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NOT IN THE PLAYBOOK

Navigating Global Supply Chain Disruption &

Material Price Volatility in Construction

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The ready availability of construction equipment and the materials used to construct projects is critical to construction-project delivery worldwide. Whether by pandemic, inflation, war, protective tariffs, or increased competition for a finite supply, scarcity of parts and materials, and their price volatility have triggered project delays — and worse still — project cancellations. Constructors are dealing with vendors who refuse to hold prices firm for any longer than short windows. Designers have become the judge of constructors' extra cost claims stemming from skyrocketing material costs or delivery delays in mid-project. Battles and finger-pointing have erupted over spiraling project delivery costs that, while recognized as possible at the outset, were beyond anyone's capacity to accurately predict. This paper explores the causes of and reaction to the supply chain disruption and the chaotic price spikes of construction materials.

A. Inventory Management 101: Supply Chain Basics

The Oxford English Dictionary defines "supply chain" as that series of processes involved in the production and supply of goods from when they are first made, grown, etc. to their final destination. While there are as many supply chains as there are products that flow through the marketplace, we cannot understand supply chain disruptions cannot without first understanding some basics about inventory management.

a. Toyota & "Just-In-Time" Production

Following World War II, Toyota set about to become a competitor in the American automotive industry. Taiichi Ohno, an industrial engineer with Toyota, developed what is today known as the Just-In-Time (JIT) production model. While Toyota prefers to call it the "Toyota Production System" (TPS) Ohno recognized that Toyota faced myriad production constraints, most notably limited resources, in post-WWII Japan. Ohno began developing a manufacturing system based on a rate of production that matched demand. Presumably, observing an American supermarket, where a customer took the desired amount of goods from the shelf and the store restocked with just enough to fill the space, inspired JIT.

The central objective of JIT is manufacturing only what is needed, when it is needed, and the amount needed. Achieving this objective hinged on eliminating excessive production resources, overproduction, excessive inventory, and unnecessary encumbrance of associated capital investment. Toyota was able to minimize its inventory and thereby slash warehouse space and reduce unnecessary cost-carrying and improve efficiency. Additionally, reduced inventory limited risk if defects or design changes in stocked parts later came to light in . Fewer stocked parts with defects meant fewer such parts requiring rework or relegation to the scrap heap.

In a 1985 paper on inventory control in manufacturing, R.C. Estall offered a stark example of the contrast between the Toyota's operations under a JIT production model and General Motors' production practices General Motors. He noted that in 1984, GM had 3,500 suppliers compared to 225 for Toyota. Moreover, GM maintained five days of inventories valued in 1982 dollars at $5 billion, whereas inventory procured on a daily basis fed Toyota's assembly lines[1]

While JIT's strength is being lean, avoiding masses of stocked inventory, and anticipating demand, the system's weakness stems from a lack of flexibility to absorb demand shocks that can arise either internally or externally to the manufacturer's operations. An internal manufacturer operation includes Ford's recent experienced inabilitye to procure computer chips for tens of thousands of its reintroduced Bronco models. With no chips for the assembled vehicles, Ford had to park Broncos in scores of open fields in

[1] R.C. Estall, *Stock control in manufacturing: the just-in-time system and its locational implications*, Department of Geography, London School of Economics and Political Science, *Area* (1985) Vol. 17.2, 129-133.

and around suburban Detroit. Factors external to the supply and production chain — such as natural disasters, a cyber attack, or worse still, a pandemic-triggered lockdown — can also upend a JIT-organized production system. On May 6, 2021, the Colonial Pipeline Company became the target of the largest publicly disclosed cyber attack against critical infrastructure. The Colonial pipeline system is comprised of more than 5,500 miles of pipeline that supplies nearly half of the refined oil for gasoline, jet fuel, and home-heating oil to the eastern seaboard. A hacker group, DarkSide, which purportedly operates out of Eastern Europe, was able to access Colonial's network and stole some 100 gigabytes of data within a two-hour period. Using that data, DarkSide's hackers infected the Colonial IT network with ransomware. To prevent the infection's spread, Colonial shut down the pipeline. The shutdown triggered immediate supply shortages, panic buying, and price spikes. On May 7, Colonial paid $4.4 million, or 75 Bitcoin, to the hackers, and on May 12, Colonial restored operations. In early June, the Justice Department found the digital wallet of the hackers and was able to recover about half of the value of the Bitcoin ransom payment.

JIT-based production also tends to promote sole-supplier relations, which puts a company at heightened risk if that supplier cannot fill orders. One of the most prominent and recurring observations about supply chain disruption is the need to expand and diversify supplier relationships so that no single supplier's inability to deliver becomes a critical choke point.

b. Just-In-Case Inventory Management

Recent shocks to the supply chain, from whatever source, have prompted a rethinking of JIT and a consideration of moving away from the lean inventory practices central to the JIT framework. Unlike JIT, a Just-In-Case ("JIC") production model is not driven by product demand but by the aim of achieving maximum production flexibility. Under a JIC model, excess inventory is kept on hand to avoid supplier delays and to enable a production surge in the event of an unforeseen spike in demand.[2]

[2] https://www.netsuite.com/portal/resource/articles/inventory-management/just-in-time-vs-just-in-case.shtml#:~:text=direct%20procurement%20costs.-,Disadvantages,30%25%20of%20total%20inventory%20value.

