King Fahad University of Petroleum and Minerals
College of Environmental Design

Eastern School Compound Cladding

Mohammed Bader

ID # 984593

Instructor Dr. Saddi Assaf

Abstract
During the last decades, various types of exterior cladding systems have been applied to buildings in Saudi Arabia. The evaluation and selection of were based on the designer's experience, with no systematic approach used. An evaluation and selection technique is presented in this paper. It helps the designer to select the most suitable system based on a scientific way combined with his experience and knowledge. 10 systems are included in this study to evaluate.

Introduction
The importance of the exterior cladding in building projects has been growing in the last decades. The verity of exterior cladding systems is increasing due to the intensive development in this field for both nonresidential and residential buildings. The following factors favor this trend: (1) the continuous expansion in high-rise building, where the designer needs light materials; (2) ever stringent functional demands; (3) rising costs of building; and (4) increased awareness of architectural and aesthetic values.
In this paper, a methodological process is used to evaluate and select the most suitable exterior cladding systems for a school compound in the Dammam city. After gathering adequate information about the project, we will make a list of many proposals as much as possible, which are collected from the field experts. These experts listed the most usable and desirable cladding systems in the region's market. Then, we will use many evaluation techniques to evaluate each system to come up with the most suitable systems that meet our criteria.

Methodology
The job plan followed in this study is as follows:

I. Gathering Information Phase
II. Speculation Phase
III. Evaluation Phase
IV. Development Phase

I. Gathering Information Phase

In this phase, all of the information we have related to the project must be prepared and documented in details, to provide us a good understanding for the problem before create solution.

