A Fundamental Study on the Risk Financing of the Cyclone Risk in India

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Background of the Research

- Recently, BRICs, in particular, the economic growth of India is remarkably high rate in theses 2-3 years. (GDP: above 8%)
- On the other hand, India is known as a Earthquake, Cyclone prone country.
  Natural disaster seems to be one of the impediment to the economic growth.
- In particular, Gujarat State of the west part of India, is a highly catastrophic earthquake and cyclone prone area.

⇒ ***How to reduce the natural disaster risk ?***
(How to transfer the risk ?)

Gujarat Earthquake (2001)

Date: Jan 26,2001

Size: Mw = 7.7

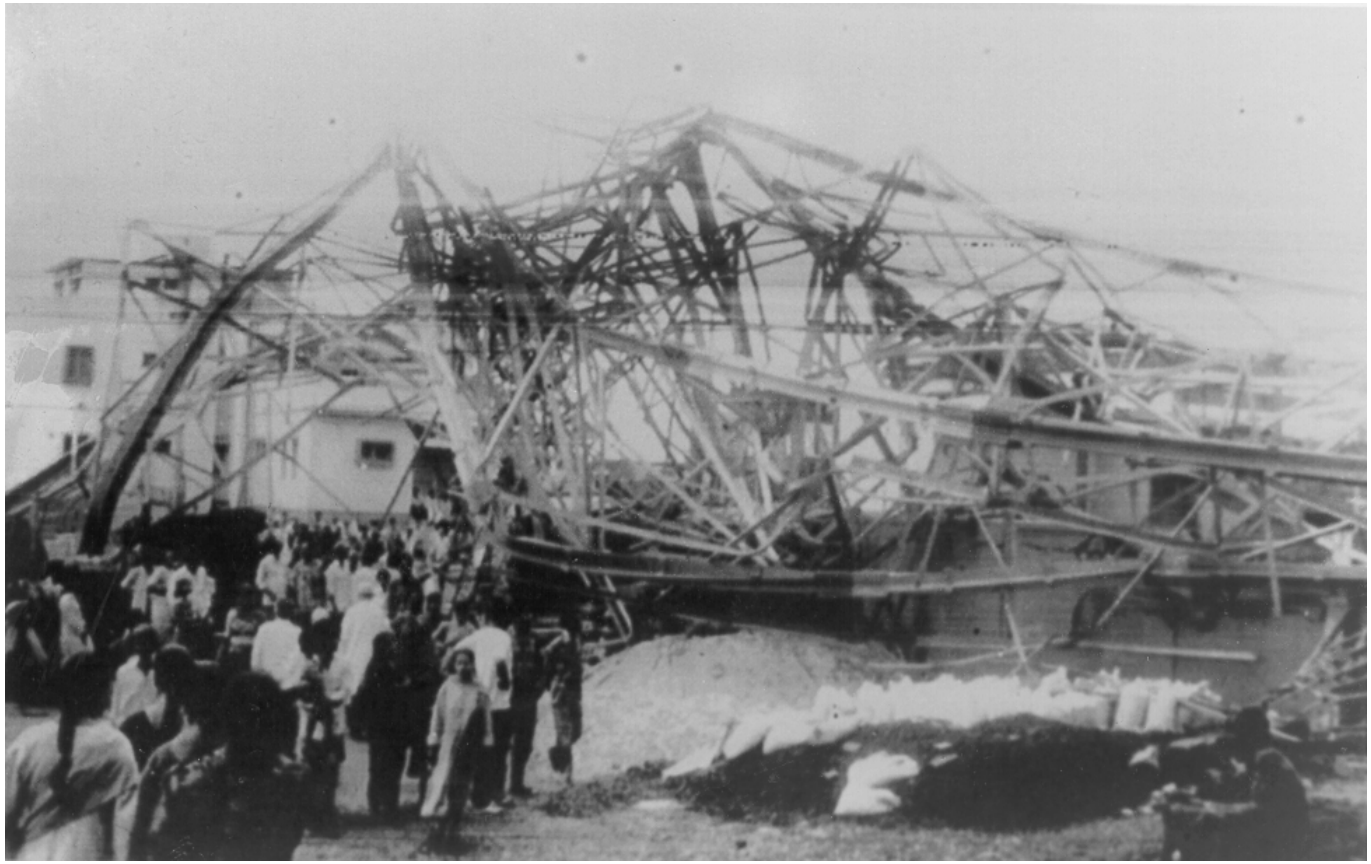
Depth: 22km (USGS)

Death: 20,005

Injury: 68,478

Num. Collapsed Bldg.: 228,906

Gujarat Cyclone 1998



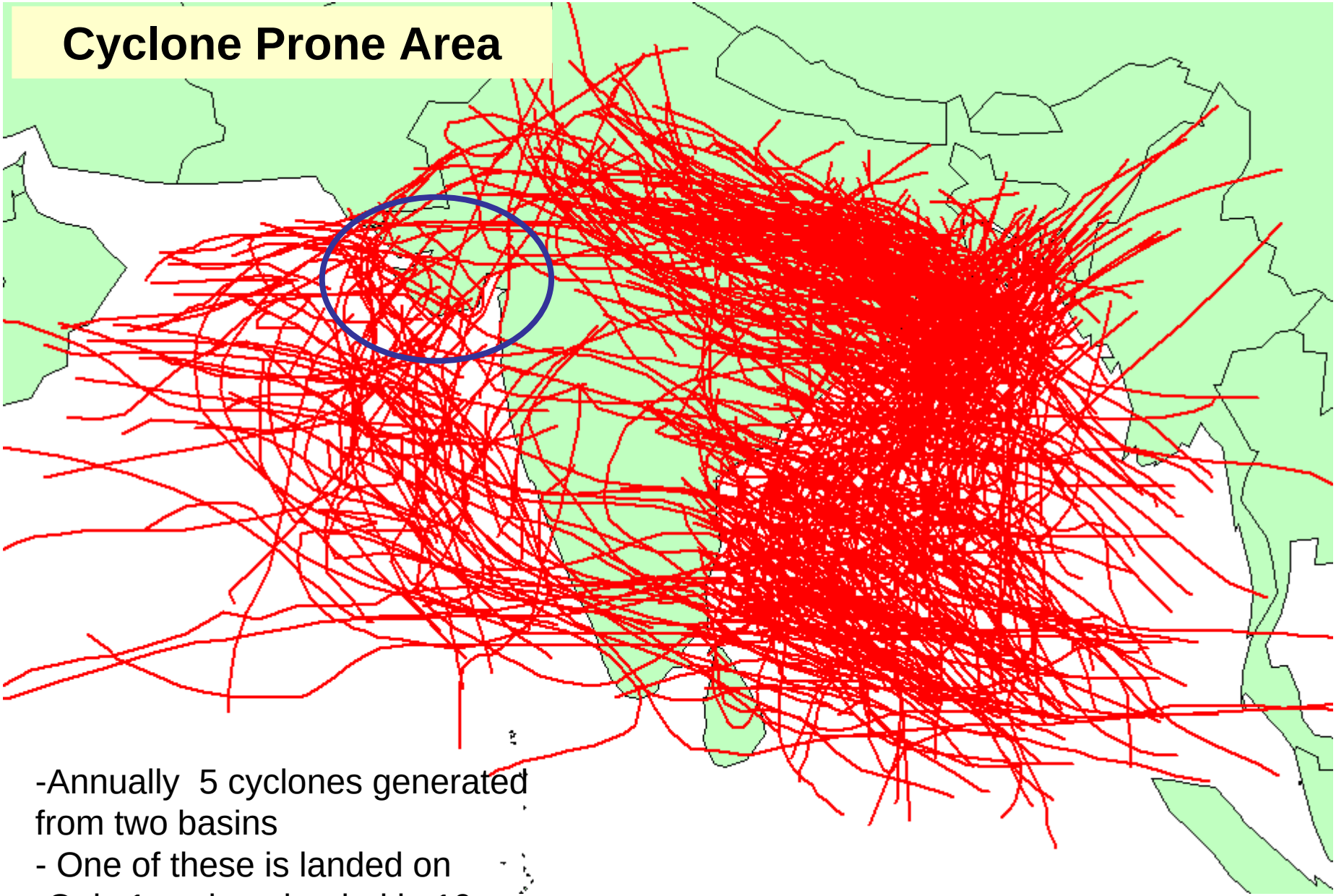
Central Pressure Depth; 938hpa （Similar to Typhoon Mireille）

