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BUILDING ENERGY UPGRADE USING MODERN MASONRY TECHNIQUES AND MATERIALS

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Introduction

The science of architecture and engineering in general is based and constantly developed around the basis of pure function in accordance to the basic principles of material science. As was proven by various different studies, the construction sector is considered to be the largest consumer of raw materials, right after the food industry. According to the statistics, the construction sector is the main culprit for the depletion of about 40% of our planet's natural resources, 40% of the available energy and 15% of the fresh water resources, while, at the same time, it produces about 25% of all waste materials and 40-50% of the various different pollutants which are considered to be the main sources of the greenhouse effect in our planet's atmosphere [1]. Thus, the selection of the materials used on the building sector should now be governed by the main environmental principles, as originally described by Brutland in 1987 (Our Common Future) and the main points of what is known today as The Circular Economy.

Under that scope, in 2010, Greece, institutionalized the most important regulatory framework for the balancing of the country's building stock (old and new alike), through the Regulation of the Energy Performance of Buildings (K.EN.A.K in Greek), admitting in an indirect way the failings of the pre-existing building insulation legislative framework, as first set and conceptualized in 1979 [2][3].

The subject of this work refers to the energy upgrading prospects which can be achieved through the direct application of modern masonry techniques (ICF - Insulated Concrete Forms), compared to the more traditional building techniques, according to the current legislative framework, taking into account the contained energy of the building materials involved alongside the social and economic implications of such a construction technique. Insulating Concrete Forms (ICFs) are representing a category of building materials which are mainly consisted of hollow blocks, planks, or panels which can be constructed out of rigid foam plastic insulation, a composite of cement and foam insulation, a composite of cement and wood chips, or other suitable insulation materials which have the ability to act as forms for cast- in-place concrete walls. The forms typically remain in place after the concrete has cured, providing a well-insulated construction. ICFs continue to gain popularity because of their light- frame construction properties and because of the fact that construction-wise they are offering a strong, durable, and energy-efficient wall system for the building sector [4]. Besides their structural function as concrete walls, they can also serve as an actively charged thermal mass to store thermal energy, which then can be passively released inside, in order to assist in space heating.

Methodology

This study will be examining the vital factors present in the energy design of a building, after the initial presentation of the most important data regarding the reasons of the shift towards energy and environmental design in general.

In this study, references will be made to the processes of the energy upgrading which is provided to a building's main structural elements (walls, roofing, floor), focusing on the factors and variables that have an immediate effect to its overall efficiency ratings.

Then, the new masonry technique will be analyzed in relation to the classic and more widespread ones, especially in comparison to the most used masonry techniques in the country, which, according to the statistics are making about 70% of the building stock today in Greece [5]. Lastly, this work will take into consideration the contained energy of the construction materials, alongside the socio-economic and environmental factors that will be affected as such, should such a construction choice be made.

Results

In comparison to the traditional and more widespread building techniques, the ICF type construction provides benefits to the overall U value. Presented below is a comparison between the overall U value of typical building materials, the U value of the typical building materials after the application of additional insulation and the typical U values of the ICF building technique:

	Existing Building	Energy Upgrade (Insulation)	ICF Building Technique
Construction Description	U (W/m²K)	U (W/m²K)	U (W/m²K)
1. Exterior Wall	1.309	0.383	0.255
2. Typical Masonry (limestone)	2.928	0.461	0.255
3. Floor	1.918	0.423	0.527
4. Roof	1.55	0.403	0.384
5. Wooden Roof	0.755	0.350	0.370

Figure 1: U value comparison. Between the various building techniques and ICF.

	Average U value U_m (W/m²K)	Decrease Percentage (%)
Existing Building	1.553	[-]
Energy Upgrade (Insulation)	0.399	74.3%
ICF Building Techniques	0.378	75.6%

Figure 2: Decrease Percentage and average U value comparison

Below are the results of the comparison of the U value decrease between the various building techniques. According to the results of this study, even though the U value of the various structural elements after the energy upgrade (additional insulation) is below the maximum accepted values, the ICF building technique offers higher thermal resistance in comparison, ergo an even lower U.

	After energy upgrade (Insulation)	ICF Building Technique
Construction Description	Decrease Percentage (%)	Decrease Percentage (%)
1. Exterior Wall	70.8%	80.5%
2. Typical Masonry (limestone)	84.3%	91.3%
3. Floor	77.9%	72.5%
4. Roof	74.0%	75.3%
5. Wooden Roof	53.7%	51.0%

Figure 3: Percentage of U value decrease between the various building techniques

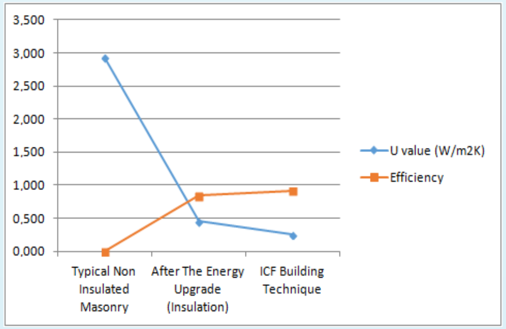

Figure 4: The efficiency is considerable while the U value decreases

Conclusions

According to the results of this particular study, it has been calculated that a structural component according to ICF standards can achieve a U value around 0.255 W/m²K, which is lower than the legislation's highest acceptable value of 0.450 W/m²K (better performance by about 56.00%) and significantly lower than a typical non insulated masonry, offering a performance increase of about 91.29% (The typical U value for such a construction has been calculated at 2.928 W/m²K).

In conclusion, a construction according to the ICF building standards, can provide a considerable energy performance increase, an increased value of its real estate market due to the material's low degradation value and the construction's overall durability, safety, energy efficiency and improved internal conditions.

As such, this particular construction technique can potentially provide long term benefits and create a considerable opportunity to prevent the deterioration of the microclimate in urban areas, ultimately tackling the long lasting issue of climate change and its effects on a social and economic level in general.

References

1. Grace K., C. Ding., (2016). Life Cycle Assessments (LCA).
2. Papaioannou G et al., (2010). Renewable Energy Sources.
3. Kosmopoulos P. et al (2017). Nero Zero Emission Buildings.
4. US Department of Housing (2002).
5. Ministry of Environment and Energy (YPEKA) (2020). Analysis of Building Energy Performance