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Recycling Plastic in Building Construction Effectively Combats Climate Change and Protects the Environment

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Abstract:

The building construction had a significant impact on the environmentin all stages. It affects climatic change, air pollution, landfill waste, and greenhouse gas emissions. So, the negative construction impact onthe environment could be decreased by utilizing reusableand green technology. Also, landfill wastes result from human use'seffect onthe environment and climatic change. Therefore, it is necessary to study and change some elements in construction buildings to decrease the negative environmental impact. Using recycling materials in case of change in construction building materials will be more beneficial for the environment and climatic changes. So, plastic product wastes have been selected because they havea dangerous effect, and some types have properties suitable for use in many elements in construction buildings. This study focused on using polypropylene(PP), increasing use on all sidesof life, and environmental waste.Brick considers an essential element in building construction, so it has been made from polypropene raw and recycled material. Therefore, the study will include properties of new brick and an analysis of its effect on building in El Arish, North Sinai, Egypt.Additionally, the study included three phases. The first phase studies the Compressive strength and the weight of hollow bricks of different sizes and materials. The second phase analyzed the zone sensible heating, Comfort Temperature, Wall Gains, Wall Costs, and HVAC Costs of various sizes for pp hollow brick and compared it with a hollow concrete brick. The third phase studies the effect of usingPP raw and recycled material. The finding will explain the impact of usingPP raw and recycled material in hollow brick inthe building and the environment.

Keywords: RecyclingPP; External envelope; Climatic changes; Energy saving.

I. Introduction

Building construction processes significantly impacted the natural environment[1-3].The result of increasing processes of building construction made a lot of various environmental impacts[4-6]. The building sector's growth helps raise subsequent CO2 emissions and Energy consumption[7, 8]. The effect generated during the construction stage can be of the same order magnitude as those caused by the building during its life cycle[9]. The construction industry has two mainside effects. On the first side, it contributes to the Egyptian and global economies. Other side causes considerable pollution, waste generation, energy consumption, and other environmental issues[10].

Construction activities include site preparation, demolition, repair, or building maintenance. All these activities at construction sites can cause the discharge of polluted water.That affects the marine environment or local watercourses, causing the emission of dust, noise, or odors[11].The construction sector generates 50%of landfill waste and 23% of air pollution, and 40% of drinking water pollution. Also, it contributes to 50% of the climatic changes [12-45].

Over 40% of greenhouse gas emissions come from construction. [13]. Additionally, an article published in Bold Business states," the construction sector contributes 25% – 40% of the world's carbon emissions". The UK Green Building Council, 'the construction sector uses more than 400 million tons of material a year, many of which harm the environment. Also, according to the World Watch Institute, "the industry consumes 40% of the world's usage in raw stones, gravel, and sand and 25% of its virgin wood per year". According to the environmental group LEED, it should save 250 metric tons of CO2 emissions annually, if it has used environmentally friendly materials during the construction process [14].Also, it is necessary to give attention to recycling and reusing material to reduce the negative impact on the environment and use our resources more effectively [15].

The recyclable architecture is realistic and feasible, increases life span, ensures adaptation through time, and increases life span, material reusability, and usability while avoiding demolition, reducing construction waste, and, consequently, CO_2 emissions [16].Waste recycling has a role in the livelihood of marginalized societies in developing economies [17]. Reducing waste in the manufacturing processes helps increase the resource efficiency of building materials [18-46]. Choosing the appropriate material is a significant step in product design [19].

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The significant participation of plastic in sustainable development and modern society is clear. The plastic industry is a substantial producer of thousands of job opportunities in recycling or manufacturing [20]. Recycling waste plastics is essential to the environment and climate change [21]. Also, nowadays, societies give attention to the Collection and disposal of plastic waste for health and economic reasons. Recycling plastic takes less energy than producing plastics from new raw materials, with a ratio of 88% [22].Plastic waste is the major crisis that overwhelms our oceans. Also, it has a growing threat to the Earth's climate, resistance to the biodegradation nature of their components, more extreme and frequent weather events that are causing widespread socioeconomic and ecological harm, and growing CO2 emissions [23-25].

Recycling plastic fosters the transition to zero-waste communities and decreases greenhouse gas emissions from the plastic lifecycle [26]. Plastic waste recycling is valuable and cost-effective because it can be used in new materials in the building and construction sector [27].The volume of plastic waste from the Egyptian household, mainly packaging waste, constitutes about 50% of the total national plastic waste from all sectors". Around 80%-90% of those consumer products' plastics are high-density polyethylene, polyethylene terephthalate, low-density polyethylene, vinyl, polypropylene(PP), polyvinyl chloride, and polystyrene [28]. Recycling plastic and avoiding disposal demand new techniques because the plastic waste will become 0.7 kg/person/day in 2050 [29-30]. Recycling positively impacts the environment because it helps decrease the need for virgin materials and reduce the impacts resulting from landfills [31].

Selecting new construction material depends on its thermal behavior because that will affect at thermal comfort of the building. So, understanding thermal comfort is essential because it affects sustainable design [32].The external envelope is the main element that affects the thermal comfort of the indoor building. The building envelope separates the indoor and outdoor environments.It has many functions, such as providing shelter, security, moisture control, solar and thermal control, indoor air quality control, fire resistance, cost-effectiveness, access to daylight, views outside, acoustics, and aesthetics. The inside temperature of the walls is directly proportional to the heat transmitted indoors [33-48].

The thermal performance of a building envelope is a significant element influencing building energy consumption, improvements to which can decrease the amount of energy required to cool and heat indoor spaces and may therefore play an essential role in reducing overall energy consumption [34-47]. Additionally, The HVAC systems in the building depended on thermal

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comfort for building occupants [35].Theoretically, buildings controlled with an HVAC system should keep at least 80% of the users feeling comfortable" [36].

All previous studies have explained the central role of construction buildings in affecting the environment and climatic changes. Also, the amount of plastic waste and its negative effect on the environment and climate has been explained. So, this study will study change the material used in construction buildings. Selecting this material depends on the properties of raw material, recycling, and the effect of the waste in the natural environment. All that can save the environment from damage and negative affect can happen to it, also lower the Cost of building, saving energy and facilitating the construction process. So, it has been selected PP because it has many valuable properties for construction operations. Also, its waste is found a lot in the environment result of the versatility of raw PP material. PP waste causes dangerous environmental effects when it recycles, which will decrease this danger to the environment and climate. This study will explain the impact of manufacturing and using raw and recycledPP in building construction in El Arish, North Sinai, Egypt. The first will design new brick to use in building construction and then calculate the Compressive strength. Secondly, study the effect of different sizes for pp hollow brick compared with a hollow concrete brick. That is all to improve the thermal comfort inside the building, save energy, and decrease the negative effect of waste PP on the environment and climate.

II. Methodology:

This paper will study the role of the external envelope in sustainability and faces climatic changes. The case study has been selected in Egypt, north Sinai, and El-Arish. So, the material of the brick used in the external envelope has been changed. The new material is PP to use on the hollow brick. Also, the study will includethe use of recycled waste of PPmaterial in this hollow brick. First, the Compressive strength of PP hollow brick was calculated using Raw PP and Recycling PP material.

Additionally, the dimension of the space to study with 10m width x 10m length x 3m highest has been determined. This model was simulated with a design-builder program to compare the PP hollow brick's different sizes with a hollow concrete brick. The analysis includes the zone sensible heating, Comfort Temperature, Wall Gains, Wall Cost (Structure + Surface Finish), and HVAC Costs.

