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# Case Study: Construction Site Utilization Planning for Custom Multifamily Residential Developments

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Previous research studies on the best practices for Construction Site Utilization Planning (CSUP) have been generic leaving decisions about the project-type specific delineation methods to the developers of site utilization plans (SUPs). This case study explored how construction industry professionals working in custom multifamily residential sector implement CSUP. The research objectives were twofold: 1) identifying the factors that affect CSUP for custom multifamily residential developments, and 2) determining the best CSUP practices for custom multifamily residential developments. Six industry professionals working for a custom multifamily residential developer were interviewed in this study. The research findings indicated that CSUP for custom multifamily residential projects should begin during early preconstruction phase, an integrated approach for CSUP should be used, and incorporation of hauling routes and typical temporary facilities at medium level of detail was critical. Some of the best CSUP practices included holding regular meetings with all stakeholders to discuss SUP, its associated updates, and enforcement policies. The interviewees suggested the SUP's efficacy should be monitored regularly depending on size and complexity of the project. The study findings are significant as they can help construction industry professionals develop more robust SUPs that are unique to the needs of custom multifamily residential developments.

**Key Words:** Site logistics, Site utilization planning, Multifamily, Residential

## Introduction

Construction site utilization planning (CSUP), also known as construction site logistics planning, is an important preconstruction planning task that affects safety, duration, environmental impacts, and budgetary performance of construction projects (Deshpande & Whitman, 2014; Elbeltagi et al., 2004; Ning et al., 2011). The objective of CSUP is to spatially plan jobsite for predicted construction activities and their associated elements to enhance safety and reduce project duration and cost (Mawdesley et al., 2002). CSUP depends on the project type, size, and location. CSUP is especially critical in vertical construction projects where space is considered one of the major constraints (Whitman et al., 2021). Also, comprehensive CSUP requires a development procedure to identify the need for temporary facilities, type of temporary facilities, their locations, space requirements, and on-site routes (Song et al., 2016; Whitman et al., 2021). Location of temporary facilities and placement of equipment are directly related to the construction sequencing and performance of a project. According

to Akinci et al. (1998), comprehensive CSUP may decrease the amount of ineffective work that is associated with poor site planning. On the other hand, poor CSUP and poor implementation of site utilization plans (SUPs) can lead to schedule delays, misplacement and improper handling of materials, financial loss, and unsafe work conditions (Mincks & Johnston, 2010).

Over the years, researchers have developed various models that utilize GIS, CAD-based tools, and mathematical techniques that help with the creation and optimization of SUPs (Mincks & Johnston, 2010; Osman et al., 2003; Xu & Song, 2015; Hammad et al., 2016; Song et al., 2016; RazaviAlavi & AbouRizk, 2017). Despite revolutionary advancements in theoretical modeling and optimization of SUPs, review of the related literature reveals an important gap. As discussed by Whitman et al. (2021), there is a need for a comprehensive study of CSUP best practices applied by industry professionals. Recognizing this gap, Zolfagharian and Irizarry (2014) emphasized the need for a rule-based evaluation system that industry professionals could use in their decision-making process for CSUP. While this system offers insight into the variables related to SUPs, it lacks the rigor of integrating best CSUP practices identified by industry professionals (Whitman et al., 2021). Whitman's study (2014) identified general best practices related to CSUP. However, as stated earlier, CSUP depends on the project type, size, and location. Literature review indicates that there are very limited studies on best CSUP practices for custom multifamily residential developments. Therefore, this case study aimed to understand how construction industry professionals working in custom multifamily residential sector implement CSUP. The specific research objectives included:

1. Identifying the factors that affect CSUP for custom multifamily residential developments.
2. Determining the best CSUP practices for custom multifamily residential developments.

It should be noted that in this study CSUP stands for Construction Site Utilization Planning and refers to the process of planning and developing site utilization plans (SUPs), while SUP refers to a product or outcome of CSUP.

## Literature Review

CSUP overlaps with other planning tasks such as budgeting, scheduling, procurement, anticipation of on-site personnel, and mobilization and demobilization of construction equipment (Elbeltagi, 2008). Therefore, for creating an effective SUP, the SUP developer should have a clear understanding of the elements associated with CSUP and the construction execution plan. In other words, in order to develop optimal SUPs, the developer should create alternative site layouts that enhance the flow of construction project resources such as personnel, equipment and materials while satisfying project constraints (Whitman, 2014). Additionally, the SUP developers should be completely familiar with elements such as space constraints on the project site, safety requirements, and temporary facilities (Whitman, 2014). According to Whitman et al. (2021), the majority of industry professionals begin CSUP in pre-bid stage of the project while some practitioners develop the SUP once the project is awarded. However, the same study concluded that the majority of industry professionals considered CSUP a continuous process over the duration of the project.

