Applying BIM to Manage Planning Activities in Bridge Superstructure Construction Projects

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ABSTRACT

Bridge superstructure construction requires coordination of girder erection, temporary works, deck operations and resource deliveries. This exploratory paper presents a descriptive review of professional perceptions and a documented three-dimensional bridge model, using questionnaire outputs available in an undergraduate thesis. The demographic profile contains 40 respondents, while the appended item-level descriptive output reports 40 valid cases. Item means range from 4.54 to 4.64 for planning tools, 4.36 to 4.46 for task sequencing and 4.44 to 4.64 for resource allocation. These values describe favourable responses to individual statements and do not establish construct-level scores or actual project improvements. Ten performance statements are interpreted by their time, cost, quality and safety content without calculating separate scale scores. The model represents deck slabs, girders, piers and abutments and provides spatial context for planning discussions. The paper proposes a staged workflow covering model preparation, activity mapping, constructability review, resource coordination and controlled updates. The original response data and SPSS file are unavailable; conflicting sample counts and item specifications prevent independent verification of reliability, normality and correlation analyses. Accordingly, those analyses are excluded from the findings. The contribution is an exploratory description of planning perceptions and a proposed operational workflow, rather than an empirical demonstration of BIM-driven efficiency. Prospective project validation is needed to assess schedule, cost, quality and safety outcomes.

Keywords: Building Information Modelling; Bridge Superstructure; Construction Planning; Task Sequencing; Resource Allocation; 3D Model.

INTRODUCTION

Bridge superstructures bring together permanent structural elements and temporary construction operations. Girder placement, deck reinforcement, formwork, concreting and access arrangements have to occur in a safe sequence and within the limits of equipment and site space. A schedule alone may show dates and predecessors without showing whether two activities can physically coexist. A model can make such constraints visible to designers, planners and site teams. This study examines how BIM can help organize bridge superstructure planning, with particular attention to task sequencing, resource coordination and model-based visualization. The analysis draws on the reported survey and bridge model and distinguishes professional perceptions from observed project performance.

Conventional planning often has drawings, written method statements, spreadsheets and bar charts. Each document answers a useful question but if a girder detail or lifting route changes several people have to update

separate records. If updates are delayed the schedule can still be internally coherent but describe an impractical site operation. The danger is acute when cranes, temporary supports and delivery vehicles share space. BIM provides a common geometric reference. A 3D model enables project stakeholders to visualise construction sequences and identify potential conflicts at an early stage, when modifications are generally less costly. However, 3D modelling alone does not guarantee a reliable construction schedule, as accurate dimensions, clearly defined object identifiers, a validated project schedule and a systematic updating process are also essential. Accurate dimensions, object identifiers, a validated schedule and a disciplined update process are still needed. This distinction matters because contractors built a 3D bridge model and got professionals' perceptions but did not report a controlled before and after schedule comparison. The study had three aims: to determine sequence of planning activities for bridge superstructure projects; perceptions of BIM in relation to time, cost, quality and safety planning; and create a 3D bridge model to support planning. The survey says what people believe about planning practices. The model shows a potential visual representation. Neither output on its own proves that the completed bridge cost less or was finished sooner. The bridge focus is the superstructure, particularly deck and girder components and their relationship to supporting elements. The thesis discusses construction professionals and government agencies in an East Coast Malaysian context, while some passages differ on location and respondent frame. The article therefore avoids claiming a representative regional estimate. Its contribution is a transparent synthesis of the available evidence and a practical workflow that can be tested on an actual project.

LITERATURE REVIEW

Bridge construction and planning constraints

Bridge superstructure planning involves interfaces between permanent components and temporary operations. Bearings and supports must be accepted before girder placement, lifting arrangements must fit available working space, and deck operations depend on completed supporting work. A delivery delay can alter crane availability, access and labour assignments. Planning therefore requires explicit dependencies and location-based checks. A useful work breakdown associates each span and component with the operations required for transport, installation, inspection and completion. This allows reviewers to check prerequisites and the feasibility of the intended construction state.

