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Research paper

Evaluating The Visibility of Building Syrian Refugee Shelters by 3D Printing Technology in Jordan

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Abstract

Syrian Refugees in Jordan are placed all over the country. Low income refugees are placed in Jordanian camps that miss the basic living standards such as water, electricity, and stable sheltering system. The weakness of refugee camps come in association to the short execution period of construction. New technologies such as 3D printing are emerging with potential to provide better sheltering solutions; however, these technologies are not yet properly explored for providing sustainable shelters to Syrian refugees in Jordan and therefore, this paper developed to evaluate the efficiency of 3D printing technology in comparison to transitional shelters that is commonly used over Jordanian camp, through developing a 3D printable shelter model that assist in studying the cost, the technical specification, and delivery time of shelter printed by the technology. After the comparison, it was found that the 3D printed shelter achieved lower construction cost, higher durability, and can be executed within the same period of transitional shelters.

Keywords: *Syrian Refugees; 3D Printing Technology; Prefabricated Shelters; Jordanian Camps.*

1. Introduction

Refugees in the Middle East become a major challenge to governments and humanitarian organizations due to the intense of conflicts hitting the region. The wars in Syria, Yamen, South Sudan and Libya, have generated millions of refugees. According to the United Nation High Commissioner Refugee 57% of global refugees comes from three countries (South Sudan, Afghanistan, and Syria). Syria generated the largest number of refugees in the Middle East among the other countries due to the internal conflict, started in 2011[1]. More than 6.3 Million refugees from Syria have been placed all over the world [2]. The last survey conducted by United Nation High Commissioner on 13th January, 2019 show that currently there are 671,551 Syrian refugee in Jordan placed between city and refugee camps. Refugee camps in Jordan hold only 20% of the total refugees living in Jordan. Zaatari Camp hosted around 80,000 refugee, Azraq Camp hoist 36,000 Refugee and the Emirati Jordanian Camp hosted 7,000 refugee [3]. The shelters provided to those in need vary from standard type of tent to prefabricated shelter [4]. The prefabricated shelters designed to remain on site between two to five years depending on the climate, and uses of the shelter by the refugees [5]. The average life span of refugee camp around the world surveyed to be between seven to seventeen years, therefore most of the provided shelter would be changed up to 9 times for a family staying for the period of the camps life [6]. The purpose of this research paper is to evaluate the visibility of 3D printing technology in building up Syrian refugee shelters in Jordan through developing a simple design model for a printable concrete shelter. The model will be further investigated from commercial and technical sides and compared to best type of shelters provided on the ground to identify how 3D printing will perform against best sheltering system provided in term of cost, durability, and quality.

2. Literature Review

2.1. Refugees Camp Problems

Syrian Refugees in Jordan are suffering from low quality shelter. First, the walls and roofs were made of weak fabric. Refugees took the initiative to limit the amount of water and sand penetration by covering the shelter roof during water and sand storms. Fig.1 present an open junction between wall and roof of prefabricated shelter. Second, the space allocated for each of the families staying in the shelter was not meeting social, and cultural needs and therefore, some of the refugees combined multiple shelters using simple fabrics as shown in Fig. 2, to increase the spacing of the shelter, as family made of 7 members would require minimum 2 rooms [4]. Timber flooring shown in Fig. 3, is another issue refugees and camp developers have to deal with, due to the ingress of water toward the shelter floor [7]. Privacy of the occupants within the premises of the shelter is the fourth problem refugee face on daily basis, therefore some of the refugees cover the windows of the shelter with fabric sheets to prevent visual access by the passers as shown in Fig 4. The ventilation levels, and light accessibility get effected by such practice [4]. Finally, the embedded kitchen shown in Fig. 5 raise high risk concern to camp developers as the kitchen built within high flammable sheltering materials [4].

Fig. 1: Open Junction [4].

Fig. 2: Shelter Extended Area [4].

Fig. 3: Shelter Wooden Floors [7].

Fig. 4: Covered Window [4].

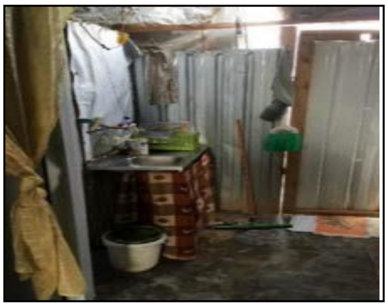

Fig. 5: Embedded Kitchen [4].

