
Effect of Design Cost on Highway Construction Project Performance

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Presentation Outline

- Introduction
 - Literature Review
 - Research Methodology
 - Construction Phase Project Performance
 - Project Selection for Analysis
 - Findings
 - Conclusions & Future Research
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Introduction

- Design Bid Build Project Delivery Method
 - Procure design, and construct separately
 - Designers perform design
 - Sometimes perform design in-house
 - Construction contract based on a completed set of design plans.
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Introduction

- Design cost is the cost paid to engineers during design phase
 - Construction cost is the contract award cost during construction phase
 - Some research studies correlation between design cost and construction cost performance.
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Literature Review

- Methods of Design cost payment (ASCE Manual #45)
 - Per diem
 - Cost plus a fixed fee
 - Fixed lump-sum payment
 - Salary cost times a multiplier plus direct non-salary expense
 - Retainer
 - Percentage of construction cost
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Literature Review

- PSMJ survey on 2008 shows that
 - Fixed lump-sum form of payment is most widely used (51%)
 - Research on professional fees (Carr & Beyor 2005)
 - Fees not adjusted over the time
 - Decline in professional fees when adjusted with inflation
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Literature Review

- Research on design quality
 - Quantitative research to find correlation between design fees and design quality (Bushait et al. 1998)
 - 58 building projects data (Average cost = \$2 million)
 - Design quality measured by Total Cost of Design Deficiency (TCDD)
 - $TCDD = \text{Cost of change order} + \text{Indirect cost resulting from delayed in project completion}$
 - Findings
 - Average design fees = 2.5 %
 - Inverse correlation: TCDD increases as design fees decreases
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Literature Review

- Research on design phase cost performance (Kuprenas 2003)
 - Quantitative research to find correlation between design cost performance and project management practices
 - 270 design projects data from Department of Public Works, City of Los Angeles (\$.5 M to \$25 M)
 - Design Cost Performance Index (DCPI)
 - = Actual Cost of Design Work Performed (ACWP) / Budgeted Cost of Design Work Performed (BCWP)
 - Average design cost of streets (Templates) = 25 % (projects over \$5M)
 - Findings
 - Significantly correlated with frequency of meetings and reporting of design progress
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Literature Review

- Research on relation between design fees & construction cost performance (Gransberg et al. 2003)
 - Quantitative research to find correlation between design cost and construction cost performance in road and bridge projects
 - 13 road projects (\$4.9 M) & 18 bridge projects (\$1.5 M)
 - Cost Growth from the Initial Estimate (CGIE)

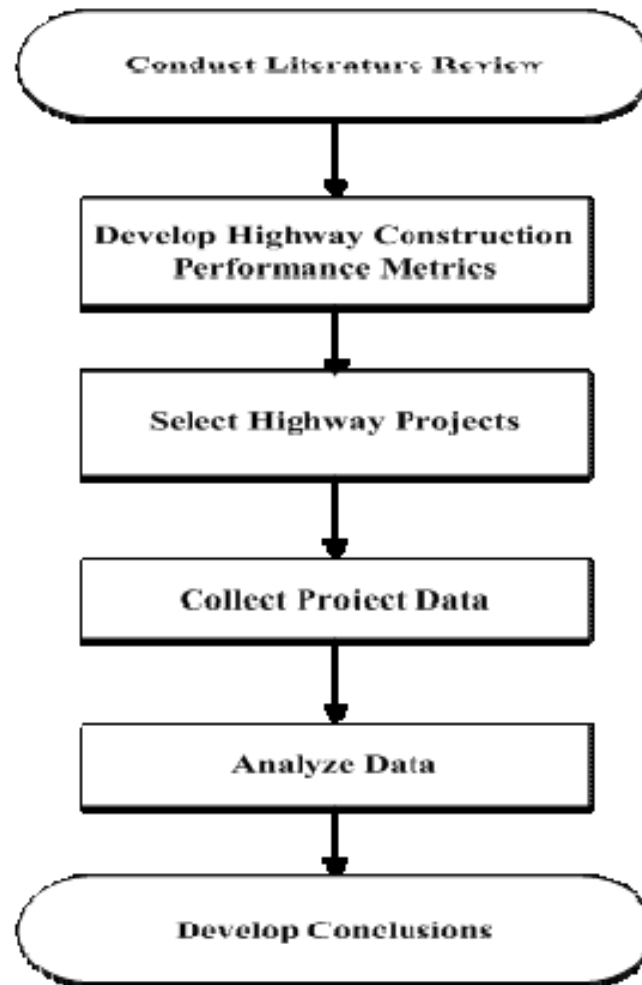
$$CGIE = \frac{\text{Final Construction Cost} - \text{Initial Estimated Cost}}{\text{Initial Estimated Cost}} \times 100\%$$

