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Where to next for Wind Engineering and Building Resilience: A view from inside an operations centre

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ABSTRACT

Community resilience relies on a well-prepared populace—one that comprehends risks, knows how to respond during unfolding events, and actively mitigates threats to safeguard valuable assets. This collective responsibility necessitates collaboration across all levels of government, industry, and the community itself.

Within the Queensland Fire and Emergency Services (QFES), our commitment extends beyond rhetoric. We actively engage in research and innovation, fortifying our preparedness for future disasters. Our esteemed collaborations with institutions like the James Cook University Cyclone Testing Station, Geoscience Australia, the University of Queensland, and the Queensland Department of Environment, Science, and Innovation have yielded state-specific hazard and risk assessments. These assessments serve as the backbone of local and district disaster risk management.

Our collaborative efforts have yielded significant outcomes: the Severe Wind Hazard Assessment for Queensland (SWHA-Q) and the Severe Wind Hazard Assessment for South East Queensland (SWHA-SEQ). These outputs enhance preparedness, inform disaster management exercises, drive commitments to bolster local resilience, and facilitate the practical application of the operational tool known as the Natural Hazard Impact and Risk Service (NHIRS) during recent tropical cyclone season.

While the commendable outputs from the SWHA-Q and SWHA-SEQ deserve recognition, there remains unfinished work. These assessments have illuminated critical research needs across various domains. Operationally, our focus must sharpen on enhancing decision-making within State and Regional operations centres. Specifically, we must address three pivotal areas:

1. ***Comprehensive Hazard Consideration:***
   - *Our information provision should extend beyond wind-related risks to encompass all hazards associated with an event.*
   - *We must broaden our scope to include diverse building assets, moving beyond stand-alone residential homes.*
2. ***Integrated Impact Products:***

- *Decision-makers, especially during recent tropical cyclone events, demand integrated products.*
- *These products should transcend wind impact information, incorporating factors like rainfall and storm surge.*

3. Inclusion of Hail Events:

- *For severe wind events, our integrated products should also account for hail impact.*
- *By addressing these aspects, we fortify our preparedness and response capabilities.*

What lies ahead for Wind Engineering and Building Resilience? The consequences of inaction regarding building standards will persistently escalate throughout society, placing additional strain on emergency services. In the spirit of collaboration and collective responsibility, we advocate for a shift toward a risk-based perspective on building resilience — one that encompasses a multitude of hazards.

INTRODUCTION

We are all aware of the devastating consequences from major tropical cyclones in Queensland. The relative contribution of the impacts from wind, storm surge, rain and the associated flooding has varied considerably. As the climate changes, so will the nature of the hazard. Predictions suggest that tropical cyclones are likely to bring additional rain for example.

As tragic as these events are, they represent an opportunity to reflect and take actions to improve. For disaster management in Queensland, these reviews have been led by the Queensland Inspector General of Emergency Management which was established in 2013 following a review of police and community safety. There have been a number of reviews stemming from tropical cyclones, notably Tropical Cyclone Debbie. The corresponding action plan covers a broad range of aspects, including evacuation, exercising, communication and messaging. This and prior reviews have led to major work in relation to cyclone shelters for example – the design, maintenance and the related messaging and evacuation process.

Amongst these actions, there have been ones relating to improved information management. Action 7b from the 2017 Tropical Cyclone Debbie Review stated:

> *Significant effort should be invested to provide disaster decision-makers at every level with a shared understanding of risks, the situation, and capability, so that they can agree the best decisions for the communities they serve.*

This action was the driver for the Severe Wind Hazard Assessment for Queensland (SWHA-Q). It resulted in publicly available information on the current and future tropical cyclone wind hazard, two wind impact scenarios as an input to risk-based planning for seven Queensland locations, a household preparedness guide and an operational wind impact forecasting tool for residential stand alone buildings. The SWHA-Q outlined the potential impacts to the community using the Queensland Emergency Risk Management Framework. This qualitative descriptors cover potential impacts to critical infrastructure (power, telecommunications, water and wastewater, fuel, transport), access and resupply, community and social, medical and public health and the environment stemming from the wind, storm surge, rainfall and potentially flooding. These qualitative descriptors aim to provide insight into the possible impacts.