2.2. Shelter Design Standards

Zaatari Refugee camp is one of Jordan Syrian refugee camps that represent above mentioned issues. The issues were addressed by design codes developed by scholar Rania Abi Mahmoud in response to hot dry climate conditions. The technical design standards oriented over eight axes: Safety and Security, Comfort, Social context, Stability, Durability/Adaptability, Being Demountable, Modularity and Flexibility, and Independent Constant Energy [8].

Fig. 6: Zaatari Camp Shelter Design Codes in Hot Dry Climate [8].

Several design models have been created to achieve the maximum performance of a shelter designed specifically for Syrian refugees in the hot dry climate. None of the models were simulated using any of BIM platform software's to present exact data of solar, thermal, structural, and architectural design specifications listed in the standards, thus a simple check list presented in Table. 1 were used to evaluate the effectiveness of the developed design models.

Table 1: Shelter Design Check List [8]

Group of specifications	Check list
Human safety	✓
Health and safety	
Control context	
Thermal comfort	✓
Acoustic comfort	
Visual comfort	
Shelter performance comfort (functional aspect, structural elements)	✓
Adaptation	
Social – fabric cohesion	
Urban context	
Structural stability	✓
Durability	
Demountable	
Modularity and flexibility (simplicity, generality and minimizing)	
Independent constant energy	✓

Design standards, codes, specifications, sketch's, and models are now all digitized using drafting computerized tools such as BIM. Building Information Model (BIM) is a revolutionary drafting and project management tool that provides a wide range of software's dedicated to establish a platform to construct a project taking in consideration the three dimensional prefaces of the model as well as the time and cost [9][10]. Revit is the main software among BIM family of applications that is used to design, analyze and create the models within a single platform. The design model by Revit contain: all the geometry, geographic locations, special relationships, quantities, and assets for all different components of the design. The software develops the architectural, structural, mechanical, electrical, and plumbing models in a single platform and in a three dimensional view [11].

2.3. The Integration Between Building Information Modelling (BIM) & 3D Printing Technology

Today innovative construction technology such as laser cutting, prefabrication, cloud based documentation systems, and 3D printing technology have made the construction process easier, more advanced, and enable better control over project budget and time [14]. Three dimensional printing a new construction methodology developed by several high-tech companies such as WinSun, ICON, and Apiscor over the last 30 years [13], [14] The use of 3D printing technology has never been investigated as construction tool to build refugee shelters through design collaborative platform [15]. Three-Dimensional printing potentials made it as intensive research zone to provide a better life to refugee in Jordan. The adoption visibility become clearer through identifying the advantages of merging the technology to design tool such as BIM that can analyze not only the technical performance of the technology but the delivery of the designed model within time frame and cost factors [16].

Building Information Modeling is a process that enables the function of multiple design software in order to give the stakeholder better understanding of the project before construction. BIM model is the initial stage of 3D printing where the designer develops the model using a sketching software if the model is simple. High complicated printable objects reach the physical form through advanced design engineering software such as Revit [16]. Three Dimensional Printing is an additive manufacturing innovative technology that depend on cast semi liquid material on layer basis to form objects [17]. BIM Architectural software such as Revit provide the modeler with the option of extract the design model to readable 3D printing file (STL) since Revit doesn’t have the capability to print the model directly and therefore model shall be processed through 3D printing software [18]. Three-Dimensional printing share the same path of analyzing the designed model by slicing the model in to uniform slices or triangular pattern as shown in below Fig. 7 [19].

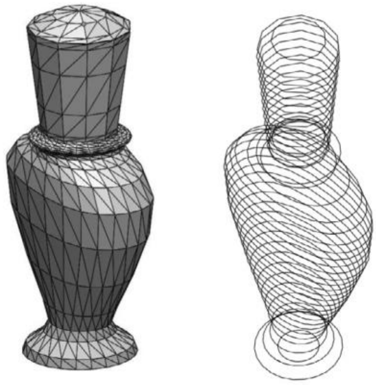

Fig. 7: Triangular and Uniform Slicing in 3D Printing Software [16].

The printer lay the material layer by layer to shape the designed object. The following Fig. 8 illustrate the phases of printing an object using 3D printing technology.

