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Design and cost comparison of the Solid Slabs and Hollow Block Slabs

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ABSTRACT
This study describes a design comparison and costs between the Solid Slabs and Hollow Block Slabs for the roof of a three-story building. As for the subject of our study, it was the ground floor ceiling. We adopted the architectural maps of the building to be implemented in the fence the higher and middle institute of the comprehensive professions Bani Walid. And included a study of design and costs between Solid Slabs and Hollow Block Slabs and then the comparison between these two cases in order to obtain results preferably one of them economically, from which we can choose the best and most appropriate type between them and get the sequential results, and where a simple and quick presentation of the plan projection was made and then we moved to the analysis and design of slabs and beams in a way Construction and each model separately, and after that, we performed the calculation of the quantities and costs for each of the proposed slabs, which were represented by a slab of solid reinforced concrete and another slab of reinforced concrete using Hollow Block and the prices were taken from the market in the centre of Bani Walid in the year 2012.

Keywords: *comparison, Solid Slabs, cost, Hollow Block Slabs.*

1 Introduction

As a result of the development that has occurred at the present time and extended to all areas of life, this progress must be accompanied by the architectural aspect of the diversity of buildings and the distribution of their functions and methods of implementation. And reinforced concrete was the leading role in the fields of building and construction and turned to the initial implementation and pre-manufacturing and multiple methods in its manufacture, and at the same time it became necessary to scrutinize the most structurally and economically for their uses so that each of its elements had a detailed study to implement it in the best way. From this principle our choice was to This project is a structural and economic study for a three-story building floor, and the ground floor contains several laboratories and an office, and the first and second floors are apartments for foreign lecturers, or administrative offices, the implementation site in front of the Amar Hall building Construction and the higher and middle institute of the comprehensive professions Bani Walid. As for the subject of our project, the ceiling of the ground floor was the focus of the project in this study, using concrete solid slabs and hollow block slabs, and then comparing these two cases to obtain a result that prefers one of them economically, which enables us to choose the best and most economical type without any Doubt, when studying the project includes many important points, which contribute to the success of this work in order to obtain an accurate study.

In reinforced-concrete buildings, a solid slab is a conventional slab which is supported by beams and columns, with the load transferred to those elements. This solid slab type (Figure 1(a)) is classified as either one-way or two-way. The other slab type is a ribbed floor slab consisting of equally spaced ribs, usually supported directly by columns. Slabs are either one-way spanning systems or two-way systems. When the space between beams is filled with lightweight material, they are called lightweight hollow block slabs; the other commonly used name is the hollow block slab (Figure 1(b)).

Hollow blocks are used to fill portions of the slab thickness; this results in a deeper arm for the reinforcement while reducing the amount of concrete and hence the self-weight of the slab. The reinforcement is located between the blocks inside the ribs. A block may be a concrete block, a briquette or styrofoam. When the ribs are in one direction, then it is a one-way hollow block slab, regardless of the rectangularity. When the ribs are in both directions, then it is a two-way hollow block slab. This type of slab has longitudinal voids running through it, which decreases the weight of the slab, as well as the amount of concrete required. These voids can also function as service ducts. A two-way hollow block slab is generally reinforced with longitudinal rebar and can achieve long spans, making it suitable for office buildings, multistorey car parks and so on (Fanella and Al-

samsam, 2005) (1). In order to make a comparison between the two types of slabs possible, the most common residential building model has been chosen in this paper.
After preparing the integrated architectural maps, we started with the structural analysis, according to the instructions of the Arab code of the engineer Imad Darwish (2,3), and the reinforcing iron was chosen according to the book Reinforced concrete (4), and then we carried out the stage of calculating the quantities and costs to complete an accurate comparison between the solid and discharged ceilings, according to the book (5), by Doctor Abdul Fattah Al-Qasabi and Eng. Mohammed Hamed Khulous (6).

