WHITE PAPER

STRUCTURAL RELIABILITY AND RISK INFORMED DECISION-MAKING BY PROPERTY OWNERS

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ABSTRACT

Structural reliability and risk-informed decision-making by property owners.

The development of high-bay warehousing facilities as distribution centres means greater risk to business in the unlikely event of structural failure. Should the owners of distribution centre properties take additional measures to hedge against this greater concentration of risk?

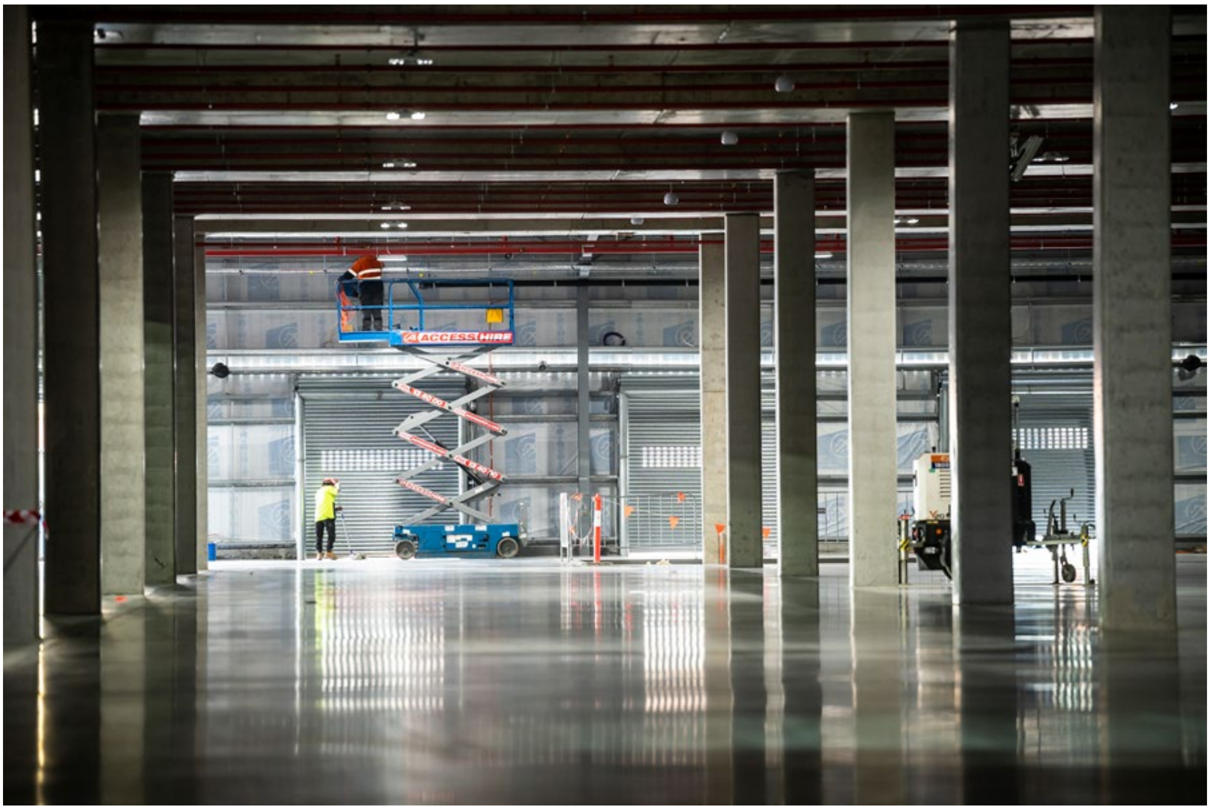
AUTHOR

Grant Roe is the Managing Director of Costin Roe Consulting, a civil and structural engineering design firm based in Sydney. Grant Roe has a Masters degree in Engineering and Masters degree in Business Administration. Grant joined Costin Structural in 1990, becoming an Associate in 1995, Partner in 1999, Director of the renamed Costin Roe Consulting in 2001, and Managing Director in 2016.