Typically, project managers are responsible for CSUP (Osman et al., 2003; Whitman et al., 2021). However, due to the complexity of CSUP, designers and SUP developers are often contracted to develop a SUP on behalf of the project owner or the general contractor (Song et al., 2018). Whitman (2014) stated that prior to the start of the project, the developed SUPs should be reviewed by project superintendents, foremen, and contractors since they have vast knowledge of material storage,

material handling, and equipment operation. According to Whitman et al. (2021), project managers typically seek input from structural, foundation, electrical, plumbing, and HVAC contractors during the CSUP process. In this process, contractors can significantly help project managers by providing information such as equipment and the type of tools that will be used on site, required storage space, and the anticipated number of personnel on site. Furthermore, project managers can incorporate critical information, such as preferred access points to the site, existing site conditions, construction traffic routes, and environmental concerns of owners, universities, and municipalities, into SUPs. However, the majority of construction industry professionals prefer medium level of detail to be incorporated into SUPs since medium level of detail includes essential temporary facilities and storage locations (Whitman et al., 2021).

Location of the construction site plays a major role in determining the space constraints. In urban areas, less space is available for construction activities as the structure itself encompasses the majority of the site. Therefore, for an efficient execution of the construction activities, space planning should be carefully handled. In contrast, space planning for large construction sites tends to be overlooked during project planning phase due to space abundance. In these cases, SUP developers place temporary facilities randomly within the site boundaries, which reduces the efficiency and safety of the workplace (Mawdesley et al., 2002). Temporary facilities play a major role in supporting construction activities over the duration of a project (Whitman et al., 2021). Type of the project, project location, and complexity of the construction schedule determine the type of temporary facilities required on a jobsite (Whitman et al., 2021). Characteristics such as shape, size, and functionality of each temporary facility should be completely understood prior to the development of a SUP. Incorporating inadequate temporary facilities may significantly impact the productivity levels on site (Elbetltagi, 2008). Development of an efficient SUP that incorporates the aforementioned elements can result in fewer workplace hazards and safety concerns (U.S. Department of Labor, 2013). For instance, incorporating Occupational Safety and Health Administration rules into SUPs reduces workplace fatalities and injuries (U.S. Department of Labor, 2013). Elbeltagi et al.'s study (2004) indicated that the storage locations of material and equipment have a significant impact on construction site safety. Hence, these locations should be carefully selected so that the movement of material and equipment can be minimized (Elbeltagi et al., 2004). In addition, it is crucial to comply with other OSHA requirements such as providing adequate access roads when developing SUPs. Industry professionals responsible for CSUP ranked movement of material, equipment, and on-site personnel as top three priorities when planning access roads to jobsite (Whitman et al., 2021).

As stated earlier, proper implementation of a well-developed SUP is key for improving construction operations (Akinci et al., 1998) and requires all trades to be involved in the project planning and well informed about site space allocation (Whitman et al., 2021). Monitoring the effectiveness and management of SUP is usually the responsibility of the site superintendent that assesses the effectiveness of a SUP by analyzing the flow of construction activities, the ability of trades to access the site and move material, and the time they spend managing contractors (Whitman et al., 2021). A software tool particularly designed for SUP development has not emerged yet; therefore, PDF overlay software such as Bluebeam, and other software such as Autodesk Revit and Computer Aided Design (CAD) are currently being used by industry professionals to develop SUPs. PDF overlay is currently the leading method for creating SUPs since it is noticeably easier to operate and requires less training to use. However, Autodesk Revit is becoming one of the most commonly used software within the construction industry due to the wide range of tools and utilities it offers (Whitman et al., 2021).

