Recent tornado damage in Japan

Wind Hazard Mitigation

Wind hazard mitigation
One of the aims of the Global COE Program at Tokyo Polytechnic University

- To mitigate wind-induced damage to buildings and other structures, we need to learn from past major disasters.
- Wind related disaster results from interaction between wind climates and structures. We need to know not only the characteristics of each factor but also how they interact with each other.
Distribution of Tornado (1991-2008)

Tornado-affected Area

whole Japan

notably at the Okinawa islands, the Japan Sea coast, Kyushu, Shikoku, the Kanto district and the south coast of Hokkaido

(JMA)
### Number of Tornado

<table>
<thead>
<tr>
<th>Year (JMA)</th>
<th>Number of tornadoes per year</th>
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<tbody>
<tr>
<td>2006</td>
<td>40~50</td>
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<tr>
<td>1961-1970</td>
<td>17 tornadoes/year</td>
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The chart shows the number of tornadoes recorded from 1961 to 2006, with a peak in 1998. The data is categorized into unknown, sea -> land, sea -> sea, and land -> land types. The chart indicates that about 13 or 17 tornadoes occur per year on average.
**Location of Tornado**

**Per km²/year**
- 0-2km: 0.000411
- 2-10km: 0.0000512
- >10km: 0.0000161

**significant within 2km from the seacoast!**

**Risk Modeling**

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Tornado Scale

Tornadoes, downbursts and other local disturbances in 2005 and 2006.
Recent Damaging Tornados in Japan

- Gust at Ogata-mura and Kotooka-machi, Akita (Nov. 8, 2005)
- Tornado at Sakata, Yamagata (Dec. 25, 2005)
- Tornado at Minehama, Akita (Dec. 26, 2005)
- Tornado at Fujisawa, Kanagawa (Apr. 20, 2006)
- Gust at Tokorozawa, Saitama (May 20, 2006)
- Gust at Sakado, Saitama (May 20, 2006)
- Tornado at Nobeoka, Miyazaki (Sep. 17, 2006)
- Tornado at Saroma, Hokkaido (Nov. 7, 2006)
- Tornado at Tsuchiura (Oct. 8, 2009)
- Tornado at Noshiro, Akita (Oct. 30 2009)
At around 12:00, a gust blew from Ogata-mura to Kotooka-machi. Damage to agricultural structures and dwellings was spread linearly over a distance of 8 km.
Gust at Ogata-mura and Kotooka-machi, Akita on November 8, 2005

> 34 m/s
Tornado at Sakata, Yamagata on December 25, 2005

- Gust damage to structures and train cars occurred around Sakata City from 19:00 to 19:20 on December 25th.

- The anemometer on the Shinkawa coast recorded a peak gust speed of 36.9 m/s at 19:06. The derailment accident, thought to be caused by this gust, occurred on the JR Uetsu-line at 19:14, causing 5 deaths and injuries to 32 people.

- Damage was scattered in a straight line from the coast to the east-northeast for a distance of about 12 km.
Tornado at Sakata, Yamagata on December 25, 2005

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Tornado at Minehama, Akita on December 26, 2005

A gust occurred in Minehama, Akita Prefecture, causing collapse of a wooden house, scattering of roofs and damage to agricultural facilities etc. from 11:10 to 11:20
Tornado at Minehama, Akita on December 26, 2005

Damage was scattered in a straight line about 5 km long. The most remarkable damage was the collapse of a two-story wooden office building.
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Tornado Damage at Fujisawa, Kanagawa on April 20, 2006

- Around 12:05, a strong wind gust occurred that caused damage in both Fujisawa City and the southwestern part of Yokohama City.

- Damage to over 40 houses was observed, with the affected area covering an area of 2 km by 50 m. The damage was estimated to be of F0-P1-P1 rank on the Fujita-Pearson (FPP) scale.
Tornado Damage at Fujisawa, on April 20, 2006
On May 20, 2006, a trough accompanying cold front moved through the Kanto area creating an unstable atmosphere that caused gusts and local heavy rain in many palaces.

In Tokorozawa City, gust damage to greenhouses and roofs of dwellings occurred at 15:40. There was also some damage to houses due to flying debris. The damaged area was spread over an area 500 m long by 50 m wide.
Blown up dust was observed (50m width). Just after its passing, it began to rain.

Damage to plastic greenhouse, blown off

Moving direction of dust. Rotation was not seen. Blown up dust was observed.

Estimated wind direction

Damage to roof tiles
Blown off a small shed (10m width)

Damage to roof tiles

Blown off metal shutter

Blown off a roof of a carport

Damage to exterior wall
Noise was observed.

A roof lifted up
Damage to roof tiles
Tornado in Nobeoka, Miyazaki on September 17, 2006

Typhoon Shanshan (T0613) was born in the eastern Philippine Sea and moved north-west. Shortly before it landed at 1400 JST, gust damage occurred in Nobeoka City, Miyazaki Prefecture.

Three people died, ninety-four buildings were completely destroyed and the limited express 'Nichirin' was derailed and overturned.
Tornado in Nobeoka, Miyazaki on September 17, 2006
Tornado in Nobeoka, Miyazaki on September 17, 2006
Tornado in Saroma, Hokkaido on November 7, 2006

- On November 7, 2006, an F3 ranked tornado struck dwellings in the Wakasa area of Saroma, Hokkaido, causing serious human and property damage.
- Nine people died and 26 were injured.
- Over 30 buildings, including a dwelling, warehouses and temporary structures were completely or partly destroyed.
- A detailed investigation of damage to buildings showed that the damaged area was about 1 km long by about 100 to 250 m wide.
Tornado in Saroma, Hokkaido on November 7, 2006

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Part of a temporary 2-storey steel frame building (length: 37.56m, width: 9m, height: 7m), which served as an office as well as a dormitory, was blown 60-90m, hitting the ground and other buildings, and nine people working in the building died. Motor trucks in the yard were blown over.
It satisfied the requirements of “Temporary house”.

However, this kind of “temporary structure” is usually re-used at another places after finishing the work at one location. It exists inside the city for a long time.

It is necessary to re-consider the design requirements on it. (Tamura, 2008, 2009)
Tornado in Saroma, Hokkaido on November 7, 2006

Courtesy of Kyodo News

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Tornado in Saroma, Hokkaido on November 7, 2006

Completely destroyed buildings

A 2-storey dwelling house was blown off;
An evidence of F3 level tornado (Metrological station)

Partly destroyed buildings

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Tornado in Saroma, Hokkaido on November 7, 2006

Miscellaneous damages

The shutter was open

Turn-over of trucks

Collapse of electrical poles

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Tornado in Saroma, Hokkaido on November 7, 2006

Damages due to flying debris
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Courtesy of Saroma-cho

Outside

Inside

Courtesy of Saroma-cho
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Courtesy of Yubetsu-cho
Falling down of a 40cm square plate was observed at a location 20km away from Saroma town.

**Materials of flying debris**

- **On site**
  - lumber, roof frame, roofing material, metal beam, home electric appliance (Refrigerator etc.), etc.

- **On the areas far away (about 10km away)**
  - Wooden chip, tinplate, clothes, glass wool, screen, etc.

*A Chain of Damage*
Tornado at Tsuchiura, Tsukuba on Oct. 8, 2009
Tornado at Noshiro, Akita on Oct. 30, 2009
Concluding Remarks

- Tornadoes caused serious damage. Their influence areas were not so large, but there were more frequent occurrences than typhoons.

- The actual wind damage to structures was a little different from that assumed in their design. For example, the major load was not always wind pressure but impact of flying debris.
Thank you very much for your attention.

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