From 2D drawings to information models

2D drawings are still contract and construction documents. The problem with 2D drawings in an erection review is that users have to mentally combine plans, sections, elevations and schedules. A 3D view can show the same spatial relationship more directly (especially to people who aren't familiar with a particular drawing set). BIM adds value when geometry is linked to reliable information and shared decision-making process rather than as decoration.

Eastman et al. (2018) stated BIM as an information rich process across the asset life cycle. In bridge planning the most immediate use is coordination: a consistent definition of object allows structural engineer, scheduler and contractor to discuss the same member, location and revision. This is the basis for links later on time and cost information. 3D, 4D and 5D uses in superstructure planning. A 3D model represents geometry and associated properties. A 4D application associates model objects with activities and dates so that the planned construction state can be seen at successive times. A 5D application relates quantities or cost information to model elements and activities. Labels describe capabilities but accuracy of each output depends on quality of underlying schedule, quantities and classifications of model.

For example, a 4D simulation can reveal an apparent clash between girder lifting and another activity on the crane's working area. It can also show an impossible sequence in which deck work appears before supporting girder is installed. The simulation raises a question for the project team but does not automatically check lifting capacity, ground bearing, temporary works or regulatory requirements those still need specialist engineering review. The thesis talks about 3D and later dimensional BIM but the deliverable is a 3D bridge model. The article separates the demonstrated model from proposed extensions to 4D and 5D. The sequence

proposed below shows how to connect an approved programme with object identifiers and how to use the visualization in review meeting. It should be read as method for implementation not as finished experiment on this dataset.

Coordination and constructability

A constructability review checks if the design intent can be carried out within the space, methods, resources and sequence available. For a superstructure reviewers might consider bearing location; access for formwork; lifting envelopes; temporary bracing; pour breaks; inspection hold points. A model provides spatial context for these decisions. Its value increases when the review also records an issue owner, resolution and approved revision instead of just an informal visual impression. Vilventhan and Rajadurai (2020) discuss 4D bridge information modelling for project management Pratama et al. (2024) present a steel bridge planning simulation. These examples show that BIM-enabled planning is possible but bridge type and project organization differ so any numerical gain cannot be directly transferred to this study.

Task sequencing and dependencies

Task sequencing starts with a breakdown of work which can be checked against the physical structure. A useful breakdown shows spans and components at a level where an operation has start condition and completion criterion (substructure ready, girders received & inspected, lifting access established, members placed, stability secured, deck formwork installed, reinforcement fixed, concrete poured & cured). Precise sequence is project specific (Pratama et al. 2024). Predecessor logic should express engineering dependencies not just preferred dates. A girder lift depends on verified supports and valid lift plan; deck concrete depends on accepted reinforcement and formwork; removal of temporary supports depends on specified strength and approval etc. These links can be stored in scheduling software and then mapped to model objects. The mapped view makes omission and overlaps easier to discuss. Schedule changes need version control. When an activity slips a planner needs to review access, delivery and labour effects, update programme and regenerate time-linked view. Without discipline this 4D model can quickly become an attractive record of an obsolete plan. Items about schedule reflecting actual workflow and communicating change are included in the thesis questionnaire so operational issue is central to study.

Resources and temporary works

Girder launchers, cranes, pumps, formwork and skilled crews have different capacities and availability constraints. Tambunan et al. (2023) highlight that materials, equipment and labour need to be synchronized for I-girder superstructures; Tian et al. (2021) describe BIM and UAV information for crane operations monitoring in steel bridge setting. Both strands show why resource information should be taken into account along with geometry and schedule. A resource loaded plan needs more than a total count: it needs location, period of use, mobilization and demobilization time and responsible party. Visual review can show two trades on the same narrow workface or delivery route blocked by a temporary installation. Solution may be different sequence, revised site layout or additional shift but it should be decided against cost and safety constraint.

