Alamin Towers,

Value Engineering Case Study

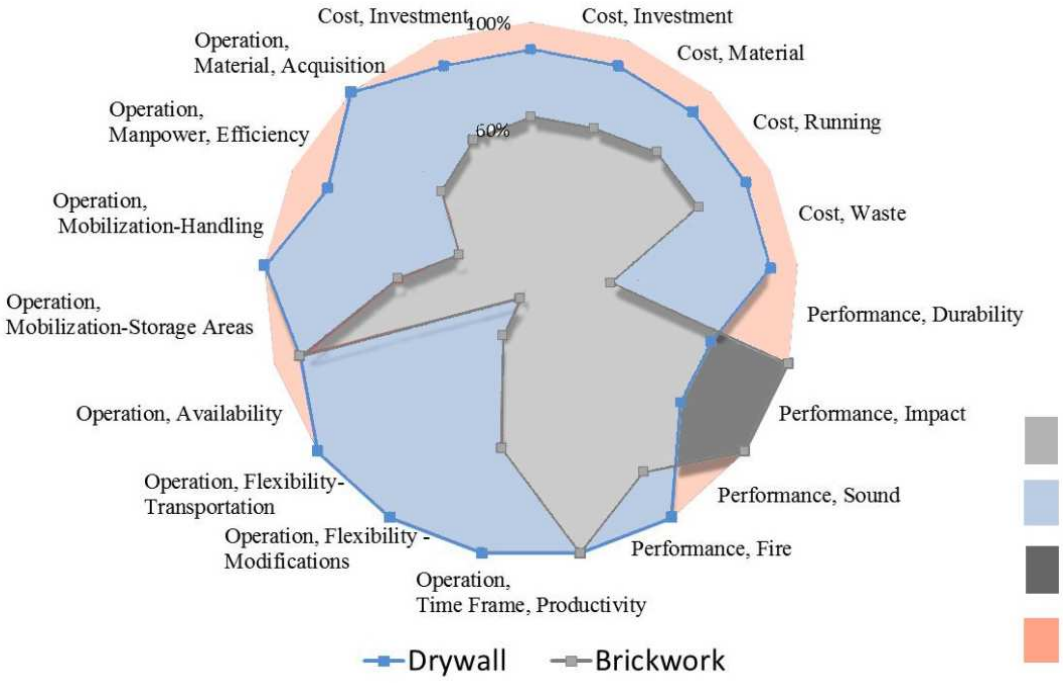


Table of Contents

1. General Definitions.

1.1. Drywall Buildings Definition.

Drywall is a lightweight system that has an average weight of 25kg/m^2; it consists of a substructure metal system that installed in the middle position between two layers of gypsum or cement bases board cladding. Drywall systems perform in the internal partitions as well as the external walls; the little thickness of the sub-structure does not allow the drywall to work as a load-bearing system (Except wind load). The component of the drywall systems are off-site produced, the elements should be getting another treatment on-site by qualified installers.

1.2. Drywall Buildings Codes

A building norm or building control system is a set of rules that specify the minimum standards for constructed objects such as buildings and non-binding. The main purposes of building norms are to protect public healthiness, safety and general welfare, as they relate to the construction and use of buildings and structures. The building code will be officially enacted law of a particular jurisdiction as by the relevant government or private body. Knauf systems are following EN, BS, DIN standards.

1.3. Value Engineering Aspects

Value Management as a way of handling which is mainly keen to motivate people, increase the level of personal skills and encourage people to think about innovation, it defines VE as “A specialized cost control technique, performed by a group of experienced professionals. The technique involves an intensive, systematic and creative study to reduce cost while enhancing reliability and performance. The technique is used to achieve the best functional balance between cost, quality and performance of a product, system or facility.

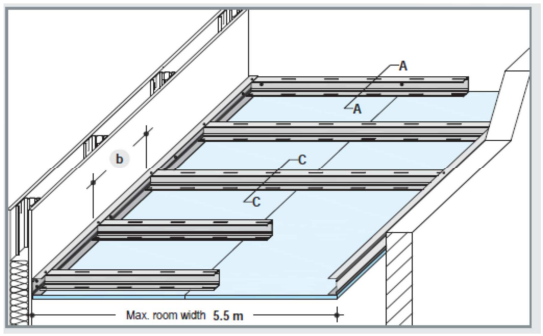
1.4. Cost Performance Aspects

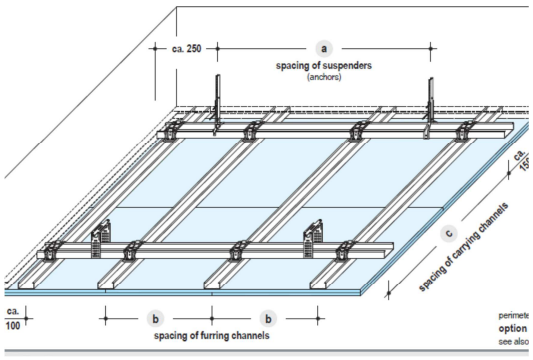
The Life-Cycle Cost model (LCC) is the final sign of the value to the owner. It includes both acquisition costs and operation costs. Model holds optimum value, because it takes into description all the expected costs over the lifetime of the project. The Life-Cycle Cost model could be working based on the annualized costs or the current value method. The total cost of a project is composed of design cost, construction cost, operation and maintenance cost. From its records in highways, the construction cost does not exceed 50% of the Life-Cycle Cost.

2. Drywall Systems Analysis

2.1. Ceiling

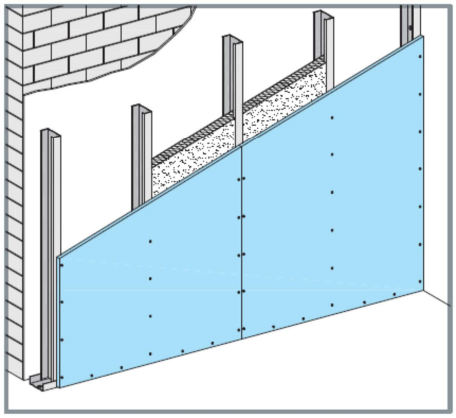
The suspended ceilings are able to cover the construction areas without any responsibility of the load bearing. The curved metal structure and flat metal structure used to cry the cladding load.