Since joining Costin Roe Consulting, Grant has worked on many significant commercial, industrial and residential projects. He is a specialist in the industrial sector and has worked on large scale industrial projects in Europe, Asia and Australia. Recently, Grant has become closely involved in the rapidly evolving logistics and fulfilment sector and has been instrumental in smoothly implementing the interface requirements between sophisticated automation systems and buildings. Grant has a keen interest in risk and structural reliability, particularly the general perception of risk and expectations at a societal level.

In contemporary supply chain management there is a strong movement away from the traditional network of warehousing facilities, staged at various locations, to having goods and resources centralised in the one national or regional facility, as with what is commonly called a “distribution centre”. With centralisation comes economies of scale, and the huge gains in efficiency delivered by consolidated investment in sophisticated and extremely costly warehouse automation systems.

While the business case for the development of distribution centres is compelling, centralisation also presents building owners with a more critical risk-management scenario than the decentralised distribution model. With decentralisation, the risk of exposure to threats like fire, earthquake, ground subsidence, tsunami, or the consequences of freak weather is confined to individual warehouse structures separated from each other by topography and distance. To better manage the unique risks associated with centralisation, an improved understanding of structural reliability and risk-informed decision-making is needed.



High-bay warehouses used as distribution centres - Woolworths National Distribution Centre, Moorebank, NSW

WHY MAJOR STRUCTURES IN AUSTRALIA WILL (RARELY) FAIL

It is very rare for any major building in Australia to suffer structural failure – so rare that if significant It is very rare for any major building in Australia to suffer structural failure – so rare that if significant structural failure occurs, no matter what the causative circumstances, it can make prime-time news and send virtual shock-waves throughout the broader community – as if structural failures may never happen here. This perception is allowed to prevail only because Australia, like most of the world’s more developed nations, has its own building codes and construction standards based partly on ISO 2394 (International Standard #2394).

In the rare event of catastrophic structural failure in Australia, such as when a freak hail-and-ice storm swept through the Eastern Creek area of Sydney on Anzac Day in 2015, causing at least eight warehouse buildings to collapse, the question is raised as to whether or not Australian standards should be changed to ensure such destruction could not happen again.

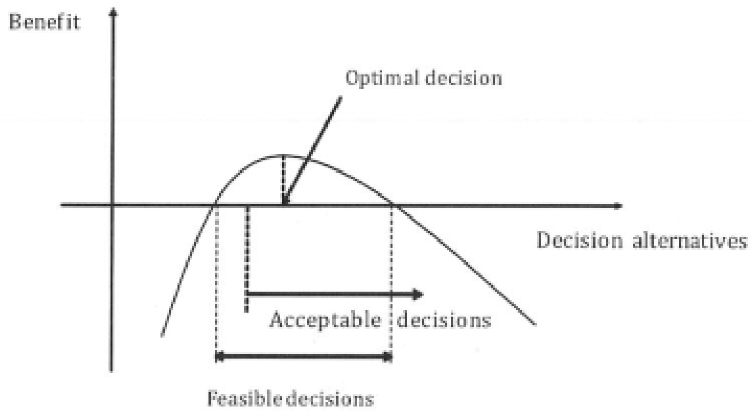


Illustration of the optimisation principle for the maximisation of benefits – from ISO 2394:2015 (E), page 19.

ISO 2394, titled "General principles on reliability for structures", defines in empirical, theoretical, and sociological terms how standards for building design, construction, maintenance, and de-commissioning are optimally formulated. The usual engineering-related computations of building resistance, and responses to actions, are refined by application of the theory of probability, and the principles of uncertainty. Consideration of the interpretation of data, performance-modelling over time, environmental factors, societal needs, and commercial realities is also included. This leads to risk-informed decision-making processes to arrive at an optimal balance between ideals and feasibility, called the "target performance level" or "safety index".

To quote from ISO 2394: "T*he appropriate degree of reliability shall be judged with due regard to the possible consequences of failure, the associated expense, and the level of efforts and procedures necessary to reduce the risk of failure and damage*."

