ESTIMATION MODEL OF FLYOVER CONSTRUCTION PRICE (CASE STUDY IN DKI JAKARTA)

Sofiatun[1]*, Ridho Bayuaji[2], Najid Najid[3]
[1] Civil Engineering Doctoral Program, Universitas Tarumanagara, Jakarta, Indonesia.
Email: sofiatun.328151011@stu.untar.ac.id Email: fi_choo@yahoo.com
[2] Department of Civil Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. Email: bayuaji@ce.its.ac.id
[3] Department of Civil Engineering, Universitas Tarumanagara, Jakarta, Indonesia. Email: najid@ft.untar.ac.id

ABSTRACT: The flyover construction price estimation model was developed to expedite the price determination and reduce the disparity between budget submission and contract value. Procedures include categorizing beam types into five categories and adding five independent variables (variablex) that account for up to 83.33 percent of the total variance. These variables include maximum span length, clearance, deepest foundation depth, work area, and traffic. In addition, the contract value on the dependent variable is amended to the reference year based on inflation statistics using 40 contract data for flyover building operations from 1992 to 2019 and adjusting for inflation. The study uses the most recent contract data to generate two models using multiple linear regression equations until the validity and model validation processes are accomplished. The first is a model for overpass construction: y (cost)=34572.895+1.994x1 (area)-12140,138x7 (beam type), with a coefficient of determination of 91.72 percent and a cost difference varying from 14.4 percent to-23.2 percent. The second model is for flyover construction, with y (cost)=-15989,788+2.162x1 (area)+8326.753x8 (kind of foundation), a coefficient of determination of 81.96 percent, and a cost variance ranging from-17.27 percent to-16.5 percent.

Keywords: Model, estimation, pricing, regression, and flyover.

1. Introduction

The Indonesian government is striving to provide the populace with additional amenities. The government is developing infrastructure efficiently to increase productivity and performance (Dianti, Khoirunnisa, & Hidayah, 2023). The department of buildings and infrastructure is responsible for enhancing the performance and infrastructure for the benefit of the citizens. Different types of decisions are made based on the structure's cost, which significantly impacts its development. Cost estimation is the responsibility of the ministries and their sub-departments, striving to improve operations for greater output. In the Indonesian context, the dependability of the construction and the durability of the initiatives must be considered. The responsibility of public sector departments is to guarantee the safety of government structures and infrastructure for the public.

Every year, new projects are initiated, and different companies engage in these projects (Mohamad et al., 2022). To improve the quality and sustainability of the infrastructure, however, the advancement of these initiatives is essential. The project's expense is distinct from the cost of other operations necessary for its continued existence. Production costs must be reduced over time, and anti-corruption measures must be implemented. Long-term improvements can be made to the operations of the Indonesian land department through the fair functioning of the government agency. Initiatives can be sustainable if a well-established model is designed and all reasonable actions are taken. Indeed, the government must improve its operations and ensure that the construction of infrastructure is secure and meets the needs of the people.

Furthermore, the construction of flyovers has become a public necessity (Giglitto, Ciolfi, & Bosswick, 2022). The government must provide a secure transportation plan to enhance and improve productivity. The construction of a flyover is proposed along with a reasonable cost estimate, and a bid is solicited. The minimal estimated cost is used to construct the flyovers and roads. However, safety measures are also considered during the superstructure's construction and design. Strategic actions can reduce the cost and other operations associated with viaduct construction, necessitating a reasonable working performance. When an improved model is developed for construction, the dependability of the work on the projects is increased.

Indeed, comprehending the cost determination process is essential in construction projects (Golikova et al., 2019; Patil & Salunkhe, 2020) because the responsible department authorizes the project's estimated cost. Similarly, the project's construction is based on the recommendations of various departments, and its approval is obtained from multiple authorities. Therefore, the project's estimated costs are determined with an awareness of how these costs can influence various types of actions. Moreover, various types of projects have different cost levels and estimations

(Deng, Song, & Chen, 2016; Gusnawan & Lubis, 2023). These initiatives must be enhanced over time, and reasonable measures must be taken to implement the associated costs. The dependability of the cost and its implementation in the project can improve the estimation and capability of projects. Different types of measurements are used in different nations to estimate the cost of various undertakings. Understanding the cost estimation for bridges and flyovers is also crucial, as it significantly impacts the implications of plans based on the nature of the project. The estimated cost fluctuates between initiatives over time.

