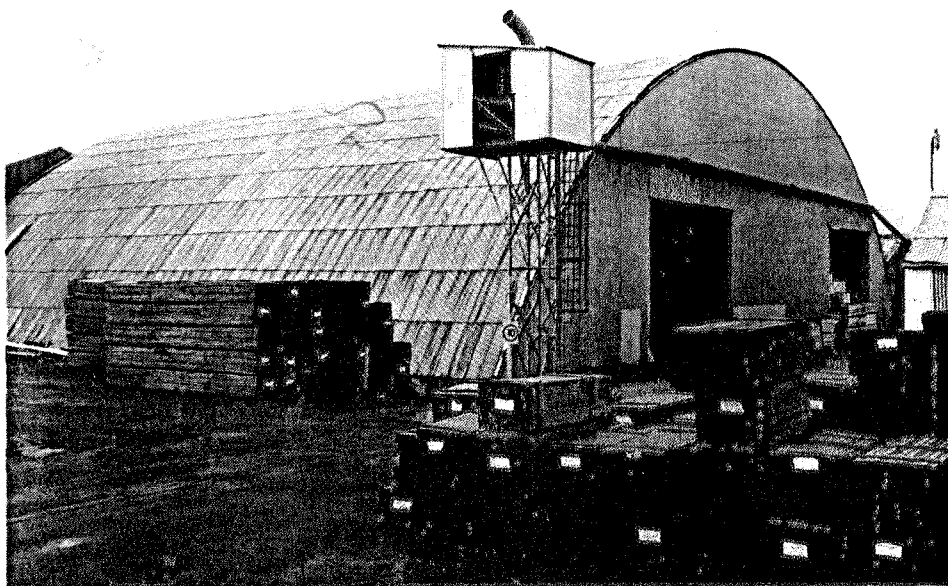


Plate 121. The unimposing exterior to the store building at Kalangadoo.

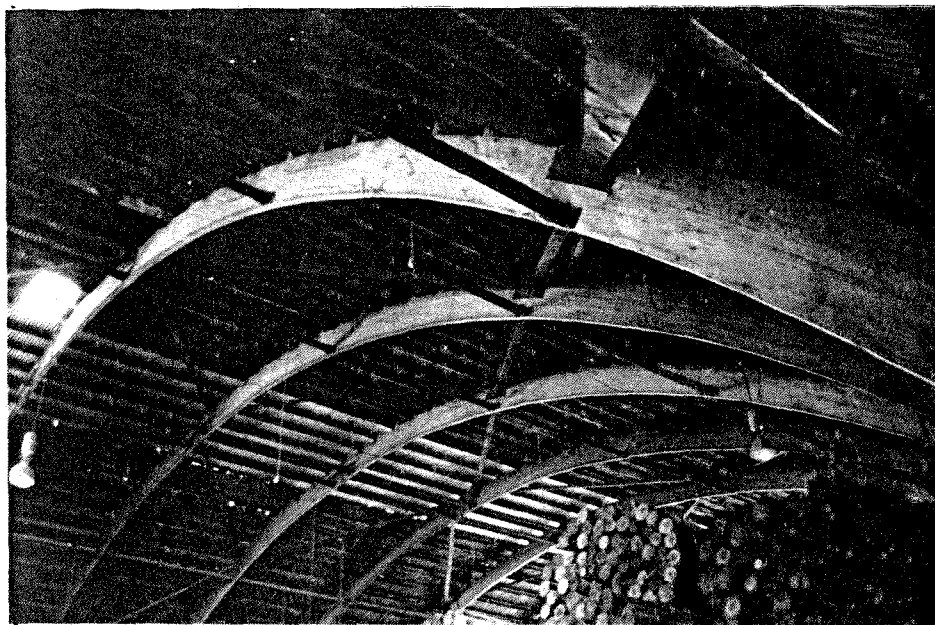


Plate 122. The 46.5 m span arches of the Kalangadoo store are probably the longest clear span laminated arches in Australia.

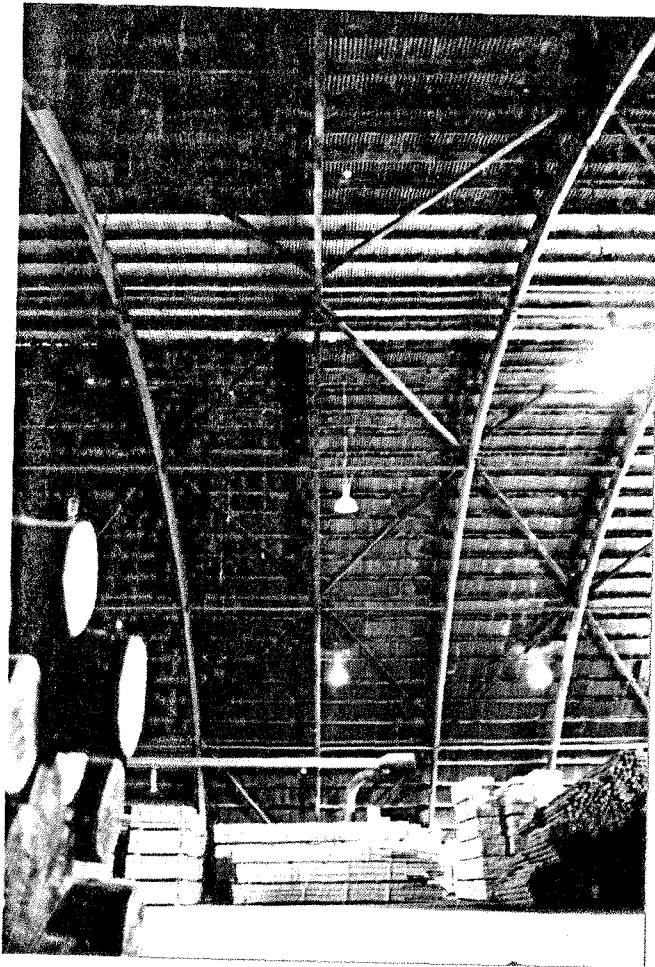
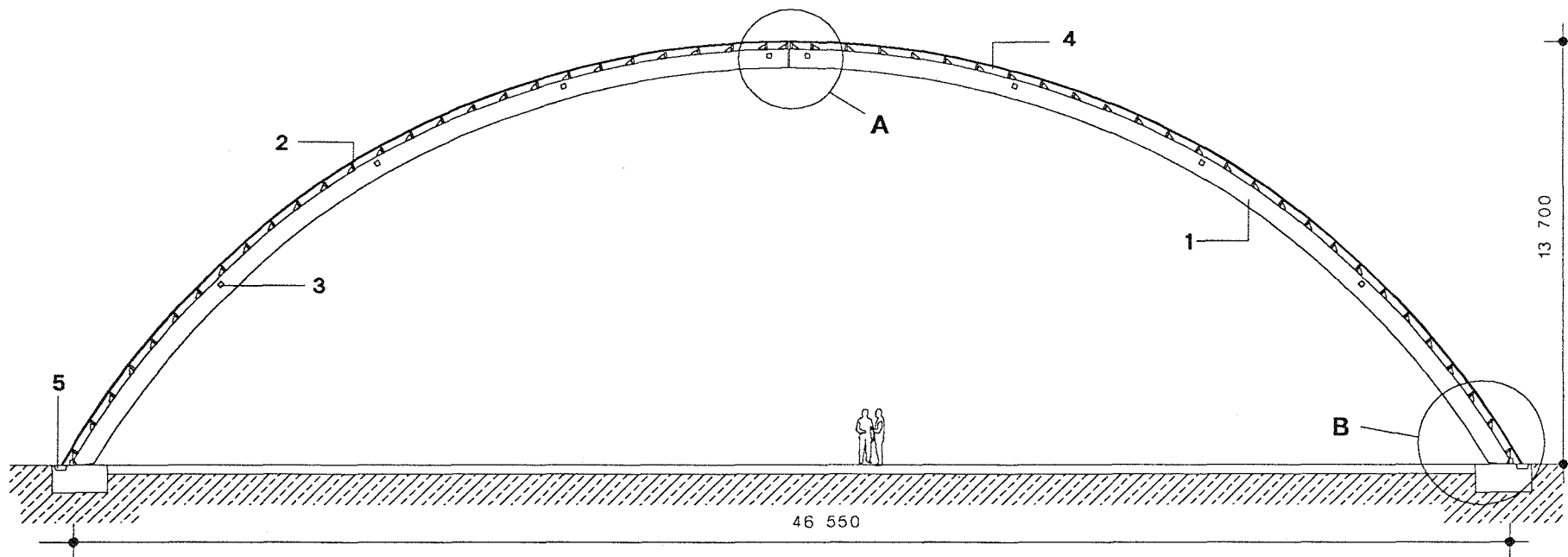


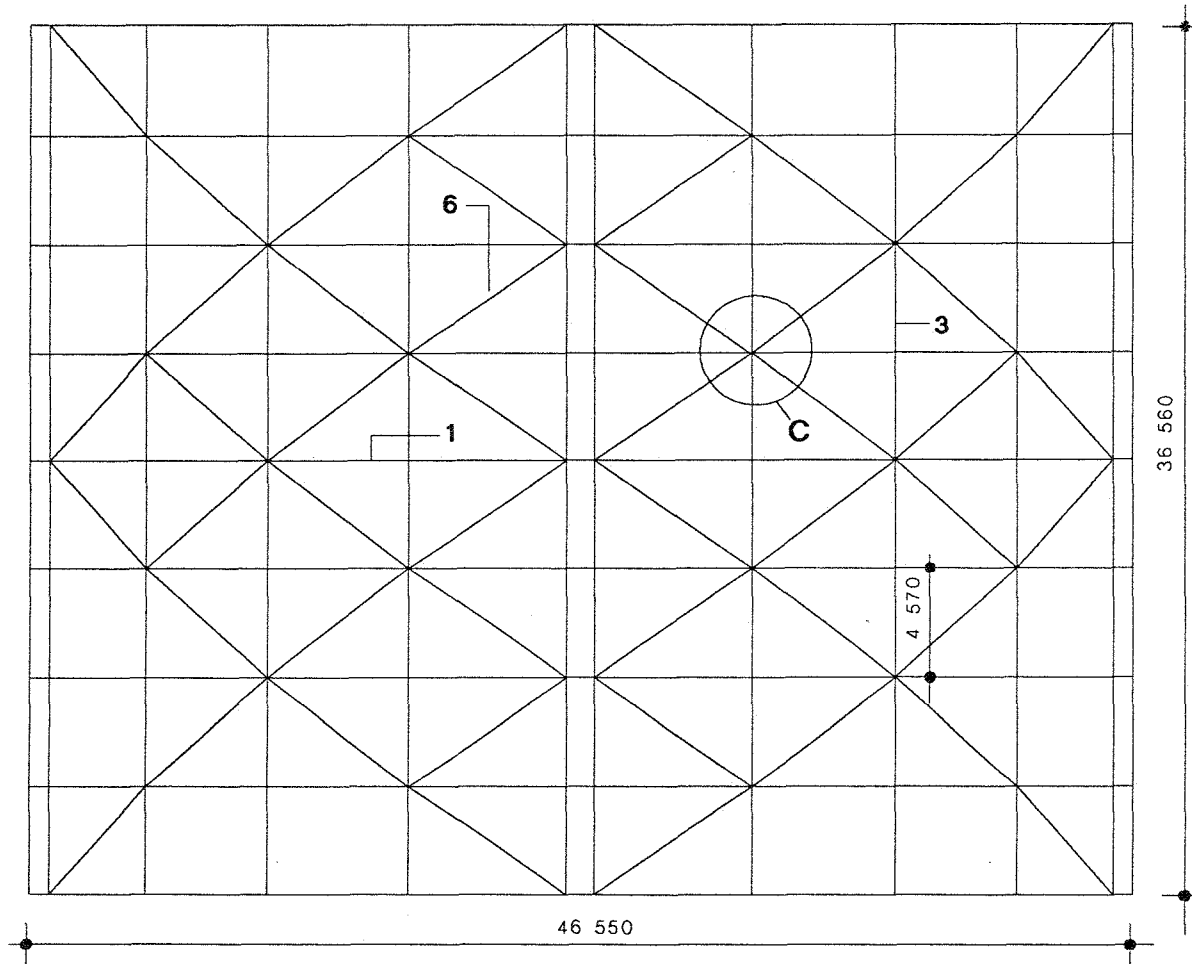
Plate 123. The lattice bracing members are solid oregon and are connected to the arches with steel bolting plates and shear connectors. Store building, Kalangadoo, SA.



Transverse Section
Figure 51

Store building, Kalangadoo

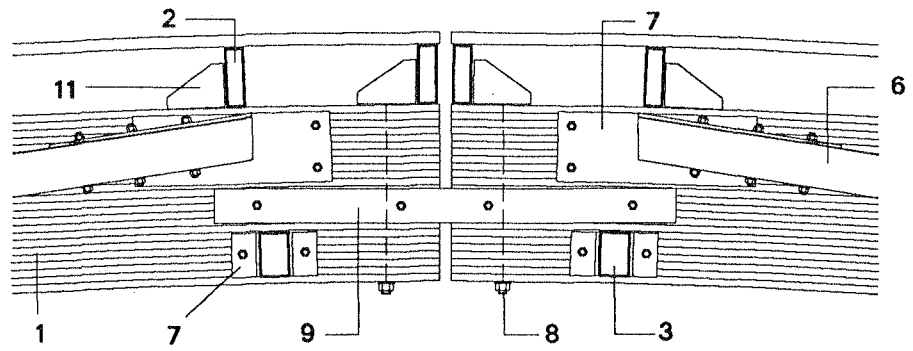
1. 620 x 140 glue laminated oregon arches
2. 200 x 50 oregon purlins at 1 000 centres
3. 150 x 150 oregon struts
4. sheet metal roof
5. edge gutter



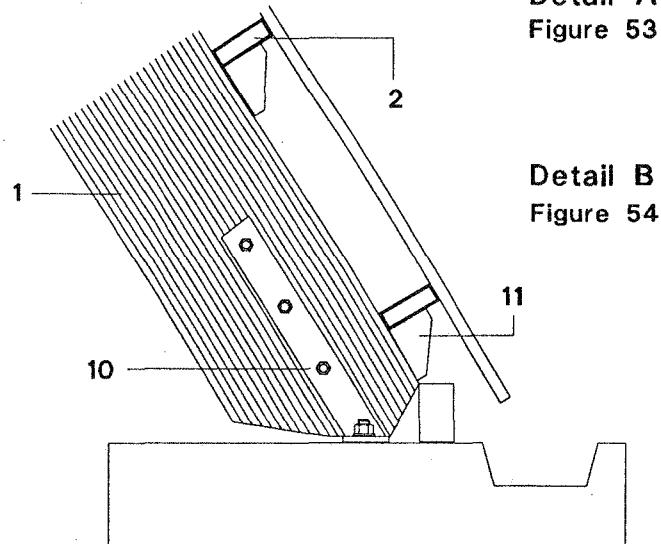
Plan
Figure 52

Store building, Kalangadoo

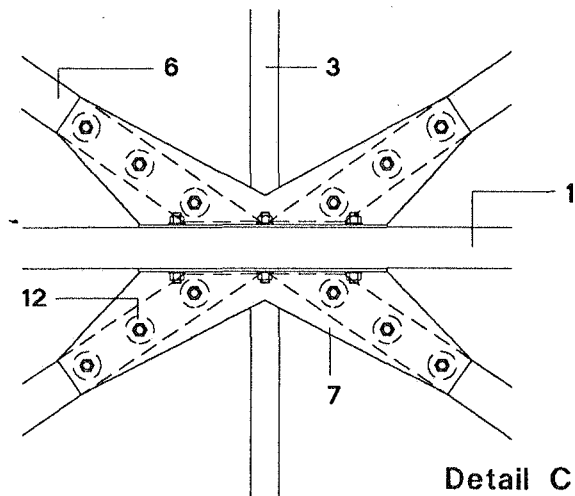
- 1. 620 x 140 glue laminated oregon arches
- 3. 150 x 150 oregon struts
- 6. 150 x 150 oregon braces



Detail A
Figure 53



Detail B
Figure 54



Detail C
Figure 55

1. 620 x 140 glue laminated oregon arches
2. 200 x 50 oregon purlins at 1 000 centres
3. 150 x 150 oregon struts
6. 150 x 150 oregon braces
7. plate steel brace & strut connection plates
8. end stitch bolt
9. arch tie plates
10. foundation fixing plates
11. purlin nailing block
12. shear connectors to jointing plates

**Store building,
Kalangadoo**

Exemplar 2. 18

Name of Structure:

Plenty River Bridge

Owners:

Shire of Diamond Valley

Address:

Across the Plenty River, Greensborough
(north of the Greensborough Station)
Vic.

Structural Engineers:

B. S. C. Consulting Engineers Pty Ltd.

Date Constructed:

1975

Structural System:

three pin foundation arches

Description:

The bridge is a three pin parabolic arch footbridge spanning 50 m over the Plenty River. Each arch member has 29 laminations of 35 mm CCA treated radiata pine and was laminated with resorcinol glues. The main bridge members are spaced by glue laminated diaphragms at 3.5 m centres.

Secondary beams provide a ramped approach to the bridge and support a floor of 150 x 75 radiata pine stringers and 140 x 50 treated radiata pine deck.

The bridge has concrete abutments and foundations. It has galvanised steel pins and jointing plates.

Development:

This bridge was the first essay in a renaissance of glue laminated arch bridge construction that continued through the 1980's. During this time, two and three pin foundation arch bridges regularly achieved spans up to 25 m in glulam jarrah and radiata. Most

were built in Victoria and Western Australia.

The Greensborough bridge has the longest clear timber bridge span ever built in Australia. The next largest was the 46.65 m Allen truss span for the vehicular bridge built at Kempsey in NSW in 1890.

Condition:

Due to fabrication and site storage problems, some delamination occurred shortly after the bridge was erected. Consequently, stitch bolts were installed in the main beams. With routine maintenance since then, the bridge has served well and appears in good condition.

References:

Catlin Smith, H. R., 1980. *Philosophy, Design and Construction of the Greensborough Footbridge*, I. E. Australia Engineering Conference, Adelaide, pp. 89-93

Catlin Smith, H. R., 1990, *Light Road Glulam Bridge at Yarrawonga, Australia*, unpublished paper.



Plate 124. The graceful 50 m span arches of the pedestrian bridge at Greensborough. It remains the longest clear span timber bridge built in Australia.



Plate 125. Secondary beams provide the approaches to the main arch span. Plenty River Bridge, Greensborough, Vic.



Plate 126. The main support pins of the arches. Plenty River Bridge, Greensborough, Vic.

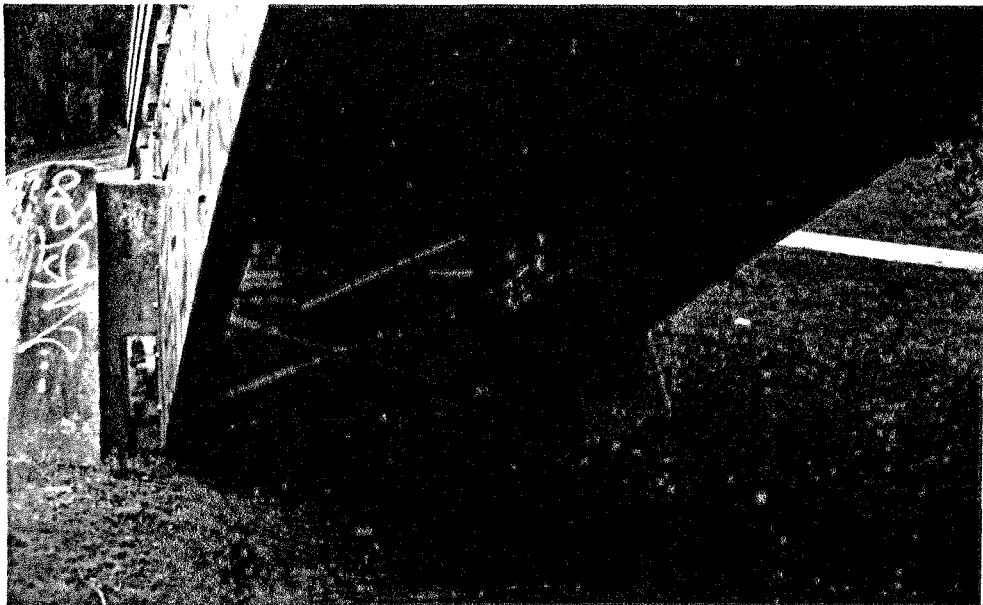
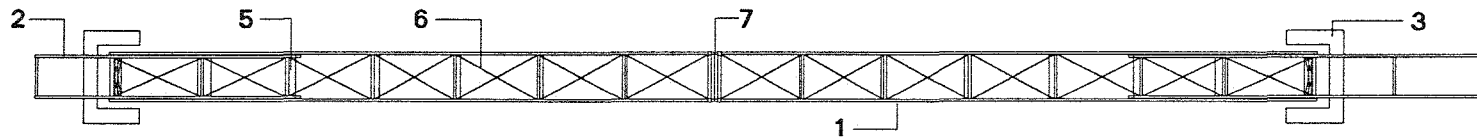
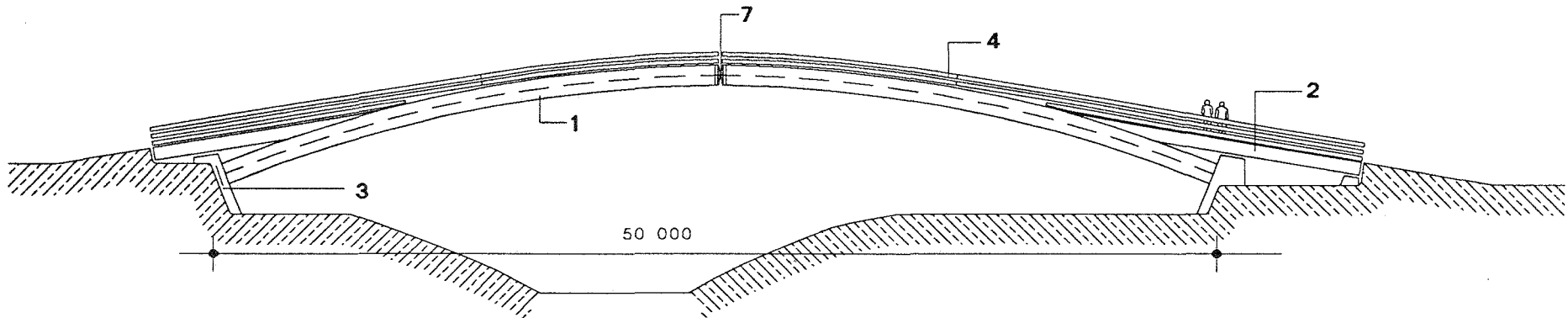


Plate 127. The arches are spaced with steel frames at the ends and timber diaphragms along its length. Each bay is then braced with diagonal steel cables. Plenty River Bridge, Greensborough, Vic.



Plan
Figure 56



Elevation
Figure 57

Plenty River Bridge, Greensborough

1. 1 015 x 150 glue laminated radiata pine arches
2. 630 x 120 glue laminated secondary approach beams
3. concrete abutments
4. timber handrails
5. glue laminated diaphragms
6. 20 dia. rod wind bracing
7. central pin

Exemplar 2. 19

Name of structure:

Potash storage facility

Owners:

Texada Mines Pty Ltd.

Address:

Caper Cuvier, WA.

Structural Engineers:

E. D. Piggott & Associates

Bullder:

Bunning Bros. Pty. Ltd.

Date Constructed:

1973

Structural System:

Three pin foundation arches

Description:

The building was a regular three pin foundation arch structure of 23 bays of glue laminated jarrah arches at 4.9 m centres. Each arch pair spanned 41 m. They stood 23.5 m high at the apex and were set out as segments of a 29.3 m circle. Each arch member consisted of a spaced pair of 705 x 133 mm glue laminated jarrah beams. These were spliced 19.8 m below the apex with a special glue laminated splice plate, shear connectors and bolts. The whole structure was braced in six complete bays. Purlins ran simple supported over the arches and were fixed to them with a cast purlin cleat. The arches supported a platform above and material bulkheads around the perimeter.

