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# Unraveling Project Pitfalls: A Forensic Exploration of Communication, Coordination, and Collaboration Breakdowns in Construction

William R. Locke, Ph.D., P.E., A.M.ASCE;[1] Gayathri Shetty, CCM, PMP, LEED AP;[2] David Anderson, Ph.D., P.E., CFEI;[3] and Cliff D. Bishop, Ph.D., P.E., S.E.[4]

[1] Senior Engineer, Exponent, Inc., Civil & Structures. Email: wlocke@exponent.com
[2] Senior Manager, Exponent, Inc., Construction Consulting. Email: gshetty@exponent.com
[3] Principal Engineer, Exponent, Inc., Thermal Sciences. Email: danderson@exponent.com
[4] Principal Engineer, Exponent, Inc., Civil & Structures. Email: cbishop@exponent.com

## ABSTRACT

Communication, coordination, and collaboration are often proclaimed as the "Three Cs to Success" for project managers and construction projects. When project managers are proficient in the Three Cs, projects are more likely to be completed on time, within budget, and with minimal to no defects. This paper provides a forensic case study where breakdowns in the Three Cs ultimately resulted in multiple project delays and a myriad of construction defects. At the onset of the project, improper communication and coordination resulted in dimensional control issues that delayed steel erection. This, in turn, necessitated adjustments to the means and methods and the installation of structural components for multiple subcontractors. As construction progressed, improper communication of said adjustments, along with a lack of collaboration, introduced additional delays and further exacerbated dimensional control issues; this resulted in defects that compromised the building envelope's ability to protect against the harsh environment and reduced the effectiveness of the structure's life safety systems. Delays were exacerbated when a propane heating setup – temporarily installed to cure concrete poured in winter due to the early delays – exploded, halting construction for months. During this time, project management failed to properly communicate daily and weekly updates, resulting in coordination issues and further straining relationships between various parties. The findings from this forensic case study discuss project managements culpability for the project failures and evaluate how breakdowns in the Three Cs could have been averted to prevent early onset issues from cascading into costly delays and defects.

## INTRODUCTION

It is no secret that the success of a construction project depends on a competent project management team. Though there is no single perfect strategy for managing a project, many managers agree that the successful realization of project goals often requires effective communication, coordination, and collaboration. Often proclaimed as the "Three Cs to Success," effective communication, coordination, and collaboration create a robust and interactive environment that allows project teams to share their knowledge and resources to prioritize achieving set goals on time, within budget, and without defects (Coleman 2016, Schedule 2021).

Communication is the act of sharing information verbally or in writing. Communication is probably the most important aspect of the Three Cs, as open and clear communication between project team members prevents assumptions and reduces the risk of misunderstandings; this is especially true when exchanging information between office and field teams, as decisions made in the office can lead to major project drawbacks and delays if not properly communicated to teams in the field. Statistics show that of projects with highly effective communication, 71% finish on time, 76% are completed in budget, and 80% meet their set goals; conversely, for projects with minimally effective communication, only 37% finish on time, 48% are completed within budget, and 52% meet their set goal (Schedule 2021).

Though there are many definitions for coordination, the *Oxford Dictionary of Construction, Surveying & Civil Engineering* defines coordination as, "the act of aligning tasks, activities, and resources so that they are managed effectively" (Gorse et al. 2012). Proper coordination often results in projects coming in on time and within budget whereas, poor coordination is often linked to construction defects, delays, and project overruns. Many experts identify poor coordination as one of the primary factors that causes disputes on construction projects (Saram et al. 2001, Alaloul et al. 2016).

Collaboration is the act of teams sharing information and working together to achieve long-term shared goals rather than short term individual goals. Successful collaboration often leads to fewer changes/ rework, projects finishing on time and within budget, higher profits, less waste, and happier stakeholders (Ellis 2022). Similar to communication and coordination, poor collaboration across project teams often results in failure to effectively achieve project goals on time, within budget, and without defects.