Enhancing SUP developer's familiarity with site constraints is identified as one of the CSUP best practices implemented by construction industry professionals (Whitman et al., 2021). Whitman et al. (2021) identified integrated CSUP as the best practice to enhance the effectiveness of SUPs. In other

words, involvement of project stakeholders such as owner, contractors, and construction management personnel in development of SUPs is crucial for achieving an effective SUP. Proper implementation of SUPs requires clear communication among all stakeholders on site. In addition to the main elements of SUPs, project stakeholders should consider incorporating weather characteristics and safety regulations into the SUPs. The effectiveness of SUPs should be monitored regularly and considering that SUPs are fluid documents, stakeholders should be kept up to date about any modifications (Whitman et al., 2021).

## Methodology

Semi-structured interviews were conducted to accomplish the research objectives. The interview questions were developed by the authors and then reviewed and approved by Colorado State University's Institutional Review Board (IRB) to protect human research participants. Participation in the interviews was voluntary. The participants were asked to sign a consent form that outlined information such as interview duration, potential risks and benefits, and data security. Six participants were recruited for the interviews based on their current role in the company and previous experience with custom multifamily residential projects. Authors interviewed a Director of Construction Operations, a Preconstruction Manager, a Senior Project Manager, a Project Manager, an Assistant Project Manager and a Senior Superintendent, that worked for the same custom multifamily residential general contracting company. The interview instrument consisted of ten open-ended questions. The first set of questions asked about the factors that affected CSUP for custom multifamily residential developments. The second set of questions asked about the best CSUP practices used by industry professionals for custom multifamily residential developments.

Each of the six personal interviews were recorded using voice memo application and immediately transcribed. Interview notes were also taken during each session. Pseudonyms were used to code the data for participant's protection. After transcription, the verbal interview data for each question were manually analyzed to identify patterns, redundancies, and repetitions in answers. Qualitative analysis of interview responses was performed due to the small sample size and open-ended nature of interview questions. For each interview question, redundancies and patterns found in participant answers were used to draw appropriate conclusions. The data were analyzed using a general inductive approach, which helped condense the raw data into a brief summary format. Furthermore, this analysis helped establish links between the research objectives and the research findings, and compare the findings of this case study to the findings of previous research. In the next section, the results are presented separately for each interview question to compare the perceptions of interviewed industry professionals.

## Results

### *Factors that Affect CSUP for Custom Multifamily Residential Developments*

When asked about **the main factors affecting CSUP for custom multifamily residential developments,** all respondents indicated space constraints and limitations on hauling routes as the main factors. This was due to the fact that most multifamily residential developments were located in active urban and suburban areas with different municipality requirements. In urban areas, the residential building structure itself encompassed the majority of the site and utilization of any off-site area for construction-related work required special permits from Department of Transportation and

Infrastructure (City and County of Denver, 2021). Participant responses to a question about **the ideal timeframe for SUP development** varied greatly. Four participants (the Preconstruction Manager, the Director of Construction Operations, the Project Manager, and the Assistant Project Manager) stated that SUP development should begin in early stages of the project preconstruction phase because CSUP in the bidding stage of a project enhanced the accuracy of construction schedule and budget. Two participants including the Senior Project Manager and the Senior Superintendent indicated that their preferred time for CSUP was just before the commencement of construction work because the use of an approved set of construction drawings reduced risk and uncertainty associated with CSUP.

Next, the participants were asked about **stakeholders whose input was critical for creation of a SUP**. All participants except the Assistant Project Manager stated that the number of contractors and trades working on site could be a critical factor in CSUP. All participants emphasized the use of an integrated approach for CSUP and indicated that the input from superintendent and the project manager was critical. Two participants (the Project Manager and the Assistant Project Manager) stated that they also sought input from the project owner. According to the Senior Project Manager, the Preconstruction Manager, and the Senior Superintendent, seeking input from contractors was also crucial in CSUP. These three participants mentioned that the contractors who typically contributed to CSUP were from foundation, structural, MEP, and civil/site work teams. Participants were also asked about the **kind of information stakeholders should provide for development of a SUP.** The Senior Project Manager, the Preconstruction Manager and the Senior Superintendent stated that they requested contactors to provide information such as type and size of the equipment that would be on site, number of employees, material delivery time, and amount of space needed for storage and staging. Additionally, the Director of Construction Operations and the Senior Project Manager indicated that requesting information about the sequence of work and duration was crucial for SUP development.

