

Article

An Analysis of Overhead Costs for Electrical and Plumbing Works in Housing Projects in Bangkok

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Abstract. Contractors' overhead costs significantly influence the financial performance of housing projects, particularly in electrical and plumbing work. This study investigates overhead cost structures using data from 15 contractors in the Bangkok Metropolitan Area to define practical benchmarks for accurate estimation. The research findings indicate that overhead costs average 9.10% of the contract value, categorized into: (1) field expenses, (2) field staff welfare and safety equipment expenses, (3) tool and vehicle expenses, and (4) general expenses. Field expenses constitute the largest proportion, averaging 81.42% and varying from 54.0% to 94.60% based on project complexity. Expenditure on field staff welfare and safety equipment accounts for 10.0%, while tool and vehicle expenses represent 6.5%, and general expenses account for 2.1%. A comparison between contractor types indicates that electrical contractors incur slightly higher overhead costs, averaging 9.50% of the contract value, compared to 8.60% for plumbing contractors. However, plumbing contractors exhibit greater variability (5.6%–13.7%) compared to electrical contractors (6.7%–11.6%). These findings highlight the limitations of applying fixed overhead percentages and underscore the necessity of accounting for contractor types and specific project characteristics. The established cost structures provide a practical basis for enhancing project cost planning and control in housing development.

Keywords: Building, Construction, Overhead Cost, Electrical Works, Plumbing Works

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1. Introduction

The construction industry is widely regarded as one of the largest and most economically volatile sectors worldwide, characterized by high levels of capital investment and financial risk [1]. In reviewing business models tailored for the construction industry, the study by Li et al. [2] highlights the synergy between technological integration and operational platforms. Central to this discussion is the supply chain, which is broadly defined to include all actors in the project delivery process, while prioritizing the contributions of contractors and subcontractors as the primary subjects of analysis. Naderi et al. [3] define construction overhead cost management as a complex process requiring accurate allocation of indirect costs to project activities, and propose an integrated model combining Activity-Based Costing (ABC) with Building Information Modelling (BIM) to enhance cost estimation accuracy. Within this context, construction overhead costs (COCs) as defined by Naderi et al. [3], play a vital role in sustaining both financial stability and daily operational efficiency across construction projects. These costs include site expenditures as well as broader administrative expenses that support project execution. For the purposes of this research study, the term COCs is used interchangeably with the shorter term "overhead costs," commonly classified as indirect costs because they cannot be directly attributed to specific construction activities, despite being essential to the overall production process [4]. Previous studies have highlighted functions supported by overhead expenditures, such as cost control, project scheduling, design coordination, workforce training, and quality assurance. These functions represent important areas where productivity improvements can be achieved [5]. Nevertheless, general contractors tend to avoid investing in specialized workforces, equipment, and tools due to the limited nature of specialized tasks within a construction project [6]. Instead, they engage subcontractors to provide specialized services, including the procurement of resources, labour, equipment, and tools [6-7]. By utilizing subcontractors, general contractors can conserve their resources and avoid considerable investments in equipment, plant, and technology for specific segments of one-time projects, which is a common scenario in the construction industry. In accordance with this, Deep et al. [8] found that more than 65% of construction companies assign a portion of their work to subcontractors, demonstrating the significance of subcontracting practices. Particularly in large-scale and complex projects, employing subcontracting services is standard practice for general contractors [9]. Consistent with the findings of Naderi et al. [3], Carr [4] further emphasizes that indirect costs encompass a wide variety of items, ranging from major expenditures such as site supervision salaries and tower crane rentals, to minor consumables like nails and hand tools, which are impractical to allocate to individual work tasks. Although indirect in nature, these overhead costs are fundamental to the successful implementation of

a project. Their accurate estimation, effective management, and ongoing control therefore remain critical factors influencing contractor competitiveness and overall project performance. Furthermore, identifying key cost variables and understanding their influences are essential for developing reliable cost models that enhance the competitiveness of both quantity surveyors and contractors [10]. In practice, however, construction projects are frequently affected by delays arising from multiple sources, including technical, managerial, and external factors [11]. Such delays often lead to extended project durations, during which overhead costs continue to accumulate, making these costs increasingly difficult to predict and control. In housing projects, cost variability is further shaped by broader economic conditions. For example, Akintoye and Skitmore [12] demonstrated that construction price fluctuations exert a significant influence on housing investment decisions. In recent years, technological advancements have offered new opportunities to improve cost efficiency and mitigate overhead inefficiencies. Abanda et al. [13], through a critical review of 122 case studies, showed that BIM enhances information integration and coordination, thereby reducing inefficiencies that contribute to rising indirect costs. This is relevant to housing developments in Bangkok, where improved information management and coordination can directly reduce site overheads. Furthermore, the calculation of overhead costs serves as a critical instrument for evaluating project cost efficiency, enabling project managers to ascertain actual resource utilization, optimize allocation, and mitigate waste within non-value-adding activities [3]. Evidence from regional studies further highlights the challenges associated with overhead cost control. In Singapore, initiatives aimed at reducing public housing delivery times identified schedule performance as a critical factor, with site management effectiveness, coordination, and labour availability playing central roles [14]. These factors have a direct impact on field expenses, labour welfare costs, and idle equipment charges. Similarly, Park and Papadopoulou [15] reported that awarding contracts solely based on the lowest bid and the widespread use of lump-sum contracts were major contributors to cost escalation in Asian construction projects. Focusing on high-rise developments in Indonesia. These findings confirm a moderate correlation between cost overruns and project scale. Specifically, the practice of awarding contracts to the lowest bidder emerged as the most significant driver of budget slippage, while the prevalence of lump-sum contracts exerted the greatest influence on the frequency of cost escalation [15]. Furthermore, Kaming et al. [16] identified inflation, inaccurate cost estimation, and project complexity as key causes of cost overruns, while delays were primarily driven by design changes, labour inefficiencies, and inadequate planning. These findings reflect challenges commonly faced in developing countries, such as Thailand, where prolonged project durations tend to increase site overhead costs. Consistent with this perspective, Love et al. [17] emphasized that unplanned changes in design,