In this paper, a forensic case study is provided to demonstrate how improper communication, coordination, and collaboration on a construction project led to early onset issues that cascaded into a myriad of construction defects, project delays, and potentially life-threatening situations. All photographs used in this paper are sourced from documentation provided to the authors during their investigation.

## PROJECT BACKGROUND

The project was located in a region where the average annual temperature ranges between 37°F and 43°F, and there are on average fifty days a year where the temperature is below 0°F. Construction consisted of erecting four main buildings on a single campus (Figure 1); buildings 1 and 2 are two stories in height, while buildings 3 and 4 are over five stories in height. The foundations consist of steel piles with concrete pile caps and a concrete slab-on-ground. Each structure is steel framed with concrete slabs cast compositely with metal pan decks. The exterior walls of each building generally consist of, from outside to inside, aluminum metal panels, rigid foam insulation, an air and vapor barrier, fiberglass mat gypsum sheathing, cold-formed metal studs, and interior wall finishes.

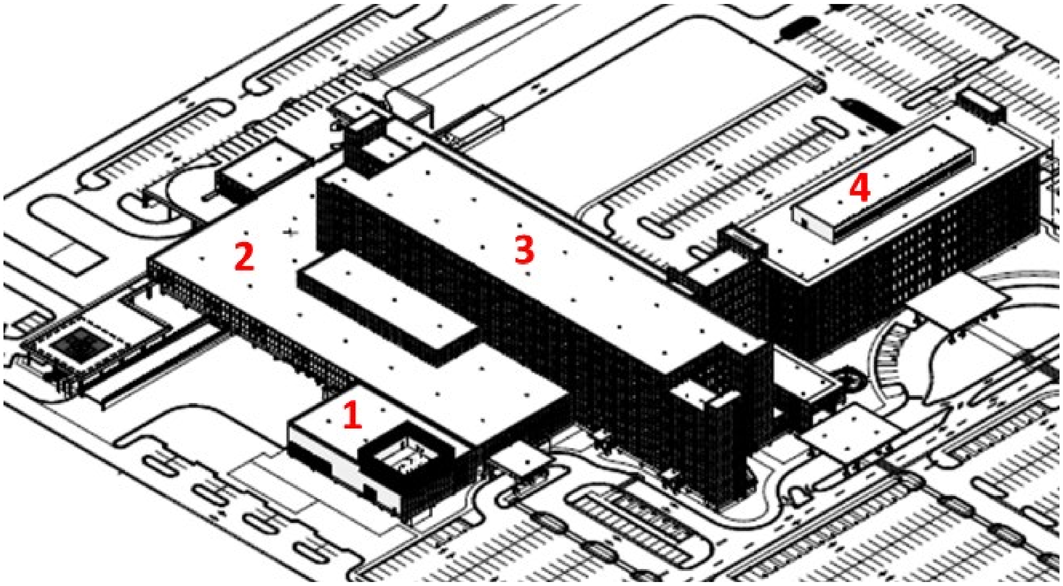



**Figure 1. Graphic outlining the four buildings constructed on the campus.**

## DIMENSIONAL CONTROL ISSUES

During construction, early issues with dimensional control resulted in the structural steel framing being out of plumb. Considering that building elements such as the deck forming (bent plates and knife plates), steel channels, cold-formed metal stud wall framing, and exterior sheathing were installed after the structural framing, issues with framing plumbness created a series of required adjustments that affected the placement of each of the subsequent elements. Figure 2 outlines the sequence of construction and provides a typical cross-section demonstrating how the various elements were integrated together.

