Thematic Report on Chinese American Contributions: Infrastructure
Infrastructure is fundamental to the functioning of every modern economy. In a country as geographically vast as the US, it is impossible to overstate the significance of a robust agriculture production system and physical networks to ensure the fast, safe and reliable transmission of people, goods, energy and information. Throughout US history, Chinese Americans have made important contributions to major infrastructure developments that have shaped the society, fueled economic growth and raised standards of living.
Overview

As of 2018, around 70,000 Chinese Americans work in the construction, utilities and agriculture sectors (Figure 1). Although making up less than 1% of the total employment in these sectors, Chinese Americans play notable roles in certain fields. In the construction sector, for example, Chinese American civil engineers account for nearly 3% of the total; and one in 30 architects in the US is Chinese American. In utilities, Chinese Americans are particularly active in computer and engineering occupations—such as computer system analysis, computer programming, and electrical and electronic engineering—and play a significant role in designing and operating utility systems. One-third of Chinese American employees in the utilities sector work in these occupations as of 2018, compared with roughly 12% of US utilities workers in general.

More than 60% of Chinese Americans who work in the US agriculture sector specialize in producing crops, including tree nuts, berries, vegetables and melons. An estimated 3,000 farms are run by Chinese American farmers as of 2017, covering 500,000 acres of land and bringing US$1.2bn worth of agricultural products to consumer markets.

Historically, Chinese Americans have made important contributions to American infrastructure development at several crucial moments in US history, despite facing legal, structural and social discrimination. The Chinese Exclusion Act of 1882 specifically prohibited the entry into the US of Chinese immigrants seeking to work in construction, farming and mining, and Chinese American representation in those occupations declined drastically after the passage of the Act. Those who managed to contribute, despite facing lasting marginalization from their industries, include skilled farmers who helped to transform California into the country’s premier agricultural state, and the workers who constructed the first transcontinental railway.

Following the repeal of discriminatory immigration policies and the opening of broader professional opportunities to Chinese Americans in the mid-20th century, the American infrastructure sector also benefited from contributions by Chinese American researchers and engineers, who promoted new materials and designs key to the evolution of modern infrastructure.

As of 2018, 2.6% of Americans working in civil engineering occupations are Chinese American, more than double their percentage in the total population.
Railway construction (1860s-1880s)

The US is home to nearly 140,000 miles of rail line, an extensive network of transportation infrastructure that has been pivotal to the country’s economic growth and prosperity. As economic historian Robert Fogel noted in 1962, the railroad is “the most important innovation of the last two-thirds of the nineteenth century” and “the prime force behind the westward movement of agriculture, the rise of the corporation, the rapid growth of modern manufacturing industry, the regional location of industry, the pattern of urbanization, and the structure of interregional trade.”

Today, freight railroads remain a mainstay of the US economy, moving nearly 40% of the nation’s goods each year and supporting 1.5m jobs.

Chinese Americans played an unparalleled role in building the country’s expansive railroad networks. In the mid-1860s, though Chinese immigrants were known to be dependable, hard workers, their employment opportunities were limited by discriminatory laws. But in 1864, labor strikes by European workers and a subsequent labor shortage led the Transcontinental Railroad’s construction director to hire between 50 and 100 Chinese workers. He was so impressed with their work that he hired approximately 3,000 more by the end of 1865. In this manner, Chinese Americans came to be the primary workforce in the construction of the first transcontinental railway across North America, as well as on the many local and regional lines that followed.

Between 1865 and 1869, as many as 20,000 Chinese workers joined the Central Pacific Railroad (CPRR) to build the western half of the transcontinental railway project.
They made up 90% of the construction workforce, carrying out all kinds of jobs, including blacksmithing, carpentry, tunneling, levelling roadbeds and laying tracks. Chinese workers risked their lives building the railroad across some of the most difficult terrain on the continent in severe weather conditions, including digging 15 tunnels through solid granite in the Sierra Nevada mountain range.