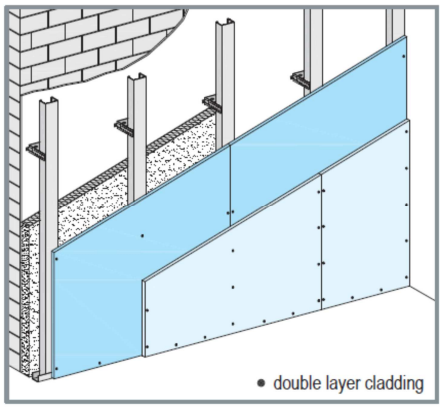




2.2. Partitions

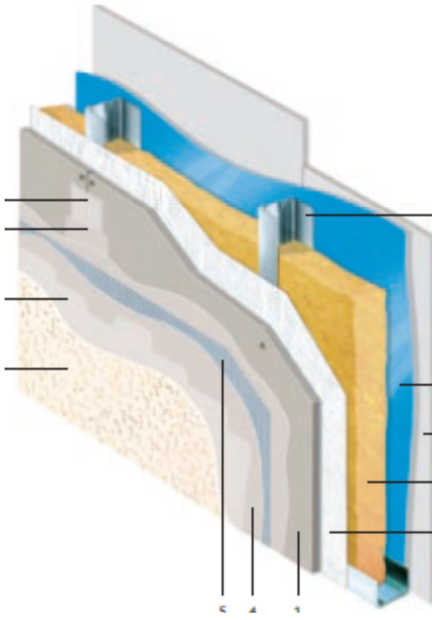
Drywall is a panel of gypsum plaster paper, which hard-pressed between two sheets. It used to make internal partition and ceilings. Drywall used as a faster alternative to conventional plaster base. A wallboard panel consists of a paper liner to an inner core essentially made of plaster wrapped





2.3. Walls.

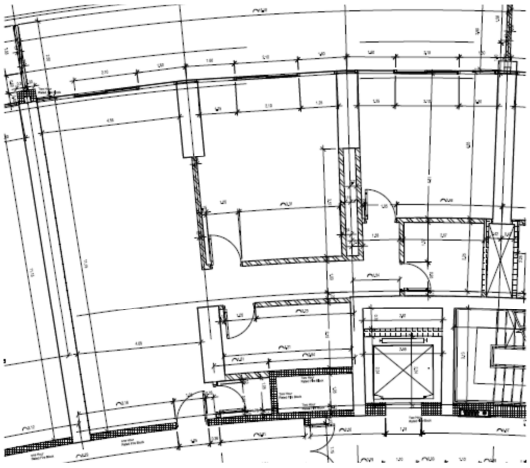
Water-managed system (directly applied). Aquapanel Cement board solution sets new principles for the construction and design of buildings through the building world. The Aquapanel system supports the construction engineers and dealers with a high quality and best cost alternative to old-style systems of construction, like brick and block. (Figure 2.2.14) refers to the components of the water-managed system of Aquapanel solutions.



3. Case study 1: Alamin Towers.

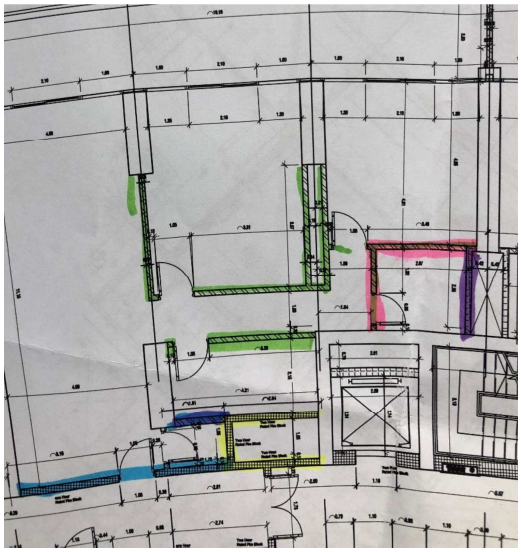
3.1. Architectural Analysis.

Submittal unit plan



The proposed unit is moderate example in space and requirements comparing to unit models throughout the tower. After studying the requirements and the specified standard as for the usual living areas we focused on durability, sound insulation along with the added value of moisture resistance performance, for the damp and wet areas water resistance and fire performance along with maximum collision resistance for the external outline walls. By these requirements several Knauf drywall solutions was implemented to replace masonry walls and plastering.

Knauf Solutions Layout:



1) **Green**, Two layers of GKI on each side partition
2) **Red**, Two layers of GKI on one side and one cement board over the other
3) **Blue,** Vidiwall single layer partition
4) **Yellow,** One layer of Vidiwall over one layer of GKF for each side
5) **Purple,** One layer of cement board for a side and a layer of GKI for the other

Used systems areas in square meters :

1) 63 M2
2) 25 M2
3) 16 M2
4) 22.5 M2
5) 8 M2

3.2. Project Financial Average

Estimated cost of supply and apply of drywall for the proposed unit:
Approximately 81,210 EGP
Estimated cost of masonry and plastering:
Approximately 94,000 EGP

Further cost reduction may occur throughout the study of larger unites also there are several other solutions to be presented to provide further more flexibility in performance.

General Notes:

- The 100% performance is being the infinity ones, due to the unavilibility of the each requested performance.
- Cost performance is being 1/X function, which is appread in a decreased position.
- Operation Flixibility performance is being a subject of timing, starting from the mobilization process, passin through the installation positionnin till the renovation end (Life Cycle Cost Management).

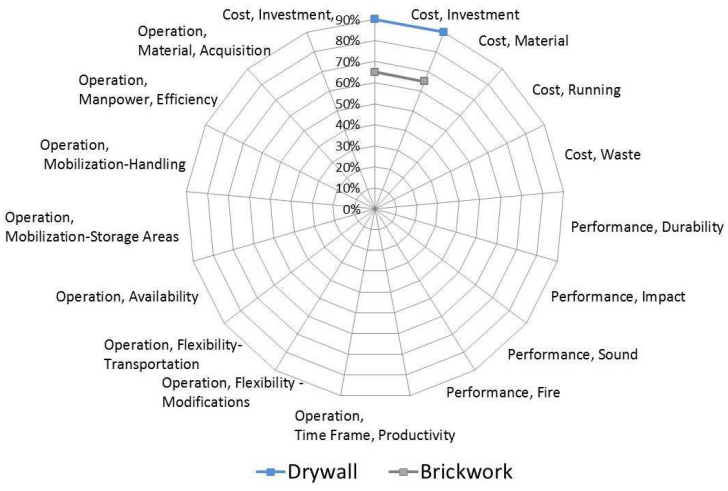
4. Value Engineering Factors of Evaluation

4.1. Life cycle Cost

Cost efficiency is being the main argument behind using the drywall construction solutions instead of the Traditional methods of construction. There is a wide range of cost assessments in construction models, starting from the potential of the investment cost, until the deprecation cost, including the initial cost, material cost, running cost, maintenance cost, resale value, inflation cost, replacement cost, and hidden cost. In this approach, Knauf will mainly focus on five types of cost management.

4.1.1. Investment Cost

The KNAUF Walls offers a range of economic advantages to investors and architects when compared with conventional building techniques. As well as the specific economic advantages, the KNAUF Exterior Wall offers specific dry lining benefits which help reduce construction times, including: Faster closing of the building envelope, enabling interior finishing, laying screed etc. to begin as early as possible whilst the exterior is still being completed Shorter drying time means less energy is consumed during the construction phase and the first year of drying Reduced time for scaffolding on-site Easier site management due to fewer interfaces between different crafts – only dry lining skills are required Just-in-time complete system solution from Knauf Lightweight delivery/storage Flexibility for retro fitting and refurbishment in the post-construction phase The façade can be demounted selectively at the end of its life cycle for more effective recycling



The investment cost is the total amount that the developer has paied to build up the infrastructure and construction elements, before the enduser attendance and payments setillment. Knauf Drywall solutions are capable to reduce cnventional exterior walls account for up to 3.32% of the construction materials plus labor cost of the building (values differ depending on type of construction). Knauf Wall system material and labor costs represent only 2.5% of total costs which equate to up to 25% savings when compared directly with conventional

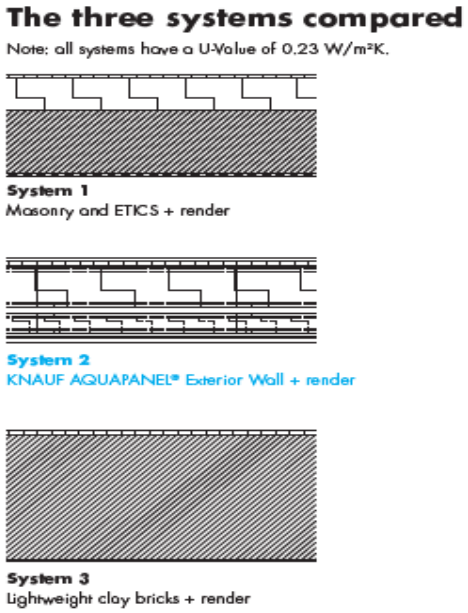
construction[1]. Hence, drywall systems are qualified to gain minimum 20% of performance in investment cost, as shown in the above mentioned quality module.