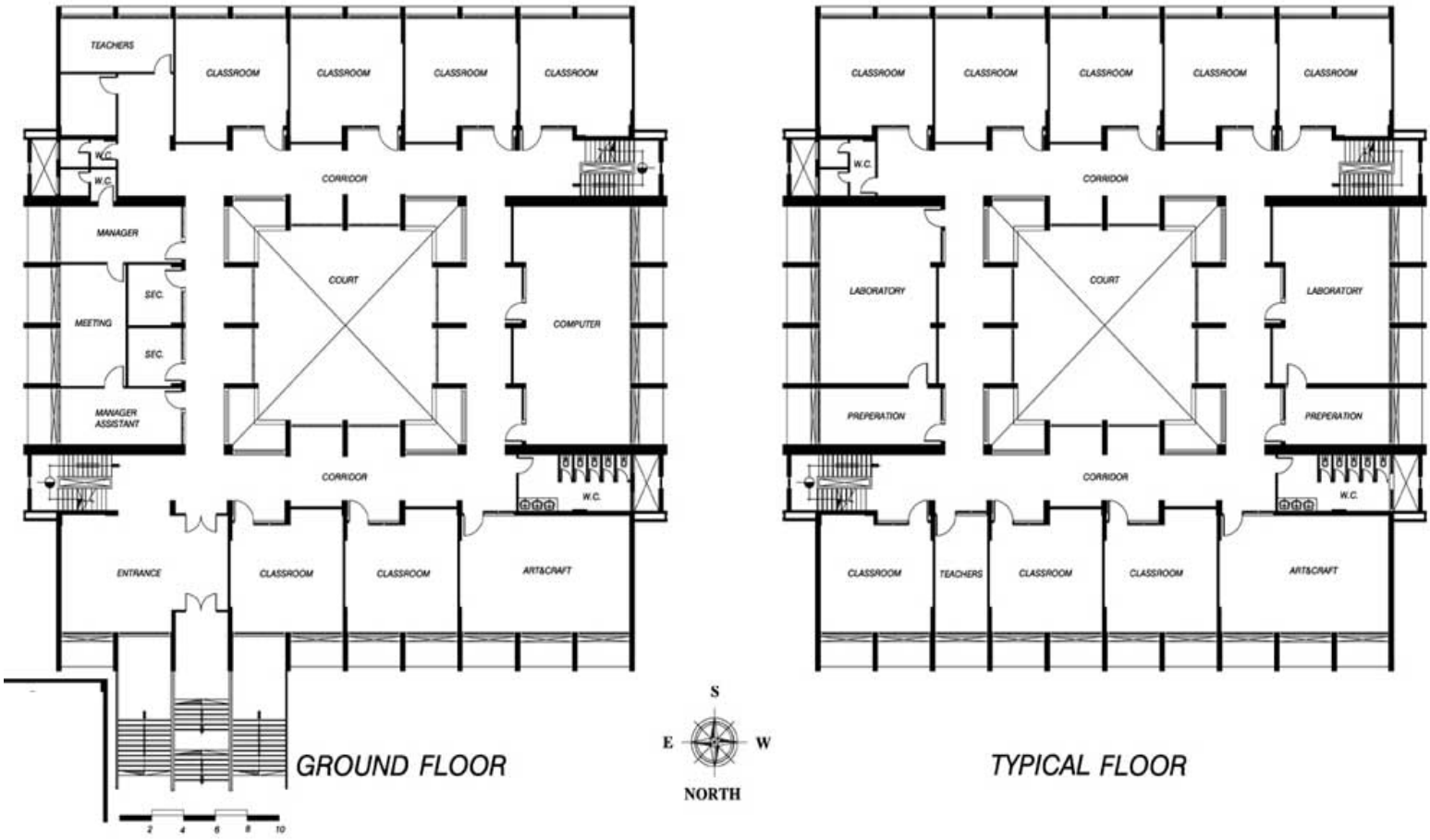
The Project

My project is a school compound, which has the following features:

- Four schools located in Dammam city
- Total area of the terrain is around 9000 M^2
- The area of each school is around 1225 M^2
- Each School has 3 typical floors, and the height for each floor is 3.5 M
- Each School has around 1890 M^2 cladding area

Fig1. School Compound Plan

Fig2. Typical and Ground Plans



Basic Functions

The basic functions of the exterior cladding are:

1. Cover the building
2. Protect the building
3. Presents the design

Objectives

The main objectives of the exterior cladding are:

- Acceptable initial cost
- Low maintenance cost
- Weather resistant
- Good look

Sources

I collected all the information I need from the following sources

1. Building Products Company (BPC), Eng: Amer Awad (Regional Manager)
2. GEMCO, Mr: Malek (Sales Manager)
3. My experience in the building materials

II. Speculation Phase

After collecting adequate information about our project, it's the time now to generate ideas and proposals.

Exterior Cladding Systems

Based on information gathering from the field experts who work in the exterior cladding systems, the following table presents 10 different types of cladding systems.

Table 1. Exterior Cladding Systems

Number	System	System Assemblies
1	Masonry Block Wall	Covered by painting over a plastering layer
2	Ceramic cladding	Installed over a plastered layer by using a waterproof adhesive
3	Marble cladding	Installed over a plastered layer by using a waterproof adhesive or mortar
4	Brick cladding	Grouted brick walls
5	Concrete	Cured in-site
6	Cement board	Installed over a steel structure
7	Precast concrete wall	Installed over s stud system, with exterior finishing
8	Clay pave cladding	Precast concrete wall panels, cured off-site
9	Speed Wall (ASK board)	Installed over s steel structure
10	Granite cladding	Installed over a plastered layer by using a waterproof adhesive or mortar

Fig 3. Claypave Cladding

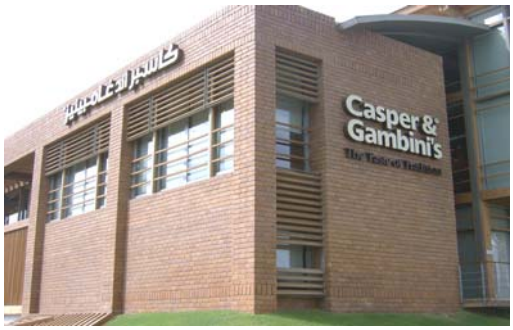


Fig 4. Cement Board Cladding

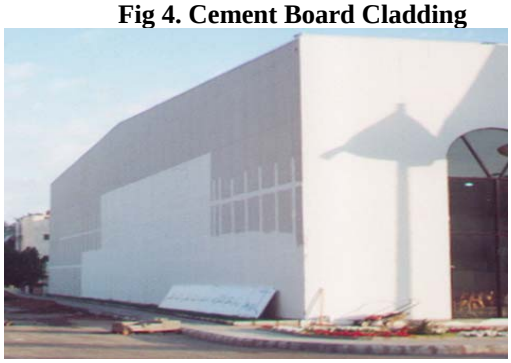


Fig 5. Aluminum panels

Fig 6. Stainless Steel Cladding

III. Evaluation Phase

In this phase, a methodological procedure will be applied and followed to come up with the most suitable solution.

