Journal of UTEC Engineering Management
Volume 02, Issue 01, 2024, 37–52
https://doi.org/10.36344/utecem.2024.v02i01.004
Research Article

Navigating Delays: A Comprehensive Study of Public Building Retrofitting Projects in Kathmandu Valley

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Article History

Received: 7 March 2024

Accepted: 4 April 2024

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DOI

https://doi.org/10.5281/zenodo.13169684

ABSTRACT

The objective of the study was to find out the present scenario of delays of retrofitting of public building with case of 11projects of Kathmandu valley. An observation and study of the project document is carried out along with questionnaire survey with 50 respondents. The maximum rate of delay in the retrofitting project is found to be 167% time overrun and minimum is found to be 42% of time overrun. Only one project among them is within the schedule with physical progress of 22%. A multiple linear regression analysis was performed to examine the influence of the variables Time overrun (Months) and Time extension with respect to initial contract (%) on the variable Physical Progress. A model summary model is obtained as follows: Physical Progress = 0.57 + 0.02 * Time overrun (Months) - 0.15 * Time extension with respect to initial contract (%) The top ranked specific delay contributing factors in a retrofitting project are as found as Impractical project schedule and duration (frequent changes in critical path), Unavailability of the numbers and skilled workforce for retrofitting projects, Delays occurred due to lack of coherence in architectural, structural, electrical, sanitary, and HVAC drawings, Approvals of shop drawings submitted by the contractor and Unavailability of the specific materials as per BOQ.

Keywords: Retrofitting, delay, attributable, hypothesis, multiple regression

Introduction

The construction industry is one of the largest businesses in the world. In developing countries, the construction industry is significant to provide employment as well as infrastructure. Nepalese Construction Industry is the second largest employer of the country that provides employment opportunity not only to the unemployed but also to the underemployed and to the seasonal workers. It contributes around 11 percent to GDP, and it uses a big part of the government budget. Similarly, about 60 percent of the nation's development budget is spent using contractors.

Most of ongoing projects in Nepal, whether they are donor funded or not, are being delayed mostly due to various issues of project management, project administration, contract management, safeguards, and multidimensional interest of stakeholders and because of the underlying uncertainties and political liquidity(Yadav & Mishra,2019).

Retrofitting is the modification of existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes. It is the concept of up gradation of lateral strength of structure, increase in ductility of structure and increase in strength. Invalid source specified.. Retrofitting is a new concept in Nepal which deals with restoring a damaged structure to its original form and function. There are no specific norms, rules, standards related to Retrofitting Projects in Nepal and due to which there are lot of issues and challenges in these projects. This research study is about an analysis of the factors causing delays and ways to manage them in Retrofitting of Public Buildings in Nepal.

Nepal, situated in one of the world's most active seismic regions, experiences frequent seismic events due to the presence of two massive tectonic plates—the Indian plate and Eurasian plate. With earthquakes posing a significant threat, it's essential to ensure the resilience of public buildings through retrofitting initiatives. However, the timely completion of these projects, managed mainly by organizations like CLPIU and DUDBC, is crucial for the country's development. Public buildings such as hospitals, schools, and administrative buildings are particularly vulnerable and require timely retrofitting to safeguard society. Despite the importance of retrofitting projects, delays persist, hindering progress and leaving communities at risk. Therefore, there is an urgent need to investigate the factors contributing to delays in retrofitting public building projects in Nepal. By identifying these issues and implementing effective management techniques, we can mitigate delays and ensure the successful implementation of retrofitting initiatives for the safety and well-being of Nepali citizens

Objective

The overall objective of the study is Navigate delays through a comprehensive Study of Retrofitting Public Building Projects in Kathmandu Valley.

Literature Review

Retrofitting

Retrofitting involves altering pre-existing structures to enhance their ability to withstand seismic events, ground motion, or soil instability caused by earthquakes. This concept involves improving the lateral strength, enhancing structural ductility, and increasing overall strength of the constructionInvalid source specified..

Retrofitting is undertaken to enhance the original strength to the current requirement so that the desired protection of lives can be guaranteed as per the current codes of practice against possible future earthquakes. Retrofitting of a building will involve either component strength enhancement or structural system modification or both. It is expected to improve the overall strength of the building Invalid source specified..

Retrofitting is described as a procedure of change of existing structure such as, Residential buildings, bridges, and historical buildings to make them impervious against seismic actions like earthquakes, volcano eruptions, and other Natural disasters. Retrofitting is the best method to make safe the existing structures from future earthquakes and other environmental factors. Retrofitting diminishes the helplessness of harm to a current

structure amid future seismic movement. It plans to reinforce a structure to fulfil the necessities of the present codes for seismic outline. With respect to conventional repair and rehabilitation, retrofit is much better and more convenient. Retrofitting helps to enhance the strength, resistivity, and overall lifespan of the structure (Mali, et al., 2022).

Retrofitting is Needed to

- Ensure the safety and security of a building, employees, structure functionality, machinery, and inventory
- Essential to reduce hazard and losses from non-structural elements.
- Predominantly concerned with structural improvement to reduce seismic hazard.
- Important buildings must be strengthened whose services are assumed to be essential just after an earthquake like hospitals Invalid source specified..