specifications, or client requirements disrupt workflows and extend timelines, increasing overhead costs for labour welfare, site administration, and managerial support. To enhance estimation accuracy, previous studies have investigated a range of advanced modelling techniques. Kim et al. [18] compared traditional regression analysis with artificial neural networks (ANNs) and case-based reasoning (CBR) models, finding that ANNs achieved the highest estimation accuracy, while CBR offered greater adaptability and long-term practical value. In a related study, Liu and Zhu [19] proposed a theoretical framework for cost estimation across various project phases, arguing that accuracy improves as control mechanisms transition from input-oriented approaches toward output- and behavioural-management approaches. Building upon the aforementioned literature, this present study focuses on overhead costs as a critical factor in project financial performance. Nabil and El-Riyati [20] further emphasized the importance of overhead costs within the overall project budget by distinguishing between home office and site overheads. Empirical evidence from Enshassi et al. [21] showed that overhead costs accounted for approximately 11 % of total construction costs in Palestine. Similarly, Ogbu and Imafidon [22] argued that while project-related factors such as size and duration are significant, the most critical driver of overhead cost escalation in civil engineering is delayed payment, which forces contractors to maintain site resources without achieving productive output. Puncreobutr et al. [23] pointed out that efficient overhead cost allocation is a vital determinant of project success for condominium developments in Thailand, particularly in mitigating the impact of indirect cost inflation. This is attributed to the more complex construction overhead costs structures of condominium projects, which involve the intricate integration of Mechanical, Electrical, and Plumbing (MEP) systems and associated architectural works.

More recent methodological developments offer potential solutions to these challenges. Neural network-based models have demonstrated strong predictive capability for estimating site overhead costs, reducing reliance on manual judgment and helping to minimize estimation errors [24-25]. Effective overhead cost control is especially critical for MEP systems, where administrative, operational, and regulatory requirements are typically more complex. These administrative overheads commonly include personnel salaries, insurance, and office expenses [26], while site overheads encompass temporary facilities, utilities, security services, and waste management [27]. In addition, safety expenditures, including protective equipment and workforce training, represent an important component of overhead costs [28]. The application of generative design tools enables the optimization of MEP system layouts during the early stages of AEC projects, allowing for more efficient space utilization and reduced design conflicts [28]. Such optimized designs help minimize change orders and shorten installation periods, directly contributing to controlling site overhead costs, consistent with the

findings of Ogbu and Imafidon [22]. Moreover, sustainability requirements, including energy systems and waste reduction measures, further intensify overhead cost pressures in contemporary construction projects [29]. Previous research has also drawn attention to the risks associated with cost misrepresentation in construction forecasting. Flyvbjerg et al. [30] argued that cost underestimation is frequently strategic rather than unintentional, often resulting in contractors having to absorb unanticipated overhead costs as projects progress. Furthermore, cost forecasts for major construction works are highly unreliable, as actual costs frequently exceed estimates by a significant margin due to "strategic misrepresentation." Radosavljević and Horner [31] further highlighted the unstable nature of labour productivity, showing that its chaotic and abnormal behaviour can undermine conventional statistical forecasting methods. Such volatility increases the likelihood of schedule disruptions, which lead to discrepancies between planned and actual project performance, subsequently raising labour welfare and administrative overhead expenses. In addition, Hanna et al. [32] demonstrated that change orders have a substantial impact on overhead costs by extending project durations and reducing labour productivity. Such discrepancies create ripple effects that inevitably escalate indirect costs, particularly those pertaining to project supervision and site-level administration. Taken together, these studies emphasize the need for more advanced predictive approaches, enhanced cost modelling, and effective management to ensure that overhead costs are both accurately forecast and properly controlled throughout the project lifecycle. Against this backdrop, the existing literature widely covers construction indirect costs and general MEP cost estimation. However, the specific overhead cost structure of electrical and plumbing trade contractors in residential projects remains largely unexamined. In addition, current estimation models are insufficient because they mainly focus on general contractors or aggregated building services, thereby failing to capture the detailed operational realities and overhead cost drivers of specialized subcontractors. To address this gap, this study investigates the overhead costs of electrical and plumbing trade contractors in residential projects located in the Bangkok Metropolitan Area. In this regard, the primary contribution of this research lies in the comprehensive empirical breakdown of trade-specific overhead costs into detailed cost items to establish their average values and observed distribution ranges across 15 housing development projects. Specifically, the present study provides contractors with a clearer understanding of the relative importance of individual overhead cost items, along with a practical benchmark model for the overall composition of project overhead expenditure. Lastly, the overhead cost classification, along with the reported empirical ranges for each item, provides contractors and estimators with an evidence-based structured checklist during tender preparation. It also serves as a preliminary reference when historical project data are unavailable,

acting as indicative benchmarks rather than fixed allowances, thereby enhancing awareness among stakeholders that each cost item must be carefully evaluated in relation to the characteristics and risks of a particular project. To achieve these objectives, the present work addresses the following specific research questions:

RQ1: What are the key overhead cost components and their empirical distributions among electrical and plumbing trade contractors in housing projects, particularly in the Bangkok Metropolitan Area?

