PRELIMINARY EVALUATION OF SELECTING AND SPECIFYING FINISHING MATERIALS FOR CONCRETE BUILDINGS IN THE EASTERN REGION

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ABSTRACT

The selection and specifying of inappropriate finishing materials is widely realized in various, small building projects and even some large projects. Inappropriate selection or inadequate finishing materials means premature failure of finishing materials that requires rehabilitation of the buildings in short intervals. This results in weakening the country's economy, since most of the finishing materials are imported from outside of the kingdom, in addition to the negative effect of deteriorated finishing materials in the facade of the buildings on the cityscape. This paper presents the result of the study to evaluate the process of selecting and specifying finishing materials during design stage for concrete buildings in the Eastern Region. The study was conducted through questioner that has been distributed to most Engineering Design Offices in the Eastern Region. The primary results of the questionnaire have shown that the majority of the participated Engineering Offices do not select and specify finishing materials especially for small and medium size projects. More than 50% of offices had received complains regarding finishing materials just within the first four years of building occupancy.

Keywords: *Survey, finishing materials, selection, specifications.*

الملخص

اختيار و توصيف مواد تشطيب غير ملائمة يلاحظ بكثرة في مشاريع متنوعة صغيرة بل وحتى في بعض المشاريع الكبيرة. الاختيار الغير مناسب لمواد التشطيب يعني الفشل المبكر لمواد التشطيب مما يتطلب أعمال ترميم وصيانة خلال فترات قصيرة. مما يؤدي إلى أضعاف الاقتصاد الوطني خصوصاً وان اغلب مواد التشطيب تستورد من الخارج. هذا بالإضافة إلى الأثر السلبي الذي تتركه مواد التشطيب المتدهورة في واجهات المباني على واجهة المدينة. تعرض هذه الورقة نتيجة دراسة تقييم اختيار وتوصيف مواد التشطيب خلال مرحلة التصميم للمباني الخرسانية في المنطقة الشرقية وذلك من خلال استبيان تم توزيعه على المكاتب الهندسية العاملة في المنطقة الشرقية. وتشير النتائج الأولية للاستبيان إلى أن نسبة كبيرة من المكاتب الهندسية لا تحدد مواد التشطيب ومواصفاتها أثناء التصميم وخاصة للمشاريع الصغيرة والمتوسطة. و تشير النتائج إلى أن اكثر من نصف المكاتب تتلقى شكاوى تتعلق بتدهور بعض مواد التشطيب خلال الأربع السنوات الأولى من إشغال المبنى.

1. INTRODUCTION

Failures of materials, construction and other parts of buildings, dissatisfaction with the environment and other criticisms about modern building have been frequently reported in the press, and discussed at conferences. The Arabian Gulf seaboard constitutes one of the most aggressive environments for concrete buildings durability in the world. Reduction in the useful service-life of concrete building materials is a major constraint on the economy of the Gulf Region countries. The low durability performance of these materials is due to several interactive factors. These are determined mainly by the adverse climate and geomorphic conditions in conjunction with inadequate material specifications and construction practices [Al-Saadoun, et al,1992]. Finishing materials are the building's first line of defense against weather and other destructive factors. Durable exterior and even interior finishing materials provide major protection for the concrete structural systems. Premature failures in finishing materials usually will lead to failures in structural components of the building at early time of building's life. Finishing materials are considered as the interface between the environment and the structural systems. The selection and specifying of inappropriate finishing materials is widely realized in various, small and medium size building projects and even some large projects. This indicates the lack of proper selection of finishing materials that suit the environment conditions in the region. [Allen, 1985]

Four parties are involved in building construction: architects and engineers, contractors, consultants, and owners. The problem of premature material failures could be the responsibility of one or more than one party. For, example, owner may initiate change of material used during construction or/and contractor may substitute some materials, or engineering office did not specify suitable materials. This lead to unanswered question on who is/are responsible for premature materials failure. The main object of this study is to investigate the role of consultants in materials selection and specification.