Retrofitting the existing buildings is one of the most environmentally friendly, economical competent and proven as an efficient solution to optimize the energy performance and could also help to prolong the life of the existing building especially to the historical buildings. Thus, the application of retrofit should be promoted across the construction and conservation industries. More research need to be done in order to have complete sets of detail data on the direct and indirect impacts of retrofit to the environment, cost differences between retrofit with the normal construction of a building, cost of maintenances as well as, the impacts to the end users and to the surround area of retrofitted buildings Invalid source specified..

Retrofitting is a pioneering and cost-effective technique of seismically intensification existing houses by strengthening structural elements and stabilizing the existing structure, making them earthquake resistant. Retrofitting is a new concept which deals with restoring a damaged structure to its original form and function. There are three categories of retrofitting: Repair, Restoration and Seismic Strengthening. People became aware about Retrofitting of buildings only after Gorkha Earthquake, 2015. After the massive Gorkha Earthquake of April 25th, 2015, large number of buildings were affected hence to enhance repair, maintenance, rehabilitation and improve of this situation many retrofitting projects were added to the list of construction projects of Nepal especially public buildings (K.C., et al., 2022).

A study conducted in Nepal concludes that retrofitting is a financially advantageous investment since the reduction in future earthquake-induced loss largely exceeds the upfront cost of the intervention. Additionally, the incremental approach allows more flexibility in allocating resources and could increase the appeal of retrofitting as a risk mitigation measureInvalid source specified..

Previous study proved that ready to use dimension and material properties defined by MRT guidelines are not sufficient for seismic loading as per new NBC code 105:2020 and are vulnerable to any major earthquakes. Hence, interventions for strengthening i.e. retrofitting is needed Invalid source specified..

A study titles “Seismic safety of schools in Kathmandu Valley, Nepal: problems and opportunities” outlines one of NSET’s projects, which is showing real potential to bring about change to existing practices. It concluded the problems in retrofitting in context of Nepal are Limited manpower, Limited resources, Mid-career training, Professional ethics, Priority from government, No recognition for traditional materials and skills and Communication gap. The opportunities associated with retrofitting are Economic front, Community participation, Craftsman, Awareness raising, Formal training, Building code, Government initiative and international initiative (Bothara, et al., 2002).

Retrofitting existing buildings stands out as an ecologically sound, cost-effective measure that has demonstrated its efficiency in enhancing energy performance. Moreover, it holds the potential to extend the lifespan of structures, particularly those of historical significance. Therefore, advocating for the widespread adoption of retrofitting methods in both the construction and preservation sectors is crucial. Further investigation is required to

accumulate comprehensive datasets encompassing the direct and indirect environmental effects of retrofitting, the economic disparities between retrofitting and standard construction procedures, maintenance expenses, as well as the repercussions for occupants and the surroundings of retrofitted edifices Invalid source specified..

Retrofitting Challenges

Adaptation and retrofitting of existing buildings in recent times has gained increasing recognition as an acceptable alternative to new buildings. But there are challenges to retrofitting and adaptation of existing buildings. The high costs of retrofitting process, poor maintenance culture of building owners, health, and safety requirements during retrofitting, building tenants' resistance to disruptive processes, inadequate government legislation are some challenges to retrofitting and adaptation of existing buildings. Health and safety practices in adaptation and retrofitting needs a more concerted effort and needed to be put in place to achieve an accident-free working environment. Building tenants' resistance to disruptive processes is a challenge to the retrofitting and adaptation as tenants who choose to stay in the facility while the process of retrofitting is on-going tend to disrupt the process through pilfering, physically assaulting workers, insulting among others. (Ernest, et al., 2016).

A study was carried out in Malaysia focused on the utilization, potential, and obstacles linked to retrofitting pre-existing structures. This study delved into the practicality, prospects, and difficulties associated with retrofitting. Two specific buildings were selected as case studies, and on-site inspections and observations of these structures were conducted. Subsequently, the gathered data was compared in tabular format for analysis. In addition to on-site visits, both primary and secondary sources were tapped into as valuable resources for this research endeavor. Challenges found were

- Expensive and inconvenient
- Internal spaces may reduce upon installation of internal wall-insulation
- Might cause negative impact to heritage and archaeological assets caused by usage of unproven methods, technologies, or instruments
- Further research is needed especially on insulation mechanism on walls and the effect on retrofit on buildings fabrics
- More education, training, and activities on maintaining and preserving the buildings need to be taught to address issues and to create awareness
- The risk of retrofitting needs to be highlighted, not just focusing on the Opportunities of retrofitting and discussion between retrofit and refurbishment Invalid source specified..

Retrofitting existing buildings for sustainability is more challenging than designing a new sustainable building from scratch (Miller & Buys, 2011). From different studies of retrofitting projects, we can observe there are various challenges in retrofitting projects which were tabulated as shown in table 1.

