International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

EIA of Sustainable Evacuating Houses by using Waste Materials from Surrounding Environment

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Accepted 22 Dec 2016, Available online 27 Dec 2016, **Vol.6, No.6 (Dec 2016)**

Abstract

In our modern world many armed conflicts and wars in some places cause mass departure of population of these places due to the bombing and missiles blasting which turns their property into ruins , Also Natural disasters such as earthquake, tornados and hurricanes cause resident people to lose their homes to be homeless and demoralized without any hope in the present or in the recent future. An urgent shelter were needed for those people to live their life the possible way as they could by suggesting a sustainable cheap systems of evacuating homes. This suggested system was needed to get rid of destroyed city wreckage in order to clean the area and to insure the mitigation of its negative impact on the surrounding environment. This was done by using the suggested unique structural architectural system of homes by sing steel water pipes from the infra structures of the city ruins as structure columns and by using a special of wreckage concrete mix which will be used in creating connecting bearing wall. This type of system will insure the disaster wreckage cleansing to be valid for new establishment also the required construction materials is available and nearby with no need to import usual one. The system was designed to be safe and sustainable for the residents with suitable architectural functions such as visual and thermal with enough ventilation. Also the roof top was equipped with vents to provide natural ventilation and to ensure the air quality within the acceptable limits. EIA for this type of sustainable houses was studied to detect its negative impact in order to avoid it and to construct suitable environmental monitoring system dealing with the surrounding environment elements. At the end of this study a group of conclusions and recommendations were deduced in order to improve the required system and also to ensure its structural and architectural competency.

Keywords: *EIA, Sustainable houses, Evacuating Houses, shelters, green design, waste material, concrete-wreckage mix.*

1. Introduction

The usual system of evacuation shelter is a camp of tint or prefabricated caravans that delivered and erected in the camp site in a fast way to provide temporary shelter for refugees who forced to leave their own homes under the circumstances of war conflict or natural disasters as shown in fig (1) and fig (2). This kind of shelters are temporary and do not provide the residents with adequate privacy or visual and thermal comfort also those people always looking for substitute sustainable home instead of temporary homes to feel safe about them self and their families and this kind of shelter may tear the families due the shortage of enough places in the evacuation camp (https://en.wikipedia.org/wiki/Refugee_shelter).

Fig.1 The Tint camp

A suggested system was studied both structurally and architecturally to be the appropriate system which suite such circumstances which will be discussed latterly.

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Fig.2 The prefabricated shelter

This system consists of a group of galvanized steel pipes and wreckage-concrete mix that existed in any destroyed urban area as shown in fig (3) to be used as construction material to build sustainable healthy shelter with enough natural ventilation and appropriate thermal and visual comfort , Also its roof are used to vegetate different crops to feed the refugees and to provide with their minimum food requirements and to create friendship with the environment as shown in fig (4) and fig(5).

Fig.3 The building wreckage

Fig.4 The suggested system front

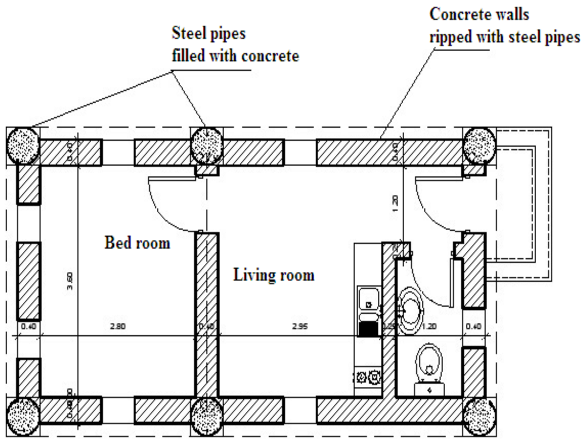

Fig.5 The suggested system Architectural plan

2. The suggested system

It consists of a group of galvanized steel pipes act as building columns will be filled with wreckage concrete mix and it will be constructed in each corner of the required system to at each system wall edge. The galvanized steel pipes will be dug in the soil enough penetration distance to act as deep foundation of the building depending on site soil friction and bearing. Each building wall will contains two set of pipes in forms pipes perpendicular to each other And these set of pipes will be filled between them the wreckage – concrete mix to contribute wall bearing system.

