The Cost of Constructing Affordable and Sustainable Housing and Community Buildings in the Andaman Islands

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SUMMARY

On 26 December 2004 there was an earthquake followed by a tsunami beneath the Indian Ocean between Indonesia and the Andaman and Nicobar Islands.

The earthquake caused a considerable number of buildings to collapse on the Andaman Islands followed by further extensive damage along the east coast and estuaries of the islands when the tsunami hit the islands.

In the case of the Nicobar Islands the tsunami caused devastation causing a substantial proportion of the surviving population to flee to the Andaman Islands resulting in the population of Port Blair, the capital of both the Andaman and Nicobar Islands, to increase from approximately 100,000 to in excess of 150,000. The author has read one estimate of 200,000, but doubts that it is as high as this.

This event resulted in a substantial quantity of earthquake resistant housing and community buildings to be required where there are few technical resources.

This paper looks at the current costs of constructing the concrete superstructure frame required for basic affordable and sustainable earthquake resistant housing, being the element with the highest cost that can be considered and reviewed to be constructed in another way using local labour, and the equivalent cost per house if a pre-cast concrete plant could be established on the Andaman Islands, to construct the houses with pre-cast concrete columns and beams. This would not only reduce the cost of constructing the housing and community buildings, but provide a long term resource to the infrastructure to the islands with the attendant employment opportunities.

This paper also considers how the equipment used to move the pre-cast components about, if made available to the island, could be used when not erecting the pre-cast frames and also create further employment for its operators.

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INTRODUCTION

Following the 26 December 2004 earthquake and tsunami under the Indian Ocean between Indonesia and the Andaman and Nicobar Islands, causing the collapse of many buildings on the Andaman Islands, the Islands' communities and regional government has struggled to reconstruct the housing and community buildings.

Whilst many private and charitable organisations, governments and non-government organisations have given money for the reconstruction, the main impediment to the reconstruction and thereby an element of the present cost, is the lack of basic construction equipment on the islands.

This paper looks at the cost of one element of the construction of the earthquake resistant, affordable and sustainable housing required on the islands, that of the reinforced concrete superstructure frame and considers how the cost can be reduced if the plant and equipment was made available to construct it in a different way. That is by setting up a pre-cast concrete plant and constructing the superstructure frame with pre-cast concrete columns and beams.

The reason this paper only considers the concrete superstructure frame is because there is little alternative, if any, to the method of constructing the foundations, the walls are constructed using blocks manufactured as a cottage industry on the islands, therefore they cannot be used in structural components and the cost of constructing the walls cannot be reduced, which leaves only the construction of the superstructure concrete frame that is worthy of review and with plant and equipment being made available, significant reductions in cost and time of construction of the frame is easily achievable.

This paper therefore examines these costs and potential savings for constructing one modest house. Multiply that by the thousands still needed and the full opportunities of construction cost and time reduction and full time employment opportunities can be grasped.

A NOTE AS TO COSTS

This paper demonstrates that for a modest four room bungalow, that is living room, bedroom, kitchen and bathroom the potential saving to construct the frame using pre-cast reinforced concrete columns and beams would be approximately 21,500 Rupees (Rps) less than by the insitu concrete method adopted currently which costs approximately 48,500 Rps.

This looks impressive, but then when you consider that at the exchange rate is 84 Rps to the £1, (as at February 2007) it is a saving of approximately £250.00. (less than 2 days wages for a tradesman in the UK). Therefore, to western eyes, why bother changing anything?

The answer is because a skilled man on the Andaman Islands earns 250-300 Rps per day. Therefore the saving on the cost of a home for that man is equal to between 72 and 86 days work and this becomes larger to the unskilled and very significant to the unemployable members of the population, such as the aged.

CURRENT METHOD OF CONSTRUCTION OF THE FRAME

At the moment construction of the structural frames for all the buildings on the islands is by using insitu concrete mixed on site using small mixers, known in the UK as 7/5 mixers.

This means the columns are constructed with prefabricated formwork in two halves that are bolted together, or if these are not available, piecemeal using timber framing and plywood. This paper only considers the cost of pre-fabricated formwork as this is the most efficient way to provide the column formwork.

