WHEN SEVERE STORMS OCCUR MORE OFTEN, HOW DO WE ENSURE RESILIENCE OF THE ROAD NETWORK?

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Summary

The resilience of a road network is the degree to which it is available to the road user. This may be compromised by severe weather, such as winter storms, hurricanes, severe thunderstorms, etc. There is a perception that the frequency of such storms is increasing, and there is interest enhancing resilience as much as possible during such storms.

This paper considers how the resilience of the road network was compromised during one winter storm, what steps were taken to recover the road network, and what measures might be taken going forward to enhance the recovery process.

Introduction

Road agencies are increasingly required to ensure the resilience of the road networks for which they have responsibility. That resilience is challenged by severe weather events, and in particular severe winter storms can close key parts of the road network for many hours, or in rare circumstances, for many days. This is not ideal, and increasing efforts are being made to address and minimize such closures.

This paper will examine one event which compromised the road network across several states in the United States for several days. We will discuss where the network was compromised and for how long, what steps were taken to recover the road network, and what measures might be taken in the future to improve resilience of the road network in similar storm events.

Storm Event and Data Collection

The storm used in this study occurred during December 2022, specifically in the week just prior to Christmas. It was forecast to impact the northern tier of U.S. States, from Wyoming in the West through New York in the East. Depending on location, more than 30 cm of snowfall was forecast, with wind speeds in excess of 80 kph and temperatures as low as -30° C. This was predicted to be a major snowstorm with significant impacts on the transportation system. Figure 1 shows the National Weather Service warnings associated with this storm event. Figure 2 shows a typical forecast graphic.

The actual storm turned out differently from the forecast, as might be expected. The more Western states got all three of the impacts (snowfall amount, wind speeds, and low temperatures) but as the storm moved East, the snowfall amounts fell below what was predicted, which lessened impacts in the states of Illinois, Indiana, Ohio, and Michigan, for example. Buffalo in New York was hit with very heavy snowfall, which was mostly lake effect snow, and combined with the wind and low temperatures this effectively closed that city for several days.

Details on the storm itself and how it impacted various agencies, along with details on how agencies responded, are given in [1]. The responses focused on three areas in particular: preparation prior to the storm, actions during the storm, and post-storm review. The study found several key lessons as reported by agencies: communication was critically important,

and had to occur at a variety of levels, for effective decision-making, authority must be delegated to an appropriate level, and the decision-making must be trusted by those higher up in the authority chain, and closing roads deliberately is a complex process that must be carefully planned.

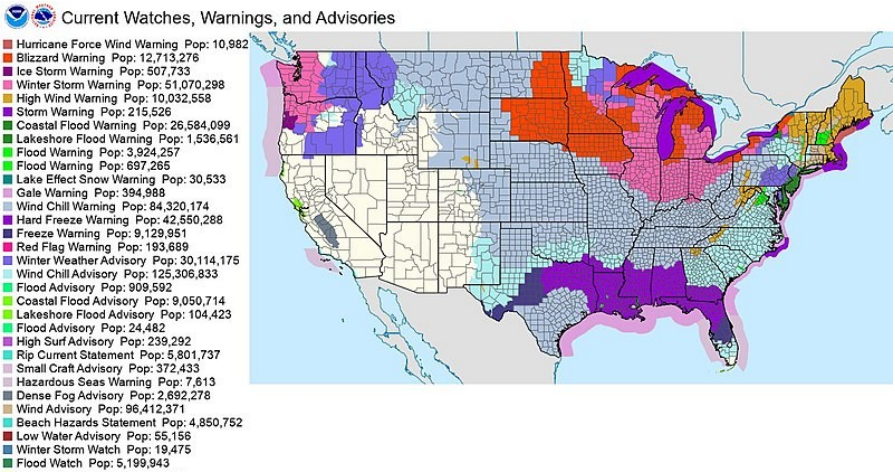

Fig. 1. National Weather Service Watches, Warnings, and Advisories associated with the storm used in this study.

Fig. 2. Typical Forecast Graphic associated with the storm.

Enhancing Resilience

In the context of this storm, the primary impact on resilience was the closure of major highways. At various times during the storm, Interstates 80, 90, 94, 35, and 25 were all closed, in some cases for more than seven consecutive days. Closing a major highway such as an Interstate is a difficult decision. These highways are almost always the highest priority roads in an area, and as such if closed then traffic is diverted onto less well serviced roads. It might be thought that road users, when faced with a closed interstate would pause their journey at that point rather than seek alternative routes, but experience showed [1] that this was not the case.

Even though closing roads is less than desirable, sometimes it is necessary. Closures may sometimes be an effective way to preserve resilience, by ensuring that a road system is returned to full operation as quickly as possible [2]. In this storm, agencies reported four reasons for closures: reduced visibility, heavy snowfall, heavy drifting, and crashes.

Of these four closure causes, drifting is a major component in two. Drifting can be significantly reduced by the use of snow fences, either artificial [3] or living [4] in type. Nonetheless, even when snow fences are present, significant drifting may still occur. Snow fences are designed to protect against the prevailing wind direction, and if a given storm has a different wind direction, the constructed fence may offer little to no protection. Further, if precipitation or wind levels are very high, even the best snow fence may become ineffective. In the December 2022 storm, this occurred in a number of locations where roads were closed.

Very high snowfall rates (more than 30 cm per hour) will rapidly make a road unpassable, and in some locations, this (or heavy drifting) resulted in the road being closed. Little can be done to mitigate heavy snowfall, so the issue then becomes how best to reopen a road. For this, consideration should be given to all possible tools in the winter operations toolbox [5].

In such cases, a number of operational decisions need to be made. If the area impacted is small, or intermittent, then plows can be dispatched to address the local closures and the road may be rapidly reopened. If closure is over a large area (as happened in the 2022 storm) this may not be possible, so instead some form of convoying may need to be used. Obviously, tightly controlled convoys do not allow the volume of traffic that an open road provides, but they do provide higher volume than a closed road.

The fourth cause of road closures is crashes, and these closures are by their nature unplanned, but foreseeable. We know that crashes are more likely in winter weather [6] and while good winter maintenance has been shown to reduce crash frequency [6] in extreme storms crashes may still happen. There are some indications that stricter enforcement of traffic regulations under severe winter storm conditions may reduce crash occurrence, although these findings are more anecdotal than data-driven at present.

Conclusions

Results from a study conducted on a single severe winter storm in December 2022 that impacted several Northern tier States in the U.S. indicates that there may be actions that can be taken to enhance road network resilience during such events. These potential actions have been presented and discussed.

Acknowledgements

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