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Formulating a Predictive Model to Improve the Quality of Building Construction Projects in India using Multi Linear Regression Technique

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Abstract: *An essential instrument for quality improvement is quality measurement. It is challenging to increase quality in building projects since there are few tools and techniques available for doing so. There is an urgent need to create new models due to the high cost of constructing projects for public structures and the absence of better instruments for gauging quality. In order to improve the quality of construction projects for government buildings and decrease maintenance, this research intends to offer owners, project managers, designers, and contractors with the essential information. In order to accomplish the goals of the research, a survey of 220 respondents was undertaken to identify the many elements influencing the quality of building projects. A literature analysis and interviews were undertaken as part of this research, which also helps to the development of a prediction model to assess the quality of these initiatives. A survey was distributed to owners, project managers, and engineers working on general construction projects in India with a personal goal of compiling a list of variables influencing the quality of government building projects. Multiple linear regression is used in the modeling process, and the most significant elements that have an impact on the project's quality are identified.*

*Keywords: C****onstruction projects, predictive model, multiple linear regression, quality management.***

I. Introduction

A construction project is any undertaking with the goal of constructing any kind of building or structure. Projects in civil engineering and architecture that include the physical assembly of a building or infrastructure are referred to as construction projects. A construction project is not a single action but rather a series of steps. Larger construction projects often include a project manager and a construction manager, both of whom need human multitasking. Larger building projects are also overseen by a design engineer, construction engineer, or professional project architect. The key to efficiently and cheaply completing construction projects is meticulous planning. Each construction management team involved in the design and execution of the infrastructure must use various safety measures and analyze the whole cost of the project to avoid work-related accidents or financial challenges. All construction projects need meticulous planning due to the project's inevitable effects on the environment and the economy.

Due to these inherent characteristics, all construction projects must undergo extensive planning in order to be successful. This planning must focus on the following aspects: the accessibility of building materials, logistics, budgetary planning, site safety, bidding, and the inconvenience the project will cause to the general public. Improving the quality of your construction projects begins with a thorough analysis of the factors affecting quality management and the development of strategies to address those factors. Some of the most common causes of project failure are the following: the utilization of defective and low-quality materials, supplier and vendor failures, mistreatment of subcontractors, failure to record changes and practices, last-minute alterations, scope creep, misunderstandings between teams, complex designs, the absence of a project management system, and the neglect of audits and testing. These variables affect every stage of a project's lifespan and may be avoided by doing rigorous due diligence in accordance with precise specifications for each one. You must use a variety of building quality methods in order to establish and adhere to these requirements. Public buildings are crucial for societal and economic development. It has an extended useful life and often needs government assistance with finance, development, and operations. An essential need for the execution of these projects is the adherence to technical requirements and quality standards. One of the most important methods for raising performance standards is to assess the quality of building projects. Additionally, it will lessen mistakes brought

on by inadequate implementation. The majority of the research, however, have been on different kinds of building projects. Construction work requires significant time and financial commitment; thus it is crucial to accurately forecast its quality.

II. Literature Review

Gilles THING LEO (2021) It's impossible to make the right choice on a construction project without considering all three points of the project management triangle QCT (Quality, Cost, Time). Indeed, in a competitive market, better, quicker, and cheaper are still crucial objectives in the creation of new industrial goods. We offer a reference framework to codify the quality criteria that distinguish a constructed structure. The degree of quality is then determined by comparing the actual performance of a building's features with the specifications established by its owner. There is also a suggestion to model the construction process so as to see how various technical and administrative decisions influence the final output. Finally, a proposal is made to portray the performance recovery permitted by a refurbishment operation as a resilient process by providing a representation of the degree of performance of each technical characteristic of a building throughout the course of its life cycle. The theoretical method is shown by a computer experiment towards the conclusion of this article. **Aawag Mohsen Alawag (2021)** It's common knowledge that Total Quality Management (TQM) techniques help businesses improve their operations and output in order to better satisfy their clients. Products and other innovations in the realm of construction sector organizations rely heavily on total quality management (TQM). In this study, we examine TQM's meaning, its advantages, and the link between TQM and project success in the building industry. The evaluated research focused on how TQM may be applied in the construction sector and how different stages of a project might benefit from it. TQM is primarily a means to an end—namely, the maintenance of business excellence via the pursuit of perpetual performance enhancements. This research adds to the body of literature on TQM and project performance by offering theoretical significance on TQM's potential to boost the performance of the construction sector. TQM has been shown to be effective in several studies, and its use is widely advocated as a means to boost business results. As this article has shown, TQM has several positive effects, including higher product quality, happier consumers, and the ability to meet and exceed customer expectations.