A. Evaluation by Comparison

The next step is to select the most feasible combination of ideas and compare them. Listing the advantages and disadvantages of each type can do this.

Table 2. Evaluation by Comparison

No.	Alternative	Advantages	Disadvantages	Rank
1	Finished Masonry Block Wall	• Low initial cost • Materials are available • Many finishing alternatives are available • Fast implementation time • Low install cost • Well known method	• Repainting is needed frequently • Water resistance is low	1
2	Ceramic cladding	• Durability • Low maintenance • Water resistant • Materials are available • Many colors are available • Can't be scratched	• Long install time • Needs skilled labors • Not compatible for exterior villa cladding	5
3	Marble cladding	• Materials are available • Many colors are available • Best aesthetics	• High initial cost • Long install time • Needs skilled labors • Can be scratched	6
4	Red Brick cladding	• Materials are available • Durability • Good aesthetics • Good thermal isolator • Fire resistant	• Long install time • Needs skilled labors • Not well know in the region	8
5	Concrete	• Well known material • Many finishing methods are available • Available	• Needs a fabrication and curing time • Frequent maintenance • Long install time • Bad water resistant • Requires a finishing in the surface	7
6	Precast Wall	• Excellent for large or repeated project • Available • Different design and shape could be • Fast in installation	• Uneconomic for small project	9

7	Cement board	• Available • Pintable • Light material • Many finishing options are available • Short time install • Low initial cost	• Needs a fabrication time • Needs skilled labors • Bad fire resistant	4
8	ASK board	• Light material • Pintable • Fire resistant • Short time install • Low initial cost	• Not always available • Not well known material	2
9	Clay pave	• Many colors and textures available • Good aesthetics • Low water absorption	• High initial cost • Needs skilled labors • Long time install • Not always available	10
10	Granite cladding	• Many colors available • Water absorption is low • Good aesthetics • Very solid material • Available • Local manufactured • long span life	• Needs skilled labors • Long time install • High initial cost	3

After using the evaluation by comparison method, we will exclude the lowest six alternatives, which are ***clay pave, precast wall, red brick cladding, concrete, marble and ceramic cladding.***

B: Weighted Evaluation

In this evaluation, we have the last two techniques in our evaluation process, paired comparisons and evaluation matrix.

1.Paired Comparison

It's used to determine the weights of importance to be assigned for each criterion. In this assignment we assume 14 important criteria, which are:

A. Initial cost
B. Aesthetics
C. Strength
D. Install time
E. Durability
F. Maintenance cost
G. Fire Safety
H. Availability
I. Flexibility
J. Thermal Property
K. Compatibility
L. Cladding size
M. Weather Resistance
N. Weight lightness

To get the relative weight of each criterion, the techniques of probability and expected value were used. Each criterion has five outcomes, and each outcome is assigned a weighted random variable. Table 4 shows the evaluation terms with their weights.

The following figure shows the criteria-scoring matrix. It illustrates the importance of every criteria comparing with the other.

Figure 7. Criteria Scoring Matrix

B	C	D	E	F	G	H	I	J	K	L	M
A-2	C-2	A-4	A-2	A-3	A-3	A\H	A-4	A-3	A-3	A\L	A-4
B	C-2	B-3	B\E	F-2	B-2	H-2	B-2	B-2	B-2	L-2	B-3
	C	C-4	C\E	C-2	C\G	H-2	C-3	C-3	C-2	C\L	C-4
		D	E-3	F-2	D\G	H-3	D/I	J-2	D\K	L-3	D\M
			E	E\F	E-2	H-2	E-2	E-2	E-3	E\L	E-3
				F	G-2	H-4	F-2	F\J	F-2	L-2	F-3
					G	H-4	G\I	G\J	G\K	L-3	G\M
						H	H-4	H-4	H-4	H-2	H-4
							I	J-2	I\K	L-3	I\M
								J	J\K	L-2	J-2
									K	L-3	K-2
										L	L-3