Radio Tower Collapsed by Intense Wind

Recent Cyclone Losses (by EM-Dat)

Dates	Country:	Location:	Disaster: Type	Numbers:	DisNo:
2-May-06	India	Uttar Pradesh, Gujarat	Wind Storm Storm	76 killed	2006-0740
18-Feb-03	India	Dholatar (Gujarat state)	Wind Storm Cyclone	5 killed 140 affected	2003-0100
28-May-01	India	Gujarat, Goa, Maharashstra, Kerala, Naliya	Wind Storm Cyclone 01A		2001-0729
Oct-01	India	Andhra Pradesh	Wind Storm Cyclone	78 killed 2,000 homeless 25,000 affected	2001-0584
28-Oct-99 30-Oct-99	India	Kendrapara, Jagatsinghpur, Khurda, Puri, Cuttack, Nayagarh, Bhadrak, Keonjhar, Dhenkanal, Balasore, Mayurbhang, Jajapur (Orissa, Andhra Pradesh, West Bengal states)	Wind Storm Cyclone 05B	9,843 killed 3,312 injured 12,625,000 affected 2,500,000 ,000 US$	1999-0425
20-May-99	India	Gujarat Coast	Wind Storm Cyclone O2a	278 killed 40,696 affected	1999-0177
9-Jun-98 11-Jun-98	India	Kutch, Porbandar, Jamnagar, Junagadh, Amreli, Bhavnagar, Banaskhanta, Surat, Bharuch, Rajkot, Valsad, Nasvari districts (Gujarat state), Barmer, Jallore districts (Rajasthan state), Ratnagiri district (Maharasthra)	Wind Storm Cyclone 03A	2,871 killed 893 injured 4,600,000 affected 469,000 ,000 US$	1998-0183

Cyclone Prone Area



-Annually 5 cyclones generated from two basins
- One of these is landed on
-Only 1 cyclone landed in 10years in Gujarat. Rare event.

Background

- For the Cyclone that has catastrophic event with low probability and highly negative impacts, we can reduce the risk with risk finance scheme ?

⇒ ***Risk hedge through the Cyclone Risk Linked Bond (Catastrophic Bond "Cat Bond") is one of solution.***

⇒ ***Therefore, the necessary to assess the cyclone risk based on the probabilistic risk analysis approach***

What is “Risk Finance” ?

Phase 1： Risk Identification

Phase 2： Risk Analysis

Phase 3： Risk Strategy

Loss Prevention

Risk Financing

（Insurance, Securitization）

Recent Movement of Risk Finance Market on Natural Disaster

Alternative Risk Transfer（ART）

⇔ Traditional Insurance

- **Risk Securitization**：

  Own retained risk transfers to the capital market instead of traditional insurance market.

- **Risk Swap**：

  Mainly, within insurance industry, insurer transfer their risk to other insurers based on the equivalent size of risk to reduce their natural hazard risk portion. Recently, private and public sector interest in the risk swap to stabilize their profit (e.g. weather derivative)

Trigger Types of the Payment by CAT-Bond

1. Indemnity Loss

- Investor provide the principal. If no natural disaster happen, investor receive the interest return from issuer.
- On the other hand, if CAT events happen and the loss exceed the triggered amount, the principal is paid to the issuer.

2. PCS Index (Property & Casualty Claim Services)

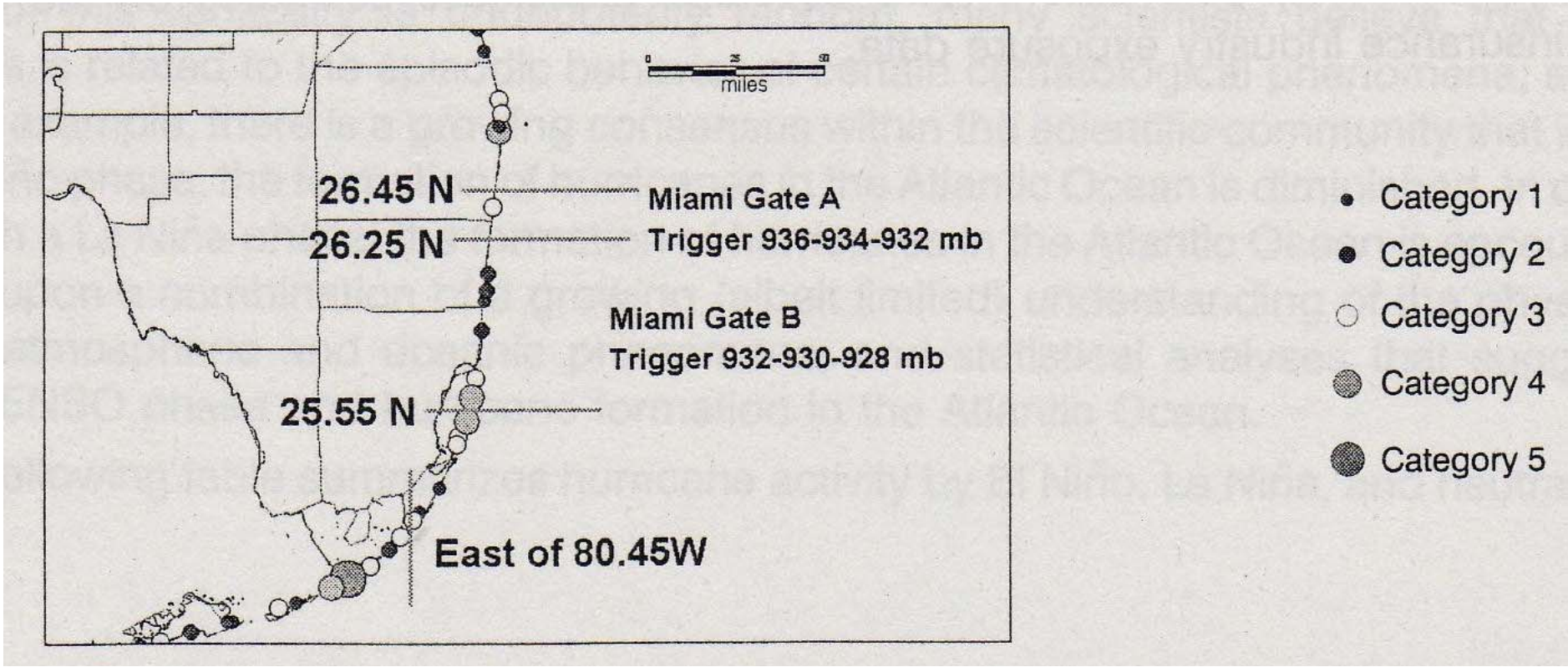
- The actual loss amount is reported to PCS after the natural disaseter.If the actual reported loss exceeds the certain triggered amount, the principal is paid to the issuer.

3. Parametric Trigger/Modeled Loss

- If the earthquake or cyclone hit the certain designed area with exceeding the pre defined size and strength, the contract amount is paid to the issuer.

Miami Area Hurricane Landfalls 1900-1999

(Prime Capital Re)



Focused Points in the Study

For designing the trigger based CAT-bond, we have to estimate the future loss cost by the cyclones for issurer. Therefore we need loss data or estimate the losses for a future long period.

