Building a predictive model to improve the quality of
government building construction projects in Iraq using Multi
Linear Regression technique

Ahmed F. H. ALFahham1* and Hatem K. B. Alajeeli2

1 MSc. Student, Civil Eng. Dept., University of Kufa, Al-Najaf, Iraq,
2 Ph.D., Ass.Prof., Civil Eng. Dept., University of Baghdad, Baghdad, Iraq. Email: dr.hatem2099@yahoo.com
*Corresponding author. Email: ahmedfalahl82@gmail.com

Abstract. Quality measurement is an important tool for quality improvement. Due to the lack of
tools and methods used to measure quality, quality improvement in construction projects is
difficult. As a result of the high cost of construction projects for public buildings and the lack of
improved tools for measuring quality, there is an urgent need to develop new models. This study
aims to provide necessary information for owners, project managers, designers, and contractors
to determine the main and secondary factors that have a major impact on improving the quality
of construction projects for government buildings and reduce maintenance. This study also
contributes to building a predictive model to measure the quality of these projects, and a literature
review and interviews were conducted. A personal figure to collect a list of factors affecting the
quality of government building projects, and the resulting factors were subject to a survey that
was sent to owners, project managers, and engineers working on general construction projects
in Iraq. Adoption of the technique of multiple linear regression in the modeling process and
determining the most important factors that affect the quality of the project.

1. Introduction
Public buildings are essential for economic growth and social development. It has a long service life and
often requires government involvement in funding, development, and operations [1]. The
implementation of the project in technical specifications and quality standards is an important criterion
for the implementation of these projects. [2]. Measuring the quality of construction projects is one of
the most important tools to improve the quality of performance. Besides, it will reduce errors due to
poor implementation [3], [4], [5], [6], and [7]. However, the rest of the studies have been focused on
other types of construction projects, [8], [9] and [10].

2. Literature review
Several studies have attempted to provide methods to solve the problem of measuring the quality of
construction projects. Some of the methods used are multiple regression analyzes [11], artificial neural
networks (ANN) [4], factor analysis, and stepwise multiple regression analysis [2] and [12]. In Hong
Kong, a model was developed to measure the quality of the building construction project by examining
factors that affect quality. The methodology used in these studies was based on interviews with project
managers to determine factors affecting quality and to develop a questionnaire based on a seven-point
scale that requires the classification of these factors to give them weight. Several factors and regression
analyses were used to develop the modeling process. The developed model can be expressed as shown
in equation (1) [2]:

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \epsilon \]
QUALITY = 5.20 + 0.50 MAN-ACT + 0.08 EFF-CON - 0.30 CLI-QUA - 0.38 CLI-TIME  \( (1) \)

Where MAN-ACT is the project management action; EFF-CON the effectiveness of construction team leader; CLI-QUA the client’s emphasis on quality and CLI-TIME the client’s emphasis on time.

3. Study methodology
Quality is very important in construction projects. This study aims to explore and evaluate the impact of factors on the quality of projects. Establishing government buildings in Iraq. Through a review of previous studies and personal interviews conducted with ten personal interviews with engineers with experience in managing and implementing construction projects in Iraq, 65 influencing factors were identified. The objectives of this study are:

- Determine the factors that affect the quality of government building construction projects.
- Evaluate and classify the most important factors affecting the quality of government building construction projects in Iraq.
- Formulate a mathematical model for predicting quality performance to raise the level of quality in construction projects for government buildings in Iraq.

3.1. Determine the factors affecting the quality of construction projects for government buildings in Iraq

From literature reviews, field visits, and personal interviews to various engineers who specialize in the implementation of construction projects, factors have been identified and divided into 14 groups that have a negative or positive impact on the quality of government construction projects. Each group contains several sub-factors, such as shown in Table (1).