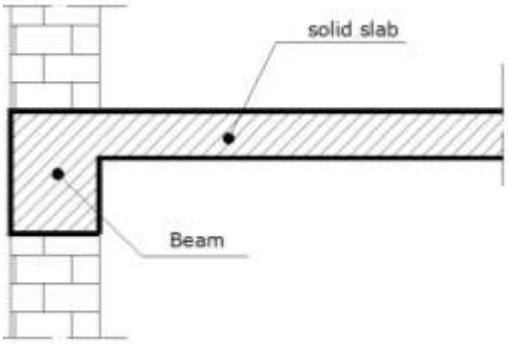


Figure 1(a) Solid Slab

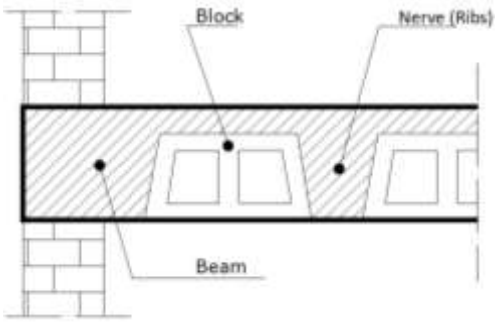


Figure 1(b) hollow block slab

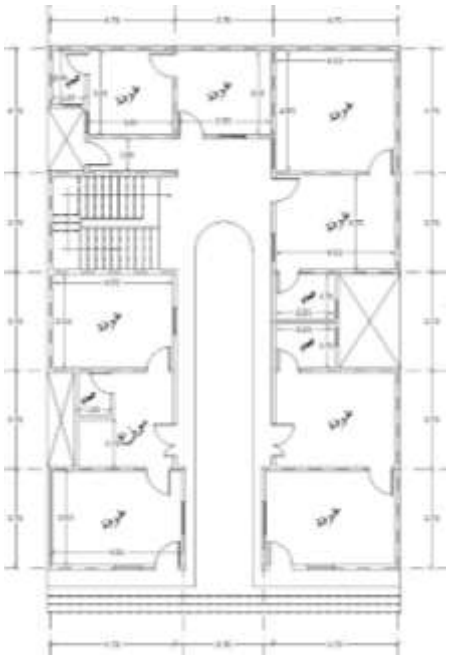
1-1 Study objectives

- Comparison between the structural design of a Solid Slabs and Hollow Block Slabs.
- Comparing the quantities and costs of a solid and hollow roof for more accurate results.
- Calculating the cost of materials and labour and choosing the best and most suitable type between the two slabs.

2 Architecture Design

2-1 Introduction to Architectural Plans:

The project that we will study is a three-story building, the area of each floor is 230 m², and the ground floor contains several laboratories, the average area for each of them does not exceed 35 m² as indicated in the architectural divisions on the plan projection of this building. As for the repeated floors, i.e. the first and second They are apartments that are used as housing for foreign lecturers, on the other hand, they are used in the form of administrative offices and according to the work in which the average area for each of them will be managed was approximately (40-35) m² and the horizontal projection shows its architectural details. The roof of the ground floor, which is the focus of our project, and in which the structural system was adopted, where the building is based on detailed rules on which columns with sections (30,40) cm (30,60) cm are established, and then the roof beams and slabs. As for the outer walls, they are 20cm thick and the inner walls Its thickness is 15cm from the hollow concrete block. The plans attached to this project show the various projections and sections of most of the elements studied so that the field is open to the implementation of the project on the ground so that our work embodies this into reality embodied by reality



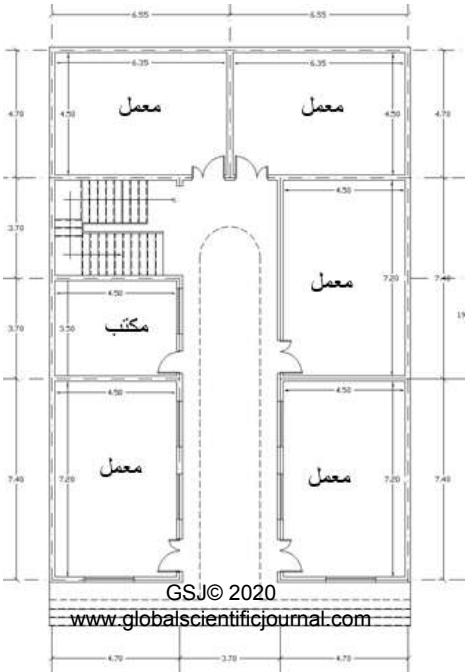


Figure 2 The plan of the ground floor and the second and third floors.