Development:

The building demonstrated many of the beneficial aspects of construction in wood:

- It was constructed quickly;
- The timber arches were lighter and easier to transport to a remote location than a steel alternative;
- The jarrah & karri used was naturally resistant to the building's corrosive contents and surrounds; and
- A structurally efficient arch form could be easily achieved;

The limited height of arch structures at the springing wasn't a disadvantage in a bulk store. The side bulkheads and the natural batter of the bulk material complimented the arch form.

This building was reported to be the largest hardwood structure in the world when it was constructed.

History:

Bunning Bros won the contract to design & construct the building in January 1973 as part of Texada Mines Pty Ltd's \$6 million potash project at Cape Cuvier. With previous experience in prefabricated building, Bunning constructed the arches in Perth and transported them to the site for assembly and erection. The building was completed by July, 1973.

Unfortunately, the building was never used as the industrial process it was intended to service never became operational.

Condition:

The structure was demolished during the late 1980's and the arches are now being used to make shelters in a caravan park near Perth.

References:

Wood World, 1974, *Largest Hardwood Building in the World*, Vol. 7, No. 2.

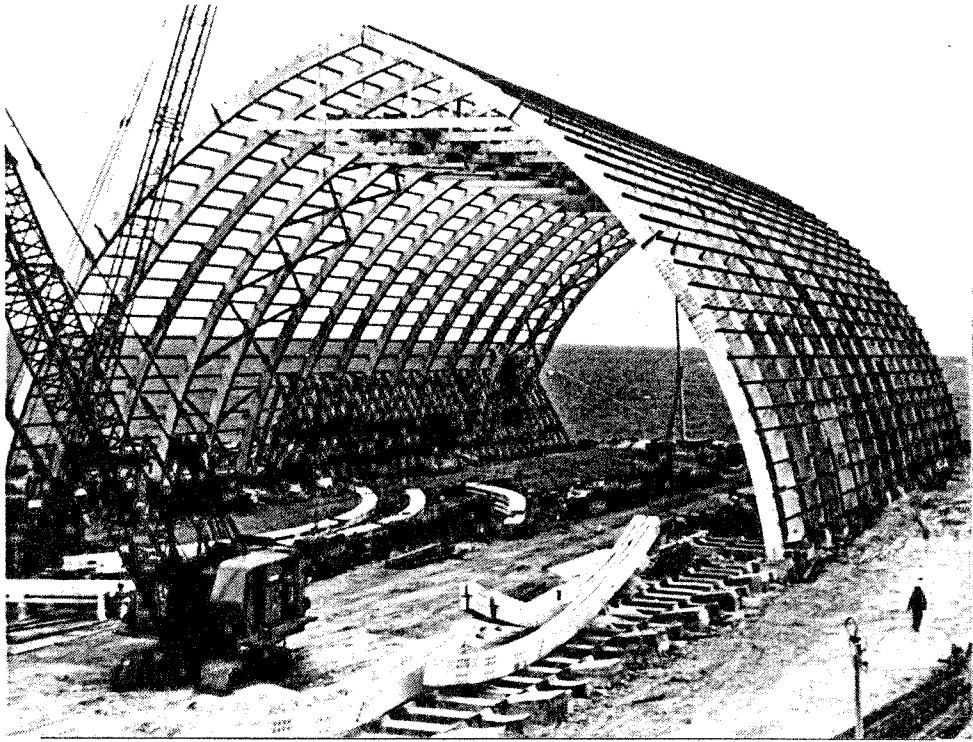


Plate 128. The store under construction for Texada Mines at Cape Cuvier, WA. The glue laminated arches span 41 m. Photo: Courtesy of Bunnings Ltd.

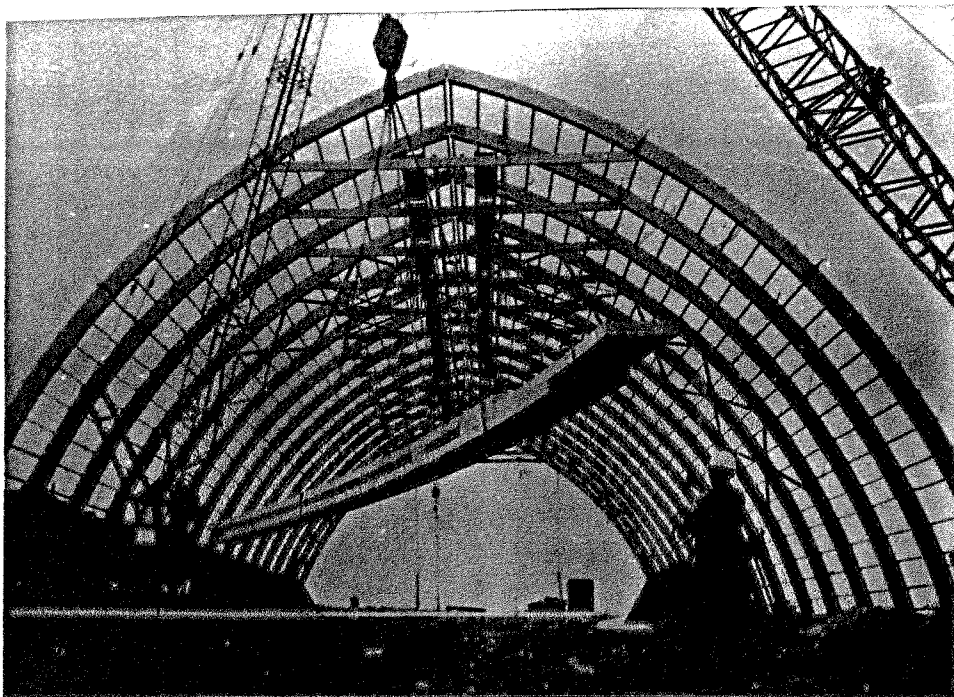


Plate 129. One of the arch segments being prepared for installation. Each arch was a double spaced member. The main splice plate is visible at the right. Texada Mines' store, Cape Cuvier, WA. Photo: Courtesy of Bunnings Ltd.

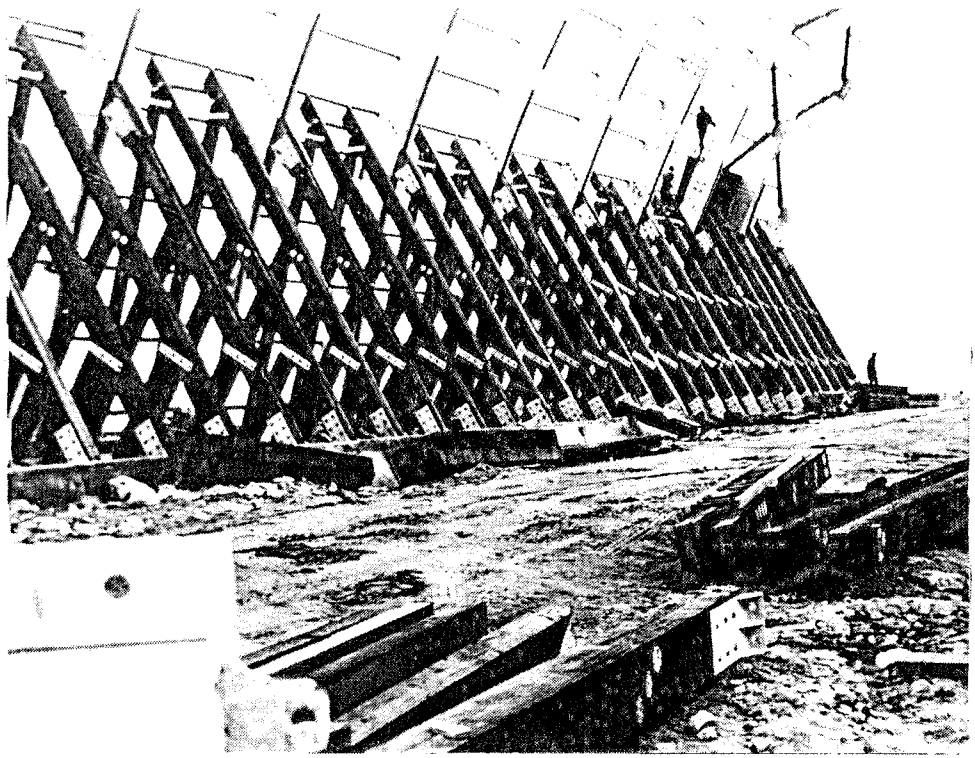


Plate 130. The buttress frames being installed. Photo: Courtesy of Bunning Ltd.

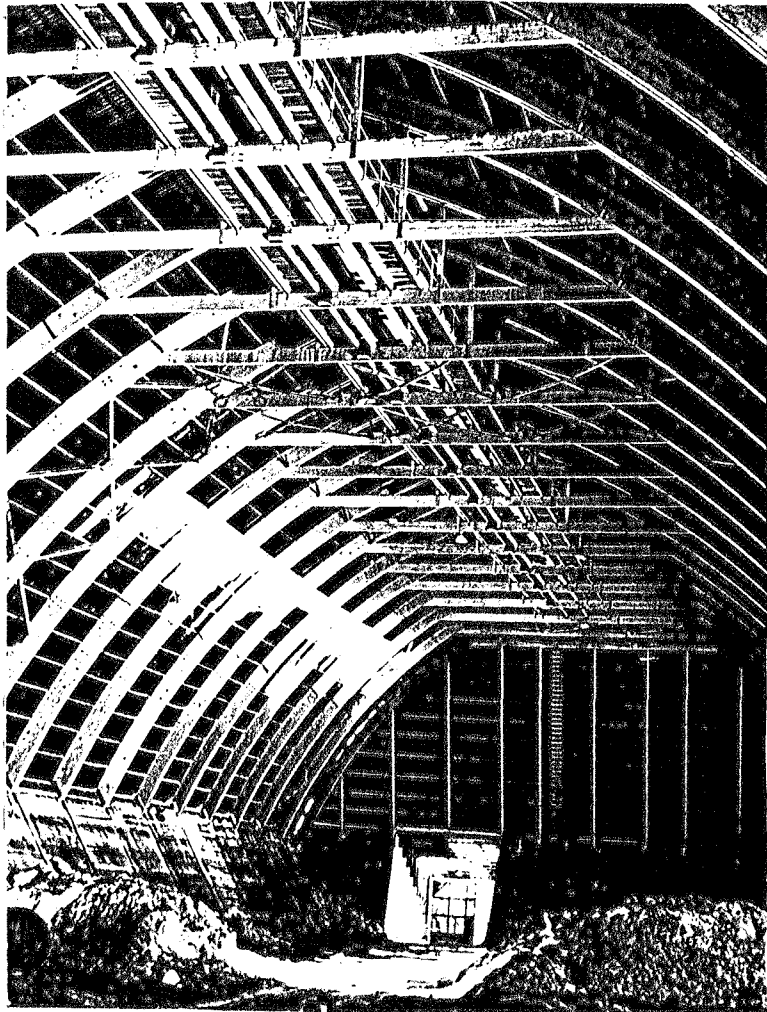
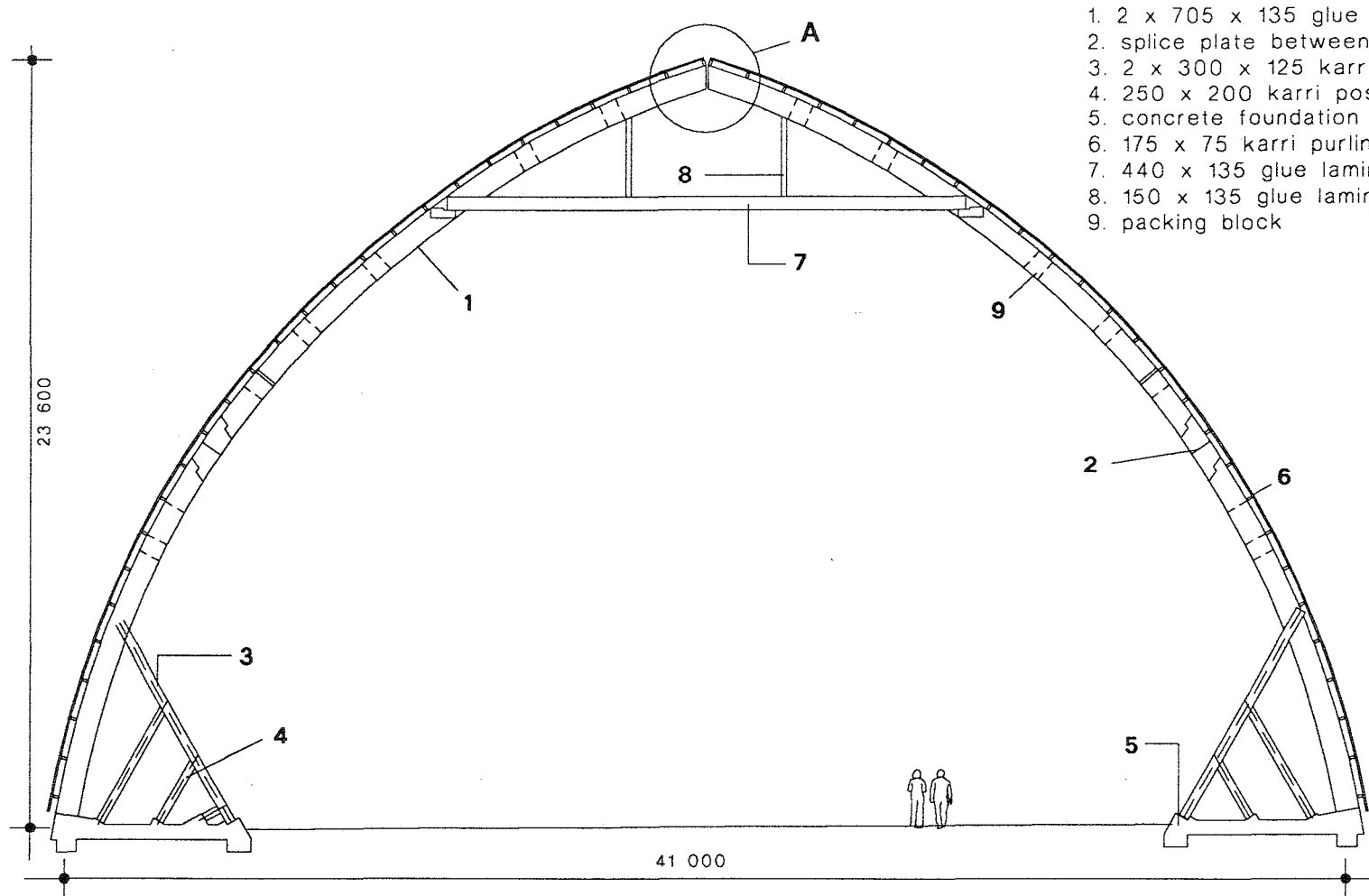


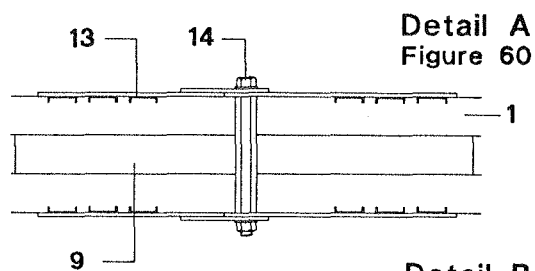
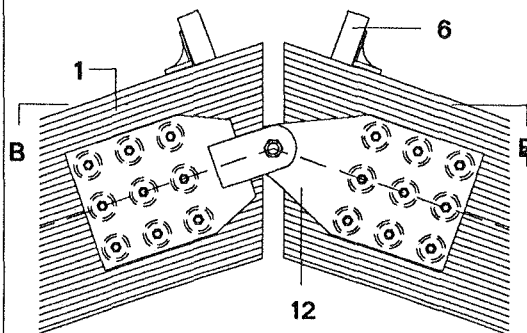
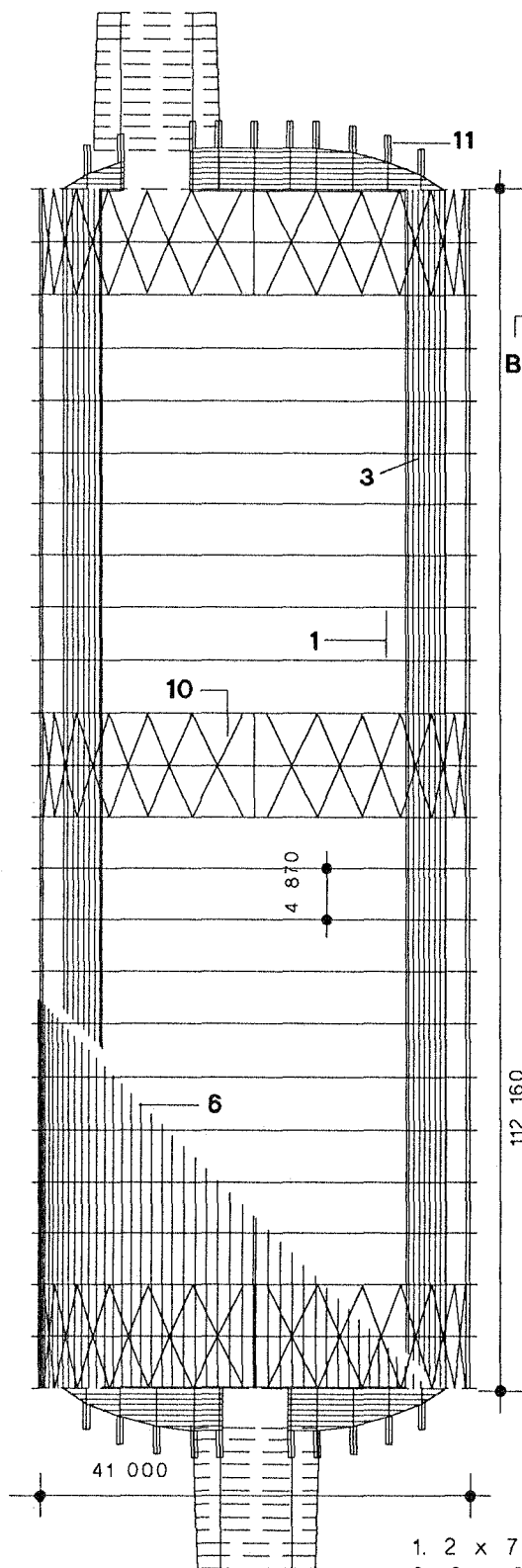
Plate 131. Inside the completed building. Photo: Courtesy of Bunnings Ltd.



1. 2 x 705 x 135 glue laminated jarrah arch
2. splice plate between arch segments
3. 2 x 300 x 125 karri bulkhead beams
4. 250 x 200 karri posts
5. concrete foundation pads
6. 175 x 75 karri purlins at 1 220 centres
7. 440 x 135 glue laminated beams
8. 150 x 135 glue laminated ties
9. packing block

**Transverse
Section
Figure 58**

**Potash store,
Cape Cuvier**



Detail A
Figure 60

Detail B
Figure 61

Plan
Figure 59

**Potash store,
Cape Cuvier**

1. 2 x 705 x 135 glue laminated jarrah arch
3. 2 x 300 x 125 karri bulkhead beams
6. 175 x 75 karri purlins at 1 220 centres
9. packing block
10. h/w bracing
11. end wall buttress frames
12. 13 hinge plates with 9 x 22 bolts
13. 100 shear connectors
14. 37 s/s bolt

Exemplar 2. 20.

Name of Structure:

Ralph Symonds' factory

Owners:

TNT Rudders

Address:

Corner of Burrows Rd & Campbell St, St. Peters, NSW

Engineer:

Ralph Symonds

Builders:

Ralph Symonds Limited

Date Constructed:

1946 - 1952

Structural System:

Three pin foundation arches

Description:

The complex has two perpendicular wings of three pin foundation arches. The larger wing consists of 32 bays at 6.1 m centres while the smaller is of 24 bays at 6.1 m centres. The arches used throughout are identical and span 31 m. Each is a 610 x 100 mm member of 29 laminations, fabricated with casein glues. The 24 arches to the west end of the long arcade are fabricated from mixed hardwoods while the remainder of the arches are radiata or oregon.

Secondary rafters run from the line of the arches to form aisles of varying width throughout the building. Purlins are standardised trussed oregon members. These are propped above the arches on each side to form a longitudinal roof light. Elsewhere, they are simply supported over the arches. The floor is concrete on fill

with tie beams cast in between the concrete bases of each arch pair. The roof is corrugated AC sheeting.

The principal framing to the end walls is 450 x 110 mm plywood box beams at 3 m centres, with vertical fixing to the slab and to the outside faces of the arches.

Development:

Symonds used his experience with glue laminated buildings during the Pacific War to develop this building form. The use of side rafters removed the wasted space found in the pure arch form and economically increased the useable floor area of the building. A straight section at the top of the arches eliminated the need for curved roofing material and it allowed Symonds to incorporate a continuous sidelight to the roof. Though it was essential to rely on natural lighting at the time, the complex roof flashing which this side light required introduced a considerable risk to beams laminated with water soluble casein glues.

The considerable beauty of this building arises from a combination of the proportion and strength of its arches, the long uninterrupted view of the structure and the accentuating light of the glazed end walls and roof lights.

History:

Symonds began work at St. Peters' site in 1946 and intended to amalgamate all his company's operations there. The original building was extended as required from that time until about 1952 when the complex reached its present form. Symonds completed his amalgamation

on the site in 1958. However, by this time, the buildings were inadequate for his requirements and he began construction of his Homebush Bay plant.

He vacated the St Peters site in about 1960.

The current owners, TNT Rudders, use the majority of the building as a bond store. The remainder is used as a waste treatment plant.

Condition:

Water penetration around the flashing for the side lights have led to the

failure of one arch and need for the strapping of others. Precautionary strapping has been carried out generally. Severe delamination of the base of four arches has occurred in the west pavilion as damp sawdust was stored against them for a considerable period. This dissolved the casein glues.

References:

Hochroth, Yvonne, 1987, *Company History of Ralph Symonds Australia P/L*, unpublished report, July.

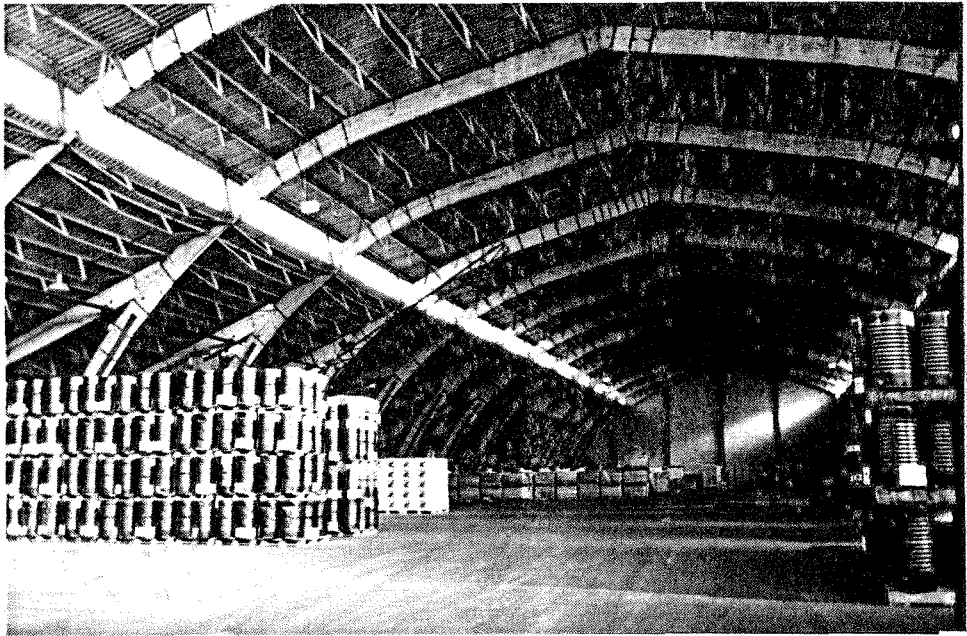


Plate 132. The 31 m span arches of the original pavilion. The building extends another 18 bays beyond the new fire wall. Ralph Symonds' factory, St Peters, NSW.



Plate 133. The spring of the arches and the secondary rafters. Note how the arches pass outside the building at the side light. Ralph Symonds' factory, St Peters, NSW.

