A PROPOSAL FOR PROTOTYPE PACKAGE OF GREEN AFFORDABLE HOME: USING FAST TRACK WALL SYSTEM

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Abstract: Adopting from CIDB annual report, Malaysian housing demands is 4% per year (280,000 establishments per year equals to nearly 2,800 projects); it is while, the figure only is highlighting first-time house buyer's statistics. Furthermore, understanding population growth statistics provides us to expect even more housing demand in near future. Considering previewed statements, dynamic increasing demands for residential building construction enforce us to enhance the main project measurement including project's "time", "cost" and "quality" while there is construction elimination in use of "human resource", and "machineries". Based on that, there is some initiative to go through industrial building system methods proposed by CIDB highlighted in strategic plan. More than that also, it is important to aid building construction to decrease its environmental defects. These environmental defects can be understood based under "construction based defects" (it includes construction, expansions and renovation of the building)". Recently, there is enrichment of construction in managing cost, time and quality, using Fast-Track Wall (FTW). Regarding the previewed statements, this study is to consider FTW as the case for green affordable housing. Thus the aim of this study is to develop a prototype green affordable home which can be applied in Malaysia considering humid region environments. Therefore, the study is proposed to conduct research in three research teams. First research team tasks to investigate green materials in the FTW- affordable home. Second research team tasks to investigate green energy requirement in the FTW-affordable home. And, third research team tasks to investigate green social requirement in the FTW-affordable home. Relatively, each team will follow the research objective including methodology in three research phases. The phases include; Phase I (Preliminary Investigation), Phase II (Desk and laboratory study), Phase III (Full-scale test study). Significance of this study are; the development of "Green" affordable home suite to the "local" requirement of the "humid region", as a "sustainable" construction solution (fast, environmental friendly, cost efficient and productive). In fact, final product would enhance the construction of affordable housing in Malaysia a sustainable manner.

Keywords: Fast-Track Wall System, First-Time House Buyer, Green Affordable Housing, Sustainable Construction

INTRODUCTION

Currently, UTM has developed and patented FTW that suit the humid rainy weather of Malaysia and it has commercialized [12, and 19]. The experience of developing this system helps to further enhance the system and investigate the suitability for the affordable green houses in

Malaysia. The FTW system has been developed by UTM under Professor Muhd Zaimi Abd. Majid [10, 12, 13, 14, 16, and19]. It used the combination of metal and plastic board or metal and plywood board as the main materials which can be reused in other similar construction. The uniformity of the formwork sizes optimizes the usage of these raw materials. FTW system will also allow faster construction period as it eliminates nine (9) construction activities as compared to the conventional formwork method. This system has been successfully applied in constructing the low cost houses around Johor, Malaysia [12, and 19].

The unique features of this system can be summarized as follows [10, 12, 13, 14, 16, and 19]: (a) System's panel is easy to handle and can be fixed manually (b) Reduce the construction waste (c) Reduce the dependency on skilled labor (d) Eco-friendly design approach with minimal use of wood (e) Reduce the number of construction activities (f) Improve the quality of construction

This invention has been recognized by Malaysia's Government through receiving an award at International Exposition of Research & Inventions of Institution of Higher Learning (PECIPTA) 2007 and R&D of the Year Award at Malaysian Construction Industry Excellence Award (MCIEA) 2009 and National IP Award (2010). FTW system has also been registered as intellectual property with Malaysian Utility Innovation Pending Number, UI 2009 0172 [12]. To conclude from literatures, it can be argued that referring to literatures in regards to affordable housing; it has the high potential to adopt FTW to green affordable house requirements.

PROBLEM STATEMENT

According to United Nation (UN) statistic reports on the Human Development Index (HDI), Malaysia is nearly in the top list of High Developing Countries. Whereas satisfaction percentage of affordable housing in Malaysia by 2010 assessed nearly 70% - thus, in term of social satisfaction, affordable housing in Malaysia was ranked 1st among all developed and developing countries in the world. In fact, it has a great potential for Malaysia to establish the knowledge developed from this successful practice of affordable housing development. It is important since; Malaysian demographic growth of 3.6 Million is expected from median age of 15-64 years old in urban area by 2015. It indicates near future trends of high demand on housing developments.