**Table 1.** The factors that affect the quality of government building construction projects in Iraq.

| Sr. | Effective factor                                                                 |
|-----|-----------------------------------------------------------------------------------|
| 1   | Group (1): Owner-related factors                                                  |
| F1.1| Type the owner and how important                                                  |
| F1.2| The extent of the required quality of the project owner                           |
| F1.3| Change orders                                                                     |
| F1.4| Realize the owner of a civil contractor in the implementation of the project      |
| F1.5| Owner experience with similar projects                                             |
| F1.6| Reduce the project budget                                                          |
| F1.7| The extent required to speed up the schedule                                       |
| 2   | Group (2): Design and specifications-related factors                              |
| F2.1| The adequacy of meetings with qualifying technically and numerically designer    |
| F2.2| Similar business and experience of the designer and a design                      |
| F2.3| The level of commitment to the principle of the improvement and development of quality in design with business continuity |
| F2.4| The delay in the delivery of design documents                                     |
| F2.5| The complexity of the project design                                              |
| F2.6| Enforceability (Methods and materials for implementation)                         |
| 3   | Group (3): The project-related factors                                            |
| F3.1| Type and nature of the project                                                    |
| F3.2| Term implementation of the project to conjecture                                  |
| F3.3| Legal disputes and claims between the various parties to the project              |
| F3.4| The project site is well organized                                                |
| F3.5| Provide infrastructure at the site (water, electricity, communications, access roads to the worksite) |
| F3.6| The breadth of the site space and ease of movement of workers and equipment       |
4 Group (4): Contract-related factors
   F4.1 Contract Type (choose less tender for the implementation of the project)
   F4.2 The clarity of the contract high degree items
   F4.3 Provide detailed specifications for the items, quantities, and drawings.
5 Group (5): Contractor-related factors
   F5.1 Time programs provided by the contractor and abide by them
   F5.2 Specialization previous cumulative experience of the contractor in the field of work
   F5.3 Entrepreneurship more segmentation and the provision of a secondary contractor
   F5.4 The existence of a previously successful business relationship between the parties to the project (the completion of the contractor to work on time, budget and quality acceptable)
   F5.5 Coordination and cooperation between contractor, supervisor, and employer
6 Group (6): Team supervision and implementation-related factors
   F6.1 Engineering awareness of the importance of quality control when engineers and supervisors, especially implementing the concept of quality assurance and quality assurance
   F6.2 Owner team experience in the supervision and inspection work for the quality of work in all stages
   F6.3 The efficiency of the contractor team (technical and administrative efficiency)
   F6.4 Cooperation between the two supervision and implementation
7 Group (7): Sub-contractor-related factors
   F7.1 Owner's contribution to the selection of sub-contractor
   F7.2 The existence of a contract between the general contractor and the contractor and subcontractor characterized by good fair terms
   F7.3 Specialization, technical competence, and experience of the sub-contractor
8 Group (8): Management-related factors
   F8.1 The importance of documentation system for all parties involved in the contracting process and implementation (correspondence, reports, change orders, time schedules, graphics workshop, tests and other ....)
   F8.2 The formation of committees follow-up policies of quality management and accreditation of laboratories eligible for examination
   F8.3 A comprehensive system of quality setting at the project level
   F8.4 The appropriate organizational and administrative structure of the employer and the contractor to follow up the quality system
   F8.5 The attention of the parties to the project quality more than the cost of the project
9 Group (9): Financial issues-related factors
   F9.1 The efficiency of the Contractor Finance (provide cash flow)
   F9.2 Credit contractor for the full amount of work done
   F9.3 The flow of monthly payments and do not delay
   F9.4 Comply with the instructions for the procedures of credit
   F9.5 Agreement on the financial discounts formula works rejected in whole or in part
   F9.6 A high variation in the cost of guessing between assignment and the actual cost of work
10 Group (10): Materials and equipment-related factors
   F10.1 The use of high-quality materials at work
   F10.2 Create lists of materials to be imported or manufactured early
   F10.3 Provide regular stores for perishable items, stores (places of accumulation) for construction materials in the workplace
   F10.4 The fluctuation of materials and mechanisms rent prices
   F10.5 Abundance and efficiency of the equipment and mechanisms used in the work
11 Group (11): Execution method-related factors
   F11.1 The use of advanced technology in the implementation
   F11.2 The use of a comprehensive and continuous supervision system
F11.3 Clear steps to receive the work done
F11.4 Examination of the final stages of the work performed
12 Group (12): The Systems Used-related factors
F12.1 Application monitoring systems and quality control
F12.2 Application and use schedules
F12.3 The use of programs and computer applications
F12.4 Use the cost control system
13 Group (13): Workforce-related factors
F13.1 The use of a specialized work team or work experience
F13.2 Provide training courses and awareness programs periodically in the field of quality workers to raise the level of efficiency
F13.3 Adoption of the principle of moral and material incentives for workers
14 Group (14): The external environment-related factors
F14.1 Stabilize the security situation
F14.2 The impact of environmental constraints
F14.3 The impact of social constraints
F14.4 The impact of legal restrictions

3.2. Questionnaire form
Questionnaire surveys are a very important and exciting data collection process. In this study, a questionnaire was created to collect data and information after identifying factors that affect the quality of government building projects in Iraq. The questionnaire consists of two stages:

- The first stage: general information.

This stage aimed to know the educational qualifications of the sample, the number of years of experience in implementing construction projects in the public or private sector, the field of field technology, and the degree of the arrangement of engineers because this affects the type and accuracy of the data that will be captured later. (110) questionnaires were distributed to experts and engineers involved in implementing and managing construction projects in Iraq. (90) of the questionnaires were approved for analysis and evaluation because some models contained a marginal and incomplete answer, as shown in Table (2).

