

MARKET INTELLIGENCE

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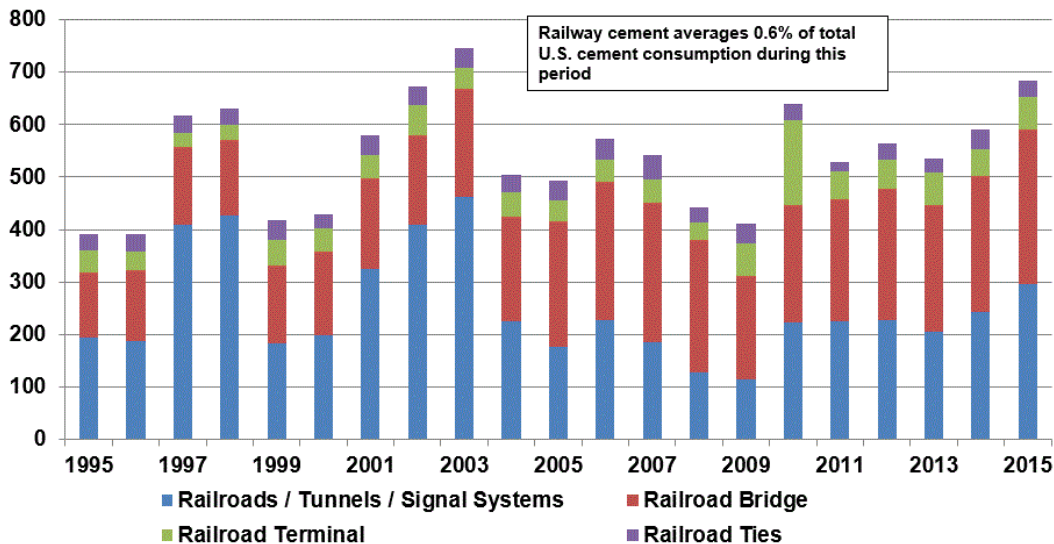
Railway-Related Cement Consumption Outlook

Overview

PCA's Market Intelligence Group is engaged in a comprehensive research project that estimates long-term opportunities for cement consumption. The study provides a 25 year outlook and evaluates both vertical (buildings) and horizontal (non-buildings) markets. The study not only estimates growth in building activity based on economic, demographic, and structural issues such as technology changes that are likely to impact demand, but also measures material market share trends in each construction segment and identifies the areas of erosion from least severe to most severe as well as opportunity.

This report is focused on the railroad market of the United States. Americans depend on the rail system for movement of goods and commodities as well as commuting. PCA has examined the current trends of the system to create an outlook for cement consumption. There are several areas of cement consumption within the railroad market. PCA identified four major categories to analyze: ties, passenger terminals, bridges, and tunnels. PCA expects cement consumption to grow to 640 thousand metric tons by 2040 compared to an average of 540 thousand metric tons historically.

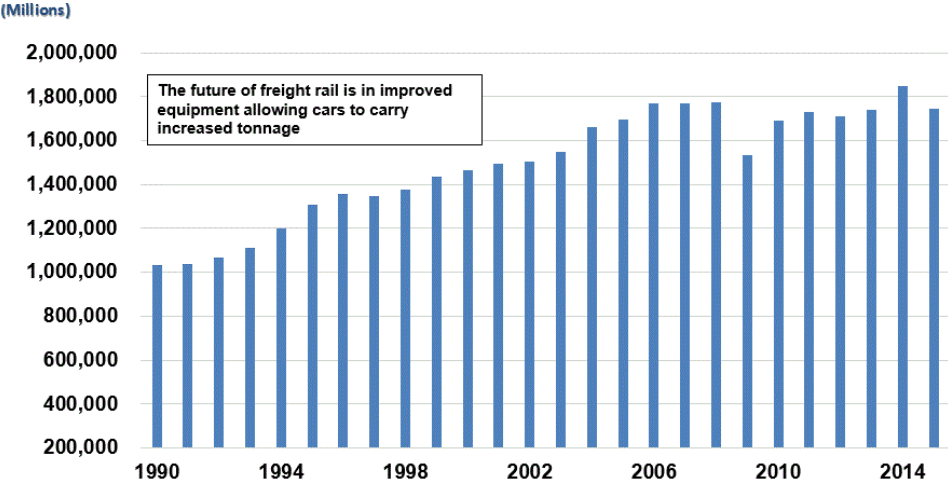
Railway-Related Cement Consumption (000) Metric Tons