This project led to the SWHA-SEQ (Edwards et al. 2022) which quantified wind risk (as average annual loss), options to reduce the risk (three retrofit strategies) and the associated cost-benefit for stand alone residential buildings. In addition to extending this work to include all hazards associated with the tropical cyclone, the SWHA-Q and SWHA-SEQ acknowledged the role that land use planning and building regulation play in reducing risk to the community. The findings from the SWHA-SEQ prompted the City of Gold Coast to initiate a five year major project – Project AIR (Advocacy, Information and Resilience) – to apply this work locally in the City of Gold Coast local government area (Sexton *et al* 2023).

What is notable is that the disaster management reviews have focused on the preparedness, response and recovery aspects of disaster management system rather than the broad environment in which it operates and specifically the preventative measures that would reduce the cost to society. One of these measures is building codes and the 2020 Royal Commission into the National Natural Disaster Arrangements made one recommendation in relation to the National Construction Code, Recommendation 19.4:

> *The Australian Building Codes Board, working with other bodies as appropriate, should:*
>
> *(1) assess the extent to which AS 3959:2018 Construction of buildings in bushfire-prone areas, and other relevant building standards, are effective in reducing risk from natural hazards to lives and property, and*
>
> *(2) conduct an evaluation as to whether the National Construction Code should be amended to specifically include, as an objective of the code, making buildings more resilient to natural hazards. All changes to regulate resilience should be proportionate and proven to be cost-effective.*

The Royal Commission's commentary on building regulation and the existing risk to the built environment acknowledged the challenges associated with changing standards. The current political environment is not conducive to changes however would these decisions encompass the costs that are associated with emergency response and degradation to commuity resilience?

DECISION MAKING

From a Queensland Fire and Emergncy Services (QFES, transitioning to Queensland Fire Department on 1 July 2024) State Operations Centre perspective, the strategic level information available through SWHA-Q and SWHA-SEQ provides insights to which areas are more likely to sustain wind damage, with the operational tool providing insight to the extent of the damage.

However, we know that wind is one component of the impacts from tropical cyclone. Recently, the Queensland storm tide evacuation mapping (contribute to Action 2b from the 2017 Tropical Cyclone Debbie Review) has been integrated at the state-level which provides insight into the potential extent of storm tide, https://www.qfes.qld.gov.au/prepare/storm-surge/evacuation-zones. This publicly available product also provides a summary of exposure (not the level of impact) within the evacuation area using the national Australian Exposure Information Portal (AEIP https://www.aeip.ga.gov.au/).

QFES has worked with FloodMapp (https://www.floodmapp.com/) to provide additional situational awareness at the state level. FloodMapp offers ForeCast, NowCast and PostCast in

their product suite to provide information for preparation, response and recovery. ForeCast provides short-term flood extent and depth forecasts as an operational data feed that is updated in real-time as the flood event unfolds. As with the storm tide example above, an AEIP analysis is required to estimate the extent of exposure to flooding using the FloodMapp inundation outputs.

Each of these information sources are displayed in online spatial platforms available within operations centres. As the quantity and avaiability of information increases, so does the challenge for decision makers.

Inside the operations centre

QFES decision making is underpinned by three key priorities; safety of life, protecting infrastructure for community safety and agency reputation. The decisions required have major implications at the political to communty level. Decision making is informed through an intelligence capability providing regular intelligence reports – from daily, to weekly to short to medium term outlook – through to longer term, strategic risk information. These intelligence reports include a detailed situational awareness, social media sentiment, a PISSEIE analysis (Political, Infrastructure, Social, Security, Environment, Information, Economic), and a Course of Action analysis for the Most Likely and Most Dangerous scenario. These reports provide the strategic backdrop to the decision maker and the development of detailed plans. The Course of Action analysis highlights the indicators and warnings that have been observed, thereby providing valuable insight to guide decision making. These decisions then translate to operational and logistical planning for resources and their deployment in sufficient time.