Despite of these issues, it is a common trend for high developing countries like Malaysia to face problem with shortage of construction human resource; including the availability of labour, shortage of skilled labour, and low productivity of construction due to extremely hot and rainy weather conditions. Furthermore, labour shortage has opened the field for internal unskilled worker to be recruited in Malaysian construction industry with in which it makes social problems also (CIDB road map 2008). Enhancement of the construction system and technologies can alleviate problems related to the issue of labour and productivity. Furthermore, in the development growth, also the reduction of construction environmental defects has to be considered (carbon foot print in Malaysia is 7.2 tons per year for example). Thus the aim of this study is to develop a prototype green affordable home which can be applied in Malaysia considering humid region environments. The system proposed for this research project can help to accelerate and enhance sustainable construction of affordable housing, also.

SINGIFICANT AND ORIGINALITY OF PROTOTYPE

Considering this background, this study is planned to innovate and improve FTW system compatible to local requirement for an affordable green house. Indeed, the improvement will enrich through compiling FTW system with an innovative sustainable construction solution (fast, environmental –friendly, cost efficient and productive).

Understanding FTW system final product to be "fast construction" method of "affordable one story houses" this section is focused on affordable housing literatures followed by FTW system. Affordable housing definition varies from affordable house for low income home buyers [1,2,7,10,11,12,13, 14,16,17,18, and 19] to Low Life Cycle Cost houses , in design, construction, operation and demolish, in micro scale, and in macro scale affordable for government to manage the housing infrastructure, also [5,6,8,9, and 15]. It can be argued that the common accepted definition in this regards is "affordable house to buy" within which it is some published statements highlighting the ever grows of affordable housing grows in upcoming years and it called "the market for future" [11 and 12]. Having this momentum there are literatures to establish standard for affordable housing design [14, 15, 9, and 7]. Focusing in construction published researches; Table1 shows the factors which affect the cost of housing construction [17]. The top ten (factors) factors are; "Inadequate labor availability, Material standard, Design quality, Design change, Poor financial control on site, Lack of coordination, Duration of contract period, Cost of materials, Disputes on site, Previous experience". The rating affect of this factors are shown in Table1.

Table 1: Expected Contribution of FTWS & FTW to top ten (10) Factors Effects Housing Construction Cost in Saudi Arabia from Malaysian Experience (Adopted from Sadi et al. [17] and Zaimi et al. [10, 12, 13, 14, 16, and 19])

Top ten (10) factors effects housing construction cost	Weight of factor calculating from overal view of "consultant" "contractor" and "real state" in Saudi	FTW Proven enhancements
Inadequate labor availability	80.6%	Elimination
Material standard	78.9%	N-A
Design quality	76.6%	Improving
Design change	76.0%	Reduce the risk
Poor financial control on site	74.3%	Reduce the risk
Lack of coordination	73.1%	Reduce the risk
Duration of contract period	72.6%	Elimination
Cost of material	72.0%	Elimination
Disputes on site	70.9%	Reduce the risk
Previous experience	70.3%	Elimination

Foot note: N-A: not applicable

Table 2: Comparison of formwork available in Malaysian market

Other Formwork Co.	Rental rate	Handling Method	Life time	Material Use	Fixing Method
PERI Framework	High RM 1000 and above	Use Crane	Long	Metal	Semi practical Unique screw
Fast save formwork	Medium (RM 800 -1000/ sq.m)	Use Crane & min 4 workers to installed	Medium	Metal	Non- practical Unique device
DAHTEC	Medium (RM 800 -1000/sq. m)	Use Crane & min 4 workers to installed	Medium	Metal	Semi practical common device
FTW	RM 500 -700/ sq.m	Can be lifted/handle by min. 1 worker(38 Kg.)	Long	Metal &Plastic / Wood	practical common screw