Railroads have always played an important role in America’s economy. The freight rail system is a \$60 billion industry and provides 221,000 jobs across the country. Roughly 40% of freight ton-miles are moved by rail. Every citizen is impacted by freight rail, with each person in the United States requiring about 40 tons of freight per year. Passenger rail lines are used by millions of Americans to commute to and from work. As overall economic growth improves, it is assumed that railroads will be under more use.¹ The vast majority of the U.S. rail network is owned and managed by seven private freight rail organizations. With over \$4 billion spent annually by these companies to maintain and expand the system, the rail network is in good condition compared to other areas of U.S. infrastructure.

All assumptions and forecasts for cement consumption in the railway system are dependent on the system miles (overall length of railroads) and traffic on the system. The freight system miles that are active have been steadily declining over the past 30 years. However, passenger miles have experienced consistent growth over the same period.² Since 1990 there has been nearly a 80% increase in annual ton miles moved on freight rail. The increase in traffic and stress means more maintenance on the existing lines. The same is true for commuter rail lines. Annual passenger miles have been rising over the past 20 years and continue to mark record highs. Commuter lines will continue to grow as the population increases and the U.S. suburbs expand outward. The majority of cement consumption in the railway market is from expansion activity rather than maintenance, meaning the passenger railway is the more important area in terms of a consumption outlook.

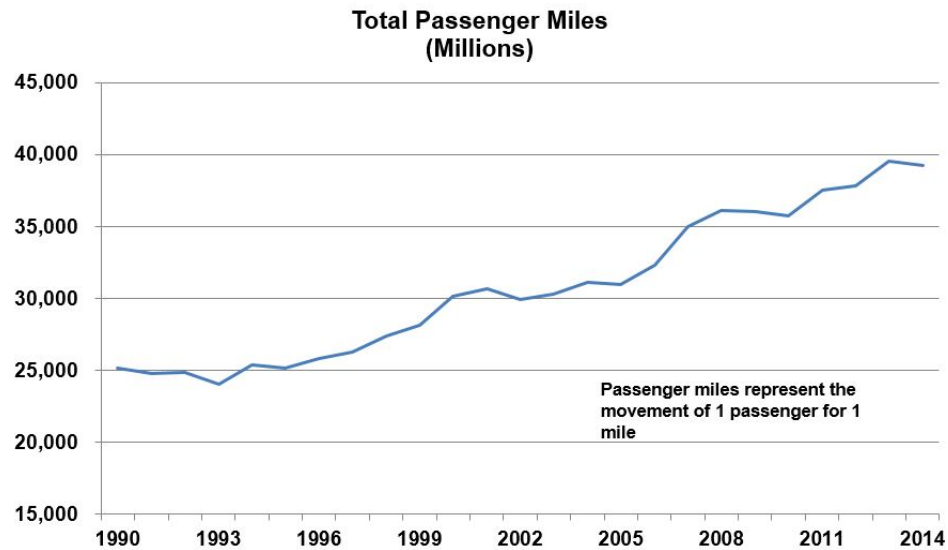
Freight Rail Traffic – Ton Miles



Source: Bureau of Transportation Statistics, Association of American Railroads

¹ U.S. Department of Transportation, Federal Railroad Administration, *Freight Rail Overview*
² Bureau of Transportation Statistics, National Transportation Statistics

Population Growth Means Passenger Growth



Source: Bureau of Transportation Statistics

Railway Demand Drivers and Forecast Assumptions

Railway construction activity can vary greatly depending on the line. The freight rail network that is used today has largely been in place for over 40 years with virtually no growth. PCA assumes no expansion of the freight network in any forecast. This means all projected construction on the system is repair/rehabilitation. Construction activity on freight lines is driven by a congestion metric based in ton-miles. High, low, and baseline projections for ton-miles are forecasted. PCA ton-mile projections are driven by coal consumption and GDP growth. The low scenario yields 2.58 trillion ton-miles by 2040, compared to the high scenario at 3.02 trillion.