There are five stages of the price estimation process before the contractor submits a price quote according to the current project cycle:

1. Budget submission by owner.
2. During the review and planning phase, the planning consultant provided an Engineer Estimate (EE) with sources based on estimated quantity and unit pricing.
3. Construction Management Consultants (CMC) prepared a Budget Estimate Plan (BEP) based on previous projects and a study of planning results.
4. The Budget Ceiling is prepared through conversations between the owner and the CMC.
5. The contract results from a tender based on a price offer from the contractor. (Figure 1).

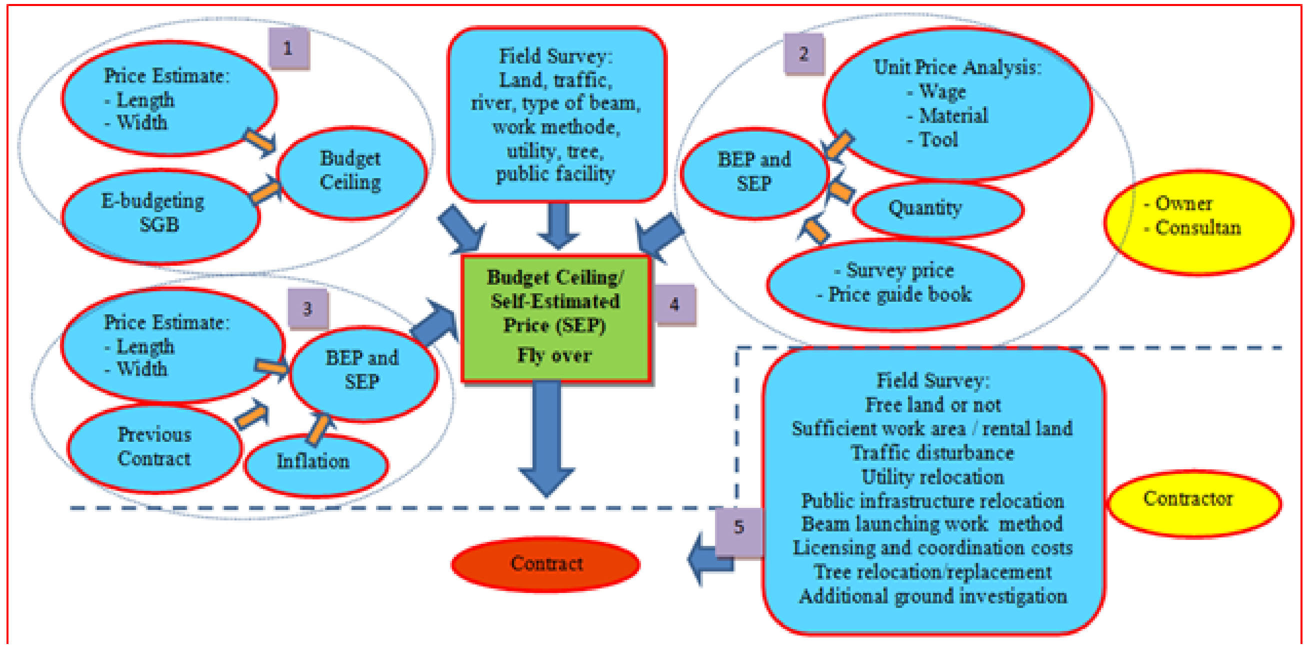

Figure 1. The Process of Making Price Estimates before the Contractor Submits a Price Offer

The Unit Price Analysis on BEP and the Calculation Results of All Work is time-consuming. It requires the employment of knowledgeable, conscientious, and patient human resources. It requires a vast array of information, such as quantity estimates derived from images or survey results, conversions to units of measurement, and many price items. One option is to use a roughly calculated budget ceiling, the projected length and width of the flyover, and the unit price or BEP for previous similar activities whose value is approximated to expedite the cost estimate. All of this requires a unique set of assumptions.

