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Winter 2018

ITALY'S AUGUST OF DISASTERS

by David Alexander

In Italy, August 2018 was marked by one tragedy after another. On the 6th of the month a road tanker containing 30 tonnes of liquid propane gas crashed head on into stationary traffic at the start of the A14 Bologna-Taranto motorway. The incident happened in the urban area of Bologna city. It immediately caused a fire that quickly generated a massive explosion and fireball. Two people were killed, including the driver of the tanker, four were critically injured and a further 139 were less seriously injured. The motorway bridge under the tanker, a robust steel and concrete structure, collapsed. Hardly more than a week later, at 11:36 a.m. on Tuesday 14th August 2018, the Morandi Bridge in Genoa collapsed during a thunderstorm. Built in the period 1963-1967, this was a reinforced concrete suspension viaduct 1,182 metres long and 90 metres high. About 200 metres of the bridge platform collapsed, killing 43 people, including some who were working underneath. In addition, 16 people sustained non-fatal injuries. The bridge spanned a river, a transportation corridor, factories and houses. Some 600 people were evacuated semi-permanently from their homes pending demolition of the rest of the bridge and the construction of a replacement. Finally, on 20th August, in the Raganello Gorge in northern Calabria 44 hikers were struck by a rapid and violent flash flood that killed ten of them, injured 11 and required a large mountain rescue operation.

All of these events were familiar to Italians. Infrastructure blockages, bridge failures, structural collapses and industrial incidents are not infrequent events. The late summer is usually marked by violent storms that send raging torrents of water down otherwise placid streams, often with victims. Behind these relatively circumscribed tragedies looms the spectre of a major earthquake, with a magnitude of perhaps 7.5, that sooner or later is bound to afflict parts of the country, probably along the Tyrrhenian Sea coast of Calabria or in eastern Sicily. This eventuality has constantly conditioned the decades-long debate about whether to build a suspension bridge between Calabria and Sicily. The events of August 2018 are bound to reignite scepticism about the wisdom of such a plan.

The Polcevera Viaduct, or Morandi Bridge, in Genoa in 2012. Source: Bbruno, Wikimedia Commons.

As the final tragedy of that long, hot August demonstrates, one driving factor is the violence of the natural environment. Italy suffers all kinds of natural hazard. Throughout the country, the weather can pass in a trice from calm conditions to concentrated violence in the form of a tornado, a cloudburst (nowadays nicknamed a 'water bomb') or an intense play of thunder and lightning. Hail, flooding and landslides often ensue. Even when the triggering cause of a major incident does not stem from natural extremes, it is as well to remember that the infrastructure takes a bashing during the course of time.

Italy has a remarkably well-developed emergency response system. After major earthquakes in 2009 and 2016-7 more emergency workers were present than members of the local population, and they were trained, equipped and fully organised. Moreover, they are all fully incorporated into a coherent national system that includes 3,600 civil protection volunteer organisations, 36 of which are federated nationally. The beauty of this system is that it is coordinated nationally, based locally and composed of people who have a direct stake in defending their own local areas against disasters.

What is missing from this system, and what successive governments have wrestled with, is how to increase mitigation before disaster occurs. Italy is highly vulnerable to a wide range of hazards and threats. What it is not good at, by and large, is risk management.

When an earthquake occurs, the government of the day would dearly like to transfer some of the enormous cost of acting as "the insurer of last resort" to the house-owners and business people who are the recipients of both the damage and the post-disaster pay-outs. Earthquake insurance is now available in Italy, but it is expensive enough to be beyond the reach of most householders. Even in areas of relatively mild seismic risk, premiums can exceed €1,000 a year for a standard family home. The matter is further complicated by the interconnectedness of so much of the urban fabric, which means that many owners must work through condominium in order to retrofit or repair houses against seismic damage. A consensus among all owners of a building can be very hard to obtain. Moreover, there is always the sensation that the government will continue to act as an "insurer of last resort" and will pay up yet again next time there are tremors. Politicians are well aware that the victims of earthquake damage are voters.

