



Research paper

Expert assessment of the impact of factors on the quality costs of facade systems

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Abstract: The article presents the results of own research on the costs of quality of aluminum-glass facades and ventilated facades from the perspective of Polish production and assembly companies. The main aim of the research was to collect information on the impact of the identified 22 factors on the quality costs associated with the implementation of facade systems. The research used an expert survey method. The selection of the research sample was non-random. Survey questionnaires were addressed to 65 respondents, including: constructors/designers, construction managers or engineers, assembly managers, production department employees, cost estimators and other specialists related to the production and installation of facade systems. The return of completed surveys was 41 (63.08%). The survey form was divided into two parts. The first part aimed to collect information about the respondents' experience. The main part of the form focuses on issues related to the costs of quality of aluminum and glass facades and ventilated facades. Respondents were asked whether the proposed 22 factors can actually affect the quality costs of implementing facade systems. Positive responses were received. Moreover, respondents were asked to assess the degree of importance of the impact of the mentioned factors on the quality costs of constructed facades and ventilated facades. For this purpose, a five-point Likert scale was used, where 1 means very low influence and 5 means very high influence. Based on the results obtained, an average rating was determined for each factor, and then each of the 22 factors was ranked according to the degree of importance. Respondents indicated that the following factors have the greatest impact on the quality costs of facade systems: assembly errors (average factor rating = 4.22), design errors (4.00) and complaints (3.83).

Keywords: expert assessment, facade systems, factors affecting quality, quality, quality costs

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1. Introduction

Issues related to the costs of quality have been developed since the 1950s.¹ The author of the work [1] defined quality costs as “An instrument for measuring quality. Gold mine”. The 1990s and the beginning of the XXI century saw the development of the definition of quality costs, which depended mainly on the way the company considered the costs incurred.

In the context of managing construction projects, it is now crucial to analyze not only costs from the perspective of planning, implementation or maintenance of facilities or buildings [2–5], but also quality costs. For example, the authors of works [6–8] made quality costs dependent solely on the defects and imperfections of products or services. In turn, in papers [9–13], quality costs were defined as financial outlays that must be incurred to ensure the assumed level of quality for all types of product. The authors of [14] did not limit themselves to defining quality costs as expenditures related to low product quality. This work notes that quality costs may be costs related to preventing, analyzing and correcting defective work or services. A different approach to quality costs was demonstrated in [15], where quality costs were defined as the difference between the product manufacturing costs and the theoretical costs if no defects and faults were detected. A different approach to quality costs was also presented in [16, 17], where quality costs were identified with the customer and the lack of customer requirements met by the company. The works [18–20] additionally emphasized the importance of quality costs and indicated that they may be part of Total Quality Management (TQM) and that they may be generated not only during the production of a given product, but throughout its entire life cycle. A similar approach was presented in [21], but the scope of information was extended to include a proposal for the classification of quality costs throughout the product life cycle, which was referred to the period of incurring quality costs divided into the product life cycle and the manufacturing process. It was indicated that the period of incurring quality costs may be an element of the narrow or broad approach, related to the organization or user (narrow approach) and market participants (broad approach), respectively. In paper [22], in relation to quality costs, attention was drawn to the following features (properties) that quality costs should be focused on:

- excellence – high quality of exquisite products is expensive;
- production – each product must comply with the design assumptions (mass production);
- process – correct, uninterrupted process allows obtaining a good product;
- product life cycle – the safety of use of the product and the need to protect the Earth’s resources require its supervision in the phases from idea, through design, production, sales, servicing until withdrawal (liquidation);
- value created and delivered to the customer – any shortcomings that reduce this value are a waste of human, material and financial resources.

This article reviews the literature on the classification of quality costs and presents the results of own research on the quality costs of aluminum-glass facades and ventilated facades from the perspective of Polish production and assembly companies. The main objective of the research was to collect information on the impact of the identified 22 factors on the quality costs associated with the implementation of facade systems. The research used the expert survey method. They were attended by 41 respondents professionally related to construction, production and assembly of facade systems. The selection of the research sample was non-random.

2. Classification of quality costs – a literature overview

Quality management in construction, and above all, issues related to quality costs, is an area widely discussed in terms of company costs or product costs. An important aspect in considering quality costs is their classification. Each definition of quality costs proposed by different authors in different periods of time determined a different division of quality costs.