Table 1. The difference in Existing Cost Estimate

SEP Year		The difference in estimated Costs (%)		
		Budget Proposal E Budgeting	Budget Plan CMC Consultant	Budget Plan CMC Owner
2014	Max	3.9	3.9	3.9
	Min	14.8	6.4	6.4
2016	Max	6.2	6.2	6.2
	Min	25.6	9.6	9.6

Table 1 indicates the expected maximum cost difference of 25.6% in the proposed budget for building work activities in 2016. It impacts the scale of the expense of constructing a flyover, which can then be used for community service costs.

Table 2. Influential Factors and Percentage of Cost Difference / Accuracy

Reference		Name	Year	Influential Factors	Construction	Cost Differences/ Accuracy (%)	Cost Differences Expectation (%)
Previous Researches	1	(Huda, 2018)	2018	Pavement and asphalt, building top materials, and masonry	Bridge	-10.20 to 6.75	Less than–38.68 to 38.05
				Work Area		-	-
Previous Researches	2 3 4 5	(Hollar et al., 2013) (Kim & Hong, 2012) (Kim & Hong, 2012) (Fragkakis, Lambropoulos, & Pantouvakis, 2010)	2012 2012 2010-2011	Cost Length Length, width, pier height, beam type	Fly over Fly over Fly over	28 16.2-	
Expert	1 2	Tambunan, D Gempur	2020 2019	Area, prices on previous projects Quantity, price estimation	Fly over Fly over	12.6 (BEP–SEP) 20 (EE–Contract)	Max 10 10-20
Research (additional variables)	1	(Fragkakis, Lambropoulos, & Tsiambaos, 2011)	2011	The volume of concrete and the weight of the reinforcing steel in the foundation→deepest foundation depth	Bridge	-	-

According to previous research and interviews with industry experts (Table 2), the construction cost of a superstructure is determined by the following variables: area, length6, width7, type of foundation8, type of beam, span, clearance, work area, deepest foundation depth, and traffic. The remaining five influencing factors (maximum span or length, discharge, work area, and traffic) have never been studied; thus, 83.33 percent of the proposed independent variables are brand-new.

2. Materials and Methods

According to Table 3, the research attitude, illustrated in Figure 2 at the bottom, categorizes beam kinds into five types.

