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Pozzolan Hollow Brick Construction and Its Impact on The Project Cost

Salem Khamis Bin Shamla
Muhammad Hussein Aljafri
Waleed Ahmed Bazaar
Department of Civil Engineering – College of Engineering and Petroleum – Hadhramout University

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I. Introduction

The Concept of Pozzolan Hollow Brick Construction:

Construction works require finding modern alternatives and means at the lowest cost in terms of weight, industry, energy consumption, saving time, sound insulation and saving the cost of transporting them.

The possibility of using lightweight materials as a building material has attracted many of the construction industry in recent years in developed countries, where the lightweight building materials industry is not different from other traditional heavy materials and meets building requirements in terms of construction.

Pozzolan bricks have a set of important properties such as low density, improved thermal and sound insulation, reduced energy demand, reduced amount of reinforcing steel and better fire resistance in addition to reducing the amount of size of structural elements such as (bridges, columns, bases) in high-rise structures.

The science of construction is in rapid progress and many changes occur in a short time. The importance of this topic appears in our urgent need for reconstruction and construction at the lowest cost and completion time, and benefit from local raw materials, so solutions and possible means must be found to use the alternative to everything that is not currently available. The brick building item is between (65% - 55%) of the project cost and up to (70%) in the building system for load-bearing walls (3) and for this it is an important and essential element so pozzolan bricks should be adopted in construction works for the following:

1. Availability of building material locally.
2. Saving the building material in terms of initial cost, transportation cost, and installation and maintenance after construction.
3. Efficiency of building material performance in terms of:
   a. Structural strength and durability.
   b. Good insulation properties (thermal and acoustic) and fire resistance.
   c. Good proportion between the weight of the material and the weights it endures.

The use of pozzolan bricks aims to spread the culture of change and reduce the impact of ideas associated with traditional materials dominating the labor market, which led to an increase in their cost.

Research Importance

a. Finding practical alternatives from light materials instead of (traditional materials).
b. Solving environmental issues using local materials.
c. View the technical and engineering properties of pozzolan bricks material.
d. Conducting a technical study to compare the advantages and benefits between using this material and the use of traditional materials in design and construction.
e. Improving thermal insulation.
f. Increasing fire resistance.
g. Significant energy savings for cooling and heating of pozzolan hollow bricks buildings.

h. Lightweight building materials save transportation cost.
i. The acoustic properties of pozzolan bricks as they absorb sound and thus reduce noise.

Research Objectives

1. Reduce construction costs by reducing the amount of reinforced concrete for structural elements.
2. Savings in the quantity and cost of reinforcement steel used in concrete.
3. Reduce the weight of concrete needed to give the required strength and durability.
4. Speed of completion of pozzolan bricks construction (reducing implementation time).
5. Providing labor wages for pozzolan bricks construction.

Target Elements

The external and internal walls of the facility are the targeted structural element to reduce the weight and thus reduce the loads of the facility as a whole. This research reviews a new structural element for the walls to be an alternative to the heavyweight cement hollow bricks, so pozzolan hollow bricks were used as a structural element for these walls. Thus, the general goal of the research is achieved, which is to reduce facility loads and reduce the sizes of structural elements.

1/General Description of the Research Facility:

1/1 Project Location Details:

1. **Site Name**: Kindergarten
2. **Location**: Yemen - Hadhramout - Mukalla - Baabood next to the Police Station
3. **Site Boundaries:**

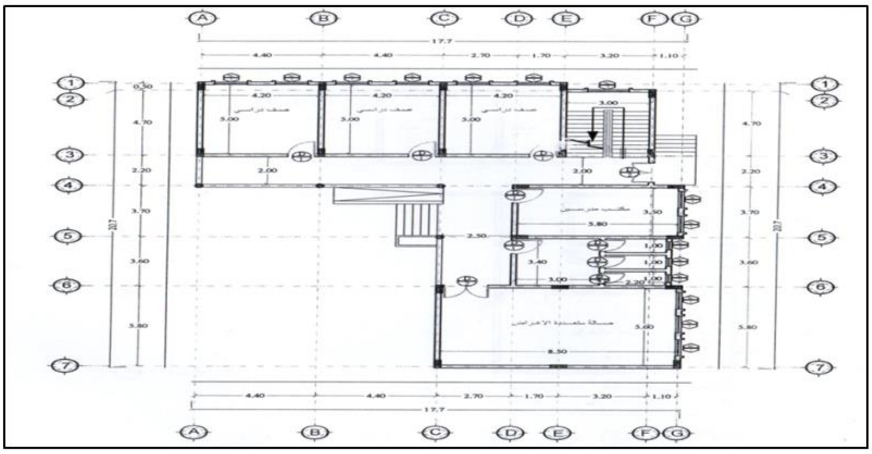
● From the north: Baabood Cemetery
● From the south: 12m Street
● From the east: 12m street
● From the West: Police Station