For example, paper [23] presents a very concise division of quality costs into direct and indirect. Gryna presented in [24] the division of quality costs from a broad perspective, in which he distinguished: repair costs, loss costs, damage costs resulting from defective elements, lost income, additional installation costs and operation and maintenance costs. A different division of quality costs was proposed in [25], where quality costs were considered as: measurable quality costs and hidden quality costs.

The issue of quality costs is also included in the ISO 9004-3 standard “Quality management and elements of the quality system” [26]. Point 2.7 of the standard classifies quality costs into groups including: operational costs of internal quality assurance (including: costs of compliance, costs of prevention, costs of assessment, costs of non-compliance, costs of internal and external errors) and costs of external quality assurance (including: costs quality system compliance assessment by certification institutions and costs of testing and assessment of product properties by independent research centers). The quality cost breakdown structure according to the ISO 9004-3 standard is shown in Fig. 1.

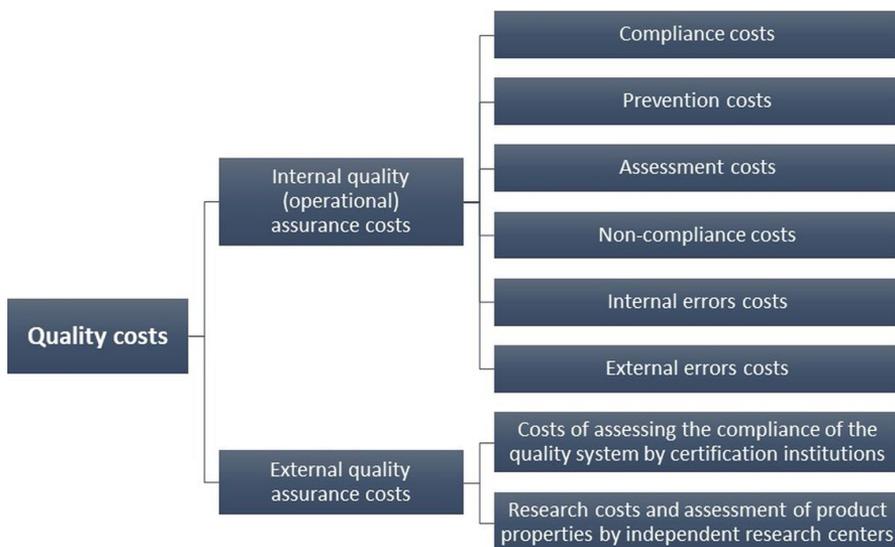


Fig. 1. Classification of quality costs according to ISO 9004-3 (own study based on [26])

Construction companies incur significant costs due to accidents, losses, repeated work, ineffectiveness of their own operations, the actions of subcontractors and suppliers, and inappropriate communication. Swedish research presented in publication [27], carried out in 1994–1996, showed that the costs of defects in the case of individual implementations ranged

from 2.3% to 9.4% of production costs. The analysis of individual defects showed that 32% of these costs had their sources in the initial phases of the investment cycle (agreements with the investor and design). 45% of the costs arose on the construction site and related to construction management, the quality of construction workers' work and the activities of subcontractors. Other costs were related to poor quality of materials or improper functioning of equipment and machines on the construction site.

The situation in Poland is not much better, and its precise assessment is prevented by the lack of detailed research and the difficulty of identifying and recording quality costs by the company. The simplest way is to divide quality costs in construction into: costs related to errors and costs related to preventing errors [28, 29]. Error costs can be characterized as the costs associated with not executing a good work the first time. Factors influencing quality errors include, for example, [30]:

- accidents;
- omission of performance (failure to perform works);
- mistakes;
- improper workmanship;
- work delays.

The factors listed above result in modifications, return to omitted work, demolitions, corrections and time extensions. Therefore, it is important to introduce preventive actions to eliminate quality errors and to allocate appropriate financial resources for this purpose. The most frequently used division of prevention costs is represented by the PAF model (Prevention, Appraisal, Failure) [31, 32]. Examples of costs associated with preventive actions according to the PAF model are presented in Fig. 2.