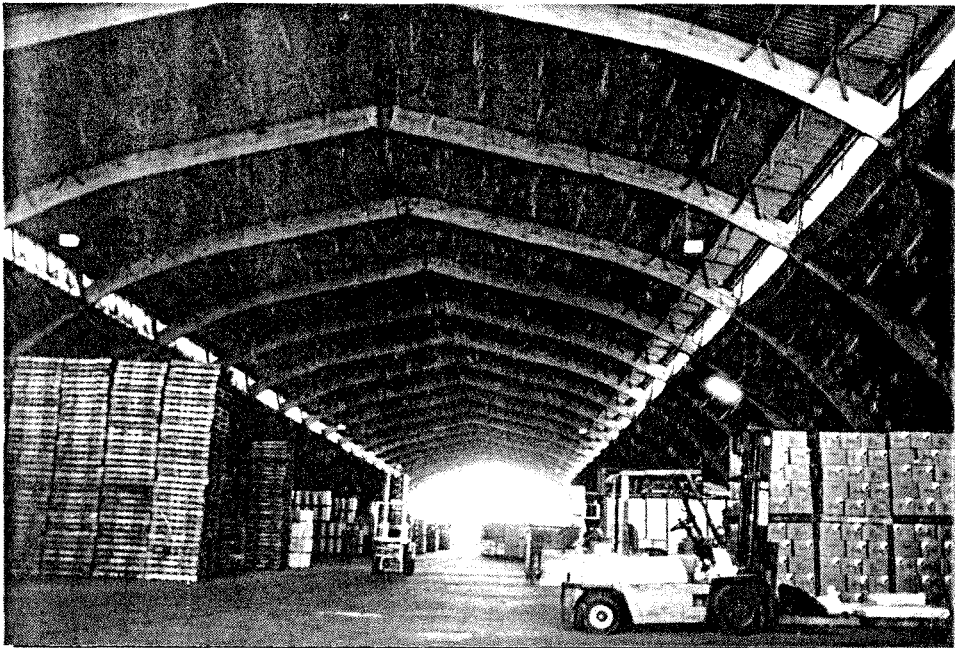


Plate 134. The second pavilion runs perpendicular to the first and uses the same arch form. It has 24 bays at 6.1 m centres. Ralph Symonds' factory, St Peters, NSW.

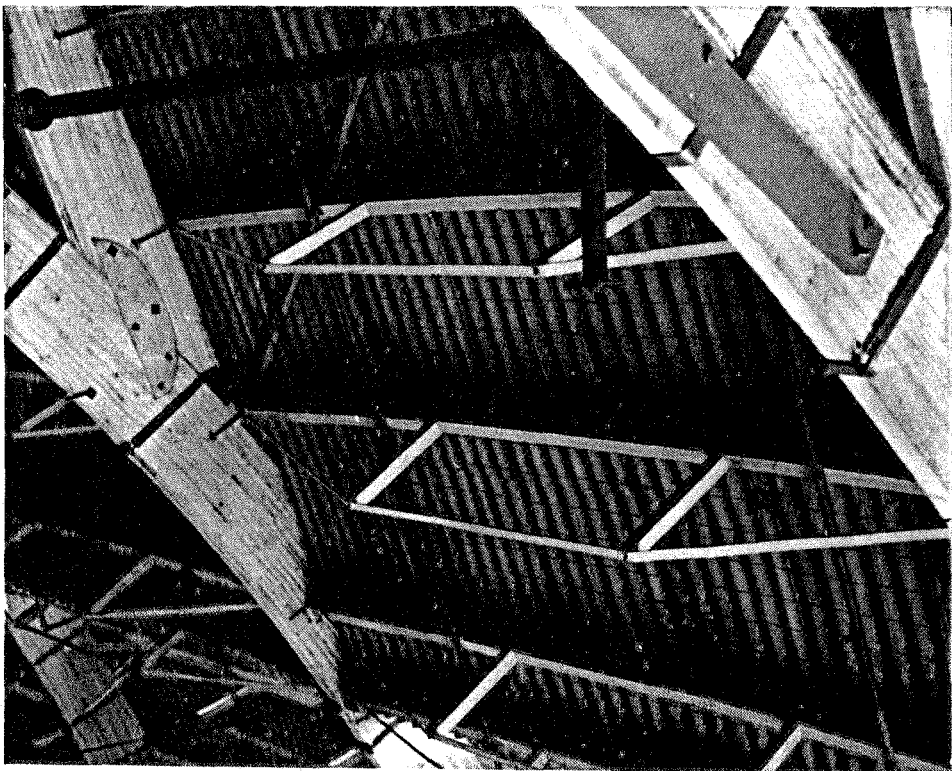
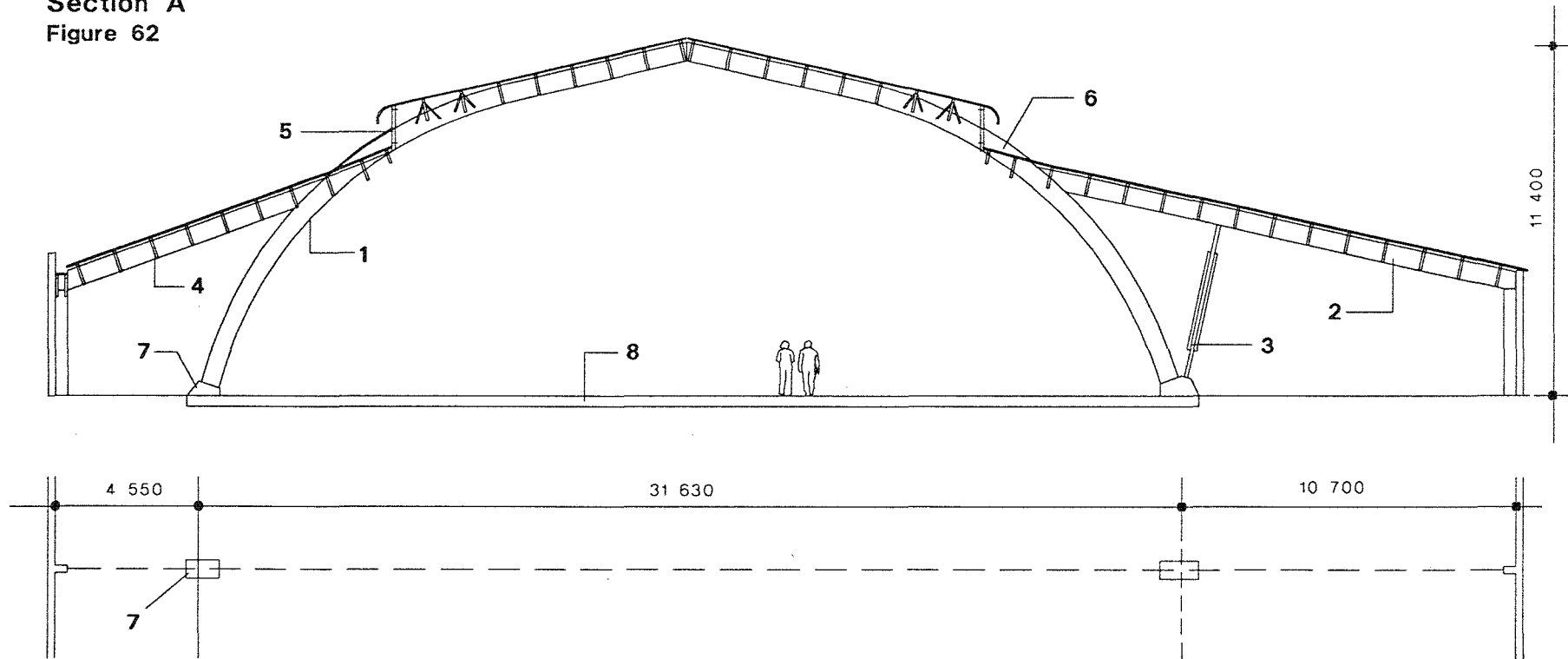


Plate 135. The purlins throughout the buildings were standardised to trussed glue laminated members. Ralph Symonds' factory, St Peters, NSW.

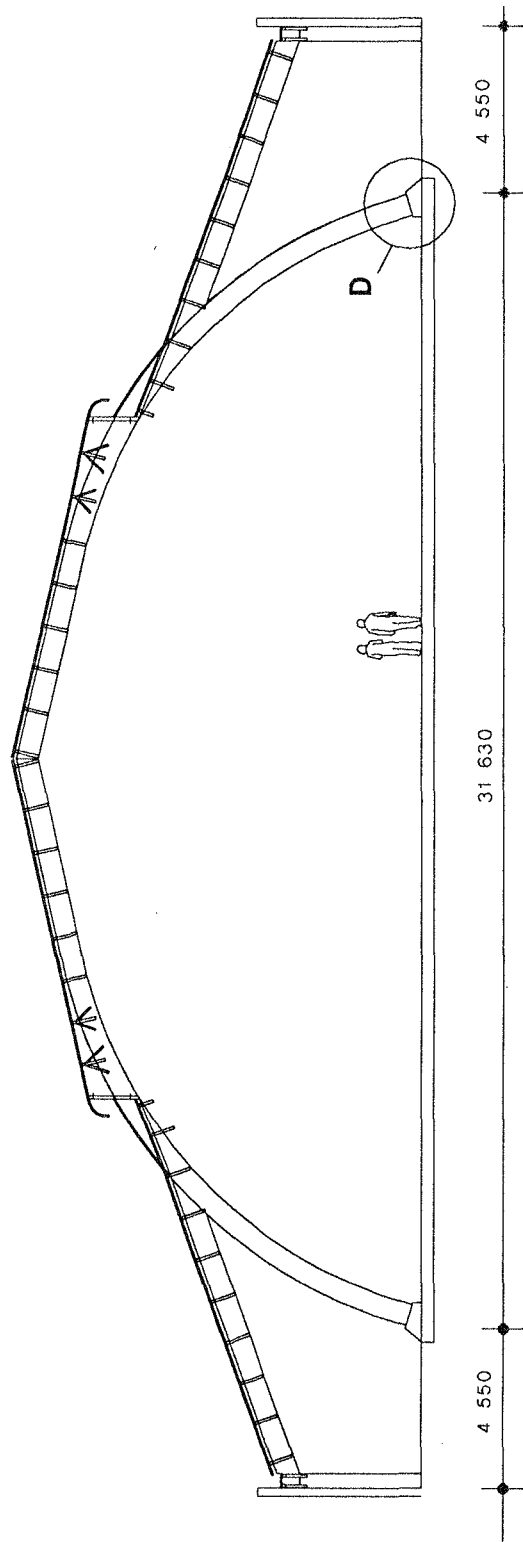
Section A
Figure 62



Part Plan
Figure 63

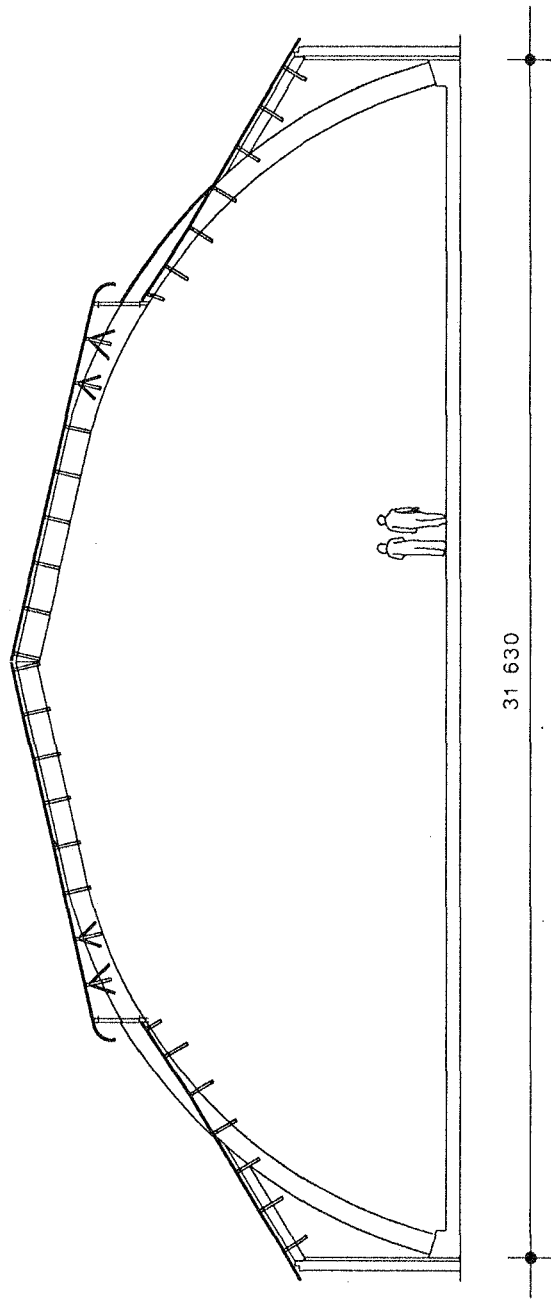
Ralph Symond's factory, St Peters

1. 600 x 100 glue laminated arch
2. 600 x 100 glue laminated secondary rafter
3. 2' x 120 dia. pipe colum
4. 120 x 75 trussed purlins
5. roof sidelights
6. flashing to arch externally
7. concrete arch base
8. base tie beam



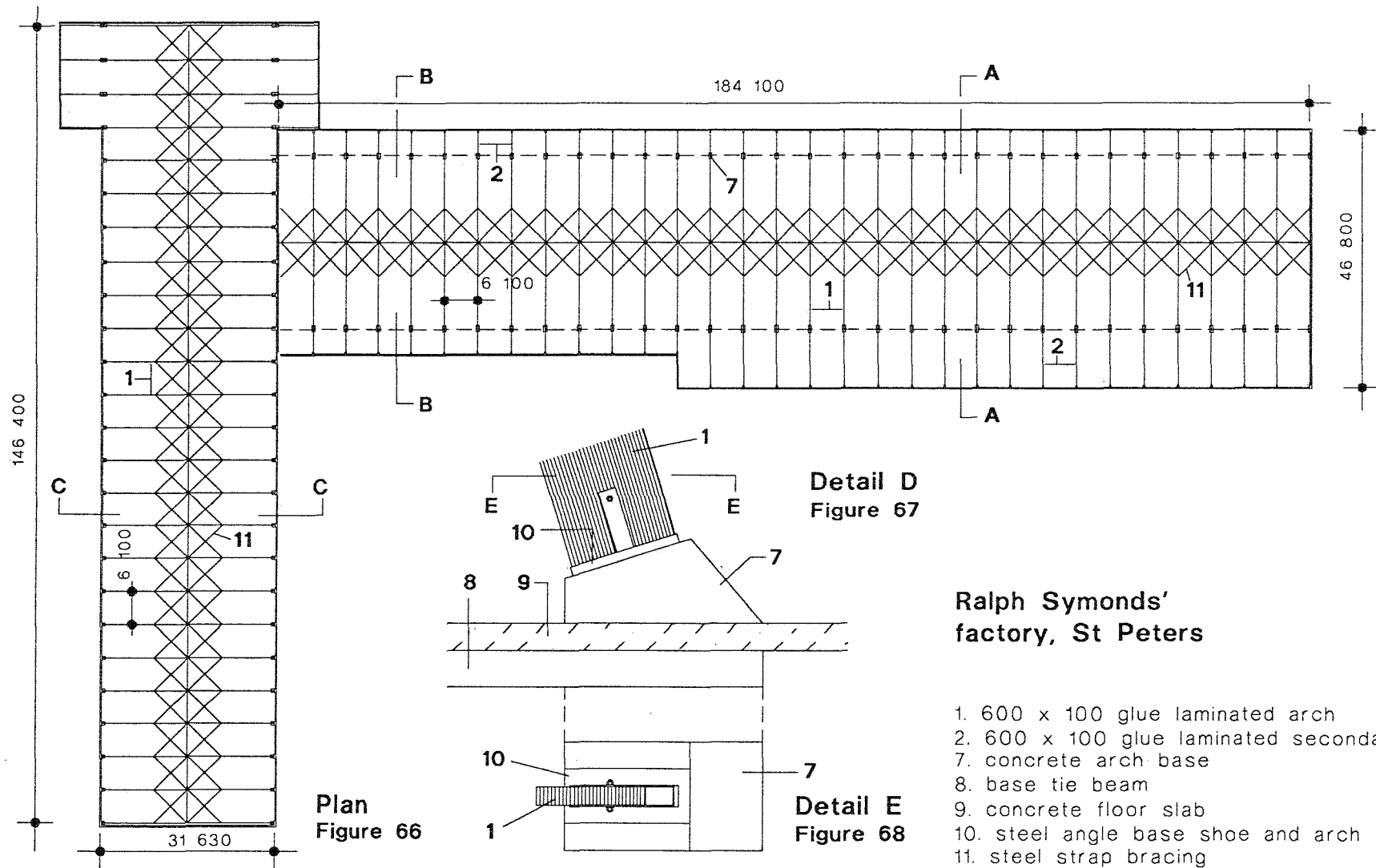
Section B
Figure 64

Ralph Symond's factory, St Peters



Section C
Figure 65

Ralph Symond's factory, St Peters



Exemplar 2. 21

Name of Structure:

Naval Stores

Owners:

Naval Support Command.

Address:

Spurway St, Ermington, NSW

Architects and Engineers:

Allied Works Council

Bullders:

Civil Construction Corp

Date Constructed:

1943

Structural System:

Three pin trussed foundation arches

Description:

Seven 125 m long by 32 m wide store buildings are built on the site. Each store is roofed by 32 three pin trussed arches in 31 bays at 4.02 m centres. The arches are boxed trussed members 600 mm wide and 950 mm high at the centre, tapering in height to each end. Each arch was constructed from green hardwood and was hand nailed on site. Purlins are simply supported green hardwood, running over the top of the arches and supporting a curved sheet metal roof. The roof structure is strutted off the arches at the crown to provide a ridge.

The arches are supported off concrete base pads and are tied down by two bolts at each foundation point

Development:

The favourable loading characteristics of arches have been recognised since ancient times and timber arches

appeared in Australia during the last half of the 19th century. Large scale peg & bolt horizontally and vertically laminated members enabled the fabrication of parabolic, semi-circular and gothic arches for bridges, large exhibition halls and ecclesiastical structures. Spans up to 26 m were achieved for bridges and 30 m for buildings. The revival of the arch as a viable timber form began with the construction of the National Spring's building and the first nailed lattice arch buildings in 1942.

As timber was largely unexplored as a reliable structural material in Australia before the war, the technology to construct these buildings was imported. The Rydalmere buildings were built to an adapted United States military design (Drawing No. CEQ 3005/30) with green Australian hardwoods replacing the original American softwoods.

Though appearing rough & haphazard initially, the arches are regular and present as a light and intricate structure. They were fabricated on site by local labour using hand tools and jig tables.

History:

With the outbreak of the Pacific war, the Allied Works Council (AWC) adopted several US military designs for timber store buildings. They included three variants of the 104 ft 3 ins (31.8 m) igloo buildings. A fourth design of a 105 ft (32 m) igloo was developed from these three by the AWC.

Though built extensively in Queensland, few are known to still exist. One single 104 ft 3 ins (31.8 m) igloo building remains at Eagle Farm

Airport in Brisbane and is listed for inclusion on the Register of the National Estate. Of a different design to the Rydalmere structures, this building has been substantially altered over time.

The Rydalmere buildings are probably the only original complex of these structures remaining in Australia.

Condition:

The buildings appear sound, showing only minimal local impact damage.

References:

Dept of Works & Housing, 1946, *A report on the structural soundness of unseasoned timbers used in structures erected for war purposes*, Dept of Works & Housing, Melbourne.



Plate 136. The three pin nailed arch structures at Rydalmere. Originally used as naval stores, they are now used as storage buildings for cars.



Plate 137. The arches being constructed by local carpenters in 1943. Naval Stores building, Rydalmere, NSW. Photo: Australian Archives

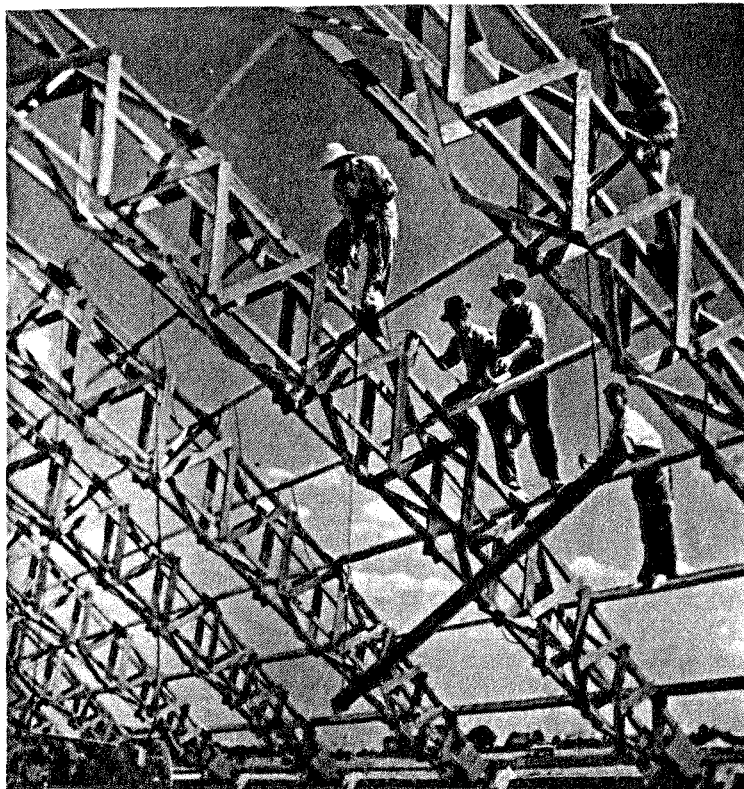


Plate 138. Carpenters installing purlins to the box arches. Naval Stores building, Rydalmere, NSW. Photo: Australian Archive

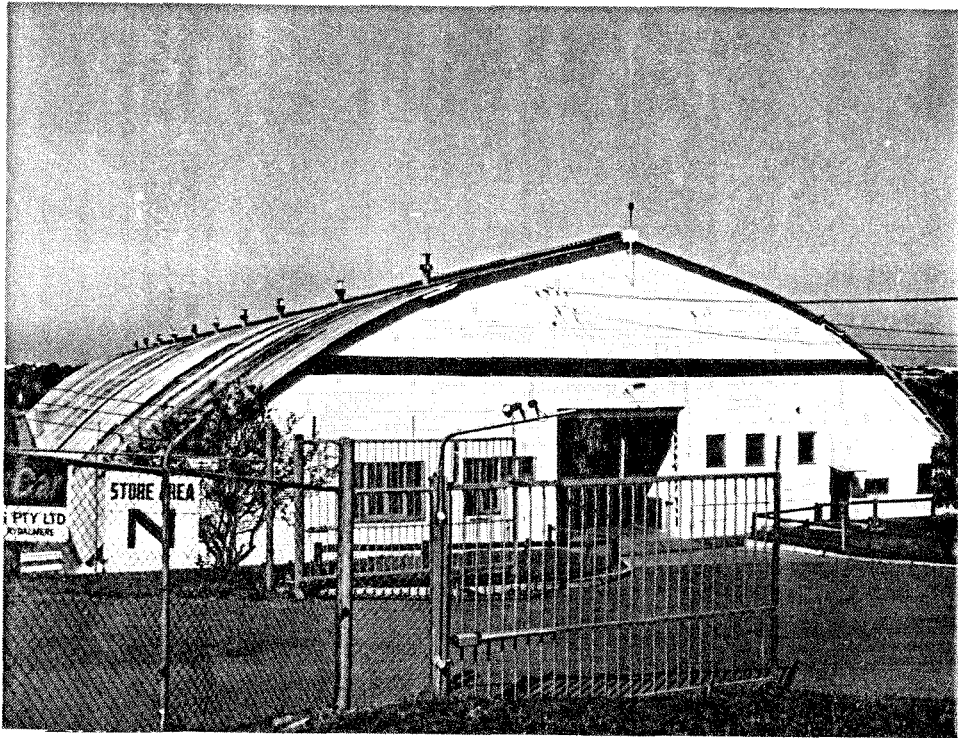


Plate 139. The exterior of one of the store buildings at Rydalmere.

