Feasibility of ISO shipping container as transitional shelter a review

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WORD COUNT 4738
TIME SUBMITTED 13-AUG-2020 10:11PM
PAPER ID 62147893

IOP Conference Series: Materials Science and Engineering

PAPER · OPEN ACCESS

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To cite this article: Philip Chie Hui Ling *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **620** 012056

Feasibility of ISO shipping container as transitional shelter- a review

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Abstract. The arising of natural disasters had increased the demand of post-disaster shelter. Over the past decades, concept of transitional shelter had been introduced as a better alternative compared to conventional shelter provision. ISO shipping container had become potential material as transitional shelter. However, the suitability of shipping container as transitional shelter is questionable as there is lack of previous study concern on this issue from different perspective of views. The aim of this paper is to provide a review on the feasibility of ISO shipping container as transitional shelter. The literature review was taken and the context analysis was done using "Technical, Economic, Legal, Operational, Schedule" (TELOS) framework. The strength and weakness of the shipping container as transitional shelter were summarized based on the framework and recommendations were suggested. With the recommendation done, the potential of shipping container to be used as transitional shelter can be fully exploited and become an outstanding alternative for conventional construction method.

1. Introduction

The increasing report of natural disasters had been observed worldwide over the past decades. According to the statistics by The United Nations Office for Disaster Risk Reduction, total of 98.6 million people had been affected by the natural disaster with over 66.5 billion US dollar economy damage in year 2015 alone [1]. Besides, the conflicts within and among the countries such as civil war, persecution or revolution encouraged the migration of local residents as refugees. The United Nation Refugee Agency had reported that till 2015 there were 21.3 million refugees and around 34 thousands people were forcibly moved from their home every day [2]. Combined with the victims from the natural disasters, these whooping numbers of people were waiting for all sort of emergency aids including food, medicine and shelter as their protection and livelihood.

Generally the conventional post-disaster shelter can be categorized into emergency shelter, temporary shelter, temporary housing, and permanent housing [3]. As the disaster occurred, the affected people will attempt to find emergency shelter to protect them, at most overnight, before the arrival of the rescue. Temporary shelter is the place where the displaced people are settled and stayed before they can move into new housing. In some cases, especially when large crowd of population are involved and the construction of permanent housing requires long period of time, temporary housing

will be provided too as alternative measures. Temporary house is more structurally sound and comfort to live compare to shelter but it is still not designed for long service life.

Currently transitional shelter had been introduced into disaster relief program as the substitute of the aforementioned traditional approach. Transitional shelter is defined as an incremental approach to provide shelter which can be upgraded, reused, relocated, resold and recycled [4]. It had been implemented since year 2004 at several disaster regions such as Sri Lanka, Jogjakarta, Aceh, Peru and Haiti [5]. Compared to conventional approach which is carried out phase-by-phase, transitional shelter is rather a continuous development of improving existing shelter which may become the permanent housing by itself, which is demonstrated in Fig. 1.

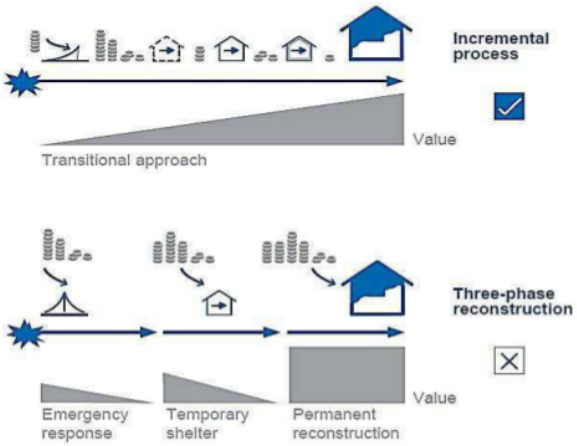

Figure 1. Transitional shelter approach (Source: IOM)

The International Organisation of Migration (IOM), in its publication, had carried out strength, weakness, opportunities and threat (SWOT) analysis of transitional shelter which were summarised in Fig. 2. With careful decision-making and detailed planning based on local scenario and available resources, the transitional shelter can become potentially the best solution for housing crisis after the migration of displaced people from conflict or disasters. The common types of material used in transitional shelter are bamboo, timber and steel frame [6]. Recently, another potential candidate had gained attention from researcher as transitional shelter that is used ISO shipping containers.