Just-in-Time vs. Just-in-Case: What's the Difference?

Just-In-Case	Just-In-Time
A "push" system where inventory purchases are not based on actual current demand.	A "pull" system where inventory is essentially purchased to order.
Focuses on maximizing flexibility with less concern for capital application.	Focuses on minimizing inventory and using capital efficiently.
Excess inventory is kept on hand to avoid running out due to supplier delays or demand spikes.	Inventory is purchased only to meet immediate production or sales needs.
Companies generally make larger, more expensive inventory orders	Less working capital is required because inventory purchases occur in smaller batches.
Valuable when demand is unpredictable or suppliers are unreliable.	Works best when demand is stable and suppliers are highly dependable.
Demand forecasting is less critical as long as there is enough inventory to meet the highest demand.	Requires accurate demand forecasts to avoid over- or under-buying inventory.

B. Unique Supply Challenges in the Construction Industry

a. Complexity of Construction

Unlike manufacturers, constructors face a litany of unique supply and procurement challenges, many of which are driven by the nature of construction itself. By its nature, the construction process typically involves site-based, one-off design that is often delivered through fixed-price contracting with a highly fragmented supply chain. Contractors are, at least in some degree, at the mercy of designers who specify the materials used and maintain control of alternates. While design/build teams and value engineering can limit or reduce the impact of material specification, the preferences of owners and factors unique to the building site likewise influence the wide variation in building material selection.

Design and construction also involve layers of regulatory compliance, building performance, and sustainability constraints many local building codes madate. On federal projects and those involving federal funding, government mandates requiring the use of American-made materials further burden the approval and delivery process.. The Infrastructure Investment and Jobs Act (IIJA; P.L. 117-58), enacted in November 2021, made changes to “Buy America” requirements for federally funded infrastructure projects. The BAA applies to all contracts for the construction, alteration, or repair of any public building or public work in the United States.

The BAA requires contractors to use only domestic construction materials in all construction contracts unless an exception applies. Construction materials include all articles, materials, or supplies that a contractor or subcontractor brings to the construction site and incorporates into the building or work.

b. A Multi-Layered, Longer Supply Chain

By its nature, construction involves long, dynamic supply chains imbued with significant uncertainties, especially related to finance and payments.[3] Typically, the construction industry has lengthy, network-structured, dynamic supply chains rather than short, vertical supply chains. AnThe fragmented, multi-layered configuration of the constructor group — with a prime or multiple prime contractors at the top and layers of subcontractors and sub-subcontractors and each of their suppliers flowing materials to the project — also constrains the construction material supply chain. One disruption in supply at any given level of the pyramid can quickly cause ripple effects in the project's critical path.

The construction supply chain is inherently longer because of the substantial lead times for off-site manufacture of specialized materials; namely, pre-stressed concrete components, structural steel, pre-engineered trusses, extruded metal components, and specially fabricated HVAC components, etc. Lead times connected with these specially manufactured materials have always constrained the construction supply chain, but supply chain disruptions manufacturers encounter procuring raw materials now compound the issues.

c. Stockpiling Has its Limits

The sudden onset of material shortages during the pandemic triggered all manner of hoarding, warehousing of masses of inventory and soaring price increases. As reported in a February 23, 2022, article in *ConstructionDive*, contractors quickly began jockeying for supplies ahead of competitors and were forced to make cash purchase before price quotes expired within just days of an order.[4] To store their hoards, they then rented or built warehouses. In time, "ghost orders" placed merely to lock down materials led to producers rationing to preserve relationships with loyal customers.

But the notion that we can mitigate construction supply chain challenges simply by stockpiling inventory is largely unworkable for contractors. Most notably, only finished, recurring-use materials can be effectively stockpiled. PVC pipe, adhesives, insulation, metal bar joists, roofing materials, some dimensional lumber, and even certain fixtures might make sense to stockpile, but mass stockpiling of building materials carries substantial risk, requires substantial carrying costs, and stockpiling of materials flies in the face of traditional lean inventory management practices. Moreover, project-specific, specially manufactured components can't be stockpiled at all.