A study on the Challenges and Opportunities in Retrofitting Government Schools within the Disaster Resilience of Schools Project in the Kathmandu Valley, Nepal, identified four key challenges: economic, technical, regulatory, and cultural hurdles. The primary economic challenge involved a discrepancy between the initial retrofitting cost and the subsequent operational expenses of retrofitted structures. Technical challenges stemmed from a deficient knowledge of the performance of aging buildings. Regulatory challenges were characterized by a disconnect between robust research, standards, and practical applications essential for informing sustainable retrofit frameworks. Lastly, cultural challenges were marked by insufficient engagement, hindering community participation in finding solutions Invalid source specified.. In the context of retrofitting projects, a study on the Challenges and Opportunities in Retrofitting Government Schools within the Disaster Resilience of Schools Project in the Kathmandu Valley, Nepal, identified four key challenges: economic, technical, regulatory, and cultural hurdles Invalid source

specified.. Additionally, studies by Invalid source specified., (Miller & Buys, 2011), (Ernest, et al., 2016), highlighted regulatory challenges, financial constraints, technical complexities, and a lack of stakeholder coordination in retrofitting projects, all of which could contribute to delays in these projects.

Table 1

Challenges of Retrofitting of Existing Buildings

Challenges	References
High cost of adaptation and retrofitting process	Miller & Buys, (2011)
Building user's resistance to disruptive processes	Miller & Buys, (2011)
Cheung et al., 2000	
Lack of funding	Dixon (2014)
Oppong & Masahudu (2014)	
Inadequate legislation	Oppong & Masahudu (2014)
The difficulty in incorporating new technologies into existing buildings	Miller & Buys, (2011)
The demand for full compliance with building codes and regulations	Shrestha et al.(2000)
Health and safety requirements during retrofitting process	Danso et al.(2015).
The location of building and its adjoining features	Wilkinson, (2012)

Methodology

Research Approach

The research is based on both qualitative and quantitative approaches. Basically, the research has been carried out using analytical methods. This study is directed towards discovering what factors cause delays in retrofitting projects. Based on the tasks carried out during research, the research work has been divided in following phases;

- **Phase 1:** In this phase the conceptual framework has been prepared based on literature review along with the identification of key factors causing delay in retrofitting projects.
- **Phase 2:** Based on the conceptual framework and key factors, a customized and purposive questionnaire for survey has been designed and initial level of validation has been carried out with the supervisor's review.
- **Phase 3:** Expert's review was taken from the experts who are involved and have significant experience in managing retrofitting projects to validate the QS designed in phase 2. This contributed to the final level validation of the questionnaire.
- **Phase 4**: the validated questionnaire was floated to the target respondents and data was received.
- **Phase 5:** Data analysis, interpretation, and presentation.

Study area

A study area is geography for which data is analyzed in a report and/ or map.

The study area for this research is Kathmandu valley where various retrofitting projects are completed or are being carried out. The list of projects for the study is tabulated in table 2 and the location map of the studied buildings is as shown in figure 1.

Study Population and Sample Selection

The target groups in this study are the project stakeholders comprising of representatives from clients, consultants, construction contractors and for which the questionnaire has been sent to get the responses. Altogether there are 31 public school buildings, 5 government administrative buildings and one hospital building where retrofitting is being carried out. In total 37 projects are considered as a population size comprising three representatives from each project with total of 185 respondents.

Table 2

Description of Selected Public Retrofitting Buildings

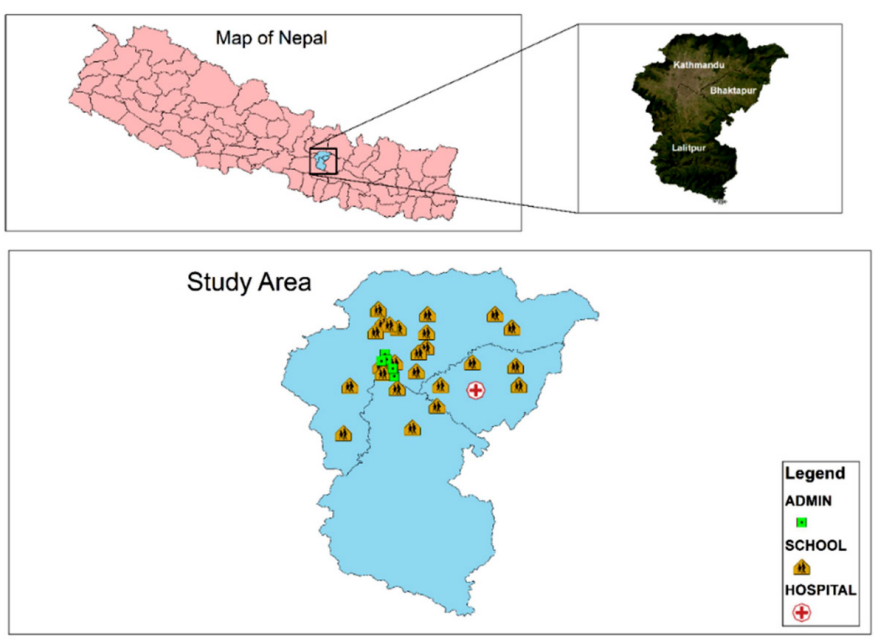
S.N	Projects Name
1	Seto Machhindranath
2	Tri Chandra College
3	Babarmahal Building
4	Singhadurbar Building
5	Bal Mandir
6	Kaiser Mahal
7	Retrofitting works of building structure at Bhaktapur Hospital
8	DRSP-Retro-02 package (2 schools)
9	DRSP-Retro-03 package (14 schools)
10	DRSP-Retro-04 package (9 schools)
11	DRSP-Retro-05 package (6 schools)

Study Population and Sample Selection

The target groups in this study are the project stakeholders comprising of representatives from clients, consultants, construction contractors and for which the questionnaire has been sent to get the responses. Altogether there are 31 public school buildings, 5 government administrative buildings and one hospital building where retrofitting is being carried out. In total 37 projects are considered as a population size comprising three representatives from each project with total of 185 respondents.