The roof system consists of set of combination pipe types (PVC pipes, Galvanized steel pipes of smaller diameter) perpendicular to each other covered by a thin RC layer, This layer is covered by insulation material such as polyethylene sheets and finished by thin layer of mortar cover. The floor will consists of tiles 20×20 cm over insulation covered mortar layer rested directly on well compacted soil as shown in fig (6) and fig (7).

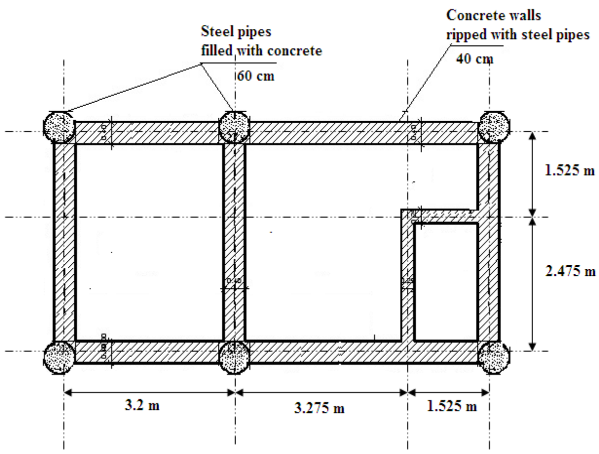

Fig.6 The structural system of the Sustainable home

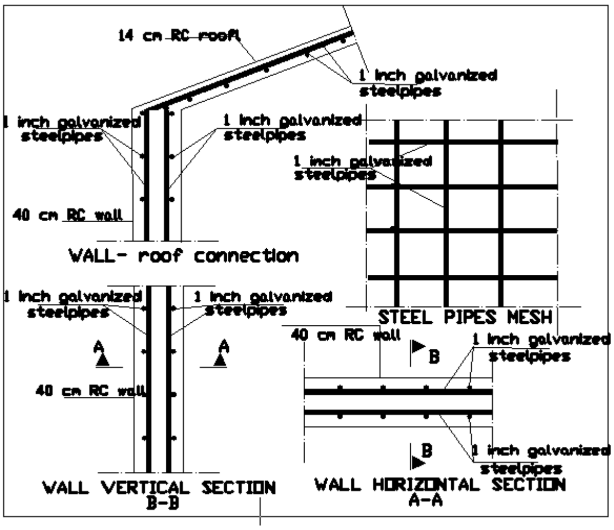

Fig.7 The roof and walls details

3. Material description

The waste materials in this study include glass, plastics, brick, stones and concrete wreckage as shown in table 1. The usage of this material not only help us to conserve natural resources in the site area but also help us to solve waste disposal crisis.

Table 1 Material types

Material type	Description
Brick	Valid from ruins of walls of any type of destroyed buildings
Stone	Valid from ruins of destroyed wall bearing buildings
plastics	Valid from ruins of walls of any type of destroyed buildings
glass	Valid from ruins of walls of any type of destroyed buildings
Concrete	Valid from ruins of destroyed concrete buildings

4. The reuse of concrete wreckage

Concrete wreckage was always trucked to be buried in any near land fill in order to dispose of it from any construction site. Another way of concrete wreckage disposal is by using it in concrete mix after we crush it instead of using coarse aggregates such as gravel. This method will reduce the concrete mix coast by reducing the needs of gravel importation t project site, Also this processes prevent the concrete wreckage from contaminate the soil as a waste non decomposed material. We have to collect the concrete wreckage free of trashes, paper, wood and glasses from the ruined sit and we put in a crushing machine aggregate collected from demolition sites is put through a crushing machine to produce elements of small sizes suitable to be used as concrete aggregates. This processes will take place in the construction site to save the time and the coast of transfer the crushed material from and into the site (https://en.wikipedia.org/wiki/Concrete_recycling).

4.1 Benefits of using concrete wreckage

The benefits of reuse of concrete wreckage instead of threw it or dump it in any near landfill are as follow:

1) Prevent soil pollution by concrete waste since it is a non decomposed material.
2) Reduce the concrete cost as a result of using it as coarse aggregate instead of buying gravels or stones.
3) Decrease CO_2 emission.