Comparative calculation for a three story office building

Here the construction of an average office building is analyzed and comparisons are made between traditional masonry construction and dry lining using the KNAUF Exterior Wall system. These comparative calculations, prepared by Prof. Dr.- Ing.

Architect Bert Bielefeld of the University of Siegen, Germany, reflect issues in the real estate industry such as investment, costs, construction period, building site logistics, building maintenance over the life cycle and profitability from the point of view of the real estate industry.

The case studies show how the KNAUF Exterior Wall is already delivering tangible benefits to investors and construction personnel.



Space gains plus increased rental potential

Basis of calculation,

	Floor surface m2
Gross closed floor surface	3,441.00
Lost space due to corridors, lifts etc. which cannot be rented	206.37
Interior/separating walls in building	134.97
Net floor surface including exterior wall	3,099.66

Space gain

	Wall thickness (m)	Length of façade (m)	Floor surface area of exterior wall m2) (2)	Net surface minus exterior wall surface (1-2)	**Floor space lost (m2)**	**% loss of space**
System 1 Masonry and ETI CS + render	0.385	446.22	171.79	2,927.87	37.92	**1.3%**
System 2 Wall + render	0.3	446.22	133.87	2,965.79	**0**	**0**
System 3 Lightweight clay bricks + render	0.52	446.22	232.03	2,867.63	98.17	**3.42%**

The calculation shows that this office building built with a KNAUF wall system offers space gains when compared with traditional building systems.

Potential rent increase

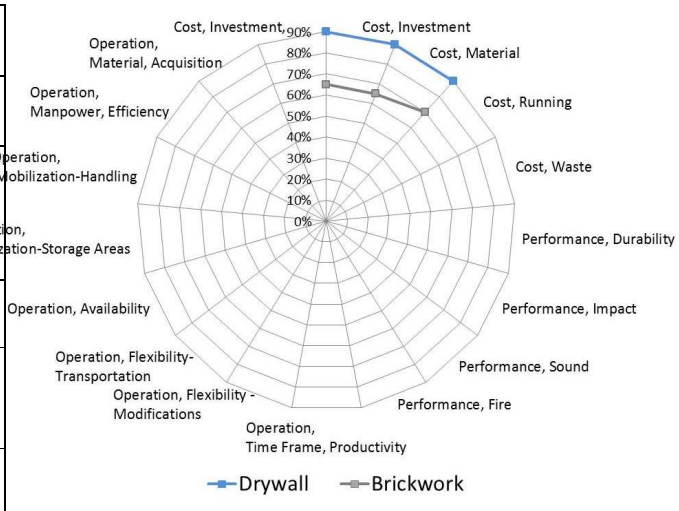
	Rentable area m2	Rental income per year (based on 10 €/m2/annum)	**Loss of potential rental income**	**% loss of potential rental income**
System 1 Masonry and ETI CS + render	2,927.87	€ 351,343.84	€ 4,551.44	**1.3%**
System 2 Wall + render	2,965.79	€ 355,895.28	€ 0	**0**
System 3 Lightweight clay bricks + render	2,867.63	€ 344,382.80	€ 11,779.68	**3.4%**

The calculation shows that this office building type with a KNAUF Wall system generates up to 3.4% more rent when compared with traditional building systems, due to the space gained inside the building.

4.1.2. Material Cost

Drywall manufacturers are depending on their capabilities to produce up all components of the construction solutions under one umbrella, which keeps all material costs well controlled and efficient enough to face the exact needs of the project. The fine end faces that the drywall boards are giving for all walls types are totally dropping any potential of plastering usage. The hereunder average prices refer to the complete system cost without labor, handling and waste costs, which allow Knauf system to gain a better position by 20%, according to the prices in point 3.2

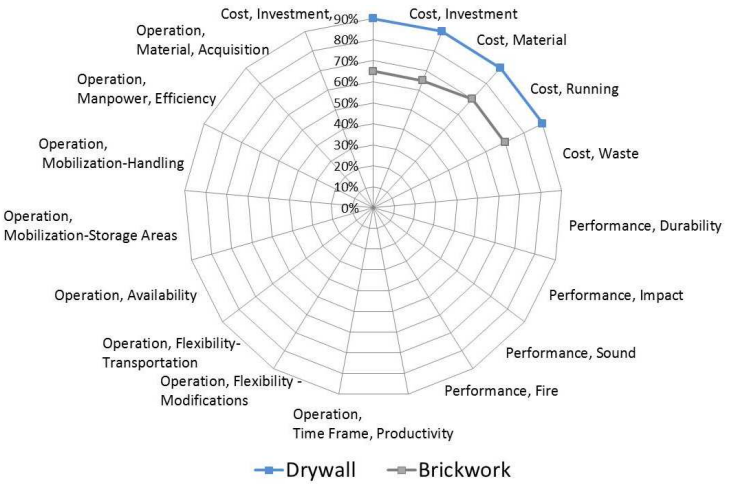
Knauf Systems	AV EGP/M2
Green, Two layers of GKI on each side partition	260
Red, Two layers of GKI on one side and one cement board over the other, no rendering	450
Blue, Vidiwall single layer partition	400
Yellow, One layer of Vidiwall over one layer of GKF for each side	320
Purple, One layer of cement board for a side and a layer of GKI for the other, no rendering	360



4.1.3. Running Cost

Running cost itself is a subject of the reaction performance more than the active one. Energy consumption has the major part of running cost values, and the rest of figures are coming from water consumption and maintenance cost.

On average, KNAUF Wall systems deliver 25% more space, with the same U-Value, than brick and block construction. This space can be used for better thermal insulation, decreasing the demand for primary energy for heating and cooling* A KNAUF Wall system has approximately 30% of the material mass per m2 of wall area compared to conventional brickwork construction. (It has approximately 25% compared to concrete construction.) This results in a primary energy requirement up to 50% lower than for traditional building methods. The comparative calculation shows that CO2 output for a KNAUF Wall is reduced by approximately 30% per m2 of wall area compared with a similar brick and block wall.



4.1.4. Waste Cost

DW material wastes measurements includes wastes of steel tracks and studs and gypsum boards. On the other side masonry wastes includes blocks, mortar and plaster for rendering. Masonry showed higher wastes material rates when compared to DW. Mortar and plaster are particular too high and demands lots of vertical and horizontal transportation from the work site to the disposal site.

