Article

Perceptions of Construction Risks Due to Fast-Track Activity Overlapping

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Abstract: Concurrent engineering through overlapping of activities (i.e., fast-tracking) has been used as a schedule acceleration technique. Fast-track construction projects are generally recognized as riskier and subject to risks arising due to the concurrency of work. This work reports the risk perception of construction professionals to three different degrees of overlapping. Semi-structured interviews were used to collect the data, and the analysis applied data transformation and descriptive statistics. The risks were mainly perceived in the middle degree of overlapping and in activities occurring earlier in the schedule. The low and high degrees of overlapping were mainly perceived as having no risk or not being feasible, respectively. The four risk types accounted for most of the perceived threats: construction error, design change, crew interference, and poor construction productivity. The findings of this study suggest that construction professionals perceive risks differently based on the amount of activity overlapping. It is consistent with previous studies that found that risks decrease as the project advances and that fast-track projects face additional risks.

Keywords: construction risk; construction risk management; risk perception; risk assessment; concurrent engineering; fast-track; overlapping

1. Introduction

The construction industry has responded to reduced project delivery times by introducing acceleration techniques into the project schedule. The conventional schedule acceleration technique is concurrent engineering, which overlaps activities that are traditionally performed sequentially. Acceleration through overlapping (also called fast-tracking) benefits the project but is generally considered riskier [1].

The basic idea is to reduce the total execution time by executing activities in parallel instead of performing these activities sequentially. The first activity in an overlapping pair is called the predecessor or upstream activity, and the second is called the successor or downstream activity. The degree of overlapping (i.e., amount of concurrency) is defined as a length of time or percent of the duration of the predecessor activity. However, the degree of overlapping can vary depending on conditions, such as the relationship type and the characteristics of the overlapped activities [1–4]. Factors involved in this relationship can influence and be the source of risks, such as the production rate of the predecessor activity, information uncertainty, resource availability, physical space, and safety conditions. Figure 1 illustrates a traditional schedule without overlapping and three overlapping scenarios with 25%, 50%, and 75% overlap. For example, if each activity has a duration of ten days, overlapping 25% in a finish-to-start relationship means the two activities will be concurrently performed during the last 2.5 days of the predecessor activity (which would also be the first 2.5 days of the successor activity).
Figure 1. Example of a traditional schedule and three different scenarios of overlapping.

Regardless of the intrinsic risks associated with a traditional construction project, there is a general consensus within the industry that fast-track projects have additional risks. Earlier studies about overlapping, either in product development or construction, mention that adopting a fast-track approach will result in more risks [1,2,5–7]. Applying overlapping in construction projects has become a routine but challenging procedure. To successfully deliver fast-track projects, it is necessary to understand the risk dynamics involved, adopt practices to manage the risks and provide attention to aspects such as the design phase, coordination, information, and project team involvement [8–10].

Since fast-track projects may be riskier, adopting a systematic and iterative process to manage these risks and identify and respond to schedule threats is essential. A risk management process includes the steps of process planning, risk identification, risk analysis, risk response strategy and implementation, and risk control [11,12]. The importance of risk management in construction and how construction risk is perceived were already the focus of earlier studies [13]. A critical step in risk management is risk identification, which primarily consists of deciding and documenting which threats the project may be exposed to. Risk identification is the process of applying various techniques to determine what, why, and how risks may happen [14]. The risk identification phase is considered essential and challenging because risks cannot be managed unless they are identified, impacting the risk management process efficiency and influencing the risk assessment accuracy [12,15]. According to Salas et al. [16], risk perception is how risks are processed, and it is the subjective judgment of professionals about risk characteristics. An improved risk identification process may also include the analysis of historical data, such as risks identified in previous, similar projects.

Traditional construction projects have always been characterized as risky, and it is natural that when new elements, such as schedule acceleration through overlapping, are introduced, additional risks might arise. In the case of overlapping, additional risks may be more changes, rework, delay, duration and effort increase in the successor activity, quality loss on the predecessor activity, poor prototyping criteria, overdesign strategy assumptions not being conservative enough, lack of design optimization and coordination, increased materials wastage, inadequate coordination between design and construction, and inadequate scheduling of the work package interfaces, to name a few [1,2,5,7,9]. Therefore, it is necessary to understand how the construction industry perceives these risks. Emerging studies about risk assessment or project acceleration in construction do not specifically address the risk perception of construction professionals when different degrees of overlapping are applied in construction projects. For example, are the risks the same when overlapping the same two activities by 25% and 50%? Even the studies that addressed uncertainties when overlapping did not consider the different degrees of overlapping. The motivation
of this work is to support the general perception that the acceleration of a construction project through activity overlapping is riskier and introduces more risk of rework. This is performed by exploring the perceptions of construction professionals of construction risks when different degrees of overlapping occur. The objectives of this work are to investigate (1) whether construction professionals have different perceptions of risk occurrence when applying three different degrees of overlapping to the same pair of activities, and (2) what risks are perceived for three different degrees of overlapping. This paper is structured in six sections: introduction, literature review, materials and methods, results, discussion, and conclusions.

