Proceedings of the First International Congress on Construction History, Madrid, 20th-24th January 2003,
ed. S. Huerta, Madrid: I. Juan de Herrera, SEdHC, ETSAM, A. E. Benvenuto, COAM, F. Dragados, 2003.

The construction works in the first railway to the «meseta»: The Alar del Rey-Santander railway 1860–1866

María Luisa Ruiz Bedia
Rafael Ferrer Torio

Construction of railways in the 19th century

Spain constructed most of its rail network in the 19th century. One fundamental aspect of railways is their sensitivity to alignment both in plan and in elevation, and the broken nature of the Spanish terrain complicated the work of the engineering technicians. Many physical obstacles had to be overcome and many risks taken with works constructed in places of difficult access in order to create a continuous track formation and enable a steam-traction adhesion railway —which was suitable for flat or small-gradient railroads— to handle inclines such as those found in Pajares (Asturias), in Orduña (Vizcaya) and, in the case that concerns us, in Bárcena (Cantabria). Spanish civil engineers were responsible for project management and supervised the works, but they were aided by foreign experts brought in by the concessionary companies, as was the case with the railway we are concerned with.

The planning and building of a railway in 19th century Spain was no easy undertaking. Since there were no general maps, different line layouts could not be planned in advance. This meant that exhaustive fieldwork had to be done so that the most suitable route could be adopted. Once a route had been chosen, a tacheometric survey was undertaken of the area affected. This was reflected in plans on different scales and, after these had been made, potential routes were fitted, the track alignment was plotted, long sections were drawn, and finally, when the gradients had been established, the earth moving was calculated. When the track formation ran through favourable terrain, economic and regular alignments could be carried out based on long straight tracks joined by large radius curves, and minimum gradients. However, when it was necessary, as in our case, to link towns situated at very different altitudes and separated by mountains and narrow valleys, with only a few kilometres between them, work was made much more difficult, and the construction of the railway formation required the building of tunnels, bridges, viaducts, other minor engineering works, and also large retaining walls.

The Alar del Rey-Santander railway

The railway line between Alar del Rey and Santander was the first stretch of railway in the Cantabrian mountains. It was promoted by the common interests of landowners of Castile and businessmen in Santander, who wanted a suitable means of transporting wheat from the Canal of Castile (Alar) to the port of Santander. In 1845, the license was obtained and the civil engineer Juan Rafo was commissioned to study the route design, which was to have two fixed points, starting at Alar del Rey and ending at the port of Santander. His report, presented one year later, was discouraging: the state of knowledge at the time meant that certain limits for gradients and curve radii could not be exceeded, and this and the difficulty of the terrain led to the project being divided into three sections. From Alar del Rey to Reinosa (first section) the obstacles were not too great because the two points were at a fairly similar altitude, and could be linked with maximum gradients of 16 pro mille; from Santander, access was made possible by following the gorge created by the river Besaya as far as Bárcena de Pie de Concha, and this constituted the third section. From here, however, a special study was necessary for the 15–km horizontal section from Bárcena to Reinosa and to overcome the 563–metre difference in height between them (second section). The preliminary studies analysed all the possible solutions, including the use of stretches with inclined planes; although these would solve the problem, they would make exploitation of the railway much more difficult.

In 1846, the project was studied by the *Dirección General de Caminos* (State Civil Engineering Department) according to the recommendations outlined in the Subercase Report. This report, made by the engineers Santa Cruz and Subercase, indicated that the use of inclined planes in the gorge of Hoz de Bárcena contravened the technical recommendations in railway legislation, and they advocated reducing the gradient by lengthening the route. Nevertheless, the line layout proposed by Rafo was finally accepted and authorisation was given to use gradients exceeding the established limits. However, the enormous financial outlay entailed in carrying out the work discouraged the concessionary company and the project was forgotten until 1851, when the granting of a new license (to the *Compañía del Ferrocarril de Isabel II*; Isabel II Railway Company) and a governmental reorganisation (new *Ministerio de Fomento*; Ministry of Public Works) finally led to the construction of this railway link. The section between Alar del Rey and Reinosa came into operation in 1857, Santander-Bárcena in 1860, and the most complicated section six years later. During this period, locomotives had been improved and were now capable of dealing with steeper gradients; this meant that the original project could be modified and a new alignment planned that did away with the inclined planes. The work was completed in 1866, almost ten years after the first section had come into operation. The delay greatly hampered the transport of goods, which could be moved quickly to Alar and to Reinosa, but then had to be unloaded, stored, and transported by horse-drawn wagons to rejoin the railway before finally reaching the port of Santander.