4. **Movement Direction:**

1. Prevailing wind: Southern
2. Monsoon wind: Northern

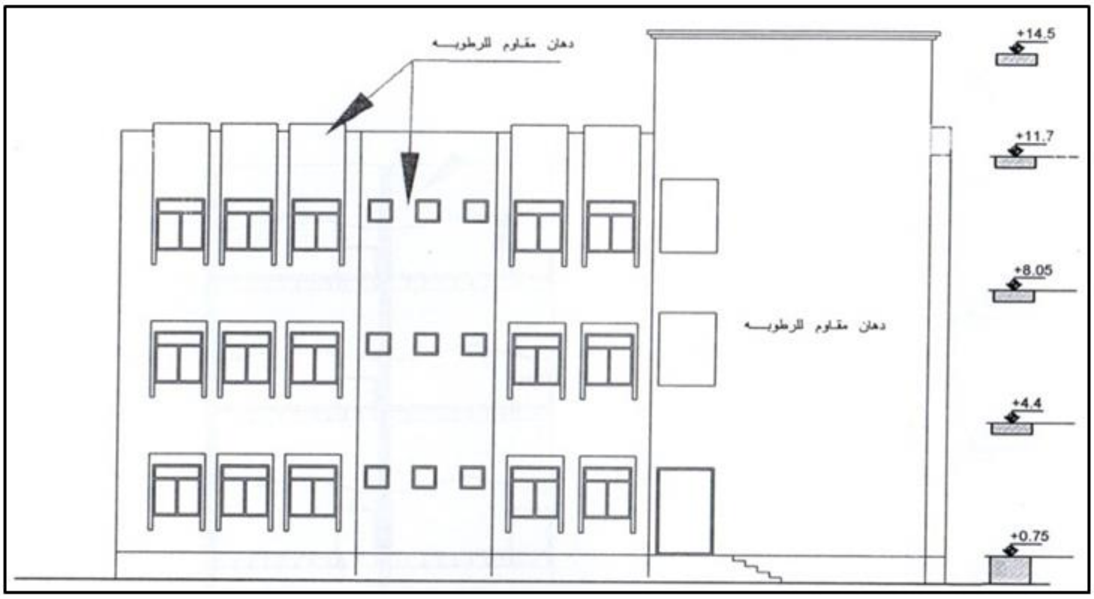
1/2 Facility Details:

1. The total area of the project is equal to (720 m^2)
2. Number of Floors are (3)
3. Architectural and construction designs and executive plans
4. Construction system is concrete structure, wall construction for interior and exterior, cement hollow bricks
5. The amount of reinforced concrete for this model is (194.8 m^3)
6. The amount of reinforcement steel is equal to (19.5 ton)
7. The horizontal projection of the ground floor, repeated floors and facades shown in the pictures figure(1.1,1.2,1.3)



(Figure 1.1)

(Figure 1.2)



(Figure 1.3)

2/ Choosing Pozzolan Hollow Bricks:

Samples of the following building materials were tested:

1. Hollow bricks made of pozzolan (volcanic gravel)
2. Cement hollow bricks (cement block) approved by the Ministry of Education

The weight and resistance in addition to the saturated density were confirmed and the results were as follows:[15]

No	Type of Block	Test condition	Age of brick (day)	Avr. Actual dimensins (cm)	Avr. Dimensions of hollow cores 3 (cm)	Groses area (cm2)	Net area (cm2)	Groses volume (cm3)	Net volume (cm3)	Weight (kg)	Apparent density (g/cm3)	Maximum comprressive load (kn)	Net area compressive strength (Mpa)
1	Pozzolan hollow brick	saturated	>28	40.1	14.9	810.0	363.0	15390.4	7925.5	**11.8**	1.49	69.5	**1.91**
				20.2	10.0								
				19.0	16.7								
2	Cement hollow brick	saturated	>14	40,5	14.6	826.2	397.0	15532,6	8450.1	**19.39**	2.29	180.9	**4.6**
				20.4	9.8								
				18.8	16.5								
				19.6	5.5								
				19.1	5.0								

(Figure 2.1)

3/Components and Properties of Bricks:
3/1 Pozzolan Hollow Brick:

a. Technical Properties

● Pozzolan (volcanic gravel) is one of the most important materials for this type of brick and is available in the area (Bir Ali) in Shabwa Governorate, south of Yemen, and away from Hadhramout Governorate, the city of Mukalla, about (130 km), brick factories in Mukalla produce large quantities of this brick to meet the needs of the market. The previous tests shown in Table (Figure 1.1) show the light weight of bricks compared to other types, which is the most important property that achieves the research objective.

● The property of resistance (breaking force) equal to (1.9 Mpa) has been verified for its ability to withstand a wall up to (5m) in height through the following relationships:

Safe fracture stress = breaking strength of bricks / safety factor (1.5 according to British code)

If Safe fracture stress = 1910 / 1.5 = 1273.3 kn/m2

Net area of bricks = 0.0363 m2

So the central force at which the brick breaks 1273.3 * 0.0363= 46.22 kn

Weight of one brick = 0.118 kn

The wall is 5m high and contains 25 bricks with dimensions of 40.1 * 20.2 * 19.0 cm.

So the weight on the lower brick = 0.118 * 25 = 2.95 kn

By comparing the breaking force of the brick, which is equal to (46.22 kn), with the weight on the lower brick, which is equal to (2.95 kn), it becomes clear that the breaking force of the brick is safe.

● The pozzolan material consists mainly of volcanic gravel, which has similar properties to clay, which is known for its good insulation of heat and sound.

b. Economic Properties

The location of the pozzolan quarry is close to Mukalla, the capital of Hadhramaut, and it is an encouraging factor for pozzolan bricks construction, given that the cost of transportation greatly affects the cost of construction in general. On this basis, pozzolan bricks, were used to build the internal and external walls to achieve the objectives of this research.