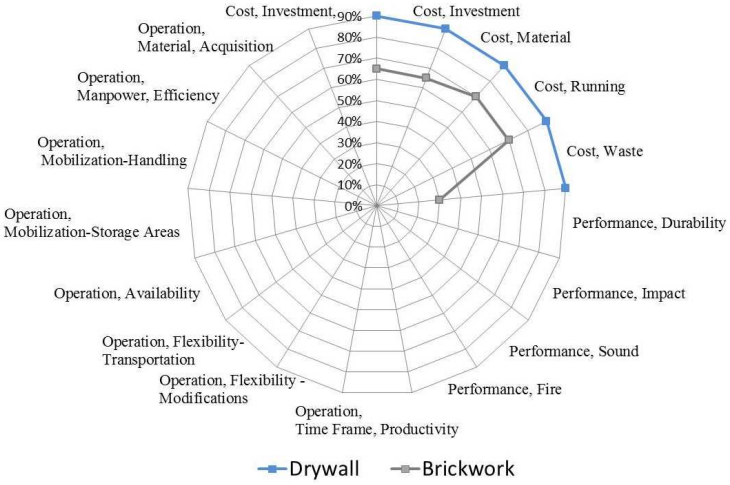


Figure 30 – Ceramic block and mortar waste.

Figure 31 – Gypsum boards waste.

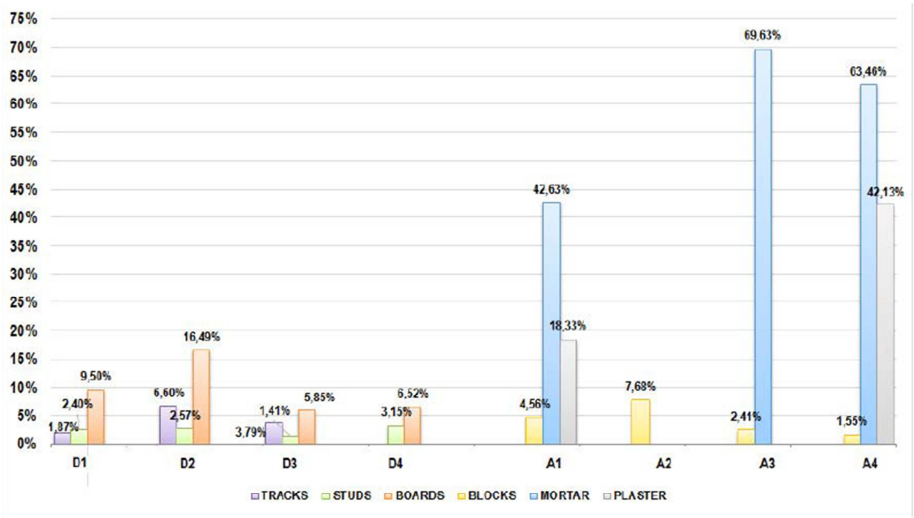
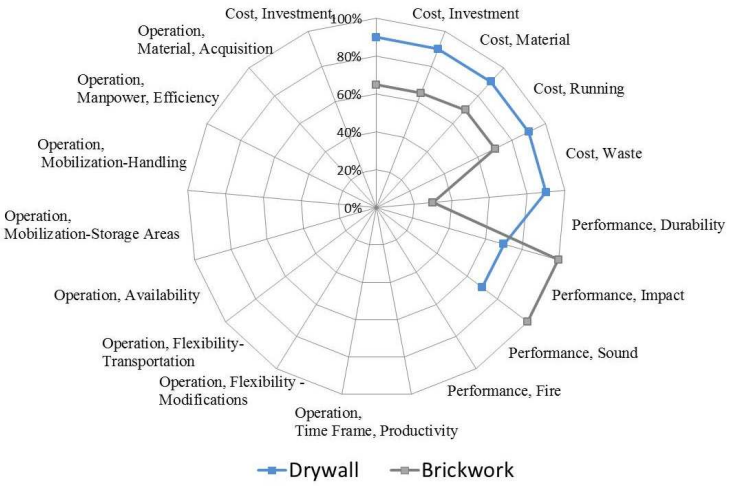


Figure 11 – Waste of materials for DW (D1 to D4) and masonry (A1 to A4) projects. Gypsum board, mortar and plaster for rending show extraordinary high rates.

4.2. Performance

4.2.1. Durability

4.2.2. Impact



As for the aspect of durability conventional drywall partition are tested to a life time of 60 years however the record shows that there are many current buildings where drywall partitions last more than 60 years also we upgraded the internal partitions by using two layers of GKI moisture resistant gypsum board and further boosting the impact resistance in external walls by using Vidiwall impact resistant board to achieve an acceptable impact and durability performance for residential facilities

K811 Vidiwall

Description, Field of Application, Sizes of the Boards, Installation, Technical Properties

Joint Technique, Surface Treatment

Composition

The Vidiwall gypsum fibreboards are composed of high quality calcinated gypsum and selected paper fibers.

Special properties

- Versatile application
- Robustness
- Moisture resistance
- Easy installation
- Optimum fire - and sound - protection

Vidiwall board informations

Thickness:	10 / 12.5 / 15/ 18 mm
Width:	1000 / 1245/ 1250 mm
Length:	1500/2000/2600/ 2750/2800/3000 mm

The Vidiwall boards are produced with differently shaped edges depending on the joint technique.

Edge shape: SK VT

The Boards are produced with 4SK; 3SK/1VT; 2SK/2VT; 1SK/3VT; and 4VT edges.

Field of application

- Metal stud partitions
- Solutions for sound protections
- Fire protection claddings
- Timber prefabricated houses – as cladding to the wall structures and for reinforcing of the building
- Drywall partitions in humid areas
- High partition walls (for more information see technical data sheet W36)

Knauf Aquapanel cement board has been chosen for wet areas to achieve maximum performance in water resistance as the product itself is 100% water resistant. Also we have to take into consideration the exceptional flexibility of drywall in humidity damage treatment and maintenance than conventional brick wall


INSTITUT FÜR BAUBIOLOGIE ROSENHEIM GMBH

Verleihungs - Urkunde

KNAUF USG SYSTEMS

D - 58638 Iserlohn

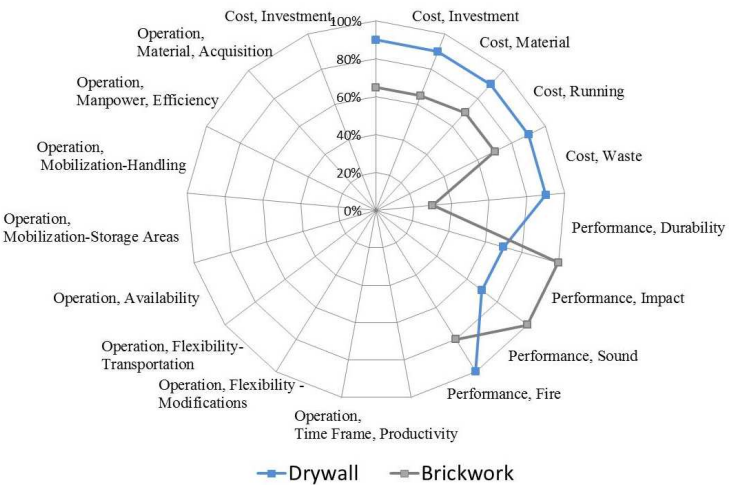
AQUAPANEL® Cement Board

Indoor, Outdoor, Floor, Maxi

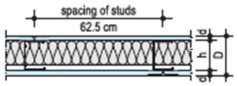
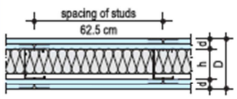
4.2.3. Sound