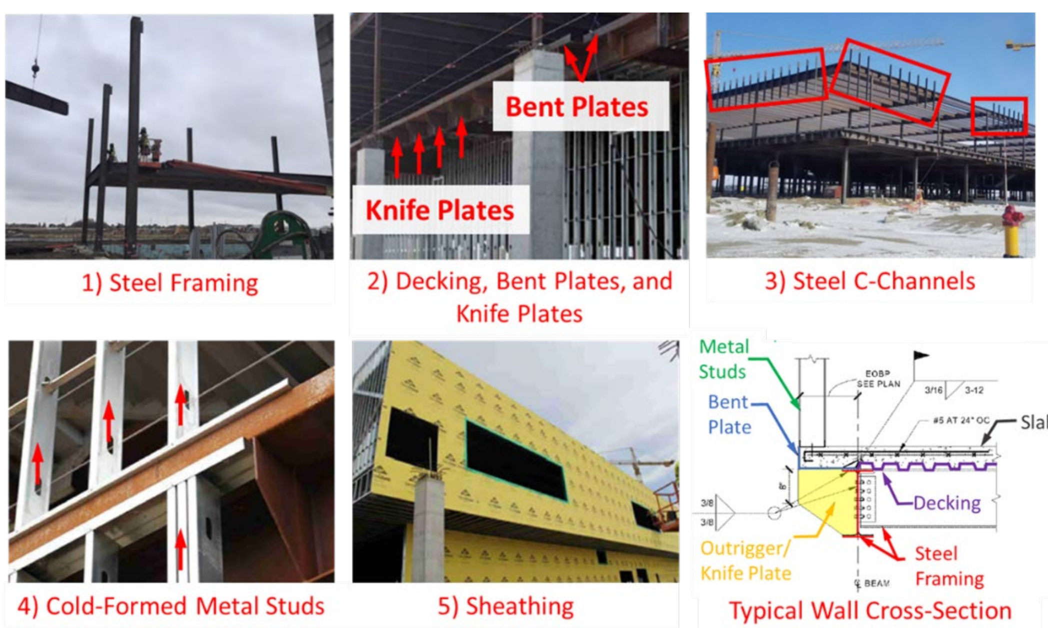



**Figure 2. Construction sequence and exterior wall cross-section.**

## Control Points and Dimensional Control

During the site development process, control points are used to set horizontal and vertical locations for footings and foundations. After vertical construction commences, the column lines are used for control in constructing each floor as the building proceeds vertically. In this project, there were notable issues with supplied control points not matching survey data, resulting in, amongst other things, the foundation walls being installed incorrectly. As construction moved past the foundations and progressed vertically, control problems became apparent that were traced back to column line issues; the column line issues were traced back to issues with plumbness.

Early in the steel framing erection process, the topic of column plumbness was discussed between the general contractor (GC) and site surveyor, and the GC requested that the site surveyor provide a column plumbness report. It is unclear to the authors if plumbness checks were ever performed or reported on. However, a later survey revealed that some columns were tilting up to several inches when measured from the ground to the roof. Per Section 7.13 of the American Institute of Steel Construction's (AISC) *Code of Standard Practice* (COSP), "the angular variation of the working line from a plumb line shall be equal to or less than 1/500 of the distance between working points" (AISC 2016). Using this information along with the updated survey data, it was determined that several columns exceeded the tolerance limits set by the COSP. Therefore, it was determined that either the plumbness checks were not performed or if they were performed and issues were identified, the issues were not properly addressed before proceeding with the next phase of construction. By not properly addressing issues with control points and plumbness early in the construction process, dimensional inconsistencies were introduced at each floor, thereby creating issues with the metal stud walls, bent plates, and the knife plates that are discussed subsequently.