The passenger rail network has grown steadily over the past 25 years and should continue into the future as the U.S. urban population continues to grow. With a strong correlation between population and passenger miles, PCA used high, low, and baseline population projections to forecast passenger miles. PCA expects passenger miles to grow to 52.4 million by 2040. Commuter system miles are then driven by passenger mileage and GDP growth assumptions. This yields 2,210 new miles of passenger railway over the forecast horizon. The low scenario reflects 1,787 new system miles, whereas the high scenario grows 2,675 miles by 2040.

Growth in miles of passenger rail and congestion for freight and passenger rail are factored into the forecasts for each of the segments (ties, terminals, bridges, tunnels) of cement consumption. The role of each will be further explained in that section. These are the two key elements that drive railroad construction activity and thus, cement consumption.

PCA acknowledges that there are substantial opportunities for growth in high-speed rail. However, due to political and economic uncertainty surrounding their construction, significant growth in this platform is not incorporated into the forecast. PCA has taken a conservative approach to the forecast for railway construction and there is potential for upside risk.

Rail Tie Outlook

There are over 15 million new rail ties laid each year by the railroad organizations. Wood is still dominant in the U.S. rail tie market. Precast concrete ties' market share has hovered around 6-8% over the past 15 years. There are several key factors that influence the use of concrete or wood ties which include initial costs, track characteristics, maintenance activities, and traffic characteristics. Concrete ties boast a service life twice as long as wood. They also provide better strength allowing for heavier trains. The future of freight rail is dependent on allowing trains to carry more weight. These innovations will allow congestion to remain manageable while still meeting the growing needs of transportation on the rail system. Roughly 20% of freight lines are considered "heavy haul" which handle over 100 million gross ton miles per year. This is an area where concrete ties have become popular.

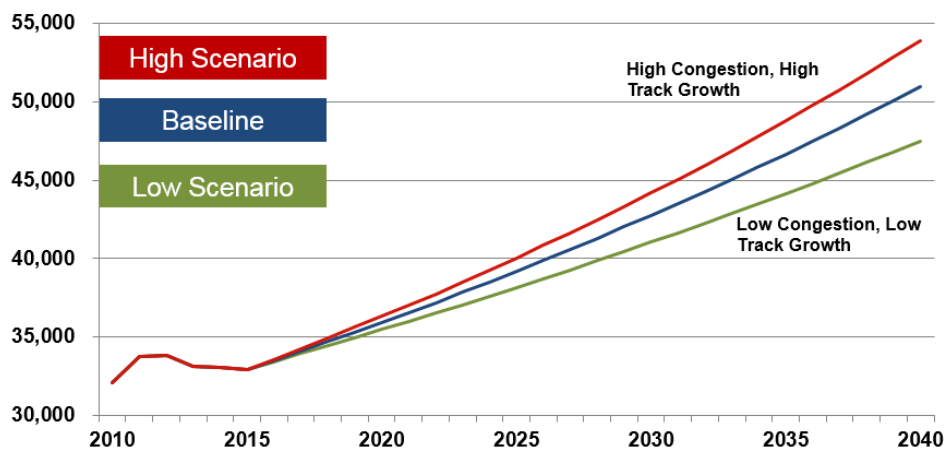
Concrete ties are very popular for commuter lines in Europe and have started to gain share in the U.S. One major advantage of concrete ties for passenger lines is the reduction in delays for maintenance. The sturdiness of concrete ties allows for very little maintenance and increased time between replacing ties. Light rail networks in congested cities across the U.S. are moving towards concrete ties for these reasons.

To estimate rail tie cement consumption, the first step was establishing how many ties will the network have and how many will be replaced each year. As noted above, PCA has held freight system miles constant throughout the forecast. Using the projections for growth in commuter system miles, a total of active rail system miles is acquired. From here, PCA uses a widely accepted average of rail ties per mile to yield how many ties are in the total market.

The next question is how many will be replaced. PCA looked at the history of the percentage of ties replaced to all ties. This percentage was then driven by separate congestion metrics for both passenger and freight lines to yield an annual estimate of ties laid in replacement. PCA used a 6.5% market share to project concrete ties laid each year. This number was used based on the historical average and industry forecasts.