Solutions for the Reinosa-Bárcena section

The difficulties presented by this section were enormous. The difference in altitude between Reinosa and Bárcena was 563 metres: 242 metres between Reinosa and Pesquera, which were 14 km apart, and 321 metres between Pesquera and Bárcena, which were separated by 7 km. The first solution consisted in covering the distance and difference in height by following the right side of the river Besaya and using four inclined planes: the first in Aldueso and the other three in the gorge of Hoz de Bárcena (from Ventorrillo to Bárcena de Pie de Concha). The total distance was over 8 km, with gradients of up to 10 % required to overcome a vertical elevation of 452 metres. The route design was planned to go through the gorge with straight alignments for each stretch and a winding engine at the head of each inclined

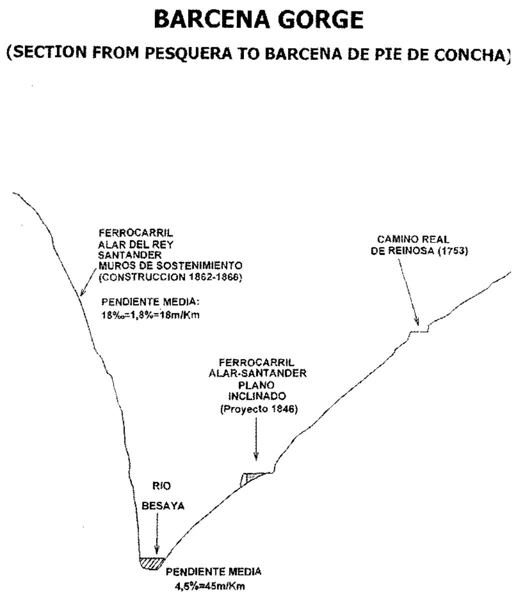

Figure 1
Corridor used for the railway line

plane to raise and lower the railway trucks. This operation would have hampered use of the line and would have made it far more costly to run. One of these inclined planes would probably have had a straight alignment coinciding with the present main road (N-611), which lies below the original *Camino Real de Reinosa* (royal highway), as can be seen in figure 1.

A later study made it possible to eliminate the inclined planes by forcing gradients to the limit (stretches of 22 pro mille) and by making the route much longer. Figure 2 contrasts the two design criteria. The short route, of some 18 km between Reinosa (height above sea level, 848 metres) and Bárcena (285 metres), made use of inclined planes. Without these, the length of the route was 34 km, an increase of 16 km. This was the solution adopted and it meant using a more circuitous route and many expensive engineering works (tunnels and cuttings), breast walls and retaining walls. Figure 3 shows the line layout required to eliminate the inclined planes.