## Bent Plates

As shown previously by the cross-section in Figure 2, a continuous bent plate was welded to the top flange of the exterior steel beams to create the formed edge for the composite concrete deck. Per early email correspondence between members of the GC team, it was noted that the subcontractor for structural framing (Framing Sub) was instructed to install bent plates based on the GC's existing control lines but measurements between control lines were ½-inch too narrow. Per the email, the Framing Sub was seeking guidance on how to proceed; no solution was communicated by the GC team within the subject email chain. Shortly after the previous email, the Framing Sub noted that installing the bent plates per the control lines resulted in varying distances relative to a concrete wall. The GC's instruction to address this issue was to ignore the control lines and install the bent plates per the concrete wall. Per a later email between the Framing Sub and GC, the subcontractor sought confirmation if it was acceptable for their bent plates to be placed inside the stud wall for locations where bent plates had been installed prior to control lines being in place and in other locations where the control lines were in place but varied between floors; the Framing Sub indicated this was to prevent interfering with the sheathing being able to pass by. The Framing Sub also asked for confirmation that any gaps that ensued between the bent plate and the stud wall (where the stud wall was moved out from the slab edge) would be filled with insulation. The GC indicated that the Framing Sub was correct with their statements and instructed the sub to proceed per their conversation. It was noted that the gaps permitted by the

GC created a condition that needed to be fire stopped; otherwise, an unsafe condition could be created that more-easily allowed fire to spread between floors.

**Knife Plates**

Knife plates are steel plates that were prefabricated off site and then welded to the exterior steel beams and the underside of the bent plate at the concrete deck edge. The function of the knife plates was to support the bent plate at the concrete deck edge and the wet weight of the concrete before curing. Per the cross-section in Figure 2, the exterior edge of the knife plates was supposed to be in line with the edge of the deck/bent plates and the metal studs above. The prefabricated dimension of the knife plates determined the edge of the deck/bent plate locations.

Pursuant to the deficient dimensional control, the bent plates needed adjustment to accommodate the changing building dimensions as discussed above. While the bent plates could be adjusted inward or outward, the knife plates that were prefabricated to specific dimensions could not be moved inward due to interference with the steel beam web and outward movement would likely trigger structural redesign. During a site visit by the architect-of-record (Arch), it was noted that the knife plates extended beyond the metal stud framing and bent plates due to the dimensional control issues. The Arch provided instruction to trim the knife plates so that they were no longer proud of the exterior studs and bent plates. An example of a trimmed knife plate is shown in Figure 3. Though the Arch instructed the knife plates to be trimmed, this was not done consistently across the project, which resulted in knife plates continuously being observed to protrude through exterior sheathing and interior gypsum board as is discussed in more detail below.

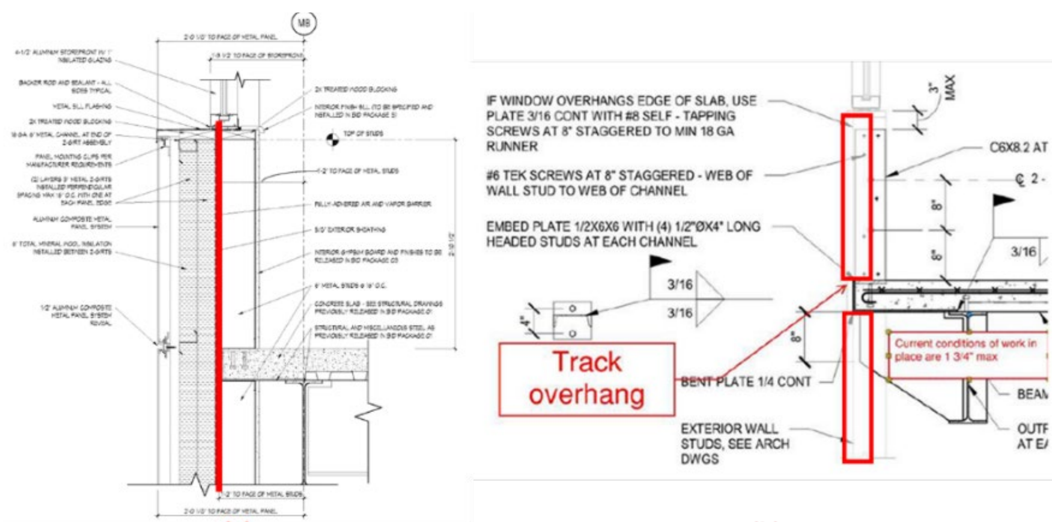
**Figure 3. Trimmed knife plate edge (indicated).**