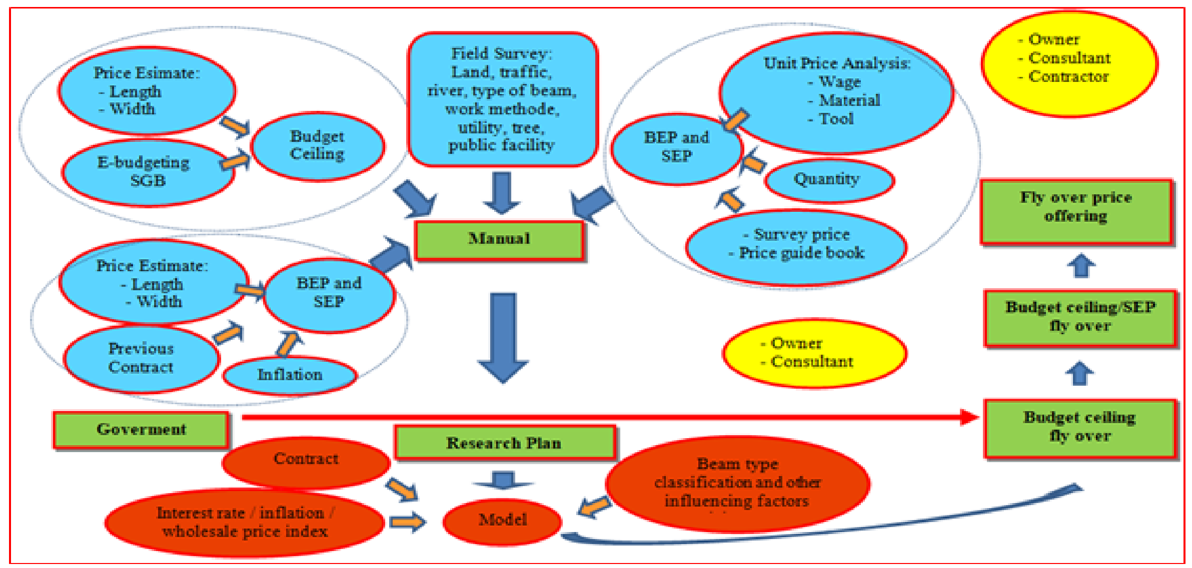

Figure 2. Research Framework of Thinking

Table 3. Beam Type Spectrum

No.	Beam Type	Box Girder	Segmental Box Girder	PCI/PCU	Box Girder+PCI/PCU	Segmental Box Girder+PCI/PCU
1	Measurement Scale	1	2	3	4	5
2	Year	1992-2006	2010-2016	2006-2009, 2012, 2016	2011-2013	2016
3	Concrete Type	Cast in site	Precast	Precast	Cast in site+Precast	Precast+Precast
4	Execution Time	Longer	Fast	Fast	Longer	Fast
5	Work Area	Enough	Limited	Limited	Enough	Limited

As time progressed, the procedure for constructing box girders was modified. To reduce the cost of employing segmental box girders combined with PCI or PCU, the box girders were initially cast in situ and subsequently as precasts. Using data from 40 flyover contracts (overpasses and flyovers) from the lower structure to the upper system constructed between 1992 and 2019, researchers adjusted the contract value to the reference year using the inflation rate.

In addition, the research methodology used to develop a unit price model is depicted in the diagram below (Figure 3).

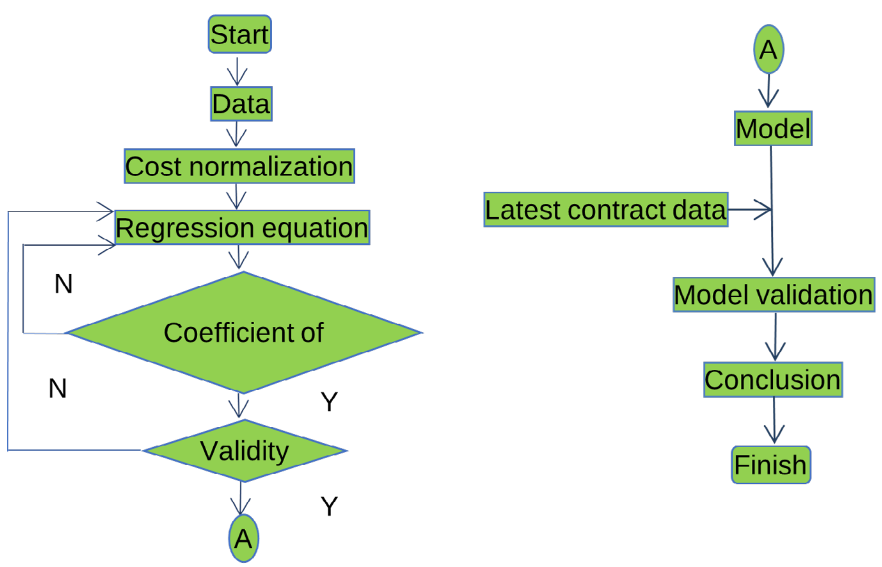

Figure 3. Research Flow

This study uses multiple linear regression equations with the following formula:

$$y=\beta_0+\beta_1x_1+\beta_2x_{2+}\beta_3x_{3+}\beta_4x_{4+}\beta_5x_5+\beta_6x_6+\beta_7x_{7+}\beta_8x_8+\beta_9x_9+\beta_{10}x_{10} \quad (1)$$

where: y=construction cost (tens of millions of Rupiah)

x_1=area (m²)
x_2=span (m)
x_3=width (m)
x_4=clearance (m)
x_5=total length (m)
x_6=deepest foundation depth (m)
x_7=type of beam
x_8=type of foundation
x_9=work area
x_{10}=traffic
β_0-β_{10}=equation parameters

A proposed model was developed after checking the coefficient of determination, validity in the form of the F test, the t-test, normality, and multicollinearity. Model validation is then performed using the most recent contract activity data.

3. Results

Researchers try to classify data with numerous

possibilities to obtain many equations to achieve the most fixed model while processing data for constructing regression equations. These equations are classified in the table below (Table 4).