2. Literature Review
2.1. General Risks in Construction

The study of risk management or of risks in construction projects has covered aspects varying from frameworks to the investigation of general risks or risks in specific areas, such as contracts, supply chain, and the engineering design phase, to name a few. Chen et al. [17] proposed a Bayesian-driven Monte Carlo (BDMC) simulation approach to study the impact on infrastructure construction schedules of interdependency between chronological and causal relationships of risk occurrence. However, this study does not consider any risk related to overlapping activities. Lee et al. [18] collected the risk perception of construction managers about predefined overseas project risks and cost overruns and compared it with the data analysis of 20 construction cases. Sobieraj and Metelski [19] developed a proprietary investment model considering different project phases and combining Monte Carlo simulation and Time-at-Risk (TaR) to assess the risk of project time extension. Nabawy and Gouda Mohamed [20] classified infrastructure project risk factors by combining different methods, such as a risk breakdown structure to classify the risks from the literature, a checklist, a questionnaire, and Back Propagation Multi-Layer Perceptron (BP-MLP) Artificial Neural Network. Mohajeri Borje Ghaleh et al. [21] investigated risks in road projects using a survey and analytical hierarchy process (AHP) but without considering the schedule acceleration. Koulinas et al. [22] presented a Monte Carlo simulation approach combined with the risk perception of a single construction risk manager, collected via a questionnaire to quantify the total delay risk of a construction project. The approach did not consider any acceleration through overlapping. Studying general risks or risk management methods in construction, Siraj and Fayek [23] examined risk identification and common risks through a literature review and content analysis. Hoseini et al. [24] used content analysis and focus groups to develop a generic maturity model to improve risk management practice. Chatterjee et al. [25] used a hybrid multi-criteria decision-making technique to categorize and describe risk issues and rank uncertain risk response strategies. Ansah et al. [26] proposed a framework to determine the severity, occurrence, and detection of risks associated with delay sources in Malaysian construction projects.

Other studies investigated construction risks that can emerge in specific areas. A hybrid approach (SD-ISM—System Dynamics-Interpretive Structural Modeling) to be applied for risk prioritization, individual risk assessment, and the overall risk impact on project objectives of risks from the design phase was proposed by Etemadinia and Tavakolan [27]. The approach aimed to provide risk prioritization, individual risk assessment, and an overall risk impact on project objectives. Diaz et al. [28] developed a framework consisting of data collection, network mapping, and simulation to assess risks associated with supply chain disruptions in the construction projects of the defense shipbuilding and repair industry. Okolelova et al. [29] analyzed risks in high-rise construction impacting the investment value using statistical and clustering analyses. Other studies explored safety risk tolerance across different world geographical regions and analyzed safety risks for sustainable construction [16,30].

The Investigation of risk perceptions in construction analyzed the influence of personality trait factors or risk perception differences among diverse project stakeholders. Lee and Foo [31] used the Big Five theory to investigate how five personal attributes (i.e.,
openness to experience, conscientiousness, extraversion, agreeableness, neuroticism) of construction practitioners in Malaysia influence risk perceptions. Other authors explored the risk perceptions of different stakeholders (i.e., owners, consultants, designers, contractors), considering that they may perceive the same construction risks differently. Al Nahyan et al. [32] used a survey, questionnaire, and nonparametric statistical techniques to examine how the roles and experiences of clients, consultants, and contractors may influence perceptions of three risk categories (i.e., technical, financial, and decision-making) in mega infrastructure projects and their indicators. Perez et al. [33] used a questionnaire and an online survey to explore factors and the risk perceptions of contractors and consultants related to risk allocation and formal risk management in commercial construction projects in Australia. Zhao et al. [34] focused on investigating the safety risk perceptions from four critical groups—architects, engineers, contractors, and safety professionals, judging the likelihood and severity of potential safety risks in the work conditions of a building system. These studies investigated how personal behavior, roles, and experience affect risk perception in construction projects, considering that perception is subjective and intuitive. However, none of these risk perception studies considered project acceleration or fast-tracking as a factor.

2.2. Risks in Projects Applying Activity Overlapping—Product Development

The study of overlapping (or concurrent engineering) originated in the product development field, trying to increase the efficiency and predictability of the development iteration process [4]. It is a well-explored area in the literature, including evolutionary acquisition and spiral development. Recent studies in this area proposed quantitative and optimization models incorporating risk into their models. Tian et al. [35] investigated the delay impact on pairs of overlapping activities due to two rework risk types (i.e., forward rework and reverse rework). Oh and Hong [36] quantitatively investigated the impact on rework and project duration by the uncertainty of cascaded information during the concurrency of multiple activities. Lu [37] proposed an optimization model to study the coordination strategy of activity overlapping in new product development, considering the rework risk caused by the probability change of the predecessor activity. Alternatively, the literature analysis study from Khan et al. [38] focused on risk mitigation in concurrent engineering in a new product development process.