This paper included three phases. The first phase studies the Compressive strength and the weight of hollow bricksof different sizes and materials. This phase contains three examples of different dimensions (Example 1- 400x200x200mm, Example 2 - 400x150x200mm- Example 3-

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400x100x200mm). The second phase analyzed the effect of varioussizes for pp hollow brick and compared it with a hollow concrete brick. This phase included the analysis of the zone sensible heating, Comfort Temperature, Wall Gains, Wall Cost (Structure + Surface Finish), and HVAC Costs.The third phase studies the effect of usingPP raw and recycled material. This phase includes calculating the amount of PP that could be used in a month using recycled material positively affecting the environment.

1. ***The first phase studies the Compressive strength of hollow brick:***According to a previous study, the average applied force for PP material is 127.29 KN. Also, the average used force for recycling PP material is 34 KN[37]. Also, the traditional dimension of hollow brick is size 400x100x200mm, 400x150x200mm, and 400x200x200mm. Additionally, the Compressive strength according to the Egyptian code (N 204 - 2015):

- Non-load bearing concrete hollow brick = 1.6 N/mm2
- Load-bearing concrete hollow brick = 4 N/mm2

This phase contains a new design for PP hollow brick, as explainedinFigure 1. Also, it has included three examples of different dimensions (Example 1- 400x200x200mm, Example 2 - 400x150x200mm- Example 3- 400x100x200mm). It has been studying the compressive strength for every example in two cases and then compared with concrete hollow brick Compressive strength according to the Egyptian code. Case 1 usedPP raw material, and case 2 used PP recycling material, compared with concrete hollow brick Compressive strength according to the Egyptian code. It also compares the weight of the PP hollow brick and hollow concrete brick at different sizes, as explainedinTable 1.

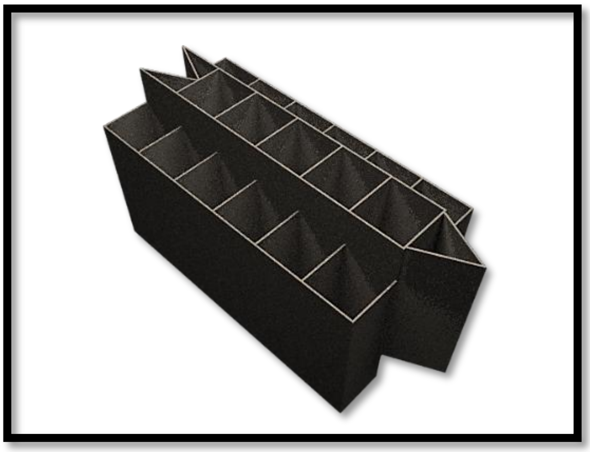

Figure 1explains the design of the PP hollow brick**.**

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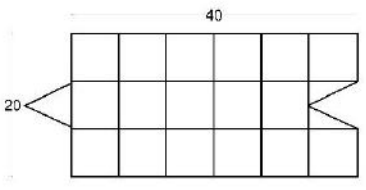
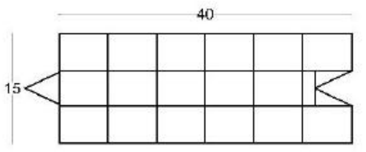
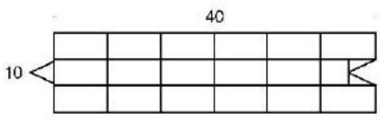
Table 1explains the Compressive strength of the three examples of pp hollow brick.

Ex.	The shape of the block and dimension	Compressive strength			
		Raw PP.		Recycling PP.	
Example 1 400x200x200mm		Brick A1	The area = 63.33 cm^2 **F = N / A** F = 127.29 *1000 / 6333 Compressive strength = 20 Mpa	Brick A2	The area = 63.33 cm^2 **F = N / A** F = 34 *1000 / 6333 Compressive strength = 5.36 Mpa
Example 2 400x150x200mm		Brick B1	The area = 55.96 cm^2 **F = N / A** F = 127.29 *1000 / 5596 Compressive strength = 22.74 Mpa	Brick B2	The area = 55.96 cm^2 **F = N / A** F = 34 *1000 / 5596 Compressive strength = 6.07 Mpa
Example 3 400x100x200mm		Brick C1	The area = 47.47 cm^2 **F = N / A** F = 127.29 *1000 / 4747 Compressive strength = 26.81 Mpa	Brick C2	The area = 47.47 cm^2 **F = N / A** F = 34 *1000 / 4747 Compressive strength = 7.16 Mpa

The second phase analyzed the effect of different sizes for pp hollow brick compared with a hollow concrete brick.

In this phase, the dimension of the space to study with 10m width x 10m length x 3m highest has been determined. It has been divided this phase to four models. Model 1 for PP hollow brick

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400x200x200mm, Model 2 for PP hollow brick 400x150x200mm, Model 3 for PP hollow brick 400x100x200mm, and model 4 for concrete hollow brick 400x200x200mmas explained at Figure 2. The concrete hollow brick 400x200x200mm has been chosen because it is the highest resistance compared with the most traditional hollow brick used in walls[39].

These modelswere simulated with a design-builder program to compare the PP hollow brick's different sizes with a hollow concrete brick. Additionally, the analysis includes the zone sensible heating, Comfort Temperature, Wall Gains, Wall Cost (Structure + Surface Finish), and HVAC Costs,as explainedinTable 2.

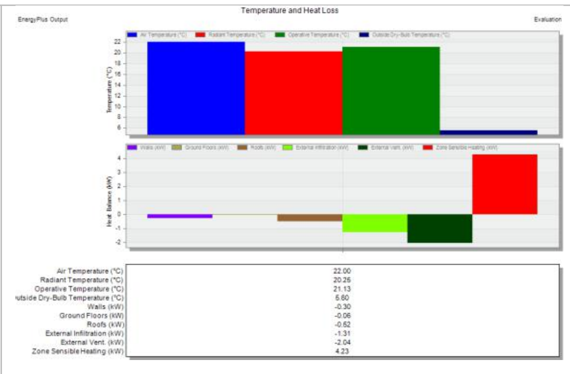
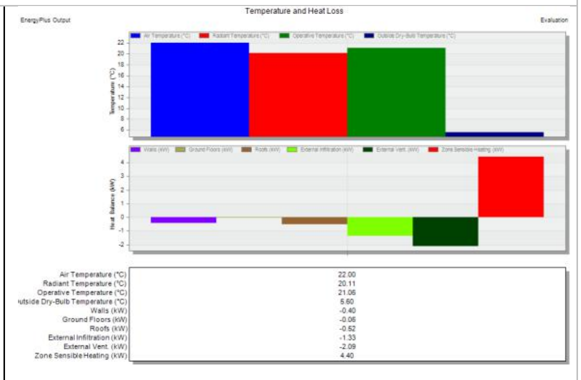
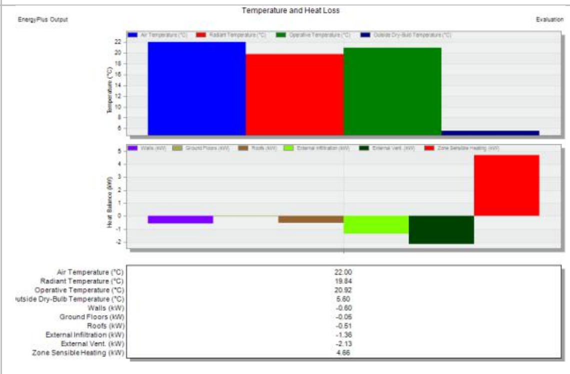
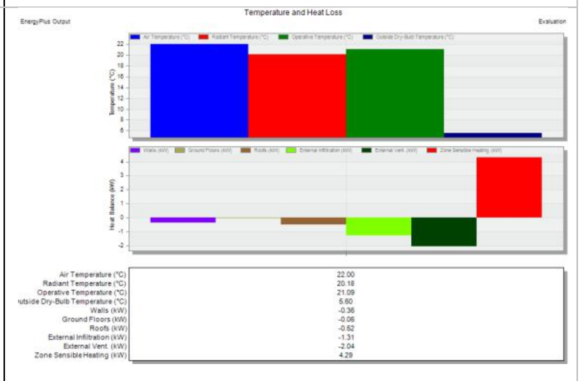
Simulation of the temperature and heat loss			
Model 1		Model 2	
	The sensible zone heating (KW) = 4.23		The sensible zone heating (KW) = 4.40
Model 3		Model 4	
	The sensible zone heating (KW) = 4.66		The sensible zone heating (KW) = 4.29