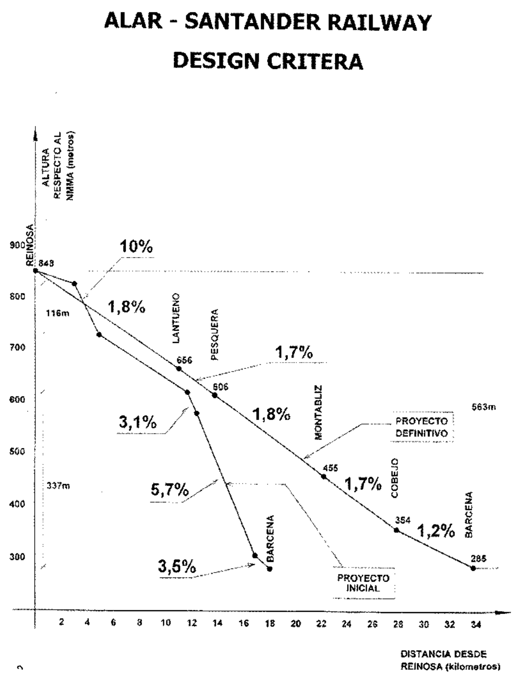

Figure 2
Long section comparing two design criteria

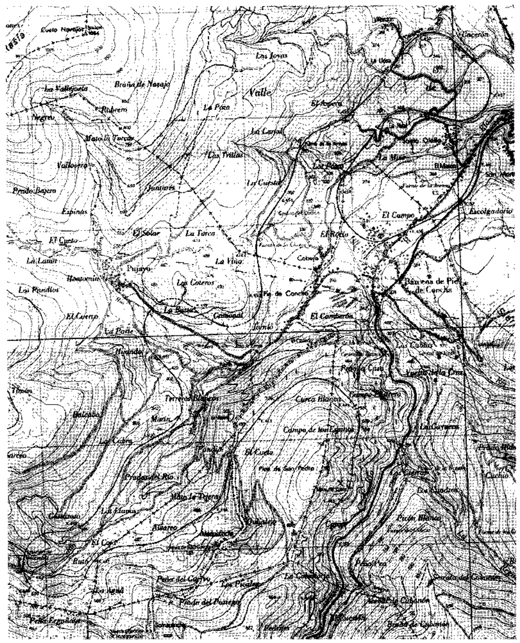

Figure 3
National Topographic Map (MTN-25). Development of the track alignment to avoid inclined planes

This decision involved situating the railway to the left of the river Besaya and making a descent that hugged the hillside. This is shown in Figure 4. The left side of the river Besaya consists of sandstone and the railway line makes its way down the valley by means of tunnels, large cuttings and the construction of breast and retaining walls for which the stone obtained in excavation was used in both ashlar masonry and coarse masonry.

Retaining walls

The stretch of railway between Pesquera (altitude, 606 metres) and Montabliz (altitude, 455 metres), a crossing point on the single line railway now obsolete, includes the most important retaining walls in the Reinosa-Bárcena section. Figure 5 gives an aerial view of the narrow gorge as it descends towards the coast. The river Besaya is flanked on its right by

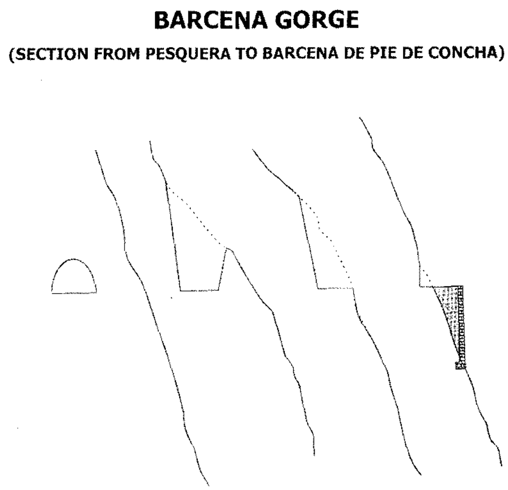

Figure 4
Types of solutions with engineering works

the present-day main trunk road (N-611) and above this is the old royal highway (*Camino Real de Reinosa*). To the left of the river is the unmistakable geometry of the railway track; in many parts, the track formation required the construction of engineering works based on rough masonry, ashlar masonry and rough ashlar work, which are outstanding for their meticulous execution.

These walls constitute track formations up to 10 metres long and 30 metres high, and they alternate with tunnels throughout the descent. Figure 6 was taken from a moving train and shows the finish of one of these hillside walls where what is striking is the correctness of the ashlar coping. In other parts, it was necessary to create a complete track formation with a two-faced retaining wall over 15 metres in height and about 200 metres in length. Sometimes the alignment does not coincide with the hillside and this displacement required the construction of a track formation over the void.