The approach of evolutionary acquisition via spiral development, or incremental development, was adopted against some of the existing risks using traditional methods in product development. Authors in this area state that incremental development can bring more advantages to developing mutable products, but it carries some other inherent risks. The studies from Mortlock [39] and Riposo et al. [40] identified some specific risks, such as technology, programmatic, and integration risks, and offered strategies to manage technical risks in product development. Other older studies in evolutionary acquisition have generally mentioned risks [41–44].

2.3. Risks in Projects Applying Activity Overlapping—Construction

Studies of risks in construction projects applying activity overlapping continue to be developed, taking different approaches. These studies were either qualitative or quantitative, sometimes considering one type of risk (e.g., risk of rework, safety hazards) or a broader view of risk management. Lu et al. [45] explored the case study of accelerating two urgent emergency projects through activity crashing, overlapping, and substitutions during the COVID-19 pandemic. Although the authors recognized the possibility of risk when overlapping, they only considered the risk of rework. Laryea and Watermeyer [46] took a more qualitative approach to explore how uncertainty in fast-track construction projects in South Africa was managed using a case study and the client delivery-management approach. Rasul et al. [10], applying a qualitative systems thinking method—causal loop diagrams, investigated the interrelation of critical risk factors and their impact on performance indicators of fast-track projects. The effect of risk management practice on
legal challenges in fast-track construction projects in Dubai was the focus of a study from Zaki [47] through a literature review and a survey using construction professionals.

Additionally, quantitative and optimization models for construction projects incorporating risks continue to receive attention. Ma and Liu [48] developed a combined optimization model—Monte Carlo simulation, an optimization algorithm, and BIM visualization—to reduce the rework risk of overlapping dependent activities by introducing communication strategies. Yu et al. [49] developed an algorithm using a fuzzy dependency structured matrix (DSM)-based scheduling to diminish uncertainty in project cash flows and overdrafts in projects applying concurrency. Ballesteros-Pérez [50] examined the risk of an unsuccessful overlap and the impact consequence on the duration and cost of fast-track projects using Stochastic Network Analysis (SNA) techniques in a stochastic model. Using Monte Carlo simulation and the chronographic scheduling logic, Francis [51] modeled uncertainties in construction schedules, including uncertainties that might arise due to project acceleration (e.g., overlapping and crashing). Finally, Isaac and Edrei [52] developed a statistical model built on real-time tracking data to reduce the workers’ exposure to safety hazards that emerge from concurrent on-site activities. Table 1 summarizes the above literature by risk topics.

Table 1. Summary of the Literature Review.

<table>
<thead>
<tr>
<th>Risk Topics</th>
<th>Literature Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only general risks in construction</td>
<td>[17–26]</td>
</tr>
<tr>
<td>Construction risks in specific areas/phases</td>
<td>[27–29]</td>
</tr>
<tr>
<td>Safety risks in construction</td>
<td>[16,30]</td>
</tr>
<tr>
<td>Influencing factors in construction risk perceptions</td>
<td>[31–34]</td>
</tr>
<tr>
<td>Concurrent engineering rework risks (product development)</td>
<td>[35–37]</td>
</tr>
<tr>
<td>Concurrent engineering risk mitigation (product development)</td>
<td>[38]</td>
</tr>
<tr>
<td>Specific and general risks in spiral development</td>
<td>[39–44]</td>
</tr>
<tr>
<td>Overlapping risks in construction (qualitative)</td>
<td>[10,45–47]</td>
</tr>
<tr>
<td>Overlapping risks in construction (quantitative and optimization)</td>
<td>[48–52]</td>
</tr>
</tbody>
</table>

The research community has not overlooked the idea that construction projects and project acceleration carry risks through overlapping. Using various qualitative and quantitative research approaches, the above pieces of literature summarized in this work helped in understanding risks in construction or risks when applying overlapping. Some of these studies acknowledge the occurrence of additional risks and the implications of different degrees of overlapping. However, these studies did not focus on risk perception when different degrees of overlapping are applied in construction projects. For example, are there new risks when overlapping the same pair of activities by 25% and 50%? None of the evolutionary acquisition studies mentioning risks offered a specific risk management approach, a list of risks, or risks in different degrees of overlapping in this area. The studies about concurrent engineering in product development projects primarily limit risks to the rework risk and the cascaded information uncertainty. The studies in construction proposed risk management frameworks, risks emerging in specific areas, and general risks. Even the studies that addressed uncertainties when overlapping did not consider the different degrees of overlapping. Therefore, this work aims to contribute to understanding risks in fast-track construction projects by exploring the risk perception of subject-matter-experts when different degrees of overlapping could apply—what are these risks, and how do they change through different pairs and degrees of overlapping.