Figure 1

Map of Study Area (Kathmandu Valley) with Location of the Buildings for Study



Since the research comprises of both qualitative and quantitative approach, to achieve the research objective the following methods have been depicted for the collection of the primary and secondary data.

Primary Data Collection

Primary data provides more actual figures and is more precise. The following methods were used to collect the primary data:

Field observation

A site visit of sampled projects has been, and the status of the project has been collected through the designated checklist. The checklist involves:

- Name of the project
- Name of the contractor
- Agreement date
- Status of time extension
- Physical progress
- Financial progress
- Reasons behind the delay

Questionnaires

A set of different questionnaires were prepared based on the literature review and has been tailored to the Nepalese context. 19 specific delay factors were identified, and a survey has been conducted using Likert's scale.

Secondary Data Collection

Journal articles, textbooks, websites, social media, news, etc. were used for the collection of secondary data. Reports and publications regarding the study were studied to gather ideas about the research problem, issues, and other ideas related to the research works. Some specific secondary data required for the study was collected from the sources are Secondary information about project status, Photographs, Relevant textbooks, Published and unpublished literature, journals, and reports and previously conducted research available in the various libraries

Data Analysis

After the process of collection of data from primary and secondary sources, they were analyzed by the descriptive method. For the easier interpretation of data, they are expressed in percentages. Those percentages are implemented for expressing the findings as a proportion of the whole. For easy understanding, these findings are expressed in the form of charts and tables.

Reliability

Cronbach's alpha is one of the most widely used measures of reliability in the social and organizational sciences Invalid source specified.. In this study, Cronbach's alpha was calculated by using SPSS and found to be 0.924 which is more than acceptable for a social science survey.

Results and Discussion

Present Scenario of Project and Delays of Retrofitting of Public Building Projects

The first objective of the study was to find out the present scenario of project and delays of retrofitting of public building projects. For this the project document has been collected from the concerned projects. The project document comprising of the initial estimated cost, initial intended completion time of the project, date of contract agreement, physical progress, financial progress, time overrun, and term extension related to the project has been collected. The summary of the project document has been tabulated in table 3 and depicted in figure 2.

Table 3

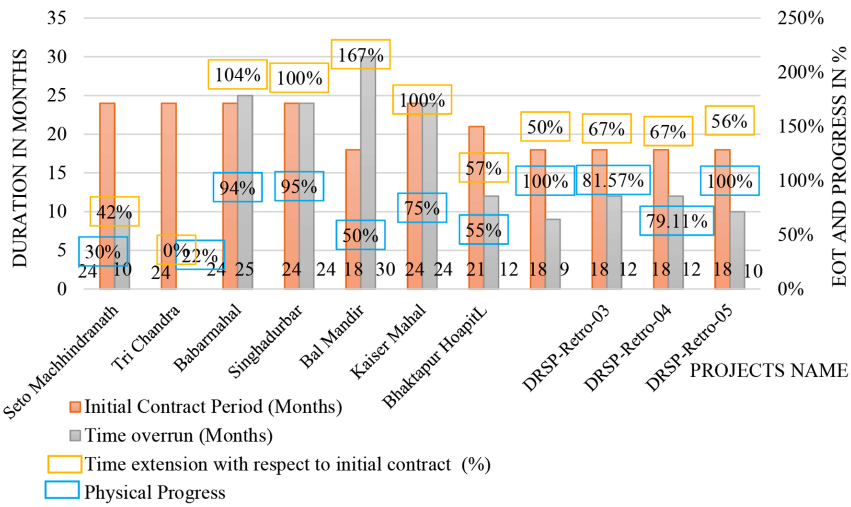
Current Scenario of the Studied Projects

SN	Projects Name	Physical Progress	Initial Contract Period (Months)	Time overrun (Months)	Time extension with respect to initial contract (%)
1	Seto Machhindranath	30%	24	10	42%
2	Tri Chandra	22%	24		0%
3	Babar mahal	94%	24	25	104%

SN	Projects Name	Physical Progress	Initial Contract Period (Months)	Time overrun (Months)	Time extension with respect to initial contract (%)
4	Singha durbar	95%	24	24	100%
5	Bal Mandir	50%	18	30	167%
6	Kaiser Mahal	75%	24	24	100%
7	Bhaktapur Hospital	55%	21	12	57%
8	DRSP-Retro-02 package (2 schools)	100%	18	9	50%
9	DRSP-Retro-03 package (14 schools)	81.57%	18	12	67%
10	DRSP-Retro-04 package (9 schools)	79.11%	18	12	67%
11	DRSP-Retro-05 package (6 schools)	100%	18	10	56%

Figure 3

Overall Scenarios, as of Poush End, 2080



Results and Discussions

The analysis encompasses 11 distinct projects, namely DRSP-Retro-02, DRSP-Retro-03, DRSP Retro-04, and DRSP-Retro-05, each involving school retrofitting initiatives with varying school counts: 2, 14, 9, and 6 schools, respectively. Five of these projects were slated for completion within 24 months post-contract, one within 21 months, and the remainder within an 18-month timeframe.