RQ2: What benchmark framework can be established to assist electrical and plumbing trade contractors in residential projects in formulating realistic overhead cost estimates? Using detailed contractor cost data, this investigation develops benchmark values and offers practical insights to support improved overhead cost estimation and control in residential housing projects. Given the current volatility in labour and material markets in recent years, further in-depth investigation into overhead costs for electrical and plumbing works is required, serving as the primary impetus for this research.

2. Methodology

The present study examines project overhead costs incurred by subcontractors responsible for electrical and plumbing works within housing development projects. The scope of the study is limited to project overhead costs, while head office overhead costs are intentionally excluded to ensure consistency in cost comparisons. Data collection was carried out through structured interviews with personnel directly involved in construction cost estimation and control activities, and a review of cost estimation records obtained from 15 electrical and plumbing trade contractors engaged in housing projects within the Bangkok Metropolitan Area. These specialized contractors were specifically selected through purposive sampling from a single large-scale real estate company focusing on residential development and operating for over 30 years, with a registered capital of approximately 1.0 billion Baht. The relevant data were collected between August 2023 and February 2024 across projects comprising both single-detached houses valued at 3.0 million Baht with a usable floor area of 158 square metres and townhouses valued at 1.5 million Baht with usable floor areas of 130–145 square metres. Table 1 illustrates the contract values of the 15 housing projects analysed, of which nine involve electrical works and the remaining six involve plumbing works. Analysis of the overhead cost data reveals a clear relationship between project overhead expenses and contract values for both electrical and plumbing works. Across the sampled projects, overhead costs range from approximately 5.6% to 13.7% of the respective contract values, as shown in Table 1. The average project overhead cost was calculated to be 9.10% of the contract value. Accordingly, the validation process of the present study was conducted through empirical data collection, including structured interviews and a review of cost estimation records from the 15 participating contractors, facilitated by

key personnel of a large-scale real estate developer. To minimise bias, the analysed data were verified using data source and investigator triangulation, combining information from the aforementioned records with cross-examination by all three researchers, as one of the co-authors directly supervised operations across the 15 projects, thereby integrating perspectives from both academic researchers and industry practitioners. An overview of the contractor profiles and cost components is presented in Tables 2 and 3. Project overhead costs were classified into four main categories. Field expenses, as summarised in Table 2, include accommodation near construction sites, utilities and telephone bills, document printing, administrative fees, contingencies related to material costs, and fuel expenses. The remaining categories (field staff welfare and safety equipment, tools and vehicles, and general expenses) are presented in Table 3. Field staff welfare and safety equipment costs comprise workers' compensation insurance, personal protective equipment (PPE), and uniforms. Tool and vehicle expenses cover the purchase of new tools and the maintenance of site vehicles, while general expenses include items such as entertainment and hospitality, as well as project accounting costs.

3. Results

The analysis of overhead costs from 15 housing development projects provides insights into the distribution and magnitude of expenses across four main categories: field expenses, field staff welfare and safety equipment expenses, tool and vehicle expenses, and general expenses. All cost values are reported in U.S. dollars. Among these categories, field expenses consistently represent the largest component of total overhead costs across all projects. Accommodation near construction sites constitutes a major component of field expenses, with costs ranging from \$303 to \$9,091. Project ID 5 was excluded from consideration as it incurred no expenses for either utilities or accommodation near construction sites.

This variation reflects differences in project location and duration, with the highest expenditures observed in projects requiring on-site accommodation. Utilities and telephone expenses contribute a relatively small proportion to total overhead costs, with utility bills ranging from \$0 to \$1,515 and telephone bills from \$76 to \$455. Expenses for document printing and administrative fees are relatively stable across projects, with printing costs ranging from \$30 to \$1,061 and administrative fees from \$36 to \$303. In contrast, contingencies allocated for material costs represent a substantial and highly variable expense, ranging from \$909 to \$9,091, depending on project scale, complexity, and exposure to material price fluctuations. Fuel expenses are moderate, ranging from \$152 to \$6,061; however, an exception is noted for Project ID 6, which incurred no fuel expenses. These costs are closely related to project size, travel distance, and site logistics.

Field staff welfare and safety equipment expenses contribute a moderate share to overall overhead costs, reflecting the ongoing requirements for insurance coverage,

safety provisions, and compliance with site regulations. Workers' compensation insurance was incurred for only a limited number of projects, with recorded costs reaching up to \$3,030. In contrast, expenditures on safety equipment and uniforms remained relatively consistent across projects, with safety costs ranging from \$61 to \$3,030. A notable exception was Project ID 11, which reported zero personal protective equipment (PPE) expenses, likely indicating that such costs were absorbed by subcontractors. Uniform expenses ranged from \$61 to \$909, reflecting standard safety compliance requirements rather than project-specific conditions. Tool and vehicle expenses comprised costs associated with the purchase of new tools and the

maintenance of site vehicles. Tool expenditures ranged from \$0 to \$1,212, indicating that some projects relied on existing equipment rather than additional purchases. Vehicle maintenance costs showed greater variability, ranging from \$0 to \$3,030, which was largely driven by project duration, transportation demands, and site operational intensity. General expenses constitute the smallest share of total overhead costs. Entertainment and hospitality expenses occurred only in select projects, with values ranging from \$0 to \$1,515. Project accounting expenses also ranged from \$0 to \$1,515, reflecting differences in the level of administrative support required for financial management and regulatory compliance.