3. Materials and Methods

The flowchart in Figure 2 presents the research design. This study used semi-structured interviews with construction and design professionals to collect data. The choice for using semi-structured interviews was to prioritize two-way communication and interaction with the respondents. Unlike a one-way method (e.g., structured questionnaire, completely
structured interview, survey), a two-way method allows interaction and feedback to guarantee that the respondents understood the concepts, and that the data represent their views instead of the researchers’ perspectives. The interviews were guided by a questionnaire based on a commercial renovation project schedule for the education sector. The research method was organized into two main phases: the data collection and the data analysis and validation. The data analysis applied data transformation and descriptive statistics.

Figure 2. Methodology Framework.

3.1. Data Collection

The data collection is threefold: describing the commercial renovation project schedule, the questionnaire, and the interviews.

The activity schedule of a commercial renovation project for the education sector was used to support the creation of the semi-structured questionnaire for the interviews. The source schedule was prepared, used, and provided by the project’s general contractor. The study limited the activities to the first-floor buildout section because the interview time was a constraint, and the interview time needed to investigate the entire project would be too long. The study considered the first ten activities of the critical path of this schedule section. Figure 3 illustrates the activities scheduled without overlapping and each of the nine potential overlapping activity pairs (e.g., P1—overlapping activities 3 and 4). Note that P3 and P4 have the same successor activity but are not redundant relationships. The pairs were organized chronologically, where Pair 1 (P1) represented the earliest activities.

The semi-structured questionnaire based on the project schedule was constructed to guide the individual interviews and collect structured information. The study considered the three degrees of overlapping Peña-Mora and Li [3] proposed: 25%, 50%, and 75%. Consequently, the study was prepared to capture the risk perceptions that could arise in 27 overlapping scenarios. The questionnaire was planned to collect up to three overlapping risks for each overlapping scenario and up to two risk mitigation actions, if applicable, for each risk identified. The initial questionnaire was tested twice and adjusted for the final application version. Each test used a different person among the target participants. An excerpt of the questionnaire for one of the overlapping pairs is available as supplementary material (Questionnaire S1).

The interview target population included project managers, construction engineers, general construction professionals, and experts in the construction industry in the U.S. Intending to minimize bias from the professionals’ risk perceptions, the participants were recruited from different teams, contractors, or project groups, the interviews were conducted individually, and they did not receive any risk clues or suggestions. The study included 13 in-person individual interviews with construction professionals. Table 2 shows
the participant demographic information by degree of education, work experience classification, time of experience, and construction sector experience. More than one sector could apply to companies.

Table 2. Participant demographic information.

<table>
<thead>
<tr>
<th>Background</th>
<th>Category</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of education</td>
<td>Associate</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Bachelor’s</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>Master’s</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>Doctorate</td>
<td>8%</td>
</tr>
<tr>
<td>Work experience</td>
<td>Design Architect/Engineer</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Construction Engineer/Manager</td>
<td>77%</td>
</tr>
<tr>
<td></td>
<td>Other/Project Manager</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Other/Multiple engineering experience</td>
<td>8%</td>
</tr>
<tr>
<td>Years of experience</td>
<td>1–10 years</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>11–20 years</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>21–30 years</td>
<td>31%</td>
</tr>
<tr>
<td></td>
<td>More than 30 years</td>
<td>31%</td>
</tr>
<tr>
<td>Construction sector experience</td>
<td>Residential Building Construction</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Non-residential Building Construction</td>
<td>55%</td>
</tr>
<tr>
<td></td>
<td>Heavy and Civil Engineering Construction</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>Specialty Trade Contractors</td>
<td>9%</td>
</tr>
</tbody>
</table>

The participants provided their risk perception for each of the 27 overlapping scenarios. First, the participant judged which three degrees of overlapping would be feasible. The degrees of overlapping considered not possible were identified as not feasible and without risk. Next, the participant identified up to three risks that could arise due to overlapping (overlapping risks) for each possible overlapping scenario. The participant could also answer that no risk was perceived. In summary, three answers were possible for each pair of activities and degree of overlapping combination: a risk description, no risk, or not feasible.

3.2. Data Analysis and Validation

The risk descriptions collected during the interviews had a free form and were transformed into structured risk descriptions and validated. The risk description transformation aimed to group similar risks under a short, structured description. The research team performed the first round of the risk description transformation by grouping the risks and...
defining the structured description. Table 3 shows an excerpt of the transformation for two of the risks. For instance, the risks of “lower production of the layout walls” and “more time to layout” were transformed into the structured risk description of “poor construction productivity”. This process was applied to all identified risks.

Table 3. Excerpt of the risk description transformation for construction error and crew interference.