However, all projects experienced delays, with the maximum time overrun reaching 167% and the minimum at 42%. Remarkably, only one project managed to adhere to the schedule, achieving a physical progress rate of 22%. Notably, most delayed projects failed to attain the intended physical progress within the initially envisaged completion period.

Figure 2 visually presents the overall project scenario, depicting initial project timelines, time overruns, physical progress, and the percentage of time extensions in relation to the initial contracts for all observed projects.

A Multiple Regression Analysis for Overall Project Scenarios

A multiple linear regression analysis was performed to examine the influence of the variables Time overrun (Months) and Time extension with respect to initial contract (%) on the variable Physical Progress.

Model Summary

The regression model showed that the variables Time overrun (Months) and Time extension with respect to initial contract (%) explained 9.92% of the variance from the variable Physical Progress. An ANOVA was used to test whether this value was significantly different from zero. Using the present sample, it was found that the effect was not significantly different from zero, F=0.44, p = .655, R2 = 0.1.

Regression coefficients

The following regression model is obtained: Physical Progress = 0.57 + 0.02 * Time overrun (Months) - 0.15 * Time extension with respect to initial contract (%) The regression model has been tabulated in the table 5 below:

Table 4

Regression Model

	Unstandardized Coefficients	Standardized Coefficients					95% confidence interval for B
Model	**B**	**Beta**	**Standard Error**	**T**	**P**	**Lower bound**	**Upper Bound**
Constant	0.57		0.18	3.12	.014	0.15	1
Time overrun (Months)	0.02	0.53	0.04	0.45	.663	-0.07	0.1
Time extension with respect to initial contract (%)	-0.15	-0.23	0.76	-0.2	.847	-1.9	1.6

Discussions

1. **Constant:** When all independent variables are equal to zero, the value of the variable Physical Progress is 0.57.
2. **Time overrun (Months):** If the value of the variable Time overrun (Months) changes by one unit, the value of the variable Physical Progress changes by 0.02.
3. **Time extension with respect to initial contract (%):** If the value of the variable Time extension with respect to initial contract (%) changes by one unit, the value of the variable Physical Progress changes by -0.15.

Standardized Regression Coefficients

The standardized coefficients betas are independent of the measured variable and are always between -1 and 1. The larger the amount of beta, the greater the contribution of the respective independent variable to explain the dependent variable Physical Progress. In this model, the variable "Time overrun (Months)" has the greatest influence on the variable Physical Progress.

Specific Delay Factors in Retrofitting of Public Building Projects

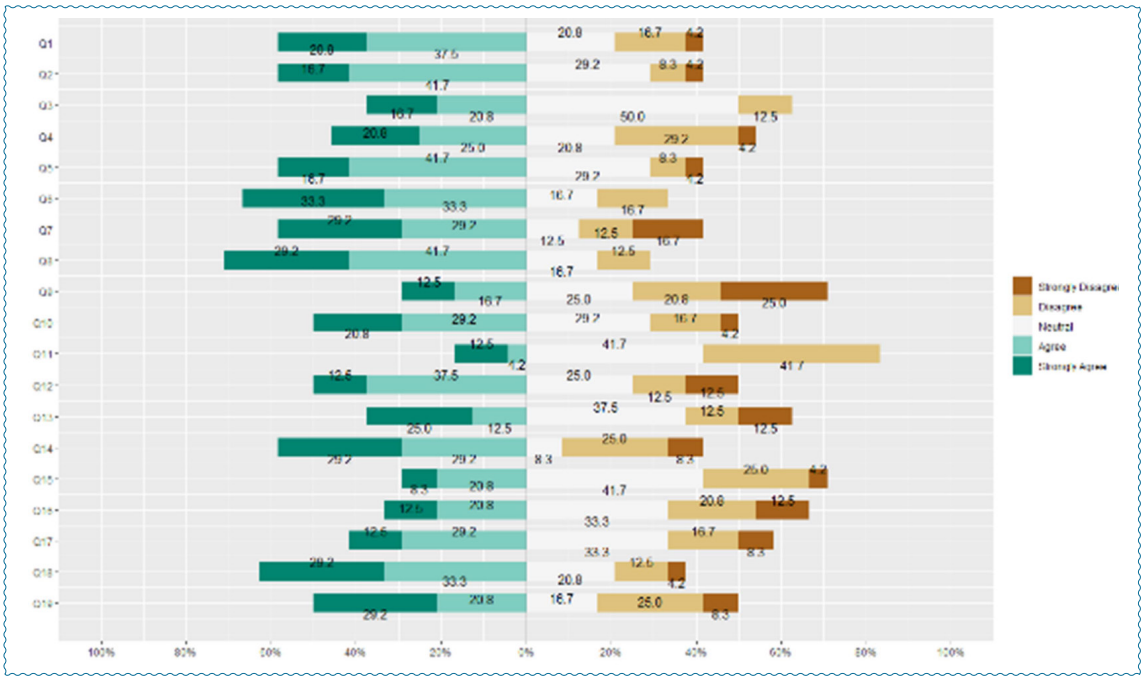
The second objective of the study was to analyze the specific delay factors in retrofitting of public building projects. Retrofitting project specific