How important:

4. Major Preference
3. Medium Preference
2. Minor Preference
1. No. Preference

From the above figure we can extract the following table:

Table 3. Evaluation Criteria and Their Relative Weights

No.	Criteria	Raw Score	Assigned Weight
A	Initial Cost	30	83.3
B	Aesthetics	15	41.6
C	Strength	25	69.4
D	Install Time	4	11.1
E	Durability	19	52.7
F	Maintenance Cost	13	36.1
G	Fire Safety	8	22.2
H	Availability	36	100
I	Flexibility	3	8.3
J	Thermal Property	9	25
K	Compatibility	6	16.7
L	Weather Resistance	24	66.6
M	Wight Lightness	3	8.3

C. Evaluation Matrix

Once the criteria elements and their weights have been established, the next task is to use these in evaluating the alternatives selected from the feasibility ranking and comparison techniques. In this process, all remaining alternatives from the previous screening stages will be evaluated against the aforementioned criteria. It's assumed that all the alternatives that have survived meet the minimal needs or basic functions of the owner or the user. The scoring system used in this analysis matrix involves assigning 1-5 points on a scale of poor to excellent. The ranks of each alternative were multiplied by the corresponding weights of the criteria, and the resulting scores entered into the matrix. The total scores were then determined for each alternative

The ranking level will be as the follows:

1. Poor
2. Fair
3. Good
4. Very Good
5. Excellent

The following table shows the evaluation matrix

Table 4. Analysis Matrix

	Initial cost	Aesthetics	Strength	Install time	Durability	Maintenance Cost	Fire Safety	Availability	Flexibility
Finished Masonry Block Wall	**8.3**	**4.2**	**7**	**1.1**	**5.3**	**3.6**	**2.2**	**10**	**0.8**
	E	E	E	E	E	E	**E**	**E**	E
	VG	**VG**	**VG**	**VG**	VG	VG	VG	VG	**VG**
	G	G	G	G	**G**	**G**	G	G	G
	F	F	F	F	F	F	F	F	F
	P	P	P	P	P	P	P	P	P
SUBTOTAL	**33.2**	**16.8**	**28**	**4.4**	**15.9**	**10.8**	**11**	**50**	**3.2**

	Thermal Property	Compatibility	Weather Resistance	Wight Lightness	
Finished Masonry Block Wall	**2.5**	**1.7**	**6.6**	**0.8**	
	E	**E**	E	E	TOTAL
	VG	VG	VG	VG	RANK 2
	G	G	**G**	G	
	F	F	F	**F**	
	P	P	P	P	
SUBTOTAL	**12.5**	**8.5**	**19.8**	**1.6**	**215.7**

	Initial cost	Aesthetics	Strength	Install time	Durability	Maintenance Cost	Fire Safety	Availability	Flexibility
ASK Board	**8.3**	**4.2**	**7**	**1.1**	**5.3**	**3.6**	**2.2**	**10**	**0.8**
	E	E	E	**E**	**E**	E	**E**	E	E
	VG	VG	**VG**	VG	VG	**VG**	VG	VG	**VG**
	G	**G**	G	G	G	G	G	G	G
	F	F	F	F	F	F	F	**F**	F
	P	P	P	P	P	P	P	P	P
SUBTOTAL	**41.5**	**12.6**	**28**	**5.5**	**26.5**	**14.4**	**11**	**20**	**3.2**

	Thermal Property	Compatibility	Weather Resistance	Wight Lightness	
ASK Board	**2.5**	**1.7**	**6.6**	**0.8**	
	E	E	**E**	**E**	
	VG	**VG**	VG	VG	TOTAL
	G	G	G	G	RANK 1
	F	F	F	F	
	P	P	P	P	
SUBTOTAL	**12.5**	**6.8**	**33**	**4**	**219**