Table 4. Equation Classification

Equation	Sample Data	Location Number	Number of Sample/Location	Group
1	Preliminary data 1992-2016	1-37	37	Total
2	Overall Data 1992-2019	1-40	40	Total
3	Overpass 2010—2014	1-18	18	Overpass
4	Overpass 2010—2012	1-10	10	Overpass
5	Overpass 2014	11-18	8	Overpass
6	Fly Over 1992-2016	19-37	19	Fly Over
7	Fly Over 1992-2019	19-40	22	Fly Over
8	Fly Over 1992-2009	19-30	12	Fly Over
9	Fly Over 1992-2003	19-26	8	Fly Over
10	Fly Over 2006-2016	27-37	11	Fly Over
11	Fly Over 2006-2016	27-40	14	Fly Over

The classification of equations is based on the nature of construction and the duration of the contract. Given that the flyover consists of overpasses and flyovers, a group that combines them is necessary. The sample data is divided into multiple contract years to generate eleven equations.

The SPSS application provides several methods for analyzing equations, including enter, sequential, forward, and backward. This investigation employs the following four methods. The findings and validity of the model equation are summarized in Table 5. According to the F test results for equations 4 and 5 in the flyover group, the two equations are unreliable (fail the F test). Therefore the equation selection process cannot continue. The flyover group has equation groups with a strong and moderate coefficient of determination (equation 6 and equation 7) and equation-free groups (equation 8, equation 9, and equation 10). Equations 1, 2, 3, and 11 have a significant coefficient of determination and satisfy the validity test. As a result, the four equations that satisfy the truth test and have a high coefficient of determination are selected as candidates for the model validation phase.

Table 5. Validity Results

Equation	Sample Data	Group	Number of Sample/Location	F Table	T Table	Method	Coefficient of Determination	F Test	Variable x	Model
1	Preliminary data 1992-2016	Total	37	2.22	2.05553	S F	0.869	80.630	1, 7, 8	1
2	Overall Data 1992-2019	Total	40	2.18	2.04523	S F	0.867	85.661	1, 7, 8	2
3	Overpass 2010—2014	Overpass	18	3.23	2.26216	S F	0.917	95.152	1, 7	3
4	Overpass 2010—2012	Overpass	10	239	12.7062	-	-	198.732	-	-
5	Overpass 2014	Overpass	8	234	12,7062	-	-	22.759	-	-
6	Fly Over 1992-2016	Fly Over	19	3.35	2.306	S F	0.706	15.434	1, 8, 10	-
7	Fly Over 1992-2019	Fly Over	22	2.85	2.20099	S F	0.573	15.086	1, 6	-
						B	0.720	14.499	1, 3, 6, 10	-
8	Fly Over 1992-2009	Fly Over	12	19.38	4.3027	-	-	5.546	-	-
9	Fly Over 1992-2003	Fly Over	8	-	-	-	-	-	-	-
10	Fly Over 2006-2016	Fly Over	11	-	-	S F	0.934	47.910	-	-
11	Fly Over 2006-2016	Fly Over	14	8.79	3.1825	S F	0.820	30.539	1, 8	4
Note: S=Stepwise, F=Forward, B=Backward										

As evidence, researchers used data from three other flyover construction projects (A, B, and C), all completed in 2019.

Equation Validation of Model 1 (Model 1)

y=-10354,891+2,591x_1-3275,705x_7+9200,471x_8 (2)

Table 6. Validation of Model 1

Fly Over Data			A	B	C
1	Contract value (ten million Rp)		14,355	16,326	26,109
2	Year		2019	2019	2019
3	Area (m^2)	x1	5,525	9.040	13,680
4	Max span (m)	x2	25	42.5	50
5	Width (m)	x3	6.5	8	18
6	Clearance (m)	x4	6.5	6.5	7
7	Length (m)	x5	850	1,130	760
8	Foundation depth (m)	x6	33	32	19
9	Beam	x7	3	3	4
10	Foundation	x8	2	2	2
11	Area	x9	2	2	1
12	Traffic	x10	1	1	2
y (tens million Rupiah)			12,534.348	21,641.801	30,388.453
y/m^2 (million Rupiah)			**22.687**	**23.940**	**22.214**
Normalization contract value (tens million Rp)			14,702.716	16,721.459	26,741.224
Contract value/m^2 (million Rp)			26.611	18.497	19.548
Contract difference against y (%)			**-17.30**	**22.74**	**12.00**

The contract difference relative tox ranges from-17.30% to 22.74%%, for a total variation of 40.04%. The construction unit price is determined by dividing the total building cost by the total area (in millions of Rupiah per square meter) within the model's validation range. Consequently, the anticipated unit price ranges from IDR 22.687 million to IDR 23.940 million per square meter. The outcomes are detailed in Table 6.