Prevention costs	Quality planning
	Quality testing
	Suppliers evaluation
	Documentation analysis
	Order review
	Occupational Health and Safety
	Quality audit
	Quality management
	Training
	Quality improvement processes
	Comparing the quality of competitive products
	Other actions to prevent defects and defects

Fig. 2. Prevention costs according to the PAF model (own study based on [32])

3. Own studies of the impact of factors on the quality costs of facade systems

Research and analyzes regarding the quality costs of aluminum-glass facades and ventilated facades in production and assembly companies have been divided into two phases. The first stage of research and analysis included the isolation of factors influencing the quality costs of facade systems. Based on the analysis of literature, company documentation, as-built documentation, as well as the authors' own experience, 22 factors were identified, which are presented in more detail in section 3.1. In the second stage, questionnaire research was conducted, which was aimed at obtaining information about the potential impact of the identified 22 quality cost factors on the costs of facade systems. In this part of the research, the expert survey method was used. Research questionnaires were addressed to specialists employed in the implementation of investments in which aluminum and glass facades and ventilated facades were designed and installed. The main assumptions of this part of the research are described in section 3.2 of this article.

3.1. Identification of factors influencing the quality costs of facade systems

As already mentioned, the first stage of the research consisted in selecting factors that could potentially influence the quality costs of facade systems. Based on the analysis of literature, company documentation, as-built documentation, as well as the authors' own experience, 22 factors were identified. The identified factors were assigned to appropriate groups according to the Czajkowski model.

Czajkowski in [33] proposed a new model for classifying quality costs. In addition to the standard division of quality costs into: prevention costs, assessment costs, costs of internal errors and costs of external errors, a new group of quality costs has been added, which are hidden costs.

The proposed division of factors influencing the quality costs of aluminum-glass facades and ventilated facades, maintaining the above-mentioned cost groups, is presented in Table 1.

Table 1. Factors describing the costs of quality of facade systems (own study)

Id.	Factors and group of factors	Factor designation
I	<i>Prevention costs</i>	
I.1	Quality management system certification	C ₁
I.2	Staff training	C ₂
I.3	Licenses and other certification	C ₃
I.4	Inspections of machines and devices	C ₄
I.5	Guarantees and insurance	C ₅

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Id.	Factors and group of factors	Factor designation
II	<i>Assessment costs</i>	
II.1	Internal audits	C ₆
II.2	Production supervision	C ₇
II.3	Supervision of assembly	C ₈
II.4	Material supply control	C ₉
II.5	Additional tests and examinations	C ₁₀
III	<i>Hidden costs</i>	
III.1	Failures and downtime	C ₁₁
III.2	Overtime (additional working hours)	C ₁₂
III.3	Additional deliveries	C ₁₃
IV	<i>Costs of internal errors</i>	
IV.1	Design errors	C ₁₄
IV.2	Errors in contract provisions	C ₁₅
IV.3	Assembly errors	C ₁₆
IV.4	Order and purchase errors	C ₁₇
V	<i>Costs of external errors</i>	
V.1	Complaints	C ₁₈
V.2	Post-warranty repairs	C ₁₉
V.3	Service	C ₂₀
V.4	Contractual penalties	C ₂₁
V.5	Low quality of information about the service	C ₂₂

3.2. Research on factors influencing the quality costs of facade systems – description of the main assumptions

Research and analysis of literature on the quality costs and factors influencing quality costs were supplemented with survey research. Survey research is a method of indirect measurement of the obtained data, which is characterized by the fact that the prepared survey questionnaire can be sent directly to the respondent, who answers the questions contained in the questionnaire in writing or electronically [34]. The advantage of the survey research method is the low cost of obtaining data and the ability to survey a relatively large number of respondents in a relatively short time. A disadvantage of survey research may be the low quality of data, which is often heterogeneous and non-objective (or not very objective) [35].

The survey questionnaire and the questions included in it were formulated in such a way as to verify the accuracy and validity of the identified factors shaping the costs of the quality of facade systems (aluminum-glass facades and ventilated facades). The questions were also formulated so that the respondent could answer easily and quickly.

Research questionnaires were sent by e-mail and delivered to respondents directly in construction offices. Ultimately, between September 2019 and July 2020, 65 forms were sent and issued, of which 41 completely completed surveys were obtained. Therefore, the return of questionnaires was approximately 63.08%.

