Australian Involvement in Constructing Affordable Housing in Developing Countries

Part 1 - General Considerations

Introduction

Australians visiting many of our neighbouring countries often comment on the apparent "poverty". However, poverty can be defined by many indicators, including:

- Disposable income, when compared to national and international averages and externally defined poverty levels;
- Access to basic services including education, medical facilities, clean water and electricity;
- The quantity and quality (including nutritional value) of food intake;
- Availability of full employment balanced by the availability of leisure time;
- Pollution levels and the local environment; and
- The quality of housing.

Whilst the true position regarding some of these indicators can be illusive to a casual observer, one can not help noticing the apparent poor quality of the housing stock. The general impression (to the average Australian) is one of poorly built and poorly maintained small houses or tiny high rise apartments in crowded villages or cities, devoid of many of the modern conveniences to which we have become accustomed. However, we must be wary of translating our Australian pre-occupation with "the immaculate family home on the quarter acre block" into cultures that may have quite different aspirations and expectations in respect of their housing needs.

Urban growth of many cities in developing countries is characterised by an increase in slum settlements and/or squatter settlements. "Slum" is the term used to define a quality of housing that is inadequate to "contribute to human development", while "squatter settlement" indicates illegal occupation, resulting in uncertainty in tenure and a reluctance of the occupants to commit financial resources to affecting material improvements. The presence of either slums or squatter settlements indicates housing poverty. (Aldrich & Sandhu 1995). The United Nations reports that, by the year 2000, slum or squatter settlements will house over half of the half of the populations of most Asian cities. (Murphy 1990)

Scarce income resources of poor families are often diverted from the provision of housing to other needs such as food, health care and consumer goods. This cause a drop in housing quality and leads directly to poor health and an increased demand for health care.(See below). The objective of the paper is to explore the practical means of improving the quality of housing.[1]

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[1] Some background analysis of social considerations is presented in this paper in order to establish a context for affordable housing. However the principal aim is to develop a practical "nut and bolts" approach to the supply of building materials.

This paper has five parts.

- Part 1 sets the context and explores the effects of various housing practices on the economy and affordability.
- Part 2 examines the specific requirements of housing policies to reduce overcrowding and homelessness, to provide adequate water supply and sanitation and to provide affordable shelter.
- Part 3 gives consideration to the technical aspects of the design and construction of affordable housing in the region, with attention to building regulations and standards.[2]
- Part 4 explores a practical role that Australia Aid Agencies and Australian businesses may play (probably in collaboration) in the provision of technical assistance, financial assistance and material assistance to indigenous people of the Asia/Pacific region in the construction of affordable housing suited to the region.
- Part 5 investigates the effects of introducing mass production of particular building products on local employment and local building costs.[3]

Geographical Limitations

The geographical limits of this study are those places within 10,000 km of the geographical centre of Australia. This includes the east coast of Africa, the east coast of Saudi Arabia, the Indian Subcontinent, the whole of east Asia (including China, Korea and Japan) and the islands of the western half of the Pacific. This boundary is considered to define a reasonable area of influence for Australian aid agencies and businesses.

Countries Examined In Detail

The countries selected for closer attention within this region are Australia, South Africa, Papua New Guinea and Indonesia.

- Australia is selected because the subject of this paper is the potential export of Australian housing technology, designs, materials or other components to underdeveloped countries. Australia is classified by the World Bank as a high-income economy.
- South Africa has an affluent business class, similar in nature to Australian business entrepreneurs, but, due to its unique history, it also has a very large poor population that

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[2] A spreadsheet, prepared by the author, has been substantially modified to enable the costs of various houses to the determined.

[3] A spreadsheet has been prepared by the author to analyse the costs of various local and Australian manufacturing options.

is housed in low-cost “affordable” housing. The relationship between the affluent suppliers of technology, materials and services and the poorer occupiers of affordable housing in South Africa is of interest to potential Australian suppliers of affordable housing technology, materials and services. South Africa is classified by the World Bank as an upper-middle-income-economy.

- Papua New Guinea is under-developed, Australia’s nearest neighbour, a former territory of Australia, the recipient of the bulk of Australia’s official aid and potentially a recipient of Australian housing technology, designs, materials or other components. Papua New Guinea is classified by the World Bank as a lower-middle-income economy.

- Indonesia is Australia’s second closest neighbour, has extremes of wealth and poverty, has the fifth largest population in the world and is potentially a huge recipient of Australian housing technology, designs, materials or other components. Indonesia is classified by the World Bank as a low-income economy.

Benchmarking Against Australian Experience

The difficulty in comparing housing quality and costs in various countries is to find a meaningful common basis on which to make comparisons. The technique used in this paper is to convert the costs of low-cost housing in overseas developing countries to the equivalent Australian costs in Year 2001. This technique has been adopted because the purpose is to examine the options of supplying certain building materials from Australia neighbouring countries. Whilst this technique may be valid for purposes of presenting alternative strategies to Australian businesses and NGOs, there are some important limitations.

- Comparisons to Australian costs is valid for imported materials but not for locally produced materials. These will be cheaper in the particular country than in Australia, due to the cheaper labour rates. For example the cost of locally produced concrete will be cheaper than Australian concrete by an amount corresponding approximately to the labour differential.[4]

- Cost comparisons of the construction labour content will not be valid.[5]

- The style and quality of Australian affordable housing differs from that to which the poor in neighbouring countries aspire.[6]

Housing in Urban and Adjacent Rural Areas

[4] This problem is further discussed in Part 4 of this paper.

[5] Part 4 deals with the relative costs of paid labour, but can not evaluate the value of labour provided by the owner (ie self help or "sweat equity" as it is sometimes known). The true value such commitment includes both psychological and financial components.

[6] A measure of the difference in housing quality can be gained from the differences in cost per square metre for various countries, discussed in Part 2.

This paper concentrates on the provision of housing for the urban poor and generally uses as its model the largest cities in each of the selected countries. However, one must recognise the enormous population difference between:

Jakarta (population 11.5 million)

Sydney and Johannesburg (Populations 3.8 and 4.0 million respectively)

Port Moresby (Populations 0.2 million)

In the smaller cities, the activities of the poor may focus on the centre, whilst in the larger cities focus will be more localised. For example, in Port Moresby, the poor may travel to the centre to work whilst in Johannesburg, many (although not all) of the poor who live in the dormitory townships, such as Soweto, work locally.

Notwithstanding these obvious differences, consideration of the larger cities must also include consideration of the dormitory suburbs. Friedmann comments, "… the relevant scale of economic life is the city region that extends outwards from the core cities up to a distance that may be roughly represented by a commuting radius of one to (at most) two hours." He states that, in Asian cities, this corresponds to a population range of five to twenty million. He further comments that it makes little sense to separate the urban from the rural in this context, adding , "Rural households in world city regions are now tightly integrated with an urban economy that is grounded in manufacturing and business services". (Friedmann 1998).

Is Housing Quality a Function of a County's Financial Health?

General poverty is sensitive to fluctuations in the financial health of a country. Healy notes that, as a result of the East Asian financial crisis, Indonesian poverty doubled from the pre-crisis levels to peak in August/September 1998 from which it then began to decline. (Healy 2000)

Because house building is a major undertaking in any country, a downturn in the economy adversely affects the *number* of houses under construction. However, it is incorrect to assume that *quality* of housing necessarily suffers as a result such short-term fluctuations, although prolonged deterioration in a currency's international purchasing power will result in difficulty in importing foreign manufactured building products.

Housing Sector Contribution To The General Economy

The construction of housing can help stimulate a sluggish economy, until other industries achieve a state of growth. Grimes states, "… for Columbia… [the] income multiplier is about 2 and about seven additional jobs are created for every US $ 10,000 spent on the construction of dwelling units". (Grimes 1976) In Australia, the importance of house construction to the general economy is indicated by the fact that the number of Building Approvals is seen as an indicator of growth or recession.

Affordable house construction, which permits construction to be staged, permits labour to be deployed gradually and consistent with it availability. (Grimes 1976) This contrasts with construction of large projects involving large labour forces for defined periods, leading to "boom and bust" building cycles, as demonstrated in the period before and after the Sydney 2000 Olympics.

Successful Affordable Housing Policies

The housing policies adopted in Singapore and Hong Kong are considered effective means of providing relatively low cost housing to large numbers of people. In these cities, housing is "regarded as an instrument for shaping cities". Yeh & Laquian attribute this success to the following policies.
Housing standards are tailored for consistency with the prevailing income levels.[7]
Buildings are designed with flexibility to meet changing demands.
Design and construction is technically sound and economically efficient.
Public housing is located near to employment.
Housing estates are large enough to include schools, markets, clinics and other facilities.
Planning includes transport considerations.
The community is encouraged to participate in estate management.

(Yeh & Laquian 1979)

Private Housing Ownership and Income

In both rich and poor countries, it is difficult for the poorer strata of society to cross the boundary from rental accommodation to home ownership. Grimes suggests that for urban dwellers, a family can not afford to purchase a dwelling whose cost is more than 2.5 times the annual family income. This translates to repayments of approximately 15 percent of income, although he notes that this can vary upwards, depending on the circumstances. (Grimes 1976)

[7] See later comment on the need to maintain minimum standards of construction.

Part 2 - Overcrowding, Sanitation and Affordability

This Part explores the current housing practices, provision of water and sewerage and house affordability in selected parts of the Africa/Asia/Pacific region.

Overcrowding

Affordable housing policies seek to house as many people as practical at the lowest cost, leading in the past to overcrowding. As affluence increases, the size of houses increases and the number of persons per household decreases.

Singapore

Tables 1 and 2 describe the changes that took place in Singapore housing as affluence increased. Table 1 indicates the increase in flat size over time. Table 2 demonstrates the increase in number of rooms and drop in overcrowding.

Table 1
Public Flats In Singapore - Areas of Flats
(Yeh 1975)

Period	Number of rooms	Average area of house m^2
First five years	1	23.5
	2	42.0
	3	53.0
After 1966	1	33.5
(Houses include a separate bathroom)	2	46.0
	3	61.5
	4	83.5
	5	120.0

Table 2
Housing In Singapore - Drop In Overcrowding
(Yeh 1975)

House type	Average number of rooms per household		Average number of persons per household	
	1996	1970	1966	1970
Bungalow	2.95	3.49	5.75	5.23
Semi-detached	3.81	3.88	5.55	5.26
Shop house	1.74	2.48	5.29	4.78
Floors of shop house	1.23	1.61	4.49	3.87
Public flats	2.17	1.92	6.44	5.53
Private flats	2.69	2.53	5.02	4.56
Attap or Zinc Roofed Houses	1.89	2.12	6.37	6.12
Others	1.32	1.50	3.93	4.22
All	**1.96**	**2.15**	**5.82**	**5.41**

Australia

In 1996, there were 105, 000 homeless people in Australia. (ABS 1999) It has been suggested that most Australians do not believe that we have an increasing homelessness problem, probably because the homeless congregate in areas geographically remote from the suburbs where most of us live. (Gregory & Hunter 1995)

In general, the housing prices in Australian cities decrease as distance from the centre increases, although other factors such as environmental quality, housing quality and access to services distort this general trend. This is demonstrated by Travers Morgan, who plots the estimated house prices of Sydney, Melbourne and Adelaide against distance from the central business district. The plots indicate that the larger city (ie Sydney) has the higher the house prices for the same radius from the CBD. (Travers Morgan 1991)

As an example, Sydney housing and poverty trends are analysed below.[8]
There is a close correlation between unemployment and low income households.

However the tendency towards owner occupation is not influenced by the family income (ie Even people with relatively low incomes are able to achieve home ownership.)

The cost (and therefore the quality) of new housing does correlate with the level of family income (ie People with low family incomes settle for less expensive houses.)

The house price distortions (from the general trend of decreasing price with distance from the CBD) are quite pronounced. The average price per new house is relatively high in "prestigious" upper north shore suburbs, even though the distance from the central business district is significantly greater than the case of inner western suburbs with relatively low cost housing.

There is no correlation between low income and high house occupancy rates. (ie Low income does not lead to overcrowding.) . This is because the higher occupancy rates generally occur in areas where children live at home with their parents rather than through overcrowding as a result of poverty. (Note: The highest bracket published by the Australian Bureau of Statistics was only 3.4 people per dwelling. This is not high by international standards.[9])

Burnley and Murphy postulate that the exurban development of Sydney is lower than in comparable United States cities, for the following reasons:

- As incomes rise, Australians seek more space, although they note that it is in suburbia that the poorest Australians live.
- Jobs are more plentiful in the eastern part of the city than in the west.
- Sydney’s freeways are less well developed than in corresponding US cities.
- Decentralisation of work practices has not been extensive.

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[8] Appendix 1 includes maps that show the distribution of Sydney Unemployment, House Occupancy Rates and Low Income (marked up with the average cost of new houses).

[9] Compare the Sydney and Singapore figures for occupancy.