He Geng (2020) Many urban building projects are now underway, all contributing to the growth of the social economy. The building information model technology is widely utilized as a management method in construction information management. Better project quality management is possible with the use of BIM computer technology, which also facilitates information exchange. The primary purpose of this article is to provide an overview of the benefits of using building information modeling (BIM) software for construction engineering management. **Wenguang Xie (2019)** China's modernisation building has picked up steam in recent years, thanks to the country's booming economy, and highway traffic engineering has been steadily expanding throughout the country. The need of building to high standards is constantly emphasized. Highway traffic engineering relies heavily on civil engineering. The quality of the build has a major impact on the final product. Consequently, this article provides a comprehensive discussion of quality management strategies applicable to highway traffic civil engineering, beginning with the pre-construction, construction, and post-construction phases. **Jinbao Cao (2018)** The building sector has become more important to the health of our economy as a whole in tandem with rising standards of living and expanding social mobility. The interests of the public service in China depend on the construction sector thriving, and this in turn impacts the stability of the national economy. Therefore, the relevant department should give construction quality a high priority, and research into construction quality management should be actively encouraged. This article offers a clear definition of quality management in construction projects, as well as an analysis of the state of quality management and control in Chinese building projects today, and some suggestions for improving the sector. Finally, the study discusses in depth the process and measures of quality management and control of construction projects, using the construction industry as an example and focusing particularly on the newly adopted technical technique.

Junying Lou (2017) The unavoidable byproduct of a highly efficient, complex, and dense urban complex is modernisation, urbanization, and globalization. In addition to fostering economic and cultural growth in the area, it will also serve as a civic landmark. BIM's information exchange, features, and capabilities for the construction of the project give a lot of aid to provide quality protection to guarantee that construction quality requirements are met, which is especially important in the context of urban development, which should be quality-oriented. This article uses a case study of a project to build an urban complex to examine the challenges inherent in ensuring high-quality work throughout the building process. When building information modeling (BIM) and augmented reality (AR) are used in the field during the construction phase, the quality of the work is improved at every step of the process. The use of BIM technology in construction quality control for the future urban complex is meant to serve as a benchmark for bettering the overall quality of projects and the productivity of the construction sector as a whole. **Luai Eid Jraisat et al. (2016)** This paper's focus is on determining which variables most strongly impact quality. This is crucial in contexts where significant amounts of money, time,