4. Results analysis and discussion

4.1. Identification of areas of respondent activity

The first question in the first part of the questionnaire referred to the respondent's profession or position. The largest group of survey participants were employees involved in the assembly of aluminum and glass facades and ventilated facades (17 = 41.5% of respondents). The second largest group were designers and constructors (12 = 29.3%), and the third largest group were cost estimators (4 = 9.8%). The smallest number of respondents were employees associated with the production department (3 = 7.3%). 5 respondents (12.2%) indicated another profession currently performed. These were quality department employees (2 = 4.9%) and managers of the complaints or service department (3 = 7.3%). The characteristics of the answers given to question 1 are presented graphically in Fig. 3.

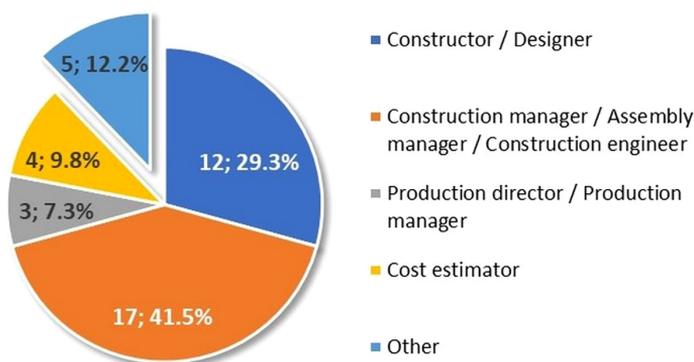


Fig. 3. Information on the profession or position held by the respondents (own study)

In the second question of the first part of the survey questionnaire, the study participants were asked to indicate their work experience. Based on the answers received, it can be concluded that the survey participants are experienced people. 14 respondents (34.1%) have professional experience of more than 5 years but less than 10 years. 11 respondents (26.8%) have over 10 years of work experience, and 7 respondents (17.1%) have over 15 years of experience. The study participants also included people who had over 20 years of work experience (5 = 12.2%). The smallest percentage of respondents (4 = 9.8%) were people with little professional experience of less than 5 years. The characteristics of the answers received from respondents to question 2 are presented in Fig. 4.

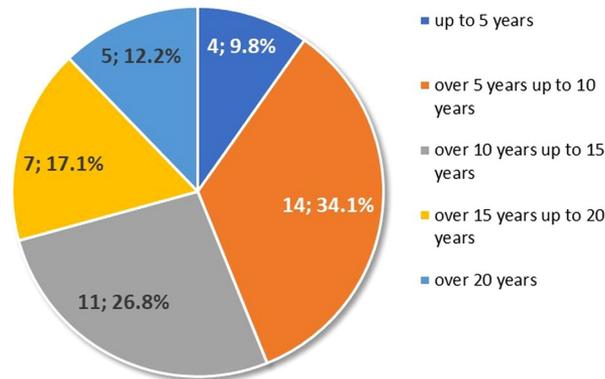


Fig. 4. Respondents' employment experience (own study)

4.2. Verification of the correctness of the analysis of quality cost factors

As mentioned in section 3.2, the second part of the survey questionnaire referred to questions about the quality costs of implementing facade systems in the form of aluminum-glass facades and ventilated facades. In the first question of this part of the questionnaire, respondents were asked, in order to verify the correctness of the analysis made by the authors regarding the identified 22 quality cost factors, whether the indicated factors actually influence and generate additional costs of the quality of the implementation of facade systems. The data resulting from the responses obtained are presented in Table 3.

Table 3. Verification of factors influencing quality costs – survey results (own study)

Id.	Factors and group of factors	Yes	No	I don't know
I	<i>Prevention costs</i>			
I.1	Quality management system certification	41	0	0
I.2	Staff training	41	0	0
I.3	Licenses and other certification	41	0	0
I.4	Inspections of machines and devices	41	0	0
I.5	Guarantees and insurance	41	0	0
II	<i>Assessment costs</i>			
II.1	Internal audits	41	0	0
II.2	Production supervision	41	0	0
II.3	Supervision of assembly	41	0	0
II.4	Material supply control	41	0	0
II.5	Additional tests and examinations	41	0	0

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Id.	Factors and group of factors	Yes	No	I don't know
III	<i>Hidden costs</i>			
III.1	Failures and downtime	41	0	0
III.2	Overtime (additional working hours)	40	0	1
III.3	Additional deliveries	41	0	0
IV	<i>Costs of internal errors</i>			
IV.1	Design errors	41	0	0
IV.2	Errors in contract provisions	41	0	0
IV.3	Assembly errors	41	0	0
IV.4	Order and purchase errors	41	0	0
V	<i>Costs of external errors</i>			
V.1	Complaints	41	0	0
V.2	Post-warranty repairs	41	0	0
V.3	Service	41	0	0
V.4	Contractual penalties	39	0	2
V.5	Low quality of information about the service	40	0	1