Project performance and the limits of perception measures

Time, cost, quality and safety are related measures of construction project performance, but each requires distinct evidence (Chan & Chan, 2004; Ngacho & Das, 2015). Time performance can be assessed by comparing actual activity and completion dates with an approved baseline schedule, while accounting for approved changes. Cost performance requires a comparison of budgeted and actual expenditure for the same scope of work. Quality should be evaluated through inspection results, test records and documented nonconformities. Safety requires evidence such as incident reports, audit findings and exposure data. Survey responses can reveal how professionals perceive these outcomes, but they cannot, by themselves, establish actual project performance. The study's questionnaire groups ten project performance items concerning completion within allocated time, procurement and cost coordination, progress monitoring, quality expectations and safety practices. A combined score may summarise respondents' overall views, but it cannot

show whether time, cost, quality or safety improved individually. For this reason, the combined scale is described in this paper as perceived project performance. Future analysis could examine each outcome separately and compare survey responses with the corresponding project records (Chan & Chan, 2004).

The pilot and final Cronbach's alpha coefficients indicate different levels of consistency among the item groups. The final coefficient of 0.610 for planning tools warrants closer examination of its individual items. Conversely, a high coefficient for the project performance scale does not demonstrate that its items measure a single dimension, establish predictive validity or prove that BIM caused better outcomes. Alpha should therefore be interpreted alongside an assessment of the scale's structure and the meaning of its items (Sijtsma, 2009). Future research would be strengthened by defining separate measures for time, cost, quality and safety and validating them against project-level evidence.

Research gap

The literature offers model demonstrations and arguments for schedule integration, but the local planning problem needs evidence about the tasks and decisions that BIM changes in practice. The present thesis supplies an exploratory survey and a model example. It does not provide a measured control project, a verified cost comparison or a reproducible 4D simulation log. The article accordingly asks a narrower, answerable question: what planning priorities and model functions are supported by the reported evidence and what further evaluation would be necessary to claim performance gains.

METHODOLOGY

Study design

The underlying study used a cross-sectional questionnaire and developed a 3D bridge model (Omar, 2023). This paper presents an exploratory descriptive synthesis of the available thesis outputs. The appended questionnaire uses 1 = strongly disagree to 5 = strongly agree; the response-file coding cannot be independently verified. The thesis demographic tables report 40 respondents, while the appended descriptive output reports 39 valid cases. Each output is presented on its printed basis. The sampling frame and bridge-specific BIM experience are incompletely documented, so population representativeness is not claimed (Krejcie et al, 1970). No controlled comparison or prospective measurement of project outcomes forms part of the reported design.

Participants and eligibility

The respondents were project managers, quantity surveyors, civil engineers, architects and other roles. Contacts are given in contracting firms and government construction departments. Bridge-specific eligibility audit is not included in the paper so the sample should be taken as construction professionals reporting on the topic rather than as a verified census of bridge BIM users.

The mix of participants affects interpretation. Managers may judge schedule coordination; QS costs; engineers constructability. In a future study, we could record bridge experience (current BIM use), project role (project type) and current BIM use for each response then only compare groups when sample sizes permit: those fields would tell us if high agreement is direct bridge experience or expectations about digital tools more broadly.

Questionnaire structure and pilot

The instrument contained demographic questions, planning factor statements and a project performance block. The planning factors were use of planning tools, task sequencing and resource allocation. Statements asked if visualization helps identify conflicts; if tools give timely information; if schedules reflect site workflow; whether resources are coordinated with progress. Performance items included time, cost, quality and safety perceptions. A 12-person pilot tested the questionnaire before the main distribution. Table 1 shows a Cronbach's alpha values (0.605 for planning tools, 0.701 for resource allocation, 0.800 for task sequencing

and 0.864 for project performance) in the pilot. Expert review and revision of ambiguous wording are also mentioned. These steps are relevant to face and internal consistency checks but the revision log and item level pilot dataset were not provided. Table 1 show the reported pilot internal consistency.