Table 1. Contract Values, Overhead Costs, and Overhead Percentages for Electrical and Plumbing Projects

Project ID	Type of Contractors	Contract Value (Electrical & Plumbing, USD)	Overhead Cost (Electrical & Plumbing, USD)	% of Contract value
1	Electrical contractors	53,030	5,516	10.40
2	Electrical contractors	133,636	8,911	6.67
3	Electrical contractors	161,212	18,606	11.54
4	Electrical contractors	38,788	3,947	10.18
5	Electrical contractors	133,485	11,516	8.63
6	Electrical contractors	136,364	10,758	7.89
7	Electrical contractors	79,152	9,190	11.61
8	Electrical contractors	303,030	29,080	9.60
9	Electrical contractors	303,030	26,363	8.70
10	Plumbing contractors	36,515	3,756	10.29
11	Plumbing contractors	91,212	5,077	5.57
12	Plumbing contractors	180,879	11,570	6.40
13	Plumbing contractors	50,909	4,304	8.45
14	Plumbing contractors	188,182	13,025	6.92
15	Plumbing contractors	72,694	9,944	13.68
Average				9.10
Max				13.68
Min				5.57

Table 2. Detailed Breakdown of Project Overhead Costs (Field Expenses) Across 15 Housing Development Projects.

Project ID	1. Field expenses (USD)						
	Accommodation near construction sites	Utilities bills	Telephone bills	Document printing	Administrative fees	Contingencies related to material costs	Fuel expenses
1	909	152	121	303	61	3,030	606
2	606	152	242	303	152	6,061	909
3	3,333	303	303	909	182	9,091	909
4	697	91	152	91	36	1,818	606
5	0	0	364	303	152	6,061	3,030
6	3,030	455	303	1,061	152	3,030	0
7	1,818	1,455	291	455	79	3,636	152
8	9,091	1,515	303	909	303	6,061	1,515
9	6,061	0	303	606	303	909	6,061
10	455	73	76	30	61	2,424	121
11	606	136	273	61	91	3,030	455
12	1,212	327	455	91	182	6,061	606
13	303	121	121	91	61	3,030	152
14	606	258	155	121	212	9,091	303
15	1,818	0	121	758	79	3,576	364

Table 3. Detailed Breakdown of Project Overhead Costs (Field Staff Welfare and Safety Equipment Expenses, Tools and Vehicles Expenses, and General Expenses) Across 15 Housing Development Projects.

Project ID	2. Field staff welfare and safety equipment expenses (USD)			3. Tools and vehicles (USD)		4. General expenses (USD)		Total
	Workers' compensation insurance	Personal protective equipment (PPE)	Uniforms	Tools	The maintenance of site vehicles	Entertainment and hospitality	Project accounting costs	
1	0	152	91	0	91	0	0	5,516
2	0	152	91	152	91	0	0	8,911
3	2,121	212	303	606	152	182	0	18,606
4	0	152	91	152	61	0	0	3,947
5	0	455	121	606	303	121	0	11,516
6	1,515	303	303	303	303	0	0	10,758
7	545	152	91	0	455	61	0	9,190
8	3,030	3,030	303	909	606	606	909	29,080
9	3,030	909	909	1,212	3,030	1,515	1,515	26,363
10	303	61	61	91	0	0	0	3,756
11	0	0	61	303	61	0	0	5,077
12	1,424	121	91	909	91	0	0	11,570
13	0	61	61	303	0	0	0	4,304
14	1,339	152	91	606	91	0	0	13,025
15	545	182	61	576	727	76	1,061	9,944

Across the 15 projects, total overhead costs per project ranged from \$3,756 to \$29,080. Higher overhead expenditures were typically associated with larger and more complex projects, particularly those requiring extended site accommodation, higher material contingencies, and increased transportation needs. Overall, field expenses accounted for the largest proportion of overhead costs, representing an average of approximately 81.42% of the total in most projects, as presented in Table 4. Field staff welfare and safety equipment expenses formed the second largest category at approximately 10.04%, while tools, the maintenance of site vehicles, and general expenses contributed comparatively smaller shares to overall overhead costs.

4. Analysis

The analysis of overhead costs across 15 housing development projects provides insights into both their composition and their relative contribution to total project overhead expenditure. Based on the findings of this study, the average overhead cost is approximately 9.10% of the contract value. Overhead costs are classified into four categories: field expenses, field staff welfare and safety equipment expenses, tool and vehicle expenses, and general expenses. For comparative purposes, all cost components are expressed as percentages of total project overhead costs, as presented in Tables 5 and 6.

Field expenses, as presented in Table 5, constitute the largest share of total project overhead costs, accounting for an average of approximately 81.42%. Within this category, accommodation near construction sites contributes about 15.04% of total overhead costs and is strongly influenced by project size and location. This expenditure reflects a

distinctive practice among Thai subcontractors, who commonly reside near job sites to reduce daily travel time and transportation costs. Utility and telephone expenses represent relatively small proportions of total overhead costs, accounting for approximately 3.06% and 2.55%, respectively. Costs related to document printing and administrative fees range from 1.29% to 3.49%, indicating a generally minor but occasionally variable impact depending on project documentation and administrative requirements. Contingencies allocated for material costs represent the largest individual component within field expenses, averaging 47.69% of total overhead costs. This category exhibits considerable variation across projects, largely driven by differences in project complexity, material availability, and exposure to price fluctuations. Fuel expenses contribute an average of 8.30% of total overhead costs and are primarily associated with project location, transportation needs, and site logistics.

As demonstrated in Table 6, field staff welfare and safety equipment expenses account for approximately 10.04% of total project overhead costs, with variations reflecting site safety requirements. Workers' compensation insurance is included only in certain projects, averaging approximately 5.96% of total overhead costs where applicable. PPE expenses typically account for around 2.59%, influenced by the safety standards stipulated by project owners. Uniform expenses, which are generally covered by contractors, remain relatively consistent across projects, accounting for approximately 1.49% of total overhead costs. Tool and vehicle expenses contribute smaller shares to total overhead costs, averaging 3.89% and 2.60%, respectively. Tool expenses include both the purchase of new equipment and the maintenance of existing tools, with costs generally increasing with longer project

durations. Vehicle maintenance expenses are influenced by the distance between the contractor's head office and the construction site, as well as the overall transportation requirements of each project. General expenses constitute the smallest share of total overhead costs, accounting for approximately 2.06%. Entertainment and hospitality expenses are incurred only in specific projects and are often informally required by project owners; these costs represent about 0.75% of total overhead expenditures. Project accounting expenses represent the remaining 1.30%, reflecting the administrative support required for financial monitoring, reporting, and regulatory compliance.