They also comment that 5% of the total housing stock is public housing, but that proportion rises to 12% in some of Sydney's outer suburbs. (Burnley & Murphy 1995)

Commenting on the debate over urban consolidation in Sydney, Stone observes, "Private consolidation in inner and middle ring suburbs ... will be largely out of the financial reach of lower income-income rental-housing groups". She continues, "... those most in need of private rental housing would not be the primary beneficiaries". (Stone 1985)

Papua New Guinea

Burgess observes that in Papua New Guinea, the inhabitants of settlements recognised by the Government are better off than those in squatter settlements, who are subject to the whim of and customary eviction by the landlord. (Burgess 1998)

Indonesia

Despite some luxurious housing for the wealthy, Indonesian housing is relatively overcrowded. Gall publishes the following analysis.

The home of an affluent Indonesian family is similar in layout to a western house, with separate rooms for entertaining guests, eating etc. However, 6% of houses do not have separate bedrooms.

Approximately 30% of houses have walls of bamboo, the cheapest material, whilst the remainder have walls of brick or wood. 66% of roofs are of tile and the remainder are steel sheet or thatch.

Although most homes in Jakarta have electricity, the national figure is only 47.3%. Only 4.2% of homes cook with electricity or natural gas, and the remainder must use wood, charcoal, or kerosene.

Approximately 13% of homes (mostly urban) have running water (generally undrinkable) with squat toilets and an open tank to scoop water out of for bathing and flushing. However, most people must draw water from streams, canals, ponds, and wells, commonly polluted to some degree.

Approximately 11% of houses have garbage picked up by sanitation workers. The remainder dispose of garbage by burning, piling it in their yards or dumping in public dumps, gutters, canals or rivers.

(Gall 1998)

Water And Sanitation

Adequate housing is an important factor in the general health and quality of life. In particular, the inclusion of water and sanitation within the housing infrastructure is critical.

Commenting on a range of studies on the reduction of diarrhoea affected by various aspects of water supply and excreta disposal, Tulchin concludes that previous studies had considerably underestimated the beneficial effects of adequate water supply.

Table 3
Water Supply and Sanitation Programs in 24 Non-intervention Studies

Parameter Affected	Number of Studies	Reduction in percentage diarrhoeal diseases (median)
Water quality	6	30%
Water availability (mostly through standpipes)	11	34%
Quality and availability	4	40%
Excreta disposal	8	40%

(Tulchin 1986)

Harpham & Tanner state, " Quality of housing is closely linked to poverty ... [and a] high risk for diarrhoeal disease and acute respiratory infections (ARI) in South African children." They quote the following statistics by von Schrinnding et al (1991) and conclude from this data that the most important interventions for reducing childhood infections are "better access to water and sanitation, general environmental health services and probably improvements in access to electricity."

Table 4
Prioritising interventions for diarrhorea in children < 5 years of age
(von Schrinnding et al 1991)

Risk factor	Odds ratio	90% confidence interval	Intervention priority
No inside tap	3.3	1.7 - 5.0	1
No inside WC	3.3	2.5 - 5.0	1
Do not own a refuse receptacle	2.5	1.3 - 5.0	2
No electricity	2.5	1.4 - 5.0	2
Overcrowding (>2 people / room)	2.0	1.3 - 3.3	3

(Harpham & Tanner 1995)

The rapid improvements in the standard of living in Singapore and Hong Kong were coincident with the improvements in housing (particularly public housing) and the associated improvements in water-borne sewerage. By 1970, 64% of housing in Singapore had an inside flush toilet, 27% had a bucket flush system while only 9% relied on outdoor facilities. (Yeh 1975)

Various estimates of water demand have been made:

> In the United States, about 40% of total usage is for domestic purposes, corresponding to approximately 260 litres/head/day. (Metcalf and Eddy, 1974)
>
> The recommendations for supplies to small towns in developing countries are.
> 10 litres per person from public taps
> 190 litres per person per day for private connections
> 65 litres/head/day for design and distribution
> (Wagner & Lanoix 1959)
>
> For basic water consumption by individuals allow 30 litres/capita/day (World Bank, 1976)

Possible improvements of water supply and sanitation for affordable housing include the supply of treated water to an inside kitchen, bathroom and toilet and efficient removal of waste. They fall into three broad categories:

- A return to the traditional values and methods of a simpler time,
- Modern treatment and reticulation systems,
- The development of systems that collect and treat water and sewage by modern methods, but within or local to the house.

Writing in support of a return to traditional methods, Burnham describes an alternative to a modern water closet. "Jenkins takes a 5 gallon plastic bucket - say an empty sheetrock compound bucket - places it under a standard toilet seat and cover, and uses it for defecation and urination. After each use he covers the bucket's contents with sawdust, which masks … odours completely and begins a compostable mixture of carbon (sawdust) and nitrogen (human deposits). When the bucket is full, it is taken to an outdoor compost pile, where it is spread on a bed of straw (a highly carbonaceous material), liberally sprinkled with rinsings from the bucket, and covered with more straw". (Burnham, 1998)

Whilst such methods may have proven effective in an earlier, less crowded age, such methods are not suitable for modern high and medium-density urban dwelling. Hasan describes a low-cost modern piped sewerage program in Orangi township, Karachi and its effect on community health. Infant mortality dropped from 130 per 1000 in 1982 to 37 in 1991, while infant morbidity dropped from 18.94 to 8.29. (Hasan, 1997) There are three options for disposing with waste water from affordable housing. , viz Open drainage piped system, closed drainage piped system and local disposal via a septic tank. (CMA SA 1978), (Metcalf & Eddy 1972)[10]

A third option recognises the high community expense involved in providing, maintaining and upgrading modern water and sewerage reticulation systems. In modern cities, rainwater is stored in on-site retention tanks, before being discharged to the stormwater sewer.

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[10] Appendix 2 describes the three option of disposing of waste water.

Drinkable water is imported long distances from large dams and treatment plants, only be used to flush sanitary waste over further distances to sewage treatment works.

A much more efficient system involving modern materials and technology could be developed. The main features of a suitable system are:

Flat concrete roof capable serving as a roof garden.

A rainwater collection and storage system at roof level.

A roof-level mini-treatment plant for the purification of rainwater to a drinkable standard.

A storage tank at ground level (probably incorporated within the structural footing system), to receive waste-water and sewage.

A ground level mini-treatment plant for the disinfection of waste-water and sewage to safe level.[11]

An overflow system to a reticulation system for community use of surplus water.

Connection to scaled-down potable water reticulation system to enable the locally collected and treated supply to be topped up.

Whilst such systems are not currently in use, it is confidently predicted that they will be developed and applied in the future. These features would necessitate minor changes in the design of houses and apartments. However, such developments are beyond the scope of this paper.

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[11] Acceptable potable water quality is defined by the World Health Organisation. (Degremeont Laing, 1973) Acceptable quality for waste-water and sewage effluent may be defined in terms of bacteria, odour, dissolved solids etc.

Affordability

For purposes of comparison, all reported costs have been converted to 2001 Australian dollars. [12]

Normal Housing
The following costs are for "normal" (ie not "affordable") housing. They have been included to provide a benchmark against which affordable housing options can be gauged.

Table 5
Normal Housing
Material and Labour Costs, Excluding Land

Country	House Style	Cost A$$_{2000}$
Australia (ABS 8731.1 2000)	Average Sydney Prices Highest average (Eastern suburbs) Lowest average (Inner city)	$ 165,600 $ 414, 850 $ 138,400
United States (Habitat for Humanity video)	Average house	$ 180,000[13] (approximately)

Table 6
Australian Kit Homes - Materials Costs To Lock-up Stage [14]

Source	Area m^2	No of rooms	Average room area m^2	Material A$ $_{2000}$ per house	Material A$ $_{2001}$ per m^2
Australia (Kit homes) [15]	197.0	11	18.2	$ 64,500	$ 325

Table 7
Australian Prefabricated Offices
(Completed Building Suitable for Housing)

Source	Area m^2	No of rooms	Average room area m^2	Material A$ $_{2000}$ per house	Material A$ $_{2001}$ per m^2
Australia (ATCO)[16]	62.1	7	8.9	$ 22,182	$ 357

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[12] For the basis and analysis of currency conversion rates and adjustment for inflation, refer to Appendix 3.

[13] The cost of the "average" house in the United States is stated in the video as "three times" as much as the Habitat for Humanity house. This equates to US $ 90,000. The difference is presumably a result of the labour content in the "average" house, which is provided by volunteers in the case of the other houses.

[14] Refer to Appendix 5 for details of the costs and descriptions of the various houses analysed in the table.

[15] The costs of Australian kit homes have been determined from the magazine, Build Home Vol 8 No 1, and are for high quality building material kits up to lock-up stage. The costs and areas have been averaged over seven houses of size ranging from 150 to 278 square metres. They have been included to indicate the upper bound of housing material costs.

[16] Quotation by ATCO Structures Pty Ltd.

Affordable Housing Materials Costs

The following costs are the materials costs for affordable housing (excluding land and labour costs) from various sources.

Table 8 **Affordable Housing - Materials Costs, Excluding Land and Labour**		
Country	House Style	Cost
India (Habitat video)	Fired red brick with plaster and whitewash walls Sheet steel roof 1-3 rooms	A$$_{2000}$ 3,000 (US $ 1,500)
Kenya (Habitat video)	Locally fired red brick walls Cement and stone (concrete?) floor Sheet steel roof	A$$_{2000}$ 2,600 (US $ 1,300)
Zaire (Habitat video)	Locally (concrete?) brick walls Cement (concrete?) floor Sheet steel roof	A$$_{2000}$ 3,200 (US $ 1,600)
United States (Habitat video)	Habitat for Housing - affordable house	A$$_{2000}$ 60,000 (approximately) US $ 30,000
South Africa (CMA-SA, 1992)	Concrete masonry house, area 50 m^2 Concrete masonry house, area 50 m^2	A$$_{2000}$ 3,000 A$$_{2000}$ 4,500

Affordable Housing - Material Costs To Lock-up Stage

The following approximate costs of building materials to lock-up stage have been calculated using a Microsoft Excel spreadsheet into which Australian unit materials costs have been input.

Thus the only variables are the building size and shape, and the materials types and sizes. This enables the hypothetical affordability of the various house options to be compared on a common basis. Although the actual on-site materials costs will be lower than these numbers (by virtue of the low-cost local content), this table permits the identification of "low cost" and "high cost" design options.

Table 9
Comparison of Approximate Costs For Affordable Housing Materials To Lock-up Stage [17]
(Calculated for standardised Australian 2001 costs)

No	Country	Area m^2 [18]	No of rooms	No of bed rooms	Average room area m^2	Material A$ $_{2000}$ per house	Material A$ $_{2001}$ per m^2
1	Generic	48.6	4	2	12.1	$ 9,499	$ 195
2	Generic	64.8	5	3	13.1	$ 10,957	$ 169
3	Australia	108.0	8	3	13.5	$ 36,268	$ 336 [19]
4	Australia	104.6	8	3	13.1	$ 23,616	$ 226
5	South Africa	68.1	6	2	11.4	$ 13,690	$ 201
6	South Africa	91.0	8	4	11.4	$ 16,985	$ 187
7	South Africa	36.0	3	1	12.0	$ 8,805	$ 245
8	South Africa	72.9	6	3	14.6	$ 14,945	$ 205
9	PNG	23.8	3	2	7.9	$ 6,447	$ 270
10	PNG	29.8	4	3	7.4	$ 7,945	$ 267
11	PNG	29.8	4	3	7.4	$ 7,633	$ 256
12	PNG	35.3	5	4	7.1	$ 8,676	$ 246
13	PNG	35.3	5	4	7.1	$ 8,822	$ 250
14	PNG	35.3	4	3	7.1	$ 8,641	$ 245
15	Solomon Is	35.8	4	2	7.2	$ 8,896	$ 248
16	Fiji	22.0	1	1	22.0	$ 4,266	$ 193
17	Fiji	41.0	4	2	10.3	$ 8,526	$ 207
18	Fiji	50.7	5	2	10.1	$ 11,233	$ 222
19	Fiji	39.5	3	2	13.1	$ 8,973	$ 227
20	Fiji	35.8	4	2	8.9	$ 6,894	$ 193
21	Vanuatu	37.3	4	2	9.3	$ 6,339	$ 170
22	Pacific Is.[20]	24.5	3	1	8.1	$ 5,644	$ 230
23	USA	91.4	6	3	15.2	$ 25,772	$ 282
24	USA	97.5	6	3	16.2	$ 23,460	$ 241
25	USA	104.8	7	4	15.0	$ 27,630	$ 264

[17] Refer to Appendix 5 for details of the costs and descriptions of the various houses analysed in the table.

[18] Areas are of habitable rooms, excluding garages, carports and verandahs.

[19] The apparently high rate is due to the large covered veranda.