- Findings
 - Average design cost of roads = 5.2 % (projects over \$5M)
 - Inversely correlated: CGIE increases as design fees decrease, the correlation is stronger in bridge projects than road projects
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Gaps in Research

- No comprehensive study done to correlate design cost and construction cost and schedule performance of large (cost > \$30M) highway projects
 - No absolute performance metrics (e.g. construction cost and delivery speed per-lane-mile) developed to compare the highway projects
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Research Methodology



Design Cost Definition

- Cost expended for designing a highway project
- The cost includes only cost paid to designers
- Design cost is expressed in percentage of total design and construction cost

$$\text{Design Cost} = \frac{\text{Total Design Cost}}{\text{Total Design and Construction Cost}} \times 100\%$$

Construction Performance Metrics

- Construction Cost Growth (CCG):

$$CCG = \frac{\text{Actual Construction Cost} - \text{Estimated Construction Cost}}{\text{Estimated Construction Cost}} \times 100\%$$

- Construction Cost-per-Lane Mile (CCPLM):

$$CCPLM = \frac{\text{Actual Construction Cost}}{\text{Total Lane Miles}}$$

Construction Performance Metrics

- Construction Schedule Growth (CSG):

$$CSG = \frac{\text{Actual Construction Duration} - \text{Estimated Construction Duration}}{\text{Estimated Construction Duration}} \times 100\%$$

- Construction Delivery-per-Lane Mile (CDSLM):

$$CDSLM = \frac{\text{Actual Construction Duration}}{\text{Total Lane Miles}}$$

Selected Highway Projects

S.N.	Name of Projects	Construction Cost	Total Length (Lane Miles)	Type of Construction	Year of Completion
1	Dallas High Five Project <i>SH45 & Loop 1, Austin</i>	\$282,200,000	64	Reconstruction/ Expansion	2006
2	Section 1 & 2	\$107,961,000	39	New Construction	2007
3	Section 3	\$80,997,000	30	New Construction	2006
4	Section 4	\$103,018,000	44	New Construction	2007
5	Section 5	\$37,610,000	28	New Construction	2006
6	Section 6	\$34,058,000	28	New Construction	2006
7	Section 7	\$63,228,000	25	New Construction	2006
8	Section 8 <i>Katy Freeway, Houston</i>	\$134,923,000	27	New Construction	2007
9	Section 1 & 2	\$276,550,000	31	Reconstruction	2007
10	Section 8 & 9	\$220,430,000	120	Reconstruction	2006
11	Section 10	\$89,750,000	47	Reconstruction	2006
Total Cost		\$1,430,725,000			

Average Construction Cost = \$135 M

Findings: Design Cost Statistics

Types of Statistics	Design Cost (%)
Mean	11.7
Median	10.2
Maximum	30.2
Minimum	3.5
Standard Deviation	8.7
No. of Samples	11

Average Design Cost = 11.7%

Findings:

Construction Performance Statistics

Types of Statistics	Cost Growth (%)	Cost per Lane Mile (\$M)	Schedule Growth (%)	Delivery Speed per Lane Mile (Days)
Mean	-1.65	3.48	2.61	28.6
Median	-1.70	2.92	0	28.2
Maximum	30.91	8.90	35.05	44.5
Minimum	-29.90	1.32	-9.07	7.7
Standard Deviation	23.68	2.20	12.06	10.3
No. of Samples	11	11	11	11