Figure 2explains the sensible zone heating (KW) for four differentmodels of hollow brick**.**

Table 2explains the analysis using the design-builder program for four different models of hollow bric

analysis	Model 1	Model 2	Model 3	Model 4
Comfort Temperature (°C)	21.13	21.06	20.92	21.09

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Wall Gains (kW)	-0.304	-0.404	-0.602	-0.358
Wall Cost (Structure + Surface Finish) (GBP)	5,040	5,040	5,040	6,720
HVAC Costs (GBP)	13,824	14,113	14,406	13,824

The third phase studies the effect of usingPP raw and recycled material.

The plastic is manufactured by injection. For manufactured PP hollow brick, it should know the model hollow brick's weight and the machine's production in the month. The machine production in the month of 86400 pieces[37].

The weight of a PP hollow brick with dimensions of 400x200x200mm is 0.74 kg. The weight of a 400x150x200mm PP hollow brick is 0.64 kilogram. The weight of a PP hollow brick with dimensions of 400x100x200mm is 0.55 kg.The weight of a PP hollow brick with dimensions of 400x200x200mm is 0.74 kg. The weight of a 400x150x200mm PP hollow brick is 0.64 kilogram. The weight of a PP hollow brick with dimensions of 400x100x200mm is 0.55 kg. The weight of hollow brick concreteof different sizes is explained inTable 3.

Table 3 explains the weight of different sizes of hollow brick concrete [38].

Brick shape			
Description	4” RAK	6” RAK	8” RAK
Size	400x100x200mm	400x150x200mm	400x200x200mm
Average Weight per Block	13.40 kg	16.90 kg	22.10 kg

The amount of PP (raw or recycled material) wanted per month for PP hollow brick with dimension 400x200x200mm is (86400 x 0.74) 63936 kg, which means 767.232 tons per year. Also, PP hollow

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brick with dimension 400x150x200mm needs (86400 x 0.64) 55296 kg of PP (raw or recycled material) per month, which mean 663.552 ton per year. Additionally, the amount of PP (raw or recycled material) wanted per month for PP hollow brick with dimension 400x100x200mm is (86400 x 0.55) 47520 kg, which means 570.24 tons per year.

III. Results and discussion

The first phase studies the Compressive strength and the weight of hollow brick:

The PPhollow brick A1 compressive strength is higher than PPhollow brick A2 with a ratio of 73.2%. The compressive strength for PP hollow brick A1 is higher than which wanted in Egyptian code in the case of load-bearing concrete hollow brick with a ratio of 80%. Also, the compressive strength for PP hollow brick A1 is higher than which wanted in Egyptian code in the case of non-load bearing concrete hollow brick with a ratio of 92%. Additionally, the compressive strength for PP hollow brick A2 is higher than which wanted in Egyptian code in the case of load-bearing concrete hollow brick with a ratio of 25.3%. Also, the compressive strength for PP hollow brick A2 is higher than which wanted in Egyptian code in the case of non-load bearing hollow concrete brick with a ratio of 70.14%,as explainedinFigure 3.

According to that, the changing material and the shape of the PP hollow brick in Ex.1 didn't negatively influence the compressive strength. So, the PP hollow brick A1 and brick A2 can be used in building construction in the loaded bearing wall and non-load bearing wall.

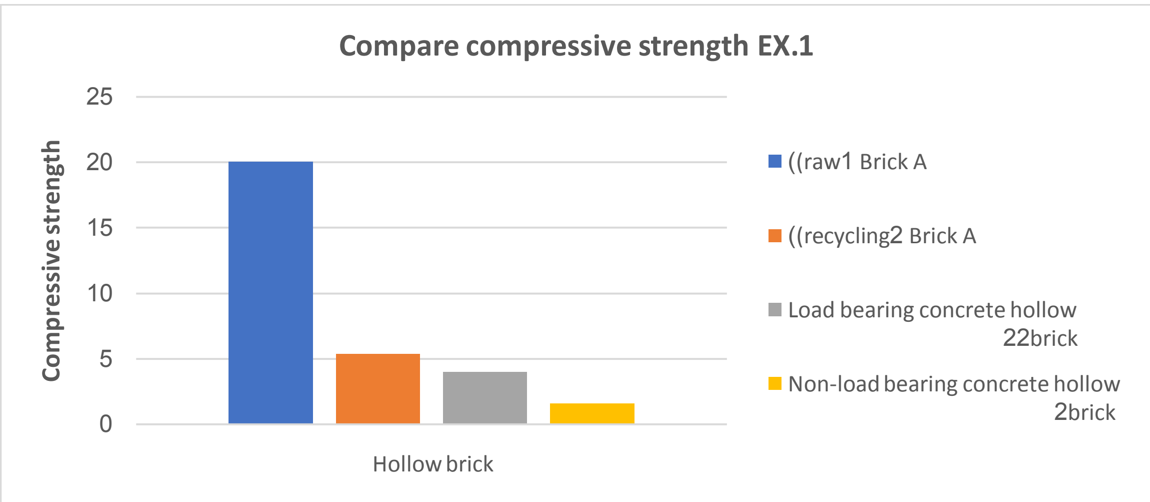

Figure 3compares the Compressive strength of the pp hollow brick EX.1 with the hollow concrete brick.

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The PPhollow brick B1 compressive strength is higher than PPhollow brick B2 with a ratio of 73.2%. The compressive strength for PP hollow brick B1 is higher than which wanted in Egyptian code in the case of load-bearing concrete hollow brick with a ratio of 82.4%. Also, the compressive strength for PP hollow brick B1 is higher than which wanted in Egyptian code in the case of non-load bearing concrete hollow brick with a ratio of 93%. Additionally, the compressive strength for PP hollow brick B2 is higher than which wanted in Egyptian code in the case of load-bearing concrete hollow brick with a ratio of 34.1%. Also, the compressive strength for PP hollow brick B2 is higher than which wanted in Egyptian code in the case of non-load bearing hollow concrete brick with a ratio of 73.64%,as explainedinFigure 4.

According to that, the changing material and the shape of the PP hollow brick in Ex.2 didn't negatively influence the compressive strength. So, the PP hollow brick B1 and brick B2 can be used in building construction in the loaded bearing wall and non-load bearing wall.