When considered collectively, the overhead cost data from the 15 housing development projects provide a practical reference for estimating overhead costs in future residential projects. The relationship between overhead cost percentages and contract values for electrical and plumbing

works is illustrated in Figure 1. The scatter plot presents data from all 15 housing projects, along with a fitted linear trendline. The corresponding regression equation, shown in Equation 1, exhibits a negative slope, indicating that the proportion of overhead costs generally decreases as the contract amount increases. This pattern suggests the presence of economies of scale, whereby larger contract values allow fixed overhead expenses to be distributed more efficiently. Despite this overall trend, the dispersion of data points around the fitted line indicates considerable variability among projects. This variability is likely influenced by specific project conditions, including site location, construction complexity, and safety requirements stipulated by project owners. Such factors highlight the importance of considering contextual conditions alongside contract value when estimating and managing the overhead costs of electrical and plumbing works in housing projects.

Table 4. Percentages of Major Overhead Cost Categories Relative to Total Project Overhead Costs

Project ID	1.Field expenses	2.Field staff welfare and safety equipment expenses	3. Tools and vehicles	4. General expenses
1	93.94%	4.41%	1.65%	0.00%
2	94.55%	2.73%	2.73%	0.00%
3	80.78%	14.17%	4.07%	0.98%
4	88.45%	6.16%	5.40%	0.00%
5	86.05%	5.00%	7.89%	1.05%
6	74.65%	19.72%	5.63%	0.00%
7	85.81%	8.57%	4.95%	0.66%
8	67.70%	21.88%	5.21%	5.21%
9	54.03%	18.39%	16.09%	11.49%
10	86.26%	11.32%	2.42%	0.00%
11	91.63%	1.20%	7.17%	0.00%
12	77.22%	14.14%	8.64%	0.00%
13	90.13%	2.83%	7.04%	0.00%
14	82.50%	12.15%	5.35%	0.00%
15	67.54%	7.92%	13.10%	11.43%
Average	81.42%	10.04%	6.49%	2.06%
Max	94.55%	21.88%	16.09%	11.49%
Min	54.03%	1.20%	1.65%	0.00%

Table 5. Breakdown of Field Expenses Across 15 Housing Development Projects

Project ID	1.Field expenses						
	Accommodation near construction sites	Utilities bills	Telephone bills	Document printing	Administrative fees	Contingencies related to material costs	Fuel expenses
1	16.48%	2.76%	2.19%	5.49%	1.11%	54.93%	10.99%
2	6.80%	1.71%	2.72%	3.40%	1.71%	68.02%	10.20%
3	17.91%	1.63%	1.63%	4.89%	0.98%	48.86%	4.89%
4	17.66%	2.31%	3.85%	2.31%	0.91%	46.06%	15.35%
5	0.00%	0.00%	3.16%	2.63%	1.32%	52.63%	26.31%
6	28.17%	4.23%	2.82%	9.86%	1.41%	28.17%	0.00%
7	19.78%	15.83%	3.17%	4.95%	0.86%	39.56%	1.65%
8	31.26%	5.21%	1.04%	3.13%	1.04%	20.84%	5.21%
9	22.99%	0.00%	1.15%	2.30%	1.15%	3.45%	22.99%
10	12.11%	1.94%	2.02%	0.80%	1.62%	64.54%	3.22%
11	11.94%	2.68%	5.38%	1.20%	1.79%	59.68%	8.96%
12	10.48%	2.83%	3.93%	0.79%	1.57%	52.39%	5.24%
13	7.04%	2.81%	2.81%	2.11%	1.42%	70.40%	3.53%
14	4.65%	1.98%	1.19%	0.93%	1.63%	69.80%	2.33%
15	18.28%	0.00%	1.22%	7.62%	0.79%	35.96%	3.66%
Average	15.04%	3.06%	2.55%	3.49%	1.29%	47.69%	8.30%
Max	31.26%	15.83%	5.38%	9.86%	1.79%	70.40%	26.31%
Min	0.00%	0.00%	1.04%	0.79%	0.79%	3.45%	0.00%

Table 6. Breakdown of Field Staff Welfare and Safety Equipment Expenses, Tools and Vehicles Expenses, and General Expenses