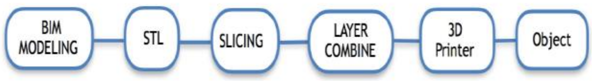

Fig. 8: Three-Dimensional Printing Process [16].

According to the literature review there was no previous research or implementation of 3D printing technology to construct shelters in Jordan for sheltering Syrian refugees. Furthermore, the integration between advanced engineering software and 3D printing for the same purpose has never been investigated. Therefore, the theory of this research paper is the integration between Revit and 3D printing will improve the shelters of Syrian refugees in Jordan by executing the shelter with in shorter time period, high stability structure, and cheaper cost over long life span. The paper aimed to study the potentials of the technology in term of execution speed, cost efficiency and manpower requirement over refugee Jordanian camp.

3. Advantages & Challenges of 3D Printing in Sheltering Refugees

The efficiency imposed by 3D printing technology on manufacturing and small projects have return a lot of investment on business owner resulting in developing the innovative technology to bigger scale construction equipment. Construction printers generate less noise than traditional machinery onsite as well as it limits the amount of dust produced during the dry casting process. The hollow core walls of 3D printed structure perform as thermal, and sound curtains against heat waves and external noise [20]. Furthermore, three-dimensional printing technology produced by the Chinese company WinSun claim to reduce project material consumption by 30%-60%, reduce execution period by 50%-70%, cut off the manpower hours by 50%-80%, and can decrease project cost by 30%-50% [21]. The efficiency of the constructed shelter using 3D printing technology can be further improved by the efficiency imposed on the design of BIM platform. Thus, building information modeling can enhance the construction of shelters in Jordan by defining the exact amount of construction material, simulate the construction cost, and estimate the construction period.

4. Three Dimensional Concrete Printing Capabilities

Concrete, steel, and timber are the most used material in building up shelters around the world [25], [26]. Three-dimensional printing technology have the ability to form objects using concrete materials that have reinforcement ingredients such as carbon fiber, adhesive water putty, and sodium silicate as hydrator. The most recent 3D printer developed by ICON named Vulcan have the capacity to build a 50-70 m^2 with 24 hours [27]. WinSun most known 3D printing company that produce massive printer advised that “The Fourth generation 3D printer have the ability to print on site 350 m^2 of concrete, and it is possible to build 10 concrete units each 35m^2 ” [28]. ApisCore 3D printing technology had the ability to build massive concrete structures during freezing temperature that reach 39 C^o below the zero [29]. The three companies were contacted to get further technical and commercial details that can be used in defining the best printer for building refugee shelters in Jordan. Only WinSun responded with the required technical and commercial information that made 3D printing a visible construction solution on Jordanian land.

4.1. Commercial Estimates Of 3D Printing Technology

WinSun proposed four different ways of providing the printer to the sheltering site. The first option is renting the printer at a cost of half million dollars per year in addition to 1.5 M USD for the technology, patents application and 300,000 USD for insurance which is refundable after returning the printer to the manufacturer. The second option is buying the machine that comes with intellectual property, patents,

training, technical support at a cost of 3M USD. The third option is buying chemicals additives from WinSun for a value of 4MUSD (at a rate of 247USD/ton) to get a free of charge printer along with all supportive equipment's such as the mixers, silos, pumps, training, and copyright. The chemical additives from WinSun contribute up to 10% of the concrete mix, the other 90% components such as water, cement, and sand can be bought locally. The printer still be functional without the added additives to the concrete, and the concrete can achieve the compressive strength from local chemical superplasticizers. The final commercial option offered by the Chinese 3D printing manufacturer is not visible to the study since the technology will be provided at 1.5 M USD against 3% annual profit from the project and as a humanitarian project there is no direct refund of it [28].
The first commercial proposal concluded that single printer can be delivered at a cost of 2M USD for a year of consumption. Taking in consideration 3 printers are required to build the refugee camp as each of the printer will print 10 shelters which mean 900 shelter will be printed in one month that is equivalent in size to Zaatari that hoist over 70,000 refugee [30]. WinSun published their capacity of constructing a small housing unit at a cost of 5,000 USD in China [26]. This paper will investigate the possibility of constructing a shelter at the same cost to compare the efficiency of Transitional shelters to 3D printed one.
The second option cost 3M USD more than the first option as each of the printer will cost 3MUSD, and therefore, the second commercial option of buying the printer seems not a cost effective as the printer will build the same quantity of shelters and at the same time span. The third quotation oriented over the additives that reinforce the concrete and give its strength characteristics. The additives purchased from WinSun shall exceed in cost 4M USD. The quantity of the additives shall exceed 48,000 m^3 to get 3 printers free of charge. The final commercial proposal is not relevant as there will be no refund from constructing refugee shelters.

