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# Localized Supply Chain Disruptions: A Case Study on the Effects of the COVID-19 Pandemic on a Commercial Roofing Project

**Matt Klimm, Rodolfo Valdes-Vasquez, Ph.D. and Erin Arneson, Ph.D.**
Colorado State University
Fort Collins, CO

The COVID-19 pandemic has highlighted the vulnerability of supply chains to unexpected disruptions, including the construction industry procurement process. Construction projects face new challenges arising from these disruptions of material supply chains. As disruptive events continue to occur, there is a need for construction professionals to collaborate to understand the workings of local material supply chains. This study seeks to examine one of these supply chains from the perspective of a commercial roofing system. A case study approach focusing on a thermoplastic polyolefin (T.P.O.) system is used to determine if any supply chain disruptions affect this roofing system in Colorado during the COVID-19 pandemic. This case study focuses on a local project, drawing upon previous research, project documents, and interviews with key project stakeholders to better grasp what impacts affect the supply of T.P.O. roofing systems in the state. Discussions with project stakeholders also reveal potential roofing supply chain impacts outside the scope of the T.P.O. system. This study provides insight into the varying degrees to which the construction industry is experiencing material supply disruptions and project cost impacts because of the pandemic. This study shows how the complexities of a crisis are likely to impose challenges on material supply chains.

**Key Words:** Roofing system, Supply chain, Case Study, Thermoplastic polyolefin (T.P.O.)

## Introduction

The full impacts of the COVID-19 pandemic on the construction industry are starting to be discovered. Many aspects of the construction process have changed to adapt to varying health concerns. Social distancing, and the resulting limitations on the number of people permitted on jobsites, is challenging an industry that relies heavily upon on-site collaboration (Jones Lang LaSalle, 2020). Construction material suppliers are not excluded from these heath adaptations. Many of the factories that produce these materials temporarily closed due to COVID-19 (LaSalle, 2020). Because of factory closures, many construction materials have extended lead times. Material supply chains are already highly susceptible to disruptions (Pradhan and Arneson, 2021). COVID-19 has added another layer of complexity.

The potential for disruptions in material procurement is concerning. These disruptions can continue for extended periods and disseminate to other supply chain tiers and links, in a ripple effect (Ivanov et al., 2014). Delays in materials could negatively impact the success of construction projects. As such, developing an understanding of localized supply chains is likely a beneficial course of action to prepare strategies to respond to future disruptions. This study seeks to offer a framework for researching and understanding the mechanics of local construction material supply chains through commercial roofing materials. Installation of a roofing system is a major milestone in a construction project. Failure to finish a roof on time can impact the construction schedule. This system was deemed an important starting point to examine localized construction supply chains and their potential for disruption.

A commercial T.P.O. roofing project in Larimer County, Colorado, was selected for a case study analysis to understand the localized commercial roofing supply chain's mechanics and impacts resulting from COVID-19. Specifically, has COVID-19 impacted the supply of the T.P.O. roofing systems in Colorado? Secondarily, are there any additional concerns the pandemic has raised for the region's supply of commercial roofing systems? To answer these questions, the focus was first placed on analyzing literature on supply chain frameworks. Conclusions from this analysis were used as a basis for the remainder of the study. Researchers took these frameworks and used them to develop semi-structured interviews with key roofing stakeholders on the case study project.

## Background

Since the onset of COVID-19, widespread awareness of global supply chain vulnerabilities has been pushed to the forefront of business conversation (McKinsey Global Institute, 2020). Supply chains have globalized, and disruptions are more commonplace. Disruptions lasting a month or longer are expected to occur approximately every four years, with the most severe events resulting in financial losses (Lund et al., 2020). The cause of disruptions is hard to predict. Severe weather, fluctuating manufacturing capabilities, and infectious diseases are just a few (Pettit et al., 2013). To combat these uncertainties, industries are starting to address challenges with technology. Technological solutions integrate real-time tracking of supply chain components, inventory levels, weather conditions, and transportation delays (Lund et al., 2020). Manufacturers, suppliers, and distributors use this data to adjust as disruptions arise (Ekanayake et al., 2020).

Drawing upon studies and technologies from other sectors proves useful to provide frameworks for further examination, as there are limited studies explicitly focused on construction supply chains' concerns. The research focusing on construction supply chains is useful in providing context into this complex system's nature. Construction supply chains can be defined as an integrated series of processes and businesses that work together to provide a forward flow of materials, labor or services, and facilitate resource sharing within regional construction industries (Arneson et al., 2016). These supply chains are composed of many interconnected companies often spread across vast geographical areas (Arneson et al., 2020), with hundreds, if not thousands, of actors engaged in short-term contractual relationships (Badi & Murtagh, 2019).