1. **Hazard**:
- Low Frequency of the Cyclone affected to Gjurart Area
  (Origination of the Cyclone from Bengal Bay; Annual 3, Arabian Sea; Annual)
  ⇒ No detailed historical loss data

2. **Wind Speed / Cyclone Parameter Data during Extreme Event**
- Insufficient Observation Data to the Public

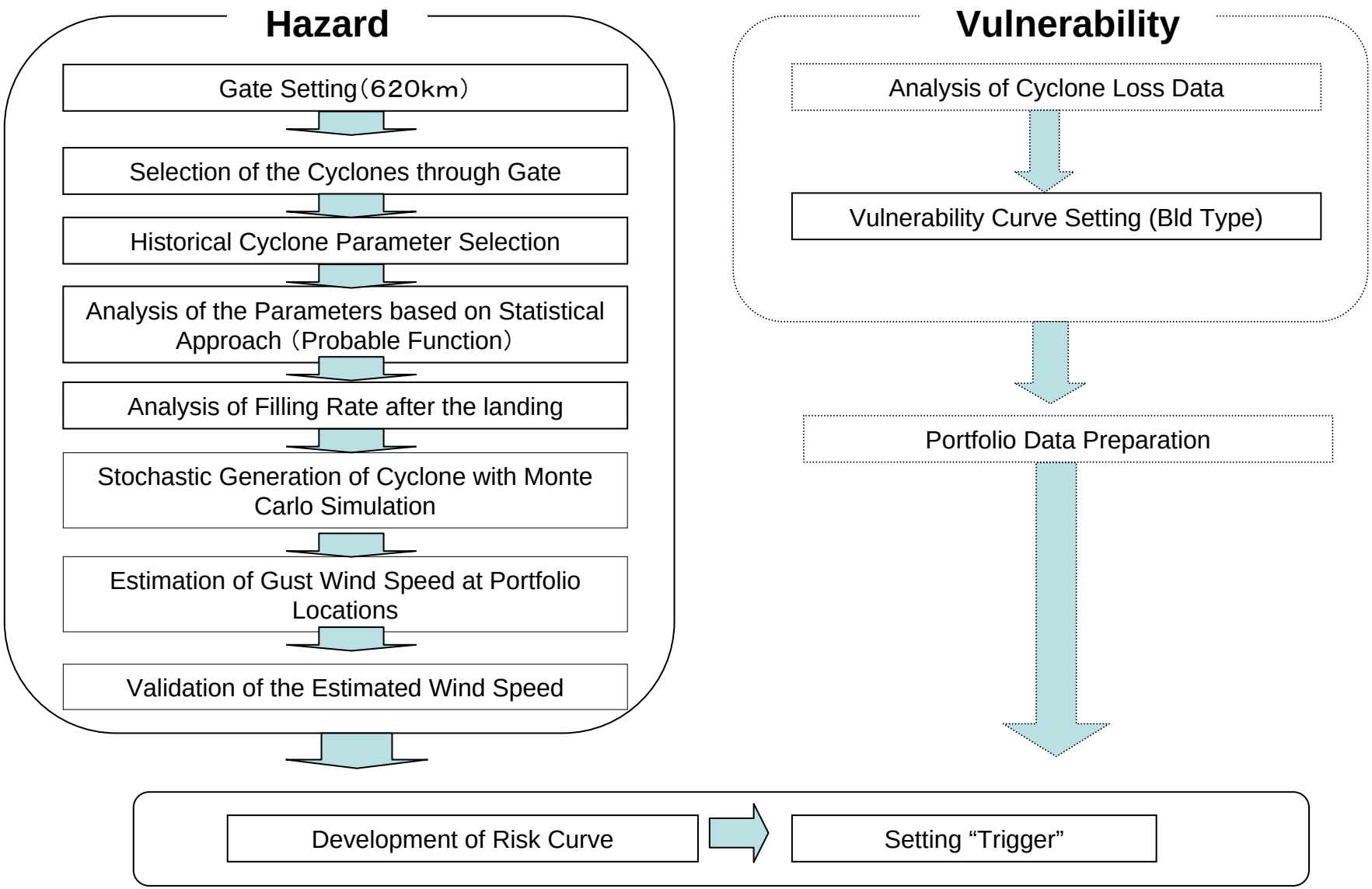
  ⇒ Accessible to the Observation Data?
  ⇒ JTWC(Joint Typhoon Warning Center)?

(3. Necessary to grapes of the wide range loss by Cyclone)
⇒ Portfolio Analysis Approach is required

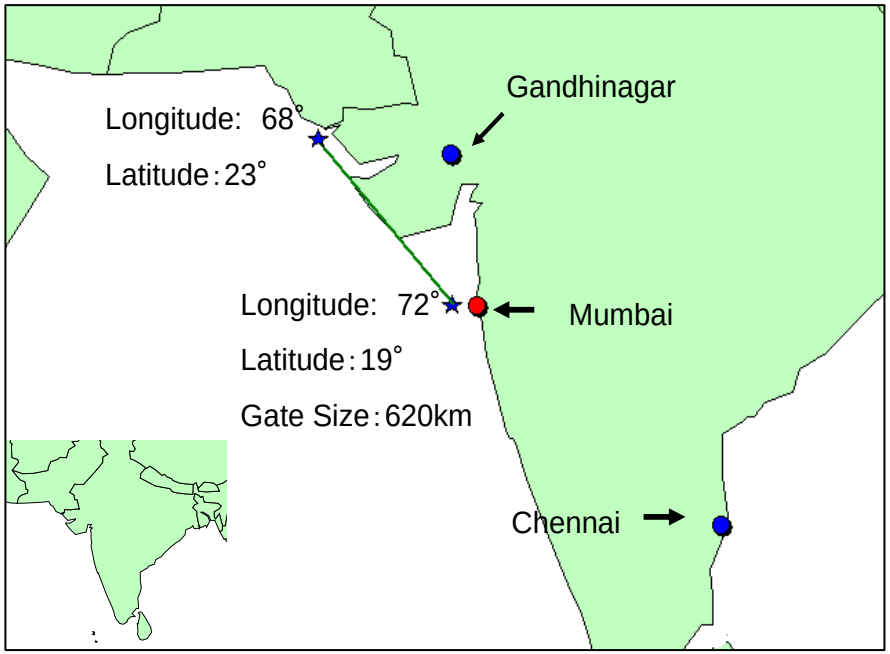
We applied the simulation approach to estimate the future loss scenarios based on historical cyclone data.

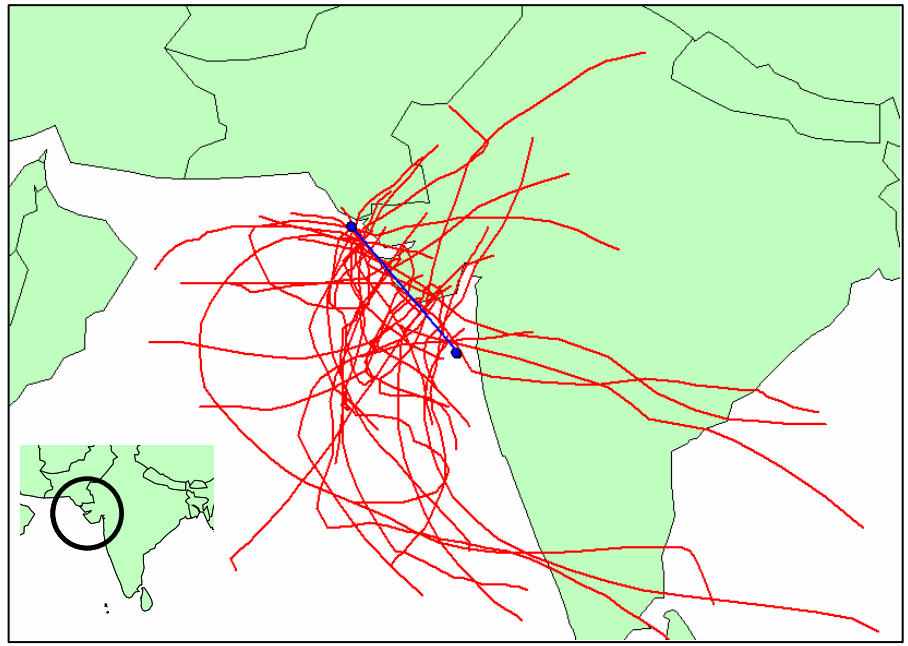
⇒ To develop the risk curve with probablistic approach

Procedure of the Study



The Gate to Capture Historical Cyclone around the Gjurart





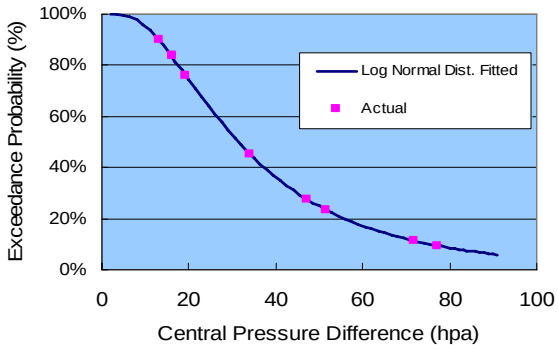
Historical Cyclone Track by JTWC (1946-2005)