It is effective to propose construction technologies to eliminate these factors. Referring to Zaimi et al. [10, 12, 13, 14, 16, and 19] developed Fast-Track Wall (FTW) system that has been patented has potential to eliminate these construction cost obstacles. This system has been applied in the construction of few various projects scale, for low cost housing projects in Malaysia [12]. From the previous projects (one storey houses) it was observed that on average approximately 50% of the construction time as compared to conventional method was saved while 20-30% of the construction cost was reduced. Labour needs are a gang of 4 persons and material used is reduced by 20 % [10, 12, 13, 14, 16, and 19]. Furthermore, 'Design Quality' is to support indoor quality of building [19]. Besides, standardization and reduction in construction time is reduced the risk of design change, poor financial control, and lack of coordination, dispute and high need on construction experience [12].

STATE OF THE AFFORDABLE HOUSING

Currently, affordable home in Malaysia provided by public services mainly in following two classes: (a) RM 45,000.00, 65 sq.m (Non-Landed Property) (b) RM 78,000.00 , 80 sq.m (landed Property)
Consider formwork available in market (Table 2).

Thus, the possible target market can be categorized under privet public and foreign affordable building projects.

Private Project

(a) Residential Developer (single and double storey house) (b) School developer (Madrasah) (c) Individual house owner "Middle and Low income group" (d) Swiftlet Industry

Public Project

(e) Ministry of rural development and regional development (f) Public Work Department (PWD), Malaysia

Foreign Project

(g) Countries in needs of affordable housing (h) ountries in needs of Emergency development (exp. after earthquake)

Only considering public projects, Investment in affordable housing in Malaysia in this early five year (by SPNB, PPRT: (a) **SPNB:** 10,000 units 'Affordable House' – 5 %, RM 70,000 (b) **PPRT**: Ministry of Rural and Regional Development: 50,000 units, RM 33,000

The Total Market Size for Affordable House is RM1.1 Billion.

Potential of Research for Wealth Creation

The ever-growing global population, demographic shifts, climate change and increasing pressure on limited natural resources have all brought sustainability to the top of environment, social and economic agendas. Therefore, sustainability addresses major challenges of tremendous opportunities to promote the traditional industries. Building Construction Industry, consequently, have realized that sustainability responds to fulfill building user requirements and ensure sustainable building performance in project life cycle through sustainable measures. Construction Industry has aimed to move toward projects that can build, operate and renovate more efficiently and achieve user requirements in more eco-efficient manner. Besides, understanding dynamic increasing loop of construction foot print in both global and local views, and also Malaysian expected housing demands (4% per year) till 2015, it is important to aid building construction to decrease its environmental defects. These environmental defects can be categorized to "operation" based and "construction" based defect. To focus on "construction" based environmental defect there are some evidences as follow (Figure 1): (a) Construction, renovation and demolish make 40% of world material flow (Olson, 2010) (b) Construction makes 10% of waste flow is demolish waste & from that 70% is landfill, it is equal to 300 kg per capita (Quinn, 2010) (c) Estimated construction, renovation and demolish Carbon foot print is 30% of total.

Considering purview statements it is and understanding market size of RM 1.1 bil. Investment in affordable housing in Malaysia in this early five year (by SPNB, PPRT), this research has potential to go to wealth creation in following agendas: (a) It is opens New Professional Job opportunities in affordable green design and construction (b) The expected knowledge developed is transferable to other countries (c) It can be used as decision support model (design support model, construction decision support model) (d) Green material for affordable home has considerable potential for market penetration (e) Formwork system for Green affordable home has considerable potential for market penetration (f) Prototype package for Green affordable home has considerable potential for market penetration