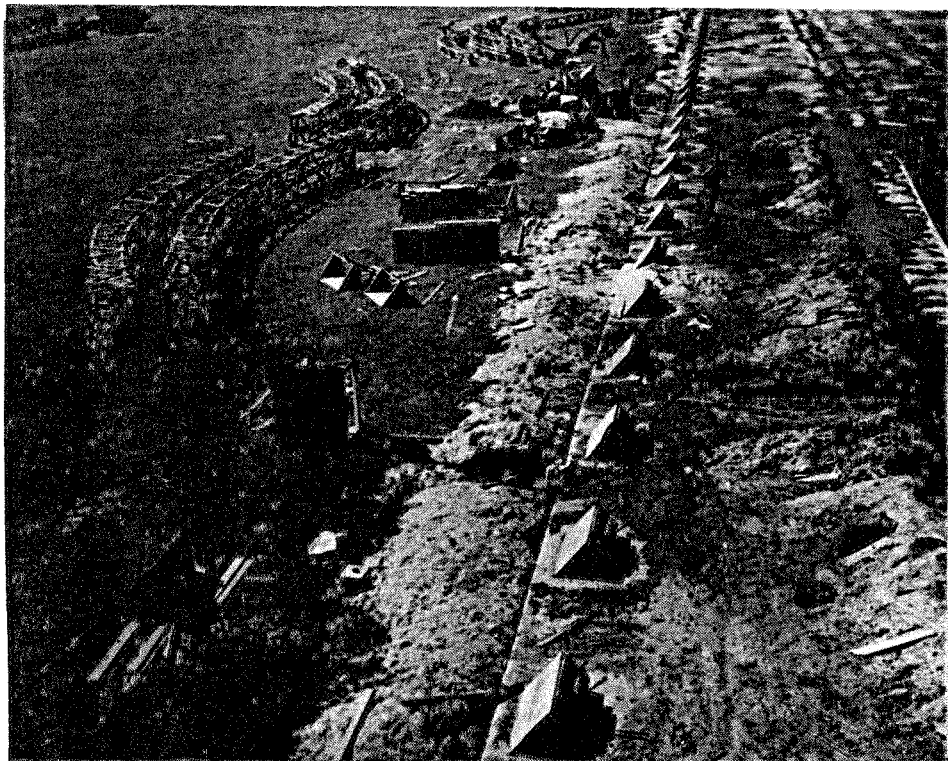


Plate 140. Box arches ready for erection on the concrete base pads. Naval Stores building, Rydalmere, NSW. Photo: Australian Archives.

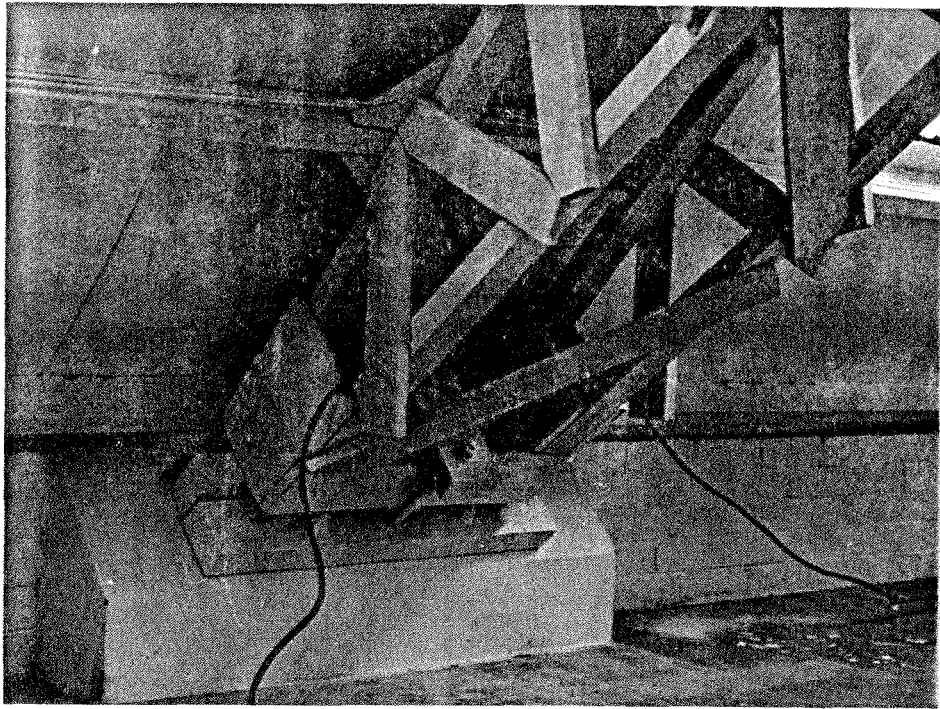


Plate 141. The base connection of the arches consisted of two tie down bolts and a hardwood "pin". Naval Stores building, Rydalmere, NSW.

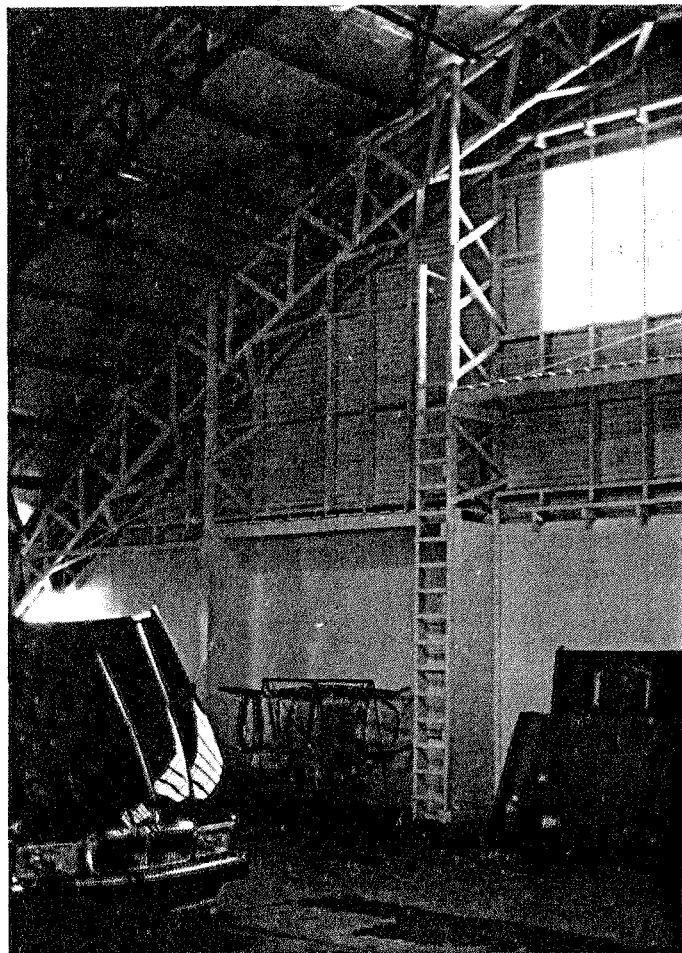
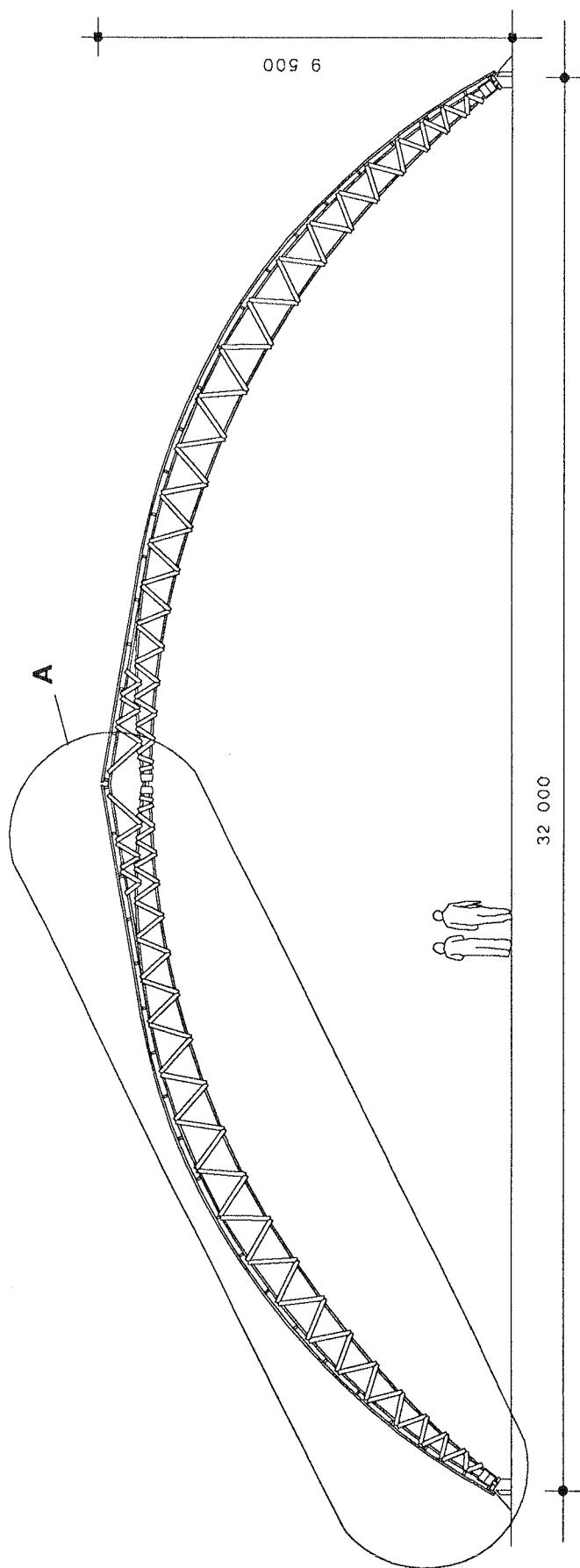
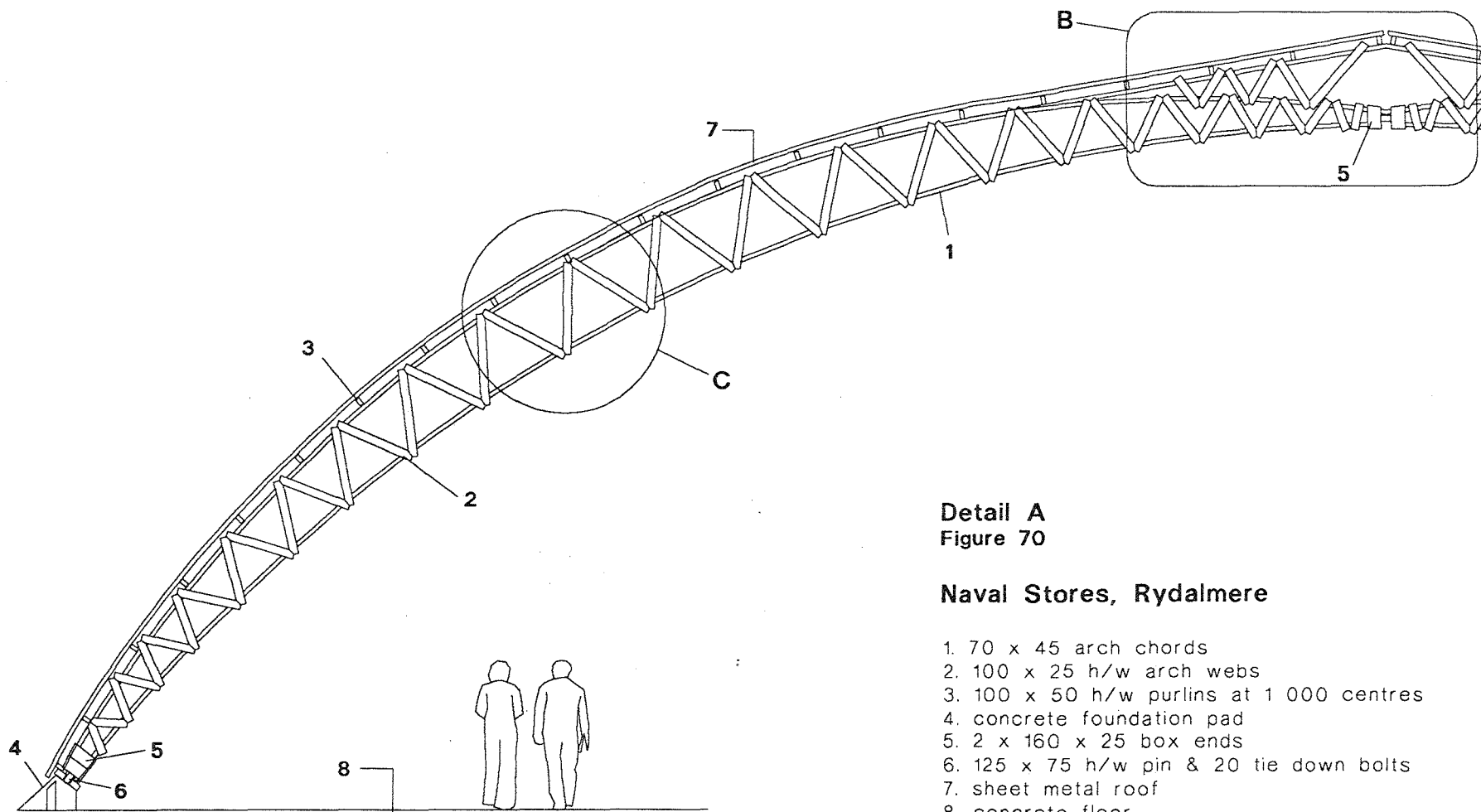


Plate 142. The latticed, end wall wind posts are nailed up from light hardwood members. The rest of the end walls are conventional plate and stud construction. Naval Stores building, Rydalmere, NSW.



Transverse Section
Figure 69

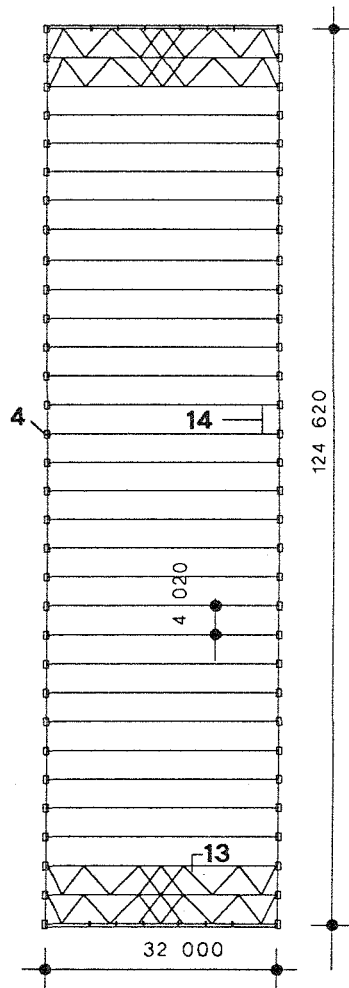
Naval Stores, Rydalmere



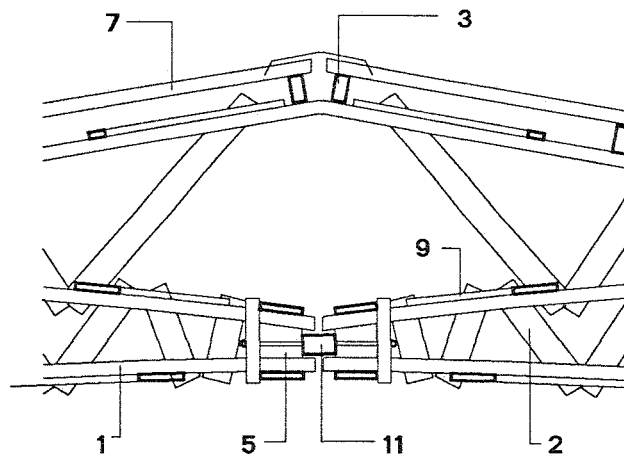
Detail A
Figure 70

Naval Stores, Rydalmere

- 1. 70 x 45 arch chords
- 2. 100 x 25 h/w arch webs
- 3. 100 x 50 h/w purlins at 1 000 centres
- 4. concrete foundation pad
- 5. 2 x 160 x 25 box ends
- 6. 125 x 75 h/w pin & 20 tie down bolts
- 7. sheet metal roof
- 8. concrete floor

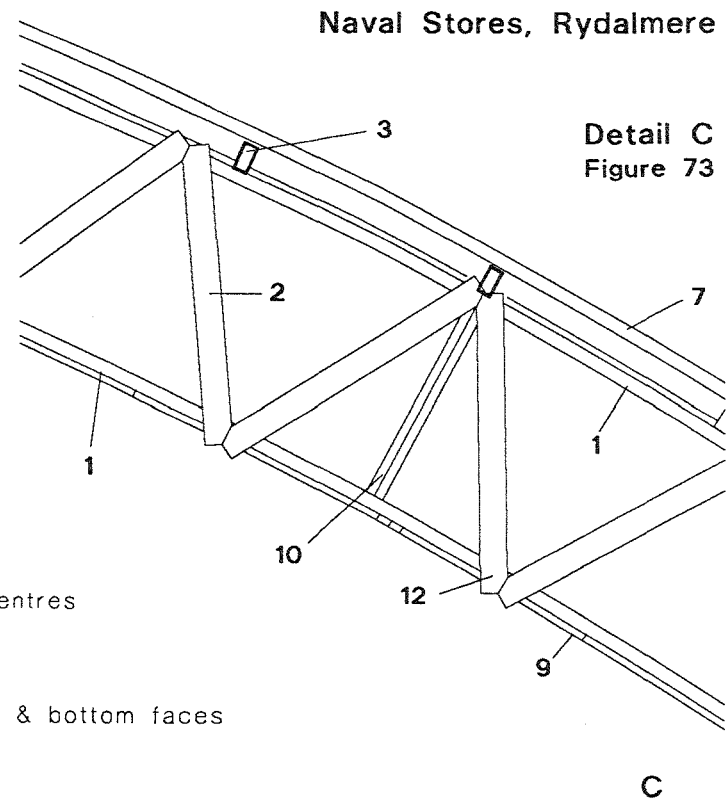


Plan
Figure 71



Detail B
Figure 72

1. 70 x 45 arch chords
2. 100 x 25 h/w arch webs
3. 100 x 50 h/w purlins at 1 000 centres
4. concrete foundation pad
5. 2 x 160 x 25 box ends
7. sheet metal roof
9. 100 x 25 h/w arch chords to top & bottom faces
10. 75 x 35 h/w internal braces
11. 150 x 75 h/w pin & steel tie rod
12. 4 x 65 nails to each web joint
13. h/w roof bracing
14. box arches



Detail C
Figure 73

Exemplar 2. 22

Name of Structure:

Workshops

Owners:

Hasting Deerings Pty Ltd.

Address:

Archerfield, Qld.

Architects and Engineers:

Allied Works Council

Builder:

Civil Construction Corps

Date Constructed:

1943

Structural System:

Three pin latticed foundation arches

Description:

Five buildings exist in this complex, with four hangars in one line and the fifth separate. Two hangar types were constructed. Both used 170 ft (51. 8 m) span box arches. The first type has standard arches springing from concrete foundations. The second has arches springing from the top of 2. 55 m high buttressed timber frames. Buildings of each type alternate in the main line of hangars and were built out of green hardwood. The fifth, separate building is of the first lower type and was built from oregon.

A characteristic building of the second type has 26 arches. These are double in each end bay, giving a structure with 23 bays at 4. 56 m centres. Each arch spans 170 ft (51. 8 m) and has a rise of 34 ft (10. 4 m) above their springing. Each box arch segment is about 1. 1 wide and 2. 3 m deep at the centre and tapers in depth at both

ends. The arches are constructed with 5 x 2. 5 ins (125 x 63 mm) chords and 3 x 1. 5 ins (75 x 38 mm) webs and were hand nailed at each joint. Each side of a vertical pair of arch chords was trussed with the webs in an opposing pattern. Two of these "flat" vertical "arches" were then spaced at 1. 1 m and tied together with horizontal webs, forming a box arch. This box was then strutted regularly inside the arch.

Diamond cross bracing runs across some portion of each of the arch bays in an apparently erratic manner. Hardwood purlins run simply supported over the arches at 900 mm centres. As the building was originally open at both ends, wind trusses run perpendicularly through and tie together the last 3 pairs of arches.

Development:

The design of the Archerfield buildings progressed the timber arch forms that had been introduced to Australia from the United States. They used the strength of Australian hardwoods to build larger and more permanent structures than the original "igloo" buildings. The significance of these structures rest with their size and durability. These buildings are the largest existing clear span timber structures in Australia and were only exceeded in span in Australia by the single 188 ft (57. 3 m) class igloo structure built at Darwin in 1944 to house B 29 aircraft. It had a timber span of 171 ft 6 ins (52. 3 m).

The buildings at Archerfield were constructed to last to the end of the war and a design stress allowance was made to exploit this temporary nature. They have however now stood for

fifty years without major structural problems. Their current owner is happy with their performance and intends to use the buildings into the foreseeable future.

Background:

At the outbreak of the Pacific War, Archerfield Airport was Queensland's major airport. With the pressing need for air defence in Brisbane, the airfield was upgraded and with Eagle Farm, became an important aircraft assembly, repair and staging point. The five hangars at Archerfield were built in 1943 and served as aircraft repair facilities. They complimented the workshops and other service buildings on the site.

With the end of the war and the return of the airfield to civilian uses, the igloos were sold off. Three are owned by Hasting Deering and two are owned by Theiss Construction.

Condition:

Both buildings examined were in satisfactory condition.

References:

Dept of Works & Housing, 1946, *A report on the structural soundness of unseasoned timbers used in structures erected for war purposes*, Dept of Works & Housing, Melbourne.

Qld. Mains Road Commission, *The History of Qld. Main Roads Commission during World War II*, published report, Qld. Mains Road Commission, p. 17

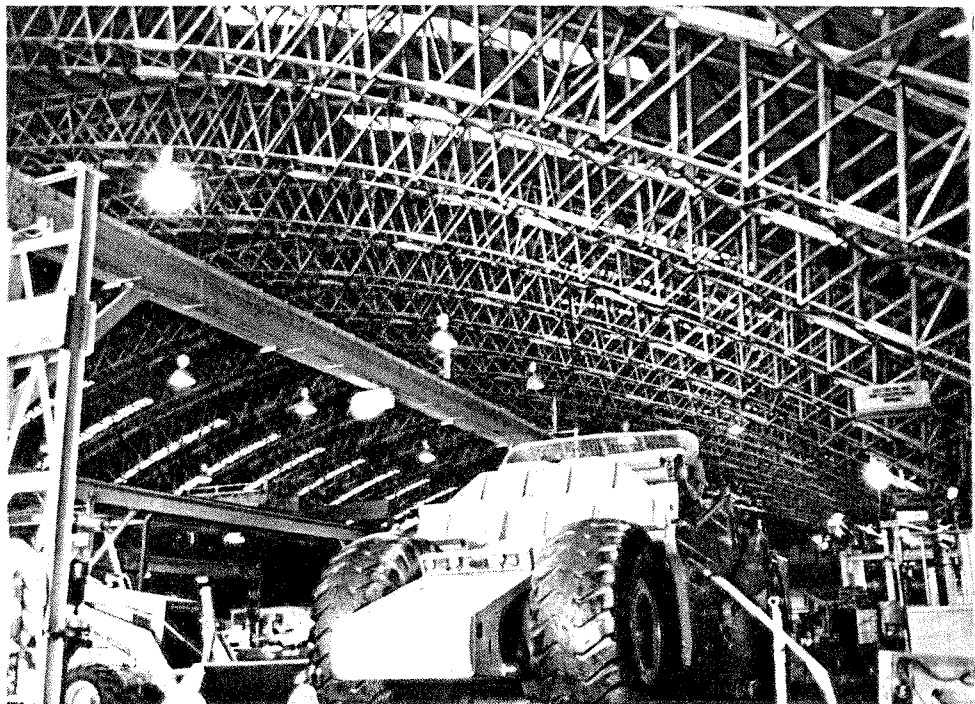


Plate 143. Looking inside one of the 170 ft hangars at Archerfield, Qld. This building now serves as a major repair works for earth moving equipment.