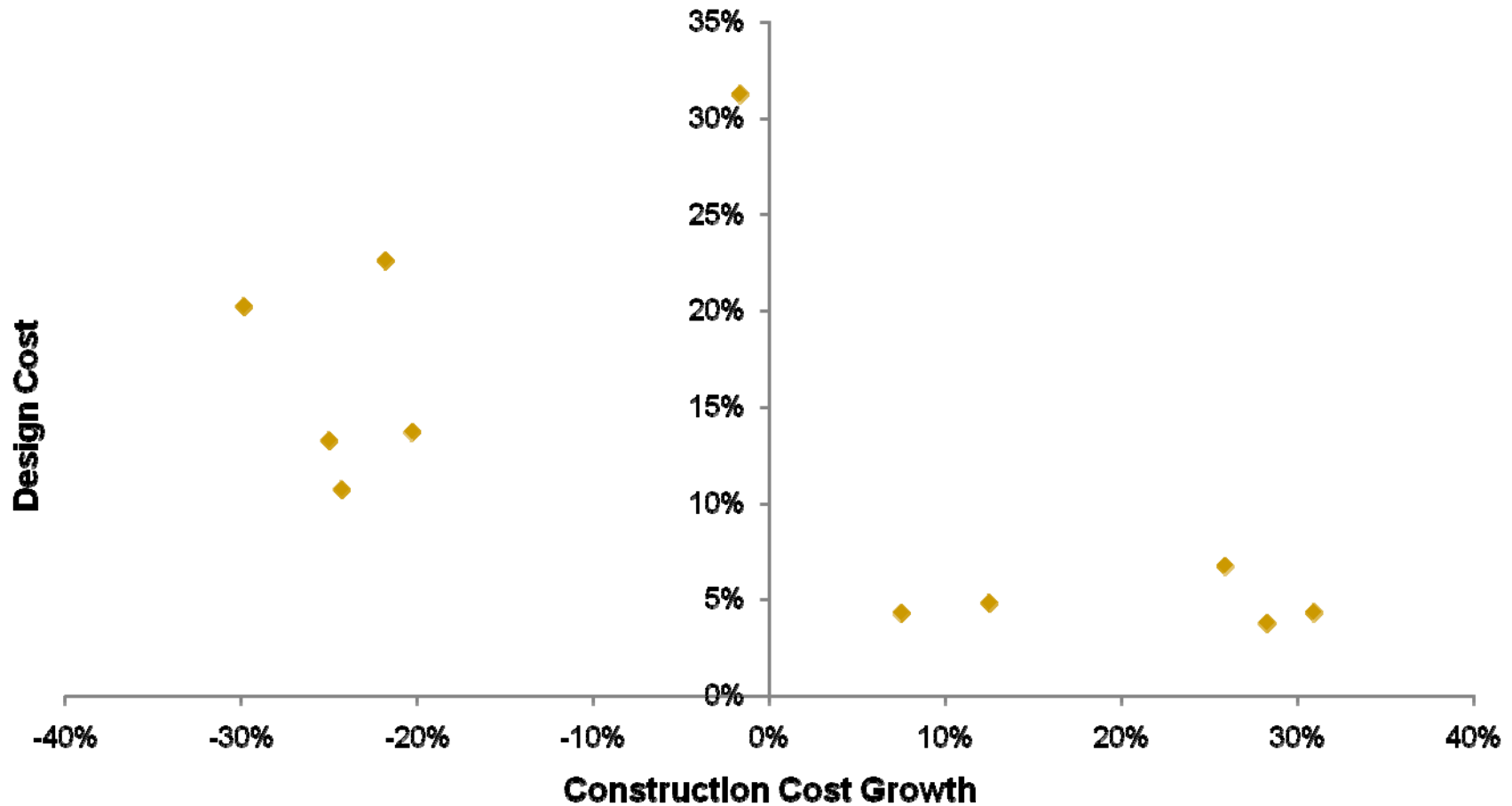
Average Cost Growth = -1.65%

Average Construction Cost-per-Lane Mile = \$3.48 M

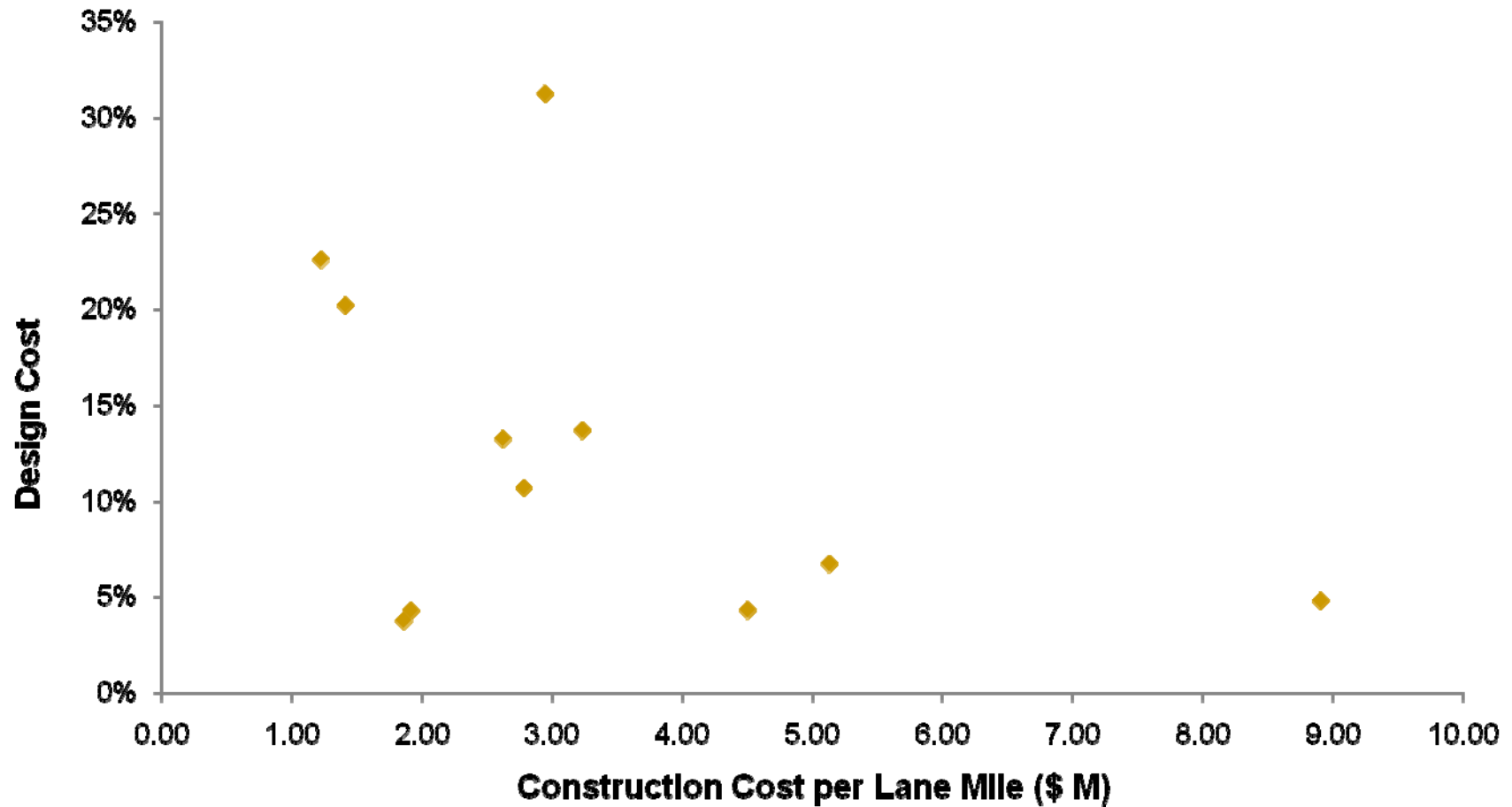
Average Schedule Growth = 2.61%