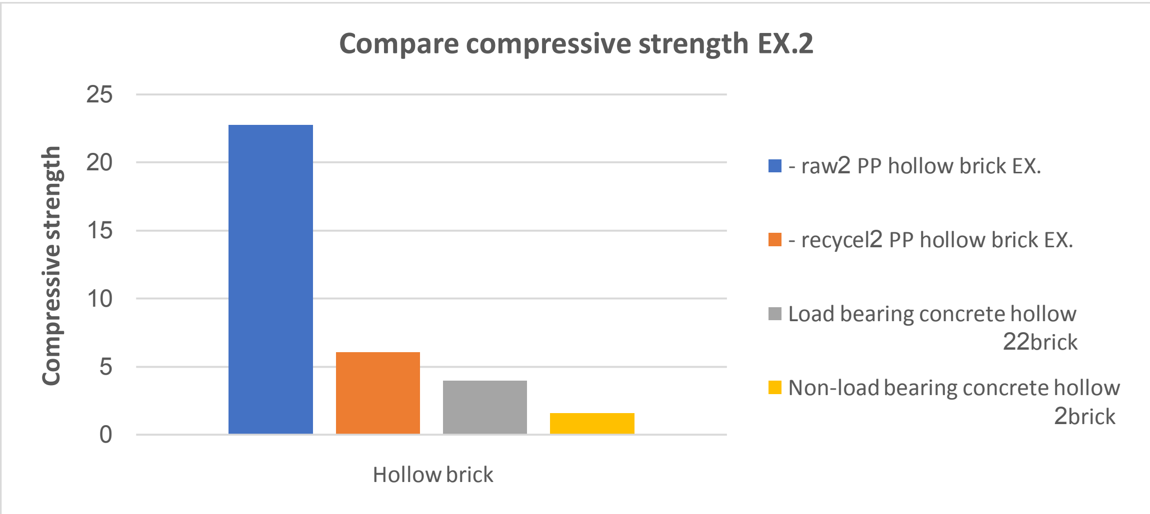

Figure 4compares the Compressive strength of the pp hollow brick EX.2 with the hollow concrete brick.

The PPhollow brick C1 compressive strength is higher than PPhollow brick C2 with a ratio of 73.2%. The compressive strength for PP hollow brick C1 is higher than which wanted in Egyptian code in the case of load-bearing concrete hollow brick with a ratio of 85%. Also, the compressive strength for PP hollow brick C1 is higher than which wanted in Egyptian code in the case of non-load bearing concrete hollow brick with a ratio of 94%. Additionally, the compressive strength for PP hollow brick C2 is higher than which wanted in Egyptian code in the case of load-bearing concrete hollow brick with a ratio of 44.13%. Also, the compressive strength for PP hollow brick

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C2 is higher than which wanted in Egyptian code in the case of non-load bearing hollow concrete brick with a ratio of 77.65%,as explainedinFigure 5.

According to that the changing material and the shape of the PP hollow brick in Ex.3 didn't negatively influence the compressive strength. So, the PP hollow brick C1 and brick C2 can be used in building construction in the loaded and non-load-bearing walls.

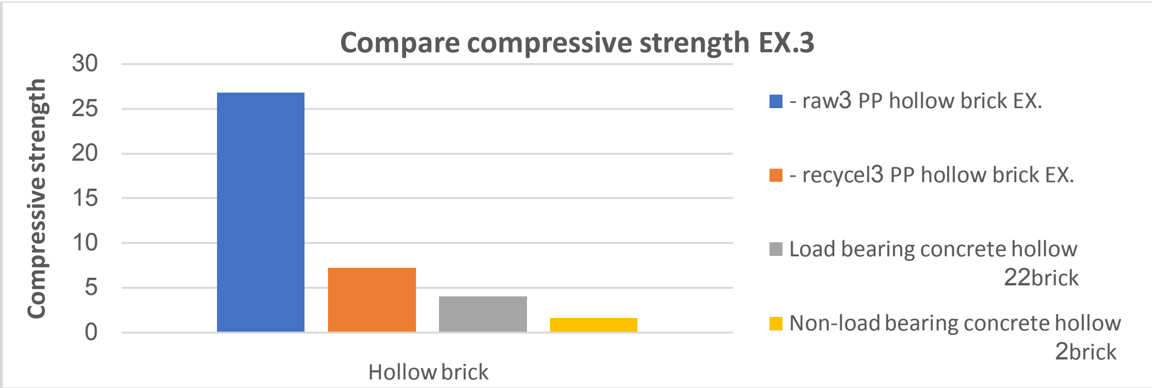

Figure 5compares the Compressive strength of the pp hollow brick EX.3 with the hollow concrete brick.

The PPhollow brick A1 compressive strength is lower than PPhollow brick B1 and brick C1. The compressive strength of PP hollow brick C1 is higher than brick B1,with a ratio of 15.18%. Also, the compressive strength of PP hollow brick C1 is higher than brick A1with a ratio of 25.4%.According to that, brick C1 is the highest, as explained inFigure 6.

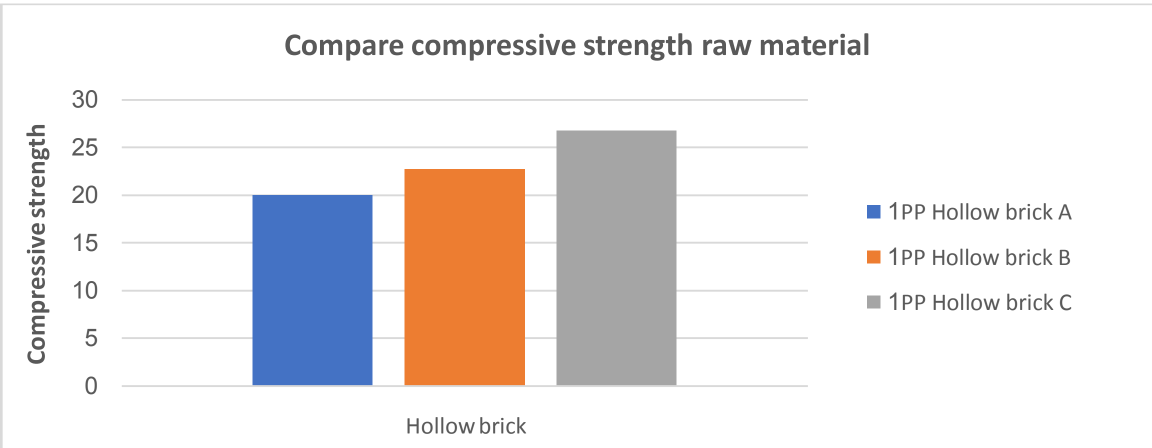

Figure 6compares the Compressive strength for the three examples of pp hollow brick, which use the raw material.

The PPhollow brick A2 compressive strength is lower than PPhollow brick B2 and brick C2. The compressive strength of PP hollow brick C2 is higher than brick B2,with a ratio of 15.22%. Also,

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the compressive strength of PP hollow brick C2 is higher than brick A2,with a ratio of 25.13%.According to that, brick C2 is the highest one,as explainedinFigure 7.