**Stud Walls**

The cold-formed metal stud walls were installed by the Drywall, Plaster, & EIFS subcontract (DPE Sub). To develop a planar surface onto which the exterior sheathing and façade could be attached, it was imperative that no elements extend outboard of the metal stud wall; this planar surface is shown schematically in Figure 4a.

Early in the project, the DPE Sub wrote an email to the GC voicing concerns with the field layout. The email indicated workers were finding layout problem areas that did not match survey data. The DPE Sub indicated that they could not proceed and that the problem areas would need to be approved for their team to move forward due to problems that will have a domino effect in the future; they even communicated that these domino effects would have added costs if they were instructed to proceed anyway. Despite voicing these concerns, the DPE Sub was instructed by the GC to continue with their work. Later in the project, the DPE Sub again voiced concerns that the bent plates on top of the first floor and bottom of the second floor were misaligned. The GC's instruction to address this issue was to proceed with the wall on the first floor shifted outwards by 2" and to follow that line up the sides of the building; Figure 4b schematically demonstrates what the GC instructed doing with the stud walls.

The strategy of moving the stud walls out was later endorsed by the Arch who instructed the DPE Sub to bring out the stud wall framing so that the stud track, knife plates, and bent plates were not proud of it. Figure 5 demonstrates a condition where a stud wall was noticeably overhanging the slab edge.




(a) (b)

**Figure 4. Schematics demonstrating (a) the designed planar surface of a stud wall and (b) stud wall overhang that was approved for the as-built design.**

**Figure 5. Photographs of the stud track (left) and stud wall (right) overhanging the edge-of-slab.**

### Breakdown in the Three Cs

The dimensional control issues were pervasive for the duration of the project and demonstrated an obvious breakdown in the Three Cs by project management. The issues started when the GC did not properly communicate and coordinate survey and plumbness data with the relevant stakeholders. Furthermore, the GC failed to effectively communicate, or sometimes failed to communicate in general, when subcontractors asked questions about the accuracy and/or availability of survey data. On several occasions, the subcontractors attempted to communicate that issues with the survey data were causing dimensional inconsistencies that would have a domino effect if work were to proceed; the GC continuously ignored these warnings and gave instructions to proceed without first communicating and collaborating with the design teams about the reported issues. On numerous occasions the GC gave instructions to subcontractors to deviate their work from the survey data/plans without first collaborating with the design teams or other subcontractors to determine the impact the instruction would have on other work. This resulted in subcontractors identifying other issues and seeking additional instructions on how to proceed. On this note, the GC did not properly coordinate the various stakeholders to account for the countless instructions being given, which continued to result in issues arising that required more unique solutions.

## BUILDING ENVELOPE AND FIREPROOFING

Adjustments to the placement of stud walls due to the dimensional control issues introduced defects that compromised each building's ability to protect against the harsh environment and reduced the effectiveness of each structure's fireproofing. Irrespective of the dimensional control issues, inherent design flaws would have caused knife plates to protrude through interior firewalls anyways, further reducing each building's ability to prevent fire/smoke transmission while safely allowing occupants to exit the buildings.

### Sheathing and Gypsum Board

According to the project specifications, the exterior walls were clad in a fiberglass mat gypsum sheathing board known as DensGlass (Georgia-Pacific 2024), while the interior stair/elevator cores were clad in gypsum board that was specific for shaft wall assemblies. As a result of the deficient dimensional control, the bent plates at the concrete deck edges, the knife-plates, and the metal stud walls required adjustments (see previous discussion). This condition led to the exterior sheathing being out-of-plumb and knife plates protruding through the sheathing on the exterior walls (Figure 6a). The lack of plumbness and protrusions in the exterior sheathing prevented the vapor barrier, exterior insulation, and metal panel façade from being installed correctly, which subjected the interior of the structure to the harsh environment.