ISO shipping container (also known as freight container or cargo container) was invented by Malcom McLean at 1956 as the universal solution of freight transportation among sea and land. Two of the most common size used shipping containers are 20-foot container and 40-foot container. According to World Shipping Council, there were over 18 million containers in global shipping industry at 2011 and with 5 years of average age for each container, around 5% of them will be disposed annually [7]. This accumulated disposed container will be dissembled, followed by recycling of reusable steel or landfill of waste residual. Therefore, it is crucial to come out with alternative solution for this large number of disposed container to conserve the limited landfill area.

ISO shipping container consists of steel frame with corrugated steel panel wall and its material is designed to cater for heavy weight from cargo and harsh environment during transportation. This makes the shipping container an excellent building material as high loading capacity and durability are main concern in structural engineering. Besides, due to the uniformity of container dimension and components set by International Organisation of Standardization, it can also be used in modular construction as Intermodal Steel Building Unit (ISBU). In fact, the concept of container house had been popularised among architects and engineers [8].

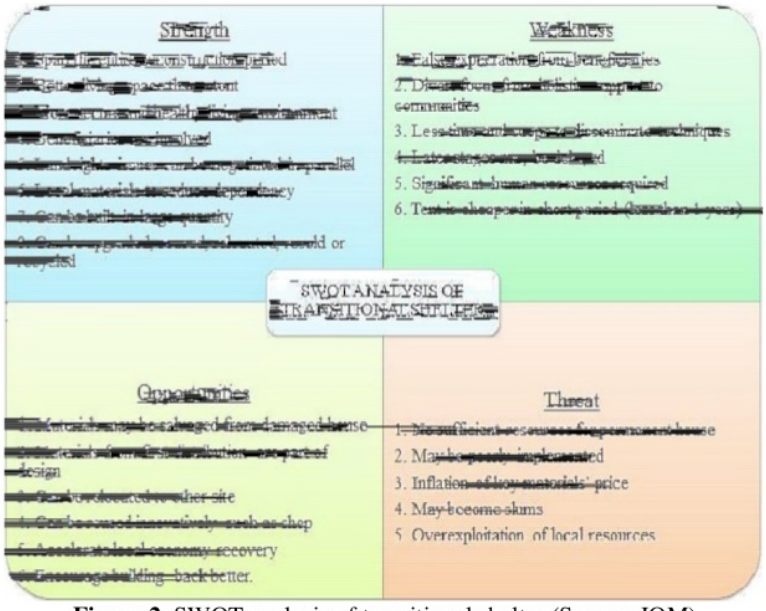

Figure 2. SWOT analysis of transitional shelter (Source: IOM)

Although the use of container as residential or even commercial building had been well established, its application in disaster relief program was only been put into practice recently. Different from daily construction, post-disaster shelter should be provided as soon as possible with minimum protection requirement, in which the aesthetic and comfort is not main concern as compared to residential building. Moreover, since different cases of disaster or conflict represent different issues, the ability of container shelter to confront each of them is questionable. Therefore, a feasibility study is needed to evaluate the suitability of shipping container as transitional shelter.

This paper aims to evaluate the feasibility of using ISO shipping container as transitional shelter which provides insight for local authorities or Non-Government Organisation (NGO) about the container transitional shelter. This can accelerate the decision making during the planning stage by taking the considerations discussed in this paper. The perspective from different viewpoints can also entrust stakeholders, whether is financial agency or beneficiaries, to have confidence on the reliability of container shelter.

2. Methodology

TELOS feasibility approach will be used as framework of this paper. TELOS stands for technical, economic, legal, operational and scheduling which are five major contributors in feasibility study. Introduced by James A. Hall in his publication "Accounting Information Systems", TELOS framework had been widely accepted in project management from different field to analysis the possibility of idea, concept or project to be put into practice [9]. The scope of work for this review paper will cover the timeframe from planning, construction, operation and demolition.

2.1. Method of analysis

Total of 22 TELOS-related works on shipping container shelter dated from year 2006 till 2016 had been revised. All the outcomes were categorised into five segments according to TELOS framework. The results among different works were compared, interpreted and summarised. The criterion for TELOS feasibility is obtained and modified based on "Feasibility Analysis and the System Proposal" by Whitten and Bentley[10].

3. Result and discussion

3.1. Technical feasibility

Technical feasibility reflects the possibility of project using the existing technology or resources available. The container transitional shelter is an innovative idea to be used in disaster relief but the technical aspect requires detailed consideration as it is different from traditional method. Most of the technical issue should be arisen and tackled prior to the construction with proper planning and design.