<table>
<thead>
<tr>
<th>Construction Error</th>
<th>Crew Interference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes/Errors in the walls causing rework</td>
<td>Catching up</td>
</tr>
<tr>
<td>Defective work</td>
<td>Crew interference</td>
</tr>
<tr>
<td>Execution error</td>
<td>Downtime of electrical crew</td>
</tr>
<tr>
<td>Redo the painting</td>
<td>Physical constraint—overrun of crews—drywall crew overrun framing</td>
</tr>
<tr>
<td>Wrong layout</td>
<td>Space problem—too many people in the same areas</td>
</tr>
</tbody>
</table>

Two subject-matter experts performed the validation of the structured risk description transformation. The validators were chosen among the original interview group participants—they were construction experts with more than 40 years of experience and familiar with the research objectives, eliminating the need to explain the research objectives and possibly influence the results. The two validators worked independently, so neither could overly influence the process. The iterative validation process started from the researcher’s first round of structured risk descriptions. Validators agreed with the risk descriptions proposed; otherwise, they suggested another structured risk description or moved risks to another structured description. The validation process did not identify who identified each risk nor excluded or added new risks.

The data analysis covered quantitative and qualitative analysis. Descriptive statistics were used to evaluate the change in answers (i.e., risk, no risk, or not feasible) across the activity pairs and degrees of overlapping—the percentage of risks identified related to the total of risks and the percentage of participants that did consider the occurrence of no risk or considered the degree of overlapping as not feasible. MS Excel supported the tabulation and calculations of the measures.

The data analysis used descriptive statistics to explore and capture the properties of the risk perception due to overlapping. First, the perception of risk occurrence per pair of activities and the degree of overlapping were analyzed. A nominal or categorical scale was used to classify the perception answers, such as identified risks, identified no risks, considered not feasible, and percentages of responses were calculated to represent the measures. For example, the percentage of respondents who identified risks was obtained by the number of respondents who identified at least one risk related to the total number of respondents. The goal was to evaluate the change in answers (i.e., risk, no risk, or not feasible) across the activity pairs and degrees of overlapping. This part of the analysis only considered if the occurrence of risk was perceived or not, but not the type of risk. The term occurrence associated with the risks used throughout this paper refers to the event or existence of the risk but not the risk probability of occurrence.

The subsequent analysis steps evaluate what types of risks due to overlapping were perceived and when those risks would arise. The types of risks perceived used the structured risk descriptions. The analysis quantified the perceived types of risk by the degree of overlapping and pair of overlapping activities. Then, it was possible to identify the top perceived overlapping risks that could arise in a construction project. The final step was to associate the risk mitigation actions with the risk types.

4. Results

The results of the interviews with construction professionals show how they perceived the existence, or not, of overlapping risks in different degrees of overlapping and which types of risks were identified. First, the results show the aggregated percentage of respon-
students for each possible answer option, such as identification of risks, identification of no risks, or consideration of the degree of overlapping as not feasible for each combination of overlapping pair and degree of overlapping. Later, the results show which types of risks were perceived by degrees of overlapping and overlapping pairs.

4.1. Risk Perception across Different Degrees of Overlapping and Pairs of Activities

Figure 4 shows the relative risk perception for each overlapping pair and the degree of overlapping. The percentage of respondents that identified risks, no risks, or considered a degree of overlapping as not feasible represents the relative risk perception. For instance, for P1 and 25% degree of overlapping, nine respondents in 13 identified risks, representing 69%. The percentage value in the legend represents the total for each perception. It is the sum of the respondents for each perception (e.g., no risk) divided by the total of possible answers. For instance, 27 total responses for no risk at 50% degree of overlapping divided by 117 possible answers (13 judgments for each of the nine overlapping pairs) represent 23%.

Figure 4. Summary of the percentage of respondents by the degree of overlapping, pair of overlapping, and risk perception.

The perception of risks due to overlapping can be observed in all pairs of activities and all degrees of overlapping, and the 50% degree of overlapping had more respondents perceiving risks. In the 50% degree of overlapping, 63% of the possible answers were related to identifying at least one risk per pair of overlapping, representing 74 answers of the possible total of 117 (13 respondents × 9 pairs of overlapping). At 50% degree of overlapping, all overlapping pairs had more than 50% of respondents perceiving risks, except for P8. For the second overlapping pair (P2), 100% of the respondents perceived risks. The total risk perception of risk for 25% and 75% degrees of overlapping was 52% and 36%, respectively. Lastly, the respondents perceived most of the risks in the first half of the project (P1 to P4), where the first four overlapping pairs concentrated 57% of the overlapping risks.

Among all three overlapping degrees, the 25% degree of overlapping was the degree with the highest perception of the no occurrence of overlapping risks. At the 25% degree of overlapping, the answers of no overlapping risks represented 45% of the possible answers. The perception that no overlapping risk would occur at the 50% and 75% degrees of overlapping represented 23% and 9% of the possible answers, respectively. Only at the 25% degree of overlapping, four pairs had more than half of the respondents identifying no risks. For a few overlapping pairs at 50% and 75% degrees of overlapping, there was equal or less than 15% of the respondents identifying no risks.