3 Structural Analysis

3-1 Ceiling design using solid slab with its beams

3-1-1 Solid Slabs design: Solid Slabs

The horizontal projection shows us the dimensions of these tiles and the shape of their relevancy, as it shows the distribution of the beams carrying these tiles and depending on that we find that the roof tiles can be given the following names: (S1, S2, S3, S4, S5, S6, S7) in Figure 3, For ease of knowledge during the design in which we relied on the instructions of the Arabic code and studied according to the flexible classic method of engineer Imad Darwish (2,3), and by comparison of two dimensions tiles, we find that: $2\langle L_1/L_2$.

This makes us design the tiles in two directions, and according to the factors given in the tables ready for the distribution of moments we find f_2, f_1 and they are used in accordance with the calculation of the moments of these slabs.

Noting that the distinctive resistance chosen for reinforced concrete is: $f_c = 200Kg/cm^2$

The concrete stress is: $\sigma_c = 200 * 0.36 = 72Kg/cm^2$

The characteristic resistance of steel for reinforcement is: $f_s = 2800Kg/cm^2$

The stress of the steel is: $\sigma_s = 2800 * 0.5 = 1400Kg/cm^2$

As for the dimensions of the slabs, they were taken from the Support centres where:

$$L_1 = 4.7, L_2 = 3.7$$

As for the thickness of the slab, we adopted by defining the equivalent circumference of the slab, which was:

$$h = \frac{(500 + 400)^2}{140} = 13\ cm$$

We adopted one thickness for each slab = 14 cm

This thickness had been verified and was consistent with the design, as the coverage thickness of the rebar was taken (2cm) and the effective height was d = 12cm. As for determining the loads affecting each of these slabs, we took a slide with a width of one meter and calculated the loads affecting it on the first floor according to the type and model of each load, depending on the first-floor plan. The live and dead loads affecting the square meter of tiles are calculated (S1, S2, S3, S4, S5, S6, S7), we determine the quality of the slab and we calculate the auxiliary moments and design moments, and the armature of the slabs is calculated as shown in Table 1.

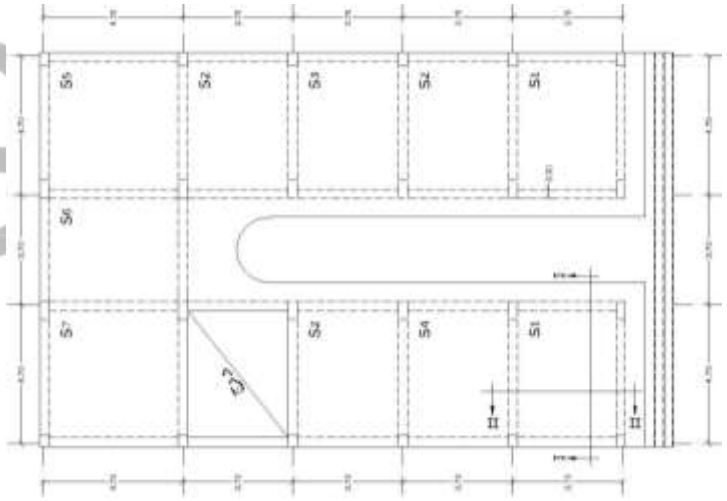
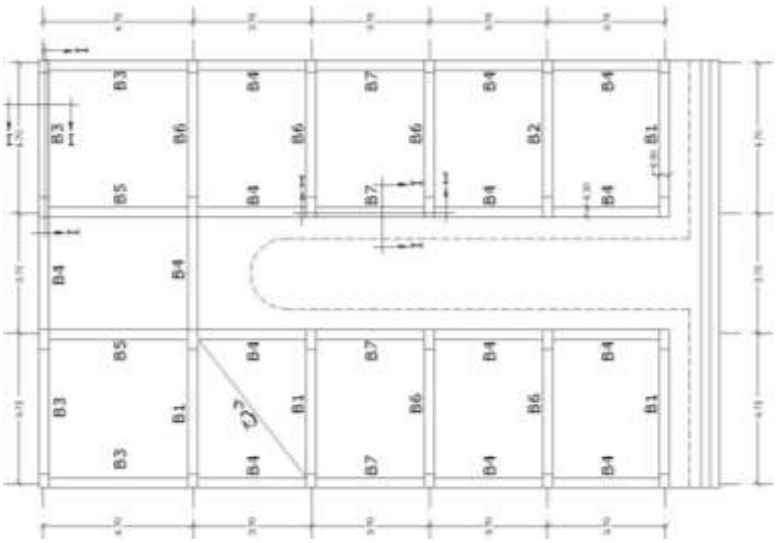