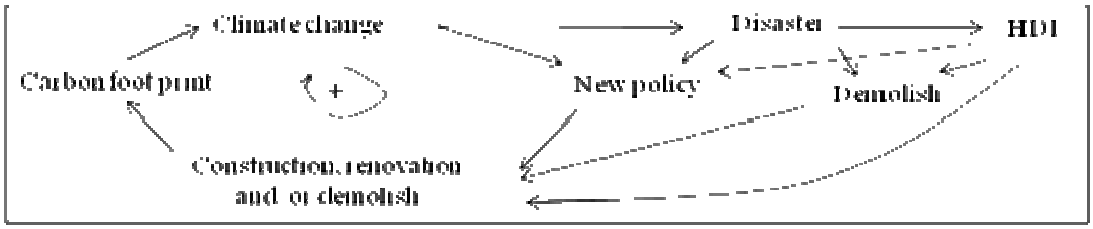

Figure 1: Dynamic increasing loop of construction foot print (Adopted from Zaimi et al. , 2011)

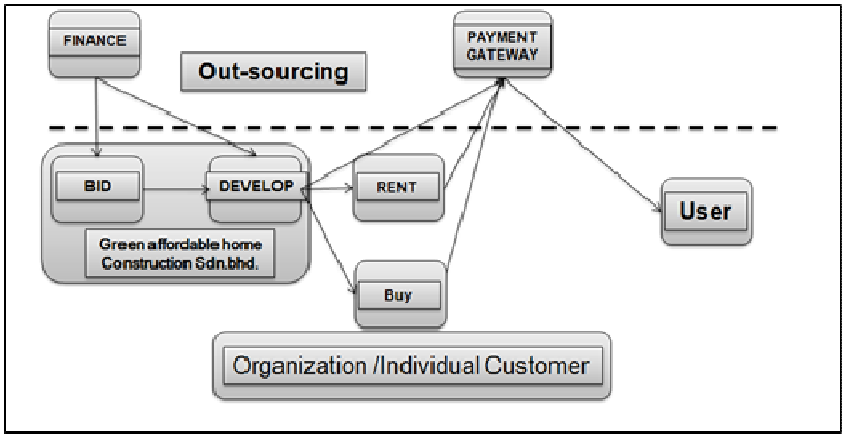

Figure 2: Expected Value Chain Activity

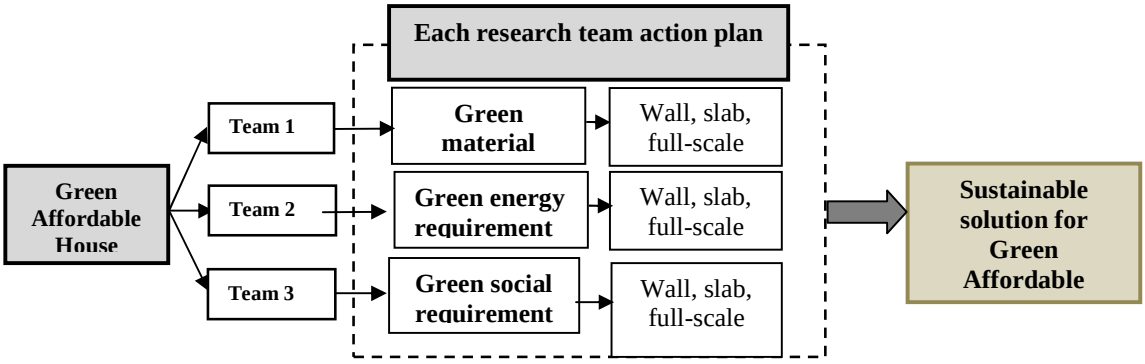

Figure 3: Research Action Plan

Table 3: Flow Chart of Research Activities (Mapping of phases and tasks to achieve objectives, compatible for each research team)