Based on the research results obtained, it can be concluded that the factors proposed by the authors were correctly identified. For factors: III.2 – “Overtime (additional working hours)”, V.4 – “Contractual penalties” and V.5 – “Low quality of information about the service”, individual respondents indicated doubts whether a given factor can influence on quality costs. It should also be mentioned that additionally, in the “others” field, respondents provided factors that may affect quality costs, i.e.:

- investor awareness;
- human factor;
- preparation of samples and models of facades.

The proposed additional factors are, in the authors’ opinion, a component of the 22 factors identified in the first phase of the research. The human factor can be referred to all errors listed in group IV – Costs of internal errors. Preparation of samples and models of facades is a component of factor II.5 – “Additional tests and examinations”, which falls into group II of costs. In turn, investor awareness refers to group V – Costs of external errors, and especially to factor V.5 – “Low quality of information about the service”.

4.3. Assessment of the degree of importance and the greatest impact of factors on the quality costs of facade systems

In the most important question from the point of view of assessing the degree of importance and the greatest impact of factors on the quality costs of facade systems, a five-point Likert scale was used, where extreme ratings meant 1 – “Very low” and 5 – “Very high” impact, respectively.

Based on the obtained survey results, an average rating was determined for each factor according to the formula (4.1), which in turn allowed them to be ranked from the most to the least important.

$$(4.1) \quad S_i = \frac{\sum_{j=1}^{N_i} a_{ij}}{N_i}$$

where:

S_i – average rating of the i -th factor for $i = 1; 2; \dots; 5$, N_i – total number of answers for the i -th factor,

a_{ij} – grade of assessment given to the i -th factor in the j -th answer.

The respondents provided a total of 902 impact assessments for the 22 identified factors influencing the quality costs of facade systems. The basic characteristics of descriptive statistics, i.e. Mean, Median, Standard deviation and Coefficient of variation, are presented in Table 4.

Table 4. Descriptive statistics of quality cost factors (own study)

Id.	Factors and group of factors	Mean	Median	Standard deviation	Coefficient of variation
I	<i>Prevention costs</i>				
I.1	Quality management system certification	2.05	2	0.63	30.78%
I.2	Staff training	2.59	3	0.87	33.47%
I.3	Licenses and other certification	2.39	3	1.12	46.66%
I.4	Inspections of machines and devices	2.39	2	0.54	22.68%
I.5	Guarantees and insurance	2.83	3	0.59	20.76%
II	<i>Assessment costs</i>				
II.1	Internal audits	1.56	1	0.74	47.62%
II.2	Production supervision	2.51	2	0.55	22.02%
II.3	Supervision of assembly	3.00	3	0.67	22.36%
II.4	Material supply control	2.88	3	0.46	15.91%
II.5	Additional tests and examinations	3.78	4	0.57	15.09%
III	<i>Hidden costs</i>				
III.1	Failures and downtime	3.73	4	0.71	19.30%
III.2	Overtime (additional working hours)	3.24	3	0.49	15.07%
III.3	Additional deliveries	3.71	4	0.72	19.30%

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Id.	Factors and group of factors	Mean	Median	Standard deviation	Coefficient of variation
IV	<i>Costs of internal errors</i>				
IV.1	Design errors	4.00	4	0.74	18.54%
IV.2	Errors in contract provisions	3.41	3	0.84	24.48%
IV.3	Assembly errors	4.22	4	0.79	18.74%
IV.4	Order and purchase errors	3.67	3	0.86	25.52%
V	<i>Costs of external errors</i>				
V.1	Complaints	3.83	4	0.50	16.89%
V.2	Post-warranty repairs	3.49	3	0.71	20.40%
V.3	Service	2.90	3	0.49	16.89%
V.4	Contractual penalties	3.22	3	0.91	28.22%
V.5	Low quality of information about the service	2.29	2	0.93	10.50%

Fig. 5 shows the ranking of factors influencing the quality costs of facade systems according to their degree of importance.