Project ID	2.Field staff welfare and safety equipment expenses			3. Tools and vehicles		4. General expenses	
	Workers' compensation insurance	Personal protective equipment (PPE)	Uniforms	Tools	The maintenance of site vehicles	Entertainment and hospitality	Project accounting costs
1	0.00%	2.76%	1.65%	0.00%	1.65%	0.00%	0.00%
2	0.00%	1.71%	1.02%	1.71%	1.02%	0.00%	0.00%
3	11.40%	1.14%	1.63%	3.26%	0.82%	0.98%	0.00%
4	0.00%	3.85%	2.31%	3.85%	1.55%	0.00%	0.00%
5	0.00%	3.95%	1.05%	5.26%	2.63%	1.05%	0.00%
6	14.08%	2.82%	2.82%	2.82%	2.82%	0.00%	0.00%
7	5.93%	1.65%	0.99%	0.00%	4.95%	0.66%	0.00%
8	10.42%	10.42%	1.04%	3.13%	2.08%	2.08%	3.13%
9	11.49%	3.45%	3.45%	4.60%	11.49%	5.75%	5.75%
10	8.07%	1.62%	1.62%	2.42%	0.00%	0.00%	0.00%
11	0.00%	0.00%	1.20%	5.97%	1.20%	0.00%	0.00%
12	12.31%	1.05%	0.79%	7.86%	0.79%	0.00%	0.00%
13	0.00%	1.42%	1.42%	7.04%	0.00%	0.00%	0.00%
14	10.28%	1.17%	0.70%	4.65%	0.70%	0.00%	0.00%
15	5.48%	1.83%	0.61%	5.79%	7.31%	0.76%	10.67%
Average	5.96%	2.59%	1.49%	3.89%	2.60%	0.75%	1.30%
Max	14.08%	10.42%	3.45%	7.86%	11.49%	5.75%	10.67%
Min	0.00%	0.00%	0.61%	0.00%	0.00%	0.00%	0.00%

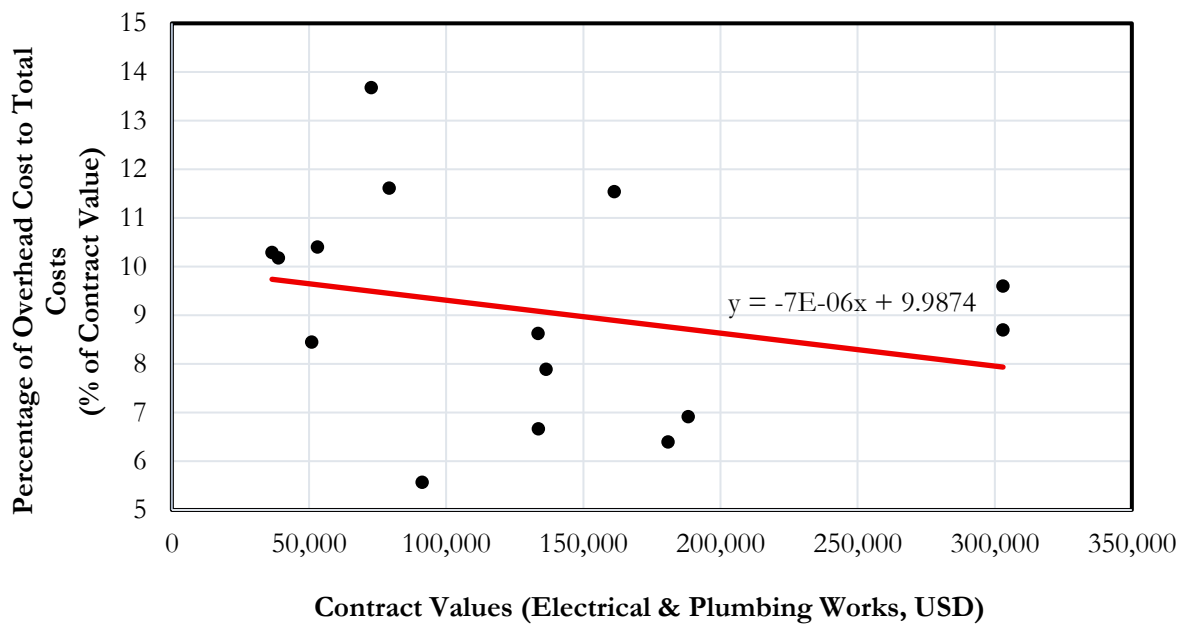


Fig. 1. Relationship Between the Percentage of Overhead Costs Relative to Total Costs and Contract Values (Electrical and Plumbing Works) for Housing Development Projects

$$y = 9.9874 - 0.000007x \quad (1)$$

The coefficient of determination (R^2) is 0.067, indicating that contract value explains only approximately 7% of the observed variation in overhead costs, which is not statistically significant ($F(1, 13) = 0.938, p = 0.350$). The above equation has limited explanatory and predictive value. Nevertheless, it can provide a broad preliminary indication for trade contractors who are new to the business or lack historical cost data. In such cases, the estimated overhead cost percentage may be considered within an approximate range of ± 4 percentage points (see Figure 1). This range should be used only as an initial reference and not as a precise prediction. The analysis results show that contingencies related to material costs constitute the largest overhead component, accounting for an average of 47.69% of total overhead costs, as shown in Table 5. This item also exhibits substantial variation, ranging from 3.45% to 70.40%. This wide range indicates that unanticipated material-related costs differ considerably among projects and cannot be adequately represented by a single percentage based only on contract value. Accommodation near construction sites is the second-largest component, averaging 15.04% and ranging from 0% to 31.26%, as shown in Table 5, followed by fuel expenses, which average 8.30% and range from 0% to 26.31%. Other meaningful overhead components include workers' compensation insurance, with an average of 5.96% and a range of 0% to 14.08%; tools, averaging 3.89% and ranging from 0% to 7.86% as demonstrated in Table 6; document printing, averaging 3.49% and ranging from 0.79% to 9.86%; and utility bills, averaging 3.06% and ranging from 0% to 15.83%, as shown in Table 5. PPE, telephone bills, site-vehicle maintenance, uniforms, administrative fees, project accounting, and entertainment

and hospitality represent smaller average shares. Nevertheless, some of these items have wide ranges, indicating that they can become significant under particular project conditions. Furthermore, the presence of zero values for several items, combined with large differences between their minimum and maximum values, demonstrates that overhead cost structures are project-specific. For example, vehicle maintenance costs range from 0% to 11.49%, PPE expenses from 0% to 10.42%, and project accounting costs from 0% to 10.67%. Thus, even items with relatively low averages should not automatically be excluded from project estimates. Their occurrence and magnitude depend on the operational and contractual circumstances of individual projects. These findings explain, at least partly, why contract value alone has little capability to predict the overhead cost percentage. Overhead costs are not a homogeneous expense governed by a single project characteristic. Instead, they comprise multiple anticipated and unanticipated items affected by site location, accommodation requirements, material price uncertainty, workforce arrangements, transportation needs, safety requirements, administrative practices, and other project-specific conditions.