The design of shipping container shelter does not have the existing code of practice or guideline to refer. Any standard about ISO shipping container is mainly on transportation purpose but not for building use. Since the container is not accessible for fresh air and light, some opening must be cut out form wall [11]. However, any aperture on the container wall will void the design capacity suggested in ISO standard. The weathering of steel in used container will also reduce the strength of container shelter. Hence, it is necessary to re-calculate the strength of shipping container with different configuration and, if possible, based on the actual loading for building purposes. Some researches on the modelling of shipping container for building purpose had been done using finite element analysis software which can be adapted by structural engineer for design purpose [12, 13]. Heat insulation and soundproof panel should also be applied to container to cater for its weakness [11].

Aside from that, the construction of container shelter should also take account of technical issue related to expertise, machinery and logistic. The modification of the container such as cutting, welding and connection requires skilled worker and the inhabitants cannot do it without assistance from expert. These will lead to difficulties in modification by end user and thus all the fittings, opening, cable and piping should be installed carefully and designed for long-term usage with consideration of increasing family members [14]. The available of crane and forklift capable to lift container should also be anticipated for rent or lease by local contractor [15]. The transportation of shipping container from port or factory to shelter area should consider capability of lorry, traffic and road condition.

The decision maker should also be attentive on the flexibility of container shelter. Most importantly, container shelter fulfils the requirement of transitional shelter in which it can be upgraded, reused, relocated, resold and recycled throughout its life cycle. The potential to stack up to seven storey makes it a better solution to cater large population if lack of accessible land [15, 16]. Besides, the modular unit can be combined, detached or grouped together to form a small community centre according to needs of local residents if necessary [11]. For example, the same container shelter can be decorated and furnished to become school or library for children. The container can also become core of the permanent housing and the upgrading work such as fencing, extension and backyard garden makes it more comparable as conventional house [17].

3.2. Economic feasibility

Economic feasibility evaluates the project value based on the cost-benefit analysis. This is often being the most anticipated part for the funding agency and financial supporter as they want to ensure the project is worth for investment. As most of the funding is come from tax or donation, the decision maker is responsible to justify the best solution which gives highest payback with lowest budget to satisfy the stakeholders.

The cost of a shelter should be determined throughout its whole life cycle, which is from construction, operation till demolition as every phase will contribute to total expenditure on the shelter. Prior to construction stage, for the case of container transitional shelter, the availability of used container at local region will reduce the initial cost for the raw materials since it is no need to send in the container from distant port in which logistic fee and taxes will be charged [18]. The construction cost will also need to cover the labor, machinery, furniture and consultancy fee. The initial cost of construction for a container shelter is 42% of the total life cycle cost [19]. This has not yet included the utility cost such as electricity, water and sewerage, the maintenance cost like painting or repair, and the demolition cost at the end of service. It is estimated that a container shelter have life cycle cost

of USD 1308 per meter square area, which is higher than prefabricated house [19]. This has not yet included the cost for specialized labor and building permit [15].

Despite of that, it is still debatable for the usage of container as transitional shelter from the economic consideration. The variation of cost for container is greatly influenced by availability of materials and other unpredicted cases during the construction [18]. Besides, the inherent properties of container as transitional shelter make it more economically promising as the permanent house can be developed from the core container shelter directly which reduce the budget for another housing development project. Even if the beneficiaries refuse to stay in the same container shelter after couple of years, the same container can be modified into holiday camp, student dorm or other accommodation for rent which can generate profit [20]. The container transitional shelter can also be refurbished or reinforced and reused during the next disaster events. The recycle value of the container can also be advantageous as it may cover the demolition cost. Hence, it is apparent that the investment on container transitional shelter does have its advantages from long term economical saving.

3.3. Legal feasibility

Legal feasibility verifies a project whether follows the law and regulation stated. The provision of the container transitional shelter is a new concept and thus the legitimate support from any department or agency should be held before commencing of the project.

The existing building code such as Uniform Building Code (UBC), International Building Code (IBC) gives the general requirement for a structure to be safe and comfort to live. The first ever container structure which had been approved by UBC was a two-storey container house designed by architect Peter DeMaria at California, USA [21]. However, there is no a well-established design code specifically for container shelter. ISO standard is only effective for container used for transportation but not building purpose. Alternatively, Eurocode, which is widely adopted in many countries, does provide some insight to check the structural integrity of a building but still troublesome to be applied directly on container house as there is no specific code for modified container structure [14]. The construction of container shelter should also comply with the local ordinance associated to sustainability. In some countries, Environmental Impact Assessment (EIA) is compulsory to be accomplished prior to construction if a sensitive area is chosen as reconstruction area to avoid or else minimize the impact towards local culture or nature.