5. Pipes types

In any destroyed urban area we may find any type of the six main types of water pipes as follow (http://civilblog.org/2015/07/02/6-types-of-pipes):

1) Plastic or PVC pipes
2) Galvanized steel (GI) pipes
3) Cast iron pipes and fitting
4) Stoneware pipes
5) Asbestos Cement (AC) pipes
6) Concrete pipes

5.1. Plastic or PVC pipes

The Plastic or PVC pipes can be found in any ruin area in form of three main types as follow:

1) The Rigid pipes and called un plasticized PVC (UPVC).
2) The Plasticized PVC pipes which has a lower strength and lower working temperature than UPVC pipes.
3) The Chlorinated PVC (CPVC) pipes which can withstand higher temperatures.

For pipes used in soil and waste water discharge systems, the thickness of the wall will be larger than that of used for roof drainage. At higher temperature, the strength of the pipes decreases. Similarly ultraviolet radiation from sunlight as well as frequent changes in temperature reduces the life of PVC pipes.

5.2. Galvanized Steel (GI) Pipes

Galvanized steel pipe is made of steel material an d this steel pipe will undergo of galvanizing processes that include a deposition of zinc thin layer to prevent rust, The steel pipes are available in different thickness according to its diameter.

Table 2 The number of hours in the different categories for air quality

Number of hours	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
I(750 ppm)	0	0	0	0	0	0	0	0	0	0	0	0	0
II(900 ppm)	0	0	1	1	0	0	0	0	0	0	0	0	1
III(1200 ppm)	0	1	1	10	1	0	0	0	0	0	0	6	19
IV(>1200 ppm)	555	491	534	511	554	522	546	546	522	556	522	531	6390

Table 3 Percentage per month for different categories of air quality

Part of year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I(750 ppm)	0.0	0.0	0.0068	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
II(900 ppm)	0.0	0.0	0.11	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
III(1200 ppm)	0.0	0.12	0.27	2.0	0.23	0.0	0.0	0.0	0.0	0.0	0.0	1.1
IV(>1200 ppm)	100	100	100	98	100	100	100	100	100	100	100	99

Table 4 Number of hours above different air change rates

Number of hours	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
> 0.20 ACH	24	24	24	60	39	30	6	16	17	33	10	19	301
> 0.35 ACH	0	1	1	1	0	0	0	2	0	1	0	0	6
> 0.50 ACH	0	0	0	0	0	0	0	1	0	0	0	0	2

Table 5 The part of the year with hours above different air change rates

Part of year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
> 0.20 ACH	3.3	3.6	3.2	8.3	5.2	4.1	0.86	2.1	2.4	4.4	1.4	2.5	3.4
> 0.35 ACH	0.0	0.13	0.079	0.1	0.012	0.0	0.0	0.31	0.0	0.09	0.0	0.065	0.066
> 0.50 ACH	0.0	0.0	0.032	0.045	0.0	0.0	0.0	0.19	0.0	0.014	0.0	0.0	0.024

6. Results

This section contains the basic results on ventilation/air quality, thermal comfort and energy. All other results can be found in the following sections (if turned on in the report menu).

6.1 Ventilation

The fig (8) shows the percentage of each month or the full year, when the ventilation rate is above 3 different levels.

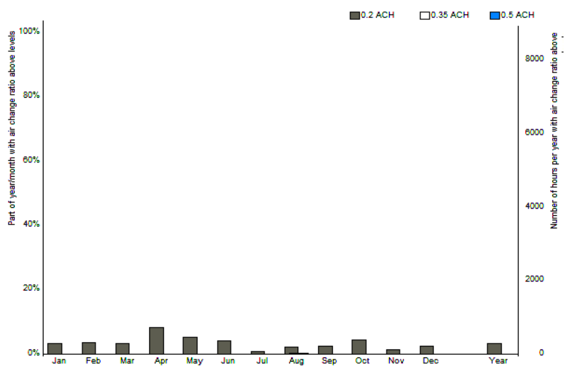

Fig.8 The percentage of ventilation rate of each month or the full year

6.2.Air quality

Table (2) is shown the number of hours in the different categories from EN 15251 for air quality measured in CO_2 level (carbon dioxide) in ppm comparing to outdoor levels, The categorized levels are I (High IAQ), II (medium IAQ), III (moderate IAQ) and IV (low IAQ). (H, Shirley, 2004).