delay related causes from the observation and the literature review along with the opinion from the experts were prepared and tailored to our purpose. Altogether, there are nineteen specific delay factors identified for the retrofitting project.

The responses have been depicted into the 100% stacked bar chart in figure 4. Neutral Value is depicted in the middle with the positive value (strongly agree and agree) on the left side and negative value (disagree and strongly disagree) in the right side. The color code has been given as white for the neutral, pale yellow for the disagree, dark yellow for the strongly disagree, light green for the agree and dark green for the strongly agree.

Figure 4

Specific Delay Factors in Retrofitting Projects



The opinion of the respondents on the specific delay factors has been further evaluated to find the mean, SD, RII and rank of each contributing factor as shown in table 7 below:

Table 5

RII Calculation Retrofitting Specific Causes of Delay

S.N.	Specific delay in retrofitting	Mean (μ)	SD	RII	Rank
1	Q1	3.54	1.12	0.708	6
2	Q2	3.58	1.00	0.717	4
3	Q3	3.42	0.91	0.683	9
4	Q4	3.29	1.21	0.658	12
5	Q5	3.58	1.00	0.717	4
6	Q6	3.83	1.07	0.766	2
7	Q7	3.42	1.44	0.683	10

S.N.	Specific delay in retrofitting	Mean (μ)	SD	RII	Rank
8	Q8	3.88	0.97	0.775	1
9	Q9	2.71	1.34	0.542	19
10	Q10	3.46	1.12	0.691	8
11	Q11	2.88	0.97	0.575	18
12	Q12	3.25	1.20	0.650	13
13	Q13	3.25	1.30	0.650	13
14	Q14	3.46	1.35	0.692	7
15	Q15	3.04	0.98	0.608	16
16	Q16	3.00	1.19	0.600	17
17	Q17	3.21	1.12	0.642	15
18	Q18	3.71	1.14	0.742	3
19	Q19	3.38	1.35	0.675	11

Results

Respondents were asked to rank the 19 specific contributing factors causing the delay in the retrofitting projects, the responses were further analyzed and found that the top ranked contributing factors are as follows:

- **Q8:** Impractical project schedule and duration (frequent changes in critical path) with RII value of 0.775 and Rank I
- **Q6:** Unavailability of the numbers and skilled workforce for retrofitting projects with RII value of 0.766 and Rank II
- **Q18:** Delays occurred due to lack of coherence in architectural, structural, electrical, sanitary, and HVAC drawings with RII value of 0.742 and Rank III
- **Q5:** Approvals of shop drawings submitted by the contractor with the RII value of 0.717 and Rank IV
- **Q2:** Unavailability of the specific materials as per BOQ with the RII value of 0.717 and Rank IV

Similarly, respondent answered that the bottom three less contributing factors are found as follows:

- **Q16:** Delays in the measurement as the quantifiable works for the IPC takes significant time with the RII values of 0.600 and rank XVII
- **Q11:** Occupational safety and health issues of workers with the RII values of 0.575 and rank XVIII
- **Q9:** Disturbances due to noise and dust with the RII values of 0.542 and rank XIX

Discussions

Based on the analysis of respondents' rankings of contributing factors causing delays in retrofitting projects, several key findings emerge:

- Impractical Project Schedule and Duration: The top-ranked factor, according to respondents, is the impractical project schedule and duration, characterized by frequent changes in the critical path. This indicates that project timelines are not well-defined or realistic, leading to disruptions and delays in project execution.
- Unavailability of Skilled Workforce: The second-ranked factor highlights the challenge of insufficient skilled workforce availability for retrofitting projects. This suggests that the project may face delays due to a shortage of qualified personnel, hindering progress and productivity.
- Lack of Coherence in Drawings: Respondents identified a lack of

coherence in architectural, structural, electrical, sanitary, and HVAC drawings as a significant contributing factor to delays. This points to issues with coordination and communication among different project stakeholders, leading to confusion and inefficiencies.

- Approval Process for Shop Drawings: Delays in the approval of shop drawings submitted by the contractor were also deemed impactful. This indicates bureaucratic or procedural bottlenecks in the approval process, slowing down project progression.
- Material Availability and Compliance: Unavailability of specific materials as per the Bill of Quantities (BOQ) was identified as another significant factor causing delays. This suggests challenges in sourcing and procuring necessary materials, impacting project timelines and continuity.