At the interior, the dimensional control issues and/or design flaws resulted in the knife plates protruding through shaft wall liners, which impacted the 2-hr fire rating of the walls. In meeting notes between the Owner, Arch, and GC, it was acknowledged that the wall had been designed such that the inside edges of the knife plates were in the same plane as the inside edge of the shaft liner. The proposed fix was supposed to be a UL-rated and approved assembly. The DPE Sub was made aware of the proposed repair and understood that the issue would be addressed by the fireproofing subcontractor (Fire Sub); however, project management did not properly communicate or coordinate between the two trades, and the defect in the 2-hr fire walls was left unaddressed (Figure 6b).

(a) (b)

**Figure 6. Photographs demonstrating knife plate penetrating (a) an exterior wall and (b) a 2-hr fire rated elevator shaft wall.**

**Fireproofing**

Other consultants noted that during construction, portions of the stud framing at interior and exterior locations were installed in such a way that precluded the installation of spray-applied fireproofing of the structural steel framing; the cold-formed studs on the exterior of the building went past the columns, which prevented access for fireproofing the exterior face of the columns. This issue was observed most frequently on the upper floors where the flange of the column was up against the exterior wall. It is believed that the adjustments to the slab edges to accommodate the deficient dimensional control may have inadvertently required the interior and exterior stud wall framing to be closer to the columns than originally envisioned in the contract documents. Note that sheathing had also been installed along several walls, which prevented access to the hidden faces of structural steel elements for fireproofing application.

**Breakdown in the Three Cs**
As indicated above, the GC failed to properly communicate, coordinate, and/or collaborate with the various stakeholders to account for the countless instructions that were given due to dimensional inconsistencies. This breakdown in the Three Cs resulted in the abovementioned issues observed for the exterior sheathing and interior gypsum board. Regarding the design issues with the shaft wall liner, project management did not properly communicate or coordinate with the subcontractors to ensure a timely repair of the 2-hr fire rated walls.

Per the contract documents, the GC was responsible for inspecting portions of work already performed to determine that such portions were in proper condition to receive subsequent work. Therefore, the GC had the obligation to properly coordinate the trades such that the metal stud walls were not constructed before fireproofing of the steel framing was installed, especially if the sequence would indeed pose a problem for proper installation and/or verification of fireproofing. Other consultants noted that the Fire Sub thought it was unusual for a building to be enclosed by studs and sheathing prior to fireproofing. Furthermore, the GC seemingly did not collaborate with the Fire Sub to ensure the instructed adjustments to the stud walls would not impact their work.

## PROPANE TANK EXPLOSION
Due to the issues encountered during earlier phases of construction, the pouring of a large concrete slab at the site was delayed well beyond its original schedule. As a result, the slab was poured during the winter months and therefore required a temporary propane heating setup to maintain adequate concrete temperatures to facilitate appropriate curing. The heating setup was comprised of sets of 1,000-gallon liquid propane tanks plumbed together in series, each feeding its own vaporizer that subsequently supplied gaseous propane to inline heaters.

The tanks were placed on the frozen ground with wood cribbing for stability. Once stabilized, the tanks were plumbed together with copper piping. Unfortunately, once the tanks were in place and plumbed together, a rise in ambient temperature caused the previously frozen ground to thaw and become prone to settlement; this led to individual tanks shifting relative to one another, creating the potential for a breach of the copper piping and thus an unintentional release of propane. The subcontractor responsible for the temporary heat noticed that the ground had become unstable due to the thawing and settling of the ground and began adjusting the tanks' wooden support cribbing on a daily basis to re-stabilize the tanks.