Rail Tie Cement Outlook: Scenarios

Metric Tons



Sources: Bureau of Transportation Statistics, Moody's Analytics, EIA, PCA

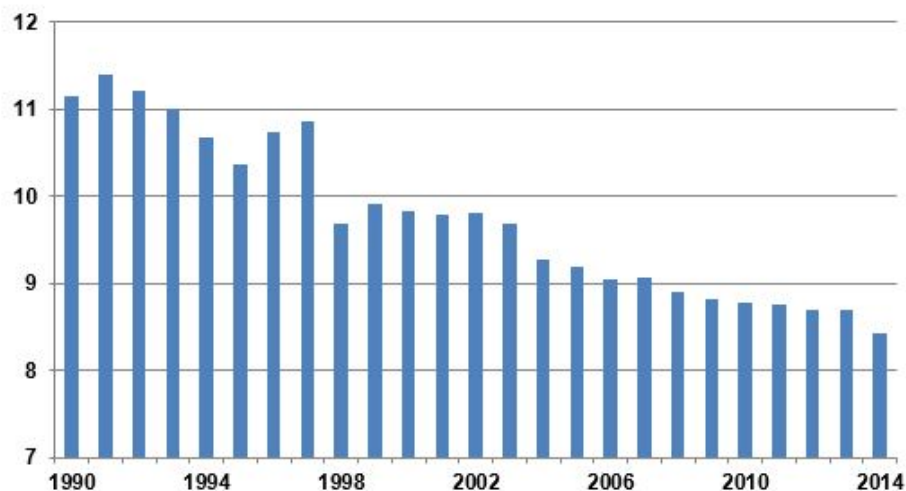
Under PCA's baseline scenario, annual cement consumption for rail ties will reach 51 thousand metric tons by 2040. Using assumptions of high congestion and high track growth, the high scenario yields 54 thousand metric tons. The low scenario yields 47 thousand metric tons.

Passenger Terminal Outlook

Terminal growth is a function of expansion in commuter railway. When new commuter routes are formed, terminal construction is an integral part of this process. Congestion, especially in urban areas, is the main driver for expansion of terminals. As the American population becomes increasingly urban with the formation of megaregions and the continued expansion of city suburbs, commuter railway growth and terminal growth will become paramount to combat congestion.

PCA does not account for freight terminals in this section of the report. While PCA acknowledges there is cement consumption each year in the freight terminal category, the amount is small and consistent. Construction of new freight terminals where cement tons would spike is rare due to a lack of area for expansion. This report is focused on future growth opportunities which is much more targeted toward the commuter side of terminal construction.

Miles of Passenger Track per Terminal



Source: Bureau of Transportation Statistics

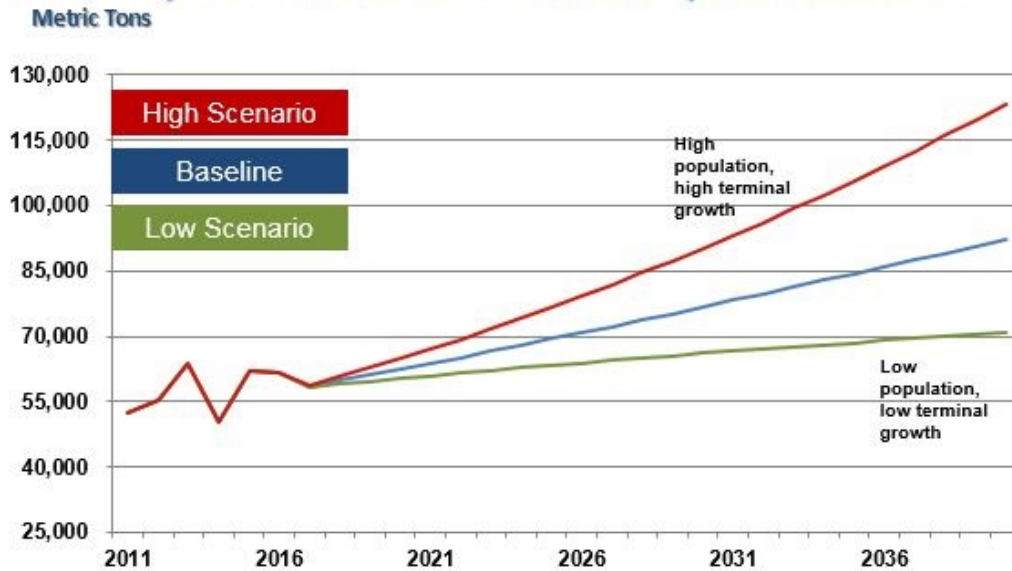
The graph above shows the increase in terminals compared to miles of commuter system. This trend has begun to materialize over the last 25 years with terminal construction growing faster than commuter system miles. This ratio will likely continue into the future to attempt to relieve congestion in urban settings. There is a point at which expansion in these areas will slow due to a lack of area.