Table (3) is shown the part of the year in the different categories from EN 15251 (European standards specifies indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics) for air quality .

6.3 Air changes rate

Table (4) is shown the number of hours above different air change rates in ACH which is a measure of the air volume added to or removed from a space divided by the volume of the space per hour.

Table(5) is shown the part of the year with hours above different air change rates in ACH to view the efficiency of the building through the year from January to December for three different levels which are 0.2 ACH, 0.35 ACH and 0.5ACH and that was shown before in fig (8) .

6.4.Thermal Comfort

The fig (9) shows the indoor temperature, outdoor temperature and the comfort range. The comfort range is calculated based on the outdoor running mean air temperature as described in EN 15251 (Gallardo.A, Palme.M Lobato.A, David.R, Beltrán, Gaona. G, ,2016)

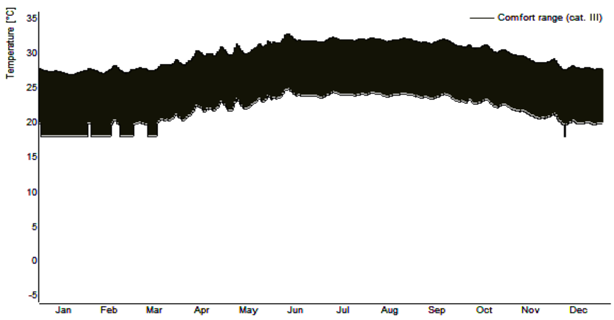

Fig.9 The indoor temperature, outdoor temperature and the comfort range

The fig (10) shows the part of the year within and out of the thermal comfort range when the occupants are at home.

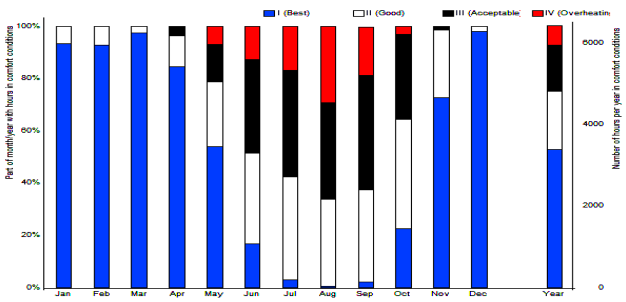

Fig.10 The part of the year within and out of the thermal comfort range

Table (6) is shown the number of hours above different temperatures, As we know the temperature range for human comfort is vary from 19 C° to 28 C°, The values in the following were expressed as percentages of the occupied hours that were above different temperature levels.

Table 6 hours above different temperatures

Temperature	Number of hours	Part of year (occupied part)
30°C	2372	37 %
29°C	2871	45 %
28°C	3176	50 %
27°C	3645	57 %
26°C	4065	63 %

6.5 Energy

The fig (11) shows the monthly energy demands(lightening only) for the building divided into contributions. The values in kWh/m² should be multiplied by the area of the house to determine the total annual energy demand (I.Kuppaswamy, 2015).

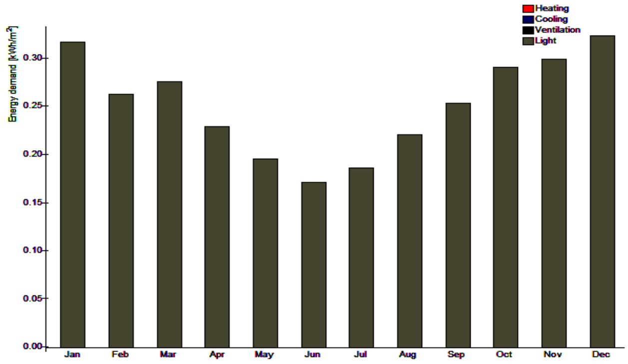

Fig.11 The monthly energy demands for the building

Table (7) is shown the energy demands for lightening in [kWh/m²], The values of electrical appliances, electrical heating system, mechanical ventilation and electrical cooling system were assumed to be equal zero.

Table (8) is shown the energy demands for building in [kWh/m²], The values were estimated to include lightening demand, electric appliances, electrical heating if needed, mechanical ventilation and electrical cooling if needed. The values were estimated for different concrete –wreckage mix wall thickness also in included value for ordinary brick wall.