- The second stage: Analysis of factors affecting the quality of construction projects in Iraq.

| Academic Certificate | Engineering disciplines | Total | Percentage |
|----------------------|-------------------------|-------|------------|
| B. Sc.               | Civil 51 | Architect 6 | Mechanic 5 | Electric 3 | 65 | 72% |
| Hi. Dipl.            | Civil 9  | Architect 1 | Mechanic 0 | Electric 0 | 10 | 11% |
| M. Sc.               | Civil 13 | Architect 1 | Mechanic 1 | Electric 0 | 15 | 17% |
| Total                | 73       | 8      | 6      | 3      | 90 | 100% |
| Percentage           | 82%      | 9%     | 6%     | 3%     | 100% |

**Figure 1.** Working Sector for research sample.

**Figure 2.** Percentage of work field for research sample.
4. Survey and analysis results

4.1. Statistical analysis

The following software package was used to obtain the results of this investigation:
1. (SPSS) version 23 was used to individually determine the relative importance index (arithmetic mean) and Cronbach alpha of impact force (1 to 5) for each factor according to the responses of the participants to the questionnaire, and also to find frequencies that are used to calculate the importance coefficient.
2. The Excel program (MS Excel 2015) was used to calculate the relatively important index of (Likert Scale).

4.2. Measuring the consistency of the questionnaire

Stability is defined as the stability of the scale and is not inconsistent with itself, which means that after a certain time the measurement is applied again to the same sample and gives the same results. The consistency value is between (zero) and (one), and the closest value indicates the high stability of the questionnaire and vice versa. The stability factor (Alpha Cronbach) was used to measure the stability of the questionnaire and guarantee the stability of the research tool, while the validity value \( \alpha \) was calculated using equation (2) as shown below:

\[
\alpha = \frac{K}{K-1} \left( 1 - \frac{\sum Si^2}{St^2} \right)
\]

Where K: the number of elements in a group. Si^2: variance in relation to point (i). St^2: variance related to the sum of the degrees of the element (k). Table (3) shows the confidence and reliability values after a thousand crunches for each factor in the questionnaire. Cronbach states that the alpha values are between (0.91 and 0.987). This area indicates a high (excellent) scale that guarantees the reliability and validity of each group in the questionnaire. Table (4) shows the relationship between groups. Factors affecting the quality of construction of government buildings in Iraq are ranked in descending order of relative importance \( RII_1 \) and arithmetic mean \( RII_2 \), with the factor having the highest arithmetic mean equal to 1.

Table (5) shows that "A high variation in the cost of guessing between assignment and the actual cost of work" is one of the most important factors affecting the quality of government building construction projects in Iraq. The second factor that affects the quality of the project is "Provide detailed specifications for the items, quantities, and drawings." is the second factor that affects the quality of the project, and the third one is the "Time programs provided by the contractor and abide by them". Therefore, the contracting period provided by the contractor should be more realistic. Sample members also believe that "The flow of monthly payments and do not delay" This affects the quality of the construction project and "Specialization previous cumulative experience of the contractor in the field of work". This is because the primary task of contractors is to collect and assign workers, equipment, and materials for a project to achieve the most cost-effectiveness, time, and quality [13]. Additionally, "using a comprehensive and continuous supervision system" and "Owner team experience in the supervision and inspection work for the quality of work in all stages " [14] The main factors contributing to the quality of projects in Egypt have also been identified. "Change orders ". The scientific explanation for these factors is that the construction project includes many teams that oversee the execution of the construction work, therefore, should be detailed and described to contractors and contractors of subcontractors, Owners, etc., roles, responsibilities, and powers of each individual among the individuals who will be involved in the implementation of the project to implement the quality management program. Moreover, "Provide regular stores for perishable items, stores (places of accumulation) for construction materials in the workplace" and "using high-quality materials at work", has been categorized as the tenth factor contributes to the quality of construction which is also supported by [15] government buildings in Iraq. As a result, it will reduce disputes between the parties involved in the project.

Table 3. Reliability and validity of the factors affecting groups.
Table 4. Pearson coefficient between the major groups