3/2 Cement Hollow Bricks (Block):

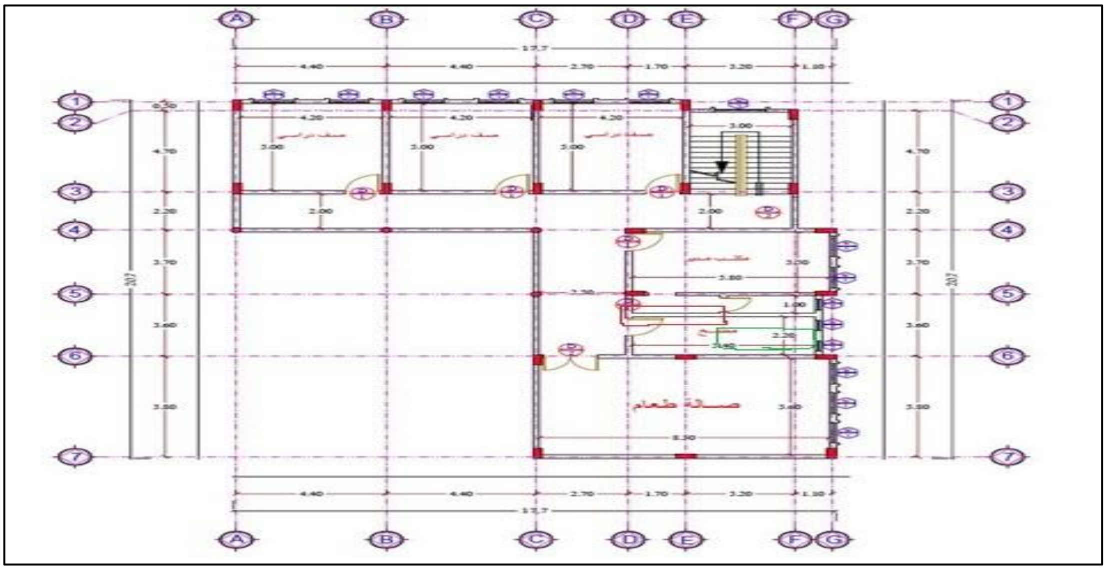
These bricks are made of cement and sand with a mixing ratio (1:3), as it was approved by the Ministry of Education to build the internal and external walls of the kindergarten construction project, the results of the tests in the previous table (figure 2.1) show the weight of the bricks = 19.4 kg .

4 / The Use of Pozzolan Bricks on The Project:

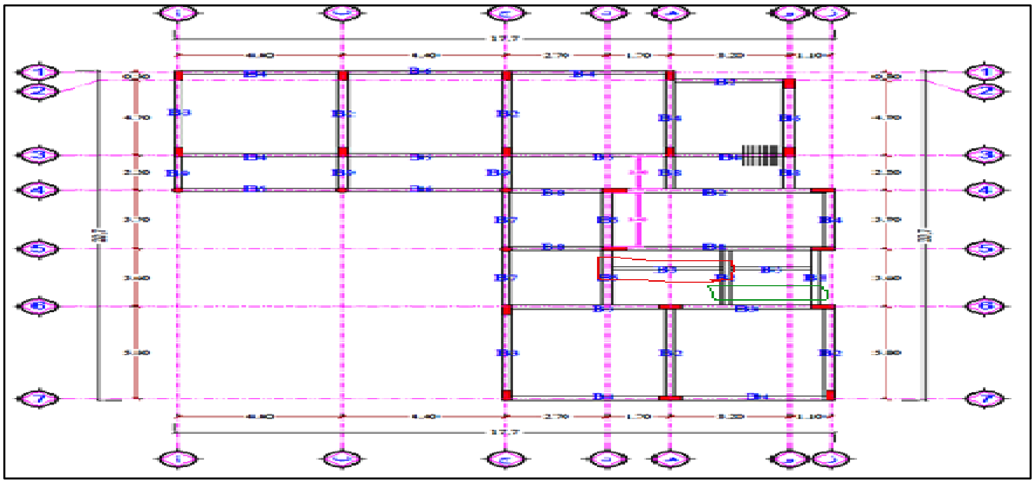
Before starting the structural analysis for the construction of internal and external walls with hollow bricks (pozzolan bricks) in the kindergarten construction project, which was described in item No. (1), this requires some minor modifications and additions to the structural designs of the project to meet the research requirements, the most important of which are:

a. Adding columns and a concrete ceiling (solid slab and bridges) to the staircase, where before the amendment, the staircase in the ministry's plans was a wooden roof (popular) and load-bearing walls for the roof without columns, and the main reason for this modification is the presence of water tanks above the wooden roof.
b. The simple support bridge in the roof of the first floor, located between the two vertical axes (E -G) and the two horizontal axes (6-5), were removed. The reason is due to the lack of the structural function of this simple bridge and the absence of any internal wall to support it.