The first step in estimating cement consumption for passenger terminals is to project the number of new terminals built each year. For purposes of this report, PCA assumes all consumption in terminal construction activity is new construction. PCA used the projections for miles of commuter rail and urban

population growth to drive terminal expansion activity. High and low projections for both factors were incorporated to yield estimates for terminal growth. High terminal growth has the ratio above of miles of commuter line per terminal dropping to 6.8 by 2040 while the low estimate has the ratio reaching 7.2.

Next, PCA determined the historical average of dollars spent on construction per terminal. This number was growing slowly over time, which is likely an indication of a larger area for each terminal to combat congestion. PCA then used terminal growth and spending projections to forecast cement tons needed based on the PCA use factor for rail terminals. Once completed, 92,000 metric tons of cement are expected to be consumed for passenger terminals by 2040. Approximately 123,000 metric tons are expected to be consumed under the high scenario while the low scenario yields 71,000 metric tons.

Railway Terminal Cement Consumption Outlook



Sources: Bureau of Transportation Statistics, Moody's Analytics, Dodge Data & Analytics, PCA

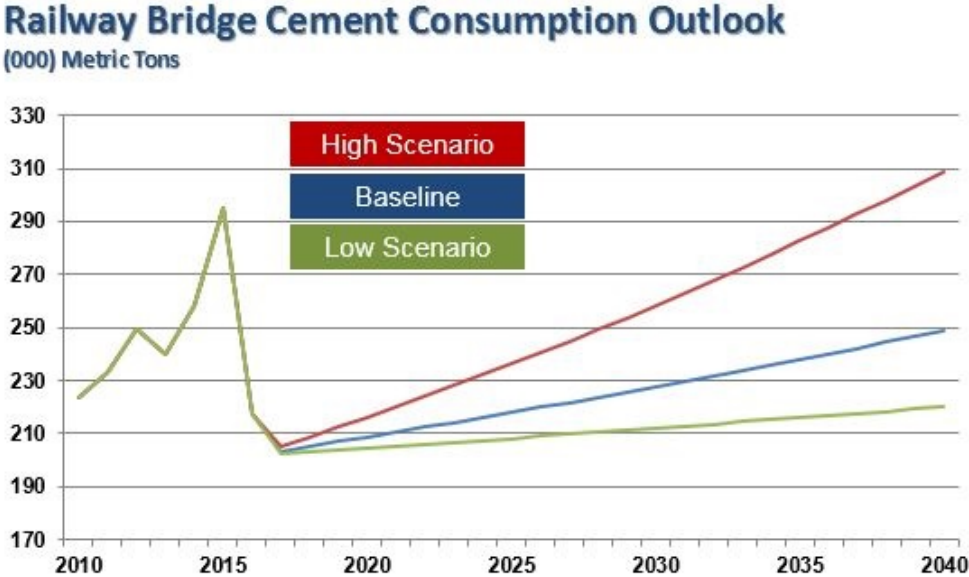
Railway Bridge Outlook

The Association of American Railroads estimates that there are roughly 100,000 active railroad bridges as of 2015. While bridges are a vital component of the rail network in the U.S., it is one of the smallest areas of investment for the railroad organizations. In 2015, bridges accounted for only 7% of capital expenditures. Since the railroads own all their infrastructure in the market, there is little data readily available on rail bridges. PCA had to make assumptions to derive cement consumption for railway bridges from the little market data that was available.

To maintain consistency, PCA based bridge growth on the overall increase in the railway system. PCA examined a ratio of bridge construction spending per miles of track. Real dollars spent on railway bridge construction activity has risen by approximately 50% in the past 25 years based on Dodge Data & Analytics contract award data. System miles are not growing as quickly as bridge spending. PCA employed a historical average of this ratio as a starting point. This ratio was driven by bridge expansion

projections. Given the history of rail companies investing little capital into bridges combined with the competition of steel rail bridges, PCA has taken a conservative outlook on the growth of bridge construction.