Historical Cyclone Data

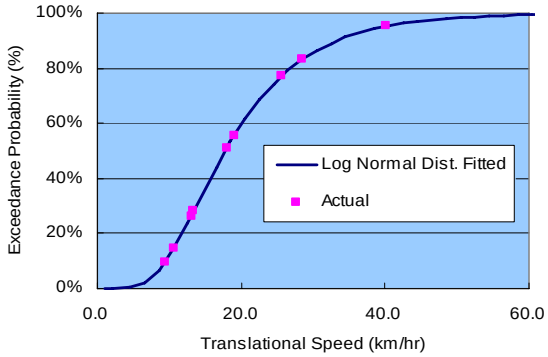
Year	Month	Day	Storm ID	Longitude (°)	Latitude (°)	Maximum Wind Speed at the Eye of Cyclone (kt)	Estimated Central Pressure (hpa)	Translational Speed (km/hr)	Angle (°)
1975	10	22	16	21.2	68.8	80	963	18	31
1976	6	2	2	19.6	71.4	40	994	13	74
1981	11	1	1	21.6	69.2	45	991	19	70
1982	11	8	5	20.1	70.3	85	958	26	75
1985	5	31	2	22.8	68.4	40	994	9	79
1996	6	18	4	20.3	70.8	65	976	13	84
1998	6	9	3	21.5	69	105	938	29	88
1999	5	20	2	23.1	67.9	110	933	11	59
2004	10	3	3	22.2	67.8	35	997	40	40