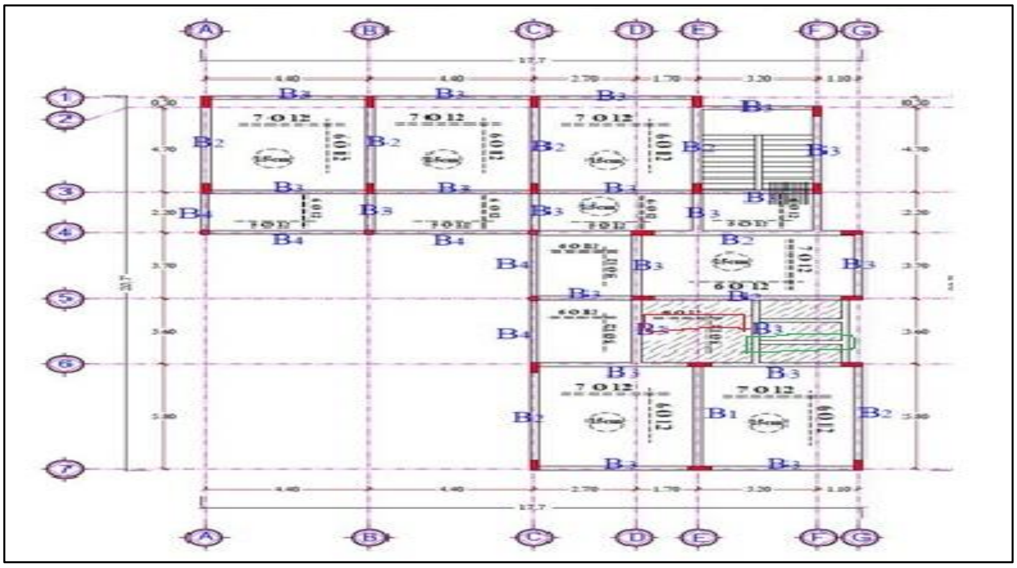
On the roof of the first floor, an inverted bridge was added between the two vertical axes (و - د) and the two horizontal axes (5-6). The reason for its addition is the presence of the kitchen wall extending between the same axes and the lack of a bridge to support this wall . It was designed to be identical to the extended wall, to preserve the architectural form.
The additions are shown on the designs in the pictures (Figure 4.1), (Figure 4.2.), (Figure 4.3)



(**Figure** 4.1)



(Figure 4.2)



(Figure 4.3)

4/1 Structural Analysis of the Two Models (Pozzolan Bricks and Regular Cement Bricks) :

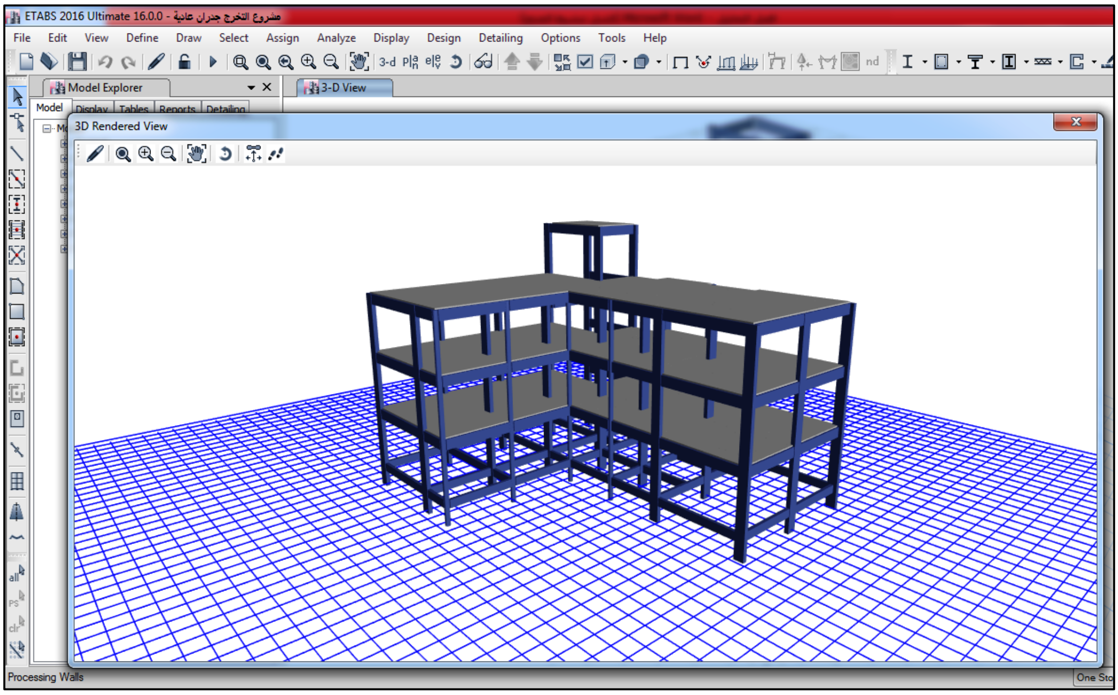
The analysis is limited to the modified chart model:

1. Pozzolan Hollow Bricks Model .
2. Cement Hollow Brick Model.

4/1/1 Structural Analysis:

Using the program (ETABS 2016), the program was adjusted to analyse according to the requirements of the British code (BS 8110), entering the definitions of the resistance of reinforced concrete $F_{CU} = 30\ N/mm^2$, defining the tensile strength of the main reinforcement steel with the following value $F_y = 400\ N/mm^2$, defining the steel Alkanes with the following value $F_y = 280\ N/mm^2$, definition of concrete sectors (slabs, columns, bridges and meads), dimensions and sizes required to be ready for the drawing stage, drawing axes and determining the number of floors of the building and the height of each floor, determining the required concrete sectors, solid slabs with thickness *15 cm*, columns of bridges and meads, shedding live load over the slabs by (3 kn/m^2) and carrying cladding by (2.5 kn/m^2), and concrete inclinations for the slabs of the last floor and the slab of the staircase (1.54 kn/m^2).

As for the loads of the stairs, they were calculated manually and were shed on the bridges of the stairs as live and dead loads distributed regularly on these bridges, and after the stage of drawing axes and sectors and shedding the loads of slabs and stairs, two copies were created for this file so that we can work on each copy separately from the other copy, so the first copy was for shedding bozzalan hollow brick loads under the item of external wall loads and internal intersections and was named (Etab file of bozzalan walls), and the second copy is for shedding hollow brick loads the traditional regular under the item of external wall loads and internal intersections and was named
(Etab file regular walls).