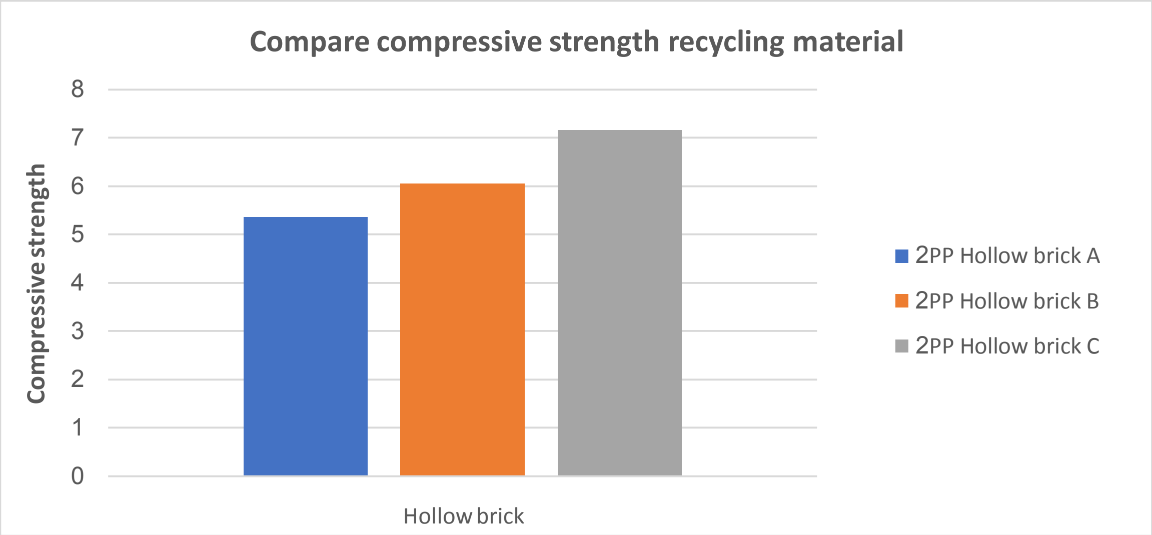

Figure 7compares the Compressive strength of the three examples of pp hollow brick, which use the recycling material.

The second phase analyzed the effect of different sizes for pp hollow brick compared with a hollow concrete brick.

The sensible zone heating for model 3 is the highest compared with model 1, model 2, and model4. The sensible zone heating for Model 1 is lower than for model 2, with a ratio of 3.68%. It is also lower than model 3's ratio of 9.22% and model 4's 1.39%, as shown inFigure 8. According to that, model 1 is the lowest one at zone sensible heating.

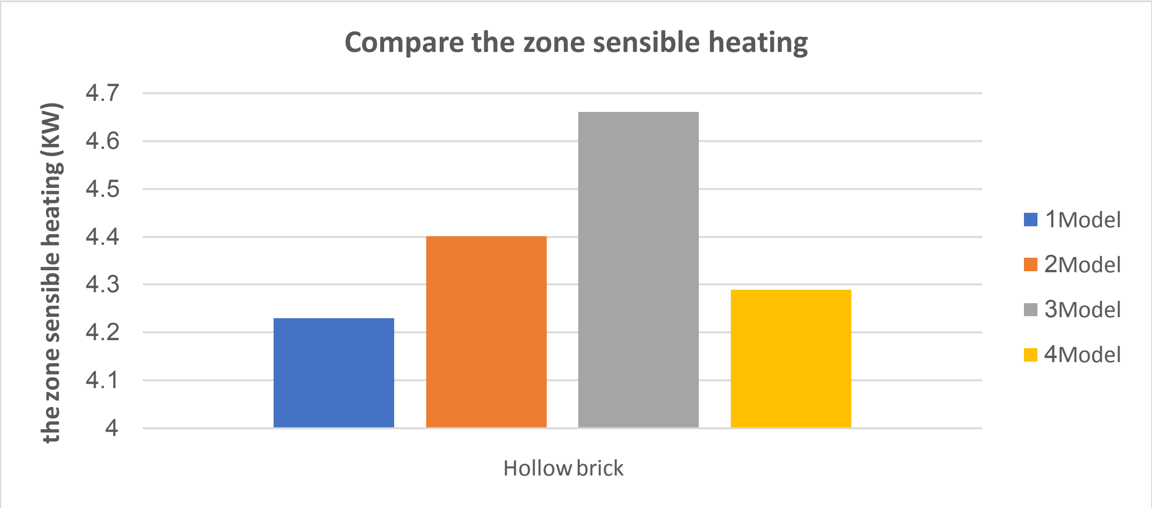

Figure 8compares the sensible zone heating for the four different models.

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The Comfort Temperature for model 1 is the highest compared with model 2, model 3, and model4. Model 1 is the lowest one at Comfort Temperature. The Comfort Temperature for Model 3 is lower than model 1 with a ratio of 0.99%. It is also lower than model 2's ratio of 0.66% and model 4's ratio of 0.80%, as explainedinFigure 9.

Although there are differences between Scientific studies about temperature for human comfort, these studies agree that the ideal temperature comfort for humans is in the approximate range of 20°C to 25°C[40]. According to that, the four models are in the range of the human comfort zone.

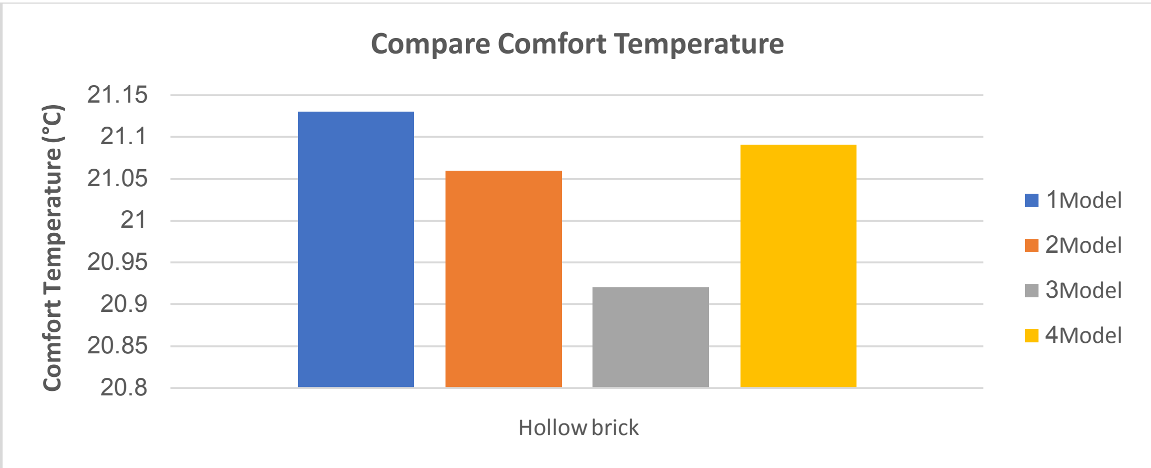

Figure 9compares Comfort Temperature for the four different models.

Model 3 is the highest wall gains. The model 1 wall gain is lower than model 4, with a ratio of 15%. The model 1 wall gain is lower than model 3, with a ratio of 49.5%. The model 1 wall gain is lower than model 2 with a ratio of 24.7%,as explainedinFigure 10. "Optimized thickness of wall insulation in different heat supply models"[41].According to that, the wall gain increases with a decrease in the thickness of the PP hollow brick. Finally, model 1 for PP hollow brick is the lowest wall gain. The wall heat resistance has decreased with increasing wall gains[42].