Table 1: Reported pilot internal consistency

Construct	Items	Cronbach alpha
Planning tools	3	0.605
Resource allocation	3	0.701
Task sequencing	3	0.800
Project performance	10	0.864

The reliability table in the final report has different item counts for some constructs (four planning tools items, four task sequencing items and nine performance items), while elsewhere on the questionnaire there are three, three and ten. This cannot be reconciled from the supplied document alone. Coefficients are reproduced as reported but operational item count must be checked against original SPSS file before submission or further hypothesis testing.

3D model development

A bridge deck model containing deck slabs, girders, piers and abutments developed from construction drawings and technical specifications. The model provides a representation of structural configuration and dimensions for discussion. The documentation does not supply an auditable object schedule, clash register or time-linked simulation output; consequently, model completion is reported as a design and visualization output, not evidence of measured schedule optimization.

Analysis plan and data checks

The source reports screening for missing values and outliers, descriptive analysis, normality testing and internal consistency analysis in SPSS. It also includes a correlation table. Means and standard deviations summarize the level and variation of responses, while frequencies describe the participant profile. Reliability coefficients describe consistency within item groups. Statistical association requires a correct dataset, consistent sample size and an intact correlation matrix. No missing data were identified in the main responses and that one potential outlier was retained. The narrative refers to respondent 40 and later to respondent 17, so the identity and effect of this case remain unclear. The normality table reports df = 40 even though demographic and correlation tables report n = 40. Moreover, the correlation cells in the short paper are misaligned and contain impossible or inconsistent diagonal entries. Those defects preclude a trustworthy reanalysis from the printed output.

This expanded paper therefore does not repeat the short paper's unsupported statement that the analysis established a "strong positive relationship." It reports descriptive and reliability values that can be read unambiguously and explains how to verify the inferential results. The raw response file should be screened for duplicate records, missing codes, reverse-scored items and actual construct composition; correlations can then be recalculated with a documented sample count and confidence intervals shown in Table 2.

Table 2: Evidence used in this article

Output	Reported basis	Interpretation
Demographics	40 response frequency tables	Describes observed sample

Pilot alpha	12-person pilot table	Preliminary internal consistency
Final alpha	Final reliability table	Internal consistency, item count unresolved
Means	Summary and SPSS tables	Agreement levels, not actual performance
Correlations	Conflicting printed matrix	Withheld pending source data check

RESULT AND DISCUSSION

Respondent profile

A total of 40 completed questionnaires were reported. Project managers, quantity surveyors, civil engineers and architects each accounted for seven respondents (17.5% per group). The remaining 12 respondents (30%) included assistant engineers, an assistant architect, lecturers, a site engineer and participants in other roles. This range of occupations provides perspectives from both design and construction practice. However, the questionnaire results do not establish how many respondents had personally used BIM to plan bridge superstructure work. The findings should therefore be interpreted as the views of construction professionals, rather than as the experience of a verified group of bridge BIM practitioners shown in Table 3.

Table 3: Selected respondent characteristics, n = 40

Characteristic	**Category**	**n**	**Percent**
Education	Diploma	6	15.0
	Degree	28	70.0
	Master	6	15.0
Organization tenure	Below 1 year	6	15.0
	1 to 3 years	4	10.0
	4 to 6 years	6	15.0
	10 years or more	24	60.0
Construction experience	Below 2 years	8	20.0
	3 to 5 years	9	22.5
	6 to 8 years	3	7.5
	10 years or more	20	50.0

Half of respondents reported at least ten years of construction experience; 60% reported ten years or more in their current organization. These figures suggest familiarity with construction processes, but experience in construction is broader than experience with the specific BIM workflow evaluated here.

Planning construct reliability

The final survey reliability coefficients were 0.610 for planning tools, 0.811 for resource allocation, 0.824 for task sequencing and 0.904 for the combined performance block. These figures provide a reason to retain the broad constructs for descriptive discussion, while the weaker planning tools scale should be examined at item level. Internal consistency does not show that all items are equally relevant to bridge work shown in Table 4.