C. Crimps in the Chain - the Pandemic and Many Other Factors

a. Pre-Pandemic Supply Pressures, Onset of Covid, & the *Bull Whip* After Effect

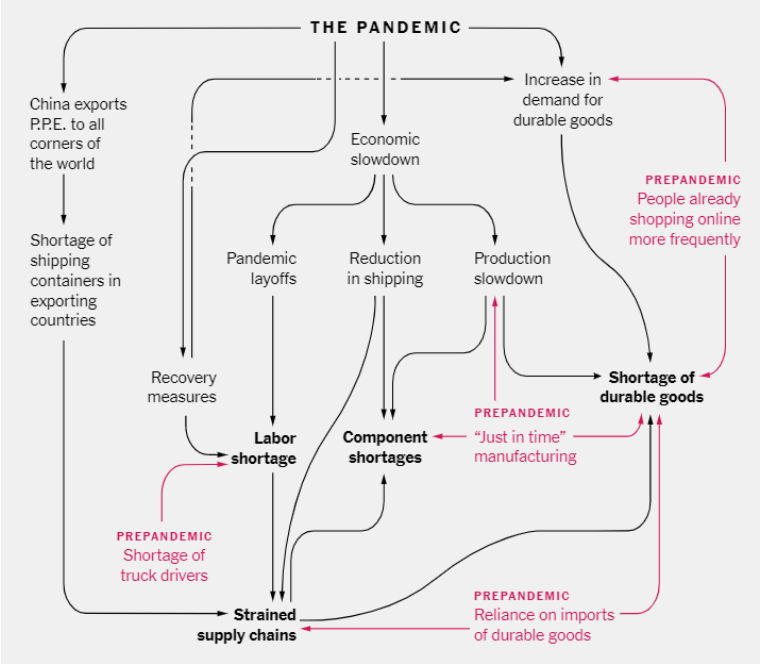
While supply chain disruption is largely attributed to the pandemic, material supply problems were affecting the construction supply chain well before the pandemic struck. These factors ran the gamut from increased demand for a finite supply as a result of emerging third world economies to trade wars and tariffs. Since the 1980s, the U.S. construction industry has become more dependent on materials produced in Southeast Asia. In the U.S., about 30 percent of all building materials imported come from China alone. That shift did not come without substantial risk that manifested during the pandemic — the

[3] *Blockchain and Smart Contracts: A Solution for Payment Issues in Construction Supply Chains*, Samudaya Nanayakkara, May 27, 2021.
[4] *Hoarding, Ghost Orders and Pop-Up Warehouses: Construction's New Supply Chain Playbook*, by Joe Bousquin, ConstructionDive, February 23, 2022.

risk stemming from far larger transportation logistics with suppliers located across the Pacific Ocean.

As the Covid pandemic spread through Asia, factories that produced materials shut down, and in time, similar shutdowns occurred around the globe. China began to pivot away from shipments of consumer goods to shipments of personal protective equipment and other products to contain the spread of Covid. That export shift diverted cargo containers away from the construction industry.

Throughout the pandemic, cargo ships from Asia continued to arrive at the ports of Los Angeles and Long Beach where 40% of shipping containers enter the U.S. Because of labor shortages and limited warehouse capacity, those shipped containers sat moored for weeks on end. The chart below provides a broad overview of the dominos that fell in the international supply chain once Covid shutdowns occurred.



At the onset of Covid, many thought the pandemic would stall demand for critical construction supplies such as wood. But t few economists or forecasters foresawg was a pandemic-induced migration that spiked demand for residential construction as homeowners decided to renovate and/or expand their houses during lockdown. Others left major urban centers indefinitely, resulting in a demand for housing nowhere near its supply.

What's more, the federal government almost immediately deemed the construction industry an "essential" business after the pandemic began. So as other industries cut back or stalled production entirely, in the U.S. — and most other countries —, jobsites kept on humming with enhanced safety protocols in place, keeping demand for building materials high but supply tight.

As Covid eased and factory production and shipping began to resume, the daily arrival of cargo ships overwhelmed an industry that was already weathering depleted port, trucking and rail transportation capacity and which had experienced pre-pandemic labor shortages. The U.S. facied a truck driver shortage even before Covid, but the nationwide shutdown slowed commerce and resulted in many drivers resorting to unemployment. That lack of drivers, which persists, has led to higher shipping rates. Even if ships were able to unload, limited warehouse facilities could not accommodate the influx of

