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An Analytical Perspective on Curtain Wall Project Management

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Abstract: Over the past four decades, propelled by China's reform and opening-up policies, urban construction in the country has undergone rapid and transformative development. Within this context, the curtain wall, serving as both the exterior enclosure and aesthetic façade of buildings, has become a defining element of modern architecture. As a specialized component within the overall construction system, curtain wall projects demand a high level of expertise in both technical execution and project management. This study explores a unique analysis and reflection on the labor management and schedule control of curtain wall projects.

Keywords: Curtain wall projects; Labor management; Schedule control

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1. Introduction

Different companies and project managers have different methods and focuses in the labor management and progress management of the projects. However, in practice, many projects continue to experience significant conflicts with labor subcontractors during the management process. The benefits of labor service companies come from the management of workers, and effective labor management methods are worthy of in-depth research and discussion. Progress management is a critical criterion by which the client (Party A) evaluates the success or failure of a construction project. Delays in project progress can jeopardize timely delivery and may result in significant contractual breaches. Effective schedule control not only ensures compliance with contractual obligations but also contributes to the contractor's professional reputation and the development of long-term collaborative relationships within the industry. When a project experiences delays that lead to a breach of contract, the opportunity to establish trust and long-term partnerships is often compromised. This makes it essential to strengthen progress management practices. Rather than relying solely on traditional methods, project managers should actively seek out more reliable and efficient strategies to ensure timely project delivery.

2. Thoughts on labor management of curtain wall projects

As a highly specialized component of construction, curtain wall projects place significant demands on the labor force. The ability of labor subcontractors to recruit and manage skilled workers directly affects the quality and safety of on-site installation. Selecting a competent and reliable labor service company can greatly enhance efficiency, allowing the curtain wall contractor and project management team to achieve more with less effort. Conversely, partnering with an underqualified subcontractor often results in increased challenges and resource consumption. When selecting a labor service company, the following key considerations should be taken into account:

2.1. Classification management of labor service companies

The curtain walls are mainly divided into framed curtain walls and unitized curtain walls according to the type of surface materials and systems. Among them, the framed curtain walls mainly include: framed stone curtain walls, framed aluminum plate curtain walls, and framed glass curtain walls. The unitized curtain walls are mainly unitized glass curtain walls. The above-mentioned curtain wall types account for 80% of the curtain wall types in the market. There are also curtain wall types such as hanging glass curtain walls, cable-net glass curtain walls, point-supported glass curtain walls, and double-layer breathing curtain walls, whose markets are smaller, but they require more professional labor skills from workers [1–5].

For the above common curtain wall types, the unitized curtain wall should be the simplest type of curtain wall for on-site construction because more than 70% of the work is completed in the processing factory, and the amount of labor and construction content required on-site is relatively small. However, since the construction scheme of the unitized curtain wall is mainly hoisting, the equipment and facilities used and the requirements for safety and quality control are completely different from those of the framed curtain wall. If the labor team and workers have only done framed curtain walls before and have no experience in unitized curtain walls, it will be very difficult to do a good job in the unitized curtain wall project.

In frame curtain walls, the construction of frame stone curtain walls is the most difficult compared to frame glass curtain walls and frame aluminum plate curtain walls [6]. Because the current mainstream frame stone curtain wall is the dry-hanging stone curtain wall. Due to specific characteristics, such as the heavy weight of the stone panels, dense grid division, numerous joints, and the use of back bolts to connect dry-hanging stone to the structural keel, stone curtain walls are among the most labor-intensive and technically demanding systems in façade construction. The complexity of the construction process, particularly the difficulty of installing back-bolt connections, results in both the highest labor costs and the greatest construction challenges among curtain wall types.

Secondly, the frame glass curtain wall presents its own set of challenges. Due to the transparent nature of glass, these curtain walls typically feature larger grid divisions, which require fewer but significantly heavier individual panels. Handling and installing these large glass units often necessitates the coordination of multiple workers. Moreover, achieving precise installation is particularly complex, as the weight of the glass complicates alignment and adjustment, demanding both skill and careful planning.

