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Engineering Marvels: The English Channel Tunnel

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The Channel Tunnel, which connects Britain to France, is a feat of engineering that the ASCE has called one of the Seven Wonders of the Modern World.

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The Channel Tunnel, or Chunnel, is a fascinating example of how major engineering infrastructural projects can simultaneously draw nations together and provide an important avenue for long-term economic growth. For much of its history, Britain remained physically isolated from the European continent by the English Channel. This separation served to protect Britain from invasion, but it also hindered trade and tourism with Europe. Following World War II, however, the relatively peaceful era experienced among western European nations culminated in a desire and need for the British Isles to draw closer to continental Europe's economic and political bloc. The completion of the Channel Tunnel signaled the realization of Britain's step toward closer ties with its closest neighbor, France, and further integration into the European region.

The first proposal for an undersea passage linking Britain and France originated from French engineer Albert Mathieu Favier in 1802. Favier envisioned twin tunnels ventilated by chimneys rising above the water surface. These tunnels would have been large enough to allow passage of horse-drawn carriages. The plan appealed to the French emperor Napoleon Bonaparte, but the British government understandably feared invasion by France, their traditional enemy, and rejected the plan. This failed project marked the first of many attempts to develop an underwater tunnel to cross the English Channel.

Actual tunneling began in the 1880s from both the British and French coasts, but after about 2,000 yards of digging, the old British fear of future invasion arose once more, leading to the sudden cancellation of the project. Public perception of the Channel's role as protector still held, and it proved slow and difficult to change. Resistance also arose from ferry and port businesses, who feared loss of revenue and jobs due to competition from a tunnel linking Britain and France. Despite these setbacks, soundings, borings and studies continued to examine the feasibility of a tunnel beneath the Channel.

By 1955, however, Harold Macmillan, the British Minister of Defense, revealed a shift in official British opinion. When questioned on what remained of Britain's strategic objections to a tunnel under the Channel, Macmillan responded with a simple "Scarcely at all," marking at last the end of the British government's justification of national security to deny construction under the Channel. Along with official approval, businesses and the construction industry viewed the idea of a fixed link as a boon, since it could create jobs and allow for the growth of businesses and trade surrounding construction of the tunnel.

The French welcomed the prospect of a link with Britain. The French expected that the Tunnel would work nicely with their successful rapid train system, the Train a Grande Vitesse. In addition, the Tunnel would promote development in the Nord Pas-de-Calais region, which suffered heavy unemployment

due to declining coal, steel and textile industries. Finally, by 1984, British Prime Minister Margaret Thatcher and French president Francois Mitterand agreed on the mutual benefit of a link across the English Channel. Soon after, their respective governments released an invitation for bids on construction of the tunnel. According to USAF Lieutenant Colonel Leslie Allen Veditz's case study on the Channel Tunnel, the invitations laid out four essential rules: "proposals had to be technically feasible, financially viable, Anglo-French, and accompanied by an Environmental Impact Assessment." Following a few months of the evaluation of ten proposals, the Channel Tunnel Group/France-Manche, soon to be known as Eurotunnel, won the bid.

Digging of the Chunnel began simultaneously from both the British and French coasts in 1987, and on December 1, 1990, the two sides of the service tunnel met, amid much celebration. In commemoration, one British worker, Graham Fagg, and one French worker, Philippe Cozette, were chosen randomly to be the first to shake hands through the opening. The Chunnel consists of three tunnels: the service tunnel and the larger north and south running tunnels on either side of it. Construction of the northern running tunnel finished on May 22, 1991, followed a month later by the completion of the southern running tunnel on June 28, 1991.

Upon completion of the main tunnels, much work remained: crossover tunnels, land tunnels from the coast to the terminals, piston relief ducts, electrical systems, fireproof doors, the ventilation system and train tracks all had to be added. Large train terminals also needed to be constructed at Folkestone in Great Britain and Coquelles in France. Once construction finished, the first test run of the entire Chunnel occurred on December 10, 1993. Months later, after further fine tuning, British Queen Elizabeth II and French president Mitterand officially inaugurated the Channel Tunnel on May 6, 1994. After six years of construction and about $21 billion spent, the Channel Tunnel project concluded.

The Chunnel spans 31.4 miles in length from terminal to terminal, while 23.5 miles of the Chunnel lies at an average of 150 ft. below the seabed, making it the world's longest underwater tunnel. Eurotunnel privately financed the entire project through equity and loan capital. Despite some financial struggles by the company, completion of the Chunnel vindicated Thatcher's faith in the power of the private sector to successfully complete a major infrastructure project. Originally conceived to cost around $3.6 billion, the project ultimately cost $21 billion to complete. As with any great engineering endeavor, the manpower and assets needed to complete the project proved equally astonishing, with the workforce totaling 13,000 by the project's conclusion. To dig the tunnels, the British and French teams used a total of 11 massive tunnel boring machines, each being 750 ft. long and weighing 15,000 tons. The boring machines typically cut through the chalky soil at a rate of 360 feet per day. To waterproof and protect the tunnels' lengths from the intense pressure of the sea above, they had to be lined with 5 ft. thick concrete walls containing enough concrete for more than 100 buildings. The north and south running tunnels are 25 ft. in diameter, serving as railway tunnels, and the service tunnel has a 16 ft. diameter. Massive 14 ft. wide, 2,500 ft. long double-decker shuttle trains hurtle through the north and south running tunnels at 100 mph. Passengers board the trains by vehicle, rather than by foot. The service tunnel is accessible by emergency and maintenance vehicles. In addition to the tunnels, a sophisticated support system had to be built to maintain them:

- two 160 MW substations on either side of the tunnel,
- 25 kV catenary systems to power the shuttle trains,
- control and communications,
- air handling units located every 1,230 ft.,
- drainage systems to remove water from the tunnels,
- a fire-fighting system,
- refrigerated water cooling system, and
- technical rooms containing maintenance equipment on each side of the service tunnel.

The American Society for Civil Engineers (ASCE) described the Chunnel as "a living, intelligent structure. Huge pistons open and close ducts, relieving the pressure that builds ahead of the train's noses. Some 300 miles of [cold-water] piping run alongside the rail tracks to drain off the heat raised by air friction."

Upon the tunnel's opening in 1994, ASCE named the Channel Tunnel as one of the Seven Wonders of the Modern World. The Chunnel indeed proved itself as a major boon for Britain, accounting for the creation of 220,000 jobs, $120 billion of total trade value between the Britain and Europe in 2014 alone, and the crossing of at least 21 million passengers each year. Even now, despite the uncertainty posed by Britain's Brexit decision to leave the European Union, economic and trade ties will remain strong, and the Chunnel will continue to play a key role in those strong ties.

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