Figure 3 The plan of the ground floor solid slab

Table 1 Design and reinforcement of Solid Slabs

Slab	Dimensions		Constants		Auxiliary moments		Design moments		Quantity of bars and diagonals					
	L_1	L_2	F_1	F_2	M_{O1}	M_{O2}	M_1	M_2	A_{S1}			A_{S2}		
S1	4.7	3.7	0.059	0.025	411.4	601.7	370.28	541.57	5	ϕ	10	5	ϕ	10
S2	4.7	3.7	0.059	0.025	508.1	743.1	457.3	669.00	5	ϕ	12	5	ϕ	10
S3	4.7	3.7	0.059	0.025	658.0	962.4	592.2	866.15	6	ϕ	12	6	ϕ	10
S4	4.7	3.7	0.059	0.025	678.2	992.0	610.4	892.77	6	ϕ	12	6	ϕ	10
S5	4.7	4.7	0.039	0.039	690.7	690.7	621.6	621.6	5	ϕ	12	6	ϕ	10
S6	4.7	3.7	0.059	0.025	507.9	742.9	457.17	668.65	6	ϕ	10	5	ϕ	10
S7	4.7	4.7	0.039	0.039	951.1	951.1	856.07	856.07	6	ϕ	12	8	ϕ	10

3-1-2 Design of the beams of the solid slab:



The beams of the solid slabs in this project are mostly continuous. To design these beams, the loads affecting the longitudinal meters are calculated and designed according to the instructions of the Arabic code of the engineer, Emad Darwish (2,3). These payloads are the payload carried on the beam from the slab after dividing each slab into strips corresponding to the refractive lines, and from that, the load of each slice was transferred to the adjacent reward in the form of a triangle or trapezoid by calculating the wall of the slab area with the applied load and using the distribution factors of these payloads in proportion to the dimensions of the tiles in addition to the beam payload itself (the self-weight of the beam) and the wall load above this beam, The height was taken preliminary and this height was fixed after conducting the necessary investigations for it. The beam width was 30cm = and the Arithmetic lengths of these beams were taken from the axes where their dimensions were. And calculating the loads, we calculate the negative moments above the supports and the positive design moments in the center of beams, and in light of the moments, we calculate the rebar at the stands and in the center of beams. The rebar was chosen for the solid slab beams according to the book Reinforced concrete (4), as in Table 2 and finally, we perform the following investigations at the largest torque: effective height, steel stress, concrete stress, shear calculation. Hence, all the sections shown in the plan projection figure 4 are studied. The beam carries all the loads transferred to it from the slab, which are in the form of a triangle, in addition to the wall load that is located directly above this beam and the self-weight of the beam itself.

Figure 4 shows the types of beams for the solid slab

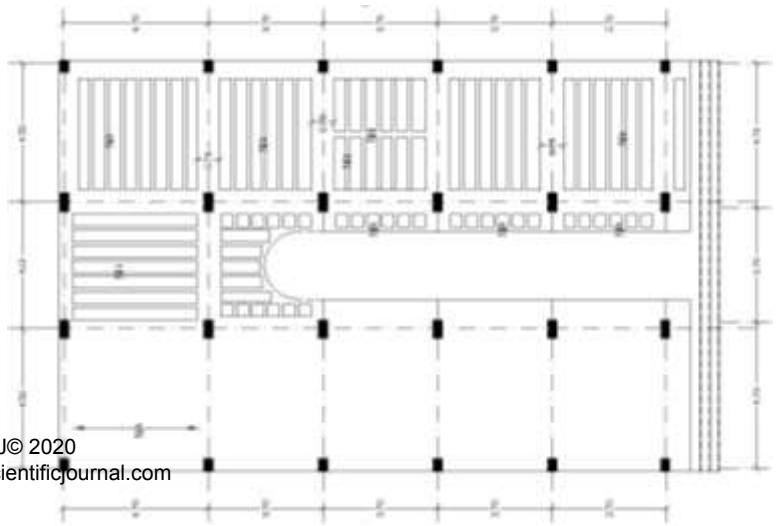
Table 2 Reinforcement steel bars beams for solid slabs