This process is both deliberate and an art. The deliberate aspects are developed through thorough data and information collection which provide the basis for the observed indicators. In short, the decision maker is relying on data from previous events, rather than simply experience. This is no different to model validation approaches, however, the power with models is the ability to forecast. The intelligence cycle can certainly accommodate such model forecasts, if they are available. These forecasts would be powerful if the supporting indicators were also available so as to inform actions ahead of an event.

The intelligence capability within the disaster management sector is emerging. Such a capability has been embedded in miliary decision making for centuries. In a similar vein, strategic planning capability is also now being translated from the military domain to disaster management (Australian Government 2017).

The intent of this paper is not to provide a treatise to disaster management decision making – there has been much written on how decision making needs to be informed by an understanding of risk, and not simply to rely on past experience alone. However, history is a valuable teacher, and in the context of intelligence, it is critical. For the purposes of this short paper and the decision making for an impending severe weather event, the indicators and characteristics of the severe weather system provide the evidence base to build intelligence reports and provide the evidence required for decision makers.

As a local government representative commented at a recent (2 May 2024) National Environment Science Program webinar *Are Tropical Cyclones moving further south*, tropical cyclone severity is based on peak wind, not rainfall, however flooding can be the worst impact. This insight reinforces the need for an integrated story and product.

Opportunities

The QFES intelligence collection process is underway, building an information database of the impacts and corresponding weather system indicators. Such a database could then be a training dataset for a machine learning system to remove the mandraulic process of scanning this material to determine the relevant indicators. The United States Government Accountability Office (US GAO 2023) identified several benefits of applying machine learning to this field. These benefits include reduced time for forecasting and warning, increased model accuracy, and reduced uncertainty of model output. FloodMapp is one such example being used in Australia. As more events occur, model performance continues to improve.

Pilkington and Mahmoud 2017 have adopted a machine learning approach for estimating impact from hurricanes. They have analysed historic hurricane events, determined the maximum wind, surge and rainfall characteristics as well as an estimate of (economic) impact. This information is then used to develop and train an artifical neural network which can then be used to predict impacts as a hurricane is forecast.

Could such an approach be developed for Queensland? Is there sufficient data to train a model to predict the impacts which can then be used for response planning? Is the economic impact a suitable proxy for use in disaster management decisions? Pilkington and Mahmoud 2017 have extended their original work to explore the spatial and temporal variations acknowledging that building codes and infrastructure protections is variable across the United States coastline. This aspect would be important in Queensland given the wind loading regions.

The insurance sector has also continued to innovate in data analytics and product development, expanding the scope of commercial insurance solutions. Parametric insurance is one such solution. Here, this insurance covers the probability of a predefined event happening instead of indemnifying the actual loss incurred. These solutions need a triggering event which means an event with pre-defined parameters are met or exceeded. Can this approach be instructive or useful for disaster management decision making as well?

The Insurance Council of Australia has recently raised their concerns of tropical cyclone impacts to Queensland. Their 2023 report highlighted that a repeat of TC Marcia and Dinah would result in insured risks that would exceed those from the 2022 SEQ flooding. These concerns are shared across the disaster management sector.

CONCLUSION

Information is critical to decision making but there are questions of its utility, reliability, accuracy and extent. What are the minimum requirements for these aspects for disaster management decision making?

It is tempting to continue to refine existing approaches, that is to have vulnerability models for more and more building types to extend the existing operational impact forecating tools, but can we practically do this in a reasonable time frame to improve our near-term decision making?

Whilst disaster managers continue to call for more information, there is the challenge of balancing the varied forms and risks of being overloaded. There is a need for integrated products for strategic and operational decision making.

In summary, this is a call to action for integrated products to inform decision making and reduce the risk to the Queensland community.

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