Additionally, the perception that the degree of overlapping would not be feasible was mostly perceived at 75% degree of overlapping. At 75% degree of overlapping, 56% of the possible answers felt under this answer option, and in five out of nine overlapping pairs, more than half of the participants perceived that 75% overlapping would not be feasible. In contrast, at 25% degree of overlapping, only 3% of the possible answers were related to this...
option. For seven out of nine overlapping pairs, the respondents had a 0% perception that it would not be feasible.

Finally, the results also show the representativeness of risk perception for the degrees of overlapping that more than 85% of the respondents considered feasible. In the case of the 25% degree of overlapping, all nine pairs were perceived as possible by more than 85% of respondents, and in four of these pairs, more than half of the participants identified risks. In the case of a 50% degree of overlapping, six pairs were perceived as feasible by more than 85% of respondents, and in all six of these pairs, more than 50% of the respondents identified risks.

4.2. Overlapping Risk Types

The semi-structured interviews with construction professionals (step 6 of the methodology framework) resulted in a list of 293 risk descriptions due to different activity degrees of overlapping. The description of the results below shows the overlapping risk types perceived across different degrees of overlapping and pairs of activities and a brief description of the top potential actions to mitigate the risks.

The transformation and validation process of the 293 overlapping risk descriptions resulted in 12 structured risk descriptions (steps 7 and 8 of the methodology framework) [53]. The 12 overlapping risk types were: construction error, construction sequence, crew interference, crew member shortage, damage by others, design change, inspection delay, layout change, poor construction productivity, safety/injury risk, water damage, and work environment. The validators treated the layout change risk type differently because they understood that layout change could have other reasons (e.g., the layout foreman may alter the layout to coordinate with other trades).

The list below provides a brief description of each risk:

- **Construction Error risk** is related to the possible occurrence of execution changes/errors, defective or incorrect work, and poor quality of work that can cause rework. It could also be related to material not being available on time or using the wrong material;
- **Construction Sequence risk** is related to the possible occurrence of performing activities out of order (i.e., having to cut the drywall to put a box);
- **Crew Interference risk** refers to the possible occurrence of events, such as when the successor activity’s crew overruns the predecessor’s crew, downtime of the successor’s crew, or physical conflict because there is no space for both crews;
- **Crew Member Shortage risk** refers to the possibility of not having enough workforce to execute both activities simultaneously;
- **Damage by Others risk** is related to the possible occurrence of physical damage caused by one trader on the work of the previous trader;
- **Design Change risk** refers to the possible change in the design due to owner change or errors or omissions causing rework, demolition, or material waste;
- **Inspection Delay risk** refers to the possible occurrence of issues caused in or due to inspection, such as delay in having the inspection, lack of permission to have the inspection, or correction needed after inspection;
- **Layout Change risk** is related to the possible change in the layout causing demolition of the succeeding work;
- **Poor Construction Productivity risk** is related to the possibility of low productivity and low efficiency of the predecessor crew;
- **Safety/Injury risk** is related to the possibility of a worker getting hurt because of the simultaneous work in a constrained space;
- **Water Damage risk** refers to the possible occurrence of having a part of the construction damaged by (rain) water because, for example, the following activity started before roofing has been completed;
- **Work Environment risk** is related to the possible defect in the succeeding work due to dust or moisture from the previous work or issues with breathability.
The total perception of these 12 overlapping risks reveals that the top four types of risks cover 80% of the threats: construction error, design change, crew interference, and poor construction productivity (Figure 5). The most representative overlapping risk was construction error, representing approximately 30% of the risks. Next was design change with 23%, crew interference identified with 18%, and poor construction productivity with 9%. These four overlapping risks were also the most representative in each degree of overlapping (Figure 5).

Figure 5. Summary of the perceived overlapping risks by the degree of overlapping.

The results of the overlapping risks by the degree of overlapping indicated that the top five risks in the 25% and 50% degrees of overlapping covered 80% of the risks, including construction error, design change, crew interference, poor construction productivity, and inspection delay (Figure 5). At the 75% degree of overlapping, four overlapping risks covered 80% of the risks, including construction error, design change, crew interference, and poor construction productivity. Indeed, construction error and design change covered more than half of the risks identified in each degree of overlapping.

The perception of the overlapping risks by pairs of activities shows that the risk perception can change for each pair (Figure 6). Still, three types of overlapping risk were identified in all overlapping pairs, and they were also among the top risks in almost all pairs of activities: construction error, design change, and crew interference. The principal overlapping risks varied along with the project phases, but three to five types covered more than 80% of the risks mentioned in each pair of activities. Alternatively, some types of risk were associated with specific pairs of activities or a project phase. For example, the inspection delay risk was associated only with activities where an inspection is necessary before work can move forward, which occurred in the middle stage of the project.
including construction error, design change, crew interference, and poor construction productivity (Figure 5). At the 75% degree of overlapping, four overlapping risks covered 80% of the risks, including construction error, design change, crew interference, and poor construction productivity. Indeed, construction error and design change covered more than half of the risks identified in each degree of overlapping.