Equation Validation of Model 2 (Model 2)

y=-9642,968+2,562x_1-3560,779x_7+9222,501x_8 (3)

Table 7. Validation of Model 2

Fly Over Data			A	B	C
1	Contract value (ten million Rp)		14,355	16,326	26,109
2	Year		2019	2019	2019
3	Area (m^2)	x1	5,525	9.040	13,680
4	Max span (m)	x2	25	42.5	50
5	Width (m)	x3	6.5	8	18
6	Clearance (m)	x4	6.5	6.5	7
7	Length (m)	x5	850	1,130	760
8	Foundation depth (m)	x6	33	32	19
9	Beam	x7	3	3	4
10	Foundation	x8	2	2	2
11	Area	x9	2	2	1
12	Traffic	x10	1	1	2
y (tens million Rupiah)			12,276.422	21,282.920	29,611.229
y/m^2 (million Rupiah)			**22.220**	**23.543**	**21.646**
Normalization contract value (tens million Rp)			14,702.716	16,721.459	26,741.224
Contract value/m^2 (million Rp)			26.611	18.497	19.548
Contract difference against y (%)			**-19.76**	**21.43**	**9.69**

The contract difference against y ranges from-19.76% to 21.43%, for a total range of 41.19%. The anticipated cost of construction units ranges from IDR 22.220 million per m^2 to IDR 23.543 million per m^2. The results are reported in Table 7.

Equation Validation of Model 3 (Model 3)

y=34572,895+1,994x_1-12140,138x_7 (4)

Table 8. Validation of Model 3

Location/ Sample	Constant	x1_Area	X7_Beam	y	y/m^2	Normalization Contract Value	Contract Value	Contract Difference Against y (%)
1	34,572.895	37,578.619	-24,280.276	47,871.239	25,399	49,073.998	26,037	-2.51
2	34,572.895	28,018,228	-24,280.276	38,310.848	27.263	37,265.955	26.519	2.73
3	34,572.895	27,828,590	-24,280.276	38,121.210	27.313	39,416.508	28.241	-3.40
4	34,572.895	26,575.690	-24,280.276	36,868.310	27.660	37,370.110	28.037	-1.36
5	34,572.895	21,036.002	-24,280.276	31,328.621	29.694	35,292.206	33.451	-12.65
6	34,572.895	39,253.432	-24,280.276	49,546.052	25.166	51,371.691	26.094	-3.68
7	34,572.895	31,402.746	-24,280.276	41,695.366	**26.473**	35,690.405	22.661	**14.40**
8	34,572.895	26,168.955	-24,280.276	36,461.575	27.780	34,869.614	26.567	4.37
9	34,572.895	9,944.203	-24,280.276	8,096.685	16.234	8,520.321	17.083	-5.23
10	34,572.895	9,769.743	-24,280.276	7,922.225	16.168	7,498.590	15.303	5.35
11	34,572.895	19,171.825	-24,280.276	29,464.445	30.642	31,160.915	32.407	-5.76
12	34,572.895	21,143.917	-24,280.276	31,436.537	29.644	32,146.535	30.313	-2.26
13	34,572.895	23,556.546	-24,280.276	33,849.165	**28.650**	41,703.064	35.297	**-23.20**
14	34,572.895	22,475.394	-24,280.276	32,768.014	29.069	32,077.676	28.457	2.11
15	34,572.895	26,512.890	-24,280.276	36,805.510	27.679	36,958.324	27.793	-0.42
16	34,572.895	28,684.165	-24,280.276	38,976.785	27.093	42,036.594	29.219	-7.85
17	34,572.895	24,395.448	-24,280.276	34,688.067	28.350	32,713.212	26.736	5.69
18	34,572.895	25,076.887	-24,280.276	35,369.507	28.122	30,318.859	24.106	14.28

The model 3 validation table reveals a difference between contracts and y ranging from-23.20% to 14.40%, for 37.60%. The anticipated building unit price ranges from IDR 26.473 million per m^2 to IDR 28.650 million per m^2. The results are reported in Table 8.