and other resources are lost annually as a result of subpar or nonexistent quality. Methodology/approach/design We take an experimental strategy. Following an overview of the relevant literature, six in-depth interviews with industry experts were undertaken, and finally, 328 questionnaires were sent to contractors and architects working in Jordan's residential building industry via in-person, organized interviews. Conclusions Both contractors and architects seem to have agreed that human resource management, customer satisfaction, and construction-specific criteria are the most significant in determining project quality. In addition, the results imply that strategic planning, continual development, and resources are not among the most crucial elements. In addition, we construct a theoretical model that includes all of the major determinants of quality. Constraints/implications of the study: The findings of this study have significant ramifications for construction industry management at all levels. Managers may maintain a balanced and integrated quality strategy by focusing on the most critical elements and catching up on the least important ones after they have a firm grasp of the quality factors at play. The study is novel and valuable since it is one of the few to examine the significance of quality elements. This is the first work on the topic of quality factors in construction management in a developing nation, and to the authors' knowledge, it is also the first to provide empirical data. It was observed by Ashok kumar (2014) that small-scale construction businesses do not have that much knowledge on quality management system, thus he devised a measuring technique for customer satisfaction with continuous improvement in the building process. Data were obtained by questionnaire and analyzed in SPSS. The questionnaire was sent to a wide range of small-scale construction businesses. The execution procedure of the super structure was the primary topic of the questionnaires. The key component that influences building quality and so raises construction expense owing to flaw in quality has been highlighted by the author. The findings also provide corrective actions to cut down on material, labor, time, and indirect cost waste. Implementing overall quality management has been confirmed by Heshammagd (2014). The author said that the introduction of complete quality management was propelled by the dedication of senior management. Decision-makers should also think about the status of the organization's infrastructure and its capacity for training and education when trying to put overall quality management into practice successfully, according to the findings. The benefits of using complete quality management on building projects of all sizes were outlined by Hosseinalidehghan et al., 2014. The author surveyed and interviewed members of the construction industry to determine the most important variables in the successful implementation of comprehensive quality management and the most significant obstacles to its widespread adoption. The writer offered a plan of action for introducing quality control into the building trades. Top management commitment and customer satisfaction were found to be the most important elements in the implementation of complete quality management in building projects. One of the biggest challenges in implementing overall quality management was getting top-level buy-in to revamp work processes and shift priorities. Research by Muhammad Asim et al., 2013 investigated the suitability and extent of implementing quality management methods in the Pakistani building sector. A questionnaire survey was administered to 30 different contractor businesses operating in the Pakistan construction sector in order to assess the most important factors. The authors arrived at the conclusion that construction contractors made the final decisions and that the vast majority of building contractors had doubts about implementing a whole quality control system. Conclusions also showed that workers' productivity increased as a consequence of better project organization and communication.

Total Quality Management (TQM) has been widely studied, and according to Faisal Talib (2013), its use has recently shifted from factories to service businesses. He delves into the literature on Total Quality Management in service businesses and the reasons for its failure, highlighting its widespread adoption and success across industries. Last but not least, the research offers thorough recommendations for successful TQM rollouts in service businesses. The research helpfully suggests a ten-step STP strategy for introducing TQM into service businesses. This research aims to provide service managers and practitioners with a grasp of TQM theory and to offer them with a framework for implementing TQM effectively. The advantages and disadvantages of implementing comprehensive quality management in Pakistan's building industry were discussed by Tahir Nawaz and Amjadaliikram (2013). Based on their analysis of the survey results, the authors conclude that a comprehensive training program for both workers and managers is essential for successful TQM implementation in Pakistan's construction sector. In addition, time and money were shown to be the two most significant aspects of project success. According to Raji and Adhmawi (2011), "Quality management as achieving the owner's needs of compliance with the norms and specification" is a definition that has emerged from the literature on quality management ideas and their application in the construction industry. Applying the ideas of TQM, which are a representation of quality management, makes this definition a reality. Furthermore, the authors advocated for a suggested quality management system for construction sites with the dual goals of 1) increasing the quality of construction projects and 2) increasing the awareness of quality management ideas among construction personnel at various managerial levels.

III. Aims of the Study

Construction projects should always prioritize quality. The purpose of this research is to investigate and assess the elements that have an effect on project quality. Thirty elements affecting the establishment of buildings in Iraq were discovered via a survey of existing literature and interviews with engineers experienced in the management and implementation of construction projects in India. The goals of this research include:

- Identify the variables that contribute to construction projects' overall quality.
- Analyze and categorize the most influential elements impacting the high quality of Indian construction projects.
- In order to improve the quality of government building construction projects in India, it is necessary to develop a mathematical model for forecasting quality performance.