The used drywall systems in this initiative achieve a higher sound insulation performance than conventional brick wall partitions as drywall reach 52

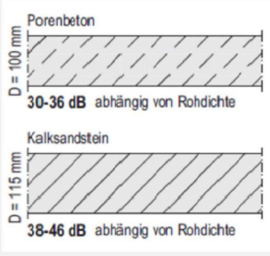
Technical data of solid wall				Calculation sound redu
material one side gypsum plaster ≥ 10 kg/m²	density material density wall kg/m³	thick-ness mm	weight per unit area kg/m²	solid wall alone dB
autoclaved aerated concrete high precision bricks (DIN 4165) glued	500 (450)	125	56	29
		175	79	33
		250	113	38
		300	135	40
		365	164	42
	700 (650)	125	81	33
		175	114	38
		250	163	42
		300	195	44
		365	237	46
light weight perforated bricks (DIN 105) type W_l , type A and B with light weight mortar	800 (770)	115	100	36
		175	145	41
		240	195	44
		300	241	47
		365	291	50



Technical Data / Sound Protection / Thermal Insulation

System For legend see page 3	Technical data dimensions: wall thick-ness D mm	stud (ca-vity) h mm	cladding thick-ness d mm	cladding type	weight approx. kg/m² 1)	Sound protection proof $R_{w,R}$ dB 2)		In-sulation nominal thickness mm 3)	Thermal insul. U value W/(m²K)
W111 Metal Stud Partition single metal stud frame - single layer cladding									
	75	50	12.5	GKB GKF	25		41	40	0.66
	100	75				1	42	40	0.65
							43	60	0.50
	125	100					42	40	0.65
							43	60	0.49
							44	80	0.40
	75	50	12.5	KNAUF Piano Piano F Sound Shield GKB / GKF	25.5		45	40	0.66
	100	75				2	46	40	0.65
							47	60	0.50
	125	100					46	40	0.65
							47	60	0.49
							48	80	0.40
W112 Metal Stud Partition single metal stud frame - double layer cladding									
	100	50	2x 12,5	GKB GKF	45		50	40	0.61
	125	75				1	51	40	0.60
							52	60	0.47
	150	100					51	40	0.60
							52	60	0.46
							53	80	0.38
	100	50	2x 12.5	KNAUF Piano Piano F Sound Shield GKB / GKF	46.5		53	40	0.61
	125	75				2	54	40	0.60
							55	60	0.47
	150	100					54	40	0.60
							55	60	0.47
							56	80	0.38

- In comparison with the traditional method of construction for the same thickness or even thinner constructions:
- Aerated concrete 100 mm
  → **R_w = 30 – 36 dB**
- Limestone 115 mm
  → **R_w = 38 – 46 dB**



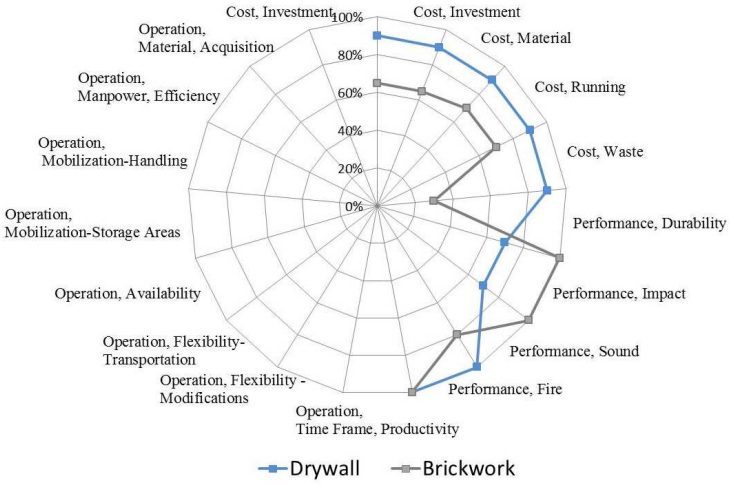
Selection of the suitable main components

4.2.4. Fire

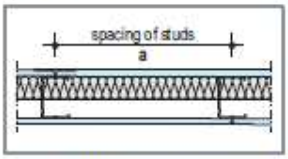
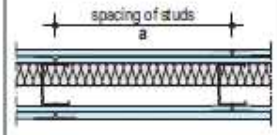
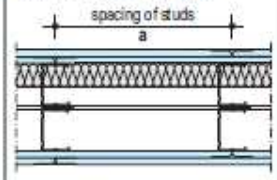
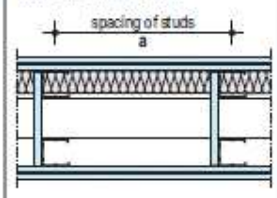
The required fire performance in the project was achieved by the selected drywall systems.

The fire performance is being evaluated by the third party tests, which were done according to DIN standard 4102-4, Chapter 4.10, Table 48.

Fire performance results have been marked based on the total complete systems components.



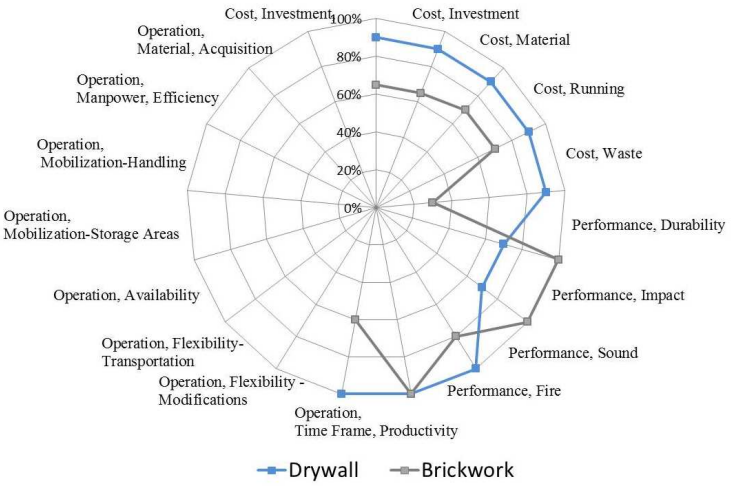
Fire Protection: DIN Solutions

System	Fire rating	Cladding: type/ building material class	Cladding: min. thickness mm	Insulation: type	Insulation: min. thickness mm	Insulation: min. density kg/m³	Max. spacing of studs -a- cm	Proof
W111 Metal Stud Partition								
	F30	Fire Resistant Boards GKF A2	12.5	mineral wool S	40	30	CW stud 62.5	DIN 4102-4 chapter 4.10 table 48
W112 / W115 / W116 Metal Stud Partition								
W112 Metal Stud Partition 	F30	Gypsum Boards GKB A2	2x 12.5		40	30		
	F60		2x 12.5		40	40		
W115 Metal Stud Partition 	F90		15 + 12.5		40	100		
		Fire Resistant Boards GKF A2	2x 12.5	mineral wool S	60	50	CW stud 62.5	DIN 4102-4 chapter 4.10 table 48
					80	30		
W116 Installation Wall 	F120		2x 18 *)		40	40		
			2x 15		60	100		
					80	50		
	F180		25 + 12.5 *)		60	100		
					80	50		

4.3. Operation

4.3.1. Time Frame, Productivity

UPR = entries / exits = human labor (Hh) / amount of service, UPR = man-hour / amount of service performed by the worker (m^2) = [Mh/m^2], UPR = ((worker (H) × work hours available (h)) / (m^2 of DW or masonry service), in all these expressions, the better the performance of workers are, the lower the UPR is. DW cumulative UPR is considerably lower than masonry.