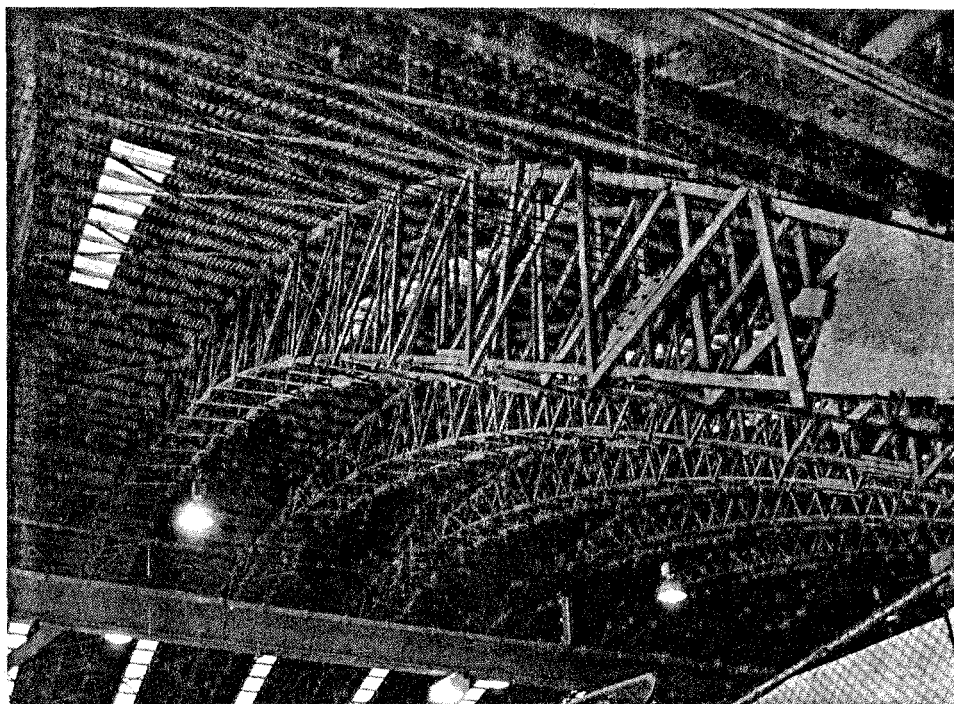


Plate 144. The slender graceful arches of the 170 ft hangars. The largest piece of timber used is the 5 x 2. 5 ins (125 x 63 mm) arch chords. These were used in 16 ft (4. 9 m) lengths. Hasting Deerings' workshops, Archerfield, Qld.



Plate 145. The ridge connections. Like the Rydalmere stores, the ridge was built up off the arches. Hasting Deerings' workshops, Archerfield, Qld.

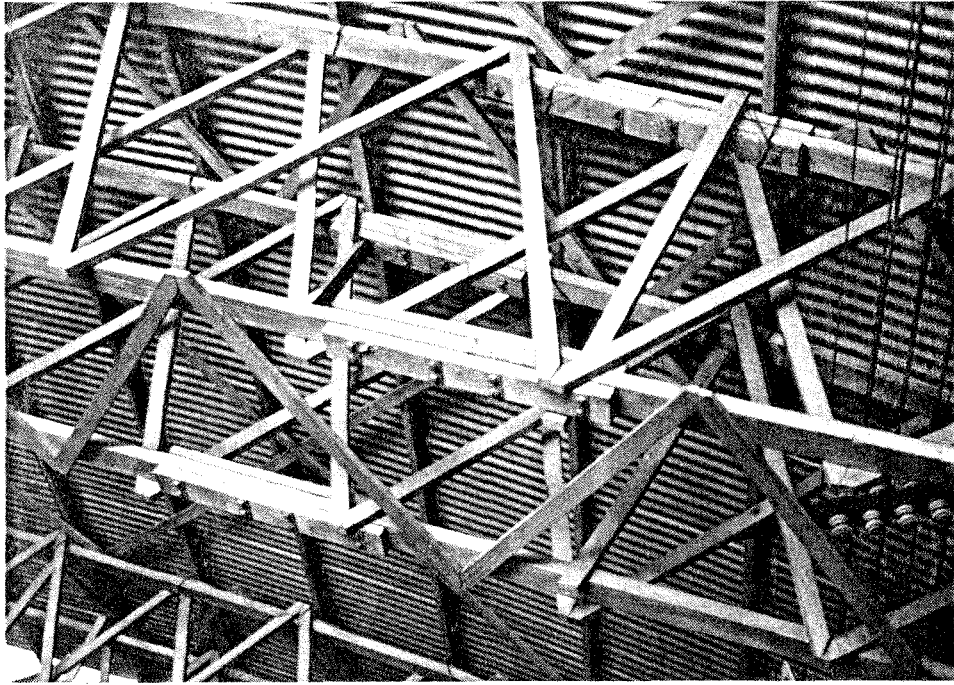


Plate 146. A section of one box arch showing the four layers of vertical webs and two layers of horizontal webs framing the arch chords. Chord splices are visible. Hasting Deerings' workshops, Archerfield, Qld.

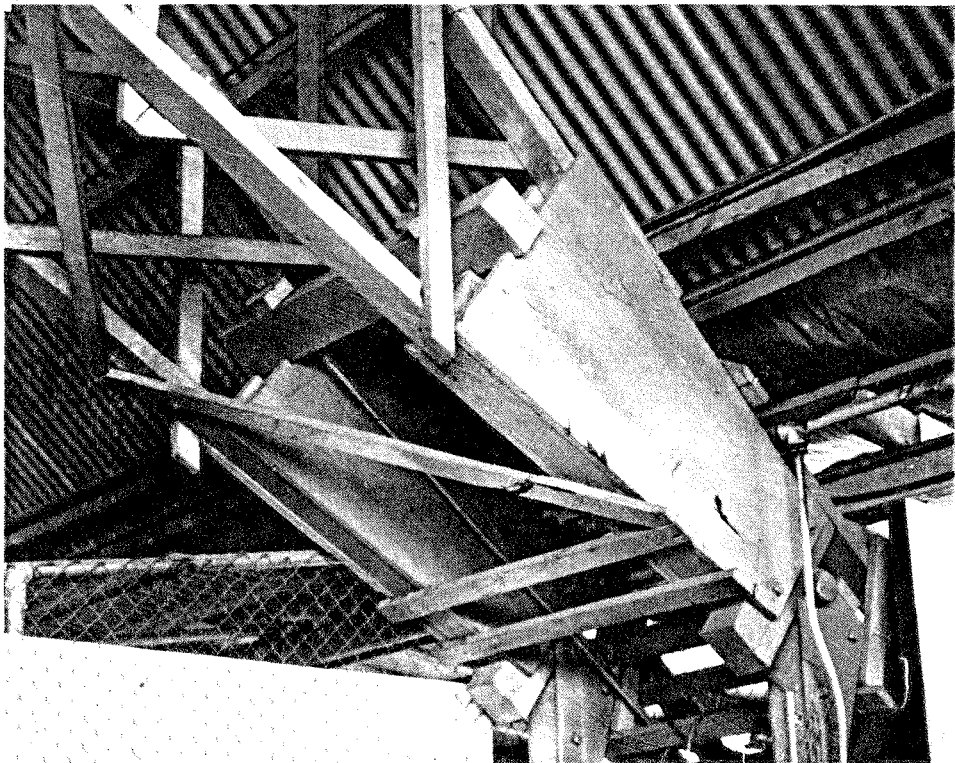


Plate 147. The base pin to the arches sitting on the buttress frame. Hasting Deerings' workshops, Archerfield, Qld.

Exemplar 2. 23

Name of Building:

Ralph Symonds' Factory

Address:

Bennelong Rd. Homebush Bay, NSW

Owners:

Industrial Equity Limited

Engineer:

Ralph Symonds

Builders:

Ralph Symonds Limited

Date Constructed:

1959

Structural System:

three pin tied arches

Description:

This factory building is constructed as three arcades of tied three pin arches at 53. 8 m centres. Each arch spans 43 m and 9. 8 m wide aisles run between each arcade. 4. 4 m wide aisles run between the outside arcades and the external walls. This makes the overall width of the building 157 m. There are 43 sets of arches in each arcade in 42 bays at 7. 6 m wide centres. This makes an overall length for the building of 319 m.

The arches have 30 laminations of New Zealand radiata pine and are 620 x 155 mm. Purlins are also glue laminated radiata and are trussed 120 x 60 mm members running simply supported between the arches. The building has a monitor roof, with both sides of each upstanding roof section glazed. The pitched intermediate roof sections are supported on a glue laminated secondary rafter, slung off

the main arches with steel strap. A steel tension rod ties the arches at their intersection with this secondary rafter. The side aisle rafters also fix to the arches on this line and plywood box beams block the arch pairs perpendicular to their span at this point. Wind bracing is 35 x 6 mm flat steel fitted with tensioners.

Development:

The design of the factory represented the culmination of Symonds' experimentation with the glue laminated arch form. Covering 5. 77 hectares, the building was the largest industrial building in the Southern Hemisphere when it was constructed. It remains the largest wooden building ever constructed in Australia.

In form, the arches and their extending rafters resemble the successful solution used at Symonds' St. Peters works. However the increase in span from 31 to 43 metres necessitated a heavier arch member. In part to negate this, Symonds introduced the tie to the arch. He then used only a a 620 x 155 mm arch member to span 43 m, while using a 600 x 100 mm to span 31 m at St. Peters. Symonds also introduced a monitor roof to improve natural light. This was essentially due to the size of the factory and the cost of electric lighting. It also eliminated the undesirable penetration of the roof by the arches as seen at St. Peters.

Both these developments, arch ties and monitor roof, were established forms of the period. Stanley & Llewellyn had used them extensively since the early 1950's, though in nothing to match the scale of this building.

The method of construction indicated Symonds' developed skill in industrial building. The entire structure was designed using a minimum of variation and all members were standardised. This enabled a high degree of prefabrication and greatly simplified erection.

This standardisation accentuates the architectural scale of the building, especially as seen in the construction photos. As the building has now been subdivided, its true scale is difficult for a visitor to gauge.

History:

Ralph Symonds Limited constructed this factory to enable an amalgamation of its various operations on the one site. After purchasing the leasehold on the 26 acre site, Symonds first prepared the land and poured the entire floor slab. This became the work platform for the fabrication of the arches and the preparation of other glue laminated elements. The arches were erected using small mobile cranes. Construction began in 1958, and was completed 18 months later. The Premier of NSW, Mr. Heffron opened the building in November, 1959.

It was Symonds' last known major work. He died in 1961.

As Ralph Symonds Limited changed hands, they lost control of the building. The current owners have subdivided the structure, cutting roads through sections to give tenants direct street access. This process is continuing.

Condition:

The building has suffered through both water penetration and movement of its land fill foundation. In about 1972, the whole structure had to be braced to resist ground movement on its northern side. In 1990, three arches collapsed after one arch failed. This was due to either wood rot or delamination at the change of angle flashing near the roof light. After subsequent testing 18 arches (out of 129) were reinforced with steel frames. The trussed purlins were also varied at this time.

The building continues to be used as an industrial structure.

References:

Hochroth, Yvonne, 1987, *Company History of Ralph Symonds Australia Limited*, unpublished report, July.

Symonds, Ralph, 1957, *Facts and Fallacies in Timber Design*, *Australian Timber Journal*, January.

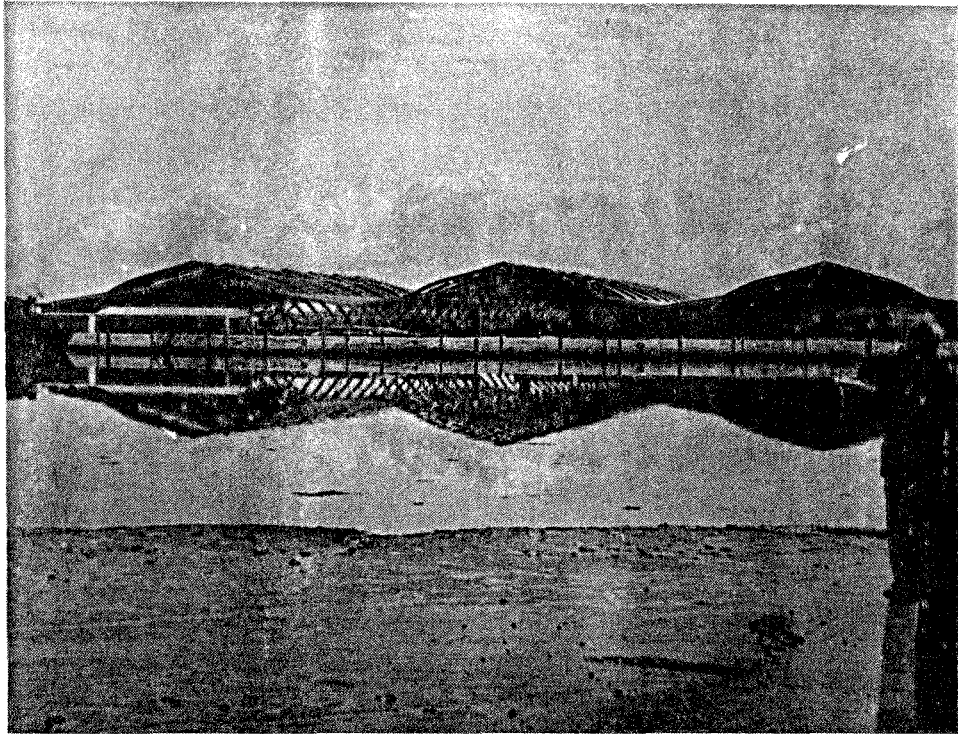


Plate 148. Ralph Symonds looking across Homebush Bay at the arcades of glue laminated arches of his new factory. Photo: uncatalogued collection, Mitchell Library

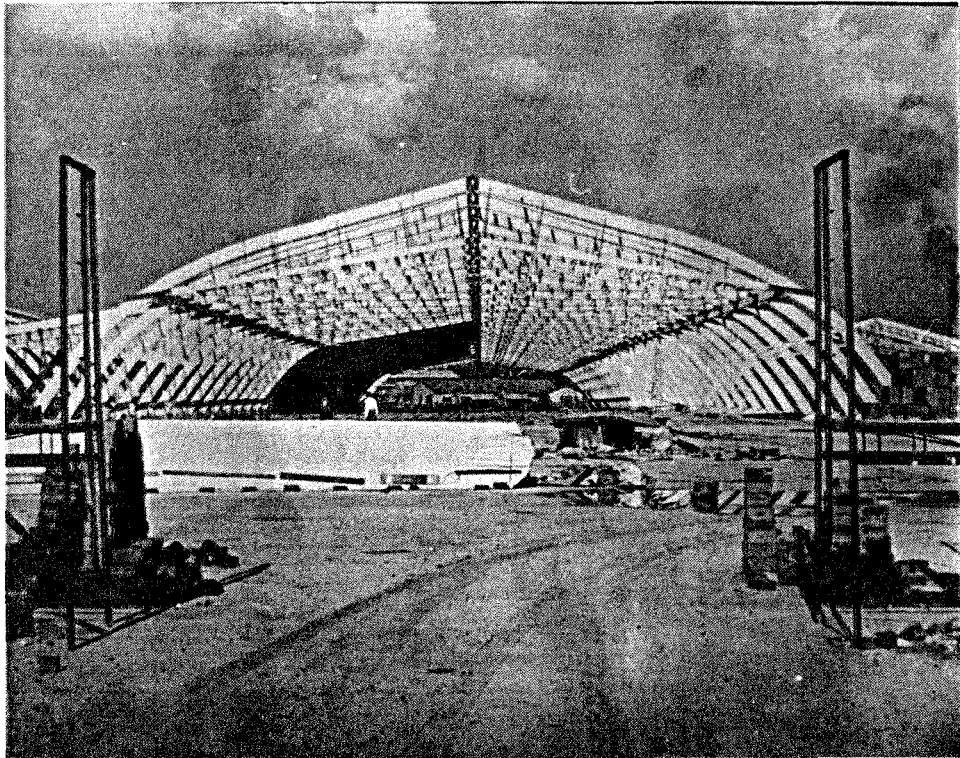


Plate 149. Looking down the central arcade of the building while under construction. Ralph Symonds' factory, Homebush Bay, NSW. Photo: uncatalogued collection, Mitchell Library.

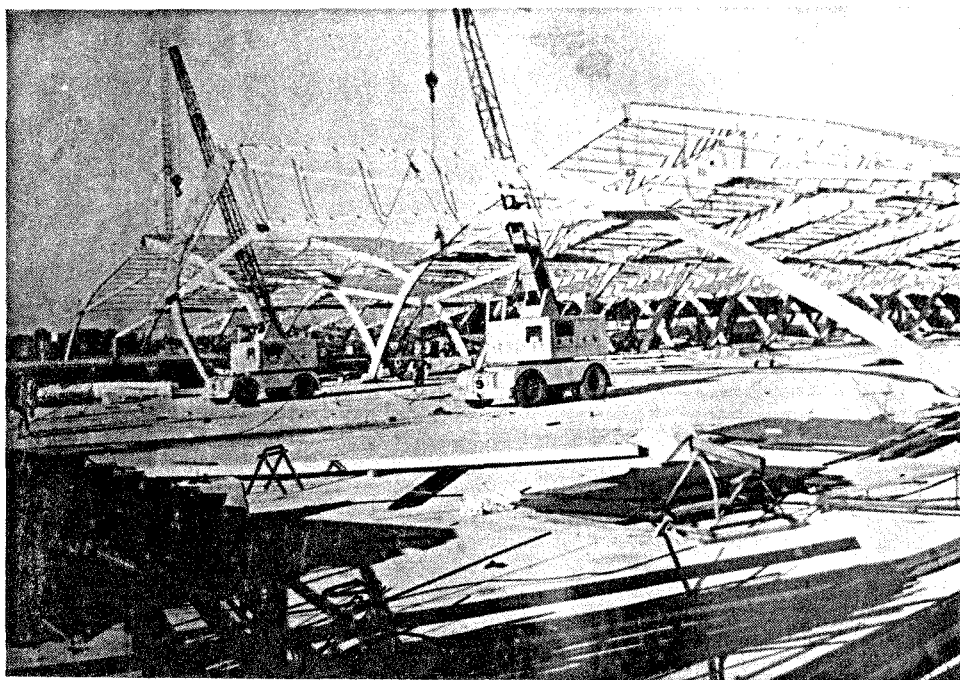


Plate 150. Arches being raised by Symonds' work crew. All building components were standardised to speed construction. Ralph Symonds' factory, Homebush Bay, NSW. Photo: uncatalogued collection, Mitchell Library

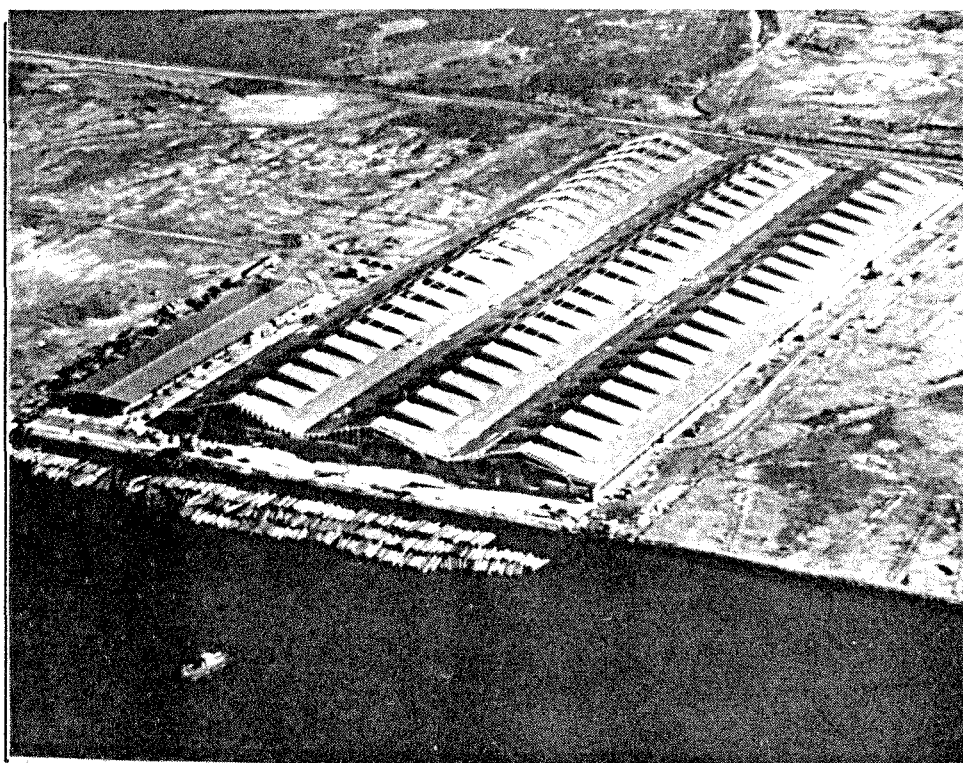


Plate 151. An aerial view of the building shows the monitor roof. The logs soaking in the foreground were used in Symonds' plywood operations. Ralph Symonds' factory, Homebush Bay, NSW. Photo: uncatalogued collection, Mitchell Library



Plate 152. Inside Ralph Symonds' factory, Homebush Bay, NSW. The trussed purlins and the tie between the arches is clearly visible.