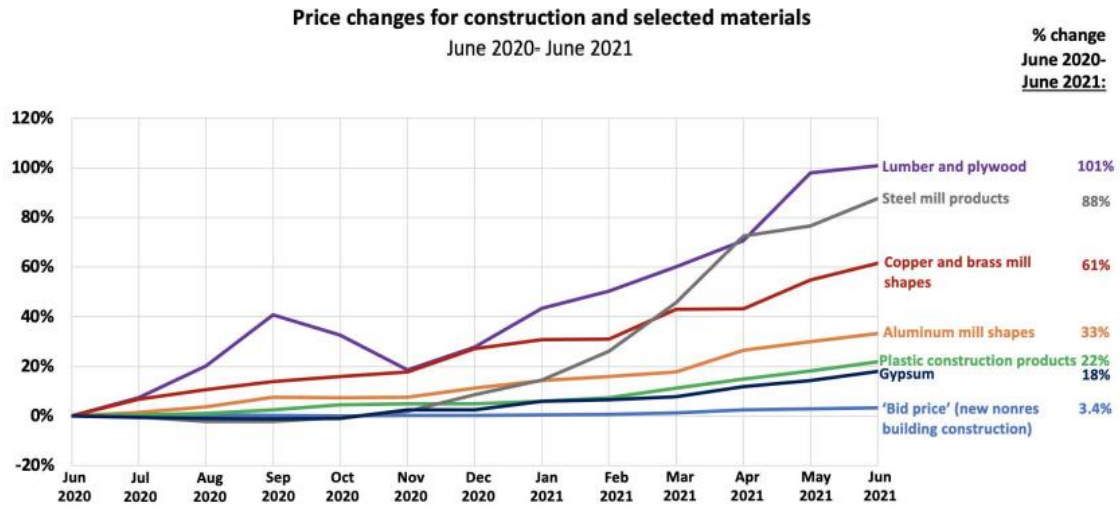
shipments.

Forecasting demand is critical to inventory control and to the underlying management of a business' supply chain. The "bullwhip effect" is a phenomenon triggered by fluctuations in any link in a product supply chain, usually at the demand end. When demand fluctuates, those changes can reverberate up the supply chain and trigger reactive supply distortions. In a simple example, if a paint contractor who regularly purchases a thousand gallons of paint places an order for 2000 gallons of paint, that surge in demand triggers reactions throughout the supply chain. The paint vendor places an order for twice its regular stock of paint, which in turn triggers increases throughout layers of discrete supplier orders. The paint company's can, pigment, and labeling suppliers all increase their inventory to meet anticipated sales of twice the normal volume of paint. The bullwhip effect can also occur on the supply side. Within the construction industry, supply shortages during the pandemic triggered runs on virtually all categories of building materials, with lumber and roofing materials leading the way.

To mitigate bullwhipped supply chain distortions, businesses must understan their supply chains and the causes of demand fluctuations. Forecasting must become more refined by using technology: For instance, myriad software companies are now promoting supply chain management software that provides real-time data on supply and demand fluctuations. Presumably, this more thorough and timely data enables businesses to forecast better demand and manage inventory and supply lead times, and it provides more reliable analysis of the root causes of supply and demand fluctuations. Streamlining product supply chains can remove links in the chain and thereby reduce the total number of opportunities for supply chain disruption.

b. Construction Materials Supply Specifics: Lumber, Ductile Iron Pipe, Cement

As if supply alone were not enough of a challenge, the cost of available materials has skyrocketed, and the recent spike in fuel costs is further driving increases. The chart below illustrates theprice volatility of six common construction materials and compares them against the incredibly modest increase in bid prices over the same period.



Source: Bureau of Labor Statistics, producer price indexes (PPIs) for new nonresidential building construction (bid prices), gypsum products, wood, metal products, and plastic products, not seasonally adjusted

According to a May, 2022, price report by AGC economist Ken Simonson, construction supply costs rose across the board, with increases reported for aluminum products (6 months in a row), diesel fuel (18 months), freight (13 months), polyvinyl chloride (PVC) products (9 months), and steel products (17 months). Items listed in short supply included appliances (3 months), steel products, transformers, and wire and cable. A few core building materials provide a representative view into how the production and supply of key building has materials has changed since shortly before the pandemic through today.

i. Lumber

As the Covid shutdown spread, lumber became extremely hard to find as mills initially curtailed production in early 2020, expecting a flattening of demand. In fact, demand surged due to a resulting boom in residential renovations and new housing builds that skyrocketed during the pandemic. Supply shortages and price spikes rose throughout much of 2020 into 2021. Some frustrated contractors captured their ire visually:

The U.S. is highly dependent on imported dimensional lumber and wood products, such as wood flooring, but it is also an exporter of forest products, namely to China. The U.S. sells logs and lumber to China, China uses the logs and lumber to produce finished wood products, and China exports these finished wood products to the world. Interestingly, the U.S. market is the leading destination for these exports.

Prior to the pandemic, the U.S.-China trade war rendered U.S. forestry vulnerable because the Chinese government imposed tariffs on American timber, which resulted in a loss in exports. Thus, American forestry was already in a crisis when Covid hit.

Roughly a quarter to one-third of lumber imported to the U.S. comes from Canada. Despite record-high American lumber prices in 2020, Canadian lumber shipments to the U.S. fell for the fourth consecutive year. The trend was largely due to a reduction in the Annual Allowable Cut (AAC) in the province of British Columbia, which reduced production volumes in that region by over a third in just five years.[5]

A majority of the overseas lumber imports in 2020 originated from Europe. Sawmills from this continent have steadily expanded their sales to the U.S. over the past three years. Throughout 2020, European shipments inched close to 3.3 million, up from 2.1 million in 2019.[6] Germany is by far the largest European supplier of lumber, followed by Sweden and Austria. Eperts expect, however, that expanded supply from the American South, eastern Canada, and overseas will meet the U.S.'s demand for softwood lumber. .