The growth in the overall railway system mileage is then applied to yield total spending on rail bridge construction. From here an average cement intensity is applied to the projected spending series to yield annual metric tons of cement. Under the baseline scenario, PCA expects railway bridge cement consumption to reach 249,000 metric tons by 2040. The high and low scenarios yield 309,000 and 220,000 respectively.



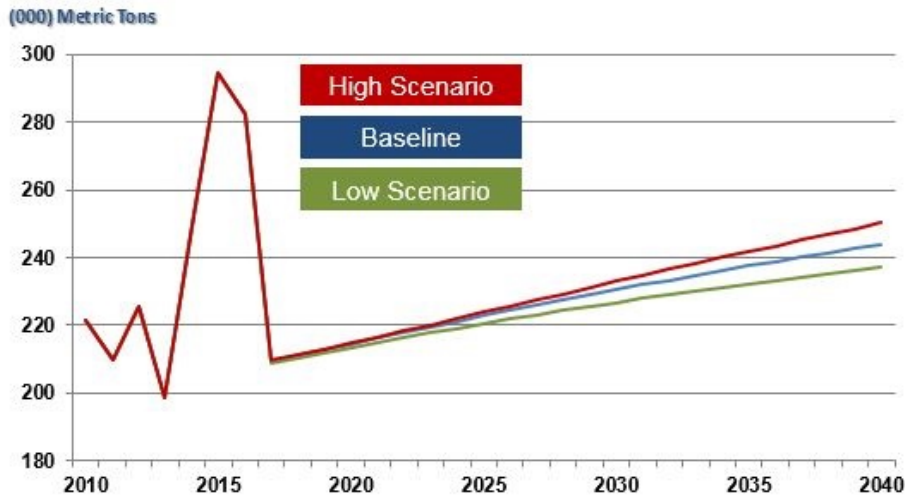
Sources: Bureau of Transportation Statistics, Association of American Railroads, Dodge Data & Analytics, PCA

Railway Tunnels & Signal System Outlook

Tunnels can be one of the largest cement consumers in the rail market when large, new projects begin construction. Concrete will always be essential in tunnel construction. Maintenance and rehabilitation to existing tunnels can also be a significant portion of consumption. Signal systems for railways often use a concrete base. Annual consumption for signal systems is very small and should not vary greatly into the future. Since maintenance levels are steady and yield lower totals, the question in forecasting this section is predicting when new tunnels will be constructed. Historical cement intensities are extremely volatile in this category. As a result, projections for tunnel cement consumption should be treated as long-term averages.

PCA again uses congestion to drive growth in tunnel construction. In metropolitan areas where population growth is expected to surge, creating new commuter rail routes is difficult as space is extremely limited. This is where new tunnels will be the most prevalent. PCA used urban population and new passenger rail system projections to drive tunnel construction activity. This yields a slow but steady growth in tunnel construction, consistent with other areas of railway construction activity. The baseline outlook for tunnel cement consumption by 2040 is 244,000 metric tons. The high scenario yields 250,000 metric tons and the low scenario projects 237,000 metric tons.