While the temporary heating setup was in use, a severe injury occurred elsewhere on the job site. As a result, the GC halted work and vacated the site except for essential personnel for several days during the OSHA investigation. The GC continued to leave the propane heaters operational during this period, as the concrete had just been poured and it would be ruined if its temperature dropped below the acceptable range for curing. Without anyone continuing to monitor and restabilize the propane tanks as needed, approximately 30 hours later, one of the propane tanks shifted in a manner that breached the copper piping. This resulted in the formation of a large propane cloud which spread and eventually ignited when it reached the pilot light of the nearby vaporizers. The heat from the initial fire ultimately caused several of the other propane tanks to explode in a process known as a boiling liquid expanding vapor explosion (BLEVE). As the construction site was mostly vacant and there was no safe way to contain the fire, the fire department allowed the fire and series of tank explosions to continue unmitigated until all the propane was consumed and the fire self-extinguished. This resulted in significant thermal damage to adjacent areas under construction and further delays.

**Breakdown in the Three Cs**

First, had prior construction delays stemming from inadequate coordination and collaboration not occurred and the concrete slab been poured on schedule during warmer months, temporary heating may not have been necessary. Further, after the temporary heating setup was installed and operational, the subcontractor knew there was an issue with ground instability but did not adequately communicate this to other stakeholders on site, including the GC. As a result, the GC did not know that it needed to allow the subcontractor back on site during the OSHA investigation to monitor and restabilize the propane tanks as needed. The subcontractor incorrectly assumed that the propane tanks were shut off and the heating process was halted during the OSHA investigation, so it did not realize it needed to continue to monitor and adjust the tanks. Had the GC and subcontractor appropriately communicated, coordinated, and collaborated in the aftermath of the unrelated job site injury and subsequent investigation, the propane tank explosion could have been avoided.

## PROJECT DELAYS

From the onset, the project was plagued with delays stemming from the GC's inability to properly plan the work and communicate their plan to the various stakeholders. The project schedule is an effective management and communication tool to keep all the stakeholders updated on the project's progress. Not only did the GC fail to produce accurate and reliable schedule updates, but they also failed to provide accurate real-time information to the subcontractors in team meetings, which ultimately led to numerous delays. The project was delayed by over a year due to the dimensional control issues that in turn delayed the steel erection.

The GC's gross mismanagement of the work and their failure to communicate, coordinate and collaborate with the project stakeholders was exacerbated following a propane heater explosion which halted the work onsite for months (see previous discussion). Due to the remote location of the project, most of the subcontractors had hired labor from neighboring states, which resulted in the project incurring labor costs even though the work onsite was suspended. Instead of proactively collaborating with the subcontractors to develop mitigation plans and action items to minimize the delays and disruption resulting from the explosion, there was little to no communication between the GC and the subcontractors during the work suspension period.

Due to the lack of planning and clear direction from the GC, the explosion-related impacts affected the subcontractors' performance for months after the resumption of work. Work inefficiencies caused by the access restrictions and late mobilizations exacerbated the delays. Additionally, a majority of the envelope work that was planned to be performed in the summer months was pushed to the winter work period due to the explosion. This resulted in further delays and loss of efficiency. The GC was eventually terminated for its lack of adequate performance. Had the GC facilitated an open line of communication to foster collaboration and coordination between the stakeholders, the outcome of the project may have been very different.

## CONCLUSIONS

Proper communication, coordination, and collaboration are paramount for the success of any construction project. Ensuring that all stakeholders, including, e.g., owners, design professionals, general contractors, subcontractors, and suppliers are kept up to date on the project helps to promote efficiency. This paper explored one such example of a breakdown in the Three Cs that led to a myriad of cascading problems on the job site. Ultimately, when a project team member indicates a potential issue on site, especially one with potentially cascading implications, the issue should be brought to the attention of all relevant parties such that a least-objectionable method of correction can be considered. That is, the project management should not sit back and just hope for the best.

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