Symbol	Quantity Account	Dimensions		bars in the long direction			bars in the width direction	
		w	h	Under bar	Up bar	bent up bar	stirrups in middle	stirrups near column
B1	4	30	55	3 ϕ 16	3 ϕ 16	2 ϕ 16	6 ϕ 20	6 ϕ 15
B2	1	30	55	3 ϕ 18	3 ϕ 18	3 ϕ 18	6 ϕ 20	6 ϕ 15
B3	4	30	55	2 ϕ 16	3 ϕ 16	2 ϕ 16	6 ϕ 20	6 ϕ 15
B4	14	30	55	2 ϕ 14	3 ϕ 14	1 ϕ 14	6 ϕ 20	6 ϕ 15
B5	2	30	55	3 ϕ 16	3 ϕ 16	2 ϕ 16	6 ϕ 20	6 ϕ 15
B6	5	30	55	3 ϕ 20	3 ϕ 20	3 ϕ 20	6 ϕ 20	6 ϕ 15
B7	4	30	55	2 ϕ 14	3 ϕ 14	2 ϕ 14	6 ϕ 20	6 ϕ 15

Figure 4 shows the types of beams for the solid slab

3-2 Design the ceiling using the Hollow Block Slabs and its beams.

3-2-1 Roof design using Hollow Block Slabs



In this part, we conducted a structural analysis and design of the roof of the studied building using the Hollow Block Slabs, following the data and requirements of the Arabic code and in a flexible manner, by Eng. Imad Darwish (2,3). The distances between the axes of two nerves were 50 cm = and we chose the width of the nerves 12cm, while the total height of the slab was h = 26cm, given that the covering thickness is 6cm of reinforced concrete and the effective height is: $d = h = d^{/} = 26 - 2 = 24cm$

According to preliminary data for the design of Hollow Block Slabs;

- The characteristic resistance of concrete: $f_c = 200Kg/cm^2$

- Distinguished resistance to steel: $f_s = 2800 Kg/cm^2$

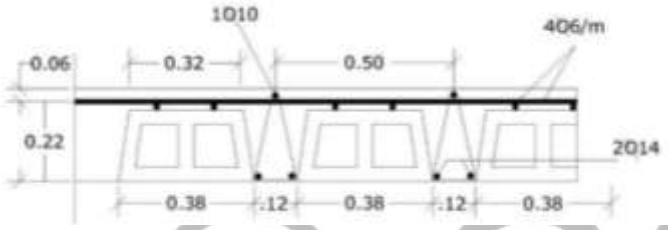
Hollow Block Slab is a hollow concrete block, with its lower base (28cm), the upper base (32cm), its height (20cm), and its width (20 cm).

After the structural design of the nerves, the reinforcing steel was chosen according to the book Reinforced concrete (4) as in Table (3).

Figure 5 The plan of the ground floor Hollow Block Slab

Table 3, Nerve bars (Ribs); -

Symbol	Dimensions		bars		stirrups	Notes
	w	h	up	under		
N1	12	24	1 ϕ 10	2 ϕ 14	6 ϕ 6	
N2	12	24	1 ϕ 8	2 ϕ 12	6 ϕ 6	
N3	12	24	1 ϕ 8	2 ϕ 10	6 ϕ 6	
N4	20	24	2 ϕ 10	2 ϕ 10	6 ϕ 6	Strengthening Rib
N5	20	24	2 ϕ 10	2 ϕ 12	6 ϕ 6	Strengthening Rib



3-2 -2 Design the beams for Hollow Block Slabs.

The beams for hollow block Slabs are hidden beams whose height is the same height as the tile (26cm). The main nerves (Ribs) that are secondary beams transfer all the loads affecting them to the main awards in the form of focused reactions equal to the distance between them to the axes spacing, and to simplify the calculations we considered that these payloads are distributed Regularly on hidden beams, the thickness of which is the same thickness of the slab as well as the self-weight in calculating the beam, according to the instructions the Arabic code of the engineer, Emad Darwish (2,3).The beams on the scheme were classified according to the architectural plan according to their initial arithmetic lengths, the dimensions of which were taken from the axes and from whom we proved those dimensions finally after conducting the necessary investigations and the dimensions of the main intermediate beams m and the dimensions of the main peripheral beams m and the dimensions of the secondary beams. On the same previous primary data, all loads affecting the linear meter are calculated from the main beams and the loads are: Weight of covering slab - Weight of floors - Wall weight if any - Weight of live loads if any - Self-weight difference – Nerve (Rib) reaction. After the structural design process, the reinforcing steel for the Horde slab beams was chosen according to the book Reinforced concrete (4) as in Table 4.