(**Figure** 4.4)

4/1/2 Wall Loads in The Two Files:

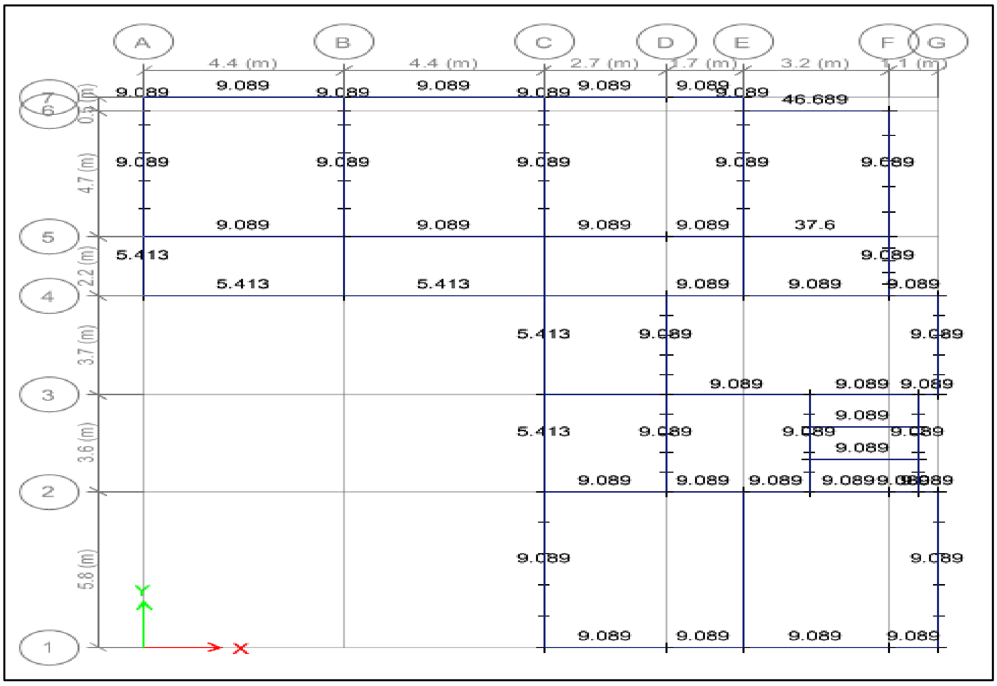
Regarding the height of the walls, it is known that the fallen bridges were in different sectors in the Ministry's model, so the heights of the walls are different. An average height of 3.05 *m* was adopted and applied to all external and internal walls. The height of the corridors and the external walls of the roof was adopted at the heights shown in the architectural drawings.

a. Wall Loads in Etab File Model of Pozzolan Brick Walls:

Saturated density of pozzolan bricks = 14.9 kn/m^3, (Figure 2.1) by multiplying this density by the thickness of the block of *20 cm* and the wall height of *3.05 m*, we obtain the uniformly distributed loads for the walls of pozzolan bricks:

$$3.05 \times 0.2 \times 14.9 = 9.089 \frac{kn}{m'}$$

It is the approved value that was assigned as loads to the external and internal walls in the file (Etab Pozzolan Brick Walls). This equation also applies to the walls of the corridors and the external walls of the roof, each according to its height.



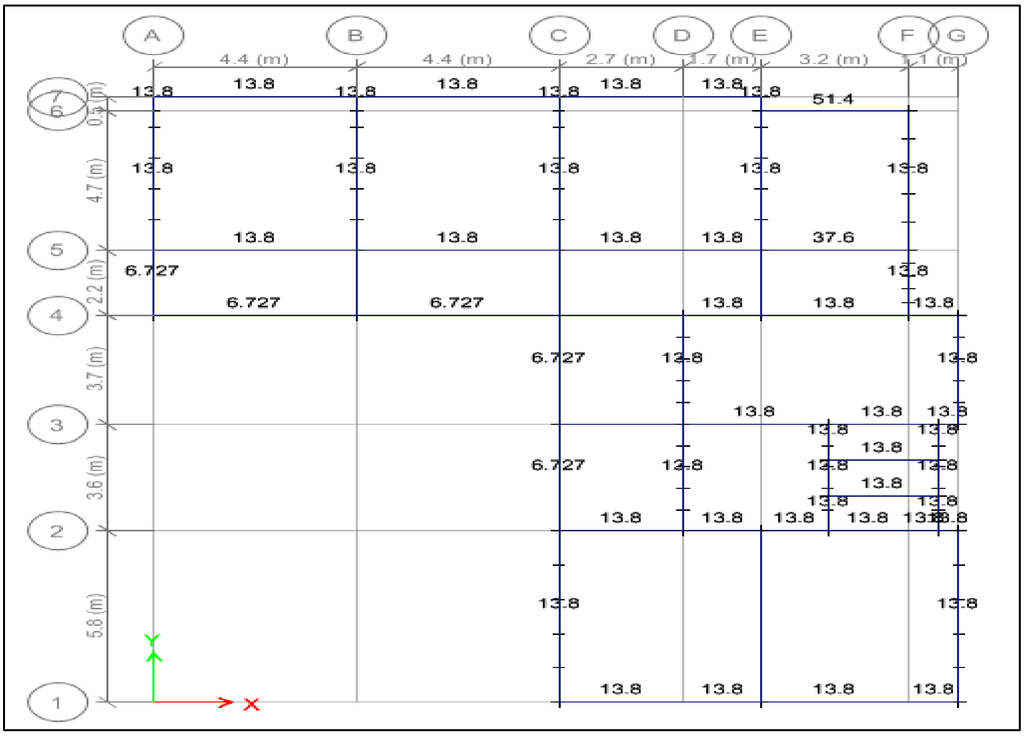
(**Figure** 4.5)

b. Wall loads in Etab File Model of Rgular Cement Hollow Brick Walls:

The saturated density of this brick is 22.9 kn/m^3, by multiplying this density by the thickness of the block *20 cm* and the height of the wall (*3.05 m*), we obtain the uniformly distributed loads, which are:

$$3.05 \times 0.2 \times 22.9 = 13.97 \frac{kn}{m'}$$

This value has been specified as the loads of the external and internal walls in the file (Etab Regular Brick Walls), and is also applied to the walls of the corridors and the external walls of the roof, each according to its height.



(**Figure** 4.6)

- After applying the loads of the external and internal walls in the two files, the command to redistribute the moments in the bridges (Releases) was used, and then the command (Auto Mesh) was used for the slabs and bridges in the two files separately, and thus each file became ready for the analysis process(Analysis),
- Designing all sectors in the two models (pozzolan brick walls and regular cement brick walls), using Excel slides approved by most structural designers. Choosing these slides because they design sectors (bases - columns - bridges - slabs) in accordance with the requirements of the British Code BS 8110. These slides verify the forces of shear, penetration, buckling, and bending, giving a safe design. As for the design itself, the basic inputs were as follows:

1. Concrete resistance to pressure in all sector $\boldsymbol{F_{cu} = 25\ \frac{N}{mm^2}}$
2. Steel reinforcement resistance to tensile in all sectors $\boldsymbol{F_y = 250\ \frac{N}{mm^2}}$
3. Soil stress below bases $\boldsymbol{250\ \frac{N}{mm^2}}$

4\2 Bases Design:
The base with the largest load located on the two axes ((6 –E)) was chosen and was named F1 as an example of the bases design in the two models:
Design of the F1 base in the two models**:**

Input Data								Output Data															
Fcu (N/mm2) =	25	Fy (N/mm2) =		250	Bearing Capacity (kN/m2) =	250		Note	Dim. of PC footing		Dim. of RC footing		Check shear stress at face column	Check punch shear stress	Check shear stress	Check for moment	Design for Long Direction				Design for Short D		
Model	Pw (kN)	Pu (kN)	Col. Dim. a (m)	Col. Dim. b (m)	h p.c (m)	Ø	H of RC (mm)		L' (m)	B' (m)	L (m)	B (m)					As (mm2)	As min. (mm2)	No. of bars/m	spacing between bars (mm)	As (mm2)	As min. (mm2)	No. of bars/m
								#DIV/0!	0.00	0.00	0.00	0.00	#DIV/0!	#DIV/0!	#####	#DIV/0!	#####	0	#DIV/0!	#DIV/0!	#####	0	#DIV/0!
F1 ويفر	1086	1536	0.25	0.60		16	600.00	OK	2.00	2.30	2.00	2.30	OK	OK	OK	OK	1079	0	6	160	1018	0	6
F1 عادي	1226	1760	0.25	0.70		16	600.00	OK	2.10	2.50	2.10	2.50	OK	OK	OK	OK	1211	0	7	140	1146	0	6
								#DIV/0!	0.00	0.00	0.00	0.00	#DIV/0!	#DIV/0!	#####	#DIV/0!	#####	0	#DIV/0!	#DIV/0!	#####	0	#DIV/0!

(**Figure** 4.7)

(Table 4.1)

NO	Differences in design **for base F1**		Pozzolan hollow bricks model	Ministry's cement hollow bricks model
1	**The sector (l x h x d) in metres**		**(0.6 * 2 * 2.3)**	(0.6 * 2.1 * 2.5)
2	**Reinforcment**	**Lower**	**6Ø16/m**	8Ø16/m
3		**Upper**	**6Ø16/m**	8Ø16/m

A small table showing the difference in F1 design between the two models

4\3 Necks and Columns Design:
Column necks are more exposed to loads. The column neck located on the axes ((6 –E)) was chosen as an example for the design of necks and columns for the two models, and it was named Column C1.

NO	Differences in design for base F1		Pozzolan hollow bricks model	Ministry's cement hollow bricks model
1	**The sector (l x h x d) in metres**		**(0.6 * 2 * 2.3)**	(0.6 * 2.1 * 2.5)
2	**Reinforcement**	**Lower**	**6Ø16/m**	8Ø16/m
3		**Upper**	**6Ø16/m**	8Ø16/m

(**Figure** 4.8)

Model	Fcu (N/mm2) =	25	Ø (mm)	Fy (N/mm2) =	250	h (mm) Choosen	As (mm2)	As (min.)	No. Of bars
	Pu (kN)	b (mm)		μ% (As/Ac)%	h (mm) Required				
C1 ويفر	1536	250	16	1.0	590	600	1334.328	1500	8
C1 عادي	1760	250	16	1.0	680	700	1365.672	1750	9
					#DIV/0!		0	0	#DIV/0!
					#DIV/0!		0	0	#DIV/0!
					#DIV/0!		0	0	#DIV/0!