U.S. imports declined to 479 million board feet in the fourth quarter of 2020, down 15 percent

[5] *The US is Increasingly Dependent on Overseas Lumber Supply as Canadian Softwood Lumber Production Continues to Decline*, Wood Resources International, January 18, 2021.
[6] *Id.*

from the 565 mmbf shipped in the third quarter and lagging the same three quarters of 2020 by 26 percent. Imports peaked at 649 mmbf in the second quarter, which was a 14-year high. Imports from the 10 largest European suppliers reached 1.6 bbf last in 2021, up 16 percent from 2020. Eurpoean exports to the U.S. declined in the second half. Shipments through the third quarter rose 36 percent compared to the 2020 pace. Strong prices within Europe, soaring ocean freight costs, and extensive shipping delays contributed to the late-year slowdown in exports.[7]

ii. Ductile Iron Pipe

Ductile iron pipe (DIP) is the primary form of cast iron pipe used for transmission of potable water. A succession of both domestic and international events has presented extreme challenges to production of this critical building material.[8]

DIP is typically manufactured with a cement mortar lining and textured polymer protective coatings on the outer surface to inhibit corrosion. The economic downturn of 2006 to 2009 triggered consolidation and closure of DIP production facilities. For every 12 DIP-producing plants in the U.S. before the downturn, there are just seven today.

Like so many industries, the onset of Covid caused widespread labor shortages that affected production and shipment of DIP, and the unavailability of machine parts further impaired plant maintenance. A year into the pandemic, ice storms from Hurricane Ida further rocked the industry, causing substantial disruption to resin production for PVC in the Gulf States. A PVC pipe shortage then triggered a shift to and run on DIP supplies.

DIP is made from 95 percent recycled scrap metals. Refined steel, on the other hand, is made from pig iron, or crude iron, a high carbon content form of raw iron. Russia and Ukraine are the two largest exporters of pig iron, representing about 65 percent of global output. With the outbreak of war in Ukraine, pig iron exports from those countries ground to a halt, prompting steel producers to compete for those same scrap metal supplies used in the production of DIP.[9]

The recent spike in fuel costs compounds the problems raw material supply issues and labor shortages caused. Production of DIP requires substantial energy expenditure to render molten metal, which is then centrifugally spun in casting moulds. With almost doubling of fuel costs, the cost of DIP production has increased exponentially.

iii. Paints and Coatings

Like ductile iron pipe, the paint and coatings industry has also experienced a succession of production challenges, most notably raw material supply dispruptions. The production of paints and coatings depends on the ready supply of resins, pigments, and base compounds, most of which are produced in Asia. Titanium dioxide, the same compound used in sunscreens, is almost entirely sourced from China. As a common paint additive, titanium dioxide provides opacity and

[7] *Id.*
[8] *How Multiple Events Collided to Affect Ductile Iron Pipe Supply*, McWane Ductile blog, April 21, 2022
[9] *Id.*

durability and enhances the longevity of paints.

Unlike DIP, the paint industry experienced a huge spike in demand at the same time supply chain disruptions began to occur. As lockdowns and working from home spurred homeowner renovations and flight to suburban housing, paint sales soared. Sales at paint and wallpaper stores in the U.S. spiked 7.8 percent in June 2021 to $1.34 billion.

As Covid shut down plants, paint manufacturers scrambled to procure pigments, resins, additives such as titanium dioxide,and cans, most of which became scarce or unobtainable.[10] Manufacturers' inability to use a secondary source because even the slightest variation in pigment precludes accurate color reproduction complicated matters

As with DIP producers, the loss of resin production caused by Hurricane Ida. stymied paint producers, which also faced challengeds due to Additionally, subfreezing temperatures destroyed invetories in the extreme winter freeze across Texas in early 2021.

iv. Cement

Cement/concrete is the second-most-utilized product in the world after potable water. The material is key to building housing, roads, airports, and other infrastructure needed to support economic development. Globally, more than 1,000 cement producers operate over 2,300 integrated cement plants and over 600 grinding stations. Five countries account for nearly three-quarters of the world's cement production: China leads with a 57-percent share, followed by India, Vietnam, the United States, and Indonesia. The majority of plants are privately owned and operated, and while the top 10 players account for about 45 percent of global capacity, the industry overall is quite fragmented.[11] Cement production creates a huge carbon footprint caused by the extensive energy expended to transform raw materials into finished cement.

Cement is manufactured by high temperature heating of silica, alumina, and iron, which results in a material called "clinker," which is then ground and mixed with limestone and gypsum to produce concrete. Concrete is essentially a mix of aggregates (sand and gravel or crushed stone) and paste (water and cement). Portland cement is a generic term to describe the type of cement used in almost all concretes.