Equation Validation of Model 11 (Model 4)

y=-15989,788+2,162x_1+8326,753x_8 (5)

Table 9. Validation of Model 4

Fly Over Data			A	B	C
1	Contract value (ten million Rp)		14,355	16,326	26,109
2	Year		2019	2019	2019
3	Area (m^2)	x1	5,525	9.040	13,680
4	Max span (m)	x2	25	42.5	50
5	Width (m)	x3	6.5	8	18
6	Clearance (m)	x4	6.5	6.5	7
7	Length (m)	x5	850	1,130	760
8	Foundation depth (m)	x6	33	32	19
9	Beam	x7	3	3	4
10	Foundation	x8	2	2	2
11	Area	x9	2	2	1
12	Traffic	x10	1	1	2
y (tens million Rupiah)			12,611.065	20,211.956	30,245.565
y/m^2 (million Rupiah)			**22.825**	**22.358**	**22.109**
Normalization contract value (tens million Rp)			14,702.716	16,721.459	26,741.224
Contract value/m^2 (million Rp)			26.611	18.497	19.548
Contract difference against y (%)			**-16.59**	**17.27**	**11.59**

The contract difference against y is from-16.59% to 17.27%, so there is a range of 33.86%. The estimated construction unit price is IDR 22.358 million per m² to 22.825 million per m². The results are reported in Table 9.

4. Discussion

The results of the range of the difference in the estimated contract costs to y from the four models yield a smaller range value in model 3 (37.60%) and model 4 (33.86%) according to the table below, where model 3 and model 4 are the selected models. In addition, it adheres to the classification of flyover categories, specifically flyovers, and flyovers. Table 10 summarizes the results.

Table 10. Model Validation Results

Equation	Sample Data	Group	Variable x	Model	The difference in Estimated Costs (%)		
1	Preliminary data 1992-2016	Total	1, 7, 8	1	22.74	-17.30	40.03
2	Overall Data 1992-2019	Total	1, 7, 8	2	21.43	-19.76	41.20
3	Overpass 2010—2014	**Overpass**	**1, 7**	**3**	**14.40**	**-23.20**	**37.60**
4	Overpass 2010—2012	Overpass	-	-	-	-	-
5	Overpass 2014	Overpass	-	-	-	-	-
6	Fly Over 1992-2016	Fly Over	1, 8, 10	-	-	-	-
7	Fly Over 1992-2019	Fly Over	1, 6	-	-	-	-
			1, 3, 6, 10	-	-	-	-
8	Fly Over 1992-2009	Fly Over	-	-	-	-	-
9	Fly Over 1992-2003	Fly Over	-	-	-	-	-
10	Fly Over 2006-2016	Fly Over	-	-	-	-	-
11	Fly Over 2006-2016	**Fly Over**	**1, 8**	**4**	**17.27**	**-16.59**	**33.86**

This study demonstrated conclusively that the models developed by this research are significant and that cost estimates for various initiatives vary. Thus, the Indonesian government must develop a comprehensive model for enhancing the understanding of the anticipated and contrast costs. In previous initiatives, the actual flyover and overpass construction costs differed from the estimated costs. Therefore, the necessary steps must be taken to improve the various perspectives that significantly impact the various types of cost. The government working departments must have an appropriate system of checks and balances for cost control and a new method for cost estimation and advancement (Yussi, Latief, & Machfudiyanto, 2022). The cost of projection and the working environment must be maintained over time, and the cost's predictability can assist the government in moving its initiatives forward (Kurnia, Latief, & Riantini, 2018). Sustainable working for improved cost estimation can be a factor in reducing the cost of government projects and their working for the construction of flyovers (Nicodemus & Latief, 2021). However, the construction should utilize the proper materials because public safety is a policy priority (Fitriani & Latief, 2019). In addition, the flyover work can be improved over time by devising new working strategies and cost estimation methods. In this manner, the research model devised is validated.