IV. Research Methodology

In order to achieve the objectives of the study, the step-by-step procedure is explained as follows:

Step-1) Identification of questions for questionnaire development
Based on the literature analysis and interviews with professionals, 38 research questions were designed to help accomplish the study's goals.

Step-2) Development of Questionnaire
Two portions, P-1 and P-2 made up the questionnaire. P-1 included demographic information including name, age, and experience level, whereas P-2 had questions directly relevant to the study's aims. The survey questionnaire resulted in 220 replies.

Step-3) Validity and Reliability test of questionnaire responses
Validity of Questionnaire
The experts were also asked to determine what proportion of the questions seemed relevant to them. The term "average congruency %" refers to the mean of the percentages reported by different experts (ACP) [Popham, 1978].
Reliability of Questionnaire data
The term "data reliability" refers to the degree to which the information gathered in a study can be relied upon. Cronbach's alpha, which measures the degree to which two sets of data are consistently associated, is used to determine the reliability of the questionnaire in this study.

Step-4) Frequency Analysis
The percentage of respondents that put their support in each agreement category is described via a frequency analysis of each variable. Summary measures for categorical variables may be generated in the form of frequency tables, bar charts, or pie charts using the frequencies technique in SPSS software.

Step-5) Multiple Linear Regression
Multiple regression, often known as multiple linear regression, is a statistical technique for estimating the value of a response variable given a set of potential predictors. Multivariate linear regression attempts to model the linear relationship between the independent (explanatory) variables and the response (dependent) variables. One way to think about multiple regression is as an expansion of ordinary least-squares (OLS) regression by integrating extra explanatory variables.

- Multiple regression, or multiple linear regression, is a statistical method for predicting the value of a response variable based on a number of independent explanatory factors.
- Linear (OLS) regression employs a single explanatory variable, whereas multiple regression uses many variables.
- MLR has found widespread use in the fields of econometrics and financial inference.

Formula and Calculation of Multiple Linear Regression

$$\mathbf{y_i = \beta_o + \beta_1.x_{i1} + \beta_2.x_{i2} + \beta_3.x_{i3} + \beta_p.x_{ip} \ldots\ldots\ldots e}$$

where, for $i=n$ observations:
y_i = dependent variable
x_i = explanatory variables
β_o = y-intercept (constant term)
β_p = each explanatory variable's slope coefficients = the model's error term (also known as the residuals)

V. Results and Discussion

In order to measure what we want to measure, something must be valid. Research methodology provides the techniques to determine the validity. The computed value of ACP for both questionnaires was 92%, which is much higher than the suggested threshold of 90%. (Poham. 1978).
The consistency or reproducibility of the measurement is referred to as reliability. This is crucial if the metric is intended to be used continuously to spot change.
The reliability of replies on the five-point scale was evaluated using Cronbach's alpha. Table 1 contains the results of the calculation of Cronbach's alpha using the SPSS program.

Development of the MLR model
Create a model to gauge the performance quality level. In this work, a model for forecasting the quality performance of construction projects in India was developed using the multiple linear regression approach on college buildings. The methods I used to create the suggested model were as follows: I began by identifying the independent and dependent variables that go through the modeling process, and I finished with sophisticated kinds of verification. Short modeling steps are described in the sections below.

Independent variables of the proposed model
According to Table 2, the top 10 quality criteria are regarded as independent variables based on the RII values. Table 2 lists these independent factors.

Table 2 Independent Variables and Dependent variable

Code	Factor	RII	Rank
F1	9. Poor technical knowledge of Contractor;	0.633	1
F2	13. Lack of construction quality criteria defined in contract;	0.632	2
F3	25. Change in specification and type of materials during construction;	0.629	3
F4	16. Highly complex Design;	0.624	4
F5	20. Lack of quality criteria for raw materials;	0.620	5
F6	21. Using faulty instruments for material quality testing;	0.620	6
F7	12. Limited construction time imposed by project clients;	0.617	7
F8	32. Hostile social environment (Chances of theft, unsocial behaviour by locals, etc.);	0.616	8
F9	19. Severely low cost product specifications defined in the contract;	0.615	9
F10	34. Hostile economic environment (High inflation rate, delay in payments, etc.);	0.613	10
	Dependent Variable: Level of Quality you achieved after the completion of the above construction project.		