Additional construction supply chain research has previously examined the effects of other unplanned events, such as natural disasters, on regional construction supply chains. Much like the current pandemic, disasters can temporarily influence how supply chains operate (Arneson et al., 2020). Natural disasters can increase demand for various construction materials almost overnight. The pandemic appears to affect supply chains similarly, impacting construction industry supply and demand, referred to as 'construction capacity.'

Construction capacity is defined as the regional construction industry's maximum building volume with available resources (Arneson et al., 2016). Shutdowns during the pandemic stopped or slowed manufacturing output (Jones Lang LaSalle, 2020). This capacity influenced the flow of available resources to various regions. Disruptions anywhere along the chain of resources can impact the final product on the jobsite. Therefore, it is vital to understand that individual construction companies' ability to supply services is directly tied to a more extensive network of resources from the supply chain (Arneson et al., 2020).

Previous construction supply chain research on post-disaster construction has examined the construction supply chain's impacts on a macro level (Arneson et al., 2016). However, there appears to be limited research into micro-level, material-specific supply chains within specific regions. By understanding the challenges of producing different construction materials, further macro-focused research can draw from scope-specific studies (Arneson et al., 2016). For example, the supply chain for a specific membrane roofing system may be relatively localized, while an asphalt shingle system could be much more complex. Understanding these implications is likely beneficial for future research and construction managers across a variety of project types.

As the previous discussion implies, there is a need to conduct material-specific supply chain research in the construction industry. Hence, this study seeks to evaluate a specific roofing system's supply chain and aims to provide a framework to understand localized, material-specific supply chains in the construction industry through a commercial roofing project case study.

## Research Design

A case study was used as the research technique. Access to a local commercial roofing project, including specifications and personnel, made this a logical method, considering the study's objectives. An overview of the research process is provided below:

- Literature Review – Understand previous research and supply chain frameworks.
- Case Study Identification – Select a local project with easy access to key stakeholders and project documents.
- Analyze Project Documents – Analyze roofing plans and specifications to identify the primary system materials.
    - Determinations of primary materials made based on coverage and function.
- Supply Chain Analysis
    - Interview Project Stakeholders – Conduct guided, semi-structured interviews with the project's roofing subcontractor and the primary material supplier.
    - Analyze Results – Compare and contrast responses from stakeholder interviews.
    - External Validation – Share results with a second roofing subcontractor, not associated with the case study project. Ask to confirm findings from interviews.

### *Case Study Identification*

The first objective of the case study approach was to select a commercial roofing system to analyze. The system needed to have widespread use amongst commercial applications to obtain the best results. A single-ply T.P.O. membrane was chosen as this system accounts for about a quarter of all commercial contractors' sales (Martin, 2017). A local construction project in Larimer County, Colorado, incorporating a T.P.O. system was then selected due to the accessibility of documents and

roofing personnel. The general contractor was able to provide these documents and introduce the research team to the roofing subcontractor.

## *Analyze Project Documents*

To understand the roofing system's characteristics, the researchers analyzed the roof drawings, details, and manufacturer literature. The objective of this step was to identify primary components of the T.P.O. system as listed below in Table 1 (listed in no particular order). Researchers created a list of system materials and narrowed them down to the top 10 items, based on function and area coverage. Figure 1 below provides a further visual representation of these roofing materials, based on project details. The approximate area of the roof is 18,000 SF, costing approximately $13.30/S.F. The T.P.O. membrane is adhered to a coverboard product, consisting of glass mat-faced ¼" fire-resistant gypsum panels. This sits on a layer polysocyanurate, which sits on a metal deck.