5. Conclusions

The selected flyover price estimation model:

a. Overpass construction

- Model y=34572,895+1,994x_1-12140,138x_7 (6)

y=cost (tens of millions of Rupiah)
x_1=area (m²)
x_7=type of beam

- The coefficient of determination is very strong (91.72%).
- The difference in estimated cost to the contract value is from 14.4% to-23.2%.
- Construction unit price is Rp 26.473 juta per m² to Rp 28.650 juta per m² (2021).

b. Fly over construction

- Model y=-15989,788+2,162x_1+8326,753x_8 (7)

y=cost (tens of millions of Rupiah)
x_1=area (m²)
x_8=type of foundation

- The coefficient of determination is very strong (81.96%).
- The difference in estimated cost to the contract value is from 17.27% to-16.59%.
- Construction unit price is Rp 22.358 juta per m² to Rp 22.825 juta per m² (2021).

First, this study has provided information regarding the overpass construction model. In this manner, the investigation demonstrated the significance of the coefficient of determination. In addition, it has been reported that the difference between the estimated cost and the contract value is extremely significant. Confirmed to a high degree, the overpass construction model also includes per-unit construction costs. This research model has reliable findings that must be conveyed constructively for the final product. However, the estimated values must be incorporated into the overpass construction model.

The second contribution of this study is a flyover construction model whose coefficient of determination is greater than 80 percent. In addition, this model revealed the considerable variance between the estimated cost of the flyover's construction and the contract values. Similarly, according to the study, there was a significant disparity between the estimated and contract costs in prior years. In addition, the unit cost of flyover construction is distinct in this study compared to other studies. The model devised by this research has confirmed, based on "empirical findings," that they must be reported fairly, and strategic actions must be taken in this manner. In addition, the overpass and flyover construction values should be accurately estimated, and a clear plan for the estimated cost and contract cost should be developed.

6. Implications and Future Directions

This research has significant ramifications because the model developed by this research has characteristic findings that previous studies have not explored. The objective of this research has been met, and a new model for estimating flyover costs is presented. Based on this model, strategic measures can be taken to comprehend the estimated costs for various initiatives. Over time, the estimated costs of various projects can be improved, and this model can be applied to the construction and cost estimation of flyovers in Indonesia. In addition, this model is limitless, and the research findings can be applied to other nations' cost estimation and planning. This research has improved our comprehension of cost estimation for various projects, and these findings can be comprehended and implemented reasonably to enhance cost estimation. The projects that necessitate accurate cost estimation must be enhanced over time, and strategic measures must be taken to improve cost estimation practices. In addition, this paradigm for the construction of overpasses and flyovers can be implemented fairly with strategic measures to improve the cost estimation of these projects. In critical discourse, the implications of this research are critical from both a theoretical and a practical standpoint, as this research reports a cost estimation model.

This study uses the most recent contract data to generate two models through multiple linear regression equations until the validity and model validation processes are accomplished. This research model includes overpass construction and flyover construction. Future research will be required to enhance these models. Future research is required to improve this model to comprehend the factors influencing project costs. The focus of the studies may be the impact of a changing environment and government policies on the construction and cost growth of the projects. In addition, the research should not be limited to the model of flyover construction and cost estimation of the overpass. Still, a comprehensive model should be developed to enhance the comprehension of cost estimation for various building projects. In addition, research is required to improve the cost estimation model by incorporating the maintenance procedure for overpasses and flyovers. Without a doubt, by utilizing these models, the knowledge regarding cost estimation can be expanded by incorporating additional literature and models.

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About Authors

Sofiatun
1Civil Engineering Doctoral Program, Universitas Tarumanagara, Jakarta, Indonesia; sofiatun.328151011@stu.untar.ac.id
Email: fi_choo@yahoo.com

Ridho Bayuaji
2Department of Civil Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia; bayuaji@ce.its.ac.id

and Najid Najid
3Department of Civil Engineering, Universitas Tarumanagara, Jakarta, Indonesia; najid@ft.untar.ac.id