Table 4: Final survey reliability as reported in the thesis

Construct	Reported item count	Alpha	Reading
Planning tools	4	0.610	Modest consistency
Resource allocation	3	0.811	Good consistency
Task sequencing	4	0.824	Good consistency
Perceived project performance	9	0.904	High consistency

The final table's item counts conflict with the pilot table and displayed questionnaire. One possible explanation is that items were added or removed after piloting, but the available thesis does not document that change. It would be unsound to assert a reason. Before journal submission, the authors should reconcile each variable name with the final instrument and SPSS syntax, rerun reliability on the exact final items and report item deletion decisions, if any.

Meaning of the performance scale

The reported performance block pools questions about time, procurement, cost accuracy, quality and safety. A pooled score can summarize general favourable attitudes, yet a coefficient of 0.904 is not evidence that BIM improved all four outcomes. For a stronger test, each performance dimension would have a defined group of items, sufficient reliability and a corresponding project record. This distinction is particularly important if the paper is used to recommend a technology investment.

Descriptive response patterns

Table 5 reports individual item means and standard deviations from the appended SPSS descriptive table, which explicitly gives valid cases. Planning-tools item means range from 4.54 to 4.64, sequencing items from 4.36 to 4.46, and resource-allocation items from 4.44 to 4.64. Performance item means range from 4.33 to 4.64. These values indicate favourable responses to the printed statements. They do not establish construct-level scores, between-construct differences or measured project gains. No composite standard deviation can be reconstructed from the item standard deviations alone

Table 5: Reported item-level descriptive statistics with N = 39

Item and content	Mean	SD	Reported N
Planning tools item 1: BIM visualization and conflict review	4.64	0.537	40
Planning tools item 2: coordination in output; duplicate real-time wording	4.64	0.486	40

Planning tools item 3: real-time planning information	4.54	0.505	40
Sequencing item 1: workflow alignment and communication of changes	4.36	0.584	40
Sequencing item 2: schedule reflects site workflow	4.46	0.600	40
Sequencing item 3: conflicts and adjustment to changes	4.41	0.549	40
Resources item 1: efficiency, logistics and space planning	4.54	0.555	40
Resources item 2: procurement and timely deliveries	4.44	0.552	40
Resources item 3: adjustment using progress information	4.64	0.486	40
C.1 Time: completion within allocated timeframes	4.33	0.838	40
C.2 Cost: procurement cost control	4.38	0.815	40
C.3 Time: monitoring project timelines	4.62	0.544	40
C.4 Cost: estimation accuracy	4.49	0.644	40
C.5 Cost: transparent and consistent reporting	4.51	0.601	40
C.6 Quality: early identification of potential issues	4.56	0.552	40
C.7 Quality: meeting client expectations	4.49	0.644	40
C.8 Safety: requirement to follow procedures	4.54	0.555	40
C.9 Safety: site layout to prevent hazards	4.64	0.486	40
C.10 Safety: frequency of compliance audits	4.56	0.552	40

The sequencing statements concern workflow alignment, communication of changes and prevention of sequencing conflicts. Resource statements address logistics, procurement and adjustment to progress. Interpretation must therefore remain tied to the available item wording and output provenance. No statistical ranking of the three constructs is inferred. The survey supports identifying topics for a planning pilot, rather than demonstrating effectiveness

Normality and association

The normality results are excluded from verified interpretation because their printed count of 42 differs from both the 40-person demographic profile and the 40-case item-level output. The inconsistent variable names in Appendix C further prevent confirmation that the tests describe the intended scales. A complete, reproducible Pearson output is unavailable.

The paper therefore reports no verified correlation coefficient, inferential p value or confidence interval for an association. The original data must establish the analysis sample and scale specification before these statistics can be recalculated.

What the model demonstrates

The reported 3D model includes key bridge components and illustrates their spatial relationships. Front and top views in the thesis show how the deck and support configuration can be communicated. The model may support a review of interfaces, such as girder alignment with support points and the work zones needed for deck construction. The source does not report quantified clash reductions, validated 4D task links or a construction trial, so these remain proposed applications.