Table 1

*Primary T.P.O. Materials*

| Key | Material Name | Category |
|---|---|---|
| 1 | T.P.O. Membrane, 60-mil | Membrane |
| 2 | T.P.O. Bonding Adhesive | Adhesive |
| 3 | Roof Board | Coverboard |
| 4 | Polyiso Insulation | Insulation |
| 5 | Fasteners & Plates | Accessories |
| 6 | Metal Coping System | Accessories |
| 7 | Flashing | Accessories |
| 8 | Mastic Adhesive | Adhesive |
| 9 | T.P.O. Walkway Rolls | Accessories |
| 10 | Fastening Accessories | Accessories |

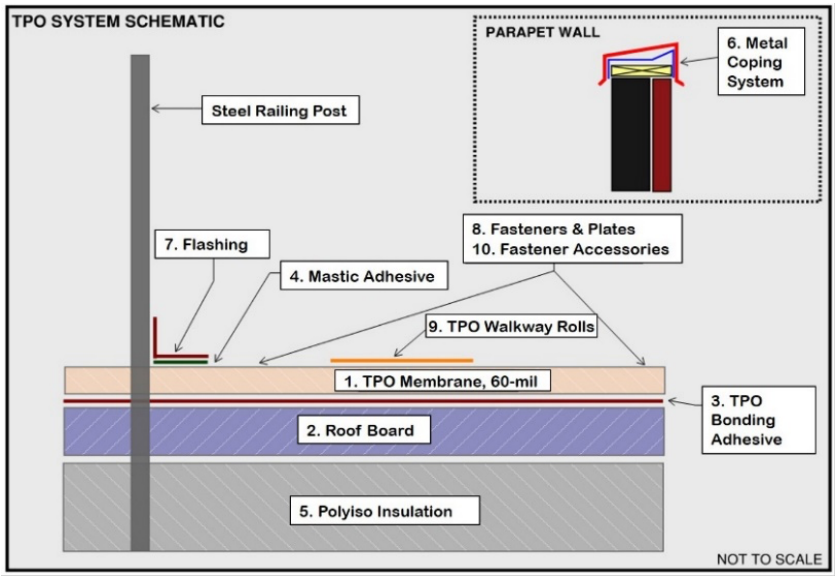


Figure 1. T.P.O. System Schematic

## *Supply Chain Analysis*

A 30-45 minute phone interview was scheduled with (2) stakeholders, including the case study project's roofing subcontractor and material distributor. The roofing subcontractor representative has over 20 years of roofing estimating experience, working at a top state contractor, and is familiar with the commercial roofing business in the area. The roofing distributor has a similar experience, working with a larger, national distribution firm. These individuals were selected because of their direct involvement in the case study project. A questionnaire was sent out to both individuals before the interview. This questionnaire was linked to a form, which was the means of collecting this qualitative data. Both questionnaires had the same number of questions related to the same topics. However, each interview was framed to gather the unique perspectives of both parties best. Table 2 provides a summary of the types of topics discussed.

Table 2

*Interview Discussion Topics*

| **Topic** | **Topic Description/Questions** |
|---|---|
| Roofing Materials | Please review the (10) T.P.O. materials (see Table 1) and confirm if they are primary components of a T.P.O. system?. Based on your experience, identified key players involved with each material and any disruptions. Are any additional roofing materials experiencing supply chain impacts? Have you experienced any delays or cost impacts (escalations) associated with these products? Who are your suppliers on each of these products? |
| Pandemic Impacts | Subcontractor topics of discussion focused primarily on labor and project delays. Distributor topics concentrate on labor and delays from manufacturers. Do you foresee any impacts over the next 12-24 months with any roofing products you install? How has the pandemic impacted your labor force? Is your organization better or worse off in terms of finding qualified labor to complete projects? Have you experienced any delays in projects you have been a part of? Has this impacted your operations? |
| Supply Chain | Topics of discussion included identifying key locations in the supply chain and inventory levels to gain a high-level understanding of the local supply chain capacity in Colorado. Could you describe the supply chain of a T.P.O. system in this region? Who are the main providers of materials, and where are they coming from? |
| Adaptability | Discussion of steps either taken in the past, currently being taken, or planned for in the future to address ways to increase each company's adaptability when responding to supply chain disruptions. |

Upon the completion of the interviews, both forms were compared side-by-side to determine patterns and discrepancies. A bulleted synthesis of the major conclusions for each topic area was then created.

A third-party subcontractor (not associated with the case study project) was then asked to review the bulleted list of conclusions. This third-party individual is the president of another major local commercial roofing company, performing projects across multiple states and over 18 years of experience. This third-party subcontractor was asked to review the list and confirm or disagree with the conclusions.

## Results and Discussions

The interviews provided crucial insights into the commercial roofing industry in Colorado. The results outlined below are structured into three primary sets. The first set of results focuses on mapping the supply chain in the region. The second set of results provides the roofing materials' supply chain impact, specifically related to the T.P.O. system. The third set gives an overview of results highlighting challenges and opportunities facing the region's commercial roofing industry.