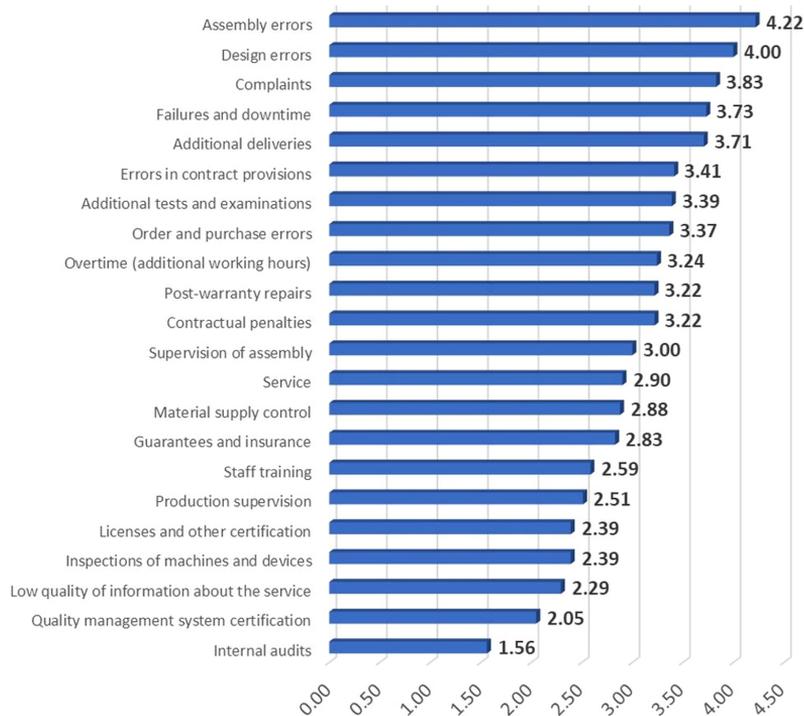


Fig. 5. Factors influencing the quality costs of facade systems according to their degree of importance (own study)

According to the data presented in Table 4 and Fig. 5, it can be concluded that the factors that have the greatest impact on the costs of the quality of aluminum-glass facades and ventilated facades according to the respondents are primarily:

- IV.3 – “Assembly errors” (average rating = 4.22);
- IV.1 – “Design errors” (4.00).

Both factors from group IV (Costs of internal errors) mentioned here obtained an average value of the assessment of the degree of impact on the costs of the quality of facade systems above 4.00, which proves that most of the respondents assessed the impact for these factors at the level of “High” or “Very high”. The next factors that have a high impact on quality costs (average impact score between 3.50 and 4.00 for most answers at the “High” or “Medium” level) are, in the opinion of respondents:

- V.1 – “Complaints” (average rating = 3.83);
- III.1 – “Failures and downtime” (3.73);
- III.3 – “Additional deliveries” (3.71).

Factors that, in the opinion of respondents, are the least important in terms of impact on the costs of the quality of aluminum-glass facades and ventilated facades (average impact assessment mainly at the “Very low” or “Low” level, i.e. between 1.00 and 2.50) proved to be:

- II.1 – “Internal audits” (average rating = 1.56);
- I.1 – “Quality management system certification” (2.05);
- V.5 – “Low quality of information about the service” (2.29);
- I.4 – “Inspections of machines and devices” (2.39);
- I.3 – “Licenses and other certification” (2.39).

Globally, the costs of group IV – Costs of internal errors, are, in the opinion of respondents, the most important group of costs in terms of their impact on the costs of the quality of facade systems. According to the respondents, factors related to group I costs – Prevention costs, have the smallest impact on quality costs.

4.4. Evaluation of the obtained survey results

As already mentioned in section 3.2 of this article, survey research is associated with a high risk that the results obtained will be heterogeneous and non-objective (or not very objective). In the context of expert assessment of the impact of factors on the quality costs of facade systems, the authors noticed, based on the analysis of data on the descriptive statistics of quality cost factors (Table 4), that for about half of the assessed factors (12 out of 22), the value of the coefficient of variation exceeded 20%, which could indicate significant differences in the obtained research results [36–38].

Taking into account the above, the authors decided to assess the quality of the data using the Kendall–Smith concordance coefficient, which is used to assess the degree of agreement of the respondents’ opinions [39]. In order to determine the value of the Kendall–Smith concordance coefficient, the following formulas were used (from 4.2 to 4.4):

$$(4.2) \quad W = \frac{12S}{m^2(n^3 - n)}$$

where: m – number of experts, n – number of variants, number of factors assessed by experts.

$$(4.3) \quad S = \sum_{j=1}^n \left(\sum_{i=1}^m x_{ij} - \bar{x} \right)^2$$

$$(4.4) \quad \bar{x} = \frac{1}{n} \sum_{i=1}^m \sum_{j=1}^n x_{ij}$$

where: \bar{x} – average value of the sum of ranks for all variants (factors), x_{ij} – rating of the i -th expert for the j -th factor.