Required Cyclone Parameters to Estimate the Gust Wind Speed

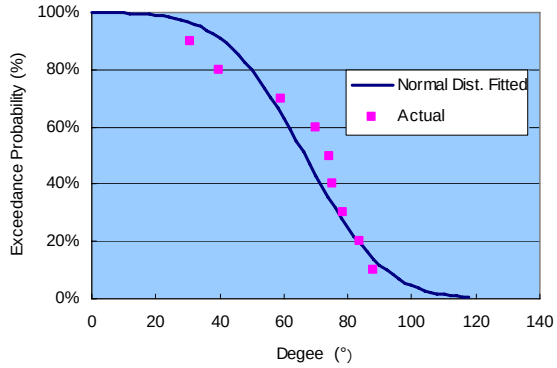
Central Pressure Depth

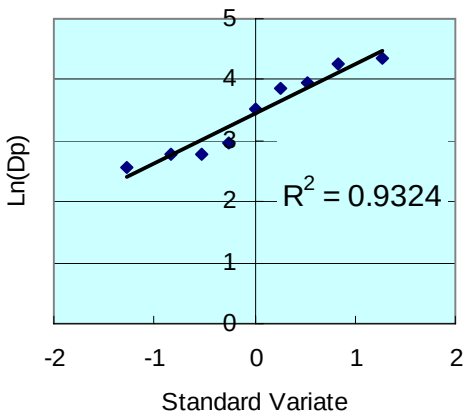


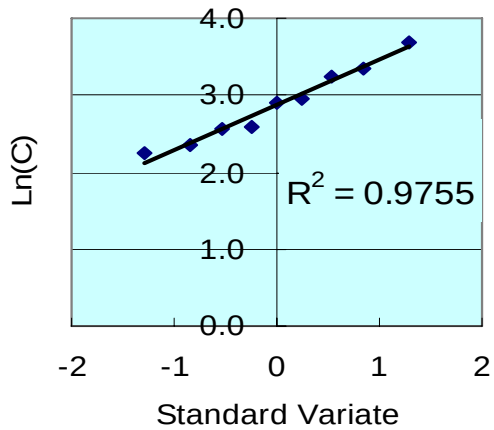
Translational Speed

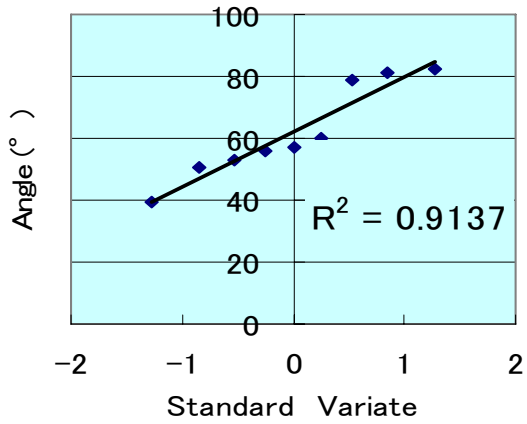


Angle to the Gate

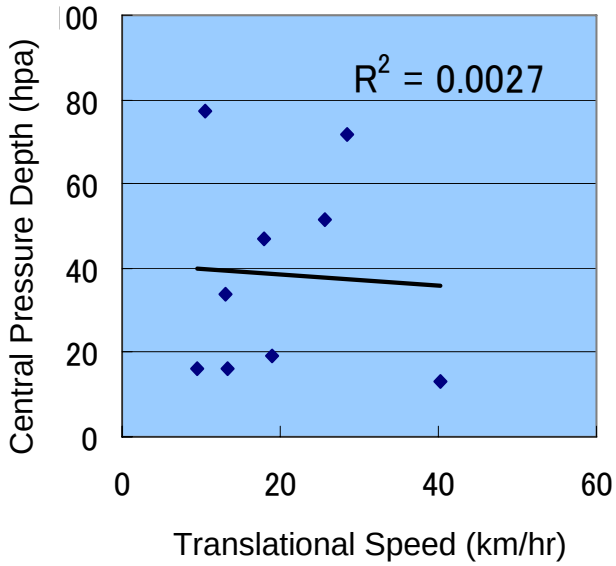


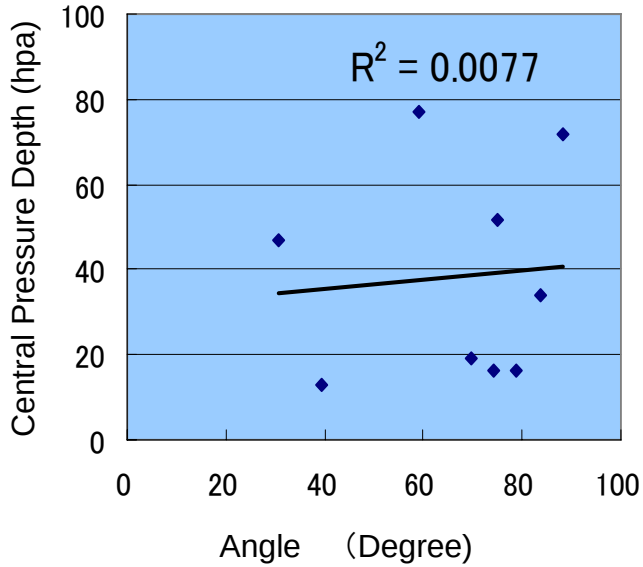


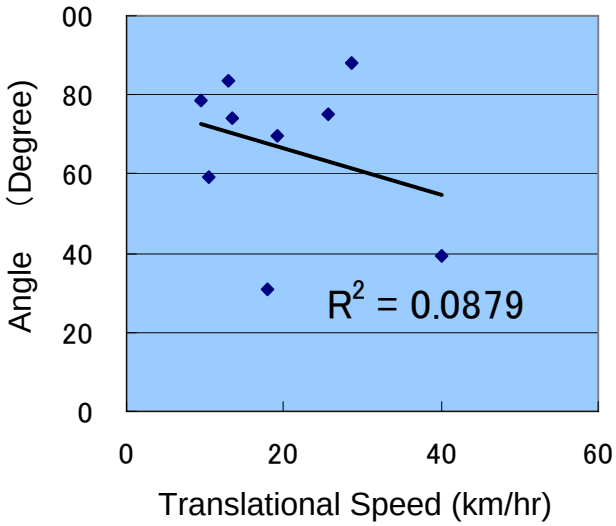




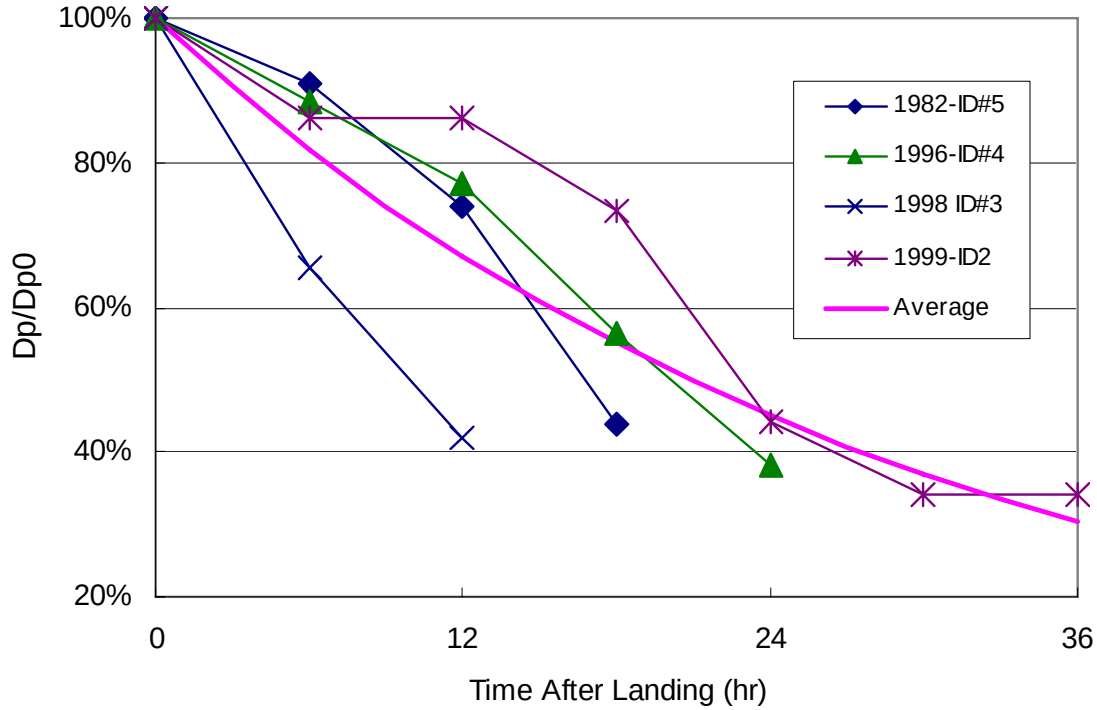
Correlation between Cyclone Parameters







Filling Rate of Central Pressure After Passing the Gate

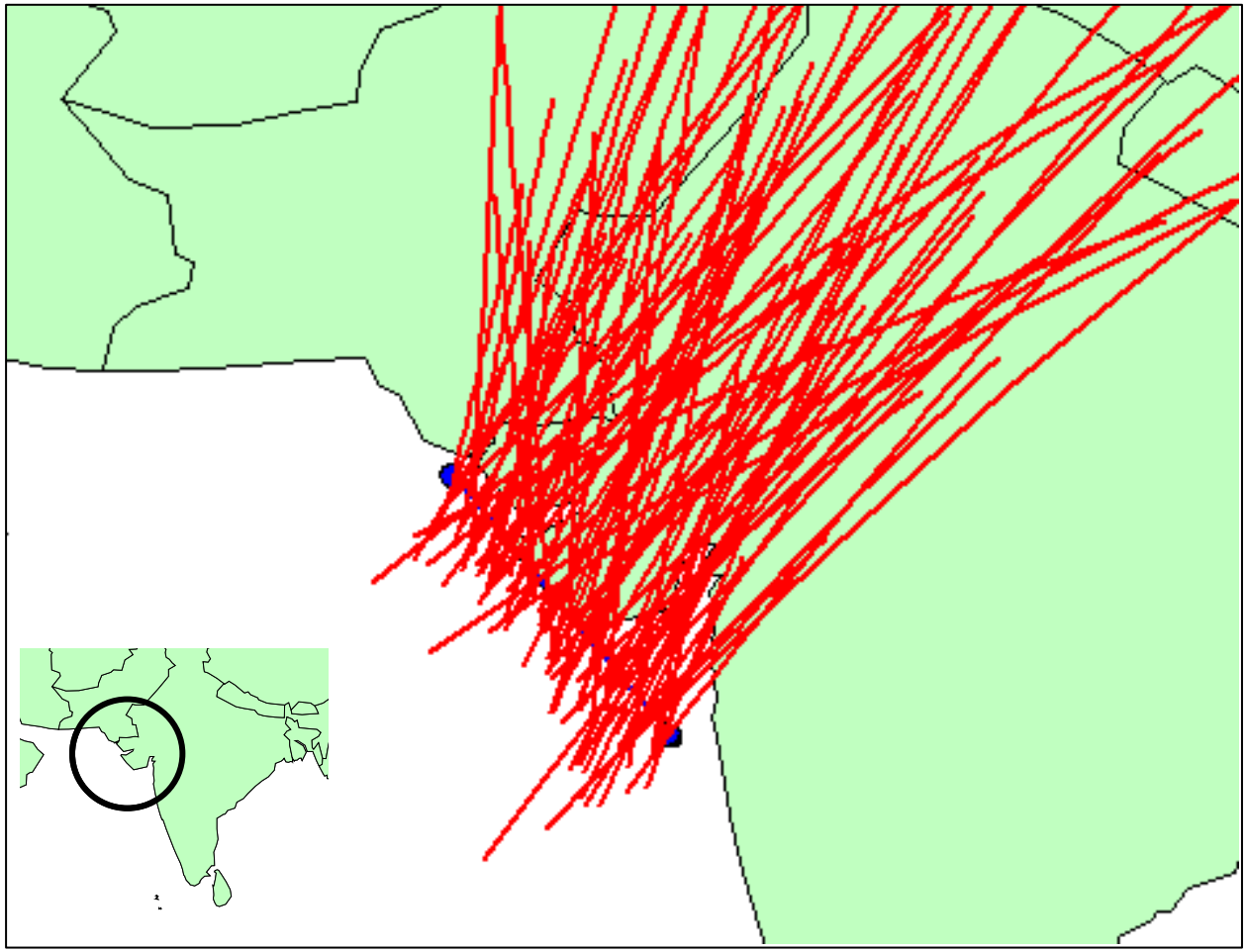


$$\Delta p = \Delta p_0 \cdot \exp(-a_p \cdot t)$$

Characteristics of Statistical Parameters

Item	Probable Distribution Type	Mean	Standard Deviation
Central Pressure Difference (hpa)	Logarithm Normal Distribution	31	0.7
Translational Speed (km/hr)	Logarithm Normal Distribution	18	0.5
Passing Angle (°)	Normal Distribution	62	15
Radius of the Maximum Wind Speed (km)	Logarithm Normal Distribution	36-52	0.4
Frequency of Cyclone Passing (number/year)	Poisson Distribution	0.26	---
Filling Rate Coefficient (a_p)	---	0.03	---

An Example of Generated Cyclone Tracks by Monte Carlo Simulation for 400 years period



Procedure of Estimation of Gust Wind Speed

Gradient Wind Speed

(without friction)

↓

Surface Wind Speed

↓

Gust Wind Speed

$$V_{gr} = \frac{c \cdot \sin\theta - fr}{2} + \sqrt{\left(\frac{c \cdot \sin\theta - fr}{2}\right)^2 + \frac{r}{\rho}\frac{\partial P(r)}{\partial r}}$$

Estimation of Surface Wind ①（Fujii etal.)

$$\frac{V_s}{V_{gr}} = G(\infty) \times \left[1 + 10^{0.0231\Delta p - 1.96}\left(\frac{\xi}{\xi_p}\right)^{m-1} \exp\left[\left(1 - \frac{1}{m}\right)\left\{1 - \left(\frac{\xi}{\xi_p}\right)\right\}^m\right]\right]$$

Estimation of Surface Wind ②（Meng etal.)

$$U(z) = v_{\theta\lambda}\left(\frac{z}{Z_G}\right)^{\alpha M} \qquad Z_G = 0.06 U_G / f_\lambda (\log R_{0\lambda})^{-1.45}$$