Objectives	Phases	Tasks
- **Objective 1.** - To develop and construct a cost effective and green formwork system for constructing load bearing wall for single and double storey houses**.** -	**Phase I** (Preliminary Investigation)	i) Interpretive content analysis on Literature review of affordable housing. ii) protocol analysis of local authorities and Universiti Teknologi Malaysia brain storming iii) Professionals close group discussion on deconstruction study and constructability study
	Phase II (Desk and laboratory study)	i)SWOT analysis on available alternative ii) LCA analysis on sustainable potentiality in design solution iii)constructability analysis on design
	Phase III (Full-scale test study)	i) Full-scale test study
- **Objective 2.** - To develop and construct a cost effective and green formwork system for constructing suspended floor slab for single and double storey houses.	**Phase I** (Preliminary Investigation)	i) Interpretive content analysis on Literature review of affordable housing. ii) protocol analysis of local authorities and Universiti Teknologi Malaysia brain storming iii) Professionals close group discussion on deconstruction study and constructability study
	Phase II (Desk and laboratory study)	i)SWOT analysis on available alternative ii) LCA analysis on sustainable potentiality in design solution iii)constructability analysis on design
	Phase III (Full-scale test study)	i) Full-scale test study
- **Objective 3.** - To constructs a full-scale double-storey green affordable house that used FTW Construction Systems.	**Phase I** (Preliminary Investigation)	i) Interpretive content analysis on Literature review of affordable housing. ii) protocol analysis of local authorities and Universiti Teknologi Malaysia brain storming iii) Professionals close group discussion on deconstruction study and constructability study
	Phase II (Desk and laboratory study)	i)SWOT analysis on available alternative ii) LCA analysis on sustainable potentiality in design solution iii)constructability analysis on design
	Phase III (Full-scale test study)	i) Full-scale test study

COMMERCIALIZATION PLAN

To bering the final prototype to commercialaization study expects to come up with following value chain of activities (Figure 2):

AIM OF STUDY AND OBJECTIVES

The aim of this study is to develop a prototype green affordable home which can be applied in Malaysia considering humid region environments.

Research and development of Construction for green affordable house involves three main phases. First research team is to investigate **green material** in the FTW-affordable home. Second research team, it is to investigate **green energy requirement** in the FTW-affordable home. And, third research team is to investigate **green social requirement** in the FTW-affordable home. Relatively, each research team will follow the research objectives and methodology in three research phases (Figure 3).

Objective 1

To develop and construct a cost effective and green formwork system for constructing load bearing wall for single and double storey houses.

Objective 2

To develop and construct a cost effective and green formwork system for constructing suspended floor slab for single and double storey houses.

Objective 3

To constructs a full-scale double-storey green affordable house that used FTW Construction Systems.

RESEARCH METHODOLOGY

Research and development of construction for green affordable house involves three main phases. First research team is to investigate **green material** in the FTW-affordable home. Second research team, it is to investigate **green energy requirement** in the FTW-affordable home. And, third research team is to investigate **green social requirement** in the FTW-affordable home. Relatively, each research team will follow the research objectives. Each objective within three research phases; the phases include; Phase I (Preliminary Investigation), Phase II (Desk and laboratory study), Phase III (Full-scale test study). This sequence of research is presented in Table 1 and Table 2.

Phase I (Preliminary Investigation)

Compatible for each research team

Step1

Preliminary research will be prepared by the researchers from Universiti Teknologi Malaysia based on the information obtained through a series of discussions with the local authorities [protocol analysis]

Step2

Literature review on related construction system that was developed earlier especially for the affordable housing. [Interpretive content analysis]

Step3

Through the preliminary research and experience and knowledge on FTW System that has been developed by UTM, the materials and technology that are suitable for affordable housing scheme will be identified. [Professionals close group discussion on "deconstruction" capability of material constructability of the technology]

Phase II (Desk and laboratory study)

Compatible for each research team

Step4

Phase II involves the development of formwork systems and testing in laboratory study. FTW construction system will be designed by taking into account several factors including sustainability, labour availability, construction period, operation, machineries requirement and other factors.

Step5

Several alternatives of formwork design will be reviewed and discussed [conducting SWOT study within group decision making methods].