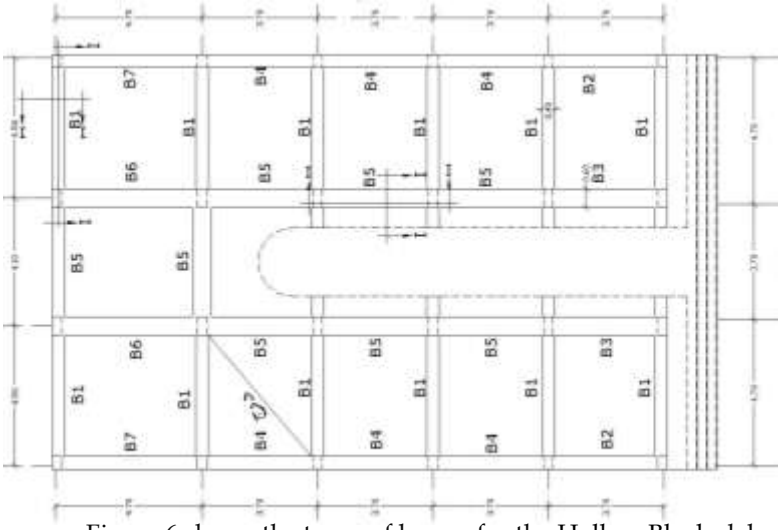


Figure 6 shows the types of beams for the Hollow Block slab

Symbol	Quantity Account	Dimensions		bars in the long direction			bars in the width direction	
		w	h	Under bar	Up bar	bent up bar	stirrups in middle	stirrups near column
B_1	12	40	26	3 ϕ 14	3 ϕ 12	2 ϕ 12	6 ϕ 20	6 ϕ 15

B_2	2	40	26	2	ϕ	16	3	ϕ	12	2	ϕ	16	6	ϕ	20	6	ϕ	15
B_3	2	60	26	3	ϕ	16	3	ϕ	12	2	ϕ	16	6	ϕ	20	6	ϕ	15
B_4	6	40	26	2	ϕ	16	3	ϕ	12	1	ϕ	14	6	ϕ	20	6	ϕ	15
B_5	8	60	26	2	ϕ	14	3	ϕ	12	3	ϕ	14	6	ϕ	20	6	ϕ	15
B_6	2	60	26	3	ϕ	18	3	ϕ	12	3	ϕ	16	6	ϕ	20	6	ϕ	15
B_7	2	40	26	2	ϕ	16	3	ϕ	12	2	ϕ	14	6	ϕ	20	6	ϕ	15

Table No. 4 Reinforcement steel beams for Hollow Block Slabs

4 Calculation of quantities

Introduction

This chapter is considered one of the very important pillars in any project that has been studied, as it is necessary to perform the calculation of quantities for the works that are required to be implemented in a preliminary manner, in the light of architectural and structural studies and plans, and that is what was put under implementation for this project, and the quantities were calculated according to the book (5) Dr. Abdul-Fattah Al-Qasabi and Eng. Muhammad Hamid Khulous(6) Through this chapter on quantities, it is possible to estimate all quantities of materials required to complete the work accurately, which makes us move away from waste, and helps us to organize orders and provides work organization in successive stages in accordance with the schedule so that the completion is complete and within the specified period. In addition, the quantities in this project must be calculated in that it allows us with complete clarity to compare the two slabs and obtain more accurate results. For this we will calculate quantities for the following works:

4-1 Quantities of concrete for solid slabs and their beams

4-2 Quantities of concrete for hollow block slabs and their beams

4-3 Quantities of reinforcing steel for solid slabs and their beams.

4-4 Quantities of reinforcing steel for hollow block slabs and their beams

Table 5 Summary of results for concrete and reinforcing steel quantities for solid slabs and hollow block slabs.

Quantities of materials	The total quantity is m^3 for the solid slabs	The total quantity is m^3 for the hollow block slabs
Concrete for the slabs	25.07 m^3	18.89 m^3
Hollow block	--	1416 block
Concrete for the beams	23.55m^3	16.76 m^3
Reinforcing steel in slabs	1914.05 kg	1519.457kg
Reinforcing steel in the beams	2316 kg	1889.06kg

5 Costs Calculation

Calculating costs is the other half of the completion of the quantities calculation for any project required to be established. The designing supervising engineer who designs and studies the plans constructively after they are integrated must have a preliminary calculation of the quantities and costs for each type of work required to be executed.