The dependent variable of the proposed model
The proposed model treats the quality performance of hypothetical Indian construction projects as the dependent variable. The answer "Y" suggests that this is the case. The proposed model variable was derived from the responses of a second survey given to the same sample. One question in the study asks how likely construction projects in India are to be successful.

Multi regression technique
A statistical modeling technique known as regression technology may be utilized for analysis and prediction in a variety of contexts. It works effectively because it has a clear mathematical structure and can explain the significance of each variable as well as the link between independent variables. The optimal linear set variables that link to independent variables are found by adjusting models. The regression equation looks like this:

$$Y= \beta_0 + \beta_1 *F1 + \beta_2 *F2 + \ldots. + \beta_n *Fn$$

Where Y is the sum of the entire estimated costs, and F1 to Fn are measurements of the different variables that may contribute to the estimation of Y, and β0, and β1 to n are the estimated constants. Whereas F1 to Fn are measures of the various variables that can influence to the assessment of Y.

Development of the MLR model
Specifically, the regression model was developed using data from 32 different project elimination techniques using multiple regression analysis (MLR). Measurement and quality equivalence predictions for public construction projects may be made by filling out a single form (QP) with all relevant information. See the ultimate quality performance formula for make-believe building projects down below. Developed:

QP = -9.350 + (0.504*F1) + (0.434*F2) + (0.348*F3) + .596*F4 +.449*F5 + .573*F6 + .310*F7 + .150*F8 + .489*F9 + .418*F10

This model is selected at maximum (R^2 = 0.933) with a standard error value (0.37583) as shown in Table (3).

Table 3 Model Coefficient

Coefficients[a]							
Model		Unstandardized Coefficients		Standardized Coefficients	t	P-Value	Collinearity Statistics
		B	Std. Error	Beta			VIF
1	(Constant)	-9.350	.874		-10.695	.000	
	F1	.504	.073	.468	6.884	.000	1.440
	F2	.433	.088	.333	4.941	.000	1.412
	F3	.348	.103	.247	3.365	.003	1.679
	F4	.596	.099	.439	6.034	.000	1.652
	F5	.449	.121	.283	3.698	.001	1.824
	F6	.573	.084	.488	6.801	.000	1.601
	F7	.310	.102	.223	3.035	.006	1.679
	F8	.150	.114	.098	1.321	.201	1.713
	F9	.489	.083	.375	5.899	.000	1.257
	F10	.418	.105	.278	3.990	.001	1.514

Basically, the null hypothesis is disproved if P-value is less than 0.05. When the P-value is greater than 0.05, the null hypothesis is not disproved. Rejecting the null hypothesis indicates that there is an impact. However, if a null hypothesis is not disproved, it indicates that no effect exists. Therefore, only F8 has no measurable impact on the building project's quality.

Table 4 Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.966[a]	.933	.900	.37583

- The R-value represents the strength of the relationship between the dependent and independent variables. A value greater than 0.4 is selected for further analysis. The current value of.966 is good.

- The coefficient of determination (R) shows how much of the total variation in the dependent variable can be attributed to the independent variables. The model can detect the relationship if the score is more than 0.5. In this case, the value is.933, which is positive.

- • The adjusted R-square in multiple regression displays the extent to which results may be extrapolated to the population as a whole, or the variance of the sample results relative to the population as a whole. When comparing R-squared and Adjusted R-squared, the gap between the two values should be small. In this case, the value of.900 is acceptable since it is near to the desired value of.933.