Despite their vital contribution to the construction of the transcontinental railroad, Chinese workers were excluded from news reports and photographs documenting its completion, from nearly all written histories of the project, and from 20th-century commemorations of the railroad’s completion. Only in recent years have Chinese railroad workers begun to emerge from the margins of history: in recognition of their contributions, the US Department of Labor inducted the Chinese railroad workers into their Hall of Fame in 2014, stating that “Their efforts, which connected the western United States to the eastern United States, laid the foundation for the extraordinary economic prosperity enjoyed by the United States in the years that followed.” Within just ten years of its completion, the transcontinental railroad was shipping US$50m worth of freight from coast to coast every year.

Chinese workers’ contributions to the proliferation of the American rail system stretches far beyond the CPRR project. After completing the first transcontinental railroad in 1869, Chinese workers fanned out across the country to work on at least 70 other rail lines. They helped to build the Northern Pacific, the Southern Pacific and the Great Northern Railroads, as well as many shorter branch lines that established regional and local transportation networks across states including California, Oregon, Washington, Nevada and Texas.

Agricultural development (1850s-1910s)

Agricultural infrastructure is critical to the functioning of the US economy and society. It is essential to ensuring an adequate food supply, sustaining economic growth and boosting job creation. Agriculture and related industries contribute over 5% of US GDP annually and provide 11% of US employment. The consumer base for American agriculture stretches far beyond the country’s borders: 20% of the American agricultural yield is exported to foreign markets every year, an important cashflow to the domestic economy. Chinese Americans played an important role in supporting the US farming expansion between the mid-19th century and the early 20th century.

Beginning in 1852, a large number of Chinese people were recruited to work on sugar and rice plantations in Hawaii. By 1887, over 50,000 Chinese laborers had arrived to work on the plantations under contract. After their contracts ended, about two-thirds decided to stay in Hawaii permanently. They soon moved on to raise livestock, grow rice, taro, coffee, garden vegetables and fruits.
On the US mainland, Chinese Americans also played an instrumental role in turning California into an agricultural powerhouse. Today, California leads the 50 states in agricultural production, accounting for over 13% of total US agricultural production. However, when the first Chinese immigrants arrived during the Gold Rush, the state relied on agriculture imports from China, Australia, Chile and Hawaii to meet the food demands of a fast-growing population. Chinese immigrants joined the farming workforce to harvest wheat crops, and grow fruits, vegetables and nuts.

Owing to their invaluable experience in controlling waterways and developing fertile farmland in inaccessible river valleys, Chinese immigrants were hired in the 1860s to reclaim swamplands in the Sacramento-San Joaquin Delta. By 1880, 88,000 acres had been reclaimed for agricultural use—notably developing Oceana County (the “Asparagus Capital of the World”) and the major source of Bartlett pears—a project that increased the land value from US$1-US$3 an acre to US$20-US$100 an acre.

California is home to one of the most prolific and well regarded wine industries in the world, producing 90% of all US wine today. In the late 19th century, Chinese immigrants helped to establish the foundation of the Californian wine industry in Napa and Sonoma by constructing roads, stone bridges, rock walls, wine cellars and irrigation ditches. They also worked in vineyards in Southern California: between 1856 and 1869, Chinese workers planted the majority of Sonoma County’s 3.2m grapevines. It is estimated that viticulture in California would have been set back 30-50 years without the contribution of Chinese vineyard workers.

While Chinese Americans were well represented in agricultural activities in the early decades of immigration, their participation in agriculture started to decline after the Chinese Exclusion Act of 1882 severely limited employment opportunities in the industry. This decline later intensified when the California Alien Land Law in 1913 prohibited “aliens ineligible for citizenship” from owning land or property. The California law, followed by similar discriminatory laws in other Western states, resulted in drastic declines in Chinese Americans’ participation in agriculture.
Although Chinese and other Asian Americans today account for less than 1% of agricultural producers, a new generation of young, entrepreneurial farmers and produce providers is emerging. This group is keen to employ their cultural heritage and diversity of experience to the project of modernizing an industry that has struggled to keep pace with globalization and changes in consumer habits.