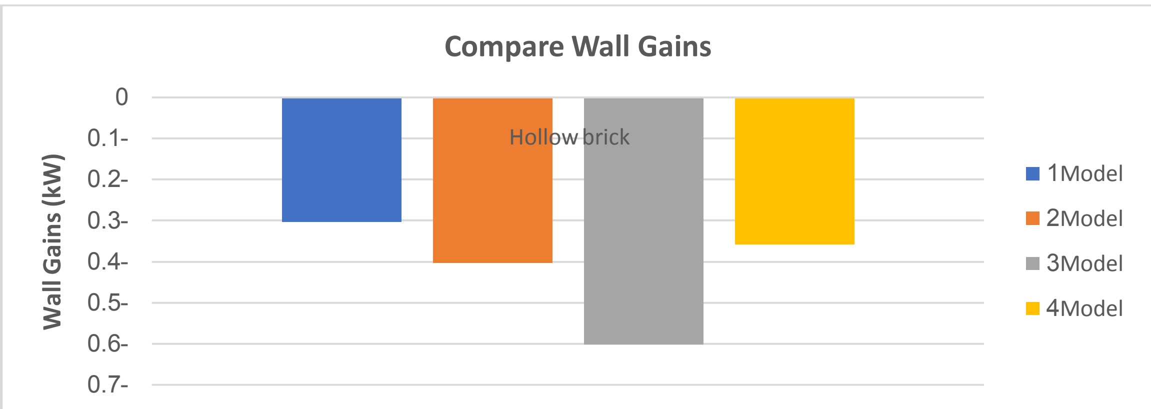

Figure 10compares Wall Gains for the four different models.

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Model 4 is the highest Cost for Wall Cost (Structure + Surface Finish) compared with model 2, model 3, and model1,as explainedinFigure 11.The PP hollow brick cost is lower than a hollow concrete brick in wall construction[37,43]. According to that, the three models of PP hollow brick (model 1 - model 2 – model 3) are lower cost than model 4 concrete hollow brick.

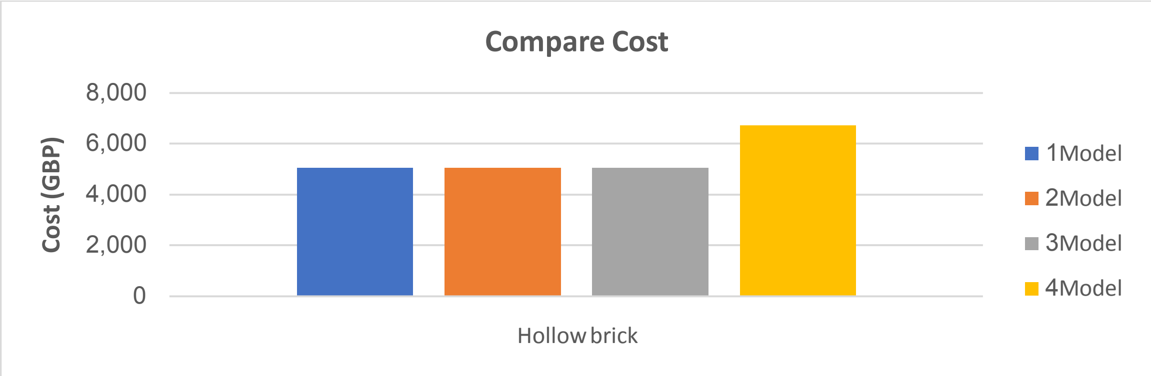

Figure 11compares the Cost for the four different models.

The thermal performance of a building envelope is the key factor influencing building energy consumption, improvements to which can reduce the amount of energy required to heat and cool interior spaces and may therefore play a significant role in reducing overall energy consumption [34]. The energy used in heating, ventilation and air conditioning at the building had been affected by the economy for occupants building. The costs of HVAC for model 3 are higher than other models. Also, model 1 is the lowest one and as same as model 4. Model 1 and model 4 are lower than model 2, with a ratio of 2%. Also, model 1 and model 4 are lower than model 3 with a ratio of 4%,as explainedinFigure 12. According to that, the suitable model for use in building to increase Cost and save energy is model 1 and model 4. The HVAC cost increases with the thickness of the external envelope.

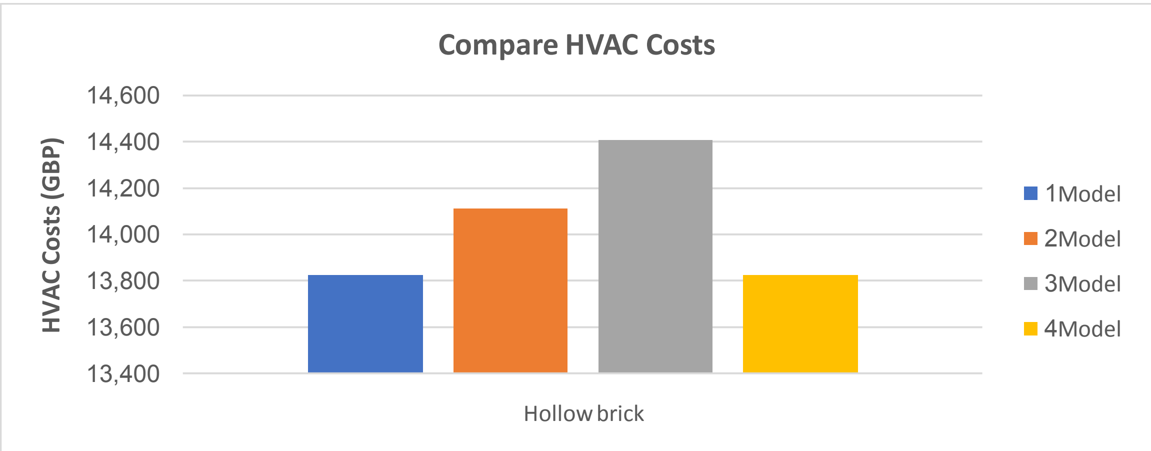

Figure 12compares HVAC Costs for the four different models.

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The third phase studies the effect of usingPP raw and recycled material.

In Example 1, the PP hollow brick weighs less than the hollow concrete brick by 96.6%. At Example 2, the PP hollow brick weighs less than the hollow concrete brick by 96.2%. In Example 3, the PP hollow brick weighs less than the hollow concrete brick by 95.8%, as seen in Figure 13.According to that,the weight of pp hollow brick is lower than hollow concrete brick in the three examples.So, using PP material in hollow brick decreases the weight of the brick compared with concrete hollow brick concrete.

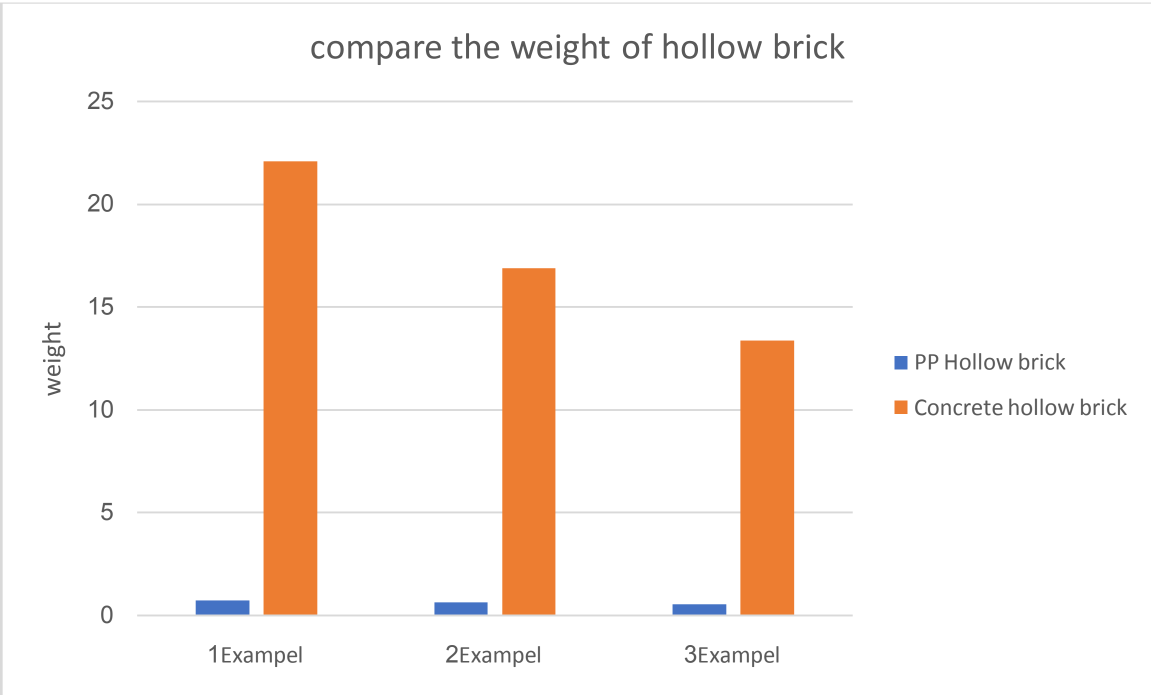

Figure 13compares the weight for the three examples of pp hollow brick with a hollow concrete brick.