2. CONSULTANTS SURVEY

For the purpose of achieving the objective of this study, a questionnaire was developed to collect the needed data to investigate and evaluate the processes of selecting and specifying finishing materials for concrete buildings. The questionnaire consists of two parts. The first part contains general questions that describe the Engineering Design Offices (Participants). The second part consists of ten (10) questions related to the criteria and ways for selecting and specifying finishing materials.

The questionnaire does not investigate the number of projects or number of complains. All answered questions represent the engineering offices responses without detail in number of projects or complains.

A total of 20 copies of the developed questionnaire were distributed by mail to the executive of the Engineering Design Offices in the Eastern Region of Saudi Arabia. The names and

addresses of the Engineering Design Offices were taken from the Chamber of Commerce & Industry for the Eastern Province, which has a list of thirty (30) registered Engineering Offices. However, out of the (30) Engineering Offices, only (20) of them are active in the field of Design and supervision of building projects. To insure getting as much as possible responses, the questionnaires were sent with prepaid and self-addressed envelope for their responses. Unfortunately, only three (3) responses were received by mail. Another eighteen (17) copies of the questionnaires were distributed to the Engineering Design Offices by hand as an attempt to increase the number of responses to the questionnaire. Out of eighteen (17) Engineering Design Offices visited, only eight (8) participated in the study. After second and third visit, most of them said that they do not have time to fill-in the questionnaire. As a result, a total of eleven (11) responses were collected.

3. DATA ANALYSIS.

The answers that were collected from the participants were tabulated and analyzed individually. Simple mathematical techniques, such as percentage and average were used in analyzing the collected data. In addition to these techniques, there is one statistical tool called "Severity Index (I_s)" that was used to analyze question number five. This method is carried out for each factor in order to know its importance with respect to the other factors based on the number of respondents selecting this factor and on the criteria by which they select it. After the (I_s) value is calculated for each factor, these factors are ranked in order according to their importance in level of criteria given that is according to the highest value of (I_s).

The formula used to calculate the Severity Index (I_s) is as follows [Al-Dabbas, 1989]:

$$I_s = \sum_{I=1,n} \alpha_i \, x_i \, / \text{ Number of x's}$$

Where: x_i = Constant expressing the weight given to i^{th} responses

α_i = Variable expressing the frequency of i^{th} responses

Example:
X1 = the frequency of "Extremely Important" response, $\alpha = 5$
X2 = the frequency of "Very Important" response, $\alpha = 4$
X3 = the frequency of "Important" response, $\alpha = 3$
X4 = the frequency of "Less Important" response, $\alpha = 2$
X5 = the frequency of "Not Important" response, $\alpha = 1$

4. ANALYSIS OF THE RESULT.

The analysis is divided into four parts; Characteristics of Participants, Selection of Finishing Material during design stage, Selection of finishing material during construction stage, and Participants Comments. After analyzing the responses, the following are observed:

4.1 Participants Profile.

The participated Engineering Design Offices are involved in different types of projects as shown in Table 1. Most of them are involved in more than one type of projects. Their rank for the types of projects they are mostly involved in was given weight from 5 to 1 where rank no. 1 represents the type of project that participants are involved in most of the time and it is given weight 5. The total weight for each type of projects and their corresponding percentage are calculated and tabulated in Table 1. Sample of calculation for the first item is shown below:

$$\text{Total Weight} = 9x5 + 0x4 + 1x3 + 1x2 + 0x1 = 50$$

The majority (82%) of the participated Engineering Offices has less than twenty (20) Engineers as shown in Figure 1. This indicates that they are small firm. However, small Engineering Offices as a total contribute heavily in the construction industry in the Eastern Province since they design and supervise the construction of most wide varieties of small and medium size residential and commercial building projects. Their assessment in this study has a great credibility.

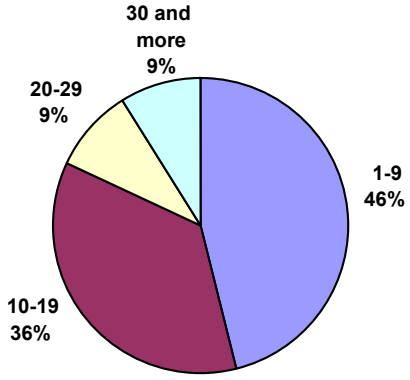

Figure 1 Number of Engineers of the Participants

The approximate annual business revenue of the participating Engineering Offices are tabulated in Table 2. The participants have different annual business volume, however, the majority of them have less than one million Saudi Riyals annual business volume. The total sample of the participating Engineering Design Offices is divided into five (5) groups according to their approximate annual business volume and the number of Engineers they employ as shown in Table 2.

