RESILIENT INFRASTRUCTURE – IMPROVING LIVES

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The threats and challenges caused by political turmoil, climate change, population growth, ever-increasing urbanization and inadequate investment are now requiring engineers to consider resilience and adaptive strategies in order to address infrastructure needs. So what is resilience? Resilience is *'the ability to withstand or recover quickly or to recoil or spring back into shape after bending, stretching or being compressed.'* A simpler way to put it, is that resilience is the ability of our infrastructure to keep functioning during and after major disruptive events or overloads. People are inimitably resilient, but not so their environmental infrastructure. When this is inadequate and inappropriate, it impacts severely on people's quality of life.

Urban societies depend heavily on the proper functioning of infrastructure systems, many of which are invisible or taken for granted. However, this reliance becomes painfully evident when infrastructure systems fail during disasters. Moreover, because of the network properties of infrastructure, damage in one location has the potential to disrupt service in extensive geographic areas. The societal disruptions caused by such failures can therefore be disproportionately high in relation to the actual physical damage. Numerous recent natural disasters have unfortunately demonstrated this phenomenon. In an Irish context we only have to look at the number and location of homes left without water and electricity in the wake of severe storms, as well as the associated transport outages wrought by the same events.

Designing resilient infrastructure systems will require collaborative efforts by engineers, working in multidisciplinary teams with other professionals, using increasingly sophisticated tools to properly advise their clients, many of whom are overwhelmed by the complexity of the infrastructure challenges they face. In addition, and as quoted at a FIDIC Conference, *'taxpayers' expectations for a more sustainable future rely on the ingenuity of engineers. The future is in our hands. It is time consulting engineers came out of the shadows and it is time public authorities were open to earlier advice and support.'* So, other than coming out of the shadows and leading the societal debate, what does the consulting engineer need to do?

The question can best be answered by first asking what it is are we trying to be resilient against and how exactly we are to design for that resilience? Well, on the 'what' side and on a global scale, the list includes floods, earthquakes, hurricanes, tsunamis, landslips, and terrorist/cyber-attacks. It also includes a list of climate change related disruptors such as increased rainfall, rising temperature, increasing wind speeds and sea level rise. In terms of the 'how' side we need to meet the following characteristics of resilient design:

- Adaptiveness: resilience will be based on an ability to respond to uncertainty and change and to 'fail safe' in critical events;
- Robustness: this is the strength within systems to allow them to continue functioning during a disruption.
- Diversity: geographic diversity means distributing assets such that a single geographic event such as a flood, cannot affect all assets.
- Redundancy: means having adequate back-up capabilities when systems fail and having alternative routes and systems in the event of elemental failure.

The degree to which we require resilience is a function of the end user requirement. The consulting engineer needs to consider what resiliency means for each part of the system's critical path. This may be milliseconds for some scenarios and weeks for others. To use a medical example, Intensive Care Units (ICU) will have a zero lag tolerance whereas hospitals may be able to function with external kitchens for some time. As a transport example think traffic route lighting versus runway lighting.

In many ways the new call to resilience is only asking consulting engineers to formalise an approach which many of them have been taking all of their professional careers. The simple act of putting dual road gullies either side of the carriageway, with separate connections to the storm carrier drain, at the base of all sag curves comes to mind as one such example of resilient design. However it is likely there is now a need to up the game to a more formal approach to resilience in design. This will include making an assessment of possible solutions with a recognised matrix to rate uncertainty, resilience and adaptability. It will also require Engineers to educate stakeholders on risk. The use of 'no regret' measures is to be recommended i.e. providing a solid foundation for change, as is maintenance of the ability to adapt with the environment. There will be a concomitant requirement to consider changing contract types so as to reward resilience in design.

Finally, the consulting engineer needs to remain engaged for the long term with ongoing monitoring, review and action in order to continue leading the societal debate.