The average cumulative UPRs of projects are 5296 Hh / m^2, while masonry reached 1.1496 Hh / m^2. These values show that DW can be built twice as fast as masonry with the same number of workers. Due to the single process of installation of drywall construction solution, that cover both installation activities as well as plastering activity in one stage, drywall solution are reducing the consumed time by 60%.

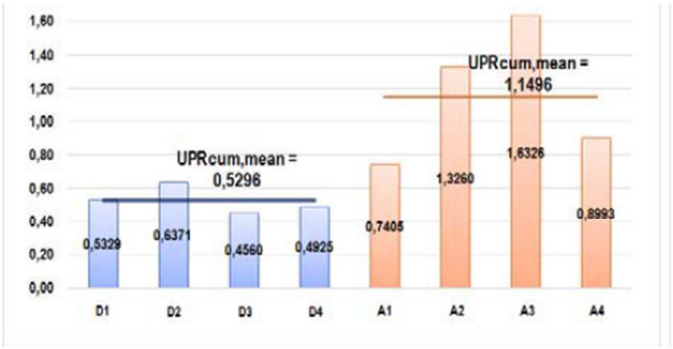
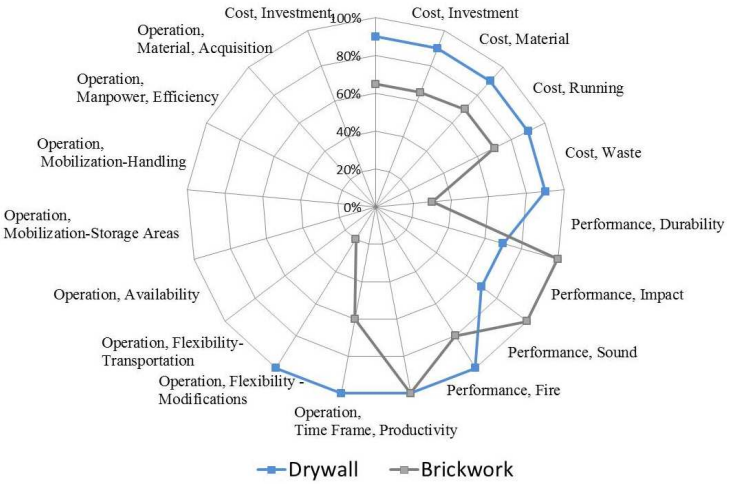


Figure 9 – Cumulative UPR for DW (D1 to D4) and masonry (A1 to A4) projects.

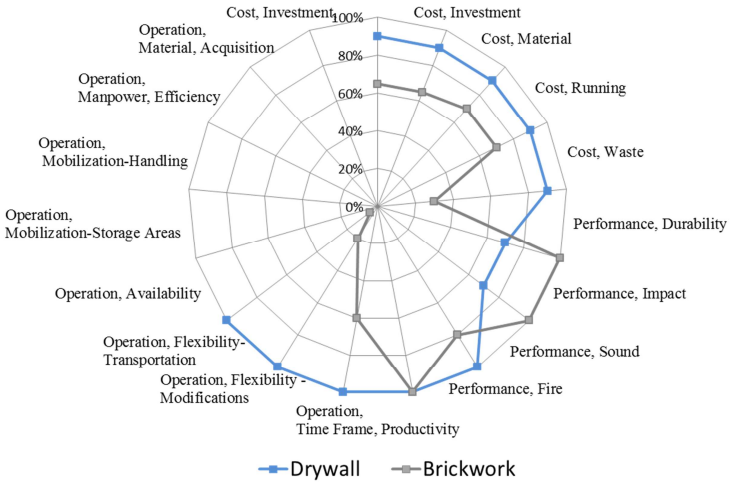
4.3.2. Flexibility, Modification

Due to the average weight of drywall construction solutions, which is approximately 30 Kg/m2, the future modification of the current designs will be done easy. Additionally, it is preferable to apply all drywall solution on the finish flooring layers. The future redesigning obstacle, which makes a big issue for the end-users are totally solved through the distributed lightweight that DW solutions are giving for. All structure systems are friendly dealing with DW, including steel structure systems. **End-user is allowed to modify his/her apartment without engineering pre-approvals.**



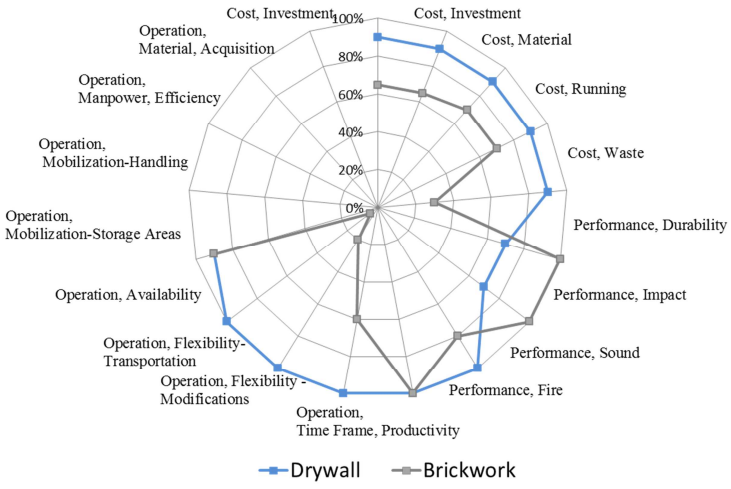
4.3.3. Flexibility, Transportation

Due to the lightweight characteristics of DW systems, in addition to packing techniques that Knauf uses to maintain the loading and unloading process of it products. Brickworks are zero competing with the DW solutions. One long truck can load 13,000 Pcs of blocks with an average of 220 m2, without plastering material. The same truck is capable to load 3,500 m2 complete systems from Knauf material, with high efficient loading space.