Besides, there are also concerns related to the land venture and ownership of container shelter. If the container is designed to become transitional shelter, it is possible that the inhabitants will stay there for decades or even many generations. This may cause the creation of illegal slum if the container shelter is constructed on the private land [21, 22]. The ownership of the container transitional shelter should also be interrogated if inhabitants wish to permanently live there [23]. The permit should be issued and the payment of taxes or service fee such as electricity and water supply should be done by the inhabitants after a specific period set by mutual agreement among inhabitant and government. Subsidy can be provided so that the container house is affordable for those low-income occupants [24].

3.4. Operational feasibility

Operational feasibility is a measure on effectiveness of a project to achieve its objective. It is often linked to user satisfaction and impacts of project on user or their surrounding environment. This is the most crucial part for the inhabitants of container shelter since they will stay in there for a long period and the container shelter shall provide them good living standard.

One method to carry out operational feasibility is by study the sustainability of container transitional shelter. Sustainability is a concept where the current development can sustain the current needs without sacrifice the future generation's needs. Contradict to some misconception which sustainability is all about preservation and conservation of nature, it covers all the social, economic and environmental aspects. The ultimate goal is to achieve balance among every aspect without

compromising any one of them. Since the economic part had been discussed previously, this section will cover social and environmental sustainability.

3.4.1 Social sustainability

One principle to achieve social sustainability of container transitional shelter is the involvement of inhabitants in the project. The involvement of local community will accelerate the social integration, which is beneficial for social recovery after a disaster as every member in community will know their own responsibility and also will cooperate with each other in reconstruction [24]. The provision of container transitional shelter at the early stage can be a ready-made product with minimum requirement for safety and security, which the residents can stay in it without any modification during emergency [25]. However, the potential of upgrading for container shelter will drive the community to modify it for better living experience. The expansion work and beautification such as brickwork and landscaping will need assistance from other residents, which boosts interaction among community and thus makes the society more heart-warming and welcoming for the displaced people who are just lost their home or family [26].

Another consideration of social sustainability is the acceptance of inhabitants on container shelter itself. Different from the container house available in market which is designed by architecture and interior designer, the container shelter supplied to the reconstruction area does not emphasize on the aesthetic value. This will make the appearance of container house not appealing, dull and old-fashioned [15], which may discourage the inhabitant's dignity and self-esteem [20]. Besides, the psychological effect of inhabitants is also being affected by their attitudes towards their shelter. The study had shown that the residents of container shelter are more potential to have post-traumatic stress reaction and less satisfaction to their new home [27]. It is significant to look after the emotional and psychological wellbeing of displaced people since they need a proper setting to heal themselves from pain and sorrow they had just experienced. Additional stress only left distortion to their mental and cause irreversible impact towards their psychological health.

3.4.2 Environmental sustainability

The environmental advantages of using container transitional shelter should be justified to ensure it does not cause detrimental impact to the ecosystem. Uses of disposed shipping container can help to extend the lifespan of shipping container and fully utilize its inherent strength for second service life. The reuse of existing material as shelter also helps to solve the congestion of unused container at port [21]. The concept of transitional shelter also eliminates the usage of additional resources for permanent housing construction [28].

The raw material itself cannot define the overall performance of container transitional shelter in sustainability. Another criterion frequently be discussed is its life cycle input assessment (LCIA). LCIA will evaluate the environmental impact of container shelter from its production, operation until final disposal [29]. The material and energy input, product output and their influences on environment will be identified and weighed. Some aspects included are embodied energy, electricity, water usage, fuel and waste generated. Embodied energy can be interpreted as total energy input in a product from manufacturing to its disposal [30]. The study on embodied energy of container shelter had been published in several papers and results suggest that container house has comparable embodied energy as conventional house [17] but higher than prefabricated house by area [19] and reversed if evaluated by per capita [31]. The study done also showed that the container house is able to achieve 6-star energy rating according to requirement of Building Code Australia [14].

There are also other sustainability concerns on using container shelter. It uses the local renewable materials which is environmental-friendly [25]. The container can be fully recycled or reuse if appropriate maintenance and management is done [25]. With proper orientation and landscaping, the container shelter has comparable thermal performance as conventional house [17]. With concept of transitional shelter, the container can be used for a long period, which also gives credit to sustainability [32].