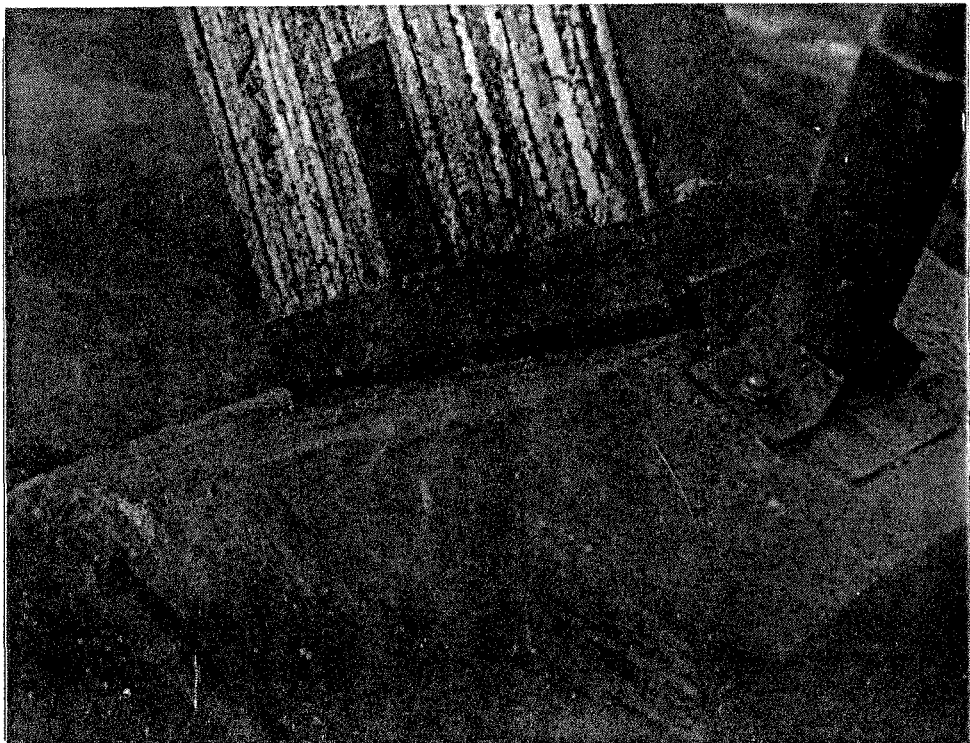
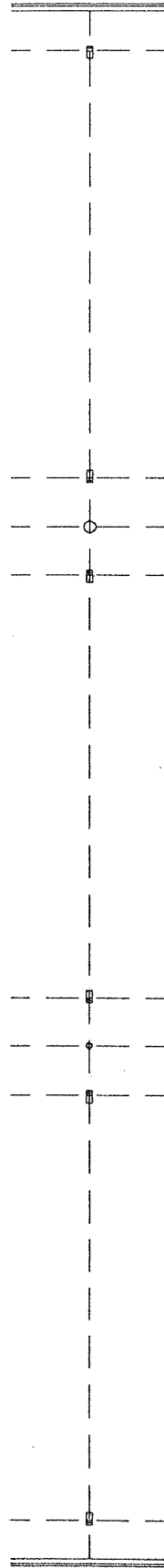
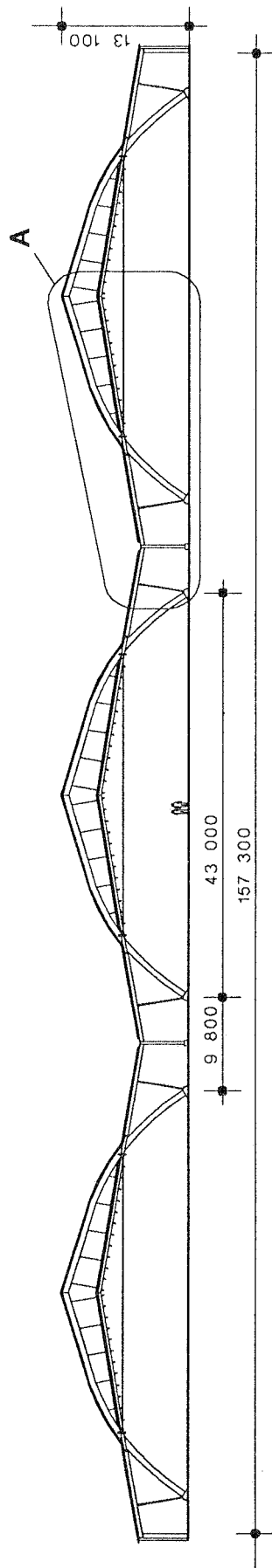


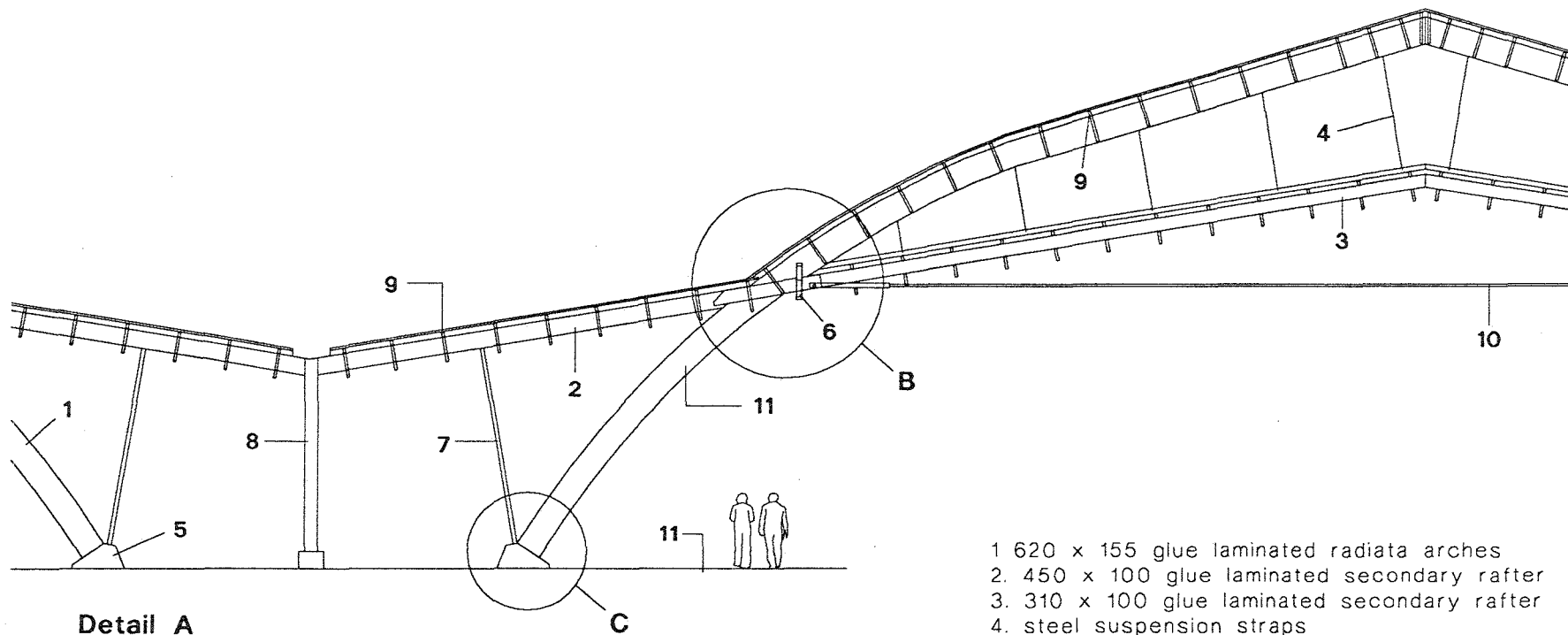
Plate 153. The base pin to the arches was very simple. They were later made into fixed joints by welding plates top and bottom of the arch shoe. Ralph Symonds' factory, Homebush Bay, NSW.

Transverse Section
Figure 74



Part Plan
Figure 75

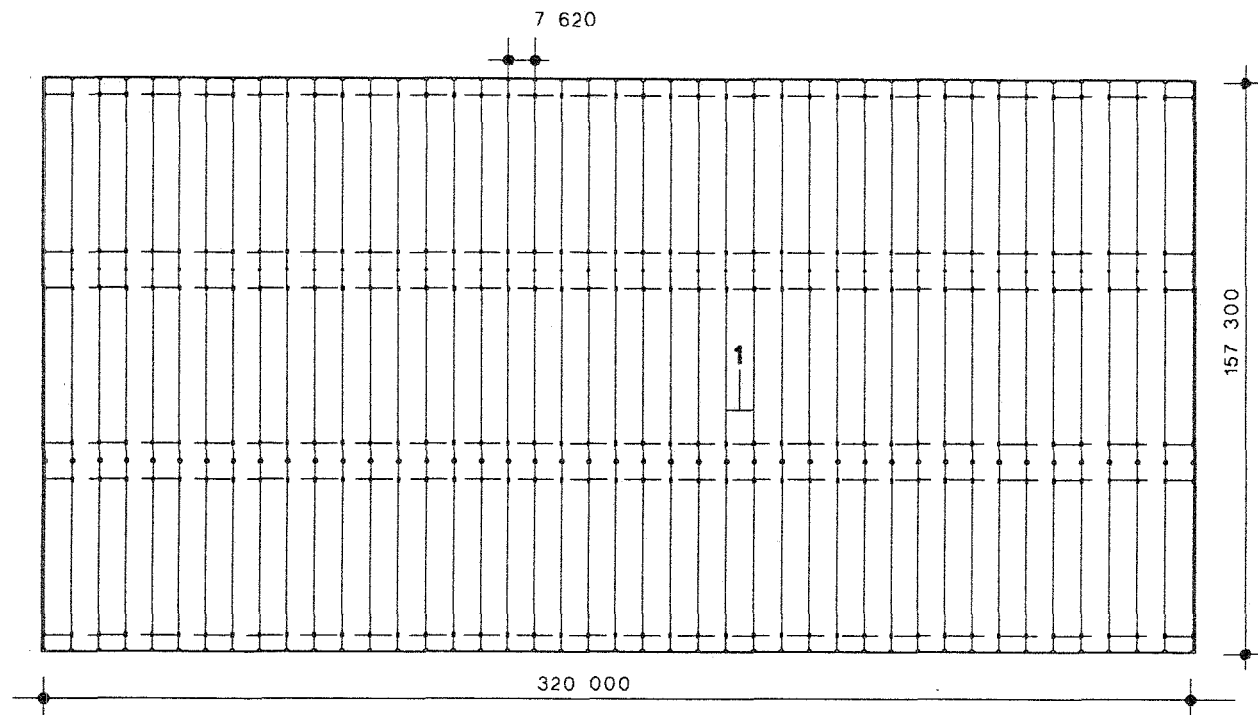
Ralph Symonds' factory, Homebush Bay



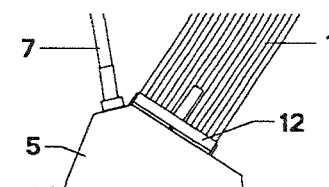
Detail A
Figure 76

Ralph Symonds' factory, Homebush Bay

- 1. 620 x 155 glue laminated radiata arches
- 2. 450 x 100 glue laminated secondary rafter
- 3. 310 x 100 glue laminated secondary rafter
- 4. steel suspension straps
- 5. concrete arch base
- 6. plywood box beam
- 7. 85 dia. steel pipe post
- 8. 290 dia. FC column and downpipe
- 9. 120 x 60 trussed purlins at 1 240 centres
- 10. pipe tie rod
- 11. concrete slab floor on fill

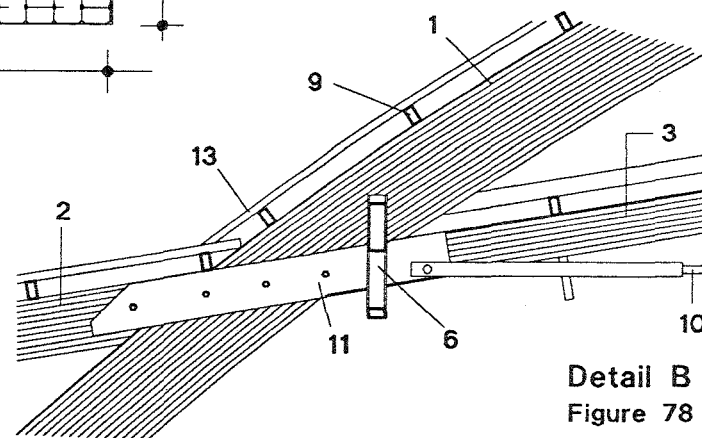


Ralph Symonds' factory
Homebush Bay



Detail C
Figure 79

Plan
Figure 77



Detail B
Figure 78

- 1 620 x 155 glue laminated radiata arches
- 2 450 x 100 glue laminated secondary rafter
- 3 310 x 100 glue laminated secondary rafter
- 5 concrete arch base
- 6 plywood box beam
- 7 85 dia. steel pipe post
- 9 120 x 60 trussed purlins at 1 240 centres
- 10 pipe tie rod
- 11 steel bolting plate
- 12 steel arch base shoe and pin
- 13 sheet metal roof

Exemplar 2. 24

Name of Structure:

John 23rd Chapel

Owners:

John 23rd. College

Address:

Mt. Claremont, Perth, WA

Architects:

Brand Deykin & Hay

Structural Engineers:

Bruechle, Gilchrist & Evans

Builder:

Clough Engineering

Date Constructed:

1986

Structural System:

Trussed beam grid

Description:

The building has a cruciform nave and transept running diagonally across a basic square plan. The nave and transept roofs are similar arrangements of different widths. The nave trusses are at 4.8 m centres and the transept ones at 3.6 m centres. Each consists of two pairs of glue laminated jarrah trusses which have straight top chords and raised bottom chords. These trusses meet to form an interlinking beam grid at the crossing. Steeply pitched rafters spring off the top chord of the truss pairs to form a pitched roof over the nave and

transept. Trussed roof beams are then supported from the bottom chord of the truss pairs to support skillion roofs in the triangle corners between the nave, transept and perimeter walls. The ceilings and walls to the nave, transept and sacristy are all jarrah lined.

Development:

This building is one of many architectural uses of engineered wood that occurred during the Portal Frame Cycle. It draws its form from more regular ecclesiastical structures and uses timber's desirable characteristics in an assured and varied way. The intersecting trusses provide visual strength, direction and complexity while the mellowing colours of the wood in the walls and ceilings blend with the composition of the church.

History:

The building is part of a large college complex that was constructed as a single project. Several of the elements of the chapel repeat in other structures.

The laminated material was supplied by Bunnings Ltd.

Condition:

The building is in satisfactory condition.

References:

Wood World, 1988, *Timber trusses combine strength and sensitivity*, February.



Plate 154. Looking across the transept of the John 23 rd. Chapel. The pitched rafters springing from the top of the trusses are visible in the centre of the photo



Plate 155. Detail of the beam grid joint. The truss chord are pairs of members.
John 23rd Chapel, Perth, WA.



Plate 156. Detail of the jarrah lining to the transept. The rafters to the side skillion roofs are also expressed. John 23rd Chapel, Perth, WA.

Chapter 3

Conclusions

It is important here to restate the aims of this research. They were to begin to establish a repertoire of Australian timber construction by:

- exploring the factors that have influenced the use of timber and timber products as building materials by the design professions in Australia; and
- documenting the extent of practice in long span or structurally unique timber structures in Australia.

This research is only be a beginning because so little non technical research has been done on the construction of timber structures in Australia. By necessity, the information outlined previously represents only the first layers of possible information about the use of timber as a building material in Australia.

However, this thesis concludes that expertise and practice in the construction of long span timber structures has occurred in discrete cycles and that it is possible to establish that:

- there has been significant construction of long span timber structures in Australia but that that construction has been discontinuous;
- there has been significant technical, practical and aesthetic development of long span timber structures in Australia but that that development has discontinuous;
- professional memory of important timber structures has been lost; and
- developed Australian expertise in timber construction has been lost.

As shown above, each cycle described above was a discrete cycle of construction. There does not appear to be any evidence that any of the cycles or the expertise used in those cycles grew out of or was a successor to a previous cycle. With the end of each cycle, the professional application knowledge built up during the cycle was lost. Only once has any of the information from one cycle resurfaced in the literature to be used by another. This was in the Australian Regionalist Cycle of the 1960's. However, they drew more on the ideas of the Rude Timber Building Cycle

rather than the actuality. It inspired them rather than educated them. All the other transitions are more distinct. With new each cycle, everything needed to be repeated. Expertise slowly evolved. Reflective development was practically impossible as successful examples were undocumented or unknown.

An examination of the forms used in each cycle best illustrate this. After the period of apparent stagnation that followed the Timber Bridge Cycle, the Pacific War cycle explored a diverse range of forms based in new timber jointing technologies. This experimentation steadied after 1943 and more regular solutions were employed: trusses, built with both bolts and shear connector joints or nailed joints, were used for simple buildings; parallel chord trusses using bolted shear connector joints were used for medium spans; and nailed box arches were used for long spans. Glue laminated timber was used but not as full building solutions after the National Springs trial. Symonds and Stanley experimented with their glue laminated arch forms as early as 1942 but their work was insignificant compared to the dominant timber construction of the time. With the end of the War, the dominant long span arch forms were abandoned and the accumulated technical, practical and architectural experience of their construction largely lost. There is no evidence that any boxed arch structure has been built in Australia since 1945 while the technical and design information included in the Dept. of Housing and Works' 1946 report appears to be unknown to today's design professionals.

Symonds' three pin glue laminated arch form and Stanley's pier to pier two pin tied glue laminated arch form can be traced directly from both men's earliest work with glue laminated timber construction. While developed during the War, their development was relatively free of the design influences of that conflict. Stanley's buildings in particular are far more sophisticated in aesthetics, construction and amenity than any of the AWC wartime structures. Neither Stanley nor Symonds exploited nailed joints. The Postwar Reconstruction Cycle used glue laminated arches derived from circular arcs for the main structure with bolts and shear connector joints fixing secondary members. Besides the construction in Sydney, buildings of this form were built in Adelaide, Melbourne and in various parts of Queensland.

The Australian Regionalist's stated a connection to the Rude Timber Building Cycle but confined this in actuality to abandoning the arch and curved forms in favour of straight members and to the surface treatment used on exposed timber. Lloyd's Timbers used oregon trusses for their 1962 store even though they had been partners in a large glue laminated arch consortium as late as 1956. The store

used bolts and steel connector plates. Plywood was used for medium span industrial portals and for rectangular and triangular box beams. However, Symonds and Stanley's work with triangular plywood box beams was unknown to the structural designers of McKay's Woden building. They relied more on wartime experience with plywood aircraft. (Bergmann 1993, pers. comm., October). Numerous small and medium span commercial timber buildings were constructed but it was 14 years after Symonds' Homebush Bay factory was opened before another long span arch building was designed and built in Australia. The architects of this cycle developed an aesthetic in timber construction that denied or was in ignorance of the practical engineering forms of the Pacific War Cycle in favour of the historic mortice and tenon truss. This aesthetic still appears to dominate popular perceptions.

Finally, there is no evidence the original practitioners of the Portal Frame Cycle used any of the previous cycles as technical or aesthetic inspiration. Yttrup (1993, pers. comm., 15 March) maintains they designed with timber in a way that made it imitate the construction forms of steel. Gardener (1992, pers. comm., 26 November) readily admits that his steel reinforced glue laminated system is designed to duplicate the appearance and performance of steel members. Nail joints were reintroduced but the experience and aesthetic of war time nailed structures is unrecognised. Today's architects are influenced by the Australian Regionalist Cycle but are constrained through the lack of documentation.

In short, each cycle effectively stands alone in aesthetic and practical development. One can only guess at the repercussions this cyclical discontinuity has had for the practice of timber engineering and architecture and for the professional use of the material as constructive reflection across cycles was effectively impossible. However, this research has shown that Australian designers have had and still demonstrate considerable skill in building with timber. They have produced diverse and successful timber solutions which, when examined and documented, can provide a repertoire of practice upon which a mature and informed design culture of building with timber in Australia can develop.

Chapter 4

Areas for Further Research.

Until now, the use of timber in Australia's industrial and commercial structures has not been systematically explored. Subsequently, no set of accepted concepts or theories exist that explain or describe the patterns outlined above. While this research did not set out to establish these concepts, it was necessary to postulate on theories of action that may explain the evidence found and I record these theories and their supporting evidence here. The following discussion of these theories is in no way complete and indicate further directions in architectural and professional research.

4. 1 The 'democratic' characteristic of timber.

I believe that the patterns of use of timber as a building material in Australia pivot on its two primary qualities:

- the physical character of the material itself; and
- the way timber can be obtained and used.

As wood is an organic material, it has physical characteristics unlike most man made materials and these characteristics vary depending on the species of tree from which the timber was cut. To hold and examine any piece of timber makes some of these evident: timber is directionally grained with uneven strength; hygroscopic; biodegradable; susceptible to shrinkage and deterioration due to water gain and loss, wear, decay caused by fungal and other rot, and white ant and marine borer attack (Wedgewood 1982). These all influence the technology of how timber is used and historically the bulk of timber research in Australia has dealt with them. Considerable literature exists on these topics.

The second quality has not been researched but I believe influences the use of timber in Australia as least as much as its technical characteristics. This quality revolves around how parts of society can obtain and use timber. I describe this as the 'democratic' characteristic of timber in the sense of the Collins (1981) definition of democratic as "for all or most of the people". An examination of the supply, production and use of timber illustrates this concept.

- Supply

The range of ownership of the raw material for timber, trees, and the low capital base required to extract logs from forests mean that the supply of logs to timber producers is varied. Logs are supplied from production forests that cover 21.55 million hectares of Australia's land mass (RAC 1992, p. 87) and they are controlled by a variety of agencies. Individual State Governments own and manage some forests while private companies manage other State forests on concession. Other forests are privately owned. This results in a diverse supply of logs that can not be effectively controlled by any single organisation. This accessibility is reinforced as the means of extracting logs from these forests need not be capital intensive or technically advanced. The most basic requirements include a chain saw and a truck with a simple crane.

- Production

Like the extraction of logs, converting logs into timber and timber products is not necessarily a capital intensive activity. The simplest bush mill produces sawn timber, relying on an old car engine to drive a single bench saw. These millers usually process locally felled logs and serve a local market where the users and producers are often acquainted. At the other extreme, production can be capital intensive. Computerised mills produce kiln dried sawn timber as a commodity traded in an open market in the face of competition from national and international producers. However, both mills produce sawn timber that competes for part of the Australian timber market. While other technologies produce different value added timber materials, such as LVL or glue laminated beams, these products share with sawn timber one basic characteristic: they can be produced with simple equipment if necessary. Only particle boards are an exception as they demand considerable capital equipment in their production. As a result, small producers of timber products can enter and leave the industry with relative ease. This ensures a diverse and potentially fluid range of suppliers.

- Use

Timber is very easy to use. Children in schools as young as four learn rudimentary wood working skill. They nail several small pieces of timber together to make boats, shapes and frames. From this simple beginning, as the user's skill with timber increases, increased quality or quantity of work results. Again, the tools required to work with timber can be very simple and inexpensive, yet effective. It is possible to frame up the roof for a house in timber with only a hammer, a hand saw, a pencil, a bevel and some nails. More expensive equipment may make the work easier or faster but they are not essential.

In summary, in each of these three areas, timber has a 'democratic' characteristic. Everyone is capable of participating in its use if they wish. Every step has a natural diversity of paths and each, from planting the seed to making the artefacts, can be achieved without major capital investment. In the extreme, any individual could carry them out. Logs can be readily accessible from diverse suppliers to the producer and timber and timber products from diverse producers to the consumer. Finally, timber is the one of easiest building materials to use. No part in this process can be effectively controlled without the consent of a wide range of people. In Australia, this control has only been exercised once, between December 1941 and 1945. The effect of this 'democratic' characteristic is substantial. It enhances timber's popular acceptance but compromise quality control in production and professional acceptance.

To date, this 'democratic' characteristic has not been recognised in Australia and there is no discussion of it in any literature. This appears to be because it is not an identifiable technical problem but a theoretical and reflective one and because it appears that the timber industry has only ever funded or supported technical research. I maintain that it is an important factor in the use of timber however, and one that need to be subject to discussion and research far beyond this short essay

4.2 Local Immediacy

The 'democratic' characteristic of timber strongly influences the structure and organisational culture of the timber industry. As outlined above, the size, production and technical capability of timber producers can vary greatly. Historical and statistical examination shows that they have been regional companies with relatively low capital bases. This has lead to a fragmentation of action (common in naturally democratic organisations) and a restriction of view I call **local immediacy**. Local immediacy is defined here as an attitude or a part of an industry culture that is used to judge action and make decisions. Local immediacy holds that for something to be worthwhile, it must be of use here and now and if it isn't, it is not worth worrying about. While all members of the timber products industry do not hold to local immediacy, I believe it influences sufficient people within the industry to affect the quality of the use of timber as a building material in Australia. This is most noticeable in; the retention of a collective memory; the promotion of technical competence into the long term; quality control and research.

Due to the effect of local immediacy, the timber and timber products industry appears neither to maintain a collective memory nor encourage any outside

organisation to preserve one. MacKenzie (1992, pers. comm., 4 December) believes that the industry is an anecdotal industry as nothing is ever recorded or kept. Everything is passed on by word of mouth. Literature searches confirm this. In action, the industry realises on current technical development and competency to ensure its markets and so concentrates on the newest applications and projects in its publications. Even reviews of existing applications or retrospectives of practice do not fit with this pattern as their promotional value is non specific and difficult to quantify. This may be one factor that caused the cycles of timber construction to be forgotten.

Also due to local immediacy, it appears the timber industry has never been capable of promoting professional competence in timber in the long term. While it has continually lauded individual case studies in timber, it has not fostered or recognised continual development. Yttrup (1993, pers. comm., 15 March) believes that there have been cyclical separations between independent professional consultants and their organisations and the timber industry. These could have been due to suspicion of the professions and was in one case at least due to the aloofness of the RAIA. However, Yttrup believes these separations were caused by the reluctance of industry members to trust and work in the long term with anyone they could not control. He believes that there is anecdotal evidence that as the Portal Frame Cycle ended, the industry disentangled itself from the external professional advice and services it sought in better economic times. Local immediacy suggests that this will minimise costs and protect local interests. In the short term, this may be correct. However, as these professionals must develop other specialities to survive, it removes those individuals with the most widespread and independent experience and knowledge in the use of timber as a building material from influencing the long term development of that material. Their experience and knowledge are lost when the next cycle begins or building demand increases. Disentanglement also removes the industry from the concerns of professional organisations and their considerable educational and technical competence. Finally, it strips previous experience of its apparent value. The effects of local immediacy on quality control and research are explored below.

Like the 'democratic' characteristic of timber, the concept of local immediacy does not appear in any Australian literature. However, if the above observation are correct, then it is apparent that the actions brought about by local immediacy have greatly influenced the use of timber as a building material in Australia. To confirm its existence and to clarify its effects, the concept of local immediacy must also be examined and discussed in far more detail than is possible here.