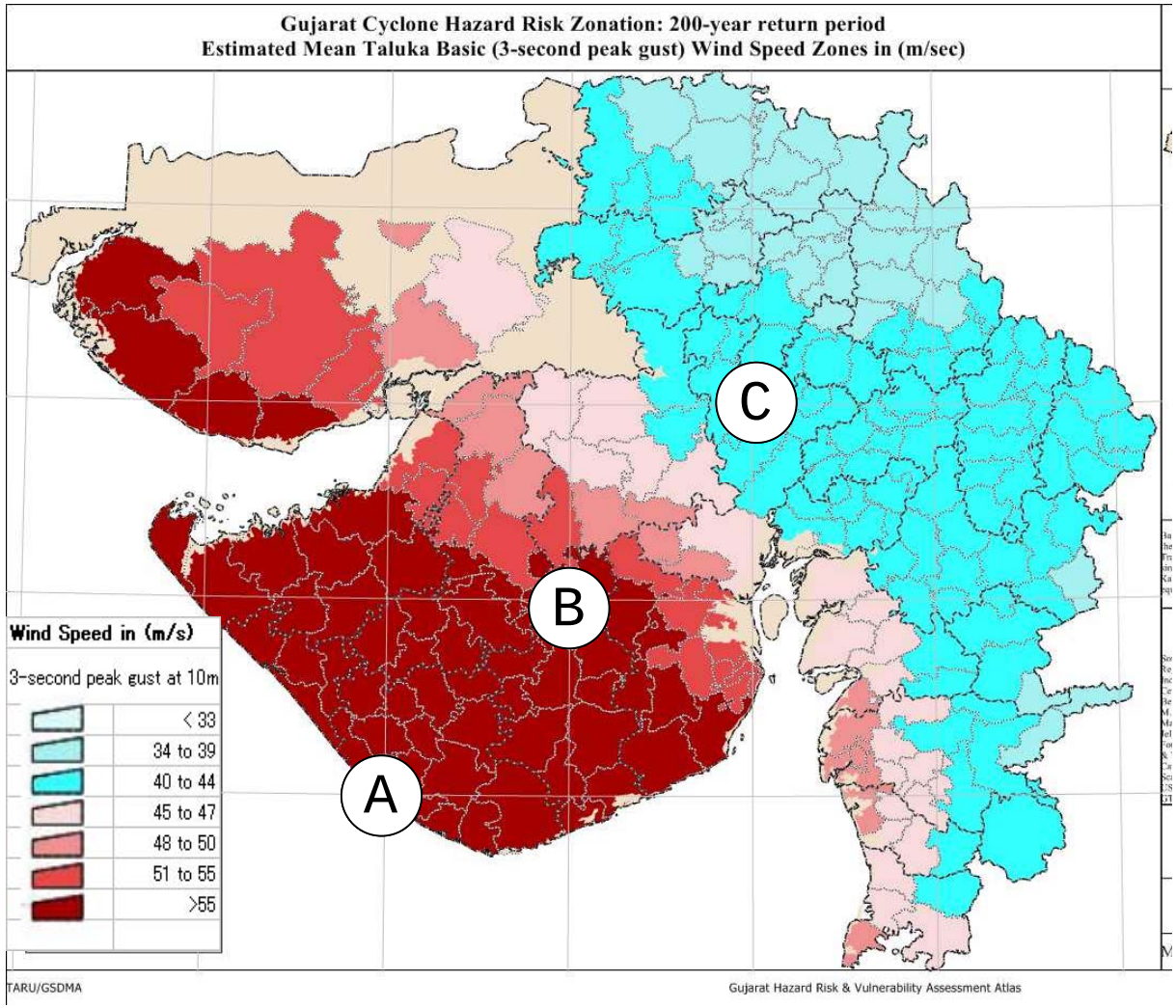
$$\alpha_M = 0.27 + 0.09\log Z_0 + 0.018(\log Z_0)^2 + 0.0016(\log Z_0)^3$$

Estimation of Surface Wind ③ (Katsuchi etal.)