The amount of PP (raw or recycled material) wanted per year for PP hollow brick with dimension 400x200x200mmis higher than other dimensions. Also, PP hollow brick with dimension 400x200x200mm is higher than PP hollow brick with dimension 400x150x200mm with a ratio of 13.5%. Additionally, PP hollow brick with dimension 400x200x200mm is higher than PP hollow brick with dimension 400x100x200mm with a ratio of 25.6%,as explainedinFigure 14.

According to that if this type of PP hollow brick manufacturing will increase the pollution of plastic waste by 767.232 tons per year. Furthermore, the attributes of recycling polypropene hollow brick might be improved by including a ratio of polypropene raw material in the manufacturing phase.Also,paint to the façade of elevation could be addedwith material to increase the resistance.

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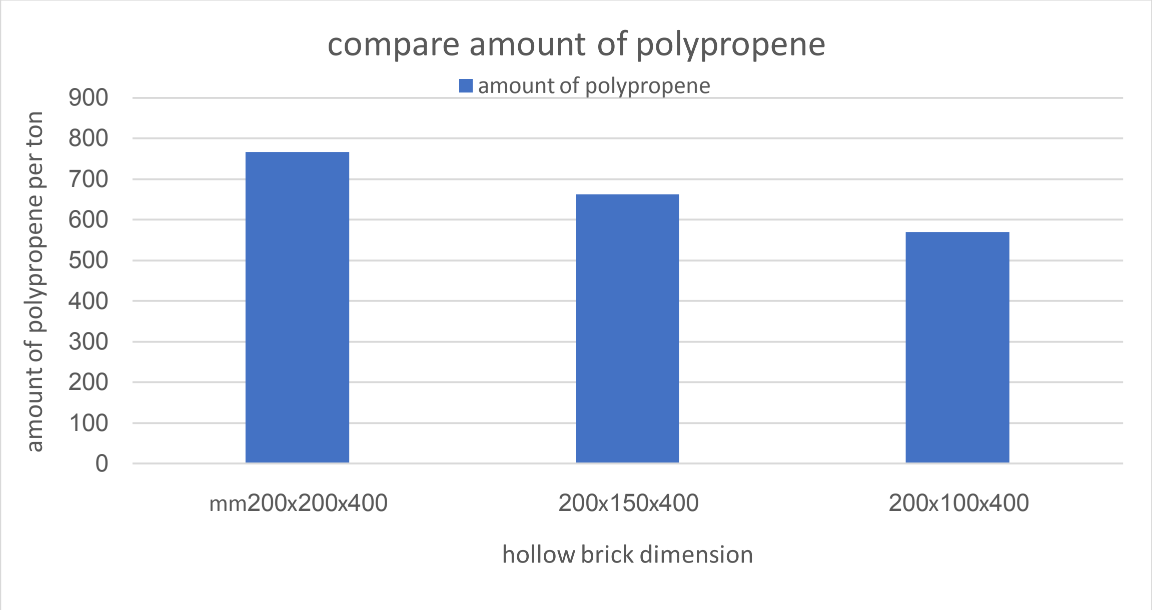

Figure 14compares the amount of polypropeneneeded per year for three PP hollow bricks.

IV. Conclusion:

PP hollow brick with dimension 400x200x200mm, PP hollow brick with size 400x150x200mm, and PP hollow brick with dimension 400x200x200mm is higher than thosewanted in Egyptian code in the case of load-bearing concrete hollow brick and non-load bearing wallconcrete hollow brick. But PP hollow brick with dimension 400x200x200mm is the maximum compressive strength.

PP hollow brick with dimensions 400x200x200mm is the lowest at zone sensible heating. The three models of PP hollow brick are in the range of the human comfort zone. The wall gain increases with a decrease in the thickness of the PP hollow brick. The wall heat resistance has been decreasing with increasing wall gains.Finally, PP hollow brickwith dimension 400x200x200mm is the lowest wall gain.

The PP hollow brick is lower Cost than hollow concrete brick with a ratio of 25%. Also, The Cost of HVAC increases with the decrease in the thickness of the external envelope. The suitable model for use in building to increase Cost and save energy is model 1, which use PP hollow brick with dimension 400x200x200mm.

Using PP material in hollow brick decreases the weight of the brick compared with concrete hollow brick concrete. According to that if this type of PP hollow brick manufacturing will increase the pollution of plastic waste by 767.232 tons per year. In addition, to enhance the qualities of recycling polypropene hollow brick, a percentage of polypropene raw material in brick manufacture should be

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included.Also, paint to the façade of elevation could be added with material to increase the resistance.

V. References

[1] Ijigah, E.A., et al., An assessment of environmental impacts of building construction projects. 2013.

[2] Rubin, E.S. and C.I. Davidson, Introduction to Engineering and the Environment. Vol. 61. 2001: McGraw-Hill New York.

[3] Ametepey, S.O. and SKAnsah, Impacts of construction activities on the environment: the case of Ghana. Journal of Construction Project Management and Innovation, 2014. 4(sup-1): p. 934-948.

[4] Dutta, A.B. and I. Sengupta, Environmental impact assessment (EIA) and construction. International Research Journal of Environmental Sciences, 2014. 3(1): p. 58-61.

[5] Tiwari, V.K., et al., A review on Environmental Impact Assessment of Construction Projects. IOSR Journal of Environmental Science, 2016. 10(1): p. 21-25.

[6] Aremu, A., A. Aremu, and D. Olukanni, Assessment of Noise pollution from sawmill activities in Ilorin, Nigeria. Nigerian Journal of Technology, 2015. 34(1): p. 72-79.

[7] Anisimova, N., The capability to reduce primary energy demand in EU housing. Energy and Buildings, 2011. 43(10): p. 2747-2751.

[8] Dujardin, S., A.-F. Marique, and J. Teller, Spatial planning as a driver of change in mobility and residential energy consumption. Energy and Buildings, 2014. 68: p. 779-785.

[9] Deng, X., et al., Environmental impact assessment based on D numbers. Expert Systems with Applications, 2014. 41(2): p. 635-643.

[10] Bassioni, H.A., et al. Barriers, drivers and stakeholders of environmental management systems implementation in Egypt. in Proceedings of the First International Conference on Sustainability and the Future, 23-25 November, British University. 2010.

[11] Sanson, K. and G.M.G. O'Mahony, CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN.

[12] Construction's Impact on the Environment, March 1st, 2016, https://sourceable.net/constructions-impact-on-the-environment/.

[13] How Construction technology could Solve The Climate Emergency- The B1M (TBM). (2019) https://www.theb1m.com/video/how-construction-technology-could-solve-the-climate-emergency.