Due to the lack of equipment the column formwork is usually set up by hand using plumbs, being stones tied to string, to assist in providing vertical alignment. (However, Nottingham University have donated some surveying equipment and a group of students will be visiting the Andamans in October 2007 to train local staff to use it, so that the time of the operation will be reduced.)

The formwork for the beams is usually made piecemeal, although there is a meaningful attempt to re-use parts of the beam formwork wherever possible. The fact that there is no basic lifting equipment on the islands means that beam formwork cannot be prefabricated because it would be too heavy and furthermore, it is also impractical to prefabricate the beam formwork because there are no beam clamps available on the islands.

The lack of beam clamps and lifting equipment means that there is a significant wastage in the timber used in beam formwork and as all the timber is imported from the mainland, this cost is significant.

The reinforcement is delivered to the islands in 12 Metre lengths. However, there are no lorries on the islands with a 12 Metre flatbed, so the reinforcement is bent over by hand to fit onto the lorries. This means that approximately 25%-30% of every reinforcement bar is unusable. Which adds to the cost of construction on the island.

This cost is then added to further because of the absence of mechanical saws with 250mm-300mm steel cutting blades to cut the reinforcement steel to length. Each bar is cut by hand using 2 men cutting it with a hand-saw. Therefore, cutting the reinforcement, constructing the cages and fixing them in position in the columns and beams in a modest four room bungalow takes 6 or 7 days (12-14 man days).

The concrete is mixed using a 7/5 cement mixer and then lifted on circular dished plates to where it is then poured into the formwork and vibrated. Due to the fact that the concrete is manhandled from the mixer to the pouring location dictates the production time.

Furthermore, the author did see sites where no poker vibrators were present and therefore a question mark remains as to whether there is honey-combing within the columns.

Sand and cement has to be imported from the mainland which adds significantly to the cost of construction on the islands.

It is illegal to extract sand on the islands for environmental reasons, but some of this cost is off-set by mixing the imported sand with the dust that arises from stone grading in the quarries on the islands. This varies according to the availability of the dust from 35% dust to 65% dust. However, as there is only limited quarrying taking place on the islands there are occasions when no dust is available.

Cement is transported to the islands in bags from Chennai (Madras). However, due to the lack of material handling equipment at Chennai docks and even less at Port Blair, the dock workers manhandle the bags of cement into nets to load and unload it on and off the ships. This is then exacerbated at Port Blair where the dock workers load the cement onto lorries using grappling hooks and then the bags of cement may be handled two or three times more, before arriving on the site where it will be used.

The result is that if a 500Kg bag of cement has 400Kg of cement in it when it arrives at the site at which it will be used, then the buyer is fortunate. This cost of wasted cement effects all construction on the islands and is significant. Furthermore, it could be virtually eliminated if there was a 20 tonne flatbed lorry with a Hiab, or similar hydraulic loading arm, on the islands to handle the bagged cement on pallets and even more so if there were two or three such lorries.

With reference to the summary below, the current cost of constructing the reinforced concrete frame is approximately 48,525 Rps and takes approximately 19 days to construct. However,

due to the available labour, it is quite possible to construct 3 or 4 bungalows concurrently on the same site without any difficulty.

CONSTRUCTING THE FRAME USING PRE-CAST CONCRETE COMPONENTS

Most of the frame construction on the islands is formed with 150 x 150mm, 200 x 200mm or 250 x 250mm reinforced concrete columns and beams. Due to this standardisation of construction, a relatively modest mass production plant could be established to manufacture the beams and columns off-site.

Joints would have to be designed to be earthquake resistant, which is not challenging from an engineering point of view.

With the columns and beams being manufactured under factory conditions the quality control of them would also be consistent and most of the completed components would only weigh 0.5 tonnes, or at most 0.75 tonnes.

A site for the pre-cast plant has been identified on the Andamans Trunk Road (ATR) near Port Mout, approximately 22 Km from Port Blair. The advantage of the site is that its natural long flat area is approximately 1.5 metres above the ATR, so lorries can park off the ATR and their platform height is near to the ground level of the plant. Therefore, loading the beams and columns and other precast products can be loaded onto the lorries with ease, if lifting equipment is not available.

The site has its own water source and three phase electricity is also available approximately 50 metres from the site. Water from the yearly monsoons can also be collected and reservoired for use in the production of the pre-cast concrete components.