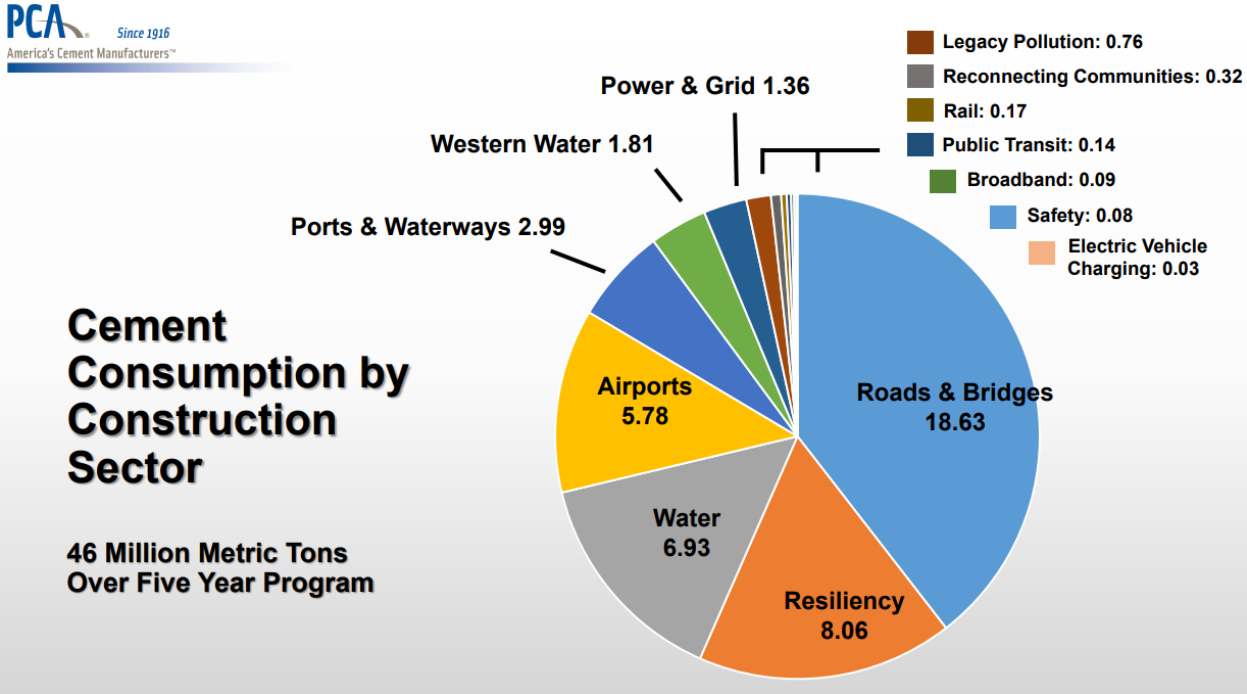
In 2021, U.S. production of cement remained under the 2005 record due to idle production plants, underutilized capacity at other plants, disruptions due to plant improvements, and the decreased costs of importing cement.

A Portland Cement Association (PCA) survey found that 28 states were experiencing supply disruptions.[12] These disruptions arose at a time when cement demand is rising. Cement consumption through June 2021 increased 7.4 percent according to the PCA, and robust growth is expected as states receive $1 trillion from the Infrastructure Investment and Jobs Act.To update 20,000 miles of highways and repair of 10,000 bridges, the PCA estimates an increased cement demand by more than seven million metric tons per year annually. The following chart

[10] Francis, Scott, *Coatings Industry Navigates Supply Chain Disruption*, PRODUCTS FINISHING, April 20, 2021.
[11] https://www.ifc.org/wps/wcm/connect/c015acbf-8465-4f8e-95e8-857511f10bbb/202008-COVID-19-impact-on-cement-industry.pdf?MOD=AJPERES&CVID=ngxQLJQ
[12] Strickland, James, REDUCING RISK IN SUPPLY CHAIN MANAGEMENT, *Holcim US*, December 14, 2021.

shows the anticipated distribution of cement over project type during the next five-year period as identified by the PCAin its spring, 2022, market forecast.

On March 30, 2022, the Tennessee Concrete Association (TCA) issued an urgent alert to industry members about concrete supply shortages across that state. The TCA alert cited unprecedented supply chain problems inhibiting delivery of raw materials used in concrete production, including Portland cement, admixtures, aggregate, and fly ash. The alert noted that Portland cement supplies were being rationed, and ready-mix producers were reducing plant hours. Experts attribute the concrete shortage to numerous factors, including an already tight labor force in the industry, plant closings and maintenance shutdowns during the pandemic that depleted inventory, and a shortage of drivers.[13]



These supply constraints were predicted to persist throughout 2022 and are not confined to Tennessee. Similar shortages have occurred in Alabama, Mississippi, Louisiana, Texas, Nevada, and California.[14]

D. The Way Forward - Managing Supply and Price in an Uncertain Market

Re·sil·ient /rəˈzilyənt/: (1) able to withstand or recover quickly from difficult conditions; (2) able to recoil or spring

[13] Oberoi, Mohit, PARTS OF THE U.S. DEAL WITH CEMENT AND CONCRETE SHORTAGE, NOT NATIONWIDE, *Market Realist Magazine*, April 5, 2022.
[14] https://www.wkrn.com/special-reports/nashville-forward/concrete-added-to-growing-list-of-supply-chain-issues-builders-are-now-facing/

back into shape after bending, stretching, or being compressed.