Table 7 The energy demands in [kWh/m²]

Energy demands	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Heating demand	0	0	0	0	0	0	0	0	0	0	0	0	0
Cooling demand	0	0	0	0	0	0	0	0	0	0	0	0	0
Ventilati on demand	0	0	0	0	0	0	0	0	0	0	0	0	0
Lighting demand	0.32	0.26	0.28	0.23	0.2	0.17	0.19	0.22	0.25	0.29	0.3	0.32	3

Table 8 Walls Total Energy Consumption

Wall type and thickness	Walls Total Energy Consumption (Kw.h/ m²)
Concrete mix wall 40 cm	86.7187
Concrete mix wall 45 cm	85.7812
Concrete mix wall 50 cm	84.8437
Ordinary wall	101.468

7. Result analysis

The ventilation inside the suggested system as shown in fig (8) which shows that the ventilation rate (number of hours per year above level) is increased in April, May, June and October. But in the same time the number of hours does not exceed 600 hours per year which indicate that the suggested system will need mechanical ventilation through these hours.

According to tables (2), (3) of air quality we found that the levels of CO_2 (Carbon dioxide) inside the suggested system is exceeding 1200 ppm most of the time (6390 hours per year, 73% of year total hours) which indicate that it needs minimum mechanical ventilation (air change rate) although the emission of CO_2 inside the house exceed normal levels. This also can be indicated in tables (4) and (5) of air change rate because both of them show that the total need for air change rate above 0.2 ACH is almost 3.4 % of total year hours.

According to fig (9)and fig (10) of thermal comfort and table (6) which show that the suggested system provide thermal comfort the maximum time along the year according to EN 15251 standards. The normal range for human thermal comfort range is 19 C° to 28 C°. The graphs show that the thermal comfort inside the house vary from best to acceptable level (50% to 63% of the year hours) and that for the level overheating is 37% of the year. At the time of overheating level we will need electrical thermal cooling to adjust the thermal comfort inside the house.
The total minimum consumed energy (lightening only) along the year can be shown in fig (11) and table (7) after we neglected other energy needs such as electrical appliances, electrical heating system, mechanical ventilation and electrical cooling system which assumed to be equal zero.

The total minimum energy needs is almost equal to 3 KWh/m^2 (3 % of the passive energy houses needs). If we added other energy needs such electrical appliances, electrical heating system, mechanical ventilation and electrical cooling system the total consumed energy along the year will never exceeds 84.8437 Kw.h/m^2 as shown in table (8) Which indicated that the suggested house system is passive house (consume energy less than 100 Kw.H/m^2).

The idea of the new wall design is not only oriented into material conservation by recycling and reusing materials, but also it is targeting minimizing energy consumption in the indoor space. The simulation results showed that the unit consumes 84.8437 kw.h/m^2 annually while the same unit if built with the normal construction skeleton building method will consume 101.468 kw.h/m^2 annually. The new construction method saves 25% less energy than the traditional skeleton building.

The standard unit was tested in the four main basic thickness to determine the optimum wall width that achieves the highest level of thermal comfort with the least amount of energy. The wall width 40 cm in north direction resulted in 86.7187 kw.h/m^2 energy consumption rate, while the 45 cm wall width resulted in 85.7812 kw.h/m^2, the 50 cm wall width resulted in 84.8437 kw.h/m^2 which supposed to be a negligible difference which makes the 40 cm wall width is the optimum to be used in the north orientation as it is slightly different in energy consumption and uses less materials. The previous study shows the significance of changing the wall width in the four basic orientations on the thermal comfort of the users inside the standard studied unit. The extent to which the thermal comfort is achieved inside the space is referred to by the amount of energy needed for the spaces to make its users reach thermal comfort. This study revealed that the use of wall width of 40 cm is the optimum.

8. Environmental impact assessment (EIA)

Environmental impact assessment (EIA) is dealing with negative and positive impacts of the projects and classifies its weight according to different categories such as poor, moderate and large in both construction and operation stage. The study will include all the surrounding elements such as water, soil, social element, human health, air and noise in order to measure the impact of the project on previous elements, At the end of the study a monitoring program to monitor the project impact during operation is obtained (Law 4/1994 of the environment).