In August 2018 the most spectacular tragedy was the collapse of the Morandi Bridge. This structure, more correctly termed the Polcevera Viaduct, was designed by the

engineer Riccardo Morandi (b. Rome, 1902-1989), who was an expert in pre-stressed concrete. Morandi aimed to provide a design that married form and function while saving costs compared with more conventional steel suspension bridges. The main problem with this approach was that in the 1960s relatively little was known about processes of decay and weakening in reinforced concrete. Nor was it expected that traffic levels would increase as much as they did in subsequent decades. Morandi, however, was explicit in stating that the money saved on construction would have to be paid out in maintenance. He designed a similar, but much longer structure, the General Rafael Urdaneta Bridge in Maracaibo, Venezuela, which was inaugurated in 1962 and still stands. Five years later, the Genoa bridge was opened with a vivacious celebration of its avant garde modernity.

The suspension cables for these bridges are encased in concrete, which is, of course, a porous material. Stresses may remain the same, but bearing capacity may be weakened by corrosion, which at Genoa may have eaten up 20 per cent of the cable width. A combination of lightning strikes and traffic vibration would then lead to severing of the cables. At Genoa, the alarm was first raised in the 1990s, when studies were carried out with non-invasive sensors and finite-element modelling of bridge performance. As a result, part of the bridge (Tower no. 11) was retrofitted with steel reinforcements that duplicated the suspension cables. The rest was untouched, including Tower 9, which collapsed in 2018. In 2003 a leading politician loudly proclaimed that talk of structural failure of the bridge was 'a fairy-tale', but some engineers were nonetheless concerned. By 2017 the situation had become critical, but instead of following advice to close the bridge, the motorway authority drew up a plan to monitor displacements and design reinforcement measures. It was too little, too late.

In Italy, collapses involved the Petrulla viaduct in Calabria in 2014, the Annone overpass (Brianza, Lombardy) in 2016, a bridge at Ancona (Marche) in 2017 and the Fossano bridge at Cuneo in 2017. The Bologna motorway bridge collapse of August 2018 was mentioned above and had a different origin to the others. After the Genoa collapse, engineers noted that the Polcevera Viaduct had been built without redundancy in its robustness or ductility. However, they added that this was normal practice in the 1960s, in which little thought was given to phenomena such as micro-cracking in pre-stressed concrete.

The Morandi Bridge after the August 2018 collapse. Source: Salvatore1991, Wikimedia Commons.

The lesson of this story is that the avoidance of disaster depends on the evolution of the view of what constitutes safety. Although several engineers raised the alarm for the Morandi Bridge in Genoa, and they did so as long as 15-20 years before the collapse occurred, the authorities nevertheless underestimated the risk. Psychologists would call this 'normalcy bias'. What it amounts to is a disaster waiting to happen. In fact, many infrastructure failures are the result of underestimating the power of natural forces, structural decay, overuse, applied stresses and strain rates. It begs the question of how many more 'disasters in waiting' there are, and what can be done to eliminate them. The transport of volatile liquid propane gas through major cities and on crowded roads highlights another source of 'latent disaster', as the Bologna incident shows.

Economists, traffic planners, urban planners, industrialists, entrepreneurs and many more people know that the functionality of infrastructure is vital to commerce and prosperity. But how much risk is tolerable? What is acceptable risk? Certainly it is higher when it comes to simple interruption of service than when it involves the risk of death or serious injury. All indications are that in Italy, and in many other countries, a more cautious attitude is needed to risk management. It should also involve a more serious, geared-up strategy. The country does not lack experts in risk, or brilliant, knowledgeable structural engineers. What it seems to lack is decision makers who, backed by public demand for safety, insist upon a more rigorous approach.

Note on the author

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Further reading

1. Bazzucchi, F., L Restuccia and G. Ferro 2018. Considerations over the Italian road bridge infrastructure safety after the Polcevera viaduct collapse: past errors and future perspectives. Frattura e Integrità Strutturale 46: 400-421.

2. Gentile, C. and F. Martinez Y Cabrera 1997. Dynamic investigation of a repaired cable-stayed bridge. Earthquake Engineering and Structural Dynamics 26: 41-59.