The dominant buzzword in the unfolding discussion of supply chain management is *resilience*. By "resilient supply chain" many commentators refer to: (1) keen awareness of demand cycles and production needs; (2) supplier relationships that are well understood and more deliberately cultivated; (3) real-time supply data that is closely monitored; and (4) defined contingency options that can be employed if otherwise-routine supply lines are disrupted. Because business supply chains vary widely from business to business, there are no one-size-fits-all solutions for achieving supply chain stability. Instead, businesses can utilize a range of tactics to blunt supply and price volatility.

In construction, contractors grapple with at least two core supply chains: the supply of equipment, parts, and tools that are necessary to enable the contractor to construct, and the supply of materials necessary to construct the project itself. Beneath the contractor are layers of subcontractors, each managing these same supply chains relative their respective trades. In large measure, the owner and architect are at the mercy of these constructor supply chains. What recent supply chain disruptions have forced is far more deliberate awareness, management, and coordination of supply challenges at all levels of project planning, design and construction, including recurring operational supply needs and project-specific supply needs.

a. Non-Project-Specific Operational Control

Risk Engineer Cheri Hanes with North America Construction advises that supply management has become so critical that contractors should establish dedicated supply chain leadership. This leadership team may be organized on both a company-wide and project-specific basis such that the contractor's supply needs are understood and tracked as projects are evaluated, contracted for, and executed.[15] Hanes also recommends contractors develop project selection and bidding protocols that enable "go/no-go" decision making in light of potential supply chain challenges, including such considerations as: (1) working with known owners who demonstrate fair contract management and who are flexible relative to design or material changes; (2) developing and insisting on reasonable schedule commitments; (3) using reasonable and current assumptions around cost that accurately account for anticipated price escalations; and (4) selecting projects that align with the company's core competencies.

Hanes also encourages implementation of a materials management plan, which tracks material procurement from point-of-origin to the project site, for all at-risk materials. The plan imposes supply monitoring procedures to confirm materials are fabricated and that they are en route to the project with known arrival times. Once delivered, materials should be checked against submittals to verify conformity with project requirements. Hanes counsels that in an environment where substitutions are more likely to occur, general contractors must be proactively involved with subcontractor material supply as well. Deliberate collaboration between all project stakeholders can further mitigate supply disruptions. Project stakeholders should review material supply challenges and contingency plans from the inception of each project to its completion.

Contractors can also reduce supply constraints by more aggressively managing equipment maintenance and preservation and by reducing construction material waste. In 2018, construction (not including

[15] Hanes, Cheri, SUPPLY CHAIN, COST, AND MATERIALS MANAGEMENT STRATEGIES FOR CONSTRUCTION, HTTPS://AXAXL.COM/FAST-FAST-FORWARD/ARTICLES/SUPPLY-CHAIN-COST-AND-MATERIALS-MANAGEMENT-STRATEGIES-FOR-CONSTRUCTION, August 24, 2021.

demolition) in the U.S. generated almost 60 million tons of construction materials waste.[16] Reducing waste is perhaps the easiest means of mitigating material supply pressures, and it involves simple, commonsense practices like reducing construction mistakes, ordering the right amount of materials in the rightquantity for the job, storing materials properly, and recycling and reusing.

b. Project-Specific Contracting Controls

So much of the discussion about mitigating construction supply chain disruption has centered on a a singular solution:force majeure relief, a creature of contract that excuses contractors from some unanticipated supply disruptions While having such a contractual safe harbor is beneficial, force majeure relief still involves subjective judgment calls about whether a disruptive event is worthy of contract relief. The following force majeure term imposes broad relief parameters intended to maximize the potential for actual recognition of a disruptive project event.

12.8 "Force Majeure: Neither Party shall be liable to the other for any failure or delay in performing an obligation under this Agreement that is due to any of the following causes, to the extent beyond its reasonable control: acts of God, accident, riots, war, terrorist act, epidemic, pandemic, quarantine, civil commotion, breakdown of communication facilities, slowdowns and/or stoppages of supplier delivery of equipment, materials or goods related to the project, breakdown of web host, breakdown of internet service provider, natural disasters and catastrophes, governmental acts or omissions, orders of health departments or other government officials, changes in laws or regulations, national strikes, fire, explosion, or other causes of damage to the Project site, or generalized lack of availability of raw materials or energy. The Contractor and its subcontractors shall not be required to perform any service that would require or may result in exposure of their employees to hazardous or unsafe conditions. Remote meetings and remote site observation and inspection by camera, web camera, video camera, unmanned aerial vehicle, or similar platform is authorized for all purposes if reasonably necessary to avoid exposing such employees to unsafe conditions."