4.2. Technical Performance Of 3D Printing In Buildings

WinSun technical data provided was close to the data available in the internet in which the supplied 4th generation on site printer can reduce the construction period from 50-70%, save the consumption of raw material by 30-60%, reduce the requirement of manpower on site by 50% minimum and can achieve up to 50% cost efficiency in the overall project value [28]. The following Fig.9 present the minimum and maximum efficiencies 3D printing on material, labour, and execution period.

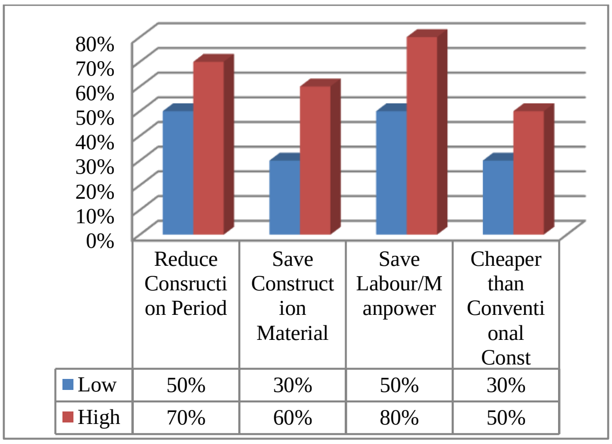

Fig. 9: The Efficiencies of Winsun 3D Printing Technology in Construction [31].

4.3. Shelter design model development and cost analysis

Design model developed through Revit shall consider the specification of the 3D printer such as the nozzle sizes, the flow ratio, and the concrete composition. 3D Printer nozzle come in different shapes and sizes, the sizes used to design the following model is 5x2.5 cm, in which each printed layer width is 5 cm and thickness 2.5cm. The design model developed in association with Islamic believes in separation between males and females. The two-bedroom shelter have a kitchen that can occupy an oven, refrigerator, and washing basin as well as full occupied toilet that have a sink, shower, and water closet [29]. The wall remains at height of 3.1m with 10cm embedded in the raft foundation. The printed wall shown in Fig. 10 is filled with zigzag 3D printed concrete that have the same thickness of the external and internal walls.

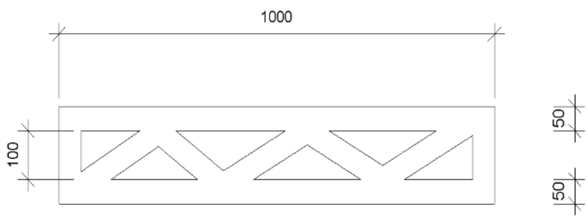

Fig. 10: 3D Printed Wall Cross Section.

The 30cm raft foundation is made of non-reinforced slab barricaded by 5cm 3D printed wall to eliminate the shuttering working during concrete cast in situ. The foundation slab is exposed 10cm from each end of the printed walls to ensure external bounding to the printed walls. The ground below the shelter assumed to be levelled and compacted. The first 50 cm of the 3D printed walls will be printed over 20cm foundation in which the foundation casting for the remaining 10cm will be resumed after the 50cm printed wall to ensure stability of 3D printed walls and to avoid any steel reinforcement toward the printed walls. A wall of 3m height would require 124 layer of concrete since each layer is 2.5cm thick. The roof is made of precast panels to ensure quickness in erection. The precast reinforced roof is made of single slab sized 3.6x10x0.15m, were the 3.6m is the width of the shelter, the 10m the length of the shelter and the 15cm is the thickness of the roof, by that the precast roof cover the shelter fully. Two windows are placed on each of the rooms at a height of 1.2m from the ground level to promote privacy of shelter occupants. The following Fig.11 represent the plan view of 3D printed Shelter in Jordan.