### *Mapping the Regional Roofing Supply Chain*

The basis of this case study is to examine the localized commercial roofing supply chain within Colorado, specifically concerning impacts from the COVID-19 pandemic. Denver is one of the primary distribution hubs for the Mountain West (Colorado Office of Economic Development and International Trade, 2020). As such, it was found that much of local roofing materials are shipped to stockyards in Denver, before being distributed further to smaller communities in the area. T.P.O. roofing products are shipped by truck from the manufacturer to Denver. Figure 2 provides a high-level overview of the supply chain's geography. Manufacturer Zones represent the general region where products for this T.P.O. system are manufactured.

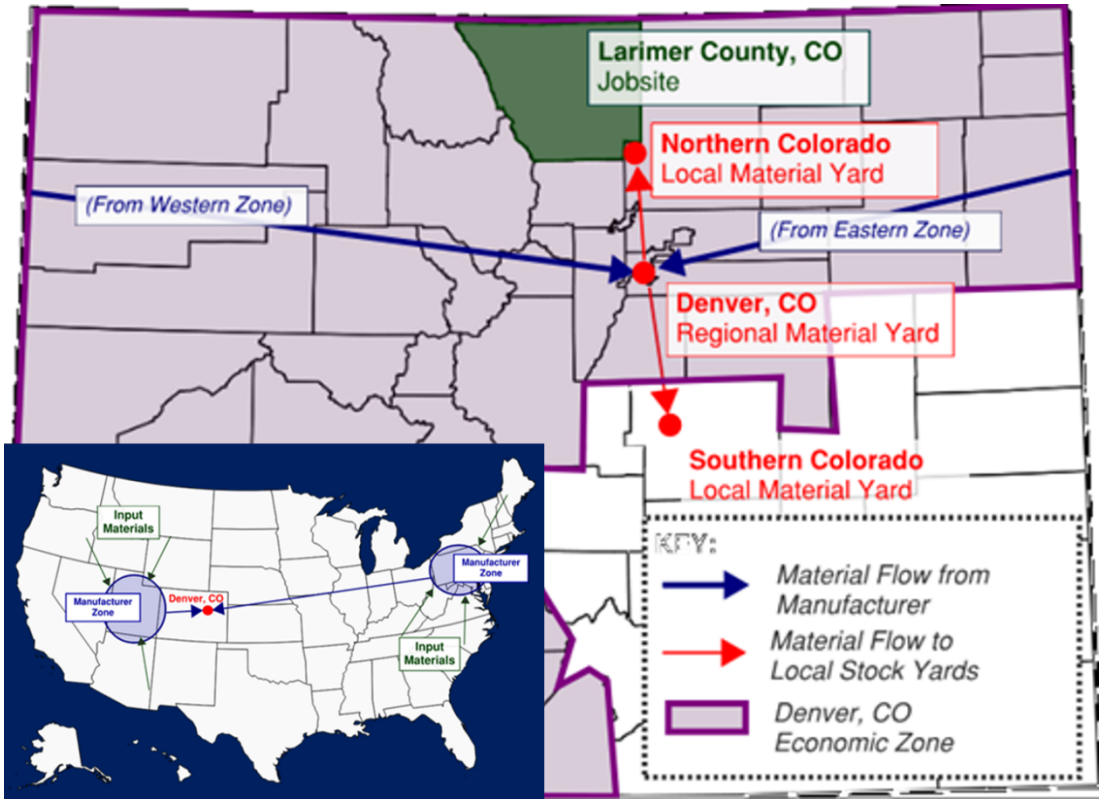


Figure 2. Regional Supply Chain

In this case study, the roofing subcontractor procured materials from the distributor. The distributor was then responsible for delivering these materials from their stockyards to the case study site.

## *T.P.O. System Supply Chain Findings*

Upon conclusion of the interviews, a clearer picture of the T.P.O. system supply chain to the case study project and the Denver market emerged. First, the ten primary materials identified in Table 1 were confirmed to be critical components of the system. Table 3 outlines the major and minor components, in addition to details regarding impacts associated with procurement.