| Group (1): Owner -related factors | Group (2): Design and specifications -related factors | Group (3): The project-related factors | Group (4): Contract -related factors | Group (5): Contractor -related factors | Group (6): Team supervision and implementation -related factors | Group (7): Sub-contractor -related factors | Group (8): Management -related factors | Group (9): Financial issues -related factors | Group (10): Materials and equipment -related factors | Group (11): Execution method -related factors | Group (12): The Systems Used -related factors | Group (13): Workforce -related factors | Group (14): The external environment -related factors |
|----------------------------------|-----------------------------------------------|----------------------------------------|--------------------------------------|----------------------------------------|----------------------------------------------------------|-----------------------------------------|----------------------------------------|----------------------------------------|----------------------------------------|------------------------------------------|-----------------------------------------|----------------------------------------|
| 1.0                              | .823                                          | .946                                   | .997                                 | .905                                   | .907                                                     | .997                                   | .979                                   | .963                                   | .996                                   | .980                                                     | .958                                    | .986                                   | .979                                   |
| G2                               | .823                                          | .613                                   | .947                                 | .974                                   | .972                                                     | .564                                   | .862                                   | .968                                   | .946                                   | .982                                                     | .987                                    | .873                                   | .872                                   |
| G3                               | .946                                          | .613                                   | 1                                    | .947                                 | .974                                                     | .972                                   | .564                                   | .862                                   | .968                                   | .946                                                     | .982                                    | .987                                    | .986                                   |
| G4                               | .997                                          | .805                                   | .947                                 | 1                                    | .924                                                     | .906                                   | .763                                   | .834                                   | .997                                   | .877                                                     | .959                                    | .979                                   | .979                                   |
| G5                               | .905                                          | .533                                   | .974                                 | .924                                 | 1                                                       | .941                                   | .460                                   | .751                                   | .941                                   | .882                                                     | .955                                    | .827                                    | .845                                   |
| G6                               | .907                                          | .521                                   | .972                                 | .906                                 | .941                                                     | 1                                       | .503                                   | .917                                   | .926                                   | .987                                                     | .989                                    | .838                                   | .809                                   |
| G7                               | .790                                          | .985                                   | .564                                 | .763                                 | .460                                                     | .503                                   | 1                                       | .653                                   | .731                                   | .535                                                     | .606                                    | .876                                   | .855                                   |
| G8                               | .863                                          | .613                                   | .862                                 | .834                                 | .751                                                     | .917                                   | .653                                   | 1                                       | .848                                   | .965                                                     | .907                                    | .837                                   | .764                                   |
| G9                               | .996                                          | .776                                   | .968                                 | .997                                 | .941                                                     | .926                                   | .731                                   | .848                                   | 1                                       | .899                                                     | .971                                    | .967                                   | .967                                   |
| G10                              | .890                                          | .531                                   | .946                                 | .877                                 | .882                                                     | .987                                   | .535                                   | .965                                   | .899                                   | 1                                                       | .969                                    | .829                                   | .780                                   |
| G11                              | .958                                          | .632                                   | .982                                 | .959                                 | .955                                                     | .989                                   | .606                                   | .907                                   | .971                                   | .969                                                     | 1                                       | .907                                    | .887                                   |
| G12                              | .986                                          | .897                                   | .879                                 | .979                                 | .827                                                     | .838                                   | .876                                   | .837                                   | .967                                   | .829                                                     | .907                                    | 1                                       | .990                                   |
| G13                              | .979                                          | .898                                   | .873                                 | .981                                 | .845                                                     | .809                                   | .855                                   | .764                                   | .967                                   | .780                                                     | .887                                    | .990                                   | 1                                       |
| G14                              | .778                                          | .403                                   | .872                                 | .815                                 | .955                                                     | .808                                   | .292                                   | .523                                   | .832                                   | .709                                                     | .827                                    | .688                                   | .743                                   |

Table (5) shows that "A high variation in the cost of guessing between assignment and the actual cost of work" is one of the most important factors affecting the quality of government building construction projects in Iraq. The second factor that affects the quality of the project is "Provide detailed specifications for the items, quantities, and drawings." is the second factor that affects the quality of the project, and the third one is the "Time programs provided by the contractor and abide by them". Therefore, the contracting period provided by the contractor should be more realistic. Sample members also believe that "The flow of monthly payments and do not delay " This affects the quality of the construction project and "Specialization previous cumulative experience of the contractor in the field of work". This is because the primary task of contractors is to collect and assign workers, equipment, and materials for a project to achieve the most cost-effectiveness, time, and quality [13]. Additionally, "using a comprehensive and continuous supervision system" and "Owner team experience in the supervision and inspection work for the quality of work in all stages " [14] The main factors contributing to the quality of projects in Egypt have also been identified. " Change orders ". The scientific explanation for these factors is that the construction project includes many teams that oversee the execution of the construction work, therefore, should be detailed and described to contractors and contractors of subcontractors, Owners, etc., roles, responsibilities and powers of each individual among the individuals who will be involved in the implementation of the project to implement the quality management program. Moreover, "Provide regular stores for perishable items, stores (places of accumulation) for construction materials in the workplace" and "using high-quality materials at work", has been categorized as the tenth factor contributes to the quality of construction which is also supported by [15]
government buildings in Iraq. As a result, it will reduce disputes between the parties involved in the project.