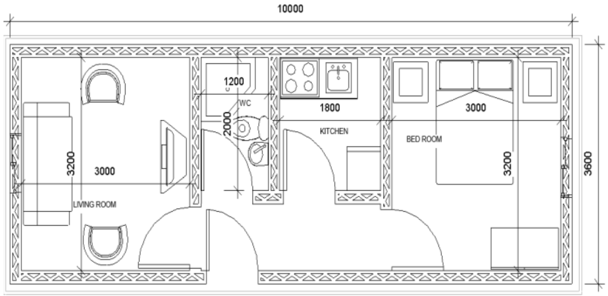

Fig. 11: 3D Printed Shelter Plan.

The designed shelter presented in Fig. 11 can accommodate 2 rooms, 1 kitchen, and 1 bathroom. The bed room sized 3x3.2m, the kitchen 1.8x2m, the toilet area is 2.4m^2, and the living room which can be turn to another bedroom for the children at night sized 3x3.2m. The living room can be divided by curtain hocked to the roof to promote privacy between the children's. Three dimensional model developed to simulate the reality of constructed shelter. The following Fig.12 represent a cross section throughout the 3D printed shelter to present the foundation, printed walls, furniture in place, doors, and windows.

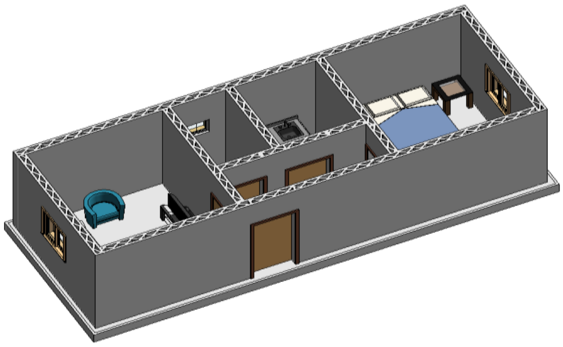

Fig. 12: 3D Printed Shelter.

Estimating the cost of the shelter depend on the location and amount of construction material. As the shelter to be placed in Jordan the unit rate of normal concrete is 104 USD/ton [30]. Kingdom concrete LLC in Amman, Jordan gave 187.5 USD/m3 for the 3D Printed concrete. The rate of the concrete includes all transportation and taxes. The mix components of 3D printed concrete presented in table. 2.

Table 2: 3D Printed Concrete Mix [31]

Material	Percentage by Weight
Cement	32%
0-2mm sand	18.2%
0-4mm gravel (0-8mm)	18.2%
0-4mm recycled roofing tiles (0-8mm)	22.7 %
Water	8.6 %
Glenium sky 631 (superplasticizer)	0.2%
Crack stop fibres	0.1%

One of Revit Architectural benefits is calculating the amount of materials used in the model to quote according to the configured quantities. The difference between traditional sheltering project and 3D printing is cost of the printer added to the cost of materials. The 3D printed wall (50mm thick) in foundation act as the frame work of the normal concrete to be casted by concrete mixer to form the shelter bottom slab, Fig. 13 represent concrete foundation casted within 3D printed shutter. The 3D printed shutter will remain in place after foundation slab casting as the 3D printed framework will eliminate the requirement of labours and tools to fix a wooden shuttering system to cast the concrete within it. The 5cm 3D printed wall as a shutter was tested on smaller span to ensure the 3D printed wall can take the lateral load generated by the concrete during casting. Fig. 14 represent column casted with the same methodology.

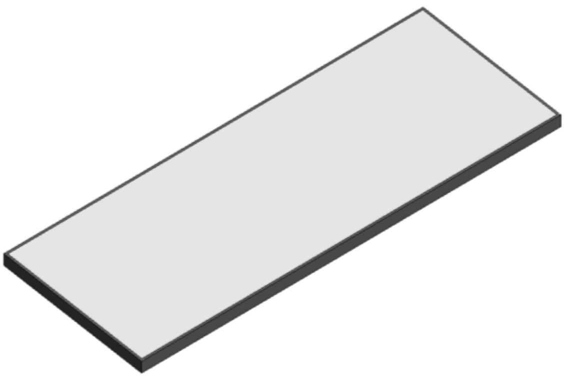

Fig. 13: Concrete Foundation within 3D printed Shutter.

Fig. 14: Concrete casted within 5cm 3D printed walls.