However, to make the plant viable a 20 tonne flat bed lorry with its own Hi-ab (or similar) hydraulic loading arm and attachment will be needed, with a small all-terrain or rough terrain mobile crane of 25 to 30 tonne capacity.

The beams and columns can then be loaded onto the flatbed lorry and transported to the site and unloaded, using the lorry's loading arm, or alternatively be erected from the lorry using the crane.

The flatbed lorry and the crane can both be hired out when not needed by the pre-cast plant, which gives further opportunities for employment, as there is no mobile crane on the islands, it would not have difficulty in being permanently employed.

Due to the thousands of homes and community buildings that require re-construction the pre-cast plant will also provide permanent employment opportunities.

Whilst I have not taken into account in my costs the cost of establishing the plant (the identified land is already owned by a charitable organisation set-up to establish local businesses), procurement of the lorry and the crane, these costs will be set off with the production of other pre-cast concrete products, such as lintels, manhole components and chambers, etc., and the hiring out of the lorry and the crane for profit. Furthermore, as the plant would be set-up by a charitable organisation with the aim of establishing local businesses, it is hoped that these set-up costs will not be encumbered upon the businesses as set-up costs, although a sinking fund would have to be established to fund their replacements.

However, even if the cost of the lorry and crane subsumes the saving in its entirety, the superstructure frame construction for each house will take 1 day, as against the 19 days currently being incurred, which means that there are considerable savings in the production time on site. This is important as it is only possible to undertake construction over 9 months of each year.

Furthermore, the charitable organisation already owns a cottage industry block making plant which would be moved to the pre-cast plant and extended so that blocks could be sold to passing trade on the ATR.

Current Cost of Constructing the Insitu Concrete Frame per House

SUMMARY

Cutting, bending, making up steel cages and erecting to columns	11,165 Rps
Making and erecting formwork to the columns	7,125 Rps
Pouring concrete to columns	7,450 Rps
Striking and cleaning column shutters	1,250 Rps
Making and erecting formwork to beams	6,140 Rps
Cutting, bending, making up steel cages and erecting to beams	8,015 Rps
Pouring concrete to beams	6,380 Rps
Striking and cleaning beam shutters	1,000 Rps
	48,525 Rps

TIME TAKEN

Making column cages	4 days	
Erecting formwork to columns	2 days	
Concreting columns	3 days	
Striking and cleaning column formwork	1 day	
Beam formwork	3 days	
Beam reinforcement	3 days	
Concreting beams	2 days	
Striking and cleaning beam formwork	1 day	19 days

Cost of Constructing the Concrete Frame per House Using Pre-Cast Concrete Components

SUMMARY

1.	Manufacturing forms for columns, stripping and cleaning	4,015 Rps
2.	Cutting, bending and fixing reinforcement	4,100 Rps
3.	Pouring concrete	5,960 Rps
4.	Manufacturing forms for beams, stripping and cleaning	3,070 Rps
5.	Cutting, bending and fixing reinforcement	3,920 Rps
6.	Pouring concrete	5,215 Rps
		26,280 Rps

Manufacture of pre-cast columns and beams	=	26,280 Rps
Erection – Labour 3 men 1 day	=	750 Rps
		27,030 Rps

(Plus cost of frame and operator for one day)

BIOGRAPHICAL NOTES

Professional Qualifications:	FCIArb; FinstCES; FCIOB; MRICS
Current Position:	Proprietor, Klein Consult Ltd
Practical experience:	In excess of 40 years experience as a senior contractor's quantity surveyor responsible for calculating costs of construction, and assisting design teams with optimum methods of construction, compiling and maintaining construction budget plans, investigating causes of divergence and compiling cost/income results using different methods of production. Advising developers and contracting clients with regard to entering into construction contracts for building and civil engineering work as to risk placement, terms and conditions. Appointed as Adjudicator on construction contract disputes varying between £8,000 and £1 million and as the Expert to arrive at an Expert Determination on other disputes.
International experience:	Represented Italian and German contractors in contractual negotiations and dispute resolution concerning contracts undertaken in the UK.
Professional Institutional Appointments:	Chairman of the Institution of Civil Engineering Surveyors' Dispute Avoidance and Resolution Panel. Member of the Construction Industry Council's Adjudication Board.

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