This indicates differences among the responses of the various size groups. Group number 1 represents large Engineering Design Offices while group number 5 represents the smaller Engineering Offices with less number of engineers. There is a correlation between annual business volume and number of engineers as seen in Table 3.

Table 1 Types of projects that the Participating Engineering Offices are involved in.

Project Type		**No. of Participants**					**Total Weight**	**%**
	Rank	**1**	**2**	**3**	**4**	**5**		
	Weight	**5**	**4**	**3**	**2**	**1**		
Building Projects		9		1	1		50	60
Electrical Projects			2	1			11	13
Civil Utilities Projects			1	1	1		9	11
Mechanical Projects		2			1		12	14
Chemical Projects						2	2	2
Total		**11**	**3**	**3**	**3**	**2**	**80**	**100**

Table 2 Approximate Annual Business Volume of the Participants.

Approximate Annual Business Revenue	**Group**	**No. of Participants**	**%**
Less than SR 1 Million	**5**	5	46
SR 1 Million – less than 4 Million	**4**	3	27
SR 4 Million – less than 7 Million	**3**	1	9
SR 7 Million – less than 10 Million	**2**	1	9
More than 10 Million	**1**	1	9
	Total	**11**	**100**

Table 3 Numbers of the Participants according to their group & Number of Engineers.

No. of Engineers	**Group**					**Total**	**%**
	1	**2**	**3**	**4**	**5**		
30 and more	1					1	9
20 – 29				1		1	9
10 – 19			1	2	1	4	36
1 - 9		1			4	5	46
Total	**1**	**1**	**1**	**3**	**5**	**11**	**100**

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4.2 Selection of Finishing Materials During Design Stage

The first important thing to know about the selection of finishing materials is whether the participated Engineering Design Offices select and determine the specifications of finishing materials in the building projects or not.

Table 4 Selection and Specifying of Finishing Materials

Do you usually select and determine specifications of the finishing material?	Group					Total	%
	1	2	3	4	5		
Yes, in all projects	1		1	1	1	4	36
Yes, in big projects only				2	3	5	46
No		1			1	2	18
Total	**1**	**1**	**1**	**3**	**5**	**11**	**100**

From Table 4, 18 % of the participants do not select and specify finishing materials at all. As expected, larger Engineering Design Offices select and specify finishing materials in all their projects. High percentage (46 %) of the participants selects and specifies finishing materials in big projects only. These participants are from various groups. This means that for small and medium size projects, 64 % of the participating Engineering Offices do not select and specify finishing materials. This explains the lack of suitable selection of finishing materials in large varieties of small and medium size residential and commercial buildings mentioned before.

The participated Engineering Offices who select and specify finishing material in all or some of their projects were asked to assess the importance of the factors that they usually consider in selecting the finishing materials. The responses were analyzed using the Severity Index (I_s) in order to rank the factor according to their importance.

Table 5 shows the responses of the participated Engineering Offices and the Severity Index (I_s) for each factor. To illustrate the method of calculating I_s , computation for the first factor is calculated as follows:

$$I_s = [\ (4x5) + (1x4) + (3x3) + (0x2) + (0x1)\ ]/5 = 33/5 = 6.6$$

Table 5 Severity Index of the factors that are usually considered in selecting the finishing materials.