It is very necessary to know the estimated value of the project before starting it or even before entering the bidding process. And that is only possible after a careful calculation of costs in line with the implementation plans, conditions, technical specifications, labor salaries, and material prices. In light of this, it is possible to know the methods of financing the project and the economic feasibility of it and the stages Funding, which is mainly related to the implementation steps, and the duration of completion in this project, and in particular the study of costs was one of the very important elements necessary to complete the comparison between the two proposed slabs. For this we will do costing for each of the following works:

5-1 The cost of reinforced concrete works for the solid slab and its beams, and the hollow block slabs and its beams.

A- Description of the materials:

Note that the ratios of the given materials – m^3 -:

No	Material description	Unit	Quantity/solid slab		Quantity/hollow block slab		Prices (LD)	
			Slab	Beam	Slab	Beam	Dinar	Dirham
1	Cement	T	0.325	0.325	0.325	0.150	145	000
2	Coarse aggregate	m^3	0.8	0.8	0.8	0.37	18	750
3	Sand	m^3	0.4	0.4	0.4	0.19	8	750
4	Reinforcement steel	T	0.098	0.076	0.111	0.407	695	000

5	Hollow block	piece	---	---	38	--	00	650
6	Fastening wires	kg	0.6	0.5	0.6	0.23	1	400
7	Water	LT	175	175	175	80.5	0	006

B - The workforce group: once for the solid slab and once for the slab for the hollow block slab, which is the following groups:

1- Carpentry workers group:

Workers	Carpenter head	Assistant	Normal worker
Daily fare (D.L)	30	25	20

- The daily throughput of the slab is 35m² per day.
- Daily productivity of 5m² beams per day.

The preparation and dismantling of the slab formwork per day.

2- Blacksmith group:

Workers	Blacksmith head	Assistant
Daily fare (D.L)	35	20

- The daily productivity of the beams is 400kg per day.
- The daily productivity of tiles is 50kg per day.

3- The group of concrete casting workers:

Workers	Carpenter head	(7) Casting workers	Blender
Daily fare (D.L)	30	20	150

- The daily productivity of casting mixer is 50m³ per day.

Table 6 Summary of Total Costs of Solid slab and hollow block slab.

Cost type	Total cost of solid slab Libyan dinars	Total cost of hollow block slab Libyan dinars
The cost of a slab	4079.36	4635.47
Cost of beams	4349.07	3066.24
The total cost of the slab	8428.43	7701.99
The cost of m²	47.722	44.92

6 Comparison (Results)

The result of the previous study of the project, and after reaching logical results according to what was proposed to implement the building roof with one of two different types of ceilings, the solid slab, and the hollow block slab, we can now summarize the most important results and recommendations that we obtained by the following points:

1- the hollow block slab that was used was one-way in which a hollow concrete block was used, which reduces its weight compared to the solid roof slab where the weight of m2 of the solid slab (1228.13kg / m^2) was the weight of m2 of the hollow block slab (790kg / m^2).

2- Hollow Block Slab in one direction and the nerves so that the distance does not exceed 70 cm between the centers of two adjacent nerves (Ribs), and here is what we cannot find in the solid slab.

3- The ceilings executed from Hollow Block, if their metaphors exceed the 5m, strengthening nerves must be implemented, and this is what the solid slab does not need.

4- The ceilings of the Hollow Block Slab are a result of the presence of the nerves, which were studied as if they were beams. You can take advantage of this by creating walls or partitions on them in a way that is suitable for those nerves (Ribs) without fear of these loads, and this is what gives them positive about the solid slab roof. While solid slabs, the load of walls or partitions was calculated and multiplied by an escalation factor (1.5), and then divided by the area of the slab to treat it as a uniformly distributed load, and this increases with a weight of m^2 of these slabs compared to the Hollow Block Slab.

5- The roof beams of the hollow block slab have been hidden design with the slab, which helps in easy implementation and leads to architectural and aesthetic flexibility for the roof, while such slabs cannot be implemented with the solid roof, due to insufficient thickness of the solid slab.