Human safety is prioritised, of course, but it is not feasible for the reliability of all structures in all locations to provide maximum protection against all potential hazards, especially when the probability of any specific type of event occurring at any particular place can be extremely remote. For the owners of warehouse buildings in the Eastern Creek area, it may not be practicable to increase the structural reliability of properties by the magnitude required to protect against damage from a type of storm so rare that it is statistically unlikely to reoccur anywhere in the area during the building's lifespan. Neither is it in the community's best interests for building owners to take extraordinary precautions against improbable risks, as all costs incurred along the supply chain are ultimately borne by the consumer. Such risk may be more effectively managed by the insurance industry. Insurers understand risk and premiums reflect the insurer's exposure to risk, based on probability. This can be implemented at much less cost to the business than large-scale structural fortifications which could prove unnecessary.

ARE AUSTRALIAN BUILDING STANDARDS ADEQUATE?

Building design and construction standards are varied in requirements between regions. These variations depend on factors including the known frequency of particular hazards occurring in any given area, and the likely potential intensity of those hazards should they occur. For example, a structure with an expansive roof, designed for an area that's routinely subjected to cyclonic winds and torrential rain, such as in Northern Queensland, would differ in required performance from the same type of structure in an area where there is more likelihood of seismic activity, such as in Newcastle, and differ again from where it would need to bear occasional loads of snow and ice, such as in Orange, NSW.

> **The rarity of significant structural failures in Australia makes it self-evident that Australian building design standards are sufficient for Australian conditions, and in accordance with societal expectations regarding public safety and the longevity of building service life.**
>
> – Grant Roe BE(Hons) MEngSc MBA MIEAust CPEng NER

Where buildings are of great strategic importance, structural reliability is increased. Hospitals, utilities, and all structures that house essential services need to withstand a broader range of potential hazards of greater intensity than typical commercial, industrial, or residential buildings. In the event of a major disaster, for example, the societal priority is for essential facilities like hospitals and relief-effort command centres to remain safe and operational throughout the post-disaster and recovery period.

WHEN EXCEEDING STANDARDS IS JUSTIFIABLE FOR BUSINESS

The supply and distribution of goods in Australia is increasingly dependent on transportation to and from distribution centres of massive size, serving vast geographical areas. The value of structural reliability to a distribution centre is exponentially more than the replacement cost of the building itself. Even with a relatively minor structural failure, such as damage to part of a roof, there is risk of human injury, loss of stock contents, damage to extremely valuable automation equipment, and disruption to building function which could go on for months or even years while remediation is completed. The value to people of a continuous supply of products throughout cities and regional areas is incalculable. These factors pose a question to facility owners as to whether increased structural reliability is necessary for their individual situation.

It is in the design stage of distribution centre development that building owners can most effectively consider the costs and benefits of opting to exceed Australian standards to

Hazard	Category
Internal gas explosion	1
Internal dust explosion	1
Internal bomb explosion	2
External bomb explosion	2
Internal fire	1
External fire	1
Impact by vehicle	1
Impact of aircraft, ships	1
Earthquakes	1
Landslide	1
Mining subsidence	1
Tornado and Typhoons/Hurricanes/ Cyclones	1
Avalanche	1
Rock fall	1
High groundwater	1
Flood	1
Storm surge	1
Volcanic eruption	1
Environmental attack	1
Tsunami	1
Vandalism	2
Public disorder effects	2
Design or assessment error	3
Material error	3
Construction error	3
User error	3
Lack of maintenance (deterioration)	3
Errors in communication	3

Overview of relevant hazards for risk assessments and structural safety – from ISO 2394:2015 (E), page 95.

achieve greater structural reliability. The objective is to improve building performance and business continuity should the building be subjected to some more severe hazard. Somewhere in this assessment is the optimal balance of structural reliability combined with sufficient insurance and contingency planning to allow the business to continue operations effectively in the unlikely but possible event of structural failure or other major calamity.

THE BASIS FOR RISK-INFORMED DECISION-MAKING

CRC engineers have the expertise and experience to successfully undertake a comprehensive analysis of any distribution centre design, proposed for any site, to report on the feasibility of increasing structural reliability in sufficient magnitude to hedge against the increased concentration of risk.

CRC uses 5D BIM technology to model the proposed building components and attributes in their entirety, including costs that recalculate in real-time when variable changes are made, and can demonstrate and examine the effects of potential or probable impacts using other advanced technology such as 2D TUFLOW flood modelling.

With the data we have available and our in-house modelling technology, what CRC can provide to the building owner is the basis for risk-informed decision-making in relation to their planned development.

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