Factors	X1	X2	X3	X4	X5	I_s
Material properties and durability	4	1	3	--	--	6.6
Availability of the material	2	4	3	--	--	7.0
Ease of installation	--	3	5	--	--	5.4
Cost of material	1	4	4	--	--	6.6
Material installing location	1	1	5	3	--	6.0
Suitability and performance of the material in hot, humid areas	3	3	3	--	--	7.2
Maintenance/Spare Parts	1	--	--	--	--	1.0
Aesthetic Factors	--	1	--	--	--	0.8

Table 6 shows the rank order of the factors that are usually considered in selecting the finishing materials according to their importance for the participants. The rank shows that the participants are giving the suitability and performance of the material in hot, humid areas more priority than cost of the material in selecting the finishing materials. While this seems to be a good practice in selecting the finishing materials, it may not be the actual practice as it is realized in wide varieties of buildings in the Eastern Province. The design engineers may not relate finishing materials properties to the characteristics of existing environment and climate such as maritime desert climates that exist in the Eastern Province. Some of the factors have the same rank because they are of the same importance. The participants have added the last two factors.

Table 6 Rank order factors that are usually considered in selecting the finishing materials based on their Severity Index (I_s)

Factors	Rank
Suitability and performance of the material in hot, humid areas	1
Availability of the material	2
Cost of material	3
Material properties and durability	3
Material installing location	4
Ease of installation	5
Maintenance/Spare Parts	6
Aesthetic Factors	7

In question number six of the questionnaire, the participants were asked how do they select the finishing materials. The responses are shown in Table 7. Forty two percent (42 %) of the participants select the finishing materials based on the general knowledge and past experience while only five percent (5%) select based on client's desire. The total number of responses is more than the number of the participated Engineering Offices because some participants use more than one way in selecting finishing materials.

Table 7 Ways of selecting finishing materials

How do you select the finishing materials?	**No. of Responses**	**%**
Based on general knowledge and past experience	9	42
From building material catalogs	5	24
Based on manufacturer brochures	5	24
Based on client's desire	1	5
Business-mate recommendation	1	5
Total	**21**	**100**

While the right place to specify the selected finishing materials is in the project's technical specifications, almost forty three percent (43 %) out of those who specify finishing materials do so. The majority of the other participants specify finishing materials in the project's plans and drawings as shown in Table 8

Table 8 Methods of specifying the selected materials.

Where do you specify the selected materials?	**No. of Responses**	**%**
In the project's plans and drawings	7	50
In the project's technical specifications	6	43
In the contract's special conditions	1	7
Total	**14**	**100**

Table 9 shows the participants responses regarding the type of specifications they are using in specifying finishing materials for both public and private projects. The result had shown that the majority of them use descriptive specifications for public projects and performance specifications for private projects. The total number of responses is more than the number of the participated Engineering Design Offices because some participants use more than one type of specifications.

Table 9 Types of Specifications of finishing materials for both Public and Private Projects

Types of Specifications	Public Projects		Private Projects	
	No. of Responses	%	No. of Responses	%
Descriptive specifications	4	27	3	25
Performance specifications	3	20	3	25
Brand-name or equal specifications	3	20	2	17
Brand-name specifications	2	13	3	25
Reference specifications	3	20	1	8
Total	**15**	**100**	**12**	**100**

4.3 Selection of Finishing Materials During Construction Stage

While the Engineering Supervision of the construction is a standard practice in an ideal construction industry, only twenty percent (20 %) of the participated Engineering Offices supervise all of their projects. The participants' responses regarding the supervision of the projects construction are shown in Table 10. From the table, only thirteen percent (13%) of the participants supervise their projects during finishing works. This indicates that the majority of the Engineering Offices are not involved in the selection and installation of finishing materials during construction stage.

Table 10 Responses regarding supervising the projects in the construction stage.

Does your firm involved in the supervision of the project during construction stage?	Group 1	Group 2	Group 3	Group 4	Group 5	Total	%
Yes, in all projects	1			1	1	3	20
Yes, for major projects only				1	2	3	20
Yes, for structural frame works only		1		2	2	5	34
Yes, for finishing works only				1	1	2	13
Not at all			1		1	2	13
Total	**1**	**1**	**1**	**5**	**7**	**15**	**100**

When the finishing materials are not selected and specified by the Engineering Design Office in the design stage, the right parties to select it during construction stage are the consultant engineer and the owner together. However, in the actual life only thirty one (31%) do so as indicated in Table 11. The Materials should not be selected by the owner alone nor by the contractor.

