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A risk model for the vulnerability of UK's south Devon coastal railway due to storm-related hazards

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Since its inception in 1845, the coastal railway between Exeter and Newton Abbott (UK) has been problematic – for those designing, building, maintaining and living with it. This vulnerability was infamously brought into sharp focus during the winter storm season of 2013/14, when a series of extratropical cyclones funnelled up the English Channel (Masselink et al, 2016, Earth Surface Process. Landforms. 41, 3) and blew easterly gales and storm surges onto the coast at Dawlish in Southern Devon, UK. A section of the seawall dating from 1846 was breached leading to £ 50m of damage, two months of travel disruption and an economic impact of up to £ 1.2bn to Devon and Cornwall in the south west of the UK (Peninsula Rail Taskforce, 2016). Various media and technical reports (Network Rail, 2014) suggested this was an exceptional and unique event, however our archival research showed that the line has always suffered from storm surge related damage and was affected on at least one occasion in the same place at Sea Lawn. The inland topography is difficult in this part of the UK for railroad infrastructure with undulating hills. For these reasons, the railway was built on a coastal ledge sandwiched between the sea and sheer cliff faces on low and relatively-flat land. This study aims to detail the specific failure mechanisms that the coastal line has suffered since its inception in 1845 looking specifically at the role of weather. Hazards are identified and a discussion made regarding the cascading nature of the events. Our data comes from extensive research of original documents from the UK National Archives, UK's Institution of Civil Engineers, Brunel University London and from contemporary reporting of the events. The methodology of archival research helped to develop a database of past failure mechanisms and classification of the damage.

Based on our study, within 12 months of construction, a major storm caused a large section of seawall to be washed away, the ensuing interruption of train services led to a review of design to improve resilience. Train operations were also vulnerable to landslips. The blasting during construction led to cliffs becoming unstable in the early years of the railway (December 1852 – February 1853). After heavy rainfall, water levels built up inside the sandstone deposits and made collapse a frequent occurrence (for example 12 March 1923). Our study reveals that a cascade of events has often been responsible for damage and interruption on the railway. A risk model is presented which shows different cascading hazards and the hierarchy of the events that led to railway failure based on the examined data for 2014. Our risk model includes various hazards such as undermining of the soft sandstone foundations, landslides, signal disruption, overtopping, foundation scour and washout of infill materials behind the wall fascia. This structure will be the basis for future studies to develop a probabilistic model for railway failure.