Beyond force majeure safeguards, a wealth of other contract terms help manage unforeseen, or foreseen but not yet manifested, supply disruptions and price volatility. They include:

- Use of allowances as a placeholder for the expected "cost of the work." If the allowance item costs more than the placeholder, the GMP is increased. If it is less, then the owner should get a deductive change order.
- Use of equitable adjustment terms that enable the contractor to apply for additional time or compensation.
- Use of ConsensusDocs Cost-adjustment clause, Document 200.1, Time and Price Impacted Material Amendment 1:

> "1. POTENTIALLY TIME AND PRICE-IMPACTED MATERIAL As of the date of this Amendment, certain markets providing essential materials to the Project are

[16] SUSTAINABLE MANAGEMENT OF CONSTRUCTION AND DEMOLITION MATERIALS, United States Environmental Protection Agency 2018 Fact Sheet; https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management.

experiencing or are expected to experience significant, industry-wide economic fluctuation during the performance of this Agreement that may impact price, availability and delivery time frames ("Potentially Time and Price-Impacted Material"). This Amendment provides for a fair allocation of the risk of such market conditions between the Owner and the Contractor and shall only apply to the Potentially Time and Price-Impacted Material(s) listed in Schedule A to this Amendment.

"2. TIME-IMPACT AND AVAILABILITY If the Contractor is delayed at any time in the commencement or progress of the Work due to a delay in the delivery of, or unavailability of, a Potentially Time and Price-Impacted Material, beyond the control of and without the fault of the Contractor, its Subcontractors and Material Suppliers, the Contractor shall be entitled to an equitable extension of the Contract Time and an equitable adjustment of the Contract Price in accordance with section 6.3 of the Agreement. The Owner and Contractor shall undertake reasonable steps to mitigate the effect of such delays."

Notwithstanding any other provision to the contrary, the Contractor shall not be liable to the Owner for any expenses, losses, or damages arising from a delay in the delivery of a Potentially Time and Price-Impacted Material item not the fault of the Contractor, its Subcontractors, and Material Suppliers.

- AIA A201-2017 General Conditions typically allow contractors to seek an extension for unavoidable delays associated with construction materials, but these General Conditions do not specifically address industry-wide price escalations caused by changes in the availability of essential materials.

- The Use of disclaimer language — conditional language — in bid proposals can provide some coverage between the time of bid and the execution of agreements after award of the job. For example, contractors and subcontractors can include language that makes their bid expressly contingent upon the current price and availability of materials and allows them to seek an equitable adjustment to their bid price if there are significant changes to the pricing and/or availability of material.

- Subcontractors should also consider including language in material purchase orders to shift somerisk of material price changes to their suppliers. Subcontractors should also require their suppliers to give prompt written notice in the event of unforeseen changes to the delivery schedule so that subcontractors can timely give notice to the contractor and owner.

Aside from negotiated contract terms, relief from contract performance may lie in various equitable legal doctrines, including:

- Impossibility of performance : While narrowly applied, the doctrine of impossibility of performance may be invoked due to an unforeseeable event or prohibited operation of law. A state-imposed lockdown would likely constitute just such an impediment to performance.

- Impracticability: The UCC excuses a seller of goods from performance where the seller can demonstrate that performance may be so difficult and expensive that it becomes impracticable, though not objectively impossible.

- Frustration of purpose: This limited excuse from contract performance applies in some jurisdictions when, due to a supervening event, the affected party's main purpose for entering the transaction is destroyed or removed. The frustrated purpose is so much the basis of the contract that without it, the transaction makes little sense. Frustration can excuse performance only if:

    - The affected party seeking to be excused can no longer accomplish its purpose for the transaction;
    - Both parties knew of the affected party's principal purpose for entering into the contract; and
    - A qualifying supervening event caused the frustration.

E. Closing Thoughts

Constructors encountered supply chain disruptions and corresponding price volatility long before the pandemic struck in early 2020, principally due to trade wars and increased competition for a finite supply of materials. But the pandemic triggered an intense acceleration in the review and management of supply chain dynamics. The pandemic also expanded the scope of affected construction industry stakeholders. No did disrupted operations confront only contractors in the field, but owners, designers, and a myriad of vendors who service the construction industry began to face these issues. Going forward, constructors can no longer assume that the ready supply of all tangible goods necessary to execute a construction project — be it equipment, parts to maintain equipment, tools, or construction materials — will be available but must instead deliberately manage these mmaterials from the point of bidding through substantial completion and perhaps even through the entire warranty period of a project.