Table 11 Selection of Finishing Materials after Design Stage

If the finishing materials are not selected and specified by your firm in the design stage, who select these materials and when?	**No. of Responses**	**%**
The owner during construction stage	5	31
The consultant engineer with the owner during construction stage	5	31
The contractor during the construction stage	3	19
The owner when he awards the contract to the contractor	2	13
Supervisor engineer during construction stage	1	6
Total	**16**	**100**

When the participants were asked about the complains they received from the owner regarding the finishing materials, sixty three percent (63%) of them said that they have received complains with various duration ranging from one to ten years. But the majority of complains (54%) were received within the first four years after the project has been completed. Most of them were received by group 5 (small Engineering Offices) as indicated in Table 12. This is considered as one of the evidences of the problems that building construction industry in Saudi Arabia is facing.

Table 12 Complains from the owner regarding the Finishing Materials.

Had your firm received any complains from the owner regarding the finishing materials?	**Group**					**Total**	**%**
	1	**2**	**3**	**4**	**5**		
Yes, usually after 1-2 years		1		1	1	3	27
Yes, usually after 2-4 years	1				2	3	27
Yes, usually after 5-10 years					1	1	9
Not			1	2	1	4	37
Total	**1**	**1**	**1**	**3**	**5**	**11**	**100**

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The types of complains are various as listed in Table 13. The complains, however, regarding failures due to low quality of materials and due to weathering in addition to deficiency in materials performance formalize sixty seven percent (67%) of the complains. They are related to unsuitable selection of finishing materials.

Table 13 Types of Complains Regarding Finishing Materials.

Types of complains received	No. of Responses	%
Failure due to incorrect installation	4	27
Failure due to low quality of materials	4	27
Materials failure due to weathering	3	20
Deficiency in materials performance	3	20
Materials failure due to unexpected use	1	6
Total	**15**	**100**

4.4 Participants Comments

Some of the participants have commented on the questionnaire of the most commonly problems they are facing regarding finishing materials and their general comments on the subject. Their comments are listed below:

- "The contractor try to have equivalent materials, but sometimes it is not good materials."
- "Most of owners try to use cheaper materials."
- "The owner change the specification without informing the office."
- "Incomplete technical drawings."
- "The lack of well experienced manpower in most projects."
- "Labor skills and not using the proper tool for installation."
- "Economic is the base for selection of building materials."
- "Well experienced manpower is highly needed for applying finishing materials."
- "Let all finishing materials be finalized prior to construction stage. This will be an advantage for the client and contract."

5. CONCLUSION

1. Large percentage (64%) of Engineering Design Offices do not select and specify finishing materials for their small and medium size building projects.

2. The study has shown that the participated design offices are giving the performance and suitability of the materials for the hot, humid areas more priority among other factors in selecting the finishing materials. However, some of them may have difficulties in relating material's properties to the characteristics of the existing environment and climate.

3. (42%) of the participated Engineering Offices select the finishing materials based on the general knowledge and past experience while only (5%) select the materials based on client's desire.

4. A number of non-professional practices by the Engineering Design Offices have been found. For example, (57%) of them specify the selected materials in the improper documents (in the project's plans and drawings and in the contracts special condition).

5. Engineering supervision of the construction projects is an important practice in satisfying quality control. Because the engineering supervision is not mandatory practice in Saudi Arabia, only (20%) of the Engineering Offices supervise all of their projects.

6. If the finishing materials are not selected and specified by the designer engineers in the design stage, the owner and contractor are involved heavily in the selection that may lead to failures in the finishing materials due to inappropriate selection.

7. (54%) of the participated Engineering Offices had received complains from the owner regarding finishing materials just within the first four years after the building has been completed. Most of the complains (67%) are regarding to weathering, performance and quality of the materials. Only (27%) of the complains are related to improper installation.

6. RECOMMENDATIONS

1. Expanding the role of engineering offices to all stages of building process.
2. Establishing standardized project handling procedures when requiring engineering services.
3. Raising awareness to the importance of engineering services.
4. Expanding the role of regulator bodies to enforce safe building practice.

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