Table 5. Factors that are arranged in descending order according to RII1, RII2.

| Sr. | RII1 *% | RII2 *% | Rank |
|-----|---------|---------|------|
| F9.6| 90.4    | 4.5     | 1    |
| F4.3| 88      | 4.4     | 2    |
| F5.1| 87.3    | 4.36    | 3    |
| F9.3| 86.2    | 4.31    | 4    |
| F5.2| 85.5    | 4.27    | 5    |
| F11.2| 84.6   | 4.23    | 6    |
| F6.2| 84      | 4.2     | 7    |
| F1.3| 83.3    | 4.16    | 8    |
| F10.3| 82    | 4.1     | 9    |
| F10.1| 81.1  | 4.05    | 10   |
| F1.1| 79.7    | 3.98    | 11   |
| F11.1| 79.5  | 3.97    | 12   |
| F2.1| 79.3    | 3.96    | 13   |
| F3.1| 78.6    | 3.93    | 14   |
| F14.1| 78.6  | 3.93    | 14   |
| F1.2| 77.7    | 3.88    | 15   |
| F13.1| 77.7  | 3.88    | 15   |
| F6.1| 76.8    | 3.84    | 16   |
| F4.1| 76.6    | 3.83    | 17   |
| F8.1| 76      | 3.8     | 18   |
| F5.3| 75.3    | 3.76    | 19   |
| F8.2| 75.3    | 3.76    | 19   |
| F8.3| 75.3    | 3.76    | 19   |
| F12.2| 75.3  | 3.76    | 19   |
| F4.2| 75.1    | 3.75    | 20   |
| F6.3| 75.1    | 3.75    | 20   |
| F11.3| 75.1  | 3.75    | 20   |
| F12.1| 75.1  | 3.75    | 20   |
| F14.2| 75.1  | 3.75    | 20   |
| F5.4| 74.8    | 3.74    | 21   |
| F6.4| 74.8    | 3.74    | 21   |
| F12.3| 74.6  | 3.73    | 22   |
| F8.4| 74.4    | 3.72    | 23   |

RII1*: Represents finding of relative importance using the Likert scale
RII2*: Represents finding of relative importance using the Arithmetic Mean.

5. Develop a model to measure the level of quality performance.

In this study, school buildings were adopted using the multiple linear regression method to develop a model for predicting the quality performance of government building projects in Iraq. I followed the steps to achieve the proposed model, starting with the identification of the independent and dependent variables that go through the modeling process and ended with advanced forms of verification. The following sections describe short steps for modeling.

5.1. Independent variables of the proposed model
In this study, RII₁ and RII₂ were adopted to define the extended model for independent variables. The factors that scored higher in the index (80%) were based on relative importance as the most important factors affecting the quality of government building projects. Therefore, this relationship leads to the selection of the first ten factors that affect performance quality, as shown in Table (6).

5.2. The dependent variable of the proposed model
The proposed model variable was determined using a second questionnaire sent to the same sample. The questionnaire contains a question to determine the quality level of government school building projects, especially for school buildings in the Najaf Governorate.

Table 6. The ten important factors that affect the quality of construction projects.

| Code | Sr. | Effective factor                                                                 |
|------|-----|----------------------------------------------------------------------------------|
| I₁   | F9.6| A high variation in the cost of guessing between assignment and the actual cost of work |
| I₂   | F4.3| Provide detailed specifications for the items, quantities, and drawings.          |
| I₃   | F5.1| Time programs provided by the contractor and abide by them                        |
| I₄   | F9.3| The flow of monthly payments and do not delay                                     |
| I₅   | F5.2| Specialization previous cumulative experience of the contractor in the field of work |
| I₆   | F11.2| The use of a comprehensive and continuous supervision system                       |
| I₇   | F6.2| Owner team experience in the supervision and inspection work for the quality of work in all stages |
| I₈   | F1.3| Change orders                                                                    |
| I₉   | F10.3| Provide regular stores for perishable items, stores (places of accumulation) for construction materials in the workplace |
| I₁₀  | F10.1| The use of high quality materials at work                                          |

5.3. Multi regression technique
Regression technology is a statistical modeling method that can be used for analysis and prediction in different visions. It is effective due to a well-defined mathematical form and its ability to explain the meaning of each variable and the relationship between independent variables. Models are adjusted to find linear set variables that best relate to independent variables. The regression equation is expressed as:

\[ Y = C + B₁I₁ + B₂I₂ + \ldots + BₙIₙ \]  \hspace{1cm} (3)

Where \( Y \) is the sum of the total estimated costs, and \( I₁ \) to \( Iₙ \) are measures of the various variables that can contribute to the estimation of \( Y \), \( C \), and \( B₁ \) to \( Bₙ \) are the estimated constant.

5.4. Development of the MLR model
Multiple regression analysis (MLR) is based on data from fifty project elimination methods that were used to develop the regression model. With this technique, all variables are entered into the form (QP) to predict the measurement and quality of equivalence of government building projects, and then one after the other. The variable with the smallest partial correlation with the dependent variable is first considered to be discarded, as shown in tables (7) and (8) of the model (QP).