4. 3 The Frames of understanding timber's use as a building material

I propose that differing frames of understanding of timber's use as a building material exist in Australia and that these frames are not explicitly recognised. In his exploration of professional practical knowledge, Schon (1983, p. 309 - 310) explains frames and the importance of their recognition:

At any given time in the life of a profession, certain ways of framing problems and roles come into good currency... When practitioners are unaware of their frames for roles and problem, they do not experience the need to choose among them. They do not attend to the ways in which they construct the reality in which they function. For them it is simply the given reality ... When a practitioner becomes aware of his frames, he also becomes aware of the possibility of alternative ways of framing the reality of his practice. He takes note of the values and norms to which he has given priority, and to those he has given less importance, or left out of account altogether.

I propose that there are two tacitly accepted frames within Australia's culture of timber use, namely:

- a. The frame of the desirable characteristics of timber as a building material;
- and
- b. The frame of the unreliability of timber as a building material.

4. 3. 1 The Frame of Desirable Characteristics

There are numerous and complex reasons why designers and the general public like to use timber as a building material and these provide the base of the frame of desirability. Most are tacitly understood as normal aspects of living and working in Australia. Consequently, the bulk of commentary on them is informal or anecdotal and few of the characteristics are explored within professional literature. This has created a considerable impediment to their understanding and exploitation. I have set out below those which I believe are fundamental to this frame of view. The explanations and arguments for each are not complete and parts of them have been used in the earlier parts of this thesis. However, each section does attempt to define areas that must be researched in greater detail.

Timber In the Built Environment

Timber has two sets of desirable characteristics in the built environment. The first set includes the environmental effects of the material's natural characteristics while the second includes its aesthetic qualities. For architects and other designers of artefacts, timber has tacit aesthetic attractions.

The infinite shape plasticity of modern technology's production, made of materials and forms that deny any self identification in their total commitment to their function, is not easily related to man's experience with living. Instead the knotty, splintery, irregularly dimensioned, warping, shrinking, swelling, directionally grained, uneven strengthened piece of wood expresses better man's grasp on the imperfect realities of life. (George Earle 1969, p. 223)

Many architects regard the design parameters on the application of load imposed by the grain of the material as desirable and as displaying honesty and they recognise the difference timber makes to an ambient environment. Sydney architect, Stewart Whitelaw (1990, p. 16) observed:

Architects love timber. They love the feeling of scale, humanity and the tangible warmth that the use of timber brings to a space. Apart from the effect of natural light, it is difficult to imagine any other design decisions that can so radically alter the feeling of a space.

Perth architect, Tony Brand (1988), recognised this when he used timber in a major religious commission saying that wood has a warmth and intimacy that is ideal in this situation. In both these observations the warmth is a visual appreciation, derived from the colour and texture of the timber as well as an environmental one, implicitly recognising timber's insulating values. The intimacy of timber is also a function of its acoustic properties. It absorbs sound, reducing sharp echoes and giving richness to tones. In describing the rude timber building of Australia's rural and industrial past, Cox, Freeland and Stacy (1980, p. 66) found timber structures:

whose strength, honesty and rightness were qualities missing in the world. The stability and permanence, the unaffectedness and confidence, the personalness and warmth that they had were new and delightful.

Architects' practice demonstrates their understanding of the attractions of timber and its association with the personal comfort and relaxation. John Connell Group (1987, p. 6) found that the building areas where architects used the greatest proportion of timber by value when compared with other materials were in tourist facilities such as hotel motels and restaurants, followed by entertainment / recreation facilities and public facilities such as hospital, libraries.

Timber In Construction.

Timber is a versatile and accessible material for construction. It is usually locally available. It can be bought from known suppliers often connected directly to the miller. It can then be cut, planed, routed or chiselled to the desired shape, either by machine or by hand. Its high strength to weight ratio and its ease of handling make

it an ideal material to frame walls, floors and roofs. Its innate workability means it is forgiving. If the wall frame is marginally too big, a planer can reduce it to size. If it is too small, an extra stud or plate can be nailed on. Timber worked into mouldings allows easy finishing around doors, windows and skirtings. The house construction industry has recognised all these factors and has accepted timber construction, especially light timber framing. 85% of wall frames, 40% of floors and 100% of roof frames constructed in 1986 in Australia were made of timber (National Timber Marketing Committee 1987). Timber and timber products are then used in joinery, doors and personalised aesthetic fittings, such as polished timber floors, panelled doors, solid timber bench tops and timber panel lining. In reality, the Australian image of the brick home is often a timber building with a single brick skin. The use of timber in housing dominates the sale and production of sawn timber in Australia. In 1991, 39% of sawn timber was sold for use in new detached or multi-unit housing. A further 23% of sawn timber was used in alterations and additions to housing (BIS Shrapnel 1991, Table 2. 7).

The characteristics that make timber a desirable construction material for housing transfers directly to the non domestic sector. Timber's high strength to weight ratio can make large scale timber construction simpler than similar steel or concrete construction. An example of this is the series of large scale timber warehouse and store buildings that were constructed during the Portal Frame cycle using the lift-up method of construction. Here the roof of the structure, often as large as 65 m x 30 m, was constructed on the floor slab. All services and roofing were installed before the whole assembly was raised in a single multi crane lift. The columns supporting the roof were hinged to the main horizontal members and folded down as the roof was raised. Similar economic technologies occur all through the history of timber building.

Along with its workability, the physical characteristics of timber can be desirable in specific applications. As some species of timber are naturally highly resistant to rot and corrosion or can be treated to be resistant, wooden structures present cost and maintenance benefits in swimming pools, chemical stores and other high corrosive environments. Timber can also be highly resistant to marine damage and borers making it suitable for pilings. Timber is also more fire resistant than bare steel. Large solid timber member chars at a predictable rate with the charcoal forming an insulating layer that protects an inner core of material. By comparison, steel under heat load loses strength and buckles without warning once the critical temperature is reached (MacKenzie 1986).

Traditional Acceptance of Timber.

The least discussed but possibly the most tacitly recognised characteristics of timber construction is its traditional acceptance. Timber is one of the oldest building materials known to man. It was used to construct shelters at least 400 000 years ago (Leakey 1981, p. 124). In Australia, the tradition of using timber for buildings of all kinds was established when the first white settlers felled the trees around Sydney harbour and used the timber and bark to build their first shelters. Since then, timber buildings and structures have been built all over this country. Cox, Freeland and Stacy (1980, p. 7) hold that these original timber buildings:

have been the mainstay of providing shelter as the continent was explored and settled... Because they were uncomplicated buildings, built by unlettered people in the most direct way, using materials readily to hand, they often have a character and honesty... Because they are made from a material with which everyone has a deep-rooted harmony and because their forms are readily comprehended, they are universal buildings whose roughness and even whose frequent dilapidation give them a powerful and emotional appeal and impact. They are buildings to be felt rather than reasoned.

The association of timber as an established part of Australian building culture and the "deep-rooted harmony" of people to the material have led the public acceptance of timber as a traditionally accepted and favoured building material, especially in private building.

Timber and the Environment.

As stated in the introduction to this thesis, timber has the potential to be a socially and environmentally sustainable building material. The Resource Assessment Commission (RAC 1991, Vol. 1, p. 298) used seven criteria to compare the quantifiable environmental impacts of common building materials. Timber displayed the most favourable or most benign environmental characteristics in at least five of the seven. Timber had the lowest process energy requirements. While recycling of timber was low compared to other building materials, timber was the only material that was renewable and biodegradable. It also had the most benign air emissions of the materials examined. Being renewable, timber has other perceived environmental benefits. Turner (1990, p. 29) observed that:

... expanded plantation areas... coupled with the maximum productivity of timber would give the biggest reduction in atmospheric carbon concentration. Timber products used in building represented long term storage of carbon limited only by

the lifespan of the structure... A wooden framed brick veneer house of 180 m² would store 7.5 tonnes of carbon compared with 2.9 tonnes of extra carbon added to the atmosphere for the same sized steel framed house'.

Environmental sustainability is a much more complex concept than a simple measure of environmental benefit or damage. It recognises that human activity over time and the health of the environment are interdependent and that environmental health has necessary social, political and economic determinants. Sturges (1991, p. 9) detailed a thorough set of criteria for his analysis of the potential sustainability of structural systems. He held in part that:

A sustainable structural system comes from raw materials that:
are abundant and renewable,
are available from sources relatively near the construction site,
utilise a variety of its source material main grades, and
require a minimum of capital intensive production processes.

A sustainable structural system's production processes:
encourage resource efficiency through dynamic and intelligent methods of utilisation,
require capital investment that encourages an optimum balance between informative, human potential and technology,
creates useful by-products, minimal or no waste, no pollutants and no toxicities.

Within its overall architectural life cycle the sustainable structural system:
exists contextually within its building's bioregion
is of a strength and capacity that encourages efficiency in use
is adaptive during its lifetime
has properties of assemblage that encourage owner/occupant potential participation in its design, construction and life,
is durable and reusable, if protected from moisture and decay, but is eventually biodegradable,

The general patterns of the use of timber in large parts of this country fit many of these criteria. However, Sturges (1991, p. 9) also recognises within his criteria that a high level of proficiency is essential for sustainability. Sustainability cannot be physical or intellectually wasteful. This does not appear to be a characteristic of the use of timber in Australia to date. Logically, there is a relationship between the potential economic, social and environmental sustainability of timber and its use as a building material because the building industry, and by inference the design professions that design the buildings and specify the use of materials in that industry, consumes or direct the consumption of 72% of all sawn timber and probably a similar proportion of other high value timber products. If timber is used intelligently and efficiently by the design professions and the building industry as a whole in long life, highly valued and intelligently designed applications then the potential for sustainable technologies to develop is likely to be greater than if the material is wasted in short life span, low value or poorly designed ones.

In summary, timber has the potential to be an environmentally and socially sustainable product and to be the basis for sustainable technologies. However, there are significant real and perceived environmental disadvantages from extracting the raw material for timber in certain circumstances. Whitelaw (1990, p. 16) explains these perceptions.

Most architects feel a responsibility to the environment far beyond the building they are currently designing. Unfortunately, the impact of some design decisions is more visible and more easily understood than others. Timber means cutting down a living tree. Steel means digging up some ore and processing it. Much less traumatic.

This trauma at the sight of chainsaws near trees is real and images do arise of environments being destroyed and wildlife being driven to extinction because of the designer specifying timber. While those who supply the logs may discount or refute these perceptions in particular instances with technical argument, the emotive attachment to nature that causes this reaction is itself one of the bases of the traditional and natural acceptance of timber in building. Further, empirical evidence and everyday examples of environmental degradation reinforce the current and historic images of what appears to be pure exploitative timber getting.

Summary.

Timber's 'democratic', physical and environmental characteristics form the basis for a frame of view that timber is a desirable building material. There is evidence that those that implicitly accept this frame are the general public in private situations and the bulk of domestic designers and tradespeople. Design professionals condition their acceptance. Many architects appear to accept it intuitively for its aesthetic and built environment appeal, using it mainly as a finish or as a small scale structural feature while a small core of engineers appears to accept it for its constructability and its potential environmental benefits.

4. 3. 2 The Frame of Unreliability

I propose that:

- the technical rationalist training of many design professionals;
- the physical characteristics of timber;
- the traditional acceptance of timber;

- the structure of the timber industry; and
- the technical concentration of the industry's research effort;

combine to form a frame of view that timber is an unreliable building material and that this view restricts the use of timber in non domestic applications.

To test this proposal, this paper will first examine why the factors listed above may lead technical rationalist design professionals to regard timber as unreliable and then see if there is evidence that they do.

Schon (1983, p. 23-24) explains the underpinning to a technical rationalist approach and exposes the foundation for the frame.

The systematic knowledge base of a profession is thought to have four essential properties. It is specialised, firmly bounded, scientific, and standardised. This last point is particularly important because it bears on the paradigmatic relationship which holds, according to Technical Rationality, between a profession's knowledge base and its practice.

In approaching a design problem, all design professionals evaluate the known performance qualities of a building material and make judgements about its suitability for a task according to the knowledge of their profession. They judge timber by the standardised criteria of other materials but as we have seen timber and its production is unlike other construction materials.

Unlike man made materials, timber is organic. In Australia, there are almost 600 native structural timbers available (Leicester 1988) besides those imported from other countries. Each has different physical properties and the knowledge necessary to use each one with confidence has been acquired slowly over generations. For some species, this process is still incomplete and their characteristics are unknown or in doubt. Further, each species has a variety of grades that must be defined before the individual pieces can be graded, either visually or mechanically, and sorted. This means that to speak of the characteristics of a piece of timber one really means to speak of hundreds of different possible sets of characteristics. This is unlike steel and concrete where more limited and easily manipulated options are available. A practical consequence of this variety is that when a new timber technology or form of use is developed, it is usually not economically feasible for it to be tested on all species and grades to obtain the standardised results that a technical rationalist discipline requires. As a result, the design professional evaluating timber for a particular task faces numerous gradients of choice or a lack of complete technical information. This encourages uncertainty,

complicates practice and contradicts a tendency for consistency and standardisation. John Connell Group (1987, p. 8) cited the variability of timber as one of the major reasons why professionals were reluctant to use timber in non domestic structural work.

The traditional acceptance of timber also works against its technical rationalist acceptance. Schon (1983, p. 32) notes that, in technical rationalist theories:

... the only significant statements about the world were those based on empirical observation, and all disagreements about the world could be resolved, in principle, by reference to observable fact.

However, the beliefs of a professional's personal practical knowledge can replace empirical fact if they are sufficiently reinforced. This appears to occur with the use of timber. The most durable and effective applications of timber are where it is used internally. Then, often unseen, timber can perform adequately for centuries. However, the most obvious ones are external applications where unprotected timber biodegrades. Here, the traditional acceptance and availability of timber have led to its use as a short term solution, then not replaced, or as a long term one, then not maintained. Commenting about the performance of timber bridges in Queensland, Doak (1935, p. 187) noted that:

Although it is customary to speak of these decrepit old structures with contempt, there was no doubt that they have been an excellent investment... the life (of observed road bridges) must have been 80 years or more.

This recognises that old timber structures subject to the weather look decrepit as they lose colour, go grey and rot around the sapwood. The empirical evidence that timber bridges may outlast their planned economic life by a factor of three is lost while an everyday perception of the unreliability of timber is reinforced. Every split timber fence that has outlived its expected life but remains standing on a lean is a similar reinforcement. This initial perception shapes assumptions of other characteristics. Boas (1936, September, p. 390) noted this as a tendency to be over critical of timber.

No one expects a piece of steel to remain the same length as winter passes into summer, and it is not regarded as a defect that it expands and contracts with changing temperature. Yet people still demand that wood should not alter with changing humidity of the atmosphere.

Another example is the approach to fire. Everyone knows wood burns. They also know that steel does not. They do not know that timber protects itself with a layer of insulating charcoal as it burns and so may maintains some structural strength longer. (MacKenzie 1986)

Quality control and research are the two factors that are essential for timber's acceptance in technical rationalist practice. Quality control is necessary to assure practitioners that the material supplied meets the standards necessary for its satisfactory performance in use. For timber, this is especially important because of the variety of species, grades and suppliers. However, due to local immediacy, the members of the various sectors of the timber products industry have not been able to agree on enforceable quality control standards. Therefore, the quality controls in force in the timber industry at any particular time have only been limited to those which the respective companies were willing to accept. If standards have been set too high by centralised efforts, sufficient members of the industry have abandoned them to rely on demand from their traditional and less discerning users. This can be seen from the level of acceptance of the Australian Hardwood Quality Council (AHQC) in Tasmania. McKenzie (1992, pers. comm., 4 December) estimated that only about 10% of producers supplying about 50% of the hardwood product of the state subscribe to the Council. Smaller timber millers generally do not subscribe. Apparently, similar situation exists in the majority of other industry sectors and states. Only the plywood industry maintains a widely applicable externally verified quality control system. It is supervised by the Plywood Association of Australia. In general, while quality control may exist in particular companies or local industry segments, recognised industry wide quality control for timber producers cannot be said to exist, or ever have existed in either appearance or in fact in the timber industry in Australia. This is adequate for the local immediate situation, limited to local customers. However, it means that quality control can not be automatically guaranteed to professionals whose technical training insists that they have assured standardised quality and who are offered that by other materials.

Local immediacy also governs the type and method of research carried out within the industry. Firms have generally only supported the research effort that they regard as essential for their requirements. Historically, this left long term strategic research to the CSIRO and the State Forestry Commissions. This had benefits. The research was funded by the Commonwealth or State governments and carried out by dedicated professional researchers for the national good. It also had drawbacks as the researchers were not practitioners. They could easily separate their basic work from the application of their research beyond the laboratory gate. This practical isolation raised the problem of who posed the questions to be solved, who received the answers and how those answers were communicated to the practicing professions. In 1976 this practical separation led the *Australian Forest Industries Journal* (AFIJ 1976) to preface its September edition with the headline:

**Research Officers (of the CSIRO) Questioned -
Interviews reveal that a lot of work has already been done,
there is a great need for communication.**

In short, practical and application research concentrated on the areas which CSIRO staff, as non practitioners, thought were important. This was complemented by component research that the timber industry, also non practitioners and with local interests, thought was necessary to market their specific products to technical rationalist professionals or directly to developers. This had two effects. First, as the research could not be targeted in sufficient quantity, it was ineffectual in challenging first the impression and eventually the prejudice that timber may be an unreliable material. Second, it led to other areas of research being neglected. These included:

- application research that took technical results and explored their possibilities in complete and economic structural solutions;
- non technical architectural research which explored the possibilities of form and the aesthetic opportunities of timber; and
- market analysis that enabled the industry as a unit to understand how the professions or the market viewed its product.

As this research was not carried out, it appears that those design professionals who did not follow classic technical rationalist practice were isolated. These professionals, many of them architects, continued to design in timber where they thought appropriate but their opportunity to use the material to its optimum was diminished.

In summary, all these factors appear to work against timber being accepted for non domestic applications controlled by design professional. The technical rationalist training of many design professionals demands consistency and standardisation yet the material is naturally variable and the industry that produces it is fragmented. Being fragmented, this industry has been historically unable to take concerted action on the issues critical to technical rationalist acceptance, such as quality control and research. As a result, a frame of unreliability might be expected to exist. I will now examine any evidence that it does.

First, design professionals do not use timber as much as they could. John Connell Group (1987, p. 6) found that for the architects and engineers contacted, 95% and 91% respectively of their work was non domestic construction. In commercial building, they found that architects use timber on average 3% by value while

engineers used none; in public buildings (hospitals, libraries), architects use 5% and engineers 4%; in entertainment and recreation buildings, architects use 5% and engineers 6%; in industrial buildings, architects use 2% and engineers nil; in Government buildings (Civic Centres etc), architects use nil and engineers nil; and in tourism buildings, architects use 11% and engineers 4%. In some of these applications, the timber use could be restricted to finishes, as in commercial or recreation facilities, or into house sized non domestic buildings, such as small tourist apartments, libraries or the like. In all areas save tourism buildings, the percentage use is so small that it is highly unlikely that timber is being used structurally save in isolated cases. By comparison to building not controlled by design professionals, Rawlinsons (1992, pers. comm., December) estimated that 30 to 40 % by value of a standard home is timber and this increases to 50% if the house has a timber floor. While there is substantial difference between the spans and requirements of the domestic and non domestic sectors, there is also significant difference in the expertise and design capabilities of the practitioners in both fields. If architects and engineers were confident in their use of timber, it is reasonable to assume that its use in structures should be higher than these figures suggest is the case. Baker's (1989) findings support this by removing statutory regulation as a valid reason for not building in timber. He found that of 26 recent major European buildings constructed from timber, only two could not have been built under the NSW building regulations, Ordinance 70. This indicates that major buildings in timber are allowed under Australian regulations and the design technology for them does exist if it is needed. In Australia, however, there does not appear to be the will.

Second, there is a lack of publication. If professionals have confidence in a material then they research its use through practice and publish papers on their findings. Outside the work of the CSIRO and Forestry Commissions and before about 1980, local practitioners published very few papers on timber engineering and most of these were by representatives of various industry supplier groups, such as Gang-Nail. Between 1928 and 1980, only one group of articles has been found to date that was written by a local practicing engineering professional about local achievement in non domestic timber engineering. Malcolm Stanley (1954, March and September) wrote them in 1954 to describe the construction process of the Ceremonial Arches. Possibly less than twenty articles in the Institution of Engineers Australia's *Journal* in the same period touch the topic of timber in building at all. Since 1980 and with the formation of the Gottstein Fellowship and its subsequent scholarships, consulting practitioners have carried out research work in true timber engineering. However, the majority of the Gottstein Fellows

researching this topic have gone overseas to carry out their work and apparently none have carried out work on long term Australian design experience.

Third, there is the shallowness of the known local repertoire in timber compared to the depth of actual Australian experience and the existence of discrete cycles of timber construction. A corollary of a frame of unreliability for timber would be that structures built from that material would be regarded as unreliable and that the practice that produced them would be regarded as unimportant. It would have no part in the recorded repertoire of the profession. Therefore, if a frame of unreliability does exist, one would expect that knowledge of any noteworthy practice would be unrecorded so that eventually it would become common belief that that noteworthy practice had never existed. This thesis has shown that this has been the case. Knowledge of the noteworthy practice of the AWC, Stanley, Symonds and countless others appear to no longer exist within the professional repertoire of current Australian design professionals. The existence of discrete cycles illustrates that this process of disregarding practice has been happening continuously since at least 1942. It also shows how short a time is needed for competent yet isolated professional practice to disappear. Cox, Freeland and Stacy showed no knowledge of Symonds' work less than seven years after his death.

Fourth, if the frames of unreliability and desirability are accepted then it is reasonable to expect that stress and frustration occurs where they meet. In practice, there is evidence that it occurs between architects and engineers when they collaborate on a timber project. Guymer (1993, pers. comm., 27 January) finds this in his practice. He believes tension exists between the disciplines when they design in timber and that structural designers often use the requirements of the codes as a shield to cover their own uncertainty and the apparent over design of timber members.

Finally, there is direct literary evidence. Current design professionals do not actively write against the use of timber in structures. However, companion professions have recorded the prejudice against the values of timber structures that exist. Lewis (1988, p. 3) described it best.

If there is one thing that stands out in any overview of timber structures in Australia, it is that they are poor relations. We have been slow to recognise them and take them seriously. We have not understood them well... We do not know how to treat them. So to speak about prejudice and ignorance in timber conservation is not to criticise conservationists; it is to speak about a prejudice which is general in the community and about a degree of ignorance which is inevitably found... as a result of that community prejudice.

In conclusion, I hold that there is substantial evidence that frames of desirability and unreliability exist side by side within Australia's design professions and that their existence has greatly influenced the use of timber as a building material in this country. If the quality of professional use of timber in Australia is to increase, it is important that the existence and extent of these frames be recognised and they become the topic of detailed research.

Appendix 1.

Database Entries

A. 1. 1 Entries to the Building Database

Each structure entered into the Building Database has a unique coded file name either six or seven characters long. The first character is a letter and denotes the use of the structure. B signifies a bridge, C a commercial building, D a domestic structure, I an industrial building and R a rural structure such as a barn. The second character or group of characters are also letters and identified the state in which the structure was built. ACT signifies the Australian Capital Territory, N represents NSW, Q represents Queensland, SA signifies South Australia, T represents Tasmania, V represents Victoria and WA Western Australia. The next characters are the first numerals and denote the date the building was constructed. A building from the eighteen hundred was numbered with an eight before the year in the century while building constructed in the twentieth century were numbered with the year in the century only. If the year of construction was unknown these numerals were replaced with a dash (-). The last two numerals are a unique and sequential number beginning with 01. The character M is included after military structures.

For example, CSA5501 is a commercial building (C) constructed in South Australia (SA) in 1955 (55) and it is the first structure (01) of this type entered, while CQ4213M is the thirteenth military/commercial structure entered that was built in Queensland in 1942. IN-01 is the first recorded industrial building in NSW whose date of construction is unknown.

A list of all structures entered in the database follows.