One such entrepreneur is Wen-Jay Ying, who started the business Local Roots NYC in 2011 to connect local farmers with customers in New York City. Today, her business supports over 15 local, small farms and nearly 20 small-batch producers in New York City, distributing more than 60,000 lbs of freshly harvested, sustainably grown local produce to approximately 1,000 households.

In the San Francisco Bay area, another young Chinese American entrepreneur, Scott Chang-Fleeman, started Shao Shan Farm in 2019 to specialize in growing certified organic Asian heritage vegetables for local chefs, grocers and communities while using social media marketing to promote farm-to-table products.

Ms Ying and Mr Chang-Fleeman are typical of a rising cohort of young Chinese American farmers and entrepreneurs who are utilizing a unique combination of cultural, social and practical knowledge to explore promising new markets for local, organic farm products, test the applications of new technology and marketing techniques, and help to bring the US's agriculture industry fully into the 21st century.

Modern infrastructure development (20th century–present)

The US's robust investment in infrastructure in the 20th century—including an interstate highway system, hundreds of airports and expanded port facilities, among others—set the foundation for the economy's strong growth in the aftermath of World War II. During this wave of infrastructure development, Chinese Americans—particularly civil engineers, architects and scientists—made notable contributions by researching and promoting innovative construction materials and designs. More recently, some Chinese American researchers have developed technologies to monitor and strengthen the resilience of infrastructure to natural and man-made hazards.

One of the most important materials in modern construction is pre-stressed concrete, which has made possible the construction of structures including high-rise skyscrapers and long-span bridges. Although the material was first invented in Europe, its widespread adoption has been attributed to the efforts of Tung-Yen (T.Y.) Lin, a visionary structural engineer best known for his pioneering work in developing prestressed concrete for practical use and his advocacy for the material's use in modern building. Dr Lin led research work to simplify the process of using prestressed concrete and helped to convene the first World Conference on Prestressed Concrete in San Francisco in 1957,
which had a huge impact on promoting the material's use in modern construction.\textsuperscript{42,43}

Whereas only 2\% of the bridges built prior to the 1956 Highway Act utilized prestressed concrete as their primary superstructure elements, the number grew to nearly 50\% by the beginning of the 21st century.\textsuperscript{44}

Also in the field of bridge design, Man-Chung Tang is a world authority on cable-stayed bridges, a cost-effective design that has gained popularity since the late 20th century.\textsuperscript{45} Dr Tang has worked on more than 100 bridges worldwide, including the eastern segment of the San Francisco-Oakland Bay Bridge, which was designed to withstand the strongest seismic motion engineers can expect in a 1,500-year period.\textsuperscript{46} Dr Tang also led the development of a definitive guideline for the design of cable-stayed bridges, which is used by engineers all over the world today.\textsuperscript{47}

Building on the developments enabled by innovators in material science and engineering, Chinese American architects and urban planners have worked on many monumental projects that contribute to the fabric of everyday American life. One such influential figure is I.M. Pei, a renowned architect who focused his career in the design and construction of public works that serve the wider community. In the 1960s, Mr Pei designed the multi-airline terminal at John F Kennedy International Airport, New York City, known as the “Sundrome.” The transportation hub was renowned for its beauty and serenity in the midst of the airport’s chaos until it was demolished in 2011 to allow an airline company
to consolidate its operations, despite the protests of historical conservationists and architecture enthusiasts.\textsuperscript{48,49} Another important work from this period is the John F Kennedy Presidential Library and Museum in Boston, Massachusetts, which, in addition to housing the documents from the Kennedy administration and the family’s personal mementos, contains 90\% of Ernest Hemingway’s existing manuscript materials.\textsuperscript{50} In addition, Mr Pei’s innovative East Building (1978) of the National Gallery of Art, Washington, DC, an elegant triangular composition, was hailed as one of his finest achievements and is a staple of the capital’s public arts infrastructure.