Accordingly, the practical value of this research lies in the overhead cost classification and the empirical ranges reported for each item. These results provide contractors and estimators with a structured checklist of costs that should be considered during tender preparation. The ranges can also serve as preliminary reference values when historical project data are unavailable. However, they should be applied as indicative benchmarks rather than fixed allowances, because the considerable variation

among projects shows that each cost item must be evaluated in relation to the characteristics and risks of the particular project. A further contribution of this research is the detailed breakdown of overhead costs presented in the pie chart in Figure 2. The findings provide contractors with a clearer understanding of the relative importance of individual overhead cost items and the overall composition of project overhead expenditures. The chart shows that contingencies related to material costs account for the largest share, followed by accommodation near job sites, fuel, and workers' compensation insurance. By identifying both major and minor cost components, this breakdown can serve as a practical reference for contractors, particularly those who are new to the business

or lack sufficient historical data, when preparing comprehensive and realistic overhead cost estimates.

In this regard, given that the specific overhead cost structure of electrical and plumbing trade contractors in residential projects remains largely unexamined, this work emphasizes the empirically derived classification of 14 overhead cost items as demonstrated in Figure 2, including their average breakdown and observed ranges across the 15 housing projects. Its principal value lies in revealing the importance and variability of both anticipated operating expenses and unanticipated material-related costs, rather than in proposing a regression equation based solely on contract value.

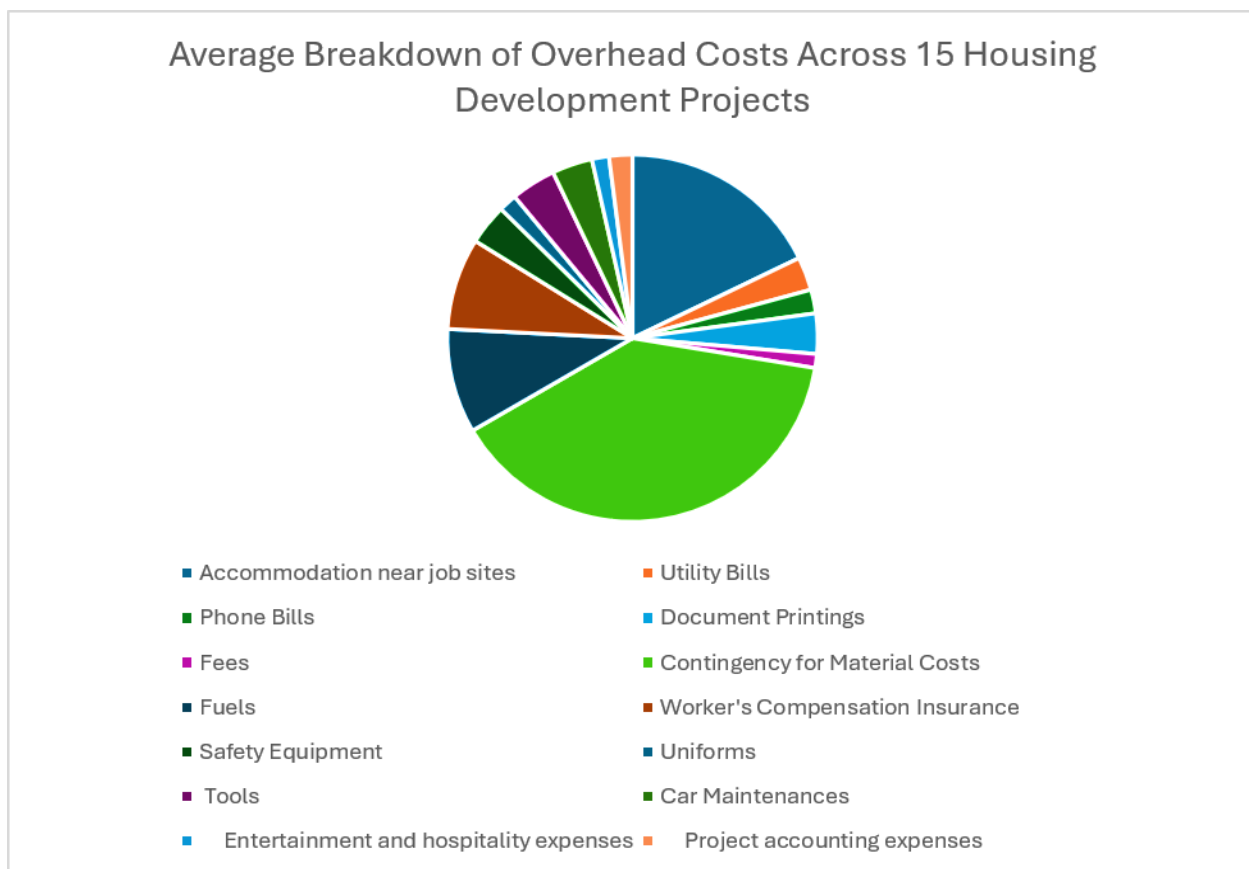


Fig. 2. Average Breakdown of Overhead Costs Across 15 Housing Development Projects