The respondents assessed the factors by selecting the appropriate variant indicated in the form to assess the importance of the factors on a five-point Likert scale. The proposed answer options enabled several of the same assessments to be made for individual issues.

In order to correctly determine the concordance coefficient, it is necessary to determine average ranks by creating an analogous series for strong ranking, in relation to the series where all objects are distinguishable [39]. The introduction of average ranks requires an adjustment to the denominator of the concordance coefficient. Then, for series with related ranks, the value of T_i should be determined, according to the formula (4.5):

$$(4.5) \quad T_i = \frac{1}{12} \sum_{j=1}^k (t_j^3 - t_j)$$

where: k – the number of groups having the same rank in the i -th series, t_j – the number of identical links in the group.

If linked ranks occur in all series, the T value should be determined as an adjustment to calculate the concordance coefficient, according to formula (4.6):

$$(4.6) \quad T = \sum_{i=1}^m T_i$$

The final form of the Kendall–Smith concordance coefficient, after taking into account the above corrections, is presented in formula (4.7):

$$(4.7) \quad W = \frac{S}{\frac{1}{12} m^2 (n^3 - n) - mT}$$

where: S – the sum of squares of deviations of individual sums from the arithmetic mean of rank sums for all n objects.

Taking into account the assumptions formulated for the purpose of calculating the concordance coefficient, appropriate ranks were selected for the issue related to the assessment of the importance of factors using a five-level rank scale, where:

- “Very low” = Rank #1;
- “Low” = Rank #2;
- “Medium” = Rank #3;
- “High” = Rank #4;
- “Very high” = Rank #5.

In the next step, a ranking procedure was performed for each of the records corresponding to respondents 1 to 41, who assessed each of the 22 factors influencing the quality costs of facade systems. Since there were combined ranks in individual series, the average rank method was used for further calculations.

Based on the ranking performed, the Kendall–Smith concordance coefficient was calculated according to the formula (4.7). To assess the degree of compliance, the assessment scale presented in [40] was used, according to which the degree of:

- “satisfactory/sufficient” is achieved for the range from 0.20 to 0.40;
- “good” – for the range from 0.41 to 0.60;
- “plus good/above good” – for the range from 0.61 to 0.80;
- “very good” – for the range from 0.81 to 0.95;
- “ideal” – for the range from 0.96 to 1.00.

The resulting value of the Kendall–Smith concordance coefficient (W) was 0.517. This allows for the following statement that when assessing the degree of importance of individual factors, the respondents agreed to a good extent. According to the authors, the demonstrated compliance of the respondents allows them to formulate conclusions and opinions based on the conducted survey research.

5. Conclusions

The article discusses the results of own research on the impact of the quality costs of aluminum-glass facades and ventilated facades from the perspective of Polish production and assembly companies, which were carried out by the authors in 2019–2020. The research was aimed at obtaining information on the impact of the identified 22 factors on the quality costs associated with the implementation of facade systems.

According to the first part of the research, respondents confirmed the correct identification of 22 factors (Table 1), assigned by the authors to five cost groups (I – Prevention costs, II – Assessment costs, III – Hidden costs, IV – Costs of internal errors and V – Costs of external errors), which affect the quality costs of facade systems.

The second part of the research, which used an expert survey method, allowed for the ranking of factors influencing the quality costs of facade systems according to their degree of importance. Respondents indicated factors that, in their opinion, have both high and low impact on the costs of the quality of facade systems. In the group of factors with a high impact, respondents indicated the following factors: IV.3 – “Assembly errors” (average rating = 4.22), IV.1 – “Design errors” (4.00), V.1 – “Complaints” (3.83), III.1 – “Failures and downtime” (3.73) and III.3 – “Additional deliveries” (3.71). In the group of factors with low impact, the respondents indicated the following factors: II.1 – “Internal audits” (average rating = 1.56), I.1 – “Quality management system certification” (2.05), V.5 – “Low quality of information about the service” (2.29), I.4 – “Inspections of machines and devices” (2.39) and I.3 – “Licenses and other certification” (2.39).