[14] How Does Construction Impact the Environent?, GoContractor , 21 June 2017, https://gocontractor.com/blog/how-does-construction-impact-the-environment/ .

[15] JOHAN ANDERSSON, DESIGNING ARCHITECTURE FOR REUSE & RECYCLING, AAHM01, Degree Project In Architecture, 2018.

[16] Ferreira Silva, M., Jayasinghe, L. B., Waldmann, D., &Hertweck, F. (2020). Recyclable architecture: Prefabricated and recyclable typologies. Sustainability, 12(4), 1342.

[17] Mwanza, B. G., &Mbohwa, C. (2017). Drivers to sustainable plastic solid waste recycling: a review. Procedia Manufacturing, 8, 649-656.

[18] Akintayo, F. O., Oyebade, O. N., Songca, S. P., Adebisi, N. O., Oluwafemi, O. S., &Fadipe, O. O. (2020). Assessment of the impacts of building construction activities on the environment. Nigerian Journal of Technology, 39(2), 325-331.

[19] S. Munn and V. Soebarto, The issues of using recycled materials in architecture, Tasmania: The 38th International Conference of Architectural Science Association ANZAScA, 2004.

[20] Jiang, X., Wang, T., Jiang, M., Xu, M., Yu, Y., Guo, B., Chen, D., Hu, S., Jiang, J., Zhang, Y., Zhu, B., 2020. Assessment of plastic stocks and flows in China: 1978-2017. Resour. Conserv. Recycl. 161, 104969. https://doi.org/10.1016/ J.RESCONREC.2020.104969.

[21] Eneh, A. E. (2015). Application of recycled plastics and its composites in the built environment. BEST: International Journal of Management, Information Technology and Engineering, 3(3), 9-16.

[22] Obiadi, B. N. (2020). The positive impact of plastic recycling in the built environment, architecture and the waters of the world. Int. J. Trend Sci. Res. Dev, 4, 1427-1435.

[23] Geyer, R., 2020. A brief history of plastics. Mare Plasticum - The Plastic Sea. Springer International Publishing, pp. 31–47 https://doi.org/10.1007/978-3-030-38945-1_2.

[24] Nielsen, T.D., Hasselbalch, J., Holmberg, K., and Stripple, J. (2020). Politics and the plastic crisis: a review throughout the plastic life cycle. WIREs Energy Environ. 9.https://doi.org/10.1002/wene.360..

[25] Milios, L., EsmailzadehDavani, A., & Yu, Y. (2018). Sustainability impact assessment of increased plastic recycling and future pathways of plastic waste management in Sweden. Recycling, 3(3), 33.

[26] Plastic & Climate The Hidden Costs of a Plastic Plane, www.ciel.org/plasticandclimate

[27] P.O. Awoyera, A. Adesina, Plastic wastes to construction products: Status, limitations and future perspective Case Stud, Constr. Mater. 12 (2020) e00330, https://doi.org/10.1016/j.cscm.2020.e00330..

[28] Mashaly, I. A. (2016). A sustainable complex fenestration system using recycled plastics.

[29] Mrowiec, B. (2018). Plastics in the circular economy (CE). Environmental Protection and Natural Resources, 29(4), 16-19.

[30] Vishnu TB, Singh KL (2020) A study on the suitability of solid waste materials in pavement construction: a review. International Journal of Pavement Research and Technology, 1-13, https://doi.org/ 10.1007/s42947-020-0273-z.

[31] Department of Environment, Climate Change and Water NSW, Environmental benefits of recycling, June 2010.

[32] J. Raish, Thermal Comfort: Designing for People, the University of Texas at Austin, school of architecture, center of sustainable development.

[33] M. Ponni , R. Baskar, A STUDY ON COMFORT TEMPERATURE AND THERMAL EFFICIENCY OF BULDINGS, International Journal of Engineering and Technology, ISSN : 0975-4024 Vol 7 No 4 Aug-Sep 2015.

[34] Daouas, N. Impact of external longwave radiation on optimum insulation thickness in Tunisian building roofs based on a dynamic analytical model. Appl. Energy 2016, 177, 136–148. [CrossRef].

[35] Ed Mazria, Architecture 2030, http://www. architecture2030.org.

[36] Kwon, M., Van Den Dobbelsteen, A., &Remøy, H. (2019). User perception of indoor temperature and preferences in energy-efficient office renovation cases in the Netherlands. In E3S Web of Conferences (Vol. 111, p. 03007). EDP Sciences.

[37] M. N. Hamdan, TOWARDS LOW-COST GREEN BUILDING WITH LOW ENERGY CONSUMPTION, Thesis, FACUKTY OF ENGINEERING - CAIRO UNIVERCITY,2017.

[38] https://almanaratain.com/product/hollow-block/

[39] M. N. H. El-Hamaida, Low Cost Green Building with Low Energy Consumption towards use PP in External Envelope, International Journal of Engineering Sciences Paradigms and Researches (IJESPR) (Vol. 33, Issue 01) and (Publishing Month: August 2016).

[40] Mohamed N. Ali &Shiba, Ahmed Salah Eldin. "Grey water treatment reused and benefit of the heat capacity of water to improve the environmental performance of internal space". Journal of Xi'an University of Architecture & Technology. ISSN: 1006-7930. Vol. XII (VII), (2020). pp. 983-992. https://doi.org/10.37896/JXAT12.07/2408.

[41] Wang, Z., & Hong, T. (2020). Learning occupants' indoor comfort temperature through a Bayesian inference approach for office buildings in United States. Renewable and Sustainable Energy Reviews, 119, 109593.

[42] Kaynakli, O. (2012). A review of the economical and optimum thermal insulation thickness for building applications. Renewable and Sustainable Energy Reviews, 16(1), 415-425.

[43] M. Ponni , R. Baskar, A STUDY ON COMFORT TEMPERATURE AND THERMAL EFFICIENCY OF BULDINGS, International Journal of Engineering and Technology, ISSN : 0975-4024 Vol 7 No 4 Aug-Sep 2015.

[44] M. Nossier, Low-Cost Green Building with Low Energy Consumption towards use PP in External Envelope, International Journal of Engineering Sciences Paradigms and Research (IJESPR) (Vol. 33, Issue 01) August 2016.

[45] Shiba, Ahmed Salah Eldin " Effects of Climate Changes on Future Architecture and the Contribution of the Developing Countries to Limit and Avoid Harms". Journal of Architecture, Arts and Humanities Science, ISSN: 2357-0342 Vol (6) Issue (26) , (2021). P. 1–13. https://doi.org/10.21608/mjaf.2020.26108.1545

[46] Shiba, Ahmed Salah Eldin "Using Nanotechnology in Producing Organic Construction Materials". International Journal of Advanced Science and Technology ISSN: 2005-4238 Vol.(29) Issue (3), (2020). pp. 8174 - 8185. http://sersc.org/journals/index.php/IJAST/article/view/8570.

[47] Shiba, Ahmed Salah Eldin. "Generating Energy from the Movement Resulted from the Human activities for Confronting the Global Energy Crisis". Advances in Environmental Biology. ISSN:1995-0756.Vol.08(2).February2014,PP:1931-1940. http://www.aensiweb.com/old/aeb/2014/1931-1940.pdf.

[48] Shiba, Ahmed Salah Eldin "A Study of Spontaneous Architecture Environmental Characteristics and Treatments in Hot Dry Regions and their re-application in Contemporary Architecture Using Green Technology" International Journal of Advanced Science and Technology.ISSN:2005-4238.Vol.29(5s).(2020).pp.1819-1830. http://sersc.org/journals/index.php/IJAST/article/view/8577.