5. Conclusions

The analysis of overhead costs from 15 housing development projects provides meaningful insights into how these expenses are distributed, their relative magnitude, and the extent of their variability across four major categories: field expenses, field staff welfare and safety equipment expenses, tool and vehicle expenses, and general expenses. Among these, field expenses consistently represent the dominant component of total overhead costs, accounting for an average of 81.42%, with observed values ranging from 54.03% to 94.55%. Accommodation costs are a particularly influential factor within this category, especially in projects with longer durations, highlighting their substantial impact on overall

overhead expenditure. Field staff welfare and safety equipment expenses constitute the second-largest category, averaging 10.04% of total overhead costs and ranging from 1.20% to 21.88%. This variation reflects differences in site safety requirements and regulatory expectations, particularly in projects with higher risk profiles. Tool and vehicle expenses account for an average of approximately 6.50% of overhead costs, with a range of 1.65% to 16.10%. These costs are largely driven by project conditions such as transportation demands, equipment usage intensity, and maintenance needs. General expenses form the smallest portion of overhead costs, averaging approximately 2.10%, although their contribution varies from 0.0% to approximately 11.50%, indicating that while generally minor, they may become significant under

certain project circumstances, reflecting differences in the level of administrative support required for financial management and regulatory compliance. The findings of this investigation align with the recent research by Zhao et al. [26], Tao et al. [27], and Pestana et al. [28], emphasizing the distinct categorization of overhead costs. Specifically, administrative overheads are characterized by personnel salaries, insurance, and office-related expenses. Conversely, site overheads encompass essential field-based components such as temporary facilities, utilities, security services, and waste management. This distinction is crucial for the effective control of site overhead costs, which has become a primary focus in contemporary construction projects to ensure financial viability and operational efficiency [29], [3].

Overall, larger and more complex projects tend to incur higher absolute overhead costs, reflecting both economies of scale and the influence of project factors such as location, construction complexity, and material availability. Taken together, these findings offer a practical framework for overhead cost estimation in future housing development projects and underscore the importance of adopting cost management strategies that are tailored to the characteristics of individual projects, rather than relying on uniform percentage allowances.

Table 7 illustrates the relationship between overhead costs and contract amounts for electrical and plumbing trade contractors. On average, electrical contractors incur slightly higher overhead costs at 9.50% of the contract value, compared with 8.60% for plumbing contractors. Despite this difference, plumbing contractors exhibit greater variability in overhead costs, with values ranging from 5.60% to 13.70%, whereas electrical contractors show a narrower range between 6.70% and 11.60%. This wider dispersion among plumbing projects may be associated with differences in project complexity, material handling requirements, and operational conditions specific to the trade. The results further suggest that projects with larger contract values tend to experience greater variability in overhead costs. This observation is consistent with previous studies indicating that increased project complexity, inadequate planning, and scheduling inefficiencies can amplify overhead cost uncertainty in larger projects, as noted in the studies conducted by Doloï [33], Ogbu and Imafidon [22], and Puncreobutr et al. [23]. In addition, large-scale projects often face challenges related to inefficient resource utilization, which can contribute to higher indirect costs, particularly in site management and administrative functions, in accordance with the studies by Ballesteros-Pérez et al. [34] and Naderi et al. [3].

While this work provides meaningful insights into the overhead cost structure of electrical and plumbing works in residential housing developments, several limitations should be acknowledged. First, the analysis is based on data from 15 electrical and plumbing trade contractors involved exclusively in residential housing projects for sale within the Bangkok Metropolitan Area. Consequently, the findings may not be fully transferable to other

construction sectors, such as commercial buildings, infrastructure projects, or rental housing developments, where overhead cost structures and operational conditions may differ. Second, the study focuses only on such electrical and plumbing contractors, excluding other MEP trades such as HVAC and fire protection systems, which may exhibit distinct overhead cost characteristics. Although the validation process of this investigation was conducted through empirical data collection, including structured interviews and a review of cost estimation records from the 15 participating contractors, a notable limitation is that the data were collected from only a single large-scale real estate developer. Different organizations may employ distinct administrative and management practices, particularly regarding the management of trade contractors. This approach may introduce subjectivity in cost reporting and categorization. As highlighted by Naderi et al. [3], construction overhead cost management is a complex process requiring the accurate allocation of indirect costs to project activities, emphasizing the importance of sustaining both financial stability and daily operational efficiency across construction projects. These costs include site expenditures as well as broader administrative expenses that support project execution. It is important to note that this study concentrates only on electrical and plumbing trade contractors in residential projects located in the Bangkok Metropolitan Area, while other MEP trades may involve different overhead cost patterns. From a practical perspective, the research findings can provide a broad preliminary indication for contractors who are new to the business or lack historical cost data. In such cases, the estimated overhead cost percentage may be considered within an approximate range of ± 4 percentage points. This range should be used only as an initial reference and not as a precise prediction. Practitioners should carefully evaluate these figures and apply them only to similarly located residential construction projects within the specified value range. Moreover, the analysis does not explicitly account for macroeconomic factors such as inflation, interest rates, or material price volatility, despite their potential influence on overhead costs over time. Furthermore, variations in project management practices and the adoption of construction technologies, which could significantly affect overhead efficiency, were not examined in detail. For instance, construction technologies such as BIM could potentially improve reliability in the cost estimation process with external pricing factors demanding the estimator's judgment [35], which is related to the exact estimation of overhead cost sources. These limitations present opportunities for future research to expand the scope of analysis by incorporating a wider range of project types and MEP trades, utilizing detailed financial records, and examining the influence of external economic conditions and emerging technologies on overhead cost management in residential construction.

Table 7. Percentages of Overhead Costs Relative to Contract Amounts for Electrical and Plumbing Works

	Electrical contractors	Plumbing contractors
Average	9.50	8.60
Max	11.60	13.70
Min	6.70	5.60

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