On the other hand, the bottom-ranked factors, such as delays in measurement, occupational safety and health issues, and disturbances due to noise and dust, were deemed less influential in causing delays. However, it's important to note that even these factors, while ranked lower, may still contribute to project inefficiencies and warrant attention for improvement.

Mishra et al., (2021) & Mishra, (2018) also analyzed valuable insights into the primary challenges faced in building and bridge projects in line with retrofitting projects, allowing stakeholders to prioritize mitigation strategies and optimize project management practices for improved efficiency and timely completion

Hypothesis Test: - Mixed ANOVA

A hypothesis test for the contributing factors has been carried out using the mixed ANOVA. The null hypothesis and alternative hypothesis are set as in table 8. The ANOVA test results has been tabulated in the table 9 below.

Table 6

Null Hypothesis and Alternative Hypothesis

Null hypothesis	Alternative hypothesis
There is no significant difference between the groups of the first factor Mean (μ) and Rank (measurement repetition) in relation to the dependent variable.	There is a significant difference between the groups of the first factor Mean (μ) and Rank (measurement repetition) in relation to the dependent variable.
There is no significant difference between the groups of the second factor Specific delay in retrofitting in relation to the dependent variable.	There is a significant difference between the groups of the second factor Specific delay in retrofitting in relation to the dependent variable.
There is no interaction effect between the factor Mean (μ) and Rank and Specific delay in retrofitting	There is an interaction effect between the factor Mean (μ) and Rank and Specific delay in retrofitting

Table 7

ANOVA Test

	Sum of squares	df	Mean Squares	F	p	η2	η2p
Mean (μ), Rank	405.35	1	405.35	0	1	0.41	1
Specific delay in retrofitting	257.28	18	14.29	NaN	aN	0.26	1
RM Factor x Specific delay in retrofitting	318.21	18	17.68	0	1	0.32	1
Residuals (Between Subjects)	0	0	NaN				

Table 8

Bonferroni Post-hoc-Tests RM Factor

		Mean diff.	Std. Error	t	p	95% CI lower limit	95% CI upper limit
Mean (μ)	Rank	-6.53	1.364	-4.788	<.001	-9.4	-3.67

Summary of Test

A mixed ANOVA was performed to test whether there was a significant difference between the groups of the first factor Mean (μ) and Rank (repeated measures) in relation to the dependent variable, a significant difference between the groups of the second factor Specific delay in retrofitting in relation to the dependent variable, and whether there was an interaction between the two factors Mean (μ) and Rank and Specific delay in retrofitting in relation to the dependent variable.

There was no significant difference in the dependent variable based on the first factor, Mean (μ), and Rank. This means that variations in Mean (μ) and Rank did not significantly affect the dependent variable.

A significant difference was found in the dependent variable based on the second factor, Specific delay in retrofitting. This suggests that variations in the Specific delay in retrofitting had a significant impact on the dependent variable.

There was no interaction effect observed between the Specific delay in retrofitting and Mean (μ) and Rank factors. In other words, the relationship between Specific delay in retrofitting and the dependent variable was not influenced by variations in Mean (μ) and Rank.

Specific delay factors in retrofitting of public building projects- Respondent's Experience

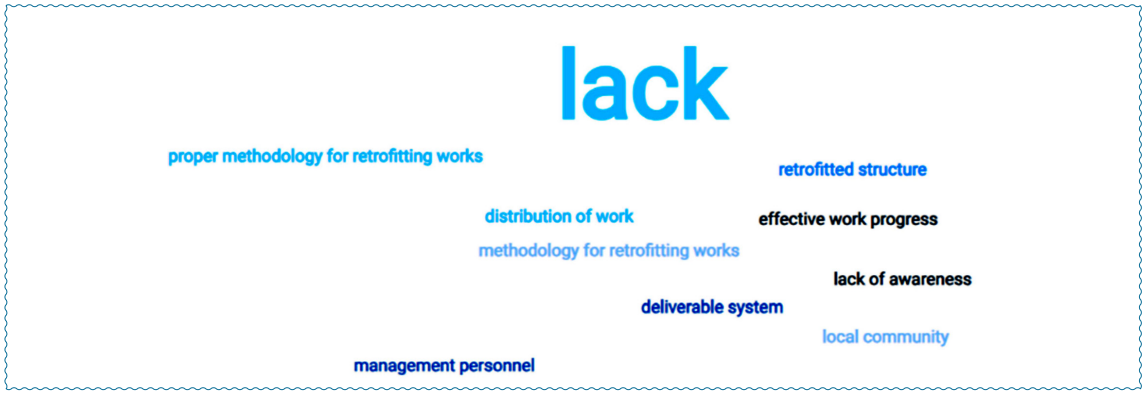
Besides the close ended question to rank the individual contributing factors specific to the delay in the retrofitting projects, an open-ended question was also asked to the respondents to list out their opinion in experience to their projects for the specific causes of delay. The responses from the open-ended question were as follows:

- Unable to use the decanting block due to COVID 19, specifically in Bhaktapur hospital retrofitting project.
- lack of deliverable system with penalty on it,
- Lack of awareness in local communities regarding effectiveness and durability of retrofitted structure,
- Lack of proper methodologies for retrofitting works by contractors,
- Management personnel as per CV should have to present on site, which gives effective work progress due to distribution of work among all as per CV provided during bidding.