[20] Low-cost house as defined in the Building Regulations of Tuvalu, Fiji, Cook Is, Solomon Is, Vanuatu and Niue.

Observations

- The materials costs of affordable housing (at Australian prices and excluding verandas, carports, tiling and fit-out) ranges from A$$_{2000}$ 169 per square metre of habitable floor space to A$$_{2000}$ 282 per square metre.
- The inclusion of verandas and the like, significantly increases the cost of housing. (Compare No 3 and No 4)
- Increasing the size of a basic house lowers the cost per square metre. (Compare No 1 and No 2, No 5 and No 6, No 7 and No 8, Nos 9, 10, 11, 12, 13 and 14)
- The minimum materials cost of an affordable house is A$$_{2000}$ 4,266, although its area is only 22.0 square metres, not much larger than the average garden shed.
- The next lowest materials cost is the one specified in the building regulations of the Pacific Island countries, although this also is quite small, at 24.5 square metres.
- The highest cost houses are the Australian and United States houses. This reflects the higher aspirations of poor within these relatively rich countries.
- The generic house (No 1 and No 2) and the Vanuatu house (No 21) appear to offer the most potential for reduced costs.
- Whilst the costs tabulated above are for materials sourced from Australia and expressed in A$$_{2000}$, comparison with the anecdotal costs in the promotional videos would indicate an apparent discrepancy. This may be explained in part by the fact that locally produced materials such as concrete and concrete masonry are cheaper than their Australian counterparts.[21]

Conclusions

In Australia, homelessness is a growing social issue, although poverty does not currently appear to lead to overcrowding. On the other hand, poverty in developing countries does lead to overcrowding.

Affordable housing must incorporate effective means of wast removal and reliable clean water supply.

In the interests of avoiding social stratification, the size, finish and affordability of housing should be determined in the context of the level of wealth existing in the surrounding community. What is acceptable in developing countries would not be acceptable in developed countries. Conversely, for developing countries, provision of housing to the standard expected in Australia is considered wasteful of scarce resources.

[21] Refer to Part 4 of this paper for a comparison on Austalian and local manufacture.

Part 3 - Affordable Housing Practices

Housing Styles

Housing styles generally reflect the local architectural traditions and cultural heritage and varies within the extremes of timber and bamboo construction and concrete and masonry, depending on the location. The following table lists the traditional housing practices of the major cultures within the four selected countries.

Table 10
Traditional Housing Styles
Source (Gall 1998)

Country	Principal Ethnic Groups	Description of Traditional Housing
Australia	Anglo Australians	Adaptation of European building styles, mostly a relatively large freestanding brick house with a tiled roof, a front lawn, and a back garden. Young couples often live in flats or townhouse
	Australian Aborigines	Generally nomadic lifestyle
South Africa[22]	Afrikaners	Similar style to most western housing
	Anglo South Africans	Similar style to most western housing
	Coloured South Africans	Have been forced to move to lower standard coloured townships.
	Xhosa	Round thatch-roofed huts
	Zulu	Thatched-roof rondavels.
Papua New Guinea	Iatmul	Villages traditionally centred on the men's house, which is the architectural centrepiece of the village
	Motu	Traditionally, the Motu built their houses in lines connected to each other by walkways over the tidal shallows. The line of houses corresponded to a decent group
	Melanesians	Traditional housing in response to the "rain, heat and mosquitos".

[22] Other South African ethnic groups, each with their unique culture and housing styles, are Karretijie, Ndebele and Sotho. (Gall 1998)

	Melpa	Men's houses are round with conical roofs. Women's houses are rectangular-shaped with pig stalls built inside.
Indonesia [23]	Javanese	Village houses have earth floors, framework of bamboo, palm trunks, or teak; walls of plaited bamboo (gedek), wood planks, or bricks; roofs of dried palm leaves (blarak) or tiles. Inside walls are moveable gedek partitions. Traditional houses do not have windows, light and air entering through chinks in the wall or holes in the roof. Roof shape reflects social status. Ordinary village houses have a serotong roof (two slopes on two sides only). Descendants of the village founders have a limasan roof (double slope on four sides). An aristocratic house has a joglo roof (three slopes on four sides) with a large pavilion in front for guests.
	Balinese	A residential compound (uma) is inhabited by a group of brothers and their families. It is surrounded by a wall with a narrow gate. It has a central courtyard, surrounded by separate pavilion-like buildings for cooking (one for each nuclear family), storing rice, and keeping pigs and for sleeping. Each compound has a shrine (snaggah), a thatched pavilion (bale) for meetings and ceremonies and a walled-in pavilion (bale daja) for family heir looms. Toilet and bathing in performed in an adjacent river. The compounds of banjar members surround a meeting pavilion (bale banjar).
	Madurese	Traditional houses are single room (slodoran or malang are) or those with more than one room (sedanan). Roof types are a gadrim with a two-ridge roof; a skedonan with four central pillars supporting the roof; and a pacenanan where the gables projecting from the two ends are carved in the shape of serpents, a style of Chinese influence. Traditional houses do not have windows.

[23] Other Indonesian ethnic groups, each with their unique culture and housing styles, are Achenese, Asmat, Bajau, Bugis, Makassarese, Malays, Mandarese, Manggarai, Minahasans, Minangkabau, Ngaju Dayak, Niasans, Sa'dan Toraja, Sasak, Sumbawans and Sundanese. (Gall 1998)

	Banjarese	All houses are raised on piles. The most common Banjar house is the rumah bubungan tinggi, with a roof that rises at 45^{o}. Roofs were once made of dried leaves, but are now more often made of shingles. Walls are of palm leaf, tree bark, bamboo plaiting or wooden planks. Beams are iron wood or other hardwoods. The front section is the palataran, an open veranda where the family relaxes and receives guests. At higher levels are the chambers panampik kecil, panampik tengah, panampik besar, and palidangan. The wall between the panampik besar and the palidangan, the tawing halat, is decorated with carvings where guests are entertained. On both sides of the palidangan are ajung, lofts for sleeping. Behind the palidangan at a lower level is the panampik dalam. Furtehr back is the padapuran, kitchen. Above the kitchen door is the katil, sleeping area for unmarried daughters.
	Sumbanese	The clan house (uma kabihu) is a large rectangular building. Ordinary houses (uma kamudungu) consist of wood without peaked roofs of plaited grass or bamboo.
	Ambonese	Traditional houses were built on wooden piles although modern houses are built on the ground. These houses have a square floor plan with an open veranda (dego-dego) in the front. The frame is timber and walls are plaited sago-palm leaf (gaba gaba). Most houses do not have windows but compensate with steep roofs and holes in the corners to release smoke. There may be a rear kitchen.
	Batak	Traditional Batak houses are rectangular built on piles. A Toba house is occupied by a single couple, unmarried children, their eldest son and his family, and any of the father's widowed sisters. It has a high saddle roof with that protruded from the walls, particualrly at the front where a veranda is over the entrance to the staircase. A Karo house caters for eight related families (each occupying 5 m^2 and sharing a hearth with another family. These rooms line up, four on either side of a central hall with a central gutter. It has identical verandas and doors at both front and back. Houses with a square plan may have a distinctive roof shape where the ends rise evenly to the ridgepole, but front and back surfaces stop short and are joined to the ridgepole by a wall.

	Dani	Compounds include a number of round men's houses, and a number of round women's houses, rectangular shared cooking houses, and a rectangular pigsty. They are built of wood with thatched roofs.

Despite a preference to preserve traditional building methods, economic considerations often override. For example, although the traditional Zulu house is a "thatched roof (round) rondavel", the practical difficulties in adapting sheet steel roofing to a conical shape dictates that affordable housing in Zulu townships is rectangular.

However, this is not always the case. Seragelden reports the construction of "an urban version of the traditional tribal house" in Kampung Kali Cho-De (Yogyakarta, Java). These houses consist of:

local stone pad footings (point foundations)
timber frame with bamboo secondary supports
coconut wood and bamboo wall panels
plaited bamboo mat floors
clay (terra cotta) or sheet steel (corrugated iron) roofing

Seragelden, I. (1997)

Sometimes changes from traditional style are a sign of increase status. Although traditional Ambonese houses were built on wooden piles, modern Muslim and Christian houses are constructed on the ground. The homes of village leaders are often European in style, with partially brick walls, windows and separate rooms inside. (Gall 1998)

A respect for local values and heritage does not necessitate slavish reproduction of poor quality housing of an earlier era. Modern Australian "mock federation" housing reflects the brick wall and pitched tile roof tradition of our European ancestry in an environment where modern composite wall and sheet steel roof would be a much more cost efficient means of providing shelter. However, this has not prevented Australian house designers from adopting innovations such as plaster board, brick veneer, concrete roof tile and modern appliances and blending them with the traditional architecture.

Improvements in House Design

Hassan reports on the improvements to affordable housing styles achieved in Orangi township (Karachi, Pakistan). He states that initially 93% of houses were single storey constructed with concrete blockwork walls and, either galvanised steel or asbestos sheet roofs. However, the desire to subsequently replace the sheet roof with a second storey supported by a reinforced concrete slab led to problems of cracking and footing settlement. He concludes that the most effective interventions undertaken by the local authority and NGOs were the provision of technical advice and training on:

the appropriate concrete block mix and curing,

the correct sizing of roof supports for the sheet steel roofing, and

the waterproofing of the walls at footing (plinth) level.

The housing package developed by the Orangi Pilot Project consisted of:

in-situ concrete footings suitable for subsequent two-storey construction, and constructed using loaned steel formwork

machine-made concrete blocks, 150 mm for loadbearing walls and 100 mm for non-loadbearing walls[24]

precast concrete batten-and-tile roofing (maximum span is 4.90 m and the most economical span is 3.65 m)

precast concrete staircases, and

training for masons and design advice.

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[24] Although Hassan reports the walls to be 150 mm and 100 mm, it is most likely that they are actually 140 mm and 90 mm respectively, with allowance for a 10 mm joint. These dimensions (or their imperial equivalents) have been adopted in most countries.

Particular Problems of Affordable Housing Sites

Affordable housing for the poor is often consigned, with disastrous consequences, to areas that are the least suitable for building, such as steep mountains, refuse tips and unstable soils. The destruction of housing and loss of life during recent mud sides in Latin America and the collapse of part of the infamous Manila Smoky Mountain garbage tip are indicative.

Approximately 14 percent of the Witwatersrand area surrounding Johannesburg, is underlain by water soluble dolomitic rock formations. The poorer townships constructed on this material are prone to disruption of services and destruction of houses when sink-holes appear, ranging from 3 metres to 50 metres in diameter, and triggered by water seepage. (Main & Williams 1994)

Whilst affordable housing often incorporates relatively low standards of construction, this a practice that should be avoided. Affordable housing must be engineered to provide for cyclonic wind load, landslip, expansive soils and subsidence as appropriate.

Building Regulations and Standards

Building regulations and the standards invoked therein vary from country to country. To a large degree they tend to concentrate on the design and construction of large buildings, and, in many countries, they either do not apply to or are not enforced for the bulk of cheaper low-rise (usually single storey) housing. However, any proposal to export Australian housing technology, designs, materials or other components to another country must be done within the context of any locally applicable regulations.

This section examines the building regulations and, by association, the principal standards for housing, which are in force in the selected countries.

International Standards

Currently there are no internationally accepted standards relating to the design and construction of housing, including affordable housing. However there have been moves by ISO to create such a standard, or group of standards.

Draft International Standard ISO TC59/SC15 *Performance Criteria for Single Family Attached and Detached Dwellings* 6/3/98 has been prepared by the relevant USA committee. Its purpose includes:

> "To facilitate international trade in housing systems, housing products and housing knowledge by replacing prescriptive standards that may serve as restraints ….."

This draft ISO standard is intended to define a suite of performance based standards, which, if written, would establish the requirements for acceptable single family dwellings. Apart from defining the building elements to be covered by such standards and the proposed method of evaluating them, the draft standard does not provide practical or useful information on the either the performance or prescriptive requirements of any of the house elements.

Australia

The national regulatory document for domestic housing, adopted in each state with some modification, is the *Building Code Of Australia, Volume 2*, prepared by the Australian Building Codes Board. It sets out the performance requirements on various parts of a house and provides a limited number of acceptable forms of construction that satisfy those requirements. It also refers to a number of Australian Standards that cover the design and construction of particular elements in more detail.[25]

Standards Australia has produced a draft Australian Standard, *Domestic construction - Structural performance criteria and verification*, which sets out the principal performance requirements for housing. When published is likely to be adopted by the Australian Building Codes Board into the Building Code of Australia.

South Africa

The national regulation for domestic housing is contained in the *National Building Regulations*.

There are two South African standards[26] that expand the requirements of the *National Building Regulations*; viz.

SABS 0400, *The application of the National Building Regulations*, 1990

SABS 0401, *The construction of dwelling houses in accordance with the National Building Regulations*, 1989.