On the ground 1/2, On the sea 2/3

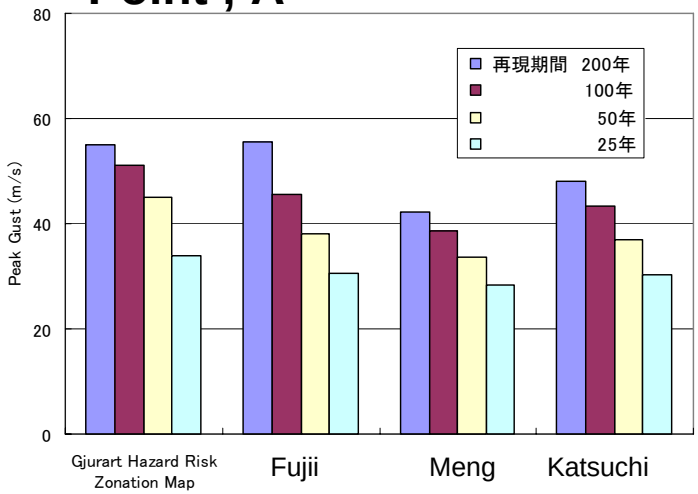
Gust Factor

Validation of the Hazard～①

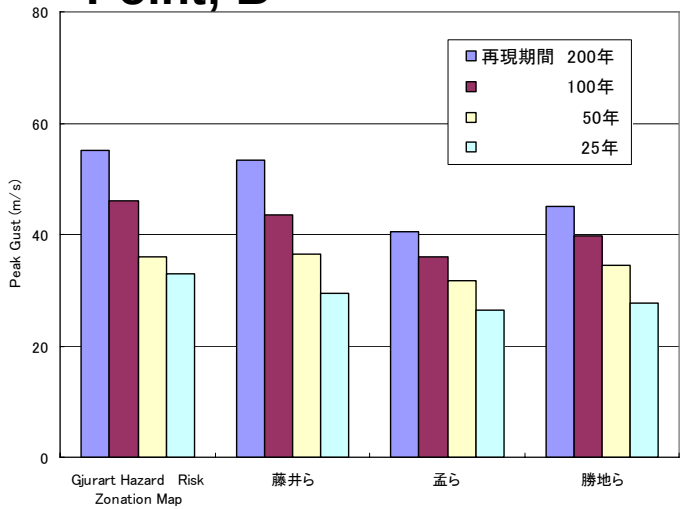


Validation of the Hazard ～②

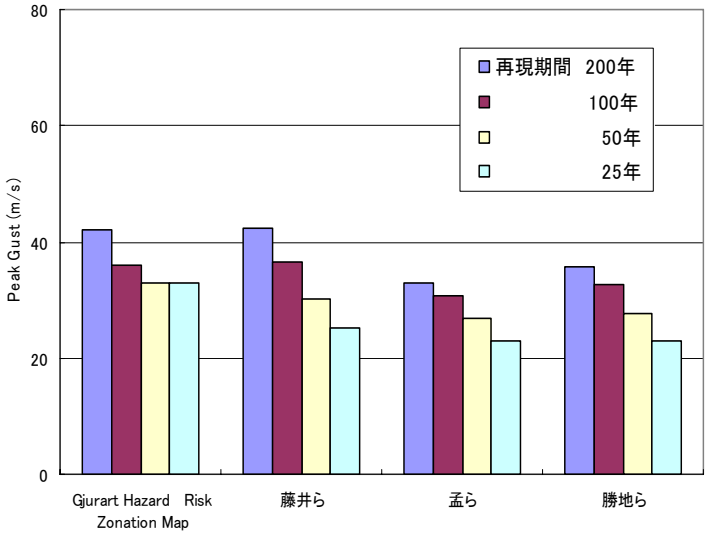
Point ; A

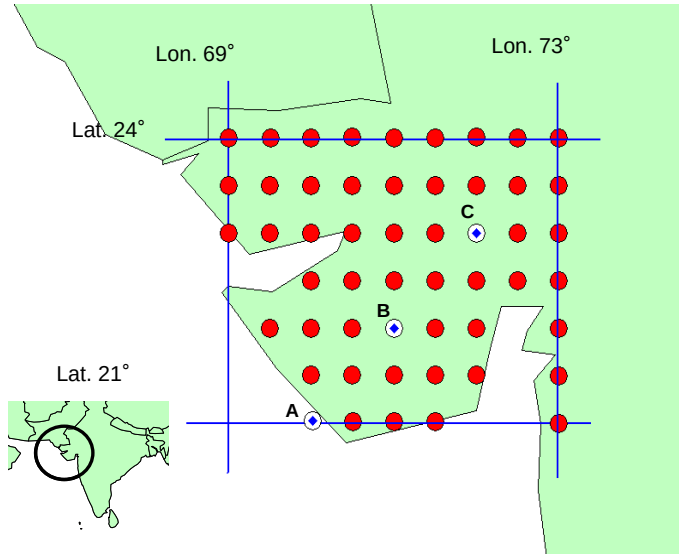


Point; B

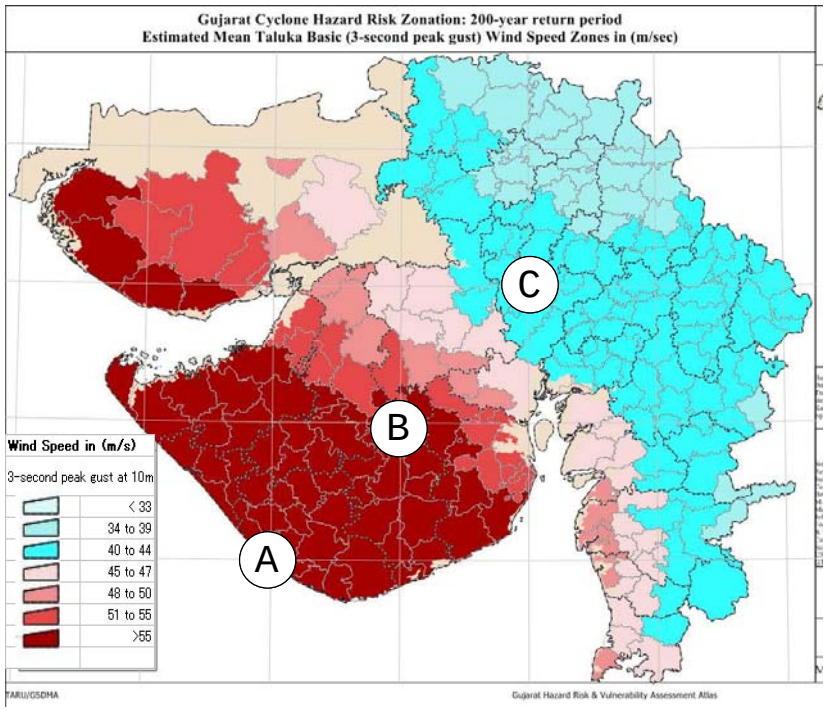


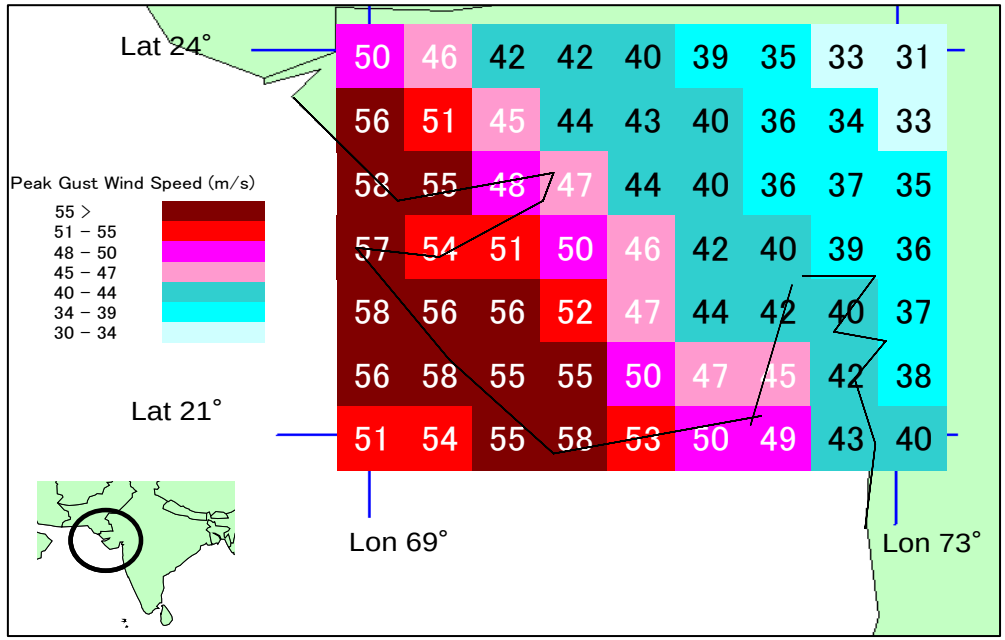
Point; C





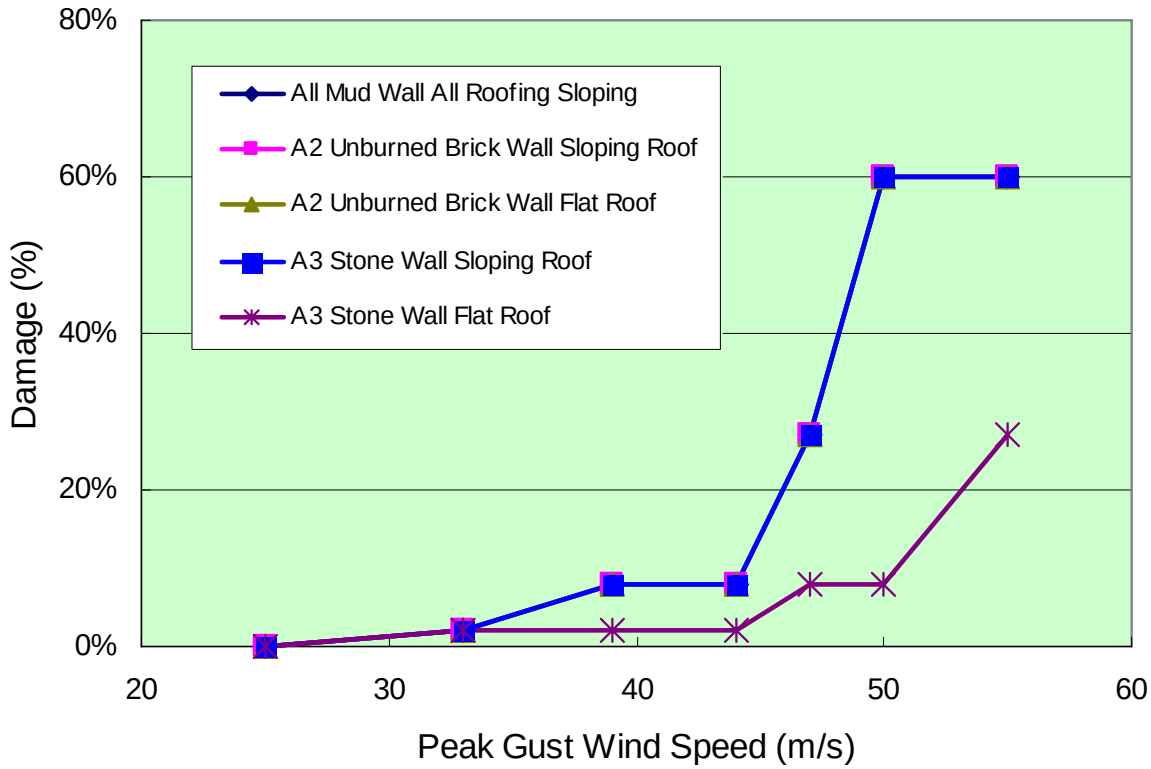
Validation of the Hazard ～③