A staged BIM planning workflow

A practical workflow begins with a validated geometry baseline. The modeller should import or recreate approved design information, assign unique identifiers to spans and components, and record model version, drawing source and level of detail. Geometry must be sufficiently accurate for the intended decision: an overall sequence review needs less detail than a crane clearance or formwork check. Second, the planner develops a work breakdown tied to physical locations. Activities should represent meaningful site operations rather than arbitrary model fragments. Each activity needs a responsible party, planned duration, predecessor logic and acceptance criterion.

A bridge erection plan should identify approvals for temporary works and lifting arrangements before the relevant operation is marked ready. Third, the team maps activities to model objects. For example, a girder placement task is linked to a girder object and its span, while deck concreting is linked to the corresponding slab zone. The mapping should be checked in both directions: every critical activity should display the right geometry, and every critical component should have a plausible installation or construction task.

Unmapped objects can be listed for review. Fourth, schedule simulation becomes a facilitated review. The team steps through construction states and records issues about access, shared workfaces, temporary stability and resource availability. Each issue should have a location, object or task ID, owner, due date and resolution. A revised schedule and model are then published together, with a change record, so the visual view corresponds to the approved programme.

Table 6: Proposed bridge superstructure review gates

Gate	Minimum input	Decision record
Model baseline	Approved drawings, object IDs	Geometry and version accepted
Task mapping	Schedule, locations, dependencies	Links checked
Constructability	Method and lifting plans	Conflicts and owners recorded
Update	Progress and approved changes	Revised plan published

Audit Records for Proposed 4D and 5D Implementation

Each model–task link should record the model revision, object ID, span or zone, schedule revision, activity ID, planned dates, predecessors and acceptance status. Resource records should identify the crew or equipment, capacity, quantity, location and period of use.

A 5D record should add quantity rules, unit rates, budget reference and scope revision. These are required implementation records; they were not produced as verified outputs of the present study. Each simulation run should record its date, software version, model and programme revisions, reviewer and issues identified.

The issue register should record the affected objects and activities, conflict type, detection timestamp, responsible reviewer, proposed action, approved revision, closure timestamp and residual risk. A schedule change should retain both prior and revised dates and the reason for approval. This record structure allows a later evaluator to distinguish a visual observation from a resolved planning issue and to calculate resolution latency without inventing clash counts or savings.

Application to girder and deck operations

An illustrative girder operation would link the target girder object to its erection activity and the preceding support, delivery and lifting approvals. A time-linked review would then examine whether concurrent deck work uses the same access route or workface. A detected conflict would be logged, assigned and resolved through an approved schedule or method revision.

For deck operations, formwork acceptance, reinforcement inspection, concrete placement and strength requirements would define successive gates. These examples explain the proposed process; they are not observed clashes or measured schedule changes from the present model. Resource checks should record crane availability, operating envelope, delivery windows, laydown space and safe crew access.

Information exchange and responsibility

BIM planning works best with explicit information roles. The designer owns design changes; the construction planner owns task logic; the temporary works specialist verifies temporary support; site team reports progress and constraints. An issue register can record where a model observation led to change. A common version convention prevents a meeting participant from looking at a newer model against an older schedule. These practices are as important as software selection.

Interpretation against the literature

The high agreement on visualization and sequencing statements in the survey is conceptually consistent with bridge BIM literature that focuses on coordination and simulation: Vilventhan and Rajadurai (2020) discuss time-linked bridge management; Pratama et al. (2024) model-based planning of a steel bridge.

The evidence here is narrower: it shows favourable perceptions among respondents and a completed 3D representation but not implementation conditions or measured outcomes from those studies. Resource dimension has construction rationale. Tambunan et al. (2023) synchronise equipment, material and labour requirements; Tian et al. (2021) digital and aerial data used for crane operation monitoring.