Finally, the frame aluminum plate curtain wall is considered the most installation-friendly among curtain wall types. Due to the lightweight nature of aluminum panels and their ease of handling, installation is relatively straightforward, resulting in the lowest labor costs compared to other systems. However, this ease of fabrication also allows for more varied and complex architectural forms. As a result, particular attention must be paid to the quality of detailed shaping and finishing during construction to ensure both visual and structural integrity.

Although aluminum plate curtain walls are the simplest to construct, practical experience has shown that even labor teams skilled in handling complex frame dry-hanging stone curtain walls may struggle with aluminum systems. This is often due to a lack of specific experience in dry-hanging aluminum plate installation, resulting in poor construction quality despite the system's relative simplicity. Therefore, even workers with over a decade of curtain wall construction experience may face difficulties in maintaining quality and meeting schedule requirements when transitioning to a different curtain wall system, particularly if their experience is limited to only one type. The risk factors associated with different types of curtain walls vary significantly. Therefore, it is essential to select labor teams that are specifically experienced and professionally trained for the particular curtain wall system being installed. Some labor service companies employ "versatile" workers who are familiar with multiple types of curtain wall systems. However, due to their broad focus, these workers often lack in-depth practical experience with any single system, which can affect the overall quality and precision of their work. Therefore, compared with the professional teams that focus on a certain type of curtain wall, they often have no advantages in construction quality, progress, and their own safety management.

2.2. Classification management of labor types

For labor service companies that specialize in a specific type of curtain wall construction, achieving the highest standards of quality requires making professional and well-informed choices at every stage of the construction process. This kind of management occurs more frequently in stone curtain walls. High-quality professional stone labor service companies typically assign skilled workers to each key stage of stone curtain wall construction. These stages include measurement and setting out, installation of embedded parts, steel keel installation, welding operations, stone panel hanging and installation, as well as sealant application for joints. Although the labor costs for stone curtain wall installation are relatively high, the quality and efficiency achieved by experienced teams are also significantly better. These specialized workers often travel across the country to undertake stone installation projects. If, in the construction of various curtain wall types, each process is handled by skilled professionals with relevant expertise, the overall construction quality and project outcomes can be greatly improved.

2.3. The sample management system of the curtain wall process

Different curtain wall processes have different technological requirements [7]. Even for the installation of a post-installed embedded part, it may seem very simple, as it is just a steel plate and four bolts. However, there are many detailed requirements involved, such as the cross positioning of the embedded plate, the depth requirements for drilling the post-installed bolt holes, the cleaning requirements for the post-installed holes, the selection requirements for chemical bolts and expansion bolts, and the depth requirements for screwing the nuts, etc. Before the construction of each process, no matter how small the process is, the project management department should make a construction process sample on the site. Moreover, the sample should be fully disclosed to the workers of this process and retained until the end of the process. This approach helps establish clear standards and procedures for workers, effectively "setting rules" that guide their tasks. At the same time, it provides project management personnel with defined criteria to follow during on-site inspections, which is essential for ensuring consistent and reliable quality across all stages of construction.

2.4. Require and assist the labor service company in carrying out refined management

In general, labor service companies tend to have limited management personnel, and the competence of these individuals can vary widely. Often, there is a lack of effective strategies and proactive thinking aimed at improving work efficiency. To address this, the project management department can implement labor

management measures, such as classification-based oversight and process-based sample management, both during the selection of labor service companies and throughout the construction phase. As labor service companies improve work efficiency, they also achieve higher construction quality. This refined approach to labor management can be maintained and applied in future projects. Furthermore, when such companies provide services for other curtain wall contractors, the good management practices they carry forward can contribute positively to raising the overall standard of labor management across the curtain wall industry.