File Name:	Structure
Bridges:	NSW
BN87701	Bridge over the Karuah River, Road 101, Monkeria
BN87801	Clarencetown Bridge over the Williams River,
BN88601	Severn River Bridge, North Line, Glen Innes and Tenterfield
BN89301	Shelleys or Junction Bridge, Plains Rd., Tumut
BN89302	Cowra Road Bridge, Cowra, NSW
BN89601	O'Connell Bridge, Fish River, 27 km east of Bathurst
BN89602	Hampden Bridge, Bayliss St, Wagga Wagga
BN89603	Bridge, Inverell
BN89801	Bridge, Morpeth
BN9001	Bridge, Macleay River, Kempsey
BN0101	Lane Cove River Bridge, Sydney
BN0201	Lansdowne Bridge, Mulwaree Ponds, 2 km s of Goulburn
BN0202	Pymont Bridge, Pymont Bridge Road, Darling Harbour
BN0203	Bridge over the MacDonald River, St Albans
BN0301	The Gundagai Road and Rail Bridge Approaches, Gundagai
BN0302	Bridge over the Clarence River, Tabulam
BN0401	Road Bridge, over the Lachlan River, Gooloogong
BN0402	Bridge over the Macquarie River, Dubbo (NE)
BN0501	Bridge over the Macdonald River, Bendemeer
BN0502	Bridge over the Macdonald River, Woolbrook
BN0801	Bridge over the Murray River, Howlong
BN0802	Bridge over Leycester Creek, Lismore
BN0901	Bridge over Pages River, Gundy
BN1101	Sportsman Creek Bridge, Lawrence, NSW
BN6301	Pedestrian Bridge, Thredbo
BN9101	Pedestrian Bridge, Umina High School, Umina
BN-02	Vehicle Bridge, Perisher

Bridges:	QLD
BQ87302	Alligator Creek Bridge, Near Yaamba,
BQ88001	Macleay Bridge, Over Logan River on the Beaudesert Rd.
BQ88101	Splitters Creek Bridge, West of Bundaberg
BQ-01	Queensland Railway Footbridges, Queensland

Bridges:	SA
BSA87601	Angle Vale Bridge, Gawler

Bridges:	VIC
BV86501	Goulburn River Bridge, Nagambie
BV89501	Hopkins River Bridge, Warrnambool
BV1601	Trestle, The Orbost Line, Nowa Nowa
BV3901	Noojee Trestle Bridge, Noojee
BV7501	Plenty River Bridge
BV8201	Ellwood Canal Pedestrian Bridge, Marine Parade, Ellwood
BV8901	Pedestrian Bridge, Merri Creek, Brunswick
BV-01	Walmer Street Footbridge, Walmer Street, Kew
BV-02	Mordialloc Creek Pedestrian Bridge, Mordialloc.

BV-04 Forest Road Pedestrian Bridge, Ferntree Gully

Bridges: WA

BWA86501 Busselton Jetty, End of Queen St, Busselton

Commercial:ACT

CACT2701 CSIRO Div. of Forestry and Forest Prod., Yarralumla

CACT2702 Old Parliament House, Parliament Square, Canberra

CACT6301 Exhibition Kiosk, Regatta Point, Lake Burley Griffin

CACT6901 Woden Food Services Building

CACT8801 Parliament House, Capitol Hill, Canberra

Commercial:NSW

CN84001 Morrowlga Woolshed, Yamble

CN85101 'Gostwyck' Woolshed, Uralla

CN87901-L Sydney Exhibition Hall, Botanical Gardens, Sydney

CN1001 NSW Government Offices, Moree

CN4001M Bellman Hangars, Location Unknown

CN4201M AWC Glue Laminated Factory, Location Unknown

CN4201P National Springs Factory, 52 O'Riordan Rd, Alexandria

CN4202M Albury AWC site, Albury

CN4203M Bathurst AWC Site, Bathurst.

CN4204M Botany AWC Site, Botany.

CN4205M RAAF No. 6 Stores Depot, Dubbo.

CN4206M Musselbrook AWC Site, Musselbrook

CN4207M Oaklands AWC Site, Oaklands

CN4208M Rutherford AWC Site, Rutherford

CN4209M St Marys AWC Site, St Marys

CN4210M Tocumwal Airport, Tocumwal

CN4211M Wagga Wagga AWC Site, Wagga Wagga

CN4212M Williamstown RAAF Base

CN4213M RAAF No. 2 Stores Depot

CN4214M Naval Stores, Rydalmere

CN4301 Alan Crook Electrical Co. Factory, Unknown, Sydney

CN4601 Ralph Symonds Ltd Factory, Burrows Rd., St Peters

CN5001 Symonds' Laminated Transportable School Buildings

CN5002 Larke Hoskins Factory, Riley St, Surrey Hills

CN5201 C. C Engineering Building, Granville

CN5301 Larke Hoskins Factory, Cosgrove Rd., Enmore

CN5302 Clark Kilns Building, Sydney

CN5303 Her Majesty's Ceremonial Arches

CN5401 Elder Smith and Co. Building, St Peters

CN6201 Forbes Golf Club, Forbes

CN6301 St Andrews Presbyterian Agricultural College, Leppington

CN6401 Recreation Hall, Lidcombe State Hospital, Lidcombe

CN6402 Dobroyd Point Aquatic Club, Rodd Point

CN6501 Gateshead High School, Newcastle

CN6701 Tocal College, Paterson

CN6801 Presbyterian Church, Manilla

CN6901	Gosford Shire Library, Gosford.
CN7201	Middle Harbour Yacht Club
CN7301	Sydney Opera House, Bennelong Point, Sydney City
CN7401	Valla Park, Coffs Harbour.
CN7501	Auburn Indoor Swimming Centre, Auburn.
CN7601	Orange Agricultural College., Orange
CN8401	NSW Forestry Commision Library, West Pennant Hills.
CN8402	Forestry Comm. Regional Offices, Thurgoona, Albury
CN8701	Dalgety Pavilion, Sydney Showground
CN8702	Carlton Clydesdale Building, Sydney Showground
CN8801	Manning Valley Tourist Information Centre, Taree
CN9001	Enmore Swimming Pool, Enmore
CN9002	Big Hammer Building Supplies, News Rd., Lambton
CN-01	Quakers Hill Uniting Church, Highfield Rd, Quakers Hill
CN-02	St Stephen's Anglican Church, Thirlmere
CN-04	Bond Stores, Newcastle
CN-05	Finger Wharf, Woolloomooloo Bay, Woolloomooloo
CN-06	Universtiy Union Buildings, University of Newcastle
CN-07	Condenser Units, Camden
CN-09	Forestry Commission Offices, Pennant Hills
CN-10	University Union, University of Newcastle

Commercial:QLD

CQ87101	St Augustine's Church, Leyburn,
CQ1201	Perry House, Cnr Albert and Elizabeth St, Brisbane
CQ1501	All Saints Church, Tambrookum
CQ2001	Woolstores, Macquarie St, Newfarm, Brisbane
CQ42-401	World War 2 Military Structures, Brisbane and Qld
CQ4202M	Archerfield Airport, Brisbane
CQ4203M	Atherton AWC Site, Atherton
CQ4204M	Breddan AWC Site, Breddan
CQ4205M	Charters Towers AWC Site, Charters Towers
CQ4206M	Charleville AWC Site, Charleville
CQ4207M	Drayton AWC Site, Drayton
CQ4208M	Harristown AWC Site, Harristown
CQ4209M	Garbutt Airport, Townsville AWC Site, Townsville
CQ4210M	Tolga AWC Site, Tolga
CQ4211M	Rockhampton AWC Site, Rockhampton
CQ4212M	Swan Hill AWC Site, Brisbane
CQ4213M	Wallangarra AWC Site
CQ5401	Cairns tied arch building, Cairns
CQ6801	Brandon Timber Hardware Centre, Coopers Plains
CQ7401	Mt Gravatt Teachers, Brisbane
CQ7501	Jindalee Hotel, Brisbane
CQ8401	St Paul's Lutheran Church, 236 King St Caboolture
CQ8701	Gladstone Harbour Ferry Terminal, Gladstone
CQ8801	Biloela Police Citizens Youth Club, Biloela
CQ8901	Kawana Community Centre, Nanyima St, Buddina
CQ9001	Twin Waters Resort, Sunshine Coast

CQ9002	Speculative House, 2A Thomsen Terrace, Buderim
CQ9101	Kingfisher Village, Fraser Island
CQ-01	Forestry Training Centre, Bruce Hwy., Gympie
CQ-02	Hyatt Coolum

Commercial:SA

CSA5501	Laminated Timber Products Factory, Hanson Rd., Adelaide
CSA5502	Laminated Arch Factory, South East SA
CSA6201	South Parkland Restaurant
CSA6401	The Arkaba Hotel / Motel, Adelaide.
CSA7101	Uni. Union Buildings, Adelaide University, Adelaide
CSA7301	Ascott Park Primary School, Adelaide
CSA8701	Elizabeth Aquadome, Adelaide
CSA8702	Olympic Sportsfield, Adelaide
CSA9101	Big Potato Restaurant, Main North Rd., Prospect
CSA-01	Pickwick's Restaurant, Stonyfell Winery Complex, SA

Commercial:TASMANIA

CT4201M	Derwent Park Slips and Store buildings, Hobart
CT7301	Devonport War Memorial Swimming Centre, Devonport
CT8901	Shearwater Country Club, Port Sorrel
CT9101	Clennet's Mitre 10, Huon Hwy, Huonville

Commercial:VIC

CV87901	Royal Exhibition Building, Nicholson St, Carlton
CV2301M	RAAF Williams, Laverton and Point Cook
CV4201M	Albert Park AWC Site, Albert Park
CV4202M	Bandiana Milpo, Bandiana
CV4203M	Broadmeadows Military Camp, Camp Rd., Melbourne
CV4204M	Flemington AWC Site, Melbourne
CV4205M	Seymour AWC Site, Seymour
CV4206M	Werribee Sewerage Farm Stores, Werribee
CV4207M	Spotswood AWC Site, Melbourne
CV4208M	RAAF No. 1 Stores Depot, Melbourne
CV4601	Glue Laminated Arch Building, Melbourne
CV5801	Beechams and Company Factory Buildings
CV6601	Aboriginal Advancement League, Melbourne Rec. Centre
CV6901	Sentimental Bloke Hotel.
CV6902	Harold Holt Memorial Swimming Centre, Malvern
CV6903	Preshil School, Kew
CV8401	St Johns Anglican Church, Upper Beaconsfield
CV8601	Dinner Plain Ski Village, Dinner Plain
CV8701	Tradesman's Entrance Hardware Store, Tullamarine
CV8702	Timber Component Merchand. Centre., Bayswater
CV9001	Brambuk Cultural Centre, Halls Gap, Grampians Nat. Park
CV9002	Carpentry Training Room, Dandenong TAFE Campus
CV-01	Paint. Build, Bundoora Campus, Phillip Inst, Melbourne
CV-02	Bowen Timber and Hardware Store, Hallam
CV-03	Box Hill Arts Centre, Station Street, Box Hill

CV-04	Lake Tyers Aboriginal Centre, Lake Tyers
CV-05	Jubilee Park Swimming Complex, Hillcrest Rd, Frankston
CV-06	Timber Industry Training Centre, Moore St, Creswick
CV-07	Box Hill Swimming and Recreation Centre, Box Hill
CV-08	Castles Timber and Hardware Complex, Sale
CV-09	Centenary Swimming Complex, Turnbull St, Collingwood
CV-10	Rainforest Centre, Orbost
CV-11	Conference Centre, School of Forestry, Creswick
CV-12	Dharrya Centre, Barrah Forest, Barrah

Commercial:WA

CWA87901	St George's Cathedral, St George's Terrace, Perth
CWA1001	Perth Modern School, Subiaco
CWA4201M	Nungarin AWC Site, Nungarin
CWA4202M	Maylands AWC Site, Maylands
CWA6701	Vasse Hotel, Busselton, Perth
CWA8001	Houhgtton Winery, Dale Rd., Middle Swan
CWA8501	Eastern States' Bookmakers Ring, Ascot Races, Perth
CWA8701	John 23rd Chapel, John 23rd. College, Mt. Claremont
CWA8901	Karri Valley Resort, Lake Beedulup, Pemberton

Domestic: QLD

DQ8701	Camp Island Residence, Camp Island, QLD
DQ-01	Carpenter Hall House, Wilston, Brisbane
DQ-02	Russell Hall House, Mons via Buderim
DQ-03	McDonald House, Mapleton
DQ-04	Murtagh / Kershaw House, Moffat Beach (Calandra)

Domestic: TASMANIA

DT7101	Woolnorth Homestead, Van Dieman Land Company Lease.
DT--01	Pole Frame House, South of Hobart

Domestic: WA

DWA89501	House, 11 Saladin St, Swanbourne, Perth
DWA0101	House, 36 Devon Rd., Swanbourne, Perth
DWA9101	Frank Young Houses

Industrial: NSW

IN5901	Ralph Symonds Factory, Bennelong Rd., Homebush Bay
IN8601	Bowmans Timber Warehouse, Seven Hills
IN8701	Weyerhaeuser (Australia) Plant, Homebush Bay
IN8901	CSR Wood Panel Store, Jepsen Ave, Tumut
IN9101	Factory Building, Cardiff
IN-01	Wheat Silos, Railway Yards, Junee
IN-02	Euchuca Wharf, Murray River Bank, Euchuca
IN-03	Portal Building, Cardiff, NSW

Industrial: QLD

IQ8601	Rockhampton Pool Maintenance Service Warehouse
IQ9001	CSR Softwood Factory, Caboolture

IQ9002	Hyne's Sawmill, Tuan
IQ9201	Pacific Salt Storage Sheds, Port Alma
IQ9202	Perma - Log Drying Area, Potassium St, Narangba.
IQ9203	Hyne's Board Shed, Tuan
IQ-01	Jinina Fire Tower, Jinina Forest.

Industrial:	SA
ISA88001	Chateau Tiblick, Near Murray River, Nagambie
ISA6301	Lloyds Timber Mills, Port Adelaide
ISA8801	Scrimber Inter. Warehouse, Jubilee Highway, Mt. Gambier
ISA8802	Softwood Holdings Factory, Mt. Gambier
ISA-01	Seppelfield Winery, near Goulburn River, SA

Industrial:	VIC
IV8201	Cooling Tower, Yallourn Power Station
IV8701	Campbellfield Industrial Units, Campbellfield
IV8901	Dale Glass Industries Factory
IV8902	Drewer Timber Component Factory, Hallam
IV9001	Le Messurier Timber Co. Warehouse
IV-01	Bruce Hutchins Twin Portals; 68 m

Industrial:	WA
IWA0601	Railway Water Tower, Forrest St, Cunderdin
IWA3501	Fire Lookout Tower, Kirup State Forest.
IWA7301	Cape Cuvier Storage Building, Texada Mines, Caper Cuvier

Rural: NSW	
RN87901	'Belltrees' Wool shed.

Rural: VIC	
RV84301	Warrock Homestead, Via Casterton

A. 1. 2 Entries to the Practitioner Database

Addison Yeates Pty Ltd., Architects, Gregory Terrace, Spring Hill, Qld.
Baker, Phillip, Architect, NSW Public Service, NSW.
Brand, Anthony, Brand, Deykin and Hay, Architects, Perth, WA.
Brand Slater, Architects, Qld.
Clare, Lindsay, Architect, Mooloolaba, Qld.
Dickson, Robert, Architects, North Adelaide, SA
Dods, Robin, Architect, Qld.
Donnelley, Warwick, Engineers, Arcadia.
Forrest, Peter, Architect, Paddington, Qld.
Guymer Bailey Architects, Fortitude Valley, Qld.
Hall, Peter, Architect, Hall, Bowe and Webber, NSW
Hall, Russell, Architect, Qld.
Hutchins, Bruce, Engineer, Victoria.
Jepsen, Dan, Engineer, Cotton Tree, Qld.
Law, Peter, Engineer, Auburn, NSW
Lembke, Conrad, Editor, AFIJ
McLeod, David, Engineer, Marybrough, Qld.
Manning, James, Royal Engineers Dept, WA
Miller, John, Engineer, Timber Engineering Group.
Parry and Rosenthal - John Taylor, Architects, West Perth, WA
Pierce, James, Structural Engineer, Brisbane, Qld.
Phillips, D. G., Engineer, Connell Wagner, . Adelaide, SA.
Proves, Brian, TDA of SA, Ashford, SA.
Stuart Whitelaw and Rolfe Chrystal, Architects, Sydney, NSW.
Van Der Meer, Jim, Engineer, Northbridge. WA
Ytrup, Peter, and Associates, Engineers, Melbourne

A. 1. 3 Sample Building Database Entry

Name: NSW Forestry Commission Library
Address: Castle Hill Rd.
Town: West Pennant Hills
State: NSW
Access Descriptors: Braced Post and Beam Structure;
Laminated timber
Designed Function: Library
Present Function: Library
History Of Use:
Date Constructed: 1984
Designed By: NSW Public Works; L. Glendenning and P. Baker
Designer's Address: Sydney
Engineered By: Tosich Constructions - Engineering Division.
Engineer's Address: Sydney
Constructed For: NSW Forestry Commission
Constructed By: Tosich Constructions P/L
Construction Cost: \$500,000
Construction Method:
Floor System:
External Wall System:
Internal Wall System:
Ceiling System:
Roofing System:
Other Principal Timber Components:
Author:
Title: Wood World
Publisher: NAFI
Date: 1986
ISBN:
Text: In November 1984, a new library was added which now holds one of the most valuable and comprehensive reference collections on forestry and forest products in Australia. The Wood Technology and Forest Research Division buildings are set deep within the maturing regrowth forest and with the addition of the library structure they now encircle a native garden and lawn area. The main buildings have essentially utilitarian interiors befitting their functions such as laboratories, workshops and an administrative centre. But particular care was

given to the design and detailing of the new library which now displays a certain elegance and spaciousness.

The functions of the library are organised around a large fan shaped room which opens towards the forest. A series of ancillary rooms - conference room, files, book stacks, amenities - wrap around this spacious main room.

Covered walkway, framed in tallowwood, links the library to the adjacent WT and FRD administration building.

The main open area which houses the main reference collection and the reading carrels are a butterfly roof which is supported in an intricate post and beam structure braced with fine steel rods. All the visible post, beams and angle braces are of dressed glue laminated brush box. The main walls of this room are in cavity brick while for the smaller ancillary rooms, radiata pine has been used for load bearing walls and roof framing. External cladding is of vertical fixed rough sawn tallowwood protected with a neutral base oil stain. Window joinery, which features a 5600 mm high window wall facing the forest is of Tasmanian Oak protected by a light organic preservative (LOSP) and finished externally with a light oil stain and clear acrylic finish. Internally the library floor is polished T and G brush box with yellowwood (*Flindersia xanthoxyla*) contrasting strips to accommodate changes in direction of the boards. Ceilings are T and G v joint Tasmanian Oak boarding; Wall lining and built - in fittings are mainly Tasmanian oak faced plywood.

Extras: Photos; plans; details

Author :

Title: Library will feature Australian Grown Timber

Publisher: AFIJ

Date: July, 1984. p. 43

ISBN:

Text: General Press release information.

Extras: Model photos

Author: Andrew Dunn

Title: Reference

Publisher:

Date: May '92

ISBN:

Text: interesting use of connections and species of timber.

Extras:

Author: Graham Holland

Title: Reference

Publisher:

Date: May '92

ISBN:

Text: Quality of Design and detailing,
demonstration of timber usage.

Extras:

Author: Phillip Baker,

Title: Reference

Publisher:

Date: May '92

ISBN:

Text: Moderate span hardwood structure prefabricated in
workshop. Project demonstrated that high quality environment could be created
using wood as the principle cladding, lining and structural element for a cost
competitive with other methods.

Extras: Literature, photos, drawings,
including working drawings.

Current Owner: Forestry Commission of NSW

Contact Person: Jenny, the Librarian

Phone No: (02) 872 0100

Postal Address.

Reference Person: Andrew Dunn, TDA of NSW

Phone No: (02) 360 3088

Postal Address:. 13 Nichol St Surrey Hills

Reference Person: Dr. Graham Holland, Dept. of Architecture,

Phone No: (02) 692 3858

Postal Address: Uni. of Sydney, Darlington, 2006

Reference Person: Phillip Baker, Public Works of NSW

Phone No: (02) 372 8500, (02) 372 8541 (fax)

Postal Address: GPO Box 5280 Sydney, 2000

A. 1. 4 Sample Practitioner Database Entry

Name: Phillip Baker
Address: NSW Public Works, 2-24 Rawson Pl, Sydney
Field of Practice: Architecture
Access Descriptors:
Practicing: Yes
Qualifications:
From:
Date of Birth:
Date of Death:
Building Reference No. CN8401
Building Name: NSW Forestry Commission Library,
Location: West Pennant Hills.
Item: Bathurst Police Station
Location: Rankin St Bathurst.
Function; Past and Present: Police Station
Date Constructed:
Others involved:
Construction Notes:
Design Notes: Timber in the building helps promote the image of
community based policing.
Author: Andrew Dunn
Title: Reference
Publisher:
Date: May '92
ISBN:
Text: Design Forestry Commission Library and a number of other
structures.
Author: Phillip Baker,
Title: Reference
Publisher:
Date: May '92
ISBN:
Text: Success in incorporating wood in major Government
Projects for both structural and fabric components. Demonstrated ability to use
wood in a way which makes it cost competitive with other materials.
Domestic Notes:
Development Notes:
Professional Notes:

Reference Person: Andrew Dunn,
Organisation: TDA of NSW
Phone No: (02) 360 3088
Postal Address: 13 Nichol St Surrey Hills
Reference Person: Phillip Baker,
Organisation: Public Works of NSW
Phone No: (02) 372 8500, (02) 372 8541 (fax)
Postal Address: GPO Box 5280 Sydney, 2000

Appendix 2

Survey Forms

Covering Letter

Dear (recipient name),

The Department of Architecture of the University of Tasmania is developing a specialist program in Timber Architecture Technology with the support of seeding funds from the Federal and Tasmanian Governments. As part of this development, I am undertaking a Research Master of Architecture with the School into developing an evaluative overview of timber usage and jointing in buildings in Australia.

The first step in achieving this is to compile a list of those buildings or structures which are regarded by those involved with the material professionally as architecturally, structurally or historically important in their use of timber, either as a major structural component or as the dominant material of the building's fabric. I ask for your support in this study by sharing your experience and knowledge in timber design.

Please find enclosed copies of two different questionnaires.

In the first questionnaire, I ask that you think of, say, three buildings that, in your opinion, exemplify timber usage in buildings in Australia. The buildings can be from any time period since European settlement till the present but must have been constructed within Australia. Complete one copy of the questionnaire for each building with the amount of information you can readily supply.

If you wish to include more than three buildings, please do so.

In the second questionnaire, I ask you to think of one person who has made a major contribution to the development of timber usage in buildings, either as an architect, as a engineer, or as a builder.

Again, complete the questionnaire with the amount of information you can readily supply and if you wish to include more than one practitioner, please do so. Please return the completed questionnaires in the envelope provided or by fax to the above number by May 8.

I believe your assistance in this research will contribute to the increased appreciation throughout the profession of the true capacities of timber in Architecture in Australia. It is hoped that results will be published early next year.

Yours Sincerely,

Gregory B. Nolan
B. Arch (Hons)
22 April, 1992

Timber Building Questionnaire 1

School of Architecture, University of Tasmania

Please photocopy this original and complete one questionnaire for *each* building.

Please fill in as many sections as you can.

The Building:

Building Name:

Address:

..... Postcode:

Present use:

Designed By:

Why is it important ?

Quality of Design; Innovation of usage; Quality of Workmanship, Historic Significance etc. Attach an extra page if needed.

.....
.....
.....
.....
.....
.....
.....

Who Owns the Building?

Current Owner:

Phone No.: (.....) Fax No.: (.....)

Additional Information

Is there any additional information you can supply about the building: photos, plans, literature references, etc.? Please list what you have available or know is available from others.

.....
.....
.....
.....

Your Details

Name:

Organisation:

Address:

Phone No: (.....) Fax No: (.....)

Timber Practitioner Questionnaire 2

School of Architecture, University of Tasmania

Please complete one questionnaire for each Practitioner. Fill in as many sections as you can.

Who is it ?

Practitioner's Name:.....

Principal Address:

..... Postcode:

Field of practice:

Why are they important ?

Quality of Design; Innovation of usage; Quality of Workmanship, Historic Significance etc. Attach an extra page if needed.

.....

.....

.....

.....

.....

Important Building Works

Include buildings or structures you believe of note.

Building Name:

Address:Postcode:

Use:

What is important about the building ?.

.....

.....

Building Name:

Address:Postcode:

Use:

What is important about the building ?.

.....

.....

Your Details

Name:

Organisation:.....

Address:

Phone No: (.....).....Fax No: (.....).....

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