The following table summarize the quantities of materials consumed to build the 3D printed shelter, as well as the unit rate and the overall cost of the shelter. The major cost of the shelter generated from the concrete as the foundation, walls, and roof are made of concrete. The main entrance door, kitchen door, toilet, door and rooms doors are made of timber. The aluminium sliding windows are placed at 1.2m from finish floor level to promote privacy. Kitchen appliances such as the kitchen sink, refrigerator, and cocker was including in a lump sum price along with the toilet sanitary-wares (water closet, wash basin, and shower basin), and rooms furniture's.

Table 3: 3D Printed Shelter Material Quantities and Cost

Item	Width (m)	Height (m^2)	Length (m)	Area (m^2)	Volume (m^3)	Concrete Volume in Ton ($1m^3$=2.41 ton)	Unit Price (USD/ton)	Total Cost (USD)
3D Printed Walls	0.2	3.1	38.8	103	15.65	37.7165	187.5	7,071.84
3D Printed Shutter	0.05	0.3	28.2	8	0.42	1.0122	187.5	189.79
Concrete Foundation	3.8	0.3	10.2	39	11.63	28.0283	104.00	2,914.94
Roof Pre-cast Panel	3.6	0.15	10	36	5.4	13.014	110.00	1,431.54
Doors x5	0.051	2.1	0.92	1.932	0.099	N/A	420.00	2,100.00
Windows x2 (Rooms)	0.2	1	1	1	0.200	N/A	85.00	170.00
Window x2 (in Kitchen, and Bathroom)	0.2	0.5	0.5	0.25	0.05	N/A	55.00	110.00
Toilet sanitary-wares, kitchen appliances, and Room furniture	N/A	N/A	N/A	N/A	N/A	N/A	1,500.00	1,500.00
Total								15,488.11

The cost configured in Table. 3 for the shelter built in Jordan still miss the additional cost imposed by the 3D printing technology over each shelter. As WinSun proposed to supply the machine by either renting it, buy it, buy material and get it free of charge, or a partnership. The first option will add an additional 600 USD on each shelter as 3 printer required to construct the camp made of 10,000 shelter, within one year. Each of the printers will cost 2M USD in which the 6M USD shall be divided on to the 10,000 unit to give 600 USD an additional cost on each unit construction cost. The second option will impose 900 USD on each shelter, as the machine cost in buying option is 3M USD. The third option will increase the construction cost by enormous amount as the chemical composition to be bought from WinSun will cost 247 USD/ton. Each shelter require 38.73 ton of 3D printed concrete. The chemical composition will contribute to 10% of the mix which mean the amount of chemical required is 3.873 ton for each shelter. The cost of chemical superplasticizers for each shelter is 956.631 USD (= 3.873tonx247 USD). The cost of chemical superplasticizers for refugee camp made of 10,000 sheltering unit is 9,566,310 USD, therefore WinSun will supply 2 free printers and the third one either will be rented or bought. As the renting is the cheaper option, additional 2M to be added to the construction cost resulting in 11.5M USD cost of printers. The cost of printers from the third commercial option will add 1,150 USD on each shelter making this option as the most expensive among others. All in all, the cheapest option of constructing a shelter in Jordan by WinSun 3D printing technology would be renting the machine rather than buying it or buying chemical products from overseas. The construction cost of 3D printed shelter in Jordan estimated to be 16,088.11USD all-inclusive cost of printer, materials, delivery, installation, maintenance, and support. A camp made of 10,000 units will be built for 161 M USD through 3D printing technology, however the shelters will last for minimum of 15 years under rough climate and usage conditions. The following segment will compare a standard transitional shelter to 3D printed shelter Jordan to evaluate the cost efficiency 3D printing can achieve over current sheltering solutions.

4.4. Technical Comparison Between 3D Printed Shelters & Transitional Shelters in Jordan

The Transitional Shelter (T-Shelter) was designed for Azraq Camp to host Syrian refugees in Jordan taking into consideration the climatic, financial, and cultural constraints. Azraq camp was constructed with 13,500 T-Shelter units to accommodate 67,000 refugees in response to protracted displacement. T-Shelters are interlocking steel structures, designed to maximize privacy and protect against severe weather conditions. The T-Shelters provide protection against the strong winds, dust, and extreme changes in climate. The T-Shelter is an interlocking steel structure covered with a double layer of IBR (Inverted Box Rib) cladding with aluminum foam insulation in between and made to withstand the harsh desert climate of the camp location [32].

Fig. 15: Transitional Shelter in Jordan [32].