Average Construction Delivery Speed-per-Lane Mile = 29 Days

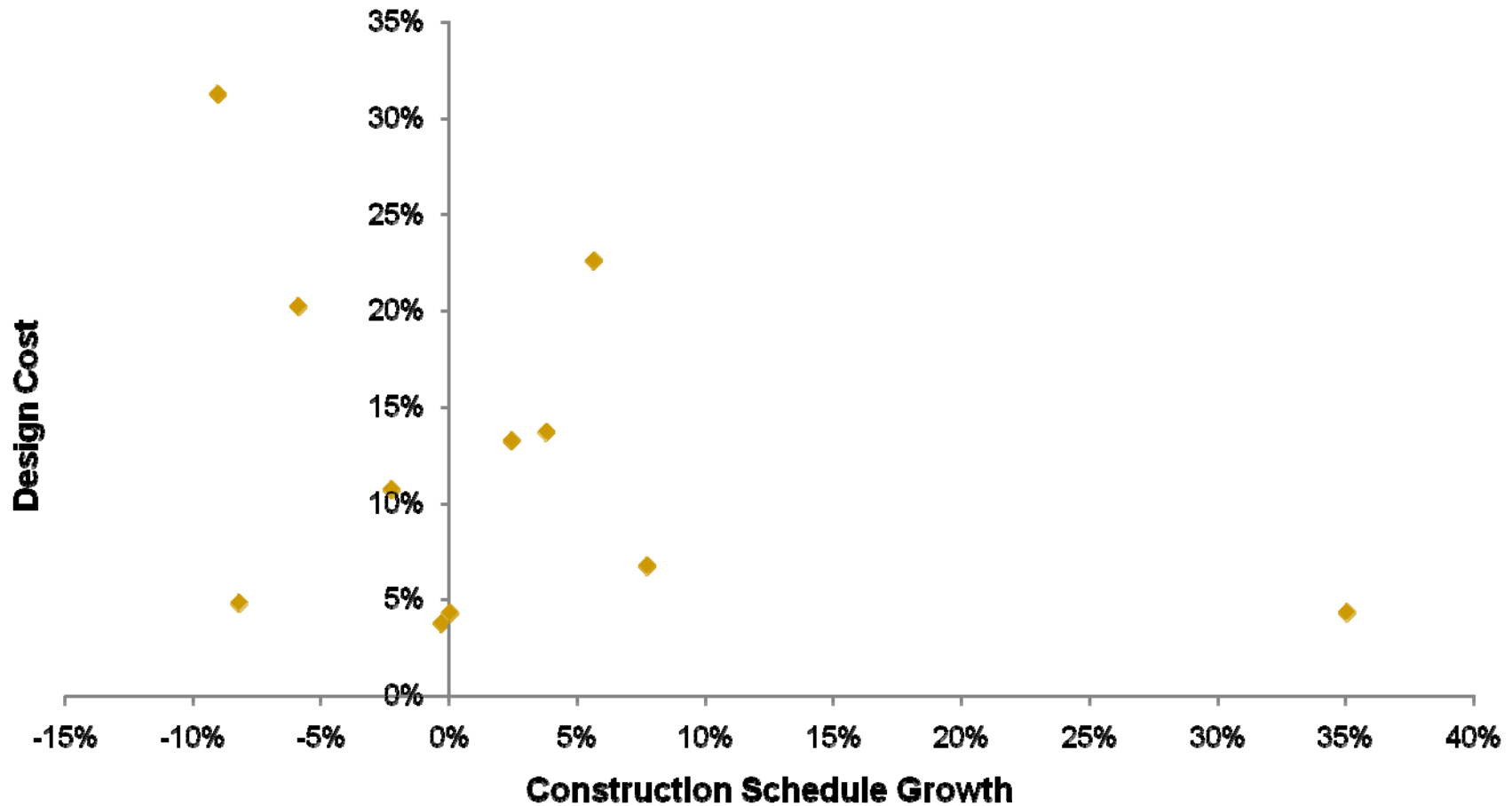
Findings: Correlation Analysis



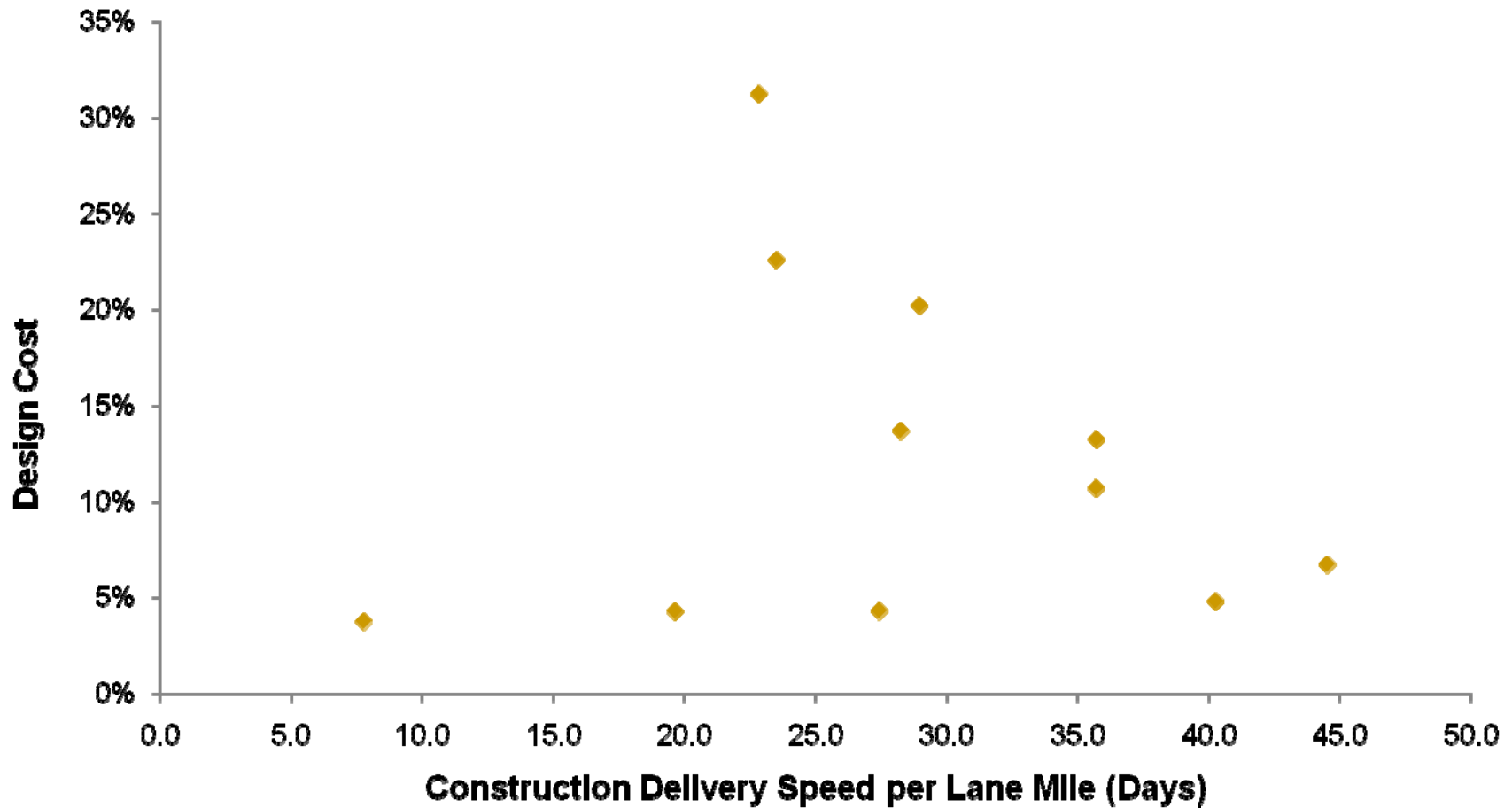
Findings: Correlation Analysis



Findings: Correlation Analysis



Findings: Correlation Analysis



Conclusions

- The trend shows
 - Construction cost growth decreases as the design cost increases
 - Construction cost-per-lane mile and delivery speed-per-lane mile decreases as design cost increases
 - Due to limited sample size, the findings cannot be generalized
 - Authors are collecting more data to validate these findings
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Thank You

Questions ?