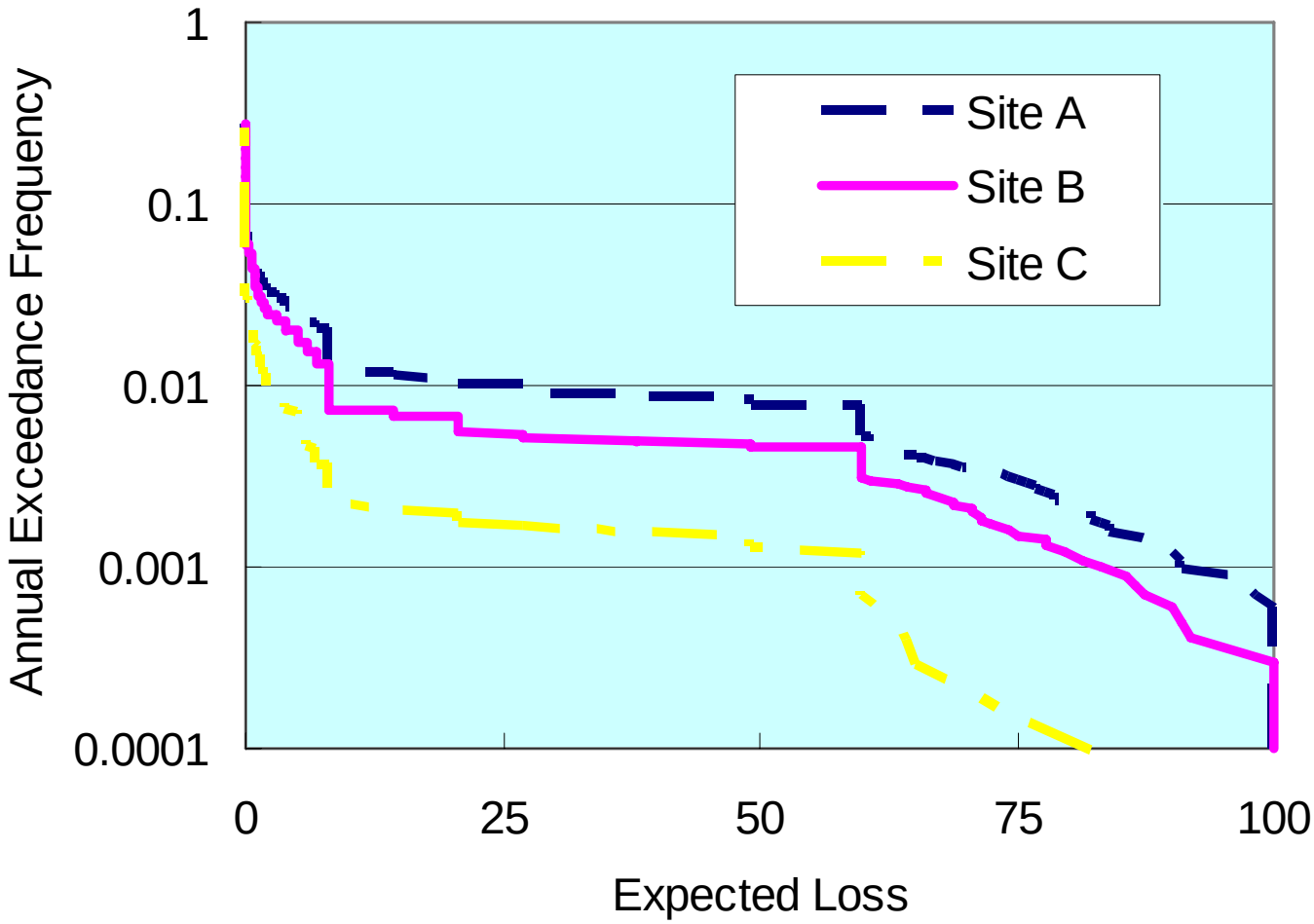


Hazard Zonation Map(200years Return Period)　　Our Estimation

Vulnerability Analysis



Risk Curve at 3 Locations



Portfolio

Num Bldg; 100

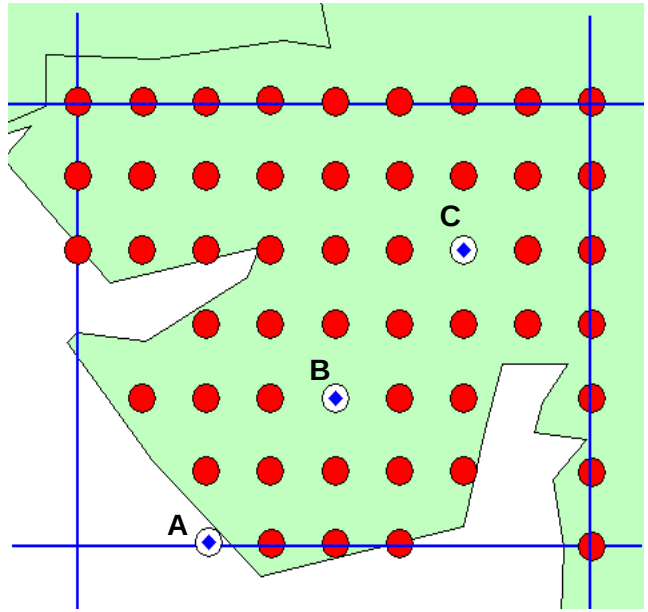
Location; Wide Spread on Gjurart State

Type of Bldg; - Unburned Brick Wall / Sloping Roof

- Stone Wall/Flat Roof

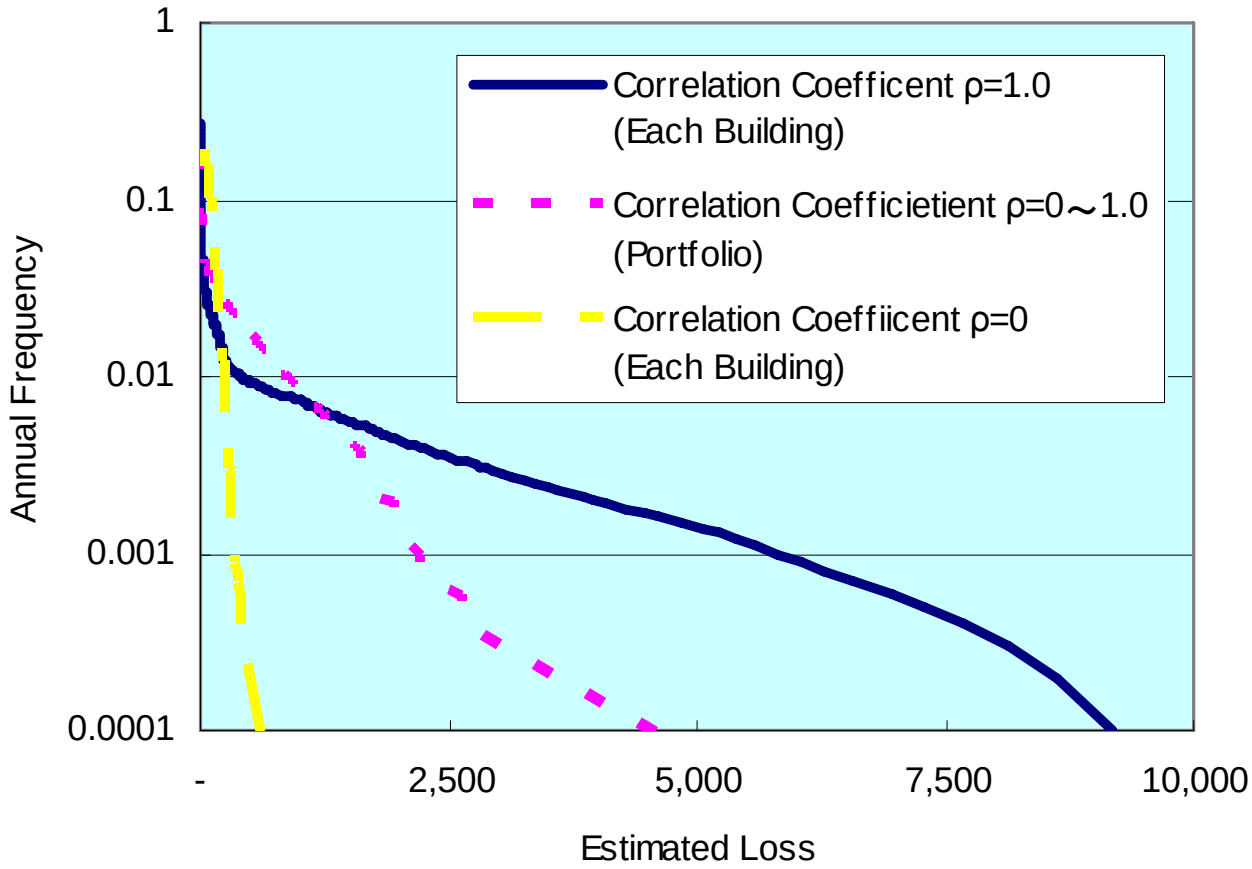
Value; 100/Bldg (No Unit)

Total Value; 10,000 (No Unit)