The steel elements, cladding, insulation, and other accessories are transported to the site in the form of a kit, which makes it easy to transport and install. The reinforced concrete flooring is later poured on site after the structure is in place. with the possibility of adding a side entrance for enhanced privacy [32]. The following schedule compare the technical performance between 3D printed shelter and T-Shelter.

Table 4: Technical Performance Between T-shelter and 3D Printed Shelters [32–34]

	Transitional (T-Shelter)	3D Printed Shelter
Floor Area	24m^2	36m^2
Ceiling Height	3300 mm	3000mm
Sphere Compliance	Yes	Yes
Windows	1 window (90x90cm)	2 windows (100x100cm)
Ventilation	4 vent pipes (Dia:15cm)	2 vent fans (50x50cm)
Door	1 steel door (1070x2000 mm)	5 timber Doors (915x2100 mm)
Expected Life Span	3 years	15-20 years
Fire Resistance	8.5m clearance between shelters	2.5 m clearance between shelters
Wind Speed	18m/s	33m/s
Snow Load	10 kg/m^2	96 kg/m^2

4.5. Commercial Comparison Between 3D Printed Shelters & Transitional Shelters In Jordan

Durability of refugee shelter play major in reducing the repair cost, as some type of shelters stand for less than a year. The more frequent the shelter changed the higher it cost over years of camp life [32]. For example, the Syrian crisis has resulted in constructing several refugee camps in Jordan such as Zaatari, Azraq, and Emirati-Jordanian camp. Zaatari Camp start receiving Syrian refugees in July, 2012 [35]. As the camp life span exceeded the 6 years the prefabricated shelters and transitional shelters become unpractical as well as inefficient as cost reduction solution and therefore, the following comparison between the transitional shelter and 3D printed shelter will illustrate how efficient 3D printed shelters will be in comparison to transitional shelters from cost and time perspectives.

Table 2: Cost Comparison between Transitional Shelters and 3D Printable Shelters [36–39]

Comparison Unit	Transitional Shelter	*3D Printed Shelter*
Cost	$ 2,442	$ 16,088.11
Construction Productivity	30Shelter/Day	
Number of Refugees per shelter	5	7
Construction Methodology	160 Labour	3 Printer
Durability	3 years	15 years
Area of Each Shelter	24 m^2	36 m^2
Unit Rate/m2	102 USD/m^2	447 USD/m^2
Shelters required to accommodate refugees	14,000	10,000
Camp Capacity (Refugee)	70,000	
Camp Construction period	1 Year	
Cost over 15 years	170.9 M USD	160.8 M USD
Construction Cost Efficiency	6%	

Transitional shelter occupants capacity found to be smaller than the 3D printed shelters, which mean additonal shelters required to accommodate the 70,000 refugees. A transitional shelter would cost 12,210 USD (=2442x5) over 15 years span, since shelter to be changed every 3 years. A refugee camp made for hoisting 70,000 refugee would require 14,000 T-shelter at a cost of 170.9 M USD where as 10,000 3D printed shelters at cost of 161 M USD would be enough to shelter same amount of refugees. Therefore, the 3D printed shelter will impose a cost effeciency of 6% in comparison to Transitional shelters over 15 years span. The efficiency can be further investigated by reducing the amount of inner wall printable profile without compormising the structural stability.

5. Conclusion

Middle East Zone is facing terrorism from all side. Major countries in the zone such as Libya, Syria, and Yemen have fallen due to internal conflicts resulted in millions of refugees displaced all over the world. Syria internal conflict has generated the largest number of refugees among other middle east countries. Syrian refugees displaced to domestic safe zone in neighboring countries such as Lebanon, Jordan, and Turkey. Jordan hoisted over seven hundred thousand Syrian refugees. Syrian Refugees settled in sheltering camp are suffering the low-quality shelters that would not last over 3 years' maximum. Three dimensional printing achieved massive outcome over the last few years it contributes to the construction industry. The technology has potentials in building small housing units at competitive cost and therefore, this paper aimed to investigate the visibility of using 3D printing technology as construction methodology to build Syrian refugee camps in Jordan. concluded that 3D printing technology have great potentials in constructing Syrian refugee shelters in Jordan through developing a simple model using Revit architectural platform. The 3D printed shelter achieved cheaper cost than transitional shelter, higher stability ratios, and long durability solution, as well as it achieved the social and cultural context of the Syrian refugees.

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