Step6

The selected formwork design is to incorporate in LCA study.

Step7

The formwork should fulfill constructability requirement. It will be designed in various combinations of sizes and shapes depending on the needs of installation. (For example in FTW system, each formwork component will be designed with targeted self-weight of less than 40 kg to enable the formwork to be handled manually. Laboratory test will be carried out to identify the strength of the mould, especially the ability to sustain pressure of wet concrete)[Constructability studies].

Table 4: Gantt Chart of Research Activities

RESEARCH ACTIVITY		3	6	9	12	15	18	21	24
Phase 1	- **Step1:** Preliminary research will be prepared by the researchers from Universiti Teknologi Malaysia based on the information obtained through a series of discussions with the local authorities [protocol analysis]								
	- **Step2:** Literature review on related construction system that was developed earlier especially for the affordable housing. [Interpretive content analysis]								
	- **Step3:** Through the preliminary research and experience and knowledge on FTW System that has been developed by UTM, the materials and technology that are suitable for affordable housing scheme will be identified. [Professionals close group discussion on "deconstruction" capability of material constructability of the technology]								
Phase 2	- **Step4:** Phase II involves the development of formwork systems and testing in laboratory study. FTW construction system will be designed by taking into account several factors including sustainability, labour availability, construction period, operation, machineries requirement and other factors.								
	- **Step5:** Several alternatives of formwork design will be reviewed and discussed [conducting SWOT study within group decision making methods].								
	- **Step6:** The selected formwork design is to incorporate in LCA study. -								
	- **Step7:** The formwork should fulfill constructability requirement. It will be designed in various combinations of sizes and shapes depending on the needs of installation. (For example in FTW system, each formwork component will be designed with targeted self-weight of less than 40 kg to enable the formwork to be handled manually. Laboratory test will be carried out to identify the strength of the mould, especially the ability to sustain pressure of wet concrete)[Constructability studies].								
Phase 3	- **Step8:** In this phase the focus of research is to apply the formwork system to construct a full scale double storey house of maximum gross floor area 1000 sq feet. The appointed contractor will construct the prototype house under the supervision of local authority and researches from UTM that will be providing expert advice on the system handling and technical matters. Based on the on-site installation, some modification may be necessary to improve the formwork systems.								
REPORT WRITING									

Phase III (Full-scale test study)

Compatible for each research team

Step8

In this phase the focus of research is to apply the formwork system to construct a full scale double storey house of maximum gross floor area 1000 sq feet. The appointed contractor will construct the prototype house under the supervision of local authority and researches from UTM that will be providing expert advice on the system handling and technical matters. Based on the on-site installation, some modification may be necessary to improve the formwork systems: (a) Building design double storey house of maximum gross floor area 1000 sq feet(b) BIM study on design output. (c) On-site construction of experimental case study [full-scale test study]

EXPECTED RESULTS

Expected 1st objective finding

Formwork system for "Wall" in green affordable home (compiled from the three research team findings)

Expected 2nd objective finding

Form work system for "Slab" in green affordable home (compiled from the three research team findings)

Expected 3rd objective finding

Development of full-scale prototype of green affordable home (fast, environmental friendly and cost efficient) in greenery of construction of affordable housing in Malaysia

Furthermore, there are number of expected research by products as follow: (a) It is opens New Professional Job opportunities in affordable green design and construction (b) The expected knowledge developed is transferable to other countries (c) It can be used as decision support model (design support model, construction decision support model) (d)Green material for affordable home (e) Formwork system for Green affordable home (f) Prototype package for Green affordable home

Expected Intellectual Property

(a) 3 award for each team final finding (b) IP on the final prototype package (c) Copy right on each objective finding of each team (at least 9 copyrights)

Expected Research Publications

(a) 3-9 Journal Papers over 2 years (from each team 1-3 papers) (b) 3-9 Conference Papers over 2 years (from each team 1-3 papers) (c) 3-9 Chapter in book over 2 years (from each team 1-3 chapter in book)

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