## *Best CSUP Practices for Multi-family Residential Developments*

Participants were asked a series of questions that helped authors determine the best CSUP practices for custom multifamily residential developments. First, participants were asked **to identify the primary elements that should be incorporated into the SUPs**. All participants indicated at least two access points at any time, and access roads that were compliant with local Fire Department and Law Enforcement requirements. Furthermore, participants stated that it was of significant importance to include temporary facilities such as staging and storage areas, erosion control measures, security fencing, trailer, temporary toilets, and trash and recycling dumpsters in SUPs. Furthermore, SUPs should identify location of the source(s) of temporary power on site. When asked about the **level of detail for SUPs**, the Assistant Project Manager stated that the level of detail depended on the complexity of the project, while the other five participants indicated that medium level of detail was sufficient for custom multifamily residential projects.

Next, the participants were asked **how they implemented SUPs in their custom multifamily residential projects.** All six participants stated that regular communication with contractors on site was the key for a successful SUP implementation. All participants mentioned that implementation of SUPs in custom multifamily residential projects was typically the responsibility of the project manager and/or site superintendent because project managers and superintendents ran day-to-day operations on construction sites while ensuring conformance to the schedule.

When asked about **metrics that helped determine the effectiveness of a SUP**, all six participants stated that site safety was a critical measure of the effectiveness of a SUP. The Director of Construction Operations and the Senior Superintendent indicated that conducting monthly inspections

to ensure compliance with the approved SUP was also an important method for determining the effectiveness of a SUP. The Assistant Project Manager pointed out that other factors such as accessibility of site for trades, ease of material movement, and efficient equipment operation throughout the site were important for determining the effectiveness of a SUP.

Next, the participants were asked about **software packages they usually used to create SUPs.** All interviewed participants except the Senior Superintendent indicated that, in general, they used software tools to develop SUPs. Participants typically used Bluebeam and Adobe Acrobat software for SUP development while they never utilized Autodesk Revit. However, all respondents except the Director of Construction Operations stated that the use of BIM and Autodesk Revit for all construction related tasks including SUP development would be inevitable in the near future since these processes and tools were becoming frequently used on construction projects.

In order to determine effective methods for developing efficient SUPs for custom multifamily residential projects, participants were asked **to discuss their best CSUP practices**. Common responses included involvement of key stakeholders such as foundation, structural, MEP, and civil/site work contractors, project managers, and superintendents throughout SUP development. Furthermore, being mindful of inclement weather conditions and their effect on site accessibility for trades, equipment, police, and fire department were of significant importance. Participants mentioned that holding regular meetings with all stakeholders involved in SUP implementation on the jobsite and informing them about SUP's associated updates and enforcement policies were some of the most important best practices for successful implementation of SUPs. Furthermore, the SUP should be monitored for effectiveness on a monthly basis. However, according to the Assistant Project Manager, the frequency of monitoring could differ depending on size and complexity of the project.

## Discussion

Previous research recognized SUP development as a critical component of most construction projects regardless of space constraints (Whitman et al., 2021). However, our research found that the main reasons for developing SUPs for custom multifamily residential projects were space constraints and hauling route limitations. In other words, it can be implied that development of a SUP for custom multifamily residential projects located in less developed areas where space is not a constraint might be deemed nonessential. This finding aligns with findings of Mawdesley et al. (2002) who found that space planning for large construction sites tended to be overlooked due to space abundance.

Similar to Whitman et al's. (2021) study, opinions of the participants in our study differed in regard to the optimal timeframe for SUP development. In our study, four participants stated that the level of complexity of SUPs could have significant impact on project's budget and schedule suggesting that SUP development should start in early stages of preconstruction. This finding aligns with that of Whitman et al. (2021) that most construction companies considered SUP development part of the estimation phase. As SUP development during estimation phase results in a more accurate budget, companies would have a higher chance of winning the award while maximizing their profit margin (Whitman et al., 2021). The remaining two participants in our study provided a different response; they suggested that developing SUP just before the commencement of the construction work was a better practice due to higher completion and accuracy of the plans and specifications. All six participants agreed that CSUP was a continuous process over the duration of the project.
Similar to the findings of Whitman et al. (2021), our results indicated that construction professionals working on custom multifamily residential projects preferred an integrated CSUP approach. In other

words, involvement of key project stakeholders such as project managers, superintendents, and contractors was crucial for development of an effective SUP. While Whitman et al. (2021) concluded that the majority of owners were involved in SUP development, our study indicated that the owner's input for SUP development was not highly prioritized in custom multifamily residential developments. The reason for this perception might be that three participants including the Senior Project Manager, the Senior Superintendent, and the Project Manager considered CSUP a part of General Contractor's means and methods that should not be altered by other stakeholders. In addition, our study indicated that the implementation of SUPs in custom multifamily residential projects was the responsibility of the project manager and the superintendent. Inclusion of project manager as a party responsible for implementation of SUPs is a new addition to the findings of Whitman et al.'s (2021) study in which only the superintendent was identified as the primary party responsible for SUP implementation.