Table 3

*T.P.O. Material Analysis*

| **Material Name** | **Category** | **Impact Overview** |
|---|---|---|
| T.P.O. Membrane, 60-mil | Membrane | Larger quantities of these materials are used on projects. As such, these typically trade more as a commodity, making more frequent price fluctuations possible. |
| Roof Board | Coverboard | |
| T.P.O. Bonding Adhesive | Adhesive | |
| Mastic Adhesive | Adhesive | |
| Polyiso Insulation | Insulation | |
| Metal Coping System | Accessories | Typically, smaller quantities are ordered for projects, thus typically less of an impact. Price escalations typically match inflation. |
| Flashing | Accessories | |
| Fasteners & Plates | Accessories | |
| T.P.O. Walkway Rolls | Accessories | |
| Fastening Accessories | Accessories | |

As displayed in Table 3, the membrane, coverboard, adhesives, and insulation are primary components of the T.P.O. system and were found to have more frequent pricing fluctuations during the installation process. The accessories, typically ordered in smaller quantities, have more consistent pricing increases based on year-over-year inflation - which was around six to seven percent annually. None of the products outlined in Table 3 experienced any major supply chain disruptions due to COVID-19 at the time of this study. The only potential issue was the production of a facer for the T.P.O. membrane, due to chemical supply issues.

## *The Regional Roofing Supply Chain Findings*

Limited impacts from COVID-19 were found to be associated the T.P.O. system. Further discussions during interviews revealed negative impacts on other roofing materials. One such material, identified by both the subcontractor and distributor, was lumber. Plywood was identified as one key material that interfaces with commercial roofing systems and was severely impacted by a lumber price escalation. The plywood price increased approximately thirty-five percent between January and November 2020, setting an all-time high purchase price (U.S. Bureau of Labor Statistics, 2021a).

Asphalt shingles were another disrupted material. COVID-19 resulted in many shingle plants shutting down, radically decreasing supply. Simultaneously, seasonal summer roofing demand and severe storms in Louisiana and Texas increased demand for asphalt shingles and drove up prices (U.S. Bureau of Labor Statistics, 2021b). Shingles are expected to continue to pose problems in the coming months. Inventory levels are low while demand remains high, and asphalt shingle prices continue to fluctuate up to five percent monthly (U.S. Bureau of Labor Statistics, 2021b). Based on these

findings, as soon as a potential project enters the pipeline, general contractors should connect with roofing subcontractors to get an up-to-date picture of the supply chain and product lead times. Discussions should be privy to weather-related disasters and pandemic production impacts, in addition to material availability and price escalations. Taking this proactive approach may lead to reduced risks from procurement delays.

To adopt ahead of potential future supply disruptions, both the subcontractor and distributor had solutions. From the subcontractor's perspective, adding new product offerings, such as metal panel installation, was viewed as the best way to hedge against a downturn by providing diversified income streams. From a distributor perspective, adaptability focused on growing stockpiles of materials to meet demand. The third-party subcontractor further confirmed the interviews' findings, reflecting low concern for T.P.O. systems and more serious concern for asphalt shingles. This roofing contractor mentioned that they experienced additional costs-related safety issues, including personal protective equipment (masks, sanitizing chemicals), operation failures (lifting materials and uncomfortable working conditions), and lower productivity associated with maintaining social distancing. These comments align with other studies' findings (McKinsey Global Institute. 2020 & Ekanayake et al., 2020).

## Conclusion

This case study found that the T.P.O. roofing system's supply chain in the Denver, Colorado region was not critically affected thus far because of the COVID-19 pandemic. However, other roofing systems, including asphalt shingle products, were found to have more critical impacts. Price escalations remain a concern in the future, as material shortages onset by reduced production levels leads to higher costs. Increasing procurement complexity continues to introduce risk for construction projects. Promoting knowledge of the challenges associated with different materials could provide construction professionals with a toolkit of resources to make better procurement decisions. In addition, paying attention to natural disasters throughout the country and any localized pandemic-induced shutdowns could prove beneficial. Knowing these activities may induce additional demand provides a reasonable basis for discussion with potential subcontractors regarding the availability of materials and likely price escalations.

Simple steps could lead to significant reductions in risk. Incorporate lead-time questions into a request for proposals (R.F.P.s). Have discussions with potential trade partners ahead of contracting regarding both material impacts and health measures being followed. Actions such as these are simple yet could provide reduced risk later in a project. Understanding roofing materials alone will likely take a significant amount of continued effort. However, further research into different systems will only add to the general knowledge base. This case study provides a specific sample of the larger whole. The results support the need for broader, industry-wide collaboration to understand local material supply chains' structure. It provides a potential framework for further research of other material supply chains and aims to promote industry discussion to share knowledge and build resiliency against future disruptions.

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