3.5 Schedule feasibility

Schedule feasibility reflects the likelihood of project completion within the time constraint. The and response time of disaster is very limiting thus provision of humanitarian aid and emergency measures should be fast and rapid [24].

The container transitional shelter can be provided to reconstruction site within couple of days. The use of local materials and prefabrication had made container in favour of fast erection[24]. Since the major structural work only involves foundation, roofing and infrastructure, the inhabitants can move into the shelter very quickly compared to conventional shelter which need time to assemble or construct on site. The only drawback is that the import of container from other port may consume time if there are not enough containers available near the local port.

A proper disaster management planning prepared before the disaster occurs will speed up the reconstruction progress as the decision-making phase will delay the response of humanitarian aid and thus overall reconstruction pace. A top-down hierarchy management system will by speedy but does not promote community involvement which will cause low satisfaction among occupants [33]. Hence, a proper management team will results in efficient coordination which in turn fast shelter construction [24].

4. Conclusion

The use of shipping container as transitional shelter has great potential to solve the housing problem for displaced people. From the discussion, it had been clearly presented that the container has its advantages from technical, economic, operational and schedule perspective. However, it is not perfect in all and some weaknesses are exposed to be tackled. The results were summarised in FIGURE 3 with disadvantages in red and advantages in blue.

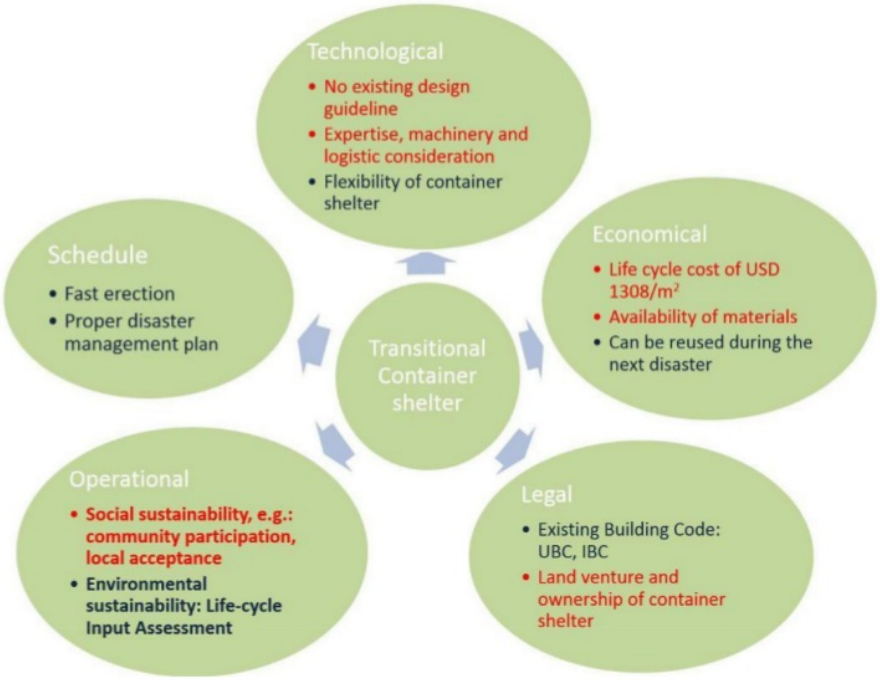

Figure 3. Summary of results

With the limitation been stated in the context, there are some recommendation for more successful container transitional shelter project.

- A standard or code of practice for container transitional shelter can be developed based on the existing building code with amendment in accordance to the design guideline proposed by other researchers or agency.
- The strength and durability of container shelter should have been inspected by professional structural engineers before being modified into shelter. Reinforcement or additional protection like painting, insulation and replacement should be done for long-term usage if necessary.
- Provision of skilled worker and heavy equipment is essential when selecting container as basic unit of transitional shelter.
- The reuse, recycling or resell of container shelter at the end of service life is crucial to achieve maximum economic and environmental benefits.
- Involvement of inhabitant in design or beautification which will make the community more appealing and higher satisfaction from local residents.
- Proper management team to coordinate and deliver the project from commencing, operating, maintenance and disposal.

If the recommendation can be done, the potential of shipping container to be used as transitional shelter can be fully exploited and become an outstanding alternative for conventional construction method.

5. Acknowledgement

The authors would like to thank Ministry of Education Malaysia and Universiti Teknologi Malaysia (UTM) for providing the financial support under grant Q.J130000.2522.12H44.

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