"THE INVOLVEMENT OF STRUCTURAL ENGINEERS IN RESIDENTIAL CONSTRUCTION IN AUSTRALIA".

Các kỹ sư kết cấu đốn hết sức lực cho xây dựng nhà ở của Australia

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1. INTRODUCTION

Traditionally structural engineers have not played a significant role in the design and construction of low rise residential structures in Australia. These structures constitute the majority of housing stock and the designs have primarily been based on a trial and error process. Recently, greater engineering input has been incorporated in the process through:

- foundation design;
- deemed to comply tables for size selection; and
- design for cyclonic conditions.

The need to reduce infrastructure costs is leading to denser population criteria in our urban design which in turn has led to the development of new innovative designs and forms of residential accommodation that require dwellings to be engineered.

The regulatory authorities for residential construction (ie State Government regulations as administered by Local Government) require confirmation of rigorous compliance conditions by professionals. Particularly for new innovative products.
2. FORMS OF RESIDENTIAL CONSTRUCTION

In Australia the major forms of residential construction are:

- **Single family dwellings**
  Traditional forms of construction are typically either:
  - timber framed structures clad with brick veneer or sheet cladding such as weatherboards; or
  - full brick construction comprising double brick skins.

Less common forms of construction such as adobe construction are also used.

Roofs may be pitched or flat and covered with tiles, (clay or concrete) or steel sheeting. Internal walls are generally lined with 10 mm thick gypsum boards. 13 mm thick gypsum boards may be attached to battens spaced at 600 mm to form a ceiling.

**Three or four storey flats**

Three or four storey flats usually incorporate thirty to forty two or three bedroom units per block. The structural form is dominated by concrete construction due to fire regulations and the need for fire rating.

Older flats were constructed from cast in place reinforced concrete comprising beams, columns, and suspended floors. Brick infill panels often formed the outer walls. New units are being constructed with the aid of extensive prefabrication of panels.

*Conversion of high rise developments to residential dwellings*

In the late 1950s a series of prefabricated multi storey, high density high rise flats were constructed as public housing in Australia. These fully engineered structures were structurally adequate but have been socially unacceptable. This deterred the construction of high density residential properties until recently. A new wave of inner city high rise residential properties are currently being developed as luxury apartments. The stimulus for these developments started with a gross over supply of office accommodation that was able to be converted to residential use.
acceptance of these new apartments has seen the development of new structures to meet the growing demand.

3. STANDARDS & REGULATIONS

Procedure for planning and design residential structures

* Architect - organises concept, design and documentation
* Approval - Local authorities in accordance with Building Code of Australia & Local government bylaws

For conventional construction contracts, the structural engineer is not involved in single dwelling structures if the structure is of a standard form where member sizes and design requirements can be obtained from deemed to comply standards. Therefore, the structural engineer is only involved if compliance is to be demonstrated, eg, exceptionally long beam, renovations, unusual loading conditions etc. For other forms of residential construction, such as high rise, full engineering designs are required with structural engineers working closely with an Architect.

Alternatively, design and contract contracts can be employed where the contractor will fulfil both design and construction functions. This technique is often used by large project builders where minimal construction time and efficiencies of scale can be realised for cost effective solutions.

To ensure a high standard of construction that complies with best practice a wide variety of structural standards have been developed. Material standards ensure the quality of materials used, design standards to ensure the safety and serviceability of the structure, and for single family dwelling there are also deemed to comply standards where the appropriate design can be obtained without first principle computations being undertaken.

For traditional forms of construction the building control is based primarily in area of fabrication. These design and construction techniques have been well proven over many years, being formalised in the deemed to comply standards. A technical infrastructure exists that allows the evaluation, appraisal and certification of designs which are outside the limits of current practice for construction and building products.

In Australia many new innovative products are currently being developed. To ensure quality, without deterring or impeding innovation, performance standards are being
developed. These performance standards typically describe the performance requirement of the product without prescribing the method of achieving the performance level requirements of the standard. This provides the designer with a high level of creative freedom and the associated responsibility to comply with the performance specification.

The responsibility for final approval of design and construction once rested with the local government authority, represented by their building surveyor. The duty of the building surveyor included the verification that the building complied with all current standards and regulations. Recently the industry has changed to a system where the certification can be carried out by experienced, registered professionals.

4.0 CONSTRUCTION PROCEDURE

Building construction is in Australia based on the extensive use of sub contractors. The construction of a typical single storey residence involves the following activities:

- Excavations;
- Concreting;
- Bricklaying;
- Carpentry and Joinery;
- Roofing;
- Plumbing;
- Electrical;
- Plastering;
- Wall and Floor Tiling;
- Glazing;
- Painting; and
- Landscaping.