The responses have been analyzed using the world cloud as shown in the figure 7

Table 7

World Cloud on the Respondent's Responses



The word cloud generated from the opinion given by the respondents has been analyzed using the keywords within the content. The content analysis based on the word cloud is defined as follows:

- **Lack:** This word appears prominently in the word cloud, indicating a significant concern or issue mentioned in the text. It suggests a scarcity or absence of something crucial, possibly referring to shortcomings in various aspects of the project.
- **Retrofitting:** The word "retrofitting" is another prominent term, suggesting that this process is a central focus of the discussion. It implies that retrofitting works are being undertaken or planned, and there may be challenges or considerations associated with this activity.
- **Effective:** The presence of the word "effective" suggests an emphasis on ensuring that actions or measures taken are successful in achieving their intended goals. It may indicate a desire for efficiency and productivity in project execution.
- **Work:** The term "work" is quite generic but still prevalent in the word cloud. It could refer to the actual physical labor involved in the project or the overall project activities and progress.
- **COVID-19:** The mention of COVID-19 indicates its impact on the project, particularly in relation to the inability to use the decanting block. This highlights the challenges posed by the pandemic and the need to adapt project plans accordingly.
- **Decanting Block:** The specific reference to the decanting block suggests its importance in the project, and the inability to use it due to COVID-19 indicates a significant setback or obstacle.
- **Awareness:** The inclusion of "awareness" suggests a need to educate or inform local communities about certain aspects related to the project, possibly its purpose, benefits, or safety considerations.
- **Local Communities:** This term indicates a focus on engaging with and involving the communities residing in the project area. It suggests a recognition of the importance of community participation or support in project implementation.
- **Durability:** The mention of "durability" implies a concern for the long-term resilience and strength of the retrofitted structure. It suggests a desire to ensure that the structure can withstand various environmental or structural challenges.
- **Proper Methodologies:** The mention of "proper methodologies" suggests a need for established or standardized approaches to conducting retrofitting works. It indicates a desire for systematic and effective procedures.

Overall, the word cloud highlights key themes and concerns related to the project, including challenges posed by COVID-19, the importance of effective project management, and the need for community awareness and engagement. The prominence of certain words reflects their significance in shaping the narrative and opinions expressed in the content.

Conclusion

This study aimed to assess the current scenario and delays associated with the retrofitting of public building projects. The findings reveal that all 11 projects analyzed experienced significant delays beyond their planned completion timelines. Specifically, five projects were scheduled for completion within 24 months, one within 21 months, and five within 18 months. However, the maximum delay recorded was an alarming 167%, while the minimum delay was 42%. Notably, only one project achieved a physical progress of 22%, indicating widespread inefficiencies across the board.

The multiple linear regression analysis performed in this study highlights the relationship between time overruns and physical progress. The model indicates that for every month of delay, physical progress is positively affected, albeit marginally, while time extensions negatively impact progress. This underscores the complex dynamics of project management in retrofitting efforts, where delays can significantly hinder overall outcomes.

The study identified several specific factors contributing to delays in retrofitting projects. The most significant factors included impractical project schedules, unavailability of skilled labor, inconsistencies in technical drawings, delays in approvals, and shortages of specific materials as per the Bill of Quantities (BOQ). In contrast, less impactful factors included delays in measurements for interim payment certificates, occupational safety and health issues, and disturbances from noise and dust.

Mixed ANOVA results indicated no significant difference between the groups concerning the first delay factor, while a significant difference was found for the second factor related to specific delays in retrofitting. Additionally, a Pearson correlation analysis revealed a strong negative correlation between the mean rank of delay factors, suggesting that as the rank of a delay factor increases, its mean impact decreases.

Respondents' experiences further illuminated the challenges faced in retrofitting projects. Key issues included the unavailability of essential materials due to COVID-19, a lack of effective delivery systems with penalties, insufficient community awareness regarding the benefits of retrofitting, inadequate methodologies employed by contractors, and the necessity for management personnel to be present on-site to facilitate effective work distribution.

In brief, the findings of this study highlight the critical need for improved project management practices in the retrofitting of public buildings. Addressing the identified delay factors through better planning, enhanced communication, and stakeholder engagement will be essential for achieving timely project completion and maximizing the benefits of retrofitting efforts. Future research should focus on developing targeted strategies to mitigate these delays and improve the overall efficiency of retrofitting projects in the public sector.

Recommendation

To minimize delays in retrofitting public building projects, it is essential to prioritize detailed project planning and scheduling, ensuring that realistic timelines are established while considering potential risks. Enhancing communication between clients and contractors is crucial to clarify project details and manage scope changes effectively; regular updates should be encouraged to prevent misunderstandings. Additionally, improving clients' planning, decision-making, and communication skills will foster better collaboration with contractors, leading to smoother project management. Despite the use of planning software, persistent delays highlight the need for proactive engagement with project management tools for timely schedule updates and issue notifications. Finally, increasing awareness and adoption of contingency plans will prepare project teams to handle unexpected challenges effectively.

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