4.3.4. Availability.

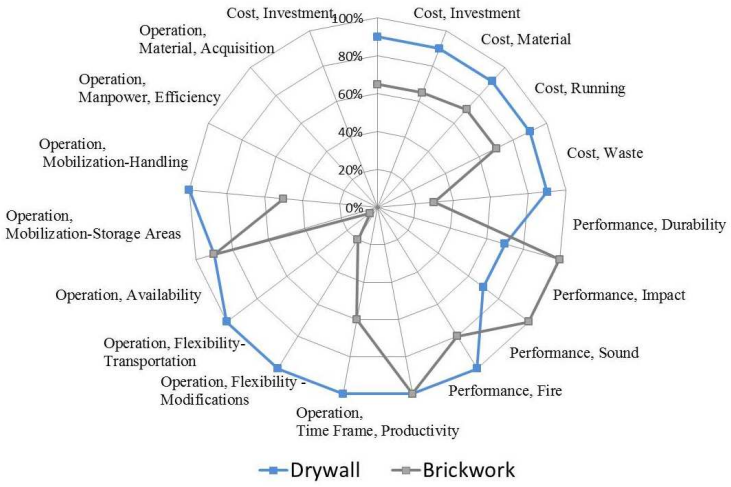
For local products, Knauf doubled its production capacity one year ago, enabling us to meet the requirements of the Egyptian market. For advanced products, Knauf increases the inventory level of Merchandizes products, meeting an approximate 150% of the expected demand. Also, Knauf is securing all material under one ceiling, which reduces the hassle of material purchasing procedures.

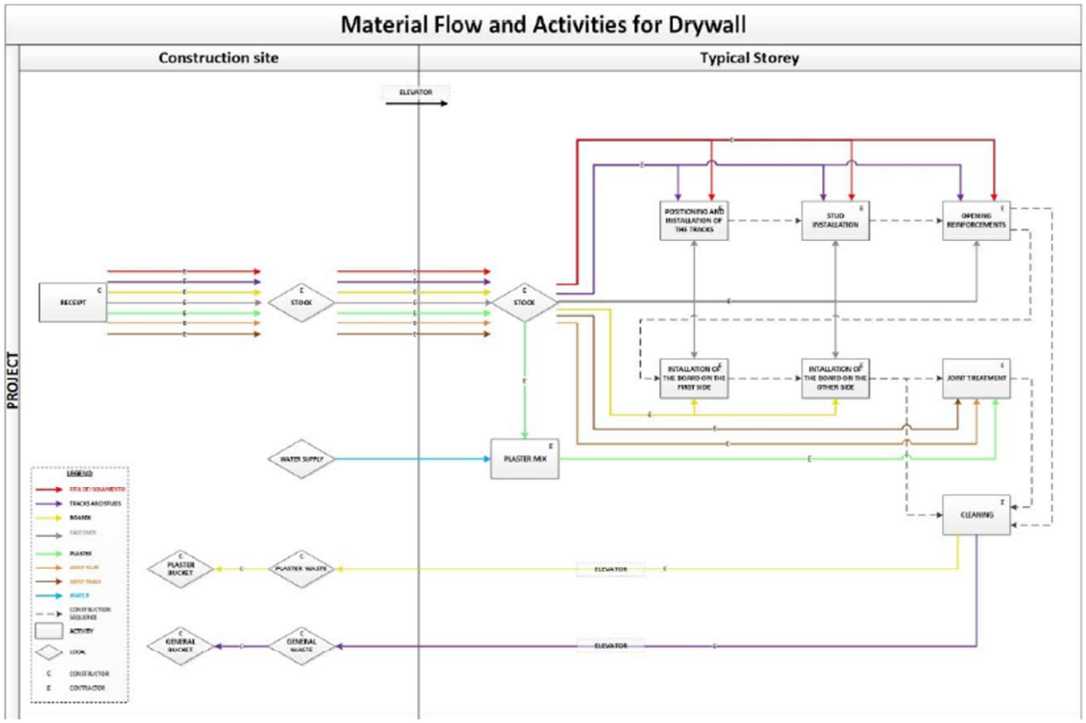


After reaching a certain point of approval for this concept of business model, Knauf will invest its efforts and money, to build up a virtual hub of Knauf Suez plant over there in Alamin area.

4.3.5. Mobilization, Storage Areas.

Constructions methods chosen for internal partitions walls have major impacts on organization and logistics at the job site. In order to understand it better two flowcharts shown in the following. They show how materials are transported and move and where services takes place. It is remarkable how the use of blockwall involves significantly more activities, more site areas and transportation facilities when comparing to DW.





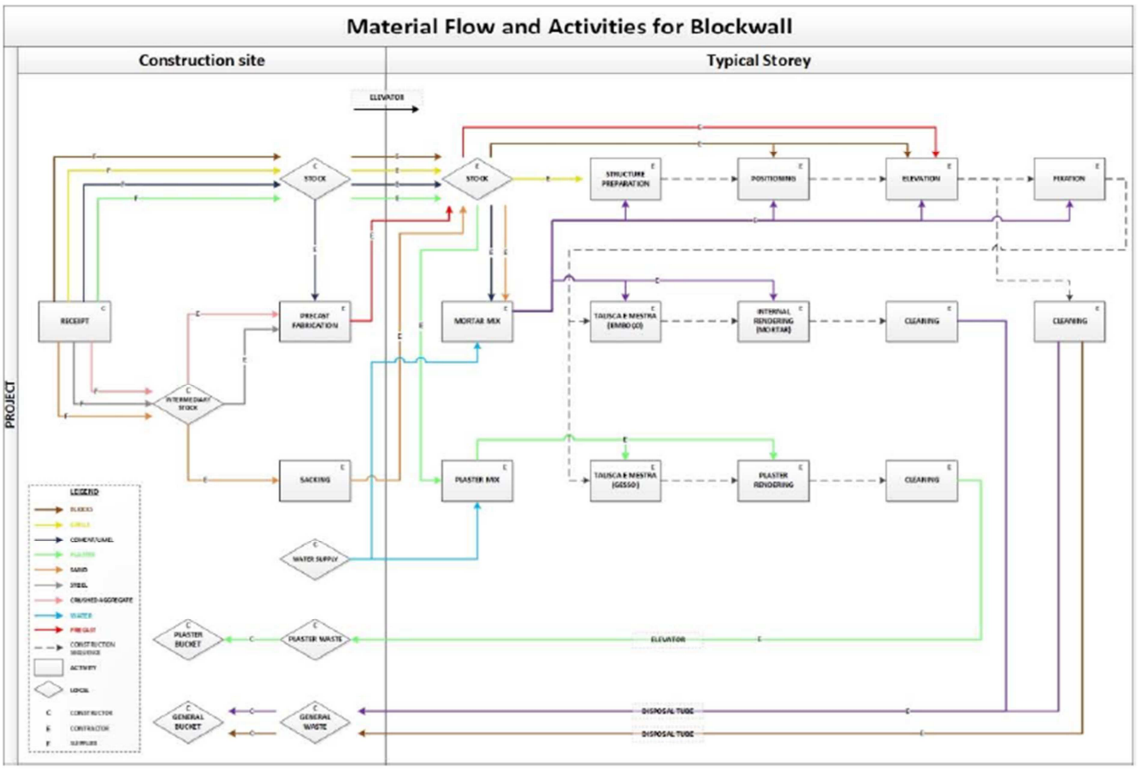
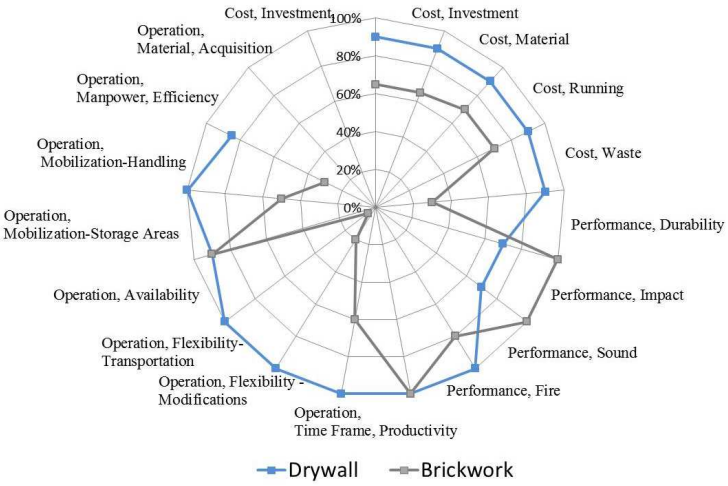


Figure 16 – Block stocks usually occupies a significant area inside the building to guarantee provision.

