1.2.1 Transportation disasters
Movement of people and goods was one of the main outcomes of the industrial revolution in Britain in the late-eighteenth century, starting with canals, which were displaced gradually by railways. Industrialization came through innovation in manufacture, especially the development of mass-produced materials such as cast-iron. While the material had been known and used since the Elizabethan period, it could only be made in small quantities by smelting iron ore with charcoal.

The Darby family of Coalbrookdale were the first to develop the use of coke in smelting ore. The coke itself was made by burning certain types of coal with a restricted supply of air, so that the carbon content was conserved, and transforming the coal into porous nodules capable of supporting a mass of material above. The coal was mined locally and the large quantities of iron that became available as a result of improved and larger furnaces using the new fuel, was cast directly into sand moulds to make domestic items such as cooking pots, grates, fireplaces, and stoves. Design with the new material culminated in the construction of the first cast-iron bridge across the Severn (Input 4).

1.2.2 Railways in Britain
The railway age started with attempts to make a steam engine small enough to be fitted to a wagon for hauling coal at collieries, the wheels moving on a wooden or iron rail for guidance. Improvements to the drive mechanism led directly to the Locomotion designed by George Stephenson, and the opening of the first passenger and goods service for the 27 miles between Stockton and Darlington in County Durham. It was opened in 1825 and was quickly followed in 1830 by a line between Manchester and Liverpool, but the opening saw the first railway fatality: local MP Mr Huskisson was run down by the locomotive Rocket.

Both railways were an immediate success, allowing raw materials and manufactures to be transported faster than by canal. Their popularity with the public was great, both for leisure and work.

The railway network expanded fast, although the greatest period of expansion occurred a little later, when railway mania took hold (Input 5). The construction teams were most efficient when laying track on the level or along slight gradients, whereas a great deal of engineering work was needed for embankments or cuttings even where dips and hills were only moderate. Understandably, bridges over river valleys and estuaries were a challenge.

Input 4 Cast-iron bridge at Ironbridge
The brittle nature of cast-iron was well known to the first designers, and its use was initially restricted to products that needed to be primarily heat-resistant – fire backs and other fireplace goods. Large-scale production was possible in the 1750s in Britain at Coalbrookdale. The Darby family used improved and larger furnaces using a blast of air to achieve higher temperatures. The coke was mixed with the iron ore and a charge of limestone was also added, the latter forming a slag, which helped remove impurities.

Coke is mainly pure carbon, and part of it dissolved in the iron to form a solution – about 4 per cent. The high carbon content lowered the melting point of the final material, so that the output from the Darby furnaces could be tapped as molten metal directly from the base of the furnace.

Once large-scale production of the material was possible, mass manufacture of standard shapes proved feasible using sand moulds. Cooking implements were among the first such products, followed by complete stoves, assembled from pre-cast components.

The size of castings was increased, culminating in the famous cast-iron bridge crossing the Severn river at what became known as Ironbridge, near Coalbrookdale in Shropshire (Figure C5). Built in 1779, it was intended as a pedestrian route for workers, and had ample clearance to allow high-masted sailboats underneath.

Owing to the brittle nature of the material in tension, structural members could only be used in compression. The designers of the bridge realized that significant tension or bending stresses could not be allowed, so all of the large cast beams were used as arches, and so were put into compression at all points in the structure. In order to join the large girders, dovetailed joints and wedges were employed, borrowing the idea from carpentry (Figure C6).

The assembly using a kit of pre-cast parts anticipated prefabrication, an idea widely used in our own time, and enabled many other similar bridges to be erected elsewhere in Britain. The original bridge and others still stand as a testimony to the skill and foresight of the designers.

Conservation of the Coalbrookdale bridge was needed in the 1970s owing to movement of the masonry abutments, which created brittle cracks in some of the beams. The affected beams were replaced or mended with epoxy resin. The masonry was supported by a counter arch of reinforced concrete and stainless steel built into the riverbed.
Figure C5  Bridge at Ironbridge, Shropshire, England

Figure C6  Joints in the bridge at Ironbridge