3. Thoughts on progress management of curtain wall project

3.1. Visualize the daily PDCA progress management

At the present stage, the conventional progress management for curtain wall projects often involves formulating the overall progress plan, annual progress plan, quarterly progress plan, monthly progress plan, and then the weekly progress plan, followed by a cycle of weekly regular meetings for progress management [8, 9]. However, project construction is often a race against time, especially for projects with high progress requirements, where the construction period is often within one year or even half a year. If the most distal end only achieves weekly progress management, the progress lag this week will likely affect next week, and the accumulation and repetition in the next week may affect the monthly progress, and further affect the quarterly or even the entire project's progress plan. Given that the surface materials of each curtain wall project are of a fixed quantity that can be counted, visual data management can be carried out during progress management to achieve daily progress visibility and thereby achieve visual daily progress management. The specific methods are as follows:

(1) Count the quantity of the surface materials of the project (count the quantity of the keels at the keel stage, and count the quantity of the unit panels for the unit curtain wall);

(2) Determine the planned installation days for the keels or surface materials;

(3) Calculate the theoretical quantity of the keels or surface materials that should be installed each day based on the quantity and the theoretical installation days, and present it in a table form (**Figure 1**).

(4) Fill in the actual quantity of the installed keels or surface materials every day during the later construction process. The planned and actual installation quantities for each day will be presented completely and intuitively on the table.

(5) If the actual installation is less than the planned installation, the project management department needs to review which link of design, procurement, processing, or construction the problem comes from and solve it on the same day or at the latest, the next day. Achieve the principle of "finishing daily affairs daily" and conduct the PDCA management of the progress every day.

Unit Curtain Wall Installation Statistics (April 28, 2010)

Date	Number of workers /Accumulated days worked	Planned number of installations	Actual installed quantity	Plan to add up the number of installations	Actual cumulative number of installations	Current progress ratio	Total installation completion ratio	Same-day arrival/Field accumulation	Cumulative field ratio	Remarks
original	5300	540	512	540	512	94.81%	21.51%	1633	68.61%	
March 17th		40	48	580	560	96.55%	23.53%			
March 18th		40	40	620	600	96.77%	25.21%			
March 19th		40	42	660	642	97.27%	26.97%			
March 20th		40	43	700	685	97.86%	28.78%			
March 21st		40	46	740	731	98.78%	30.71%			
March 22nd		40	47	780	778	99.74%	32.69%	77/1710	71.85%	
March 23rd	112/5412	40	38	820	816	99.51%	34.29%	54/1764	74.12%	
March 24th	112/5524	40	43	860	859	99.88%	36.09%	35/1799	75.59%	
March 25th	115/5639	40	42	900	901	100.11%	37.86%	72/1871	78.61%	
March 26th	115/5754	40	46	940	947	100.74%	39.79%	45/1916	80.50%	
March 27th	115/5869	40	43	980	990	101.02%	41.60	19/1935	81.30%	
March 28th	112/5981	40	43	1020	1033	101.27%	43.40	0/1935	81.30%	
March 29th	112/6093	40	45	1060	1078	101.70%	45.29%	0/1935	81.30%	
March 30th	119/6212	40	50	1100	1128	102.55%	47.39%	33/1963	82.69%	
March 31st	119/6331	40	47	1140	1175	103.07%	49.37%	0/1968	82.69%	
April 1st	119/6450	45	36	1185	1211	102.19%	50.88%	94/2062	86.64%	
April 2nd	119/6569	26	50	1211	1261	104.13%	52.98%	28/2090	87.82%	At this stage, only one working face to the west of the podium building was installed
April 3rd	119/6688	26	22	1237	1283	103.72%	53.91%	37/2147	90.21%	
April 4th	119/6807	26	23	1263	1306	103.40%	54.87%	0/2147	90.21%	
April 5th	109/6916	26	17	1289	1323	102.64%	55.59%	0/2147	90.21%	
April 6th	109/7025	26	28	1315	1351	102.74%	56.76%	56/2203	92.56%	
April 7th	109/7134	30	15	1345	1366	101.56%	57.39%	56/2259	94.92%	
April 8th	109/7243	30	27	1375	1393	101.31%	58.53%	86/2345	98.53%	
April 9th	109/7352	30	33	1405	1426	101.49%	59.92%	0/2345	98.53%	
April 10th	109/7461	45	35	1450	1461	100.76%	61.39%	27/2372	99.66%	At this stage, the west of the podium building, the window glass of the podium building and the south of the main building were installed simultaneously
April 11th		45								
April 12th		45								
April 13th		45								
April 14th		45								
April 15th		45								

Figure 1. Unit curtain wall installation statistics (April 28, 2010)