Table 5: ANOVA Table

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	P-Value
1	Regression	41.034	10	4.103	29.051	.000[b]
	Residual	2.966	21	.141		
	Total	44.000	31			

Analysis of variance (ANOVA) test is conducted to check the overall adequacy of the model. In other words we need to check whether all the model parameters are significant or not. This test of hypothesis is about whether H0 = B1=B3=……=Bn=0, is accepted or rejected. The existence of a linear connection between QP and the factors F1, F2,..., and F10 is tested here. The P-value of 0.000 in Table 5 is less than 0.05, hence the null hypothesis is rejected. Hence we concluded that at least one of the explanatory or independent variable among F1, F2 …F10 have linear relationship with dependent variable QP, and so they contributes significantly in the model

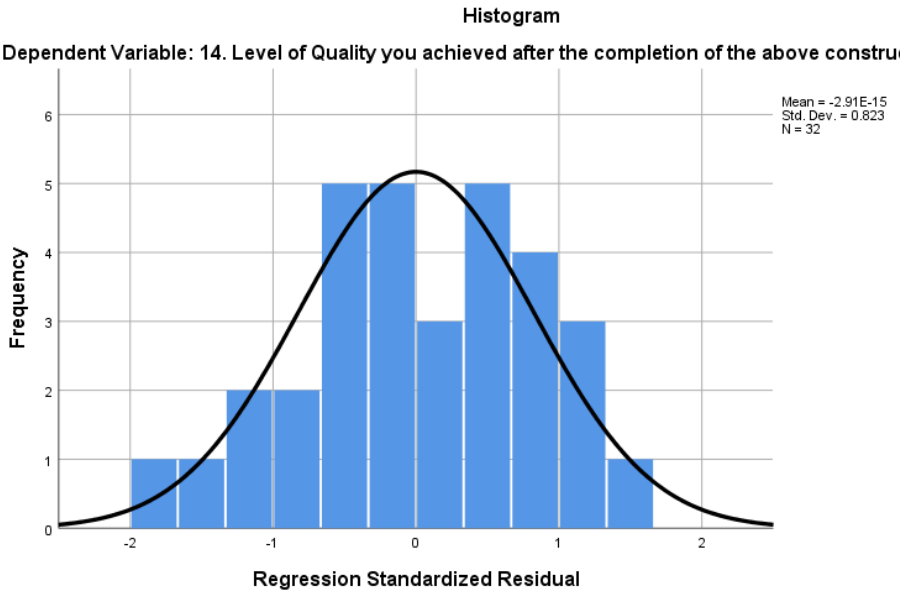

Fig. 1: Histogram Plot between Frequency and Regression Standardized Residual

For the normality assumption for residuals to hold, the residuals' histogram should take on a bell-shaped distribution with equal tails.