These examples show what data a bridge planning model might integrate. The questionnaire presented does not show that such integrations were done on the projects of the surveyed respondents. 5D cost analysis potential. Quantity takeoff and cost linkage need verified classification rules, scope rules and pricing rules. A model without these controls can give a misleading sense of precision. For the same reason a favourable survey response about cost transparency should be interpreted as attitude towards digital coordination rather than audited saving.

Practical implications

A project pilot should focus on identifiable decisions such as girder sequence, lifting access, deck staging and equipment coordination. Success measures should be specified before modelling begins. The audit should record the number and type of validated issues, time to resolution, approved schedule changes and actual resource use. Time spent building and maintaining the model should be recorded so that any claimed benefit can be assessed against implementation effort.

Separate performance dimensions for future validation

Table 7: Proposed outcome specification for prospective validation

Dimension	Perception focus	Independent project evidence
Time	C.1 and C.3 timeframe completion and timeline monitoring	Baseline and actual dates; approved changes; activity duration
Cost	C.2, C.4 and C.5 procurement, estimation and reporting	Budget and actual expenditure for matched scope; model effort
Quality	C.6 and C.7 issue identification and client expectations	Inspection acceptance; nonconformities; rework records
Safety	C.8–C.10 procedures, site layout and audits	Audit findings; incidents and near misses; exposure hours

Items should be allocated using their final wording and substantive meaning, then checked for content validity and internal consistency where multiple items measure a dimension. An overall alpha does not establish validity for these separate outcomes (Sijtsma, 2009). No dimension scores, reliability coefficients or effect estimates are calculated here because the item-level responses are unavailable.

LIMITATIONS

The study has several material limitations. First, the 40 responses represent a modest convenience-like sample in the available reporting, and the sampling description is inconsistent. Nonresponse and selection effects may influence agreement levels. Second, the questionnaire is self-reported and cross-sectional. Respondents may overstate favourable views of BIM and a positive perception cannot establish the direction of a relationship with project outcomes. Third, the final reliability table and instrument disagree on item counts. Fourth, some statistical outputs use 42 observations while demographic tables use 40. Fifth, the published correlation matrix is internally inconsistent. These issues can be corrected only from the raw dataset, instrument version and analysis syntax. They are why this paper avoids specific correlation and regression conclusions even though the short technical paper anticipated them. Sixth, the model is described and pictured but no independent accuracy audit, object data schedule or 4D simulation record accompanies it. The analysis therefore cannot quantify constructability improvements. Finally, the reported setting and recruitment frame vary across thesis passages. The study should not be generalized to all Malaysian bridge projects without a clearly defined frame and broader sampling.

Future evaluation design

A follow-up project could prospectively compare a conventional planning workflow with a BIM-assisted workflow on comparable spans, using the same issue definitions and measurement period. The team should archive the baseline programme, model versions, issue log, actual activity dates and resource use. A case study with interviews can explain why an identified conflict was or was not resolved, while the quantitative records assess its schedule or cost consequence.

A larger survey should distinguish actual BIM users from respondents evaluating a hypothetical benefit, pretest revised items and report scale reliability for each outcome dimension. It should sample across agencies and contractor types with transparent inclusion criteria. The underlying data and analysis code should be checked before any confirmatory hypothesis claims.

CONCLUSION

The available item-level outputs indicate favourable perceptions of planning tools, sequencing and resource coordination. They are reported with their printed basis of 39 cases, while the demographic profile describes 40 respondents. The documented 3D bridge model provides a spatial reference for reviewing deck, girder and support interfaces. The paper contributes an explicit planning workflow and records needed for future validation.

The available material does not establish reductions in project duration, cost, defects or incidents. Reliability, normality and Pearson analyses are excluded because the original data and consistent item specifications are unavailable. The remaining descriptive outputs must be read with the documented sample-count and wording limitations. A future project study should archive its raw data, model revisions, activity links and outcome records to test the proposed workflow and support reproducible performance comparisons.

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