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Figure 6. Summary of the perception of overlapping risks by pair of overlapping.

4.3. Risk Mitigation Actions

Although risk mitigation actions were not the primary purpose of the research, the respondents included recommended mitigation actions for these 12 overlapping risks, mainly to crew/workers, coordination, and contract. The mitigation actions related to crew/workers were associated with the level of experience, training, and quantity. The mitigation actions related to coordination were communication, work checking, site inspection and cleaning, scheduling. The mitigation actions related to the contract were associated with the agreement with the owner and risk transference to the subcontractor. The list below summarizes the risk mitigation actions collected through the survey.

- Adequate sequencing, balance of the work (i.e., maximizing distance locations, installation of the roof), ensure that production rates are met;
- Check BIM drawings, BIM model clash detection, virtual layovers;
- Check materials and activities schedule, review of quantity takeoff;
- Checkpoint review;
- Clean jobsite, coach the teams about the additional risks of working together;
- Communication between different team participants (e.g., design team, construction team, superintendent, foreman, traders, crews);
- Control of the subcontractor;
- Coordinate with the inspectors ahead of time;
- Coordination (by the project manager, with the crews, with the inspectors);
- Earlier recognition of needed changes by the owner;
- Get blocks or barricades, use dustless sanders, use exhaust fans, use face respirators and full suits;
- Have a crew in place to correct issues;
- Have a good scheduling and coordination, look-ahead plan;
- Have an experienced team (i.e., workers’ crew, foreman, superintendent, project manager);
- Have a good submittal process (i.e., review, preinstallation, Architects Supplemental Information (ASI), installation);
- Improve crew competence/training;
- Increase the number of workers/productivity, use multiple crews, increase work time, schedule different shifts;
- Increase of work supervision;
- Involvement of Owner, Architect, Engineer, Construction, and Management to make sure everything is correct before going forward;
- Keep the owner informed about the impact on cost and time;
- Perform pre-inspections, inspections;
- Quality control;
- Resource loading on schedule and check materials (e.g., workers, materials);
- Staging the work (i.e., plan and control physical areas) to avoid conflict;
- Transfer risk to the subcontractor.

5. Discussion

The construction professionals perceived more overlapping risks in the overlapping of activities that occur earlier in the schedule. The first four overlapping pairs had 57% of the total risks identified. It suggests that project managers should identify the risks due to overlapping early on in the project and act to eliminate or mitigate these overlapping risks early to avoid a cascade of issues. If the risk response actions require change, adjustments, or acquisitions, they will likely cost less at this point than during the later phases of the project. Although this trend was observed for a small part of the project used in the study, it is consistent with many project management materials that indicate that risks tend to decline as a project progresses.

The medium degree of overlapping (50%) concentrated many overlapping risks, but the other two degrees of overlapping also deserve some discussion. The medium degree of overlapping alone had 40% of the overlapping risks perceived, and the 25% and 50% degrees of overlapping together had approximately 73% of the overlapping risks. It might sound counter-intuitive that the higher degree of overlapping, 75%, did not contain most of the perceived threats. One could mistakenly conclude that the 75% degree of overlapping was not risky, but the explanation is that interviewees mainly perceived this degree of overlapping as impractical. It indicates that construction professionals might avoid scheduling activities with high levels of concurrency; therefore, no overlapping risk arises. Another counterpoint is the relative perception of no overlapping risks at the 25% degree of overlapping. The existence of a relatively high perception that no overlapping risks could occur at the 25% degree of overlapping does not mean that the project is not exposed to overlapping risks. It indicates that the construction professionals did not perceive any additional risks due to overlapping compared to the risks that would have occurred without overlapping.

The findings also show a concentration of overlapping risk in four risk types and five risk mitigation actions. The risk types of construction error, design change, crew interference, and poor construction productivity explained more than 80% of the threats perceived due to overlapping. This concentration also occurred in the different degrees of overlapping. The risks of construction error and design change can cause some rework, which can impact the strategy to deliver the project faster and also impact the project cost. The risks of crew interference and poor construction productivity can cause idle time for the crew that needs to work on the successor activity; consequently, it can impact the project duration and cost. Therefore, when resources are limited, the few risks that account for most occurrences can work as a starting point for future analysis, monitoring, and mitigation. The results suggested that construction professionals adopt different risk mitigation approaches to the same risk, depending on the degree of overlapping. However, five mitigation actions were the most common. For example, ensure good communication, ensure crew/worker is trained and has the experience, perform the right sequencing of the work, check design/drawings, and allocate experienced crew/worker. Table 4 emphasizes the top risk mitigation actions associated with the top four risks.
Table 4. Top risk mitigation actions associated with the top four risks.