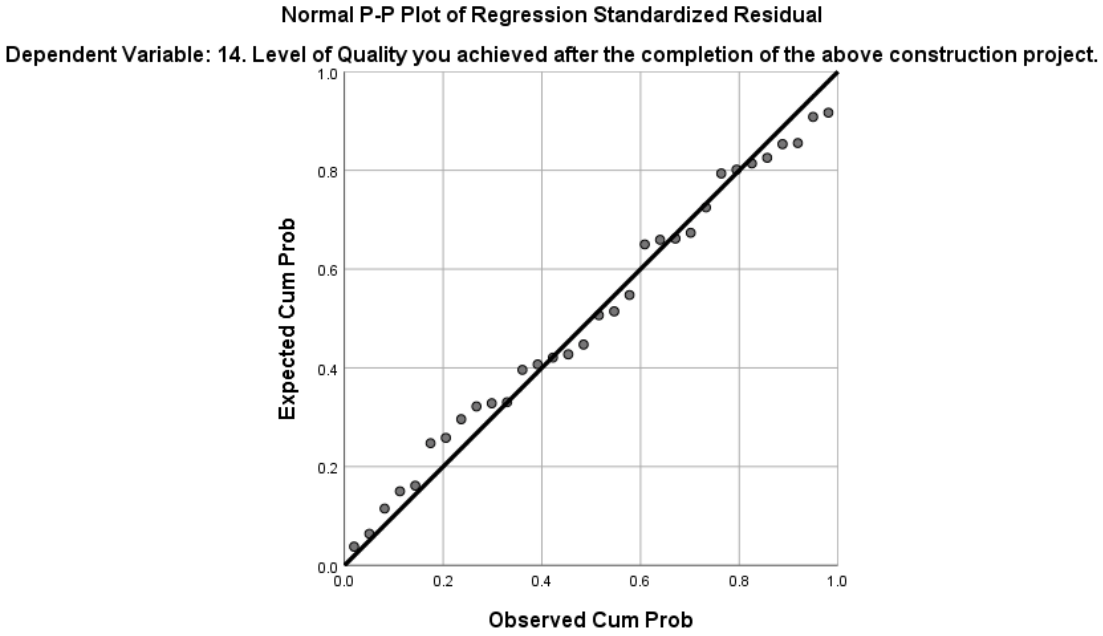

Fig. 2: Normal P-P Plot of Regression Standardized Residual

In Figure 2, we see a typical linear trend in a plot of probabilities. Because there are no outlying points or curves in this graph, we may safely infer that the variance of the error components is constant (homoscedasticity). There is more evidence that the error terms are regularly distributed.

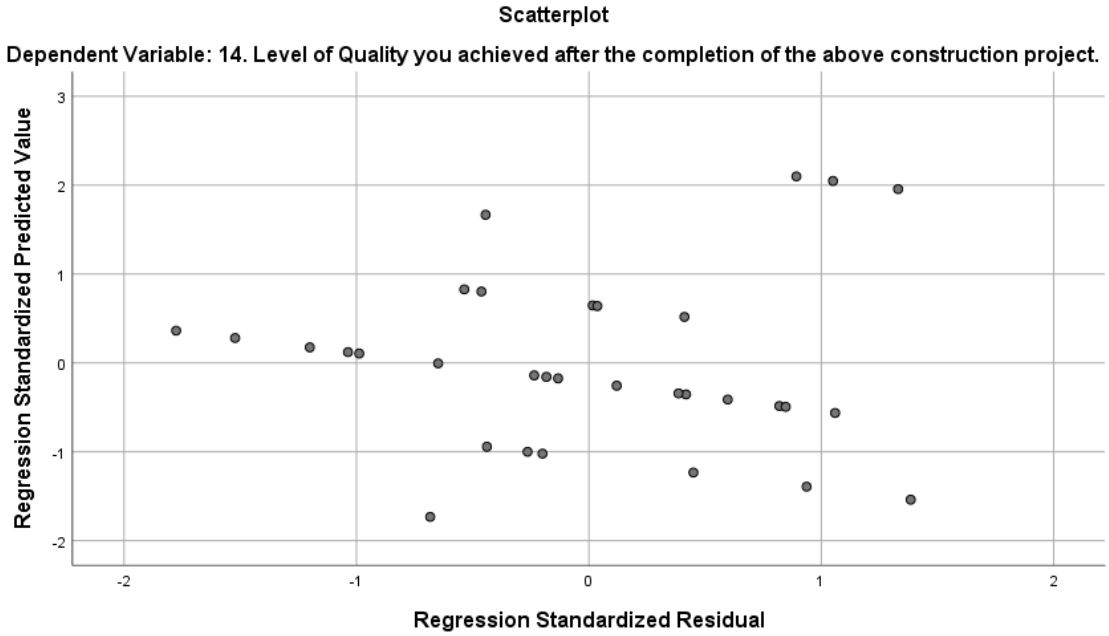

Fig. 3: Standardized model residual and prediction scatter plot (QP).