Figure 13 – Gypsum boards are also stocked inside the building but demands a smaller area

4.3.6. Mobilization, Handling

Daily activities of material flow from project's stock areas to installation locations made a very big hassle for Subcontractors and installers; they usually consume long time and efforts to keep all needed material of the daily works well maintained. Drywall construction solution is classified as a semi off-site material, as most of its components are produced in factories (Boards-Profiles-Accessories). This philosophy of semi prefabrication changed the model unit of each wall from 25*12*6 CM to 120*300*10 CM, which is quite efficient for internal maneuvering of products, in addition to the 90% less weight of dead loads.



a. Material reception in two of the projects studied

Figure 14 – Ceramic blocks are received at the construction site. General contractor manages acquisition and supply.

Figure 15 – DW studs profiles being delivered at the site. Supply and transportation is under installer control.

Figure 18 – Dry set bags of mortar for masonry are heavy and regular stocks.

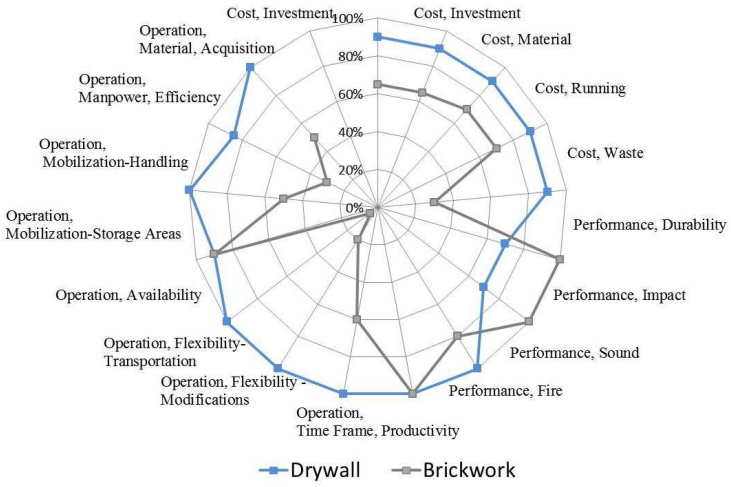
Figure 19 – Tracks and studs profiles stock placed outside the building without protection.

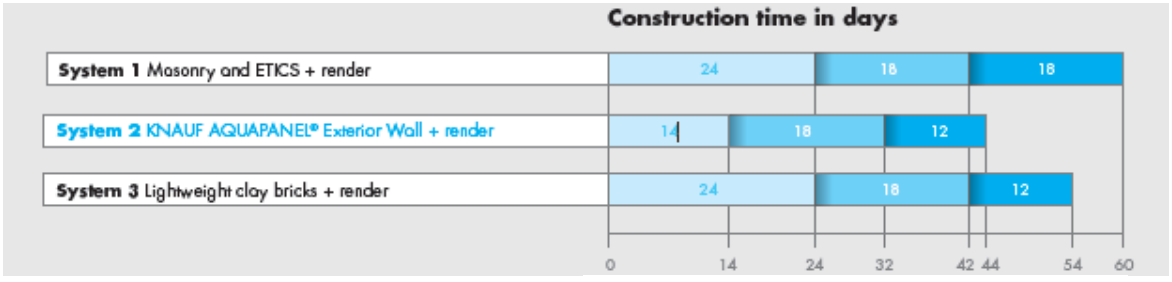
Figure 22 – Concrete blocks at the floor where masonry is just to be built.

Figure 23 – Gypsum board at he where DW is just to be installed.

4.3.7. Manpower, Efficiency

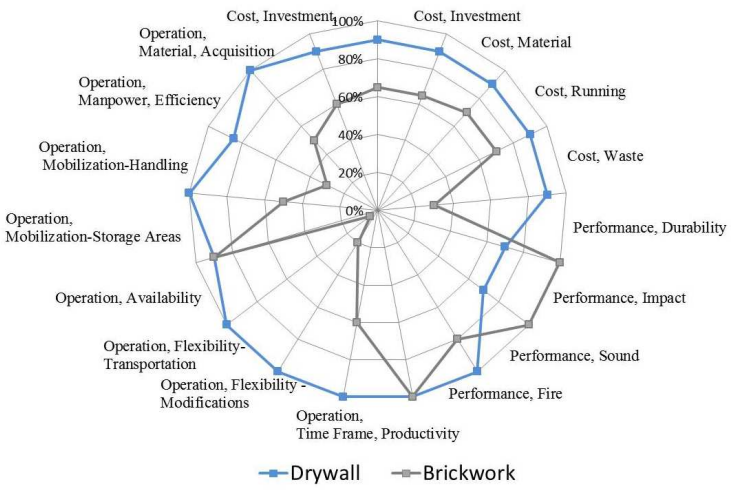
The following calculation shows that the KNAUF Exterior Wall can be built 10 days faster, which equates to an 18.5% time saving up to building envelope stage. Further time can be saved (26.7%) up to the end of the render stage. This calculation as well, assuming that all walls need a direct rendering on the final surfaces of boards, which is not existed in Alamin case study. Therefore, rendering time, which is 12 days less, will be totally deducted from the final timeline, as the fair surfaces of internal boars doesn't need rendering process.





Potential savings/lower investment costs can be achieved based on material and labor costs. The share of the KNAUF Wall building material and labor costs is lower compared with traditional masonry. Lower weight (up to 75% less) means a cheaper load bearing structure is possible than can be achieved using brick and block. The 100% performance is being the infinity ones, due to the unavailability of the each requested performance. Cost performance is being 1/X function, which is appear in a de creased position. Operation Flexibility performance is being a subject of timing, starting from the Mobilization process, passing through the installation positioning till the renovation end (Life Cycle Cost Management).

4.3.8. Material, Acquisition



There are some differences between DW and masonry wall related to materials acquisition and hiring of labor. The main difference is that DW is usually sold both materials and labor by combined price. Therefore, technical and commercial responsibility is more centralized when compared with masonry. There is a single subcontractor or supplier from whom the general contractor requires and purchases it. In masonry construction, all activities are more dispersed. General constructor usually requires and purchase blocks, mortar, grout and steel separately from different suppliers. This means that the masonry subcontractor do not take to whole work under its responsibility since materials and design are not included in the contract. Therefore, the general contractor have to deal with a larger number of suppliers, materials and logistics issues.

5. Final Value Module Diagrams Analysis