Noting that the dropping beams that were studied with the solid slab were carrying a larger section and this is what we observed clearly in comparison to the percentage of reinforcement of the beams where the dropping beams of the solid slab were

(98kg / m2) while the percentage of reinforcing the hidden beams of hollow block slabs (115kg / m2).
Note that hidden beams reduce the distance to nerves in addition to architectural requirements and as a result of the use of hollow concrete blocks in hollow block slab and relatively large thickness with a solid slab, which provides better conditions for thermal and acoustic insulation against moisture than solid slabs roof.
In addition to those previous results, the study of costs for the two ceilings has produced very important results and must be taken seriously because the economic factor is considered one of the most important factors that play an important role in the selection; so, we have summarized the results in the following table7 .

Table 7 Costs for Solid slabs and Hollow Block Slabs for m^3

Cost type	The cost of m^3 for the solid sabs		The cost of m^3 for the hollow block slabs	
	Dinar	Dirham	Dinar	Dirham
The cost of materials for the roof slab	125	700	92	380
The cost of labor for the slab	37	019	32	062
The total cost of the slab	162	719	124	406
The cost of materials for the beams	142	300	154	81
The labor cost of the beams	42	347	28	14
The total cost of the beams	184	647	182	95

The total cost of the solid slabs = 8428.43 dinars.
The total cost of the hollow block slabs = 7701.92 dinars.
The cost of m^2 of solid slabs = 47.772 dinars.
The cost of m^2 of the hollow block slabs = 44.92 dinars.

- The percentage of savings per square meter between Solid slabs and Hollow Block Slabs;
  - Percentage of savings for the hollow block Slabs with its beams compared to the solid slabs with its beams for $m^2 = 6.23\%$

$$47.722 - 44.92 = 2.80$$

$$\frac{100 * 2.80}{44.92} = 6.23\ \%$$

**** For slabs**:
The percent of the labor cost of the solid slab to the total cost m^3 = 37.019 dinars
The percent of the labor cost of the hollow block slabs to the total cost m^3 = 32.026 dinars
The percent of labor-saving between solid slabs and hollow block slabs:

$$37.019 - 32.026 = 4.993$$

$$\frac{100 * 4.99}{32.26} = 15.59\%$$

- The percentage of availability of the hollow block slabs over the solid slabs m^2= 15.59%

**** For beams:**
The percent of the labor cost of solid slab beams to the total cost m3 = 42.347 dinars
The percent of the labor cost of hollow block slab beams to the total cost m3 = 28.14 dinars

- * Percentage of labor saving between solid slab beams and hollow block slab beams:

$$42.374 - 28.14 = 14.23$$
$$\frac{100 * 14.23}{28.14} = 58.50\ \%$$

Percentage of savings for the labor cost hollow block slabs beams for solid slab beams $m^2 = 58.50\%$

7 Conclusion

This paper which includes a study and comparison between the Solid slabs and hollow block slabs and the comparison between them and the best and most appropriate choice and the results were very important and must be taken seriously because the economic factor is one of the most important factors that play an important role in the selection; therefore it was found that the cost of m2 of the solid slabs roof = 47.772 Libyan dinars and while The cost of m2 of the hollow block slabs roof is = 44.92 Libyan dinars and the percentage of savings for the hollow block slabs roof is over the solid slabs roof. In light of the above, we have outlined the most important points extracted from that study, relying on the completion of our study on some scientific sources.

References

1- Fanella DA and Alsamsam IM (2005) Design of Reinforced Concrete Floor Systems. Portland Cement Association, Skokie, IL, USA.
2- Eng. Imad Darwish: Simplified structural guide (flat roof design).
3- Eng. Imad Darwish: Simplified Structural Manual (Designing Continuous Awards).
4- Reinforced concrete: -
   - Dr. Engineer Nader Nabil Anis
   - Dr. Engineer Mohamed Suleiman Tadfi
   - Engineer Mohamed Samir Al-Mudarres
   - Engineer Youssef Hmida
5- Engineer Mohamed Hamed Khulous: Calculation of quantities and specifications of works and performance equipment.
6- Dr. Eng. Abd Al-Fattah Al-Qasabi: Calculating the quantities of construction works.
7- Graduation project entitled design comparison and costs between solid slab and hollow block slab.
   - Hussain Al-Theeb
   - Zakia Muhammad