The above table shows the visualized progress management and PDCA progress cycle management adopted in the Chengdu Chunghwa Plaza project. This project is 166 meters high and has a 57,000-square-meter glass curtain wall. All the Welcon glass is imported from the United States. The glass is transported by sea to Shanghai and processed into unit panels at the Shanghai factory of Shanghai Meite Curtain Wall Co., Ltd., and then transported by road for more than 1,600 kilometers to Chengdu for installation. For a project of this scale, characterized by an extensive supply chain and a large installation area, the implementation of the aforementioned management methods enabled the successful completion of all unit curtain wall installations within seven and a half months, representing a significant achievement in project progress control and execution efficiency.

3.2. Advanced progress management of material procurement

In the design, procurement, processing, and construction links of curtain wall progress management, the progress is often most affected by procurement, and the affected progress is the most difficult to recover [10, 11]. Because the procurement link is closer to the front end of the project, and all curtain wall materials are custom-sized and produced on order. The types and specifications of the involved materials are numerous, and the materials need to be sent to the factory or the site in a supporting manner to ensure processing or construction. The production cycle of the main materials is about 15 to 30 days. Material delays often happen because the approved manufacturers have limited production capacity at certain times or do not follow the order sequence when processing. This leads to mismatched materials and affects the installation schedule. If procurement progress is not proactively managed at the material factory, and issues such as delayed or mismatched deliveries are only identified upon the scheduled arrival date, the resulting disruptions can significantly impact the project schedule. Therefore, to ensure effective control of material supply, personnel from the project management department should be assigned to key material manufacturers in advance, particularly during the early stages or critical periods of material production and delivery. Only in this way can it be ensured that the materials required for the project can be produced on schedule, and the arriving materials are the required materials. At the same time, material quality inspection should be conducted prior to shipment, ensuring that only qualified materials are delivered to the site. This proactive approach helps prevent project delays caused by the return of non-compliant materials after their arrival.

3.3. Project department-oriented progress management

The mode of project management varies from company to company. Some attach importance to the vertical management of the project management department, while others emphasize the parallel management of various functional departments of the company. Since the project management department is the forefront department facing the project site, it directly deals with various parties such as the project management client, supervisor, and general contractor. Being closest to the site, the project management department is best positioned to receive and respond to the latest project demands. However, if it lacks sufficient authority to coordinate resources across design, procurement, fabrication, and construction, the timely implementation of progress measures may be compromised. This can result in the dilution or delay of critical project information as it is transmitted through hierarchical layers. The ultimate consequence is delayed response, diminished operational efficiency, and weakened execution on site, all of which can adversely affect overall project performance [12–15].

To address this, the curtain wall company should fully empower the project management department, particularly the project manager, by ensuring that authority, responsibility, and accountability are properly aligned. Under this structure, the project's lead designer can serve as the technical lead, the procurement

specialist as the purchasing lead, and the fabrication plant representative as the processing lead, all operating under the coordination and direction of the project management department. At the same time, a complete project assessment system should be formulated to ensure that the relevant project design, purchasing, and processing personnel in charge can share the benefits of successful project management and bear the losses of ineffective project management. In this way, the project manager can be like a commanding general in the project, directing wherever needed, and the promotion of various project tasks can be carried out in an orderly manner. The company manages and inspects the daily work of each project at the institutional level, with each performing its own duties, having priorities, and only then can the project progress and other tasks proceed smoothly.

The regular inflow and outflow of project construction funds serves as a fundamental guarantee for the timely supply of materials. Developing a rational financial plan for income and expenditure at both the project and project management levels, alongside promoting the effective execution of external receivables and internal disbursements, constitutes a crucial mechanism for ensuring steady project progress.

4. Conclusion

This study explores advanced strategies and methodologies for labor management in curtain wall construction, focusing on fine-grained material classification, visual template-guided supervision, and detailed daily dynamic worker management. In addition, it examines progress management from the perspectives of segmented visual progress tracking, pre-construction material procurement, and project department–oriented coordination. The aim is to provide insights that may stimulate further reflection and discussion regarding the study.

Disclosure statement

The authors declare no conflict of interest.

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