In urban planning, one of the most prominent examples is Weiming Lu, who was instrumental in a number of urban renewal projects in Los Angeles, Minneapolis and Dallas, among many other cities. In St. Paul, Mr Lu presided over an effort to transform empty warehouses and parking lots in the historic Lowertown to a new urban village in the early 1970s.\textsuperscript{51} The project yielded 2,600 housing units and retained 12,000 jobs, as well as accomplishing important social goals such as the provision of housing to low-income populations, and the fostering of community, entrepreneurship and economic growth.\textsuperscript{52} In Dallas, Mr Lu led an urban design program that helped to save the Texas School Book Depository, rejuvenated the West End District, created the Art District, helped to save Swiss Avenue, and protected the city’s escarpment district and flood plain.\textsuperscript{53} Mr Lu’s work exemplifies how urban planning can improve the lives of countless Americans.

More recently, as the deficit in infrastructure investment persists in the US and risks of natural and man-made hazards grow, some Chinese American researchers have committed to developing new technologies to monitor the health of infrastructure, including by predicting and preventing damage.

For example, Maria Q Feng, a professor at the Department of Civil Engineering and Engineering Mechanics at Columbia University, is at the forefront of developing sensors and microwave imaging technology to collect data related to the health condition of civil infrastructure systems, in addition to detecting and assessing damages through data analysis, image processing and system identification algorithms.\textsuperscript{54} The aim of Dr Feng’s research is to help to prevent the sort of catastrophic failure of civil infrastructure that incurs massive economic costs and loss of lives.

Separately, Philip Li-Fan Liu, director of the School of Civil and Environmental Engineering at Cornell University, is a frontline researcher in using computer modelling to predict tsunami and wave dynamics and damage. Dr Liu’s research has contributed to the fundamental understanding of wave processes and hence coastal protection, and has considerable applicability to practical engineering problems, helping to mitigate risk and damage.\textsuperscript{55}

Both Dr Feng and Dr Liu have received prestigious awards from professional organizations including the American Society of Civil Engineering. However, they are only two individuals
out of the thousands of Chinese Americans whose work supports the modernization and advancement of infrastructure in the US. As of 2018, 2.6% of Americans working in civil engineering and environmental engineering occupations are Chinese American, more than double their percentage in the total population.\textsuperscript{56}

Conclusion

A number of major American infrastructure projects have benefited from significant contributions by Chinese Americans, from the expansion of agricultural infrastructure and the establishment of transportation networks to innovative building techniques and engineering advancements that enabled the construction of cities and towns as we know them. Such projects have helped to connect rural and suburban areas of agricultural production with the urban cityscapes of the country’s economic hubs. Since their arrival in the US, Chinese American workers, builders, farmers and engineers have brought both immediate and long-term economic benefits to the country, creating new economic opportunities and enabling growth and development across society.
1 Includes crop production; animal production, aquaculture, fishing, hunting, and forestry.
2 US Census Bureau, 2018 American Community Survey 5-year estimates, public use microdata sample (PUMS); The Economist Intelligence Unit analysis.
3 US Census Bureau, 2018 American Community Survey 1-year estimates, PUMS; The Economist Intelligence Unit analysis.
4 US Census Bureau, 2018 American Community Survey 5-year estimates, PUMS; The Economist Intelligence Unit analysis.
5 US Census Bureau, 2018 American Community Survey 1-year estimates, PUMS; The Economist Intelligence Unit analysis.
6 According to USDA 2017 Census of Agriculture, Asian Americans operated 18,338 farms, covering 2.9 million acres of land and selling $7.5 billion in agriculture products. The Economist Intelligence Unit estimated the data for Chinese Americans based on their percentage (16%) in Asian Americans who work in the agriculture sector, according to American Community Survey 2018 5-year estimates.
14 Yung et al., Chinese American Voices: From the Gold Rush to the Present.
15 PBS Asian American documentary 2020.
33 Yung, Chang, and Lai, Chinese American Voices: From the Gold Rush to the Present.
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40 Prestressed concrete combines steel wires with concrete to allow the construction of elegant high-rises and bridges able to withstand earthquakes and heavy loads.


43 “Dr. T. Y. Lin: Memorial Tribute.”


53 “Mr. Weiming Lu,”


56 US Census Bureau, 2018 American Community Survey 1-year estimates, PUMS, The Economist Intelligence Unit analysis.
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