	Initial cost	Aesthetics	Strength	Install time	Durability	Maintenance Cost	Fire Safety	Availability	Flexibility
	8.3	**4.2**	**7**	**1.1**	**5.3**	**3.6**	**2.2**	**10**	**0.8**
	E	E	**E**	E	**E**	E	**E**	**E**	E
	VG	**VG**	VG	VG	VG	**VG**	VG	VG	VG
	G	G	G	G	G	G	G	G	G
	F	F	F	**F**	F	F	F	F	F
Granite Cladding	**P**	P	P	P	P	P	P	P	**P**
SUBTOTAL	**8.3**	**16.8**	**35**	**2.2**	**26.5**	**14.4**	**11**	**50**	**0.8**

	Thermal Property	Compatibility	Weather Resistance	Wight Lightness	
	2.5	**1.7**	**6.6**	**0.8**	
	E	E	**E**	E	
	VG	VG	VG	VG	TOTAL
	G	G	G	G	RANK 3
	F	**F**	F	F	
Granite Cladding	P	P	P	**P**	
SUBTOTAL	**10**	**3.4**	**33**	**0.8**	**212.2**

	Initial cost	Aesthetics	Strength	Install time	Durability	Maintenance Cost	Fire Safety	Availability	Flexibility
Cement Board	**8.3**	**4.2**	**7**	**1.1**	**5.3**	**3.6**	**2.2**	**10**	**0.8**
	E	E	E	**E**	E	E	E	E	**E**
	VG	**VG**	VG	VG	VG	VG	VG	**VG**	VG
	G	G	G	G	**G**	**G**	G	G	G
	F	F	**F**	F	F	F	**F**	F	F
	P	P	P	P	P	P	P	P	P
SUBTOTAL	**41.5**	**16.8**	**14**	**5.5**	**15.3**	**10.8**	**4.4**	**40**	**3**

	Thermal Property	Compatibility	Weather Resistance	Wight Lightness	
Cement Board	**2.5**	**1.7**	**6.6**	**0.8**	
	E	E	E	**E**	
	VG	VG	VG	VG	TOTAL
	G	**G**	**G**	G	RANK 4
	F	F	F	F	
	P	P	P	P	
SUBTOTAL	**5**	**5.1**	**19.8**	**4**	**185.2**

IV. Development Phase

In this phase, we will ensure that the selected alternatives meet the user's requirements. Also we will try to calculate the initial and maintenance cost of the selected system and trying to create a solution which can reduce the total cost with marinating the same quality and the basic function.

Costs

The following tables shows the initial and maintenance costs for ASK board and masonry block wall.

Table5. Initial and Maitenance Cost

	ASK Board	Masonry Block Wall
Initial Cost \ M²	130	80
Maintenance & Painting cost \ year\ M²	10	5

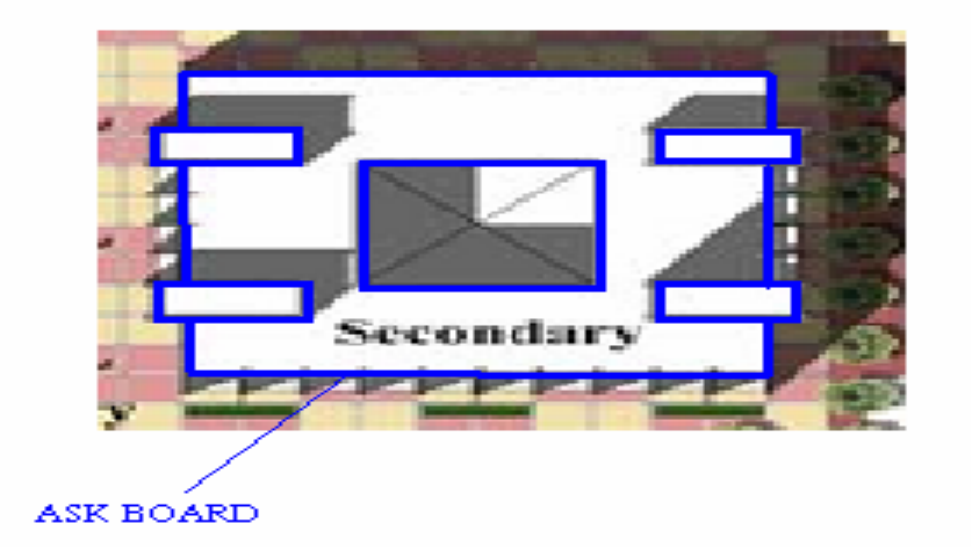
Cost Calculation

When we clad the building with ASK board, we will get the following result:

- Initial Cost=1890*130=**245600** SR\building
- Cost of the 4 buildings = **982800 SR**

- Maintenance Cost = 1890 * 10 = 18900 SR\year\ M²
- Cost of maintenance for 4 building = 75600 \year \ M²

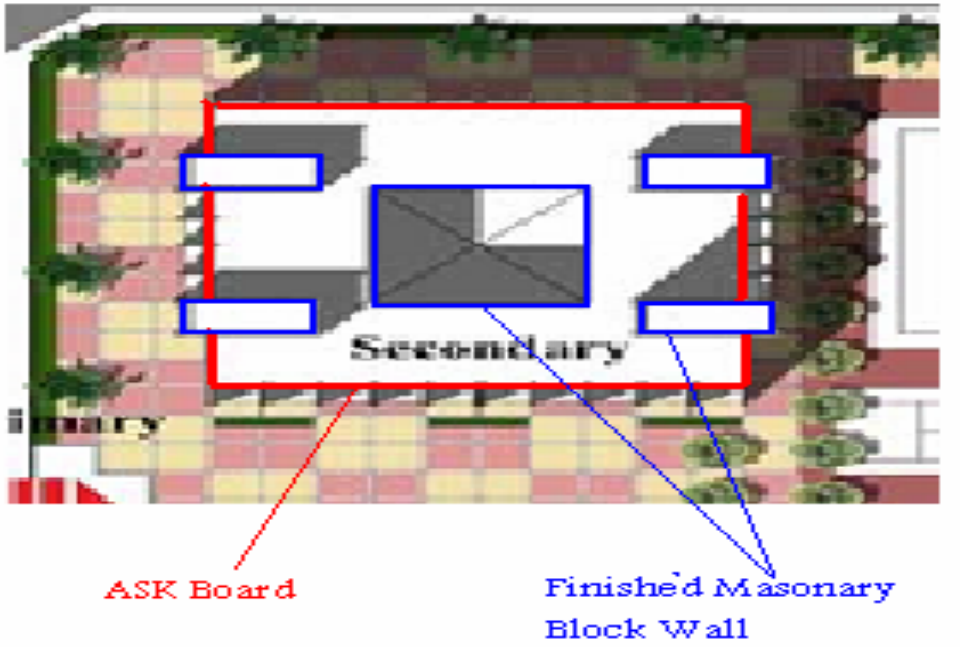
Fig8: ASK board is used for the all of the building



Another Solution

It's the time now to develop a method which reduces the cost of the cladding. So, a combination of two different types of cladding can be used in the project without affecting the basic function of the building, as shown in the picture

Fig9: ASK board is used around the building in the most important areas which present the building design and protect it, and masonry block wall used in less important area like the interior core and the stair walls.



- Cost Initial Cost= (1470 M^2 * 130 SR) + (420 M^2 * 80SR)
  = 191100 + 33600 = **224700** SR
- Total Initial Cost = **898800** SR
- Total Saving Percent = (982800-898800)\982800 * 100 = 8.5 %

- Maintenance and Painting Cost = (1470 M^2 * 10) + (420 M^2 * 5)
  = 14700 + 2100 = **16800** SR \ yr \ M^2
- Total Maintenance Cost = **67200** SR \ yr \ M^2
- Total Saving Percent = (75600- 67200) / 75600 * 100 = 11.1 %

Conclusion

this paper presented a proposed method of evaluating and selecting exterior cladding systems witch utilized the value engineering principles. The method depends on a survey of the existing exterior cladding systems used in the region, and, in this particular case, 10 different exterior cladding systems were identified. Also, this method requires identification of the main criteria needed to evaluate the systems.

The final results of this paper shows that ***ASK board*** and ***Finished Masonry Block Wall*** are the most suitable cladding system in our region.