The use of different specialist sub-contractors for these tasks provides great flexibility and has proven itself to be most cost efficient. It enables efficiency of scale, a high degree of expertise, and completion to drive sub contractors involved in the residential building industry to deliver a high quality product for a very competitive price.

The competitive price of Australian houses has been noticed by the Japanese as is typified by Mr Kenichi Ohmae [1], a former head of the McKinsey management consulting group in Japan when he stated:
"The Australian price for building a house is one-fourth that of Japan's and Australia is twice as competitive as the Americans."

Relative costs to build a single storey residence are presented in Table 1.

<table>
<thead>
<tr>
<th>Country</th>
<th>Approximate Cost (per square meter)</th>
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<tbody>
<tr>
<td>Japan</td>
<td>A$1,600</td>
</tr>
<tr>
<td>USA</td>
<td>A$800</td>
</tr>
<tr>
<td>Canada</td>
<td>A$600</td>
</tr>
<tr>
<td>Australia</td>
<td>A$400</td>
</tr>
</tbody>
</table>

In addition to the benefits of Australia's sub-contract system, prefabrication of components is used extensively to minimising the need for expensive site labour. For example, trusses, wall framing and window/door assemblies are manufactured and transported to site in modular form. Internal walls comprise sheet gypsum board. This board provides a straight, flat surface ready for finishing.

5.0 DETAILS OF INNOVATIVE SYSTEMS

There is a trend to incorporate the positive features of the three major forms of residential construction, (single dwellings, three or four storey flats and high rise developments) into new residential developments. The use of prefabricated components and sub-contract labour is now being used in all areas of building construction. Structural engineers have developed new techniques and design to meet the needs of industry.

A good example of this is the use of cold formed steel as a framing material. Cold formed steel framing currently accounts for a significant and increasing proportion of the nation's domestic framing market and has great potential for overseas export. It is easy to assemble, lightweight, and stacks into a small volume for storage and transport purposes. It does not swell or rot and is not susceptible to borer attack. Steel is proving to be a viable construction material to timber.

Advantageous features of cold-formed steel include the consistency and accuracy of profile dimensions obtained using the roll-forming process, the infinite variety of profile
shapes which can be formed and the high strength to weight ratios which can be achieved by the use of thin material. Galvanized or precoated materials are normally used to minimise corrosion. All conventional connection methods can be used and in addition a wide variety of special types of jointing such as clinching are often employed.

The current performance of cold formed steel framing is well understood [2], [3] & [4]. Structural engineers are currently researching the possibility of refining their designs to take advantage of system effects and the increased stiffness from secondary load paths.

The use of tilt-up construction has increased significantly recently with the advent of proprietary lifting and accessory equipment, [5]. A variety of architectural treatments allow designers to enhance the basic economic advantage of this system with a variety of finishes such as painting and different textures. Panels are designed to allow lifting by available cranes. Connections are designed to ensure that a series of panels act as a single structural entity whilst allowing movement. Junctions are made waterproof and where required, fire rated. The use of precast concrete panels is also popular where the benefits of a controlled casting environment can be used.

Australian constructors have developed their own specialist techniques for the construction of high rise developments. In such cases structural engineers work closely with the constructor to harmonise the final design with the constructors preferred construction technique. Typical forms include:

- Full concrete construction. A concrete core is cast with the aid of jump or slip forms. Floors and beams are cast in situ with the aid of table forms that are able to be lifted from floor to floor. Floors may also be cast with the aid of steel decking to form steel concrete composite floors.

- Concrete cores combined with skeleton steel frames are used by some constructors to provide great flexibility in their work program.

- Extensive use of prefabrication is used for infill panels and flooring. Typical prefabricated flooring systems include proprietary systems such as:
  - Hollow core slabs;
  - Transfloor systems.

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6.0 CONCLUDING REMARKS

The Australian residential building industry has shown itself to be an extremely cost efficient in the design and delivery of a variety of residential construction forms. The key factors contributing to the success of this industry can be summarised as:

- Development of technical infrastructure to provide certification of innovative products to ensure quality and performance;

- The extensive use of a flexible, competitive subcontracting system; and

- The acceptance of the industry to introduce new and creative construction techniques.

The attitude of the industry is enabling cost effective solutions to be developed to slow the urban sprawl of Australian cities, construct on poor ground conditions and utilise under used space in office complexes.

REFERENCES


2. PHAM, L., "Structural Performance Requirements for Domestic Steel Framing", National Association of Steel Framed Housing NASH - AISC, 1991

3. PHAM, L. and STARK, G., Australian Performance Standards for Domestic Metal Framing", Colloquium on Serviceability of Building, Göteborg, 8-11 June, 1993.