عمود مستطيل / عمود مربع / عمود دائري

(**Figure** 4.9)

NO	Differences in design for column **C1**		Pozzolan hollow bricks model	Ministry's cement hollow bricks model
1	**The sector (l x h) in metres**		(0.25 × 0.60)	**(0.25 × 0.70)**
2	**Reinforcement**	Necks	10Ø16	**10Ø16**
3		rest of the floors	6Ø16	**10Ø16**

(Table 3.2)

Table of differences in C1 design between the two models

4/4 Bridge Design:
The bridge located on the axes (E-6,7) was chosen as an example of bridge design and was named B1):

Input data						**Output data**								
Model	Fcu	25	Fy	250		Secondary Reinforcement					Main Reinforcement			
	M (kN.m)	b (mm)	Ø (mm)	d (mm)	d' (mm)	If com. St. req.	As' (mm2)	As' min. (mm2)	No. of bar	As' prov.	As (mm2)	As min. (mm2)	No. of bar	As prov. (mm2)
B1 ويفر	143	250	16	700	50	No			0	0	910.111507	420	5	1005
B1 عادي	145	250	16	700	50	No			0	0	923.637671	420	5	1005
						#####	#DIV/0!	#####	#####	#####	#DIV/0!	0	#####	#####
						#####	#DIV/0!	#####	#####	#####	#DIV/0!	0	#####	#####

Design for moment / Shear / Deflection

(Table 4.3)

Table of differences in design (B1) between the two models

NO	Differences in design for bridge B1		Pozzolan hollow bricks model	Ministry's cement hollow bricks model
1	**The sector (l x h) in metres**		**(0.25 × 0.70)**	(0.25 × 0.70)
2	**Lower**	**Reinforcement**	**3Ø16**	3Ø16
3	**Upper**		**2Ø16**	3Ø16
4	**Bent-up**		**3Ø16**	2Ø16
5	**Alkanes**		**Ø8/12cm**	Ø8/15cm

4\5 Slab Design:
Since the loads on the slabs are the same in the two models, the moments are identical, so the design will be identical. Therefore, the design for the Ministry's model was adopted.

4/6 Calculating Quantities:
Calculating the quantities of reinforced concrete, reinforcement steel, and construction works for all sectors in the two models are shown in the tables of quantities for the various concrete sectors in the appendices, including:

a. Quantity Inventory:

Total amount of construction work for the entire facility = 675 m^2.
Details of calculating the quantity of construction works are shown in the inventory table with the appendices

b. Reinforced Concrete Quantities Inventory:

The inventory table for reinforced and regular concrete works for the two models is shown in (Table 4.4)

(**Table**4.4)

Main Items	Ministry's cement hollow bricks model	Pozzolan hollow bricks model
The cost of construction work in riyals	3,510,000	**4,509,000**
The cost of the concrete structure (reinforced concrete+brick) in riyals	27,109,800	**23,353,600**
The cost of excavation, backfilling and insulation work in riyals	1,259,470	**962,200**
The total in riyals	**31,879,300**	28,824,800

c. Reinforcement Steel Quantities Inventory:
Reinforcement steel quantities inventory for the two models in table (Table 4.5)

(**Table** 4.5)

No	The amount of reinforcement steel /ton	Ministry's cement hollow bricks model	Pozzolan hollow bricks model	The difference between the pozzolan and cement bricks%
1	reinforcement steel for bases	2.244	1.387	**%38.19**
2	reinforcement steel for columns and necks	5.65	4.25	**%24.77**
3	reinforcement steel for stairs and roofs	8.08	8.08	**%0.0**
4	reinforcement steel for bridges and meads	10.114	8.795	**%13.04**
5	Total reinforcement steel for previous items (in ton)	**26.088**	**22.512**	%13.7

4\7 Analysis of Unit Prices:

After quantities inventory for construction and concrete works, the unit prices were analyzed and the results of the analysis were as follows:

(**Table**4.6)

A table showing the results of the price analysis

Since the flat area of the facilities is ($720m^2$), the cost per square meter for the two models is shown in the table as follows:

The model	*The cost of the square meter for the bone of the facility*	*The difference in the cost per square meter compared to the pozzolan brick model*
pozzolan *brick*	**ريال 40,035**	________________
cement *brick*	**ريال 44,280**	*4,245 four thousand two hundred and forty-five riyals.*

(**Table**4.7)

So the difference in the cost per square meter between the two models of pozzolan bricks and cement bricks is estimated at approximately (4,245 riyals)

5/ Results:

1. The difference between the Ministry's model implemented on reality for building internal and external walls and the model for building with pozzolan hollow bricks is shown in the table as follows:

(**Table** 5.1)