Due to the fact that for approximately half of the assessed factors (12 out of 22), the coefficient of variation exceeded 20% (Table 4), the authors assessed the quality of the data using the Kendall–Smith concordance coefficient, which is used to assess the degree of

agreement of the respondents' opinions. The resulting value was $W = 0.517$. This allows to conclude that when assessing the degree of importance of individual factors, the respondents agreed to a good extent.

In the future, the authors intend to continue research on the quality costs of aluminum-glass facades and ventilated facades in order to determine the cost premium for the increased quality of facade systems. Additionally, the authors allow for the possibility of extending their own research on the costs of quality of aluminum-glass facades and ventilated facades to, among others, the Czech Republic and Slovakia.

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Ocena ekspercka wpływu czynników na koszty jakości systemów fasadowych

Słowa kluczowe: czynniki wpływające na jakość, jakość, koszty jakości, ocena ekspercka, systemy fasadowe

Streszczenie:

Celem głównym artykułu jest prezentacja wyników badań nad kosztami jakości fasad aluminiowo-szklanych oraz elewacji wentylowanych w perspektywie polskich przedsiębiorstw produkcyjno-montażowych, które zostały przeprowadzone przez autorów w latach 2019–2020 na terenie Polski. Badania zostały ukierunkowane na pozyskanie informacji na temat wpływu zidentyfikowanych 22 czynników na

koszty jakości związane z realizacją systemów fasadowych. W badaniach wykorzystano metodę ankiety eksperckiej. Dobór próby badawczej był nielosowy. Kwestionariusze ankietowe zostały skierowane do 65 respondentów, wśród których można wyróżnić: konstruktorów/projektantów, kierowników lub inżynierów budów, kierowników montażu, pracowników działu produkcji, kosztorysantów oraz pozostałych specjalistów związanych z produkcją i montażem systemów fasadowych. Uzyskano zwrot wypełnionych ankiet na poziomie 41 (63,08%). Formularz ankietowy został podzielony na dwie części. Pierwsza część miała na celu zebranie informacji o doświadczeniu badanych. W zasadniczej części formularza skupiono się na problematyce związanej z kosztami jakości wykonania fasad aluminiowo-szklanych i elewacji wentylowanych. Respondentów zapytano o to, czy zaproponowane 22 czynniki faktycznie mogą wpływać na koszty jakości realizacji systemów fasadowych. Uzyskano pozytywne odpowiedzi. Ponadto respondentów poproszono o ocenę stopnia ważności wpływu wymienionych czynników na koszty jakości wykonanych fasad i elewacji wentylowanych. W tym celu zastosowano pięciostopniową skalę Likerta, gdzie: 1 oznacza wpływ „bardzo niski”, 2 – „niski”, 3 – „średni”, 4 – „wysoki” a 5 – „bardzo wysoki”. Na podstawie otrzymanych wyników wyznaczono ocenę średnią dla każdego czynnika, a następnie uszeregowano każdy z 22 czynników względem stopnia ważności (rys. 5). Respondenci wskazali, że największy wpływ na koszty jakości systemów fasadowych mają następujące czynniki: błędy montażu (średnia ocena czynnika = 4,22); błędy projektowe (4,00); reklamacje (3,83); awarie i przestoje (3,73); dodatkowe dostawy (3,71). Najmniejszy wpływ na koszty jakości systemów fasadowych mają zdaniem badanych następujące czynniki: audyty wewnętrzne (średnia ocena czynnika = 1,56); certyfikacja systemu zarządzania jakością (2,05); niska jakość informacji o usłudze (2,29); przeglądy maszyn i urządzeń (2,39); licencje i pozostała certyfikacja (2,39). Z uwagi na fakt, że dla około połowy ocenionych czynników (12 spośród 22), wartość współczynnika zmienności przekroczyła 20% (tabela 4), autorzy dokonali oceny jakości danych wykorzystując w tym celu współczynnik konkordancji Kendalla–Smitha, który służy do oceny stopnia zgodności opinii ankietowanych. Otrzymano w wyniku wartość $W = 0,517$, co pozwala stwierdzić, że w przypadku oceny stopnia ważności poszczególnych czynników, ankietowani byli zgodni w stopniu dobrym.

Received: 2024-09-30, Revised: 2024-12-11