Our study, similar to the Elbetagi et al. (2004) and Whitman et al. (2021) studies, indicated that information such as type and size of the equipment that would be on site, number of employees, material delivery time, and amount of space needed for storage and staging were critical for SUP development. Key elements that should be incorporated into SUPs for custom multifamily residential projects were similar to elements of SUPs developed for other types of construction projects. In other words, authors did not find a deviation from the temporary facilities required for custom multifamily residential developments as compared to other construction project types as indicated by Whitman et al. (2021). The findings of our study also echoed the results of previous research in regard to the preferred SUP's level of detail. The majority of interviewed industry professionals preferred a medium level of detail with only essential temporary facilities and storage locations incorporated into the plans, which confirms findings of Whitman et al. (2021).

Metrics used for determining the effectiveness of a SUP on custom multifamily residential projects are similar to those identified by Whitman et al. (2021). Our study found that factors such as site safety, site accessibility for trades, ease of material movement, and efficient equipment operation throughout the site could be used to determine the effectiveness of a SUP. These findings align with those of Whitman et al.'s (2021) study focusing on construction industry in general that identified flow of construction activities, ability to access and move material, and the time spent managing contractors as the main measures used for determining the effectiveness of SUPs. Majority of construction industry professionals used software tools to develop SUPs (Whitman et al., 2021). This aligns with the findings of our study that indicated the majority of the participants used Bluebeam to develop SUPs for their custom multifamily residential projects. According to Whitman et al. (2021), PDF overlay software such as Bluebeam was the most frequently used tool for SUP creation; however, the use of Autodesk Revit and Computer Aided Design (CAD) was also very common. This finding is in contrast with our results; our study participants stated they had never used tools such as Autodesk Revit or CAD for SUP development.

## Conclusions

Literature review indicated that the previously documented best CSUP practices were generic, leaving the decisions about project-type specific delineation methods to the developers of SUPs. This case study aimed to understand how construction industry professionals working in custom multifamily residential sector implemented CSUP. The two major research objectives were: 1) to identify the factors that affect the CSUP for custom multifamily residential developments, and 2) to determine the best CSUP practices used for SUP creation in this sector. In addition, authors compared their findings

to the findings of the previous research in this field. According to the findings of this study, CSUP for custom multifamily residential projects should begin in early stages of the preconstruction phase to help enhance the accuracy of construction schedule and budget planning. Due to large number of trades that participate in custom multifamily residential projects, SUP developers should use an integrated CSUP approach. In other words, involvement of key project stakeholders such as foundation, structural, MEP, and civil/site work contractors, project managers, and superintendents in SUP development is crucial. Incorporating the typical temporary facilities at medium level of detail into the SUP for custom multifamily residential developments is recommended. Additionally, developers of SUPs for custom multifamily residential projects should be mindful of hauling routes due to space and regulatory restrictions unique to urban and suburban areas. Holding regular meetings with all stakeholders involved in SUP implementation on the jobsite and informing them about SUP's associated updates and enforcement policies are some of the most important best practices for successful implementation of SUPs. It is recommended to monitor the effectiveness of SUPs on a monthly basis. However, the frequency of monitoring can differ depending on size and complexity of the project.

This study contributes to the existing body of knowledge by focusing on custom multifamily residential sector. The major contribution is that study findings could help construction industry professionals with development of more robust SUPs that are unique to the needs of the custom multifamily residential developments. This research had the following limitations. The sample for this case study consisted of six industry professionals with extensive background in custom multifamily residential construction projects along the front range of Colorado. In addition, these six professionals worked for the same construction company. Hence, due to the small size and exclusivity of the sample, the findings of this study cannot be generalized. Therefore, future research should utilize a larger sample size. Future study could develop a practical framework for the site utilization planning process specific to custom multifamily residential developments. In addition, future research could focus on developing optimal site utilization plans specific to custom multifamily residential developments and creating their graphical representations.

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