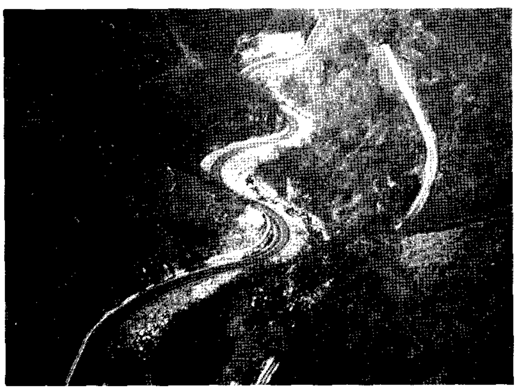

Figure 5
The line layout and its field of influence

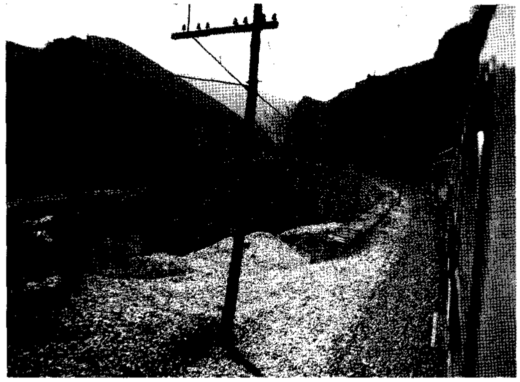

Figure 6
Hillside retaining wall

Bridges for the embankments

Another of the engineering features of this railway constructed between 1860 and 1866 is the category of bridges located under the great embankments. One of the most remarkable is the bridge situated close to Montabliz station. It allows both the road to the Saja-Besaya Reserve and the river Bisueña, a tributary of the Besaya, to pass under the railway. The embankment rises 16 metres above the level of the road, and the ashlar masonry bridge has a span of 8 metres, a height of 10 metres over the river bed, a vault length of 40 metres and a distance of 80 metres between the furthest points of the wing walls-that is, a structure of considerable dimensions exceeding those established in the *Modelos de Pontones para Carreteras* (Models of Bridges for Roads) compiled by the Commission of Civil Engineers in 1858, in which the maximum values recorded were spans of 6 metres and heights of 10 metres. In both cases, the typology was very similar with semicircular arches, ashlar and coarse masonry, and elements such as abutments, wing walls, barrel vaults and dressed coping stones.

Reference list

A.G.A. Ferrocarril de Alar del Rey a Santander. Varios legajos.

Ferrer Torio, R.: «El ferrocarril de Alar del Rey a Santander. 1852–1866», *Cursos sobre el patrimonio histórico*, Santander, Servicio de Publicaciones de la Universidad de Cantabria, 1999.

«Ferrocarril de Alar a Santader», *Revista de Obras Públicas*, nº 9, Tomo XXII, 1874.

Goschler, Ch.: *Traité pratique de l'entretien et de l'explotation des chemins de fer*. Paris, Librairie Polytechnique, 1870.

Juanes, C.: «Los puentes», *Cien Años de Ferrocarril en España*, Madrid, Comisión Oficial para la Conmemoración del Primer Centenario del Ferrocarril en España, 1948.

Mateo del Peral, D.: «Los orígenes de la política ferrovaria en España», *Los ferrocarriles en España, 1844–1943*, Madrid, Banco de España, 1978.

Modelos de pontones para carreteras. Comisión de Ingenieros de Caminos, 1858.

Ruiz Bedia, M. L.; Ferrer Torio, R.; del Jesús Clemente, M.: «Cantería en el ámbito de las obra públicas», *El Arte de la Cantería. V Centenario del Nacimiento de Rodrigo Gil de Hontañón*. Santander, Diciembre 2000.

Ruiz Bedia, M. L.: «Ferrocarril y obras públicas en el siglo XIX: la construcción del camino del tren», *Ferocarril en La Rioja*, Logroño, Instituto de Estudios Riojanos, 2002