Below is the final quality performance formula for schools building construction projects Developed:

\[ QP = -0.3176 + (0.0497*I₁) - (0.0820*I₂) + (0.0070*I₃) + (0.0211*I₄) + (0.0146*I₅) + (0.0006*I₆) + (0.0386*I₇) - (0.1391*I₈) \]  \hspace{1cm} (4)

Table (6) of the sample (QP) shows that with the exception of “Provide detailed specifications for the items, quantities, and drawings (I₂)”. In addition, " The use of a comprehensive and continuous supervision system (I₆)" Parameters were excluded because of their unimportance, as shown in Table
This model is selected at maximum ($R^2 = 0.886$) with a standard error value (0.02555) as shown in Table (7).

| Parameter | Unstandardized Coefficients | Standardized Coefficients Beta | t | Significance |
|-----------|-----------------------------|--------------------------------|---|--------------|
| Constant  | -0.3176                     | 2.9574                         | -10.74 | 0.9155       |
| $I_1$     | 0.0497                      | 0.1337                         | 0.290 | 0.7141       |
| $I_3$     | -0.0820                     | 0.1094                         | -0.1871 | 0.4619 |
| $I_4$     | 0.0070                      | 0.0017                         | 0.3386 | 0.0006       |
| $I_5$     | 0.0211                      | 0.0067                         | 0.3994 | 3.1449       |
| $I_7$     | 0.0146                      | 0.0060                         | 0.2580 | 2.4239       |
| $I_8$     | 0.0006                      | 0.0006                         | 0.0850 | 1.0243       |
| $I_9$     | 0.0386                      | 0.0174                         | 0.4721 | 2.2525       |
| $I_{10}$  | -0.1391                     | 0.2833                         | -0.0928 | 0.6286 |

*Model represents quality performance in school building construction projects.

| Model | $R$  | $R^2$ | Adjusted $R^2$ | Std. Error of the Estimate |
|-------|------|-------|----------------|---------------------------|
| 1     | .941a| .886  | .842           | 0.02555                   |
| 2     | .941b| .885  | .848           | 0.02504                   |
| 3     | .940c| .884  | .853           | 0.02462                   |
| 4     | .936d| .876  | .850           | 0.02490                   |
| 5     | .933e| .870  | .849           | 0.02495                   |

The relative importance of the independent variables is assessed by examining their standard parameters, i.e. for the typical beta values (QP) in Table (7). Predictions with higher standard parameters like "$A$ high variation in the cost of guessing between assignment and the actual cost of work $I_1$"," Provide regular stores for perishable items, stores (places of accumulation) for construction materials in the workplace $I_9$"," Specialization previous cumulative experience of the contractor in the field of work $I_5$"," Owner team experience in the supervision and inspection work for the quality of work in all stages $I_7$"," The flow of monthly payments and do not delay $I_4$"," The use of high-quality materials at work $I_{10}$". Therefore, the value of ($I_1$) indicates the strong effect while ($I_{10}$) indicates the weak effect of the relative importance [16].

5.5. Multi-collinearity assessments

In order to evaluate the multiple linear relationships between variables and changes, model inflation factors (VIF) were observed as shown in Table (9). Tolerance refers to the variance ratio for this variable that is not calculated by other predictors in the model and calculated using the formula ($1 - R^2$) for each variable. The tolerance varies from (0), which is the ideal linear relationship to (1) any related linear relationship. A tolerance with values below (0.1) generally indicates a collinearity problem. The variable inflation factor (VIF) is another indication for the diagnosis of several linear relationships and only reflects the value tolerance. The high value (VIF) of the variable indicates the strong correlation between this variable and the two remaining predictors. Variables with a higher tolerance certainly have small variable inflation factors. The differential inflation factor greater than (10) indicates the formation of several linear relationships. Because the measurement of quality performance includes tolerance values
and values (VIF) that do not violate the above criteria, multiple linear relationships are not a serious problem in this analysis.