The establishment of sustainable houses has many positive and negative impacts on the surrounding environment with its different elements. The deposal of city ruins that was resulted from natural disasters and war conflict by using it as houses structural elements will be considered as positive impact, Also the idea of providing a suitable sustainable house for the refugees as permanent shelters that will give them adequate thermal and visual comfort will be categorized as social negative impact.

The project negative impact will be resulted from the processes of sustainable houses construction that will produce dust and cement traces to the air due to cement-wreckage admixture and soil excavation, These hazard traces in air will contribute a risk for labor health and their respiratory system. The labor activities and their transportation methods in the site will cause negative impact, Also the construction tools sounds and the worker noise will be considered as a negative impact for this project.

During houses operation untreated sewage water effluent from houses may contribute a health risk because it will be a good environmental for pathogens and viruses, Also sewage water will contaminate the near water ground aquifer if there is any.

The environmental impact assessment of the project during construction can be shown in the following table(9), Also The environmental impact assessment of the project during operation processes can be shown in the following table(10).

Table 9 The environmental impact assessment during construction processes

Activity type	The impact	Environmental Element				
		Air and noise	Water	Soil	Social	Health
The construction workers activities	The transportation of workers by vehicles may lead to Air pollution due to fuel combustion and also a loud noise	Poor	Non	Non	Non	Poor
The construction materials	Colloidal Traces of Some construction material such as cement in air and the fall of some part of it on the ground	Poor	Non	Poor	Non	Poor
The construction equipment	Air pollution due to fuel combustion and also a loud noise	Poor	Non	Non	Non	Non

Table 10 The environmental impact assessment during operation processes

Activity type	The impact	Environmental Element				
		Air and noise	water	Soil	Social	Human health
The water cycle	1-untreated sewage water effluent 2-The excessive pulling up of water from near underground aquifer for Potable water needs that May cause groundwater depletion	Non Non	Moderate Poor	Non Non	Non Non	Moderate Non
Energy source unit	1-The equipment result noise and air pollutants 2-The emission of Co2 due to diesel fuel combustion	Poor Poor	Non Non	Non Non	Non Non	Non Poor

8.1. Negative impact mitigation

According to tables (9) and (10) the suggested system during both construction stage and operation stage has poor negative impact on the surrounding environment and that can be neglected except some negative impacts have to be mitigated such as:

a) Houses untreated sewage which need special treatment system to turn it to acceptable water quality before we get rid of it by injecting into the soil or through it to near wet land.
b) Air quality inside and outside houses must be within the acceptable quality by using mechanical ventilation inside the houses if needed and to control houses and vehicles emissions.
c) Noise by vehicles must be controlled by using it in good conditions suitable to the residential houses and urban area.

9. Environmental monitoring program

The monitoring program is designed in order to measure the environmental indicators such as water, soil, social element, air and noise related to EIA study. The monitoring program must include measuring of different environmental elements to form periodic report. The different environmental elements parameters which will be measured during specified interval time are as follow:

a) Air quality and noise.
b) Effluent waste water.
c) Houses resident's health.
d) Houses solid waste.
e) Social development through time.

The system will be responsible to analyze any received complains to investigate it and to provide suitable solutions in order to avoid its negative impact.

Conclusions

1) The suggested system of sustainable house is Environmental friendly compared with alternative system because it will help the environments to get rid of the cities ruins.
2) The suggested system of sustainable house provides suitable thermal comfort for indoor climate according to international standards.
3) The suggested system of sustainable house minimizes the required energy consumption.
4) The suggested system of sustainable house provides adequate natural air ventilation.
5) The optimum wall thickness For The suggested system is 40 cm.
6) The suggested system saves 25% of consumed energy compared to traditional skeleton system.
7) The suggested system needs minimum mechanical ventilation in order to ensure the indoor air good quality.
8) In order to avoid the negative impact of the untreated effluent sewage on the surrounding environment a suitable sewage treatment system will be needed.
9) Environmental monitoring program is needed to monitor the suggested sustainable houses during operation.

11. Recommendations

1-Experimental study for the suggested system of sustainable house should be achieved.
2-Cost analysis study for the suggested system of sustainable house should be achieved.

3-Hydraulic system for water cycle for the suggested system of sustainable house should be studied.

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