<table>
<thead>
<tr>
<th>Risk Mitigation Actions</th>
<th>Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication between different team participants (e.g., design team, construction team, superintendent, foreman, traders, crews)</td>
<td>Construction error Design change Crew interference Poor construction productivity</td>
</tr>
<tr>
<td>Increase the number of workers/productivity, use multiple crews, increase work time, schedule different shifts</td>
<td>Construction error Crew interference</td>
</tr>
<tr>
<td>Perform pre-inspections, inspections</td>
<td>Construction error Design change</td>
</tr>
<tr>
<td>Adequate sequencing, balance of the work (i.e., maximizing distance locations, installation of the roof), ensure that production rates are met</td>
<td>Crew interference</td>
</tr>
<tr>
<td>Check BIM drawings, BIM model clash detection, virtual layovers</td>
<td>Construction error Design change</td>
</tr>
<tr>
<td>Have experienced team (i.e., workers’ crew, foreman, superintendent, project manager)</td>
<td>Construction error Design change Crew interference</td>
</tr>
</tbody>
</table>

One last discussion point is acknowledging that some of the overlapping risks identified in this work could also occur using a scheduling approach without overlapping. Using our prior industry experience and previous study results, we agree that, for instance, the risks of design change, poor construction productivity, and damage by others could also occur in a situation without overlapping. We propose one possible explanation: these risks could have a higher severity on the fast-track approach than in a scheduling approach without concurrency.

6. Conclusions

This study aims to capture the perception of risks in fast-track construction projects that could arise from different degrees of overlapping. The results obtained through semi-structured interviews with construction professionals suggest that the perceptions of overlapping risks were more concentrated in the early activities, the medium degree of overlapping (50%), and a few types of risks, such as construction error, design change, crew interference, and poor construction productivity. We also note similarities and differences in findings with previous studies.

These findings agree with those of other researchers who indicated that risks tend to decrease as the project advances and that fast-track projects face additional risks. Decreasing the risks as the project advances is consistent with the findings of the Project Management Institute [14]. We also subscribe to the common belief that a fast-track approach faces additional threats compared to traditional projects without overlapping [1,2,5–7]. The number of participants perceiving overlapping risks was higher than those perceiving no risks, supporting the belief that fast-track projects face additional risks.

In contrast, our results question Ballesteros-Pérez’s claim [50] that, on average, the overlap between activities cannot be more than 25% of the predecessor’s duration. This claim also differed from the Peña-Mora and Li’s [3] overlapping framework. The possible explanations are that Ballesteros-Pérez based the conclusion on (1) the assumption that risk increases linearly with overlapping, which might not be accurate, and (2) a mathematical model. However, our findings showed that construction professionals have a different perception, relying on their experience and perceiving higher degrees of overlapping as being possible.

These findings shed light on the issue of riskiness when accelerating construction projects by activity overlapping. It not only supports the common belief that fast-track projects are riskier but also indicates that different degrees of overlapping carry different
overlapping risks. It provides insights into how construction professionals perceive the potential overlapping risks, their changes, and the types of risk. It can offer additional information to future studies modeling the risk assessment in fast-track, considering the impact of different degrees of overlapping and some impact types.

Lastly, the construction professionals offered during the interviews that it was not common to think about overlapping risks and that formal risk management was challenging. Therefore, this work can have a positive impact on construction practice. Construction professionals should know that even avoiding high degrees of activity overlapping, a fast-tracking strategy with low to medium degrees of overlapping can carry additional risks. They should evaluate potential types of risk and plan to manage them at the project beginning to avoid jeopardizing the strategy, including assessing the need to adopt different mitigation approaches to the same risk, depending on the degree of overlapping.

The findings of this study refine and share the view of previous studies; however, generalizations should be taken with caution. The comparison of the results of this study was limited to other studies that investigated overlapping risks in more general ways, because no other studies were identified that focused on risk perception for different degrees of overlapping. It would be desirable to reproduce this study with a larger sample size and other construction projects. Therefore, caution is needed when generalizing the types of risks to different types of construction.

Future studies can build on risk perception changes through different degrees of overlapping to further understand risks in construction. Replication of the study can compare the results among studies using other construction project types and other acceleration strategies using overlapping (e.g., spiral development). Considering different risk perceptions for different degrees of overlapping can also be used in future studies developing scheduling models considering acceleration through overlapping.

Considering that the fast-track acceleration strategy has been common in construction projects but is generally believed to be riskier, this study captures the construction professionals’ perception of construction risks in fast-track construction projects when different degrees of overlapping might be applied. We hope this work can assist and encourage other studies to contribute to the success of accelerated projects in construction.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/eng4040162/s1, Questionnaire S1: Overlapping risk perception questionnaire.

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