If you look at the scatterplot of the standardized residuals vs the predicted (fitted) values, you'll see that the residuals are spread out evenly over the horizontal axis. The residuals seem to "bounce erratically" about the 0 line. It seems plausible to assume a linear connection based on this. The residuals may be thought of as a "horizontal band" that approximately surrounds the 0 line. This indicates that the error terms have similar variances (homoscedasticity) There is no "standout" residual from the overall random distribution. So, it seems there are no anomalies.

VI. Conclusion

MLR was used to develop a model that predicts quality performance based on the identified essential criteria in the current investigation. The intended quality performance in building construction projects may be accomplished with the management of the identified essential components and the use of the prediction model. This section concludes the study and discusses its limits, future directions, and implications:

Impacts of several elements on the quality of Indian building projects are analyzed and assessed. For this purpose, 220 responses were collected, and analysis of collected data illustrate following major points:

- P-1 questionnaires is found to be valid as the ACP value was estimated as 92%.
- The estimated values of Cronbach's Alpha are 0.823 and 0.891, which demonstrate the reliability of the data obtained from the questionnaire survey.
- In the questionnaire survey, most of the respondents were supervisor (12.7 % frequency).
- In the questionnaire survey, 33.2 % respondents were government employee, 36.4 % respondents were private employee, and 30.5 % respondents were other employee.
- In the questionnaire survey, qualification level of 18.6 % respondents was diploma, qualification level of 15.9 % respondents was degree, qualification level of 23.6 % respondents was post-Graduation, and qualification level of 25 % respondents was PhD.
- In the questionnaire survey, working experience of 29.1 % respondents was 1-2 years, 18.6% of respondents had job experience between 3 and 5 years, while 15.9% had experience between 5 and 10 years, working experience of 24.5 % respondents was 10-20 years, and working experience of 11.8 % respondents was above 20 years.
- In the questionnaire survey, 50.9 % respondents were know about quality control in the construction sector.

To accomplish the intended quality performance, the project specialists might focus on a few elements rather than managing all the factors at once. Based on the frequency and descriptive analysis of data, followings were the top 5 most important quality factors for construction projects;

- Poor technical knowledge of Contractor;
- Lack of construction quality criteria defined in contract;
- Modifications to the specifications and materials used during construction;
- Highly complex Design;
- Lack of quality criteria for raw materials;

Followings are the 5 least important quality factors for construction projects;

- a lack of collaboration and relationships amongst project members;
- Infrastructure installation at the location;
- Lack of supervision by client;
- Improper site installation of equipment's and facilities;
- Lack of management commitment to quality;

Based on MLR, following conclusion can be made:

- Only factor F_8 (Social environment of construction site) has no significant impact over quality of building construction project.
- R, R-square and Adjusted R-square values are calculated as 0.966, 0.933 and 0.900, which shows that developed MLR model is best fitted model.
- "(F4) Highly complex Design" indicates the strongest relative effect while "(F7) Limited construction time imposed by project clients" indicates the weakest effect of the relative importance over quality performance.
- The suggested model validates each assumption established for the MLR, allowing the project manager and his team to utilize it intelligently to forecast the project's quality performance over time.
- The high level of predictive capacity (R-sq(pred) is 84.90%) demonstrates the accuracy of the parameters discovered via statistical analysis and demonstrates their applicability in predicting the performance quality of building construction projects.

Finally, excellent building quality is a must and the result of a superb team effort. It calls for qualified personnel, dedicated management, dependable suppliers, and competent subcontractors. Each participant in the project should be pleased with their effort and grateful for that of their colleagues.

VII. Scope for Future Work

- Similar model can be developed to predict the time and cost of project.
- Time and cost performance of project can be predicted using MLR technique.
- An interface may be created to make it easier for users to enter data and to access the generated quality performance prediction model's predictions. In order to know the pertinent quality performance, the project team will be able to make immediate the factor inputs after the user interface has been established.

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