Table 9. Collinearity test for the model (QP).

| Parameter | VIF  | Tolerance |
|-----------|------|-----------|
| I1        | 0.8911 | 1.1222    |
| I3        | 0.0875 | 11.4290   |
| I4        | 0.7697 | 1.2992    |
| I5        | 0.3380 | 2.9587    |
| I7        | 0.4810 | 2.0791    |
| I8        | 0.7917 | 1.2631    |
| I9        | 0.1211 | 8.2556    |
| I10       | 0.1525 | 6.5594    |

5.6. Multiple regression diagnostics

An important part of regression analysis is verifying that the required assumptions are met. The residual analysis is performed to evaluate the assumptions of linearity, the natural state, and symmetric inequality, which indicate different aspects of the distribution of degrees and the nature of the primary relationship between the variables. These assumptions can be verified using the remaining scatterplot, which is created as part of the multiple regression procedure. The residuals are the differences between the observed values and the expected values. Homosexuality is a description of data in which different error terms appear constant on the values of an independent variable. The standardized residual plot is run to verify the assumption of the normal state. The QP pattern diagram shown in Figure 3 indicates that the standard residue falls within the region between the standard deviation of -2 and +2 from the mean. Consequently, the assumption does not violate normality, and prediction errors are generally distributed. Naturalism is the assumption that each variable and all linear sets of variables are naturally distributed. When the assumption is fulfilled, the residual of the analysis is also distributed naturally and independently. From the regular P-P drawing in Figure (4) of the pattern (QP), it can be seen that the points are a straight diagonal line from the bottom left to the top right. This does not indicate significant deviations from normality. Defines the difference between the expected values and the obtained sum and is a measure of the prediction error. In most analyzes, the remainder of the total sum of the sample is zero. The residual square value provides a measure of how well the prediction is. When the predictions are close to the values obtained, the square errors are small. How the residual is distributed is of most importance in evaluating the extent to which the data satisfy the assumptions of multiple regression analyzes. For the QP model in the scatter diagram shown in Figure 5, the pieces of debris appear to be scattered randomly around a horizontal line; Therefore, the fixed and linear variance was assumed.

5.7. Model validation

One of the most important steps in developing a quality model is to test its accuracy and suitability. The test and evaluation of the developed form include some test or verification data. Verification data should be some representative data of the target population, but should not be used in model development. Quality is determined using equation (4) of the model (QP) and compared with actual data records. QP is working fine. To assess the validity of the model derived equation (QP) for quality performance in school building construction projects (QP), the natural logarithm (Ln) of the expected values (QP) is plotted against the natural logarithm (Ln); The actual values from the verification data set are drawn. The coefficient of determination (R²) was found to be (86.35%), as shown in Figure (6) of the model (QP), and therefore, it can be concluded that this model shows a moderate agreement with the actual observations. Table (10) shows the statistical measures used to verify the regression performance of the model (QP) in equation (4) of quality performance in construction projects for school buildings (QP) as the average error rate (MPE), the average absolute percentage error (MAPE), Average percentage precision (% AA), determination coefficient (R²) and correlation coefficient (R). From Table (11) of the Model (QP), it was found that the MAPE and AA ratio generated by MLR (QP) was (3.4547%) and (96.545%), respectively. Therefore, it can be concluded that the MLR (QP) model also shows a good
agreement with the actual observations. Finally, it is clearly seen that this model for government school building construction projects in Iraq has the ability to generalize any dataset within the range of data used to develop the MLR model. The QP form can be used to predict the quality of construction of government school building construction projects in Iraq for the ten data not used in the construction models. It can be said that the results of the generalization of the model in ($R^2 = 89.51\%$) are very good as shown in Figure (7).

Table 10. Actual and predicted quality performance from equation (4)

| No. of Project | LN(I1)  | I2      | LN(I3)  | I4 | I5 | I6 | I7 | I8 | I9 | I10 | Actual (QP) | Predicted (QP) |
|---------------|---------|---------|---------|----|----|----|----|----|----|-----|-------------|-----------------|
| 41            | 20.8976 | 2.0000  | 5.65249 | 36 | 7  | 2  | 8  | 30 | 2  | 0.8500 | 0.7780       | 0.74958         |
| 42            | 20.8648 | 3.0000  | 5.87774 | 38 | 9  | 3  | 11 | 60 | 3  | 0.9300 | 0.8600       | 0.87471         |
| 43            | 20.8352 | 2.0000  | 5.5835  | 34 | 6  | 2  | 9  | 46 | 2  | 0.8300 | 0.7080       | 0.74394         |
| 44            | 20.8394 | 3.0000  | 5.84354 | 33 | 10 | 3  | 11 | 55 | 3  | 0.9100 | 0.8500       | 0.86222         |
| 45            | 20.8437 | 2.0000  | 5.55683 | 28 | 6  | 2  | 9  | 44 | 2  | 0.8300 | 0.7020       | 0.70344         |
| 46            | 20.8854 | 1.0000  | 5.57595 | 31 | 7  | 1  | 8  | 45 | 1  | 0.8000 | 0.6700       | 0.69752         |
| 47            | 20.8895 | 2.0000  | 5.58725 | 28 | 8  | 2  | 10 | 30 | 2  | 0.8400 | 0.7470       | 0.75028         |
| 48            | 20.8002 | 1.0000  | 5.48894 | 33 | 8  | 1  | 9  | 48 | 1  | 0.8000 | 0.7500       | 0.75185         |
| 49            | 20.7958 | 2.0000  | 5.66988 | 29 | 7  | 2  | 9  | 37 | 2  | 0.8300 | 0.7000       | 0.71571         |
| 50            | 20.7868 | 2.0000  | 5.61313 | 27 | 6  | 2  | 8  | 52 | 2  | 0.8300 | 0.7100       | 0.67917         |

Figure 3. Histogram of the standardized residuals for the model (QP).