Railway Tunnel & Signal System Cement Consumption Outlook

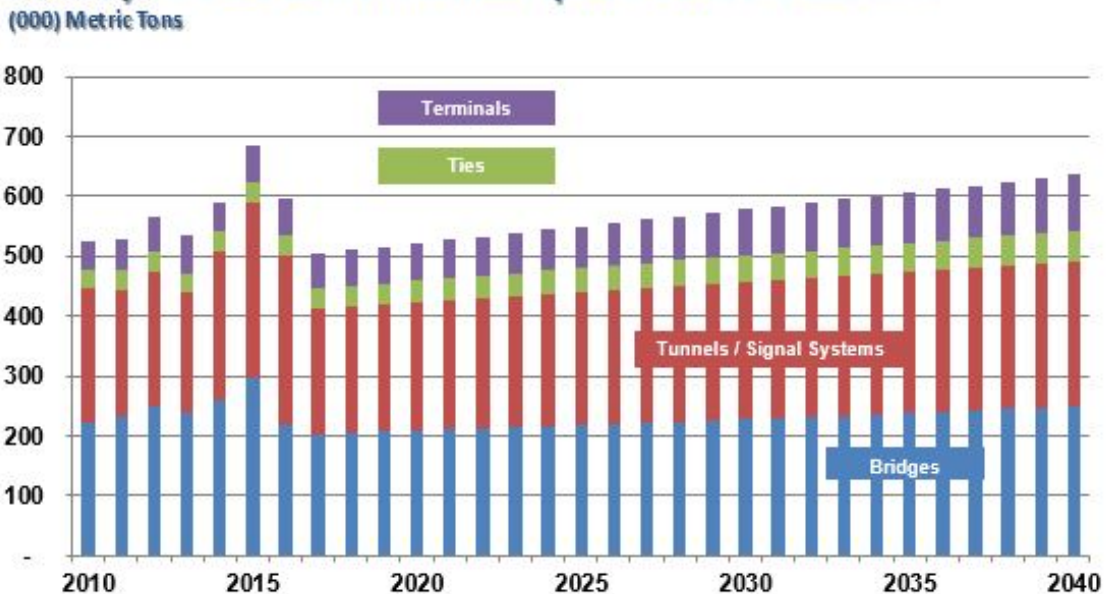


Sources: Bureau of Transportation Statistics, Dodge Data & Analytics, PCA

Total Consumption Projections & Conclusion

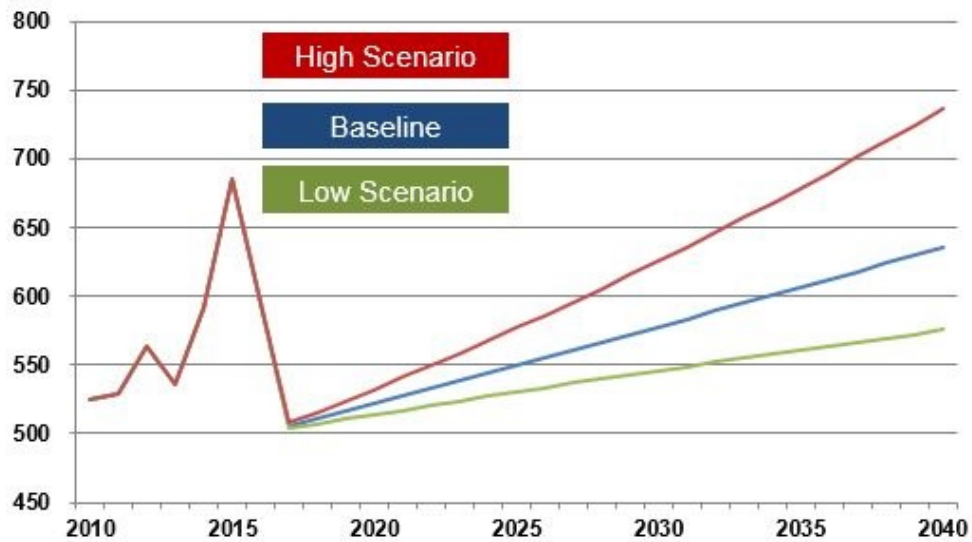
The railway market is not a large cement consumer but it is one that has experienced steady growth that PCA believes will continue into the future. Increases in the U.S. population and overall economic growth will lead to increased congestion on current rail lines forcing new construction and increasing levels of maintenance. By 2040, demand for railway related cement is projected at 636,000 metric tons. Of this, 8% will be attributed to rail ties. Terminals are expected to account for 15% of railway consumption. Tunnels and bridges will account for 38% and 39% respectively.

Railway-Related Cement Consumption Outlook: Baseline



Railway-Related Cement Consumption Outlook: Scenarios

(000) Metric Tons



Under favorable conditions, PCA projects the high scenario for railway consumption to reach 736,000 metric tons by 2040. If growth is slower than expected, railway construction is expected to yield 575,000 metric tons.

Risks to Forecast

PCA takes a conservative approach to forecasting segments of the railway market. This means there are segments of consumption that fall under the umbrella of the railroad industry that are not included within this analysis. The largest area of upside risk is that of high-speed rail and Hyperloop advances. There are several reasons high-speed rail has not grown in the United States as it has in Europe and Asia, including population density, property rights, and infrastructure funding. Through PCA's research, Hyperloop technology appears to be in its infancy stage and requires significantly more research and development before they can be seriously considered as a viable option for transportation. PCA also acknowledges rail yards as an area of potential growth for cement consumption that is not covered in this report.