The National Home Builders Registration Council has produced a three-part manual (bound in two volumes) that set out the general requirements, design standards and construction standards for housing. These manuals effectively provide the "deemed-to-satisfy" details for housing. Although they do not differentiate between normal and affordable (or low-cost) housing, many of the details are relatively simple, and not beyond the ability of a competent tradesman to achieve relatively cheaply.

Papua New Guinea

The national regulation for domestic housing is contained in the Papua New Guinea Building Act and Regulations (Chapter 301) 1994.[27] The format and style of the PNG regulations are similar to earlier versions of the Building Code of Australia. Although there are some local standards, many of the details are referenced to Australian Standards. Affordable housing would be covered by Class 1 buildings (similar to Australia)

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[25] The Australian Standards relevant to housing are listed in Appendix 7.

[26] A partial list of South African Standards relevant to housing are listed in Appendix 8.

[27] A partial list of Papua New Guinea Standards relevant to housing are listed in Appendix 9.

Indonesia [28]
The Indonesian Building Regulations could not be obtained for this paper.

Tuvalu, Vanuatu, Niue, Cook Islands, Fiji, Solomon Islands
For each country, the Australian International Development Assistance Bureau (AIDAB) has provided funding to produce a suite of three documents in similar format.

National Building Code
A Partial Commentary of the National Building Code
Home Building Manual

The format of the National Building Codes of each country is based on the Building Code of Australia that was in place in 1990.

Details of "affordable housing" (of specific dimensions 4.8 m x 5.1 m) are given in Appendix H of each *Home Building Manual*, which states,

> "The room sizes in this section are kept small enough to avoid the use of purlins for the roof. The small sizes also permit the use of partially grouted masonry wall which will resist the applicable forces."

These standard details have been included in the costings considered above.

Conclusions

- Where practical, affordable housing should reflect the architectural style of the area in which it is to be located. However, this should not restrict the adoption of variations and improvements to suit structural requirements and changing aspirations of the occupants.

- Affordable housing should be designed and constructed in accordance with local building regulations and standards. Where these are not adequate, international standards should be used.

- Particular attention should be paid to design for cyclonic wind loading, earthquake loading and unstable foundations.

[28] The Indonesian building regulations were not available. A partial list of Indonesian Standards relevant to housing are listed in Appendix 10.

Part 4 - A Role For Australia Aid Agencies And Businesses

This Part explores a practical role that Australia Aid Agencies and Australian businesses may play (probably in collaboration) in the provision of technical assistance, financial assistance and material assistance to indigenous people of the Asia/Pacific region in the construction of affordable housing suited to the region.

Cultural Considerations

Before launching into the provision of financial, material or physical assistance for affordable housing in developing countries, individuals and organisations should give close consideration to the cultural differences between the donor and recipient populations.

This applies, not only to the different aspirations in respect of housing conditions and styles, but also to community attitudes.

Fuller describes how Nancy Cardwell led a Habitat for Humanity work camp in Papua New Guinea. He relates, "Nancy loved to travel .... she knew only vaguely that Papua New Guinea was some where in the South Pacific .... ". He describes how the team of nine Americans and fourteen New Guineans became involved in a tribal pay-back killing, and the reluctance of the locals to "share" their overseas benefactors with other tribes. The team ultimately succeeded in brining about significant improvements in housing in various parts of the country (the point of Fuller's optimistic story). (Fuller 1995) However, one is left with the impression that a little more preparation and sensitivity to cultural issues by overseas teams may increase their ability to affect positive change in housing conditions.

Financial Aid

Papua New Guinea will receive an estimated A$ 329.7 million of overseas development aid from the Australian government in 2000-01, and is the largest recipient of Australian aid. (Downer 2000)

Indonesia will receive an estimated A$ 120.5 million of overseas development aid from the Australian government in 2000-01, and is the second largest recipient of Australian aid. (Downer 2000)

East Timor will receive an estimated A$ 40.0 million of overseas development aid from the Australian government in 2000-01, and is the sixth largest recipient of Australian aid. (Downer 2000)

Such aid could include Australian housing technology, designs, materials or other components.

Corporate Assistance

One major Australian company, Honey well, has incorporated the provision of labour on a voluntary basis into its corporate training program. (Habitat for Humanity Australia, *A Home Of Their Own*, Australia (video))

Suppliers of building products could be encouraged to supply building materials at cost (or less) for use in affordable housing in developing countries. These products could be packaged, containerised and shipped to ports in the recipient countries for uses in approved projects. In order to avoid pilfering and corruption, such shipments and their ultimate use would have to be closely supervised and monitored by aid agencies with experience in this field.

Voluntary Labour

Habitat for Humanity is an organisation that provides voluntary labour, often from developed countries, to assist in the construction of affordable housing, both at home and in developing countries. The eventual owner is expected to contribute a significant proportion of the labour or "sweat equity".

One concern relating to the use of voluntary construction labour is the quality of workmanship. The construction practices of volunteers depicted on various videos would be unacceptable on most building sites. (eg One video shows an unskilled volunteer filling the perpendicular joints of concrete blockwork by trowelling mortar into the space after the blocks had been laid, rather than conventional practice of "buttering the perps" before the block is laid.) Such practices lead to lower quality of construction than one would expect from commercially constructed housing in a developed economy. (Several videos - Habitat for Humanity International).

The use of prefabrication into components that can be easily assembled on site will help to alleviate quality problems originating with unskilled labour.

Prefabrication and Simplified Systems

Set out below are a few of the many proprietary building systems and prefabricated products that can be used or adapted for affordable housing.

Habitat Prefabricated House

Nirimba TAFE (Sydney) uses trainee labour to construct prefabricated houses for Habitat for Humanity Western Sydney. [29] These are lifted by crane onto low-loaders, transported to site and then placed by crane on footings and piers already in position. Verandas, steps, carports and other add-on features are then constructed on site. (Habitat for Humanity working file 2001)

[29] Two of the houses are illustrated in drawings for Houses No 3 and 4 in Appendix 5.

Habitat Polystyrene/Render Panels
Habitat for Humanity (USA) has commenced constructing houses using 1.2 x 2.4 metre prefabricated polystyrene panels factory fitted steel mesh each side. The panels can be bolted into position using unskilled labour and then coated on each side with 25 mm of cement render. (Habitat for Humanity International, *Broken Windows, Building Dreams* (video))

Rapid Wall
Rapid Wall is wall and ceiling system consisting of two fibreglass reinforced gypsum (Gypcrete) sheets which are held apart by top and bottom web members. The panels may be filled with gypsum plaster for particular applications. The advertised cost of Rapid Wall ex-factory in Australia is "less than $ 40.00 per square metre". (Australian Concrete Services 1994)

Ritek
Ritek is prefabricated wall system consisting of two fibre cement sheets which are bonded to a number of expanded polystyrene studs thus creating cores within the panel. These cores contain reinforcing steel and concrete grout to provide the requisite strength. Alternatively, steel studs can be used to provide additional strength. (Building Solutions Pty Ltd 1994)

Proprietary Bricks and Blocks
Several brick and block systems, developed overseas during the last four decades, employ "dry stacking" rather than being laid in a conventional mortar bed. This reduces the reliance on skilled labour for the construction.

Some innovations include:

- Vertically keyed concrete blocks for staggered stack bond construction[30]
- Fibreglass reinforced renders to provide strength which would otherwise be required of mortar bed and perpendicular joints
- Hoaned clay bricks dipped and set in thin bed adhesive. (Austral Bricks 2001)
- Reinforced and steel reinforced dry-stacked concrete blockwork. (Smart Masonry 2001)

The principal draw-back of such systems is the need for close manufacturing tolerances when constructed in stretcher (running) bond (ie the normal brick pattern). Although such tolerances can be achieved by hoaning, the cost is considerable.

[30] See Houses No 1 and 2 in Appendix 5.

Technology and Design

Australian businesses and government agencies, aid agencies and private organisations can contribute regulatory assistance and standard designs to developing countries.

For example:

The building regulations of Papua New Guinea are modelled on the Building Code of Australia and reference several Australian Standards.

The building regulations of Tuvalu, Fiji, Cook Is, Solomon Is, Vanuatu and Niue were produced by a consortium of organisations from Australia, New Zealand and United States and funded by the Australian International Development Assistance Bureau (AIDAB). The standards include a "deemed-to-comply" design for affordable housing.

Supply Of Housing Components

Locally Produced Products
It is not an economical or efficient practice to import those products that can be produced locally, particularly the heavy or bulky products. This includes:

- Cement, sand and aggregate for the manufacture of concrete and mortar.
- Concrete blocks for the walls
- Concrete roof tiles[31]

Timber roof and wall framing may also be produced locally, although the procurement of adequate timber without destroying environmentally valuable forests may be difficult. The use of indigenous "coco lumber" for roof and wall framing in tropical applications is considered to be of sufficient significance to warrant specific mention in the video, *Broken Windows, Building Dreams.* (Habitat for Humanity International, *Broken Windows, Building Dreams* (video))

Imported products
It is postulated that those building components that are difficult to procure can be imported to the country in which they are to be used. This includes:

Roof sheeting and fixings.
- Galvanised steel purlins, bridging and fixings.
- Sheet metal flashings to ridge and gable barges

Ceiling insulation blanket with lightweight foil adhered
- Galvanised steel track edge form for concrete slab and footings
- Steel fabric reinforcement
- Trench mesh reinforcement
- Bar chairs for concrete slab and footings

[31] The local manufacture of cement and concrete products is discussed in more detail in Section 5.

- PVC membrane
- Adhesive tape
- Galvanised steel posts and fixings
- Bolts and nuts

Bagged mortar or adhesive liquid and powder for masonry walls

Conclusions

The expenditure of financial aid directed towards the provision of affordable housing should be managed by aid agencies experienced in this type of work.

There is a role for volunteers, but this must be undertaken with sensitivity and awareness of local cultures and housing aspirations.

Australian businesses should be encouraged to cooperate with appropriate aid agencies to make specific easily transported building components available for affordable housing projects in developing countries.

Part 5 - Local Manufacture of Building Products

Local manufacturing of selected building products and the resulting increase in employment can be encouraged by local housing projects. Fuller describes how the local church in Mbandaka in Zaire purchased a struggling concrete block manufacturing plant from a Belgian businessman in order to reduce unemployment and service the growing local house building activity. (Fuller 2000), (Fuller & Scott 1980)

In reporting on the dramatic increase in concrete block production resulting from the Orangi housing program, Hassan states, "Almost 60 percent of the blocks manufactured in Orangi are exported to other localities of Karachi." He notes that this new industry has generated a large number of jobs for Orangi residents, mostly associated with transportation, loading and unloading.[32] (Hassan, 1997)

However, local mass production of such products may be a "double-edged-sword", on one hand providing low-cost building products while, on the other hand, destroying local production by existing labour-intensive methods.

This Part investigates the effects of introducing local mass production of certain building products on the local cost of the product costs and on local employment

Methodology

Described below is an analysis (contained in detail in a Microsoft Excel spreadsheet[33]) of three options for the indigenous manufacture of concrete building products.[34] [35] The spreadsheet has been use to determine the relative financial viability of various manufacturing options in four types of economy.

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[32] It is significant that "production" was not included in the list of new jobs. In fact, automated mass-production is likely to result in a reduction of production jobs, as discussed later in this section.

[33] For spreadsheet, see Appendix 6.

[34] Whilst the three options have been idealised to enable comparisons, they are still based on a combination of real Australian costs, comparison of GDP per capita data and the author's experience in the concrete block industry.

[35] The author has visited many large and small concrete product manufacturing factories in Australia, in addition to several overseas. The "factories" that best model the three options are:

- Option 1 - Automated mass production
  - Many large and small automated concrete block and tile plants in Australia
  - Similar automated factory in Jakarta, Indonesia. Operated by Monier PT.
- Option 2 - Mechanically assisted single production
  - Rural village near Benkulu, Sumartra, Indonesia.
- Option 3 - Manual single concrete block mould
  - Concrete block "manufacture" carried out in a poor suburban area of Harare, Zimbabwe, without electricity and with water drawn from a well that frequently runs dry. The business is operated by Ulita Chisuo (a middle aged woman, who used her second loan (A$ 3,000) in 1999 to establish a wool knitting business, a tuck shop and to purchase moulds for the concrete block manufacture.

Using the World Bank classifications, the four economy types and representative countries are:

High-income	Australia
Upper middle-income	South Africa
Lower middle-income	Papua New Guinea
Low-income	Indonesia

(World Bank, 1994)

Concrete Blockmaking Process

The three methods of [36]concrete blockmaking analysed in this paper are summarise below.

Option 1 - Automated mass production
This is a capital intensive manufacture, low labour option, based on modern high speed concrete block manufacturing equipment. The machinery chosen in this example is:

Automatic weigh batching and mixing
Columbia C8 electrically powered hydraulically operated "two block" machine
Manual off-bearer
Forklift transfer of "green" block to the curing chambers
Gas or oil burner curing

Being one of the smallest commercially available automated plants, it represents the option requiring the least capital input of the truly automated plants. It requires a reliable electricity supply, access to gas or oil supplies.