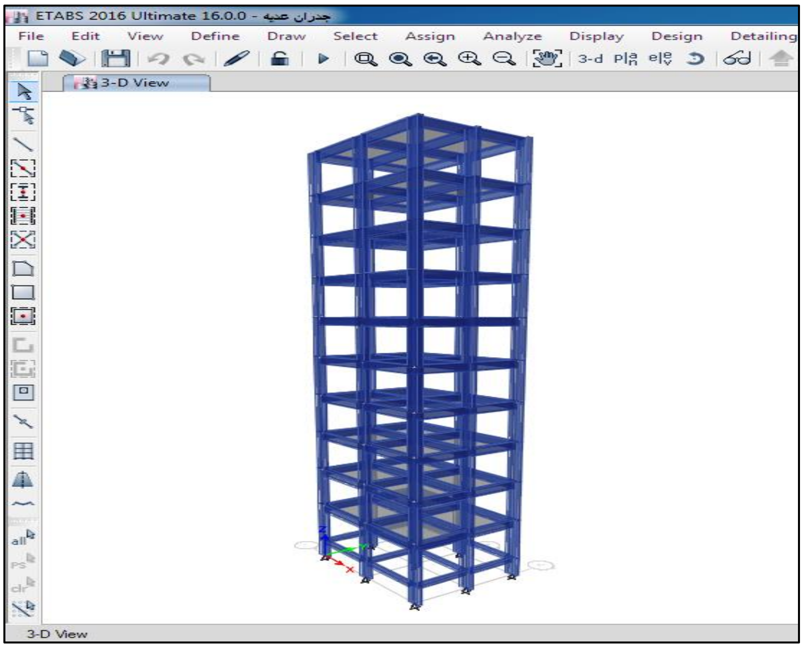
1	**Total facility loads (KN)**	**19874. 214**	**23306. 108**	**3432**	**14**
2	**The total volume of reinforced concrete**	**210 m^3**	**243. 44 m^3**	**33. 44 m^3**	**13. 73**
3	**Total weight of reinforcement steel /ton**	**22. 512**	**26. 08**	**3. 57**	**13. 7**
4	Cost of construction work / Yemeni riyals	**4,509,0**	**3,510,0**	**- 999,0**	**−28. 5**
5	**The cost of reinforced concrete works / riyals**	**24,315,800**	**28,369,270**	**4,053,470**	**14. 3**
6	**Total cost (4+5)**	**28,824,800**	**31,879,300**	**3,054,500**	**9. 5**
7	**Cost per square meter / riyals**	**40,035**	**44,280**	**4,245**	**9. 5**

2. The difference in the cost per square meter between building walls using pozzolan bricks and building walls using cement bricks is about (4,245 riyals)
3. The difference in the total cost between the model of building with cement bricks for the internal and external walls and the model of building with pozzolan bricks is about "4,856,000" Yemeni riyals, meaning the reduction in the project construction cost is about (14.4%).
4. If ten kindergarten buildings were implemented with the same model, then the savings in the ten kindergartens would be: **4,856,000** × **10** **=48,560,000** riyals, as this amount is sufficient to establish an additional kindergarten .
5. **The cost savings by using pozzolana bricks for horizontal facilites increases when compared to vertical facilites:**

This was verified as to whether the use of pozzolan hollow bricks significantly saves cost for horizontal facilites such as commercial markets and others when compared to its use for construction in high vertical facilites such as towers. This was done by applying the research criteria to two rooms of different sizes and equal number of recurring floors, up to (10) A role for each room as follows:

1. The dimensions of the first room are: (6m×8m), and it is horizontal.
2. The dimensions of the second room are: (3m×4m) and it is vertical.

After analyzing the two rooms in Etab program:
a. Using pozzolan hollow bricks to build the external and internal walls of the two rooms.
b. Use regular cement hollow bricks to build the external and internal walls of the two rooms.



(**figure** 5.1)
An image of Etab program for the analysis process for the small and large room models

• The results of the analysis, design, and inventory of small room tower quantities (vertical buildings) based on the two systems of construction with pozzolan hollow bricks and construction with regular cement hollow bricks are shown in the following table (Table 5.2)

(**Table** 5.2)

No	Statement of constructions for horizontal construction	Construction with cement hollow bricks	Construction with pozzlan hollow bricks	The amount of difference in quantities	Difference rate%
1	Total volume of concrete m^3	179.5	144.88	34.62	19.29
2	Total weight of reinforcement steel/ton	19.23	16.38	2.85	14.83

• The results of the analysis, design and inventory of the quantities of the large room tower (horizontal buildings) based on the two systems of construction with pozzolanic hollow bricks and construction with regular cement hollow bricks are shown in the following table (Table 5.3):

(**Table** 5.3)

No	Statement of constructions for vertical construction	Construction with cement hollow bricks	Construction with pozzlan hollow bricks	The amount of difference in quantities	Difference rate%
1	Total volume of concrete m^3	49.7	44.39	5.31	10.68
2	Total weight of reinforcement steel/ton	5.185	4.653	0.532	10.26

• We conclude from the two tables (Table 5.2, 5.3) that building with pozzolan hollow bricks has a direct effect on the amount of reinforced concrete and the total weight of reinforcement steel in vertical and horizontal facilities if compared with building with regular cement hollow bricks, as follows:

a. The volume of reinforced concrete is less by (10.68%) in vertical facilities
b. The volume of reinforced concrete is less by (19.29%) in horizontal facilities
c. The total weight of reinforcement steel is lower by (10.26) in vertical facilities
d. The total weight of reinforcement steel is lower by (14.83) in horizontal facilities

6\ Recommendation :

Pozzolan hollow brick construction for the following projects:

1. Recurring Units Projects:
To achieve savings in the projects cost for repeated units, whether public or private, we recommend using pozzolan hollow brick construction for internal and external walls, as it is likely to save the cost of a facility out of every five projects similar in designs and site conditions.
2. Horizontal Facilitis:
Where the analysis and design of the two towers models of pozzolan hollow brick construction and regular cement hollow bricks construction for the first rooms (8×6) and the second (4 x 3) with the height of the towers = 10 floors proved that the most savings in the volume of reinforced concrete were in horizontal facilities compared to vertical facilities.
3. Stalled Projects:
Some of the state's projects have stalled due to deficiencies in the design of the bases because the facility loads are larger than the sizes in which these bases were designed. The best solution to this problem is to reduce the loads by using pozzolan hollow brick construction for internal and external walls.
4. Reconstruction Projects:
Grants provided for reconstruction projects in the field of construction are often limited, and the ideal solution for investing these amounts is to use pozzolan bricks to implement the largest number of housing units for affected families.

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