Figure 4. Regular probability graph of the standardized residual model (QP).

Figure 5. Scatterplot of standardized residual vs. standardized predicted value for the model (QP).

Figure 6. Observed vs. Predicted Quality Performance model (QP).
Table 11. The result of statistical measurements for the Regression model (QP).

| Description | Statistical Parameters |
|-------------|------------------------|
| E           | -0.5591%               |
| RMSE        | 0.0314                 |
| MAPE        | 3.4547%                |
| AA          | 96.545%                |
| R           | 0.929                  |
| R²          | 0.863                  |

Figure 7. Generalization of MLR model Quality Performance [Researcher].

6. Summary and conclusions

Through a detailed review of the literature, field visits, and personal interviews of engineers at the job site, 65 factors that affect the quality of the project were identified. A closed questionnaire was designed and distributed to (110) engineers, contractors, and stakeholders, (90) questionnaires were used, and ten factors of relative importance greater than (80%) were selected due to their significant impact on quality. Besides, the study provides a model to measure the quality of the project. This model is based on various linear regression analyzes and is called "QP". The factors (first, third, fourth, fifth, seventh, eighth, ninth, and tenth) were found to be the most influential in the multiple linear regression equation, and the factors (second and sixth) were excluded as evidence of their insignificance. The eight factors that affect quality were included in the model as independent variables. Forty data projects were used to build and test the model (QP), while the data from the remaining ten projects were used for verification. The remaining analysis was performed to assess linear assumptions and normal conditions. The MLR model was validated and showed very good performance (R² = 86.35%).

7. References

[1] Warsame, A. 2013. Framework for quality improvement of infrastructure projects. *Journal of Civil Engineering and Architecture*, 7(12), 1529–1539.

[2] Chan, A. P. C., & Tam, C. M. 2000. Factors affecting the quality of building projects in Hong Kong. *International Journal of Quality & Reliability Management*, 17(4/5), 423–442.

[3] Jha, K. N., & Chockalingam, C. T. 2009. Prediction of quality performance using artificial neural networks. *Journal of Advances in Management Research*.

[4] Shanmugapriya, S., & Subramanian, K. 2015. Ranking of key quality factors in the Indian construction industry. *International Research Journal of Engineering and Technology*, 2(7), 907–913.

[5] Yenurkar, A. M., & Wankhade, M. W. 2015. Assessment of factors affecting quality management in construction industry. *IJRESTs*, 1(8), 320–328.

[6] Hobana, K. S., & Ambika, D. 2016. Evaluation of factors affecting quality in construction projects. *International Journal Of Innovative Research in Science, Engineering and Technology* (An ISO 3297: 2007 Certified Organization) Vol. 5.

[7] Fegade, R., & Bhangale, P. 2016. Identification of the factors affecting the quality in high rise building. *International Journal of Latest Trends in Engineering and Technology*, 6(3), 297–301.

[8] El-Hamrawy, S. A.-K., El-Maaty, A. E. A., & Akal, A. Y. 2017. Proposed models to measure the quality of highway projects. *Engineering, Construction and Architectural Management*.

[9] ABDEL-RAZEK, R. H. 1998. Factors affecting construction quality in Egypt: identification and relative importance. *Engineering, Construction and Architectural Management*.

[10] Issa, U. H. 2012. Developing an assessment model for factors affecting the quality in the construction industry. *Journal of Civil Engineering and Architecture*, 6(3), 364.

[11] Ling, F. Y. Y. 2005. Models for predicting quality of building projects. *Engineering, Construction and Architectural Management*.

[12] Rustom, R. N., & Amer, M. I. 2006. Modeling the factors affecting quality in building
construction projects in gaza strip. Journal of Construction Research, 7(01n02), 33–47.

[13] Omole, A. O. 1986. Causes of the high cost of building and civil engineering construction in Nigeria. The Nigerian Quantity Surveyor, 6, 1–2.

[14] Akal, A., Abu El-Maaty, A., & El-Hamrawy, S. 2016. A circular framework for evaluating highway construction projects success: AHP approach. Civil Engineering Journal, 2(7), 324–333.

[15] Knutson, M. J. 1986. Building a quality PC concrete pavement. Solutions for Pavement Rehabilitation Problems, 165–186. ASCE.

[16] Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. 2007. Using multivariate statistics (Vol. 5). Pearson Boston, MA