Option 2 - Mechanically assisted manual production
This is labour intensive multiple-unit manufacture assisted by "low technology-low capital investment" equipment which has been designed to reduce the manufacturing costs. The machinery chosen in this example is:

Weigh batching and mixing in a manually (or electrically) powered mixer
Mechanically or electrically powered "one block" egg-layer machine
Atmospheric curing

This option requires minimum capital input. It does not require an electricity supply or access to gas or oil supplies.

Option 3 - Manual single concrete block mould
This is labour intensive manufacture, based on manually mixing bagged cement and locally quarried sand and aggregate. Typically the mix will be prepared in a tub and poured into a steel or aluminium mould, perhaps several at a time, and allowed to cure overnight before being stripped from the mould.

[36] A description of the concrete block making process is set out in Appendix 11.

Assumptions

The spreadsheet analysis is based on the following assumptions. Despite the approximate nature of some of the assumptions, the broad conclusions are still considered to be valid. Given more exact data for specific applications, each of these assumptions could be refined.

Required profit before tax

The "required profit before tax" (ie a measure of the profitability of a business in excess of all costs, including depreciation) can be input manually to the spreadsheet. An investor will nominate this rate, based on the prevailing commercial interest rates, the level of investment involved, the projected turnover of the business and a strategy of reducing the level of indebtedness over a particular duration. In order to compare all business options on a common basis, the following assumption is made in this paper:

$$\text{Required profit before tax} = \frac{\text{Depreciation of total assets}}{\text{Total costs for the particular year}}$$

Therefore, if production is low during a particular year, there is a requirement to increase the profit (in percentage terms) in order to repay any borrowings needed to acquire the productive assets (or to compensate for forgone investment opportunities if borrowing is not needed). Conversely, if the total value of the assets is low compared to turnover, it is assumed that the need to repay outstanding loans quickly will be diminished. (Note: This may not hold true in many cases, depending on the attitude of the lender.)[37]

Product mix

The external dimensions, percentage solid and method of moulding (ie "on-flat" or "on-edge") affect the cost of each concrete product. The spreadsheet is capable of analysing a mix of three different products. For purposes of this paper, it has been assumed that:

50% is 390 x 190 x 90 mm hollow units (know as 1001), 75% solid, made on edge and used principally for partition walls,

30% is 398 x 398 x 60 mm solid "flag" paving units, 100% solid, made on flat and used principally for flooring or external paving

20% is 390 x 190 x 140 mm hollow units (know as 1501), 68% solid, made on edge and used principally for loadbearing external walls.

(CMAA, 2000)

Concrete Mix

The concrete mix affects the strength, durability and cost of concrete blocks. The mix adopted in this analysis is:

10% portland cement
45% sand
45% crushed stone aggregate

[37] An alternative criterion is considered in Appendix 12.

In general terms, the strength may increased by increasing the cement : (sand + aggregate) ratio and the aggregate : sand ratio.

(Pfeiffenberger, 1985)
(Lane 1997)
(Bullen & Humpola, 1995)

Materials costs

The materials costs have been estimated from the current costs of commercially available bagged portland cement, sand and aggregate supplies in Australia. The proximity of the manufacturing plant to suitable supplies of sand and aggregate makes significant difference to the transport costs associated with these materials. To simplify the analysis, it has been assumed that:

the cost of portland cement is the same in all countries, since it is manufactured by capital intensive methods in major centres and shipped to the point of final use

the cost of sand and aggregate is cheaper in a developing country, although not in direct proportion to the GDP/capita, since there is either a degree of mechanisation or a very high labour input involved in its quarrying and transport. In the absence of more precise data, the following assumption is used.

$$\text{Local cost per tonne} = \frac{\text{Australian cost per tonne}}{(\text{Local GDP per capita} / \text{Australian GDP per capita})^2}$$

Summary Of The Data

Table 11
Case 1 "Realistic Production"
ie a level of production required to make an automatic plant viable
Scenario Number
Average Price Per Unit A$ $_{2001}$
Number Of People Employed
Year 1 Gross Profit %
Year 1 Cash Flow

Economy Type	Country	**Option 1 Automated mass production**	**Option 2 Mechanically assisted manual production**	**Option 3 Manual single concrete block mould**
High-income	Australia	111 $ 1.63 2 19.5% - $ 547,463	114 $ 1.61 5 4.0% -$ 130,200	117 $1.87 16 0.0% -$ 2,093
Upper middle-income	South Africa	121 $ 1.14 2 30.8% - $ 547,463	124 $ 1.31 5 4.9% -$ 130,200	127 $ 1.63 16 0.1% -$ 2,093
Lower middle-income	Papua New Guinea	131 $ 1.05 2 33.3% - $ 547,463	134 $ 0.78 5 20.2% -$ 130,200	137 $ 1.57 16 0.1% -$ 2,093
Low-income	Indonesia	141 $ 1.04 2 34.4% - $ 547,463	144 $ 1.23 5 5.3% -$ 130,200	147 $ 1.55 16 0.1% -$ 2,093

Table 12
Case 2 "Pessimistic Production"
ie a quarter of the level of production required to make an automatic plant viable
Scenario Number
Average Price Per Unit A$ $_{2001}$
Number Of People Employed
Year 1 Gross Profit %
Year 1 Cash Flow

Economy Type	Country	**Option 1 Automated mass production**	**Option 2 Mechanically assisted manual production**	**Option 3 Manual single concrete block mould**
High-income	Australia	112 $ 4.24 2 33.1% - $ 547,463	115 $ 2.33 5 11.8% -$ 130,200	118 $1.88 16 0.2% -$ 2,093
Upper middle-income	South Africa	122 $ 2.88 2 57.7% - $ 547,463	125 $ 1.73 5 16.6% -$ 130,200	128 $ 1.63 16 0.2% -$ 2,093
Lower middle-income	Papua New Guinea	132 $ 2.69 2 64.3% - $ 547,463	135 $ 1.63 5 17.8% -$ 130,200	138 $ 1.56 16 0.3% -$ 2,093
Low-income	Indonesia	142 $ 2.66 2 65.7% - $ 547,463	145 $ 1.61 5 18.1% -$ 130,200	148 $ 1.55 16 0.3% -$ 2,093

Observations

The following observations are based on the assumption, that within any market, low priced product will "drive out" higher product.

In a high income country, an automated factory operating at reasonably high percentage of its capacity will underprice both mechanically assisted production and manual production. (Comparing Scenarios 111, 114 and 117) This is the case that is common in Australia, where almost all production includes a degree of automation. [38]

Similarly, in a low income country, an automated factory operating at reasonably high percentage of its capacity will underprice both mechanically assisted production and manual production. (Comparing Scenarios 141, 144 and 147) This is the case that is common outside the large cities in countries like Indonesia.

It follows that, in middle income countries, the same trend is observed.

In a high income country, an automated factory operating at a low output will produce product that is overpriced compared to both mechanically assisted production and manual production. (Comparing Scenarios 111, 114 and 117) However, in Australia low-priced product produced by automated factories in other areas gains market penetration, rather than these two options gaining success.

In a low income country, an automated factory operating at a low output will produce product that is overpriced compared to both mechanically assisted production and manual production. (Comparing Scenarios 142, 145 and 148) This is the case that is common in the large cities in countries like Indonesia.

It follows that, in middle income countries, the same trend is observed.

The risk to capital (indicated by the Year 1 negative cash flow) is much higher for automated factories than in cases where manual production is employed.

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[38] Most large Australian cities have two or more factories, each with two or more machines that have a capacity three or more times the capacity of the machine described in this paper.

Conclusions

In high-income countries, building products manufactured locally by automated processes can be distributed cheaper than their manually manufactured competitors.

In low-income and middle-income countries, building products manufactured locally by automated processes can be distributed cheaper than their manually manufactured competitors only if the market is predictable and sufficiently large enough to provide a reasonable return on the capital invested. Otherwise, manually produced products will hold a competitive edge.

In low-income and middle-income countries, building products manufactured locally by mechanically assisted manual methods may provide a cheap building products, a reasonable level of local employment and a reasonable return on a relatively low level of investment.

In the short term, manual production and mechanically assisted manual production provide more opportunities for local employment than automated production.

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Appendix 1
Sydney Low Income, Unemployment and House Occupancy Ratios

The following maps have been reproduced from a social atlas based on 1991Australian Bureau of Statistics data. (Farrell, 1993)

The new house prices (excluding land price) for the September quarter of 2000 are calculated from Australian Bureau of Statistics data on building approvals. (ABS 8731.1 2000)

Table 13
New House Approvals, Prices (excluding land price) and Distance from CBD (September quarter 2000)
(ABS 8731.1 2000)

Area	No of new houses approved	Total cost of new houses $	Average cost of new houses $ /house	Distance to central business district km
Sydney	2,345	$ 388,425,000	$ 165,600	Average
Inner Sydney	15	$ 2,076,000	$ 138,400	0
Eastern suburbs	20	$ 8,297,000	$ 414, 850	7
St. George-Sutherland	131	$ 25,178,000	$ 192,190	21
Canterbury-Bankstown	65	$ 11,198,000	$ 172,280	15
Fairfield-Liverpool	294	$ 44,918,000	$ 152,780	27
Outer South Western Sydney	315	$ 43,881,000	$ 139,300	24
Inner Western Sydney	14	$ 3,349,000	$ 239,200	9
Central Western Sydney	105	$ 15,584,000	$ 148,400	24
Outer Western Sydney	248	$ 36,383,000	$ 146,700	42
Blacktown-Baulkham Hills	475	$ 75,158,000	$ 158,200	24
Lower Northern Sydney	69	$ 19,681,000	$ 285,200	9
Hornsby Ku-ring-gai	137	$ 26, 397,000	$ 192,680	18
Northern Beaches	58	$ 17, 393,000	$ 299,880	15
Gosford-Wyong	399	$ 58,932,000	$ 147,700	80

Appendix 2
Water and Sewage Installations for Affordable Housing

Set out in the below are details for the supply of water and three alternatives for the disposal of sewage and waste water from affordable housing.

The sewage and waste water disposal options are:

disposal via open piped systems;
disposal via closed piped systems; and
on-site treatment using a septic tank.

(CMA SA 1978)

A further description of the operation of a septic tank is as follows.
Although single chamber systems can be used dual-chamber systems, although dual chamber systems are preferred. The first chamber provides for sedimentaion, sludge digestions and sludge storage. The second chamber permits additional sludge digestion and storage and provides a buffer against the accidental discharge of other material.

(Metcalf & Eddy, 1972).

Appendix 3
Basis of Cost Comparisons
(Including Currency Exchange Rated, Inflation and GDP/capita)

Reported costs have been converted to Year 2001 Australian dollars, based on the following assumptions:

Exchange Rates
The average of the buying and selling rated quoted at the beginning of May 2001 has been used. The relevant conversions are:

Australian Dollar : South African Rand	A $ 1.00 = R 4.07
Australian Dollar : Papua New Guinea Kina	A $ 1.00 = K 1.30
Australian Dollar : Indonesian Rupiah	A $ 1.00 = R 23.50 [39]
Australian Dollar : United States Dollar	A $ 1.00 = US $ 0.50

(Sydney Morning Herald, 5th May 2001)
(Commonwealth Bank of Australia, 3rd May 2001)

Inflation
Changes in costs due to inflation are based on the indices tabulated below:

	Average Annual Inflation Rate %	
	1970-1980	1980-1992
Australia	11.8%	6.4%
South Africa	13.0%	14.3%
Papua New Guinea	9.1%	5.1%
Indonesia	21.5%	8.4%
United States	7.5%	3.9%

(World Bank, 1994)

The CPI changes for Sydney are reproduced in Appendix 4. (ABS 6401.1, 2001) During the ten years for the beginning of 1991 to the beginning of 2001, the CPI rose by 24.7%, corresponding to an average annual rate of 2.2%.

The Interaction of Currency Exchange Rates and Inflation
It is recognised that this conversion involves some potential errors related to the different exchange rated in existence at various times and different inflation rates in the subject countries. However, to a significant degree these changes tend to compensate for each other. As inflation pushes up costs in a country, the value of its currency drops in proportion. Whilst there are many other factors affecting the exchange rates (as demonstrated by the dramatic drop in the value of the Indonesian Rupiah in 1997-99), the conversion process noted above is considered to be sufficiently accurate for the international cost comparisons carried out in this paper.

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[39] 1n 1997-98 the Indonesian Rupiah dropped to approximately 30 % of its former exchange rate (bottoming at 15% in mid 1998). This drastically reduced the growth rate, but the effect over a long period is difficult to determine. The Far Eastern Economic Review of 15th July 1999 reports that the rupiah is up 28% against the US dollar since the 7th June 1999 election.

GDP per capita

It is not possible to determine from the available data the average incomes of various groups within a particular country. For example, real GDP growth may result from a significant increase in incomes of the wealthy and mask the fact that the poor may have simultaneously suffered a decrease in income.

In the simulations produced in this paper, it is assumed that the workers involved in manufacturing building products and in building houses have incomes close to the average for that country.

The following GDP per capita for various countries have been used to estimate the value of local manufacturing and building labour costs in Australian dollar terms. The relativities between the Australian value and those for the other countries are important, not the absolute values. Therefore, the use of 1994 data does not invalidate the analysis.

	GDP per capita
Australia	US$ $_{1992}$ 17,260
South Africa	US$ $_{1992}$ 2,670
Papua New Guinea	US$ $_{1992}$ 950
Indonesia	US$ $_{1992}$ 670
United States	US$ $_{1992}$ 23,240

(World Bank, 1994)

Appendix 4
House Price Movements In Australia

The following data show the changes in Sydney house prices over a ten year period, corrected for changes in the CPI (Consumer Price Index).

Table 14
House Price Movements In Australia
(ABS 6401.0, 2001), (ABS 6416.0, 2001)

Year	Month	Sydney CPI	Sydney Established House Prices Actual Prices	Constant Prices	
		6401.0	6416.0		
		A	B	C=B/A	C/C_{av}
1992	M	107.0		0.000	
	J	106.5		0.000	
	S	106.9	103.7	0.970	0.979
	D	107.4	104.6	0.974	0.983
1993	M	108.2	106.6	0.985	0.994
	J	108.4	106.3	0.981	0.990
	S	107.7	107.4	0.997	1.006
	D	108.8	107.1	0.984	0.993
1994	M	109.1	109.3	1.002	1.011
	J	110.0	111.4	1.013	1.022
	S	111.0	114.3	1.030	1.039
	D	111.8	112.4	1.005	1.015
1995	M	113.7	114.9	1.011	1.020
	J	115.4	113.2	0.981	0.990
	S	117.3	115.8	0.987	0.996
	D	118.3	115.2	0.974	0.983
1996	M	119.1	115.4	0.969	0.978
	J	119.9	116.7	0.973	0.982
	S	120.2	117.5	0.978	0.987
	D	120.4	118.0	0.980	0.989
1997	M	120.6	119.4	0.990	0.999
	J	120.2	120.5	1.002	1.012
	S	119.8	123.6	1.032	1.041
	D	120.1	125.0	1.041	1.050
1998	M	120.7	130.9	1.085	1.095
	J	121.4	134.4	1.107	1.117
	S	121.9	133.2	1.093	1.103
	D	122.4	136.8	1.118	1.128
1999	M	122.6	138.9	1.133	1.143
	J	123.0	142.6	1.159	1.170
	S	124.1	145.8	1.175	1.186
	D	124.7	151.5	1.215	1.226
2000	M	125.8	156.5	1.244	1.256
	J	127.0	158.4	1.247	1.259
	S	131.6	162.3	1.233	1.245
	D	132.2		0.000	0.000
Average		111.5	110.5	0.991	1.000

Appendix 5 - Materials Costs Of Affordable Houses

Materials Costs Of Affordable Houses

The following materials costings are based on the prices of commercially available materials in Sydney Australia in April 2001. It does not include labour or transport costs.

Plans of each house are included in this appendix.

The costs are analysed using the Excel spreadsheet included in Appendix 6.

General Notes

Combined kitchens and living areas are counted as one room.

Separate toilet room are counted as part of an associated bathroom.

Reported floor areas exclude the area of any covered verandah.

The building materials used to construct houses to lock-up stage may be supplied to a housing site on a project-by-project basis from building products suppliers and manufacturers or may be supplied as "kit homes".

If materials are supplied in "kit form", they will not include such bulk materials as mass concrete.

House No	**1**
Country	Generic
Source	R Johnston
Floor plan area	48.6 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	4
Number of bedrooms	2
Average room area	12.1 m^2
Floor material	Concrete
Wall material	Masonry
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 9,499 per house
Material cost	A$ $_{2001}$ 195 per m^2

House No	**2**
Country	Generic
Source	R Johnston
Floor plan area	64.8 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	4
Number of bedrooms	2
Average room area	13.1 m^2
Floor material	Concrete
Wall material	Masonry
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 10,957 per house
Material cost	A$ $_{2001}$ 169 per m^2

House No	**3**
Country	Australia
Source	Habitat for Humanity
Floor plan area	108.0 m^2
Is a verandah constructed?	Yes
Number of storeys	1
Total number of rooms	8
Number of bedrooms	3
Average room area	13.5
Floor material	Particle board or timber
Wall material	Hardboard cladding
Roof material	Steel
Internal wall finishes	Plasterboard
Material cost	A$ $_{2000}$ 36,268 per house (Including veranda cost)
Material cost	A$ $_{2001}$ 336per m^2

House No	**4**
Country	Australia
Source	Habitat for Humanity
Floor plan area	104.6 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	8
Number of bedrooms	3
Average room area	13.1 m^2
Floor material	Particle board or timber
Wall material	Hardboard cladding
Roof material	Steel
Internal wall finishes	Plasterboard
Material cost	A$ $_{2000}$ 23,616 per house
Material cost	A$ $_{2001}$ 226 per m^2

House No	**5**
Country	South Africa
Source	Concrete Manufacturers Association (South Africa)
Floor plan area	68.1m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	6
Number of bedrooms	2
Average room area	11.4 m^2
Floor material	Concrete
Wall material	Masonry
Roof material	Steel
Internal wall finishes	Nil
Material cost	A\$ $_{2000}$ 13,690 per house
Material cost	A\$ $_{2001}$ 201 per m^2

House No	**6**
Country	South Africa
Source	Concrete Manufacturers Association (South Africa)
Floor plan area	91.0 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	8
Number of bedrooms	4
Average room area	11.4 m^2
Floor material	Concrete
Wall material	Masonry
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 16,985 per house
Material cost	A$ $_{2001}$ 187 per m^2

House No	**7**
Country	South Africa
Source	Concrete Manufacturers Association (South Africa)
Floor plan area	36.0 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	3
Number of bedrooms	1
Average room area	12.0 m^2
Floor material	Concrete
Wall material	Masonry
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 8,805 per house
Material cost	A$ $_{2001}$ 245 per m^2

House No	**8**
Country	South Africa
Source	Concrete Manufacturers Association (South Africa)
Floor plan area	72.9 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	6
Number of bedrooms	3
Average room area	14.6 m^2
Floor material	Concrete
Wall material	Masonry
Roof material	Steel
Electrical supply	Not included in costing
Material cost	A$ $_{2000}$ 14,945 per house
Material cost	A$ $_{2001}$ 205 per m^2

House No	**9**
Country	Papua New Guinea
Source	Habitat for Humanity
Floor plan area	23.8 m^2
Is a verandah constructed?	Yes
Number of storeys	1
Total number of rooms	3
Number of bedrooms	2
Average room area	7.9 m^2
Floor material	Particle board or timber
Wall material	Timber
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 6,447 per house
Material cost	A$ $_{2001}$ 270 per m^2

House No	**10**
Country	Papua New Guinea
Source	Habitat for Humanity
Floor plan area	29.8
Is a verandah constructed?	Yes
Number of storeys	1
Total number of rooms	4
Number of bedrooms	3
Average room area	7.4 m^2
Floor material	Particle board or timber
Wall material	Timber
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 7,945 per house
Material cost	A$ $_{2001}$ 267 per m^2

House No	**11**
Country	Papua New Guinea
Source	Habitat for Humanity
Floor plan area	29.8 m^2
Is a verandah constructed?	Yes
Number of storeys	1
Total number of rooms	4
Number of bedrooms	3
Average room area	29.8 m^2
Floor material	Particle board or timber
Wall material	Timber
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 7,633 per house
Material cost	A$ $_{2001}$ 256 per m^2

House No	**12**
Country	Papua New Guinea
Source	Habitat for Humanity
Floor plan area	35.3 m^2
Is a verandah constructed?	Yes
Number of storeys	1
Total number of rooms	5
Number of bedrooms	4
Average room area	7.1 m^2
Floor material	Particle board or timber
Wall material	Timber
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 8,667 per house
Material cost	A$ $_{2001}$ 246 per m^2

House No	**13**
Country	Papua New Guinea
Source	Habitat for Humanity
Floor plan area	35.3 m^2
Is a verandah constructed?	Yes
Number of storeys	1
Total number of rooms	5
Number of bedrooms	4
Average room area	7.1 m^2
Floor material	Particle board or timber
Wall material	Timber
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 8,822 per house
Material cost	A$ $_{2001}$ 250 per m^2

House No	**14**
Country	Papua New Guinea
Source	Habitat for Humanity
Floor plan area	35.7 m^2
Is a verandah constructed?	Yes
Number of storeys	1
Total number of rooms	4
Number of bedrooms	3
Average room area	7.1 m^2
Floor material	Particle board or timber
Wall material	Timber
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 8,641 per house
Material cost	A$ $_{2001}$ 245 per m^2

House No	**15**
Country	Solomon Islands
Source	Habitat for Humanity
Floor plan area	35.8 m^2
Is a verandah constructed?	Yes
Number of storeys	1
Total number of rooms	4
Number of bedrooms	2
Average room area	7.2 m^2
Floor material	Particle board or timber
Wall material	Timber
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 8,896 per house
Material cost	A$ $_{2001}$ 248 per m^2

House No	**16**
Country	Fiji
Source	Habitat for Humanity
Floor plan area	22.0 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	1
Number of bedrooms	1
Average room area	22.0 m^2
Floor material	Concrete
Wall material	Steel
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 4,266 per house
Material cost	A$ $_{2001}$ 193 per m^2

House No	**17**
Country	Fiji
Source	Habitat for Humanity
Floor plan area	41.0 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	4
Number of bedrooms	2
Average room area	10.3 m^2
Floor material	Particle board or timber
Wall material	Steel
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 8,526 per house
Material cost	A$ $_{2001}$ 207 per m^2

House No	**18**
Country	Fiji
Source	Habitat for Humanity
Floor plan area	50.7 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	5
Number of bedrooms	2
Average room area	10.1 m^2
Floor material	Concrete
Wall material	Steel
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 11,233 per house
Material cost	A$ $_{2001}$ 222 per m^2

House No	**19**
Country	Fiji
Source	Habitat for Humanity
Floor plan area	39.5 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	3
Number of bedrooms	2
Average room area	13.1 m^2
Floor material	Concrete
Wall material	Masonry
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 8,973 per house
Material cost	A$ $_{2001}$ 227per m^2

House No	**20**
Country	Fiji
Source	Habitat for Humanity
Floor plan area	35.8 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	4
Number of bedrooms	2
Average room area	8.9 m^2
Floor material	Particle board or timber
Wall material	Timber
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 6,894 per house
Material cost	A$ $_{2001}$ 193 per m^2

House No	**21**
Country	Vanuatu
Source	Habitat for Humanity
Floor plan area	37.3 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	4
Number of bedrooms	2
Average room area	9.3 m^2
Floor material	Concrete
Wall material	Masonry + Copra Bag/Mesh Wire/Concrete
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 6,339 per house
Material cost	A$ $_{2001}$ 170 per m^2

House No	**22**
Country	Pacific Island countries (Tuvalu, Fiji, Cook Is, Solomon Is, Vanuatu and Niue)
Source	National Building Code - Home Building Manual
Floor plan area	24.5 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	3
Number of bedrooms	1
Average room area	8.1 m^2
Floor material	Concrete
Wall material	Steel
Roof material	Steel
Internal wall finishes	Nil
Material cost	A$ $_{2000}$ 5,644 per house
Material cost	A$ $_{2001}$ 230 per m^2

House No	**23**
Country	USA
Source	Habitat for Humanity (Alexander 1990)
Floor plan area	91.4 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	6
Number of bedrooms	3
Average room area	15.2 m^2
Floor material	Concrete
Wall material	Masonry
Roof material	Steel
Internal wall finishes	Plasterboard
Material cost	A$ $_{2000}$ 25,772 per house
Material cost	A$ $_{2001}$ 282 per m^2

House No	**24**
Country	USA
Source	Habitat for Humanity (Alexander 1990)
Floor plan area	97.5 m^2
Is a verandah constructed?	No
Number of storeys	2
Total number of rooms	6
Number of bedrooms	3
Average room area	16.2 m^2
Floor material	Concrete
Wall material	Masonry
Roof material	Steel
Internal wall finishes	Plasterboard
Material cost	A$ $_{2000}$ 23,460 per house
Material cost	A$ $_{2001}$ 241 per m^2

House No	**25**
Country	USA
Source	Habitat for Humanity (Alexander 1990)
Floor plan area	104.8 m^2
Is a verandah constructed?	No
Number of storeys	1
Total number of rooms	7
Number of bedrooms	4
Average room area	15.0 m^2
Floor material	Concrete
Wall material	Masonry
Roof material	Steel
Internal wall finishes	Plasterboard
Material cost	A$ $_{2000}$ 27,630 per house
Material cost	A$ $_{2001}$ 264 per m^2

Appendix 6
Microsoft Excel Spreadsheet For The Estimation Of House Materials

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Appendix 7
Australian Standards Relevant To Housing

1 - Site Establishment
AS 2601The demolition of structures
AS/NZS 4576 Guidelines for scaffolding
AS/NZS 1576.1 Scaffolding - General requirements
AS 1576.2 Scaffolding - Couplers and accessories
AS/NZS 1576.3 Scaffolding - Prefabricated and tube-and-coupler scaffolding
AS 1576.4 Scaffolding - Suspended scaffolding
AS/NZS 1576.5 Scaffolding - Prefabricated splitheads and trestles
AS 1577-1993 Scaffold planks

Building industry guide - A WorkCover building and construction industry guide to workers compensation, long service benefits, rehabilitation, worksite health and safety and certification.
The WorkCover Authority Of New South Wales, Order No 300, October 1996.

Code Of Practice - Amenities for construction work
The WorkCover Authority Of New South Wales, Order No 317, March 1997.

Code Of Practice - Safe work on roofs - Part 2 - Residential buildings
The WorkCover Authority Of New South Wales, Order No 317, March 1997.

Providing first aid at work
The WorkCover Authority Of New South Wales, Order No 105, May 1998.

Six steps to occupational health and safety
The WorkCover Authority Of New South Wales, Order No 217, February 1997.

Skin cancer and outdoor workers - a guide for employers
The WorkCover Authority Of New South Wales, Order No 116

Skin cancer and outdoor workers - a guide for workers
The WorkCover Authority Of New South Wales

Living with fibro
The WorkCover Authority Of New South Wales, Order No 315

Health and Safety Notes - Chrysotile (white asbestos) and workplace health and safety
The WorkCover Authority Of New South Wales

Removal of asbestos cement sheeting
The WorkCover Authority Of New South Wales, Ref:RR/96.111

2 - Earthworks And Site Drainage
AS 2870.1 Residential slabs and footings - Construction

3 - Concrete

AS 3600 Concrete Structures
AS 3610 Formwork for concrete
AS 3660.1 Protection of buildings from subterranean termites - New buildings
AS 2870 Residential slabs and footings - Construction
AS 4200.1 Pliable building membranes and underlays - Part 1 Materials
AS 1304 Welded wire reinforcing fabric for concrete
CSIRO Pamphlet 10-19 *Guide to Home Owners on Foundation Maintenance and Footing Performance*.

4 - Retaining Walls

AS 4455 Masonry units and segmental pavers
AS 3972 Portland and blended cements
AS 1672.1 Limes and Limestone - Part 1 Limes for building
AS 2758.1 Aggregates and rock for engineering purposes - Part 1 Concrete aggregates
AS 2001.2.3 Methods of test for textiles - Part 2.3 Determination of breaking force and extension of textile fabrics
AS 3706.2 Geotextiles method of test - Part 2 Determination of tensile properties - Widestrip method
AS 3706.3 Geotextiles method of test - Part 3 Determination of tearing strength - Trapezoidal method
AS 3706.4 Geotextiels method of test - Part 4 Determination of burst strength - California bearing ratio (CBR) plunger method
AS 3706.7 Geotextiles method of test - Part 7 Determination of pore size distribution - Dry sieving method
AS 3706.9 Geotextiles method of test - Part 9 Determination of transmissivity
Various product brochures and installation manuals from materials suppliers.

5 - Drainage And Plumbing

AS/NZS 3500 (Compendium) National Plumbing and Drainage Code
AS/NZS 3500.1 Water supply
AS/NZS 3500.2 Sanitary plumbing and sanitary drainage
AS/NZS 3500.3 Stormwater drainage
AS/NZS 3500.4 Hot water supply
AS 3740 Waterproofing of wet areas within residential buildings
AS 4058 Precast concrete pipes (pressure and non-pressure)
AS 1477 PVC pipes and fittings for pressure applications
AS 1260 PVC pipes and fittings for drain, waste and vent applications
AS 1254 Un-plasticised PVC (UPVC) pipes and fittings for storm and surface water applications
AS 2032 Code of practice for the installation of UPVC pipe systems
AS 2033 Installation of polyethylene pipe systems
AS 1432 Copper tubes for plumbing, gasfitting and drainage applications
AS 3495 Authorization requirements for plumbing products - Stainless steel non-pressure pipes and fittings
AS 2887 Plastic waste fittings
AS 1589 Copper and copper alloy waste fittings
AS 1172.1 Water closets of 6/3 L capacity - Pans
AS 1172.2 Water closets of 6/3 L capacity - Cisterns

AS 1371Toilet seats of moulded plastics
AS 1756 Household sinks
AS/NZS 1229 Laundry troughs and tubs
AS/NZS 1730 Washbasins
AS 3588 Shower bases and shower modules
AS 2023 Baths for ablutionary purposes
AS 3861 Spa baths

6 - Windows, Doors And Glazing
AS 1664 Rules for the use of aluminium in structures (know as the SAA Aluminium Structures Code)
AS 2208 Safety glazing materials in buildings
AS 1288 Glass in buildings
AS 2047 Windows
AS 2688 Timber doors
AS 4285 Skylights

7 - Structural Steel Work
AS 4100 Steel structures
AS 3678 Structural steel - Hot-rolled plates, floorplates and slabs
AS 1111 ISO metric hexagon commercial bolts and screws
AS 1554 Structural steel welding
AS 1627 Metal finishing - preparation and pre-treatment of surfaces
AS 4680 Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
AS 1252 High strength steel bolts with associated nuts and washers for structural engineering
AS/NZS 2312 Guide to the protection of iron and steel against exterior atmospheric corrosion
AS 1627.4 Abrasive blast cleaning
AS 1627.5 Pickling, descaling and oxide removal
AS/NZS 3750.1 Paints for steel structures - Part 1 Epoxy mastic (two-pack)
AS/NZS 3750.13 Paints for steel structures - Part 13 Epoxy primer (two-pack)
AS/NZS 3750.14 Paints for steel structures - Part 14 High-build epoxy (two-pack)
AS/NZS 3750.15 Paints for steel structures - Part 15 Inorganic zinc silicate paint

8 - Wall, Roof And Floor Framing
AS 1684 National Timber Framing Code
AS 1720.1 Timber structures - Part 1 Design methods
AS 3623 Domestic metal framing
AS 4600 Cold-formed steel structures

9 - Carpentry And Joinery
AS 2270 - Plywood and blockboard for internal use
AS 2271 - Plywood and blockboard for external use
AS/NZS 1859.1 - Particleboard
AS/NZS 1859.2 - Medium density fibreboard (MDF)
AS/NZS 1859.3 - Decorative overlaid wood panels
AS/NZS 1859.4 - Hardboard
AS/NZS 1859.5 Fibre insulating board (insulation board)

AS 1783 - Lining boards milled from Australia grown conifers (softwoods) (excluding radiata pine and cypress pine)
AS 1784 Preservative-treated cladding (weather-boards and chamferboards) boards milled from Australia grown conifers (softwoods) (excluding radiata pine and cypress pine)
AS 1785 Mouldings milled from Australia grown conifers (softwoods) (excluding radiata pine and cypress pine)
AS 1786 Joinery timber milled from Australia grown conifers (softwoods) (excluding radiata pine and cypress pine)
AS 1787 Preservative-treated fascia boards and barge boards milled from Australia grown conifers (softwoods) (excluding radiata pine and cypress pine)
AS 1810 - Timber - Seasoned cypress pine - Milled products
AS 2796 - Timber - Seasoned hardwood - Milled products
AS 2908.1 - Cellulose-cement products - Corrugated sheets
AS 2908.1 - Cellulose-cement products - Flat sheets
AS/NZS 2904 - Flashings
AS/NZS 4256.4 - Unplasticised polyvinyl chloride (uPVC) sheet
AS/NZS 4256.3 - Glass Fibre Reinforced Polyester (GRP) sheet
AS/NZS 4256.5 - Polycarbonate

10 - Roof Cladding
AS/NZS 1562.1 Design and installation of sheet roof and wall cladding - Part 1 Materials
AS/NZS 4256 Plastic roof and wall cladding materials
AS/NZS 4597 Installation of roof slates and shingles (non-interlocking type)
AS 2049 Roof Tiles
AS 1684 National Timber Framing Code
AS 4200.1 Pliable building membranes and underlays - Part 1 Materials
AS 4200.2 Pliable building membranes and underlays - Part 2 Installation requirements
AS 2050 Fixings on roof tiles
AS 1530 Methods for fire tests on building materials, components and structures
AS 1397 Specification and supply of concrete
AS 3742 Mineral wool thermal insulation - batt and blanket

11 - Roof Plumbing
AS 3500.2 National Plumbing and Drainage Code - Part 2 Sanitary plumbing and drainage
AS 2179.1 Specifications for rainwater goods, accessories and fasteners - Part 1 Metal shape or sheet rainwater goods, metal accessories and fasteners
AS 2179.2 Specifications for rainwater goods, accessories and fasteners - Part 2 PVC rainwater goods and accessories
AS 2180 Metal rainwater goods - Selection and installation

12 - Masonry
AS 3700 Masonry structures
AS/NZS 2904 Damp-proof courses and flashings
AS/NZS 4455 Masonry units and segmental pavers
AS/NZS 4456 Masonry units and segmental pavers - Methods of test
AS/NZS 2699.1 Built-in components for masonry construction Part 1: Wall ties
AS/NZS 2699.2 Built-in components for masonry construction Part 2: Connectors and accessories

AS/NZS 2699.3 Built-in components for masonry construction Part 3: Lintels and shelf angles (durability requirements)
AS 3972 Portland and blended cements
AS 1672.1 Limes and Limestone - Part 1 Limes for building
AS 2578.1 Aggregates and rock for engineering purposes - Part 1 Concrete aggregates
AS 3600 Concrete structures
AS 2870 Residential slabs and footings - Construction
AS 1397 Specification and supply of concrete
AS/NZS 4680 Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
AS/NZS 4534 Zinc and zinc/aluminium-alloy coatings on steel wire
AS 3660.1 Protection of buildings from subterranean termites - Prevention, detection and treatment of infestation - New buildings
AS 1449 Wrought alloy steels - Stainless and heat-resisting steel plate, sheet and strip
AS 4791 Hot-dip galvanised (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialised process
AS 1302 Steel reinforcing bars for concrete
AS 1304 Welded wire reinforcing fabric for concrete

13 - Ceiling And Wall Lining
AS 2588 Gypsum plasterboard
AS 2589 Gypsum linings in residential and light commercial construction - Application and finishing

14 - Insulation
AS 3742 Mineral wool thermal insulation - Batt and blanket
AS 2461 Mineral wool thermal insulation loose fill
AS 2462 Cellulosic fibre thermal insulation
AS 2463 Sea grass bulk thermal insulation
AS 1366 Rigid cellular plastic sheets for thermal insulation
AS 4073 Urea-formaldehyde foam thermal insulation - In situ set foam
AS 4200 Pliable building membranes and underlays
AS 3999 Thermal insulation of dwellings - Bulk insulation - Installation
AS 2627 Thermal insulation for dwellings
AS 2627.1 Thermal insulation for dwellings - Part 1 Thermal insulation of roof/ceilings and walls in dwellings

15 - Floor And Wall Tiling
AS 3958.1 Ceramic tiles - Part 1 Guide to the installation of ceramic tiles
AS 3958.2 Ceramic tiles - Part 2 Guide to the selection of a ceramic tiling system
AS 2358 Adhesives - For fixing ceramic tiles
AS 3740 Waterproofing of wet areas within residential buildings
AS 3972 Portland and blended cements
AS 1672 Limes and Limestone - Part 1 Limes for building
AS 2758.1 Aggregates and rock for engineering purposes - Part 1 Concrete aggregates
AS 2870 Residential Slab and footings - Construction

16 - Electrical Installation
AS/NZS 3000 Electrical installations (known as the Australian /NewZealand Wiring Rules)

17 - Kitchen
AS 4386.1 Domestic kitchen assemblies - Part 1 Kitchen units
AS 4386.2 Domestic kitchen assemblies - Part 1 Installation

18 - Vehicular Doors
AS/NZS 4505 Domestic garage doors

19 - Painting
AS 2311 The painting of buildings
AS 2312 Guide to the protection of iron and steel against exterior atmospheric corrosion

20 - Resilient Floor Coverings
AS 1884 Floor coverings - Resilient sheets and tiles - Laying and maintenance
AS 1889.1 PVC floor tiles - Part 1 Semi rigid
AS 1889.2 PVC floor tiles - Part 2 Flexible
AS 2055.1 PVC sheet floor-covering - Part 1 Unbacked, flexible
AS 3553 Adhesives for floor and wall applications - Resilient vinyl, linoleum and rubber sheet tiles - Interior and exterior use.

21 - Carpets And Soft Furnishings
AS 2454 Textile floor coverings - Terminology
AS 2455 Textile floor coverings - Installation practice

22 - Window And Door Shutters
AS/NZS 2803 Doors - Security screens
AS/NZS 2804 Installation of security screen doors
AS/NZS 4604 Security window grilles
AS/NZS 4605 Installation of Security window grilles

23 - Mechanical Ventilation

24 - Brick Cleaning
Cleaning Of Masonry - Code Of Practice
NSW Building And Construction Industry Training Committee Limited - 1985

Cleaning Brickwork
Experimental Building Station
Department Of Construction November, 1968.

A Survey Of Recent Research Into The Control Of Efflorescence In Concrete Masonry
Morrish, CF and Johnston, RK
Cement And Concrete Association Of Australia T52 1980

25 - Landscaping
AS 4419 Soils for landscaping and garden use
AS 4454 Compost, soil conditioners and mulches
AS 3743 Potting mixes
AS 3700 Masonry Structures

26 - Fencing
AS 1926 Swimming pool safety
AS 1926.1 Swimming pool safety - Part 1 Fencing for swimming pools
AS 1725 Galvanised rail-less chainwire security fences and gates
AS 2423 Galvanised wire fencing products

27 - Paving
AS 3727 Guide to residential pavements
AS 1141.33 Methods for sampling and testing aggregates - Part 33 Clay and fine silt (setting method)
AS 4455 Masonry units and segmental pavers
AS/NZS 3661.1 Slip resistance of pedestrian surfaces -Part 1 Requirements
AS/NZS 4456.3 Masonry units and segmental pavers - methods of test - Part 3 Determining dimensions
AS/NZS 4456.5 Masonry units and segmental pavers - methods of test - Part 5 Determining breaking load of segmental paving units
AS/NZS 4456.9 Masonry units and segmental pavers - methods of test - Part 9 Determining abrasion resistance
AS/NZS 4456.10 Masonry units and segmental pavers - methods of test - Part 10 Determining resistance to salt
AS 1289 Methods of testing soils for engineering purposes
AS 2150 Hot mix asphalt
AS 2734 Asphalt (hot-mixed) paving - Guide to good practice
AS 3600 Concrete Structures
AS 1302 Steel reinforcing bars for concrete
AS 1304 Welded wire reinforcing fabric for concrete

28 - Metalwork And Balustrades
AS 4100 Steel Structures
AS 1664 Rules for the use of aluminium in structures (know as the SAA Aluminium Structures Code)
AS 2208 Safety glazing materials in buildings

Appendix 8
South African Standards Relevant To Housing - Partial List

South African Standards, 1990, *The application of the National Building Regulations*, SABS 0400 1990-08-23

South African Standards, 1989, *The construction of dwelling houses in accordance with the National Building Regulations*, SABS 0401 1989-02-27

Appendix 9
Papua New Guinea Standards Relevant To Housing - Partial List

PNGS 1002 - Code of practice for Concrete Structures

PNGS 1003 - Code of practice for Steel Structures

PNGS 1004 - Code of practice for Reinforced Masonry Structures

PNGS 1292 - Code of practice for the design of Timber Structures

AS 1664 - Aluminium structures (except that loads shall be calculated from PNGS 1001)

AS 1538 - Cold formed steel structures (except that loads shall be calculated from PNGS 1001)

AS 1288 - Glass in buildings (except that loads shall be calculated from PNGS 1001)

Appendix 10
Indonesian Standards Relevant To Housing - Partial List

Indonesian Standards, 1981, *Loading specification for houses and buildings, Guide for design,* SNI 03 1727 1981

Indonesian Standards, 1981, *Building and its environment for fire protection in houses and buildings, Guide for design,* SNI 03 1735 1981

Indonesian Standards, 1981, *Building structure for fire protection in building and housing,* SNI 03 1736 1981

Indonesian Standards, 1989, *Reinforced concrete and structure of reinforced wall for houses and buildings, Guide for design,* SNI 03 1734 1989

Indonesian Standards, 1989, *Steel construction for buildings, Guide for design,* SNI 03 1729 1989

Indonesian Standards, 1991, *Wood for housing and buildings* SNI 03 2445 1991

Appendix 11
Concrete Blockmaking Process

Three options are considered in this paper:
- Option 1 - Automated mass production
- Option 2 - Mechanically assisted manual production
- Option 3 - Manual single concrete block mould

Option 1 - Automated mass production
This is a capital intensive manufacture, low labour option, based on modern high-speed concrete block manufacturing equipment.

Raw materials are delivered to silos and bins, with the various sizes of aggregates stored separately.

Cement and aggregates are weighed automatically to predetermined quantities. A very “dry” cohesive concrete is used in masonry manufacture, in conjunction with powerful mould vibration at the same time as pressure is applied to the concrete in the mould. As freshly moulded units are extruded down from the machine mould approximately every ten seconds, they must have sufficient “green strength” to permit them to be handled without damage or distortion.

The mixing of concrete is controlled automatically in most plants and is linked with the batching plant to provide a concrete output suited to the consumption of the block machine. A moisture sensor controls the addition of water. It maintains the correct moisture content and consistency in the concrete as it is delivered from the mixer to the blockmaking machine. In some plants, automatic compensation of fine aggregate weight for moisture content is provided by feedback from the moisture sensor to the batch weigher, but in others the operator and the quality control inspector will note changes and compensate manually.

From the mixer, concrete of the correct proportions and workability is transported either by gravity or mechanically to the blockmaking machine. Machine pallets are heavy steel plates designed to act as a mould bottom. Before each new cycle of the machine, a fresh machine pallet is placed under the mould. The mould is filled and the blocks vibrated. The blocks are then extruded downwards from the mould, remaining on the pallet which travels with them to form a tray on which they are transported until they are cured and about to be assembled into “cubes” at the packaging station.

Most high production block machines employ a mould, core, stripper shoe and machine pallet arrangements. They differ only in size, the number of units that can be made per machine cycle (ie. on each machine pallet), the system of actuation (electro mechanical or electro hydraulic) and the method by which vibration is applied to the mould and the “green” blocks. Mould vibration systems are either vibrator units directly attached to the mould or remote units connected to the mould by rods. Rectangular units can be manufactured "on edge" in the block machine, ensuring that the whole of the machine cavity is effectively used. Thus, for each machine cycle a larger number of units may be manufactured in this way than would otherwise result from units manufactured "on the flat".

Moulded “green” blocks are transported mechanically from the block machine on the machine pallets to the curing chambers. Freshly moulded or "green" concrete units are deposited on a steel pallet. These may be:

- loaded into steel racks for transport by forklift or kiln car to and from the kilns or curing areas,
- loaded directly onto an automatic transfer car, or
- transported to and from the kiln or curing area by a conveyor system.

Low pressure steam curing was one of the earliest accelerated curing methods used. In this system, saturated steam, at atmospheric pressure and at temperatures above about 70^{o}C, is introduced into insulated chambers containing racks of “green” blocks. Hydration, the chemical reaction between cement and water, which causes hardening, is accelerated at high temperature in a vapour-saturated atmosphere. About 90% of the 28 day atmospheric temperature cured strength of the concrete is developed in 18 to 24 hours by this process. Units may thus be handled and packaged the day after moulding and used within seven days or less. Figure 2.16 illustrates typical low pressure steam curing chambers.

Other low pressure curing systems use gas or oil burners to heat the curing chamber. Steam is generated by spraying water on a hot plate that is heated by the burner. These systems offer economies in capital expenditure, as a steam boiler is not needed. They can be programmed for automatic operation without the need for an attendant, resulting in economy in operation. The results achieved are generally similar to those available with medium temperature low pressure steam curing. Burner systems have the advantage that a drying period may be added at the end of the curing cycle.

When the hardened concrete units have been returned from the kiln or curing area, they are automatically removed from the steel pallets, realigned and pushed into a cubic shape using an automatic cubing machine. In some factories, cubes of finished product are shrink-wrapped. When required, units may be split, rumbled or polished using equipment installed at the factory.

After cured blocks are unloaded from the racks or curing chambers, they are removed mechanically from the machine pallets and transported by conveyor to the palletising station, where they are assembled into “cubes” of standard sizes, usually measuring approximately 1.2 x 1.2 x 1.2m.

Between the machine pallet stripping station and the cuber, a continuous inspection is made for units of sub-standard appearance, which are rejected and removed. Sampling for testing for compliance with Australian Standards AS/NZS 4455 and AS/NZS 4456, as appropriate, is carried out also at this stage.

After palletising, the “cubes” are either stacked in the storage area for future transport to job sites. Normally, loading is carried out in the storage yard by forklift truck.

Option 2 - Mechanically assisted manual production

This is labour intensive multiple-unit manufacture assisted by "low technology-low capital investment" equipment which has been designed to reduce the manufacturing costs.

The machinery chosen in this example is:

Weigh batching and mixing in a manually (or electrically) powered mixer
Mechanically or electrically powered "one block" egg-layer machine
Atmospheric curing

Option 3 - Manual single concrete block mould

This is labour intensive manufacture, based on manually mixing bagged cement and locally quarried sand and aggregate. Typically the mix will be prepared in a tub and poured into a steel or aluminium mould, perhaps several at a time, and allowed to cure overnight before being stripped from the mould.

Appendix 12
Microsoft Excel Spreadsheet For The Analysis Of Concrete Blockmaking

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Appendix 13
Analysis Of Concrete Masonry Manufacturing Businesses Using An Alternate Profit Criterion

Profit Criterion

The "required profit before tax" used in the body of this paper is:

$$\text{Required profit before tax} = \frac{\text{Depreciation of total assets}}{\text{Total costs for the particular year}}$$

AlternateProfit Criterion

This appendix considers the effect of an alternative criterion:

$$\text{Required profit before tax} = \frac{\text{Commercial borrowing rate x Total assets opening value}}{\text{Total costs for the particular year}}$$

If production is low during a particular year, there is a requirement to increase the profit (in percentage terms) in order to service any borrowings needed to acquire the productive assets (or to compensate for forgone investment opportunities if borrowing is not needed). Conversely, if the total value of the assets is low compared to turnover, it is assumed that the need to repay outstanding loans quickly will be diminished. (Note: This may not hold true in many cases, depending on the attitude of the lender.)

Table 15
Case 1 "Realistic Production"
ie a level of production required to make an automatic plant viable
Scenario Number
Average Price Per Unit A$ $_{2001}$
Number Of People Employed
Year 1 Gross Profit %
Year 1 Cash Flow

Economy Type	Country	**Option 1 Automated mass production**	**Option 2 Mechanically assisted manual production**	**Option 3 Manual single concrete block mould**
High-income	Australia	11 $ 1.50 2 9.5% - $ 590,195	14 $ 1.58 5 2.0% -$ 140,100	17 $1.87 16 0.0% -$ 2,252
Upper middle-income	South Africa	21 $ 1.01 2 14.7% -$ 590,195	24 $ 1.28 5 2.5% -$ 140,100	27 $ 1.63 16 0.0% -$ 2,252
Lower middle-income	Papua New Guinea	31 $ 0.93 2 16.4% - $ 590,195	34 $ 1.21 5 2.6% -$ 140,100	37 $ 1.56 16 0.0% -$ 2,252
Low-income	Indonesia	41 $ 0.91 2 16.7% - $ 590,195	44 $ 1.20 5 2.6% -$ 140,100	47 $ 1.56 16 0.0% -$ 2,252

Table 16 Case 2 "Pessimistic Production" ie a quarter of the level of production required to make an automatic plant viable Scenario Number Average Price Per Unit A$ $_{2001}$ Number Of People Employed Year 1 Gross Profit % Year 1 Cash Flow				
Economy Type	Country	**Option 1 Automated mass production**	**Option 2 Mechanically assisted manual production**	**Option 3 Manual single concrete block mould**
High-income	Australia	12 $ 3.70 2 9.5% - $ 590,195	15 $ 2.21 5 2.0% -$ 140,100	18 $1.88 16 0.1% -$ 2,252
Upper middle-income	South Africa	22 $ 2.35 2 28.5% -$ 590,195	25 $ 1.61 5 8.3% -$ 140,100	28 $ 1.63 16 0.1% -$ 2,252
Lower middle-income	Papua New Guinea	32 $ 2.16 2 16.4% - $ 590,195	35 $ 1.51 5 2.6% -$ 140,100	38 $ 1.57 16 0.0% -$ 2,252
Low-income	Indonesia	42 $ 2.12 2 32.5% - $ 590,195	45 $ 1.49 5 9.0% -$ 140,100	48 $ 1.55 16 0.1% -$ 2,252

Conclusion

It can be seen that the changed criterion permits slightly lower prices in the case of the automated plants, but has no significant effect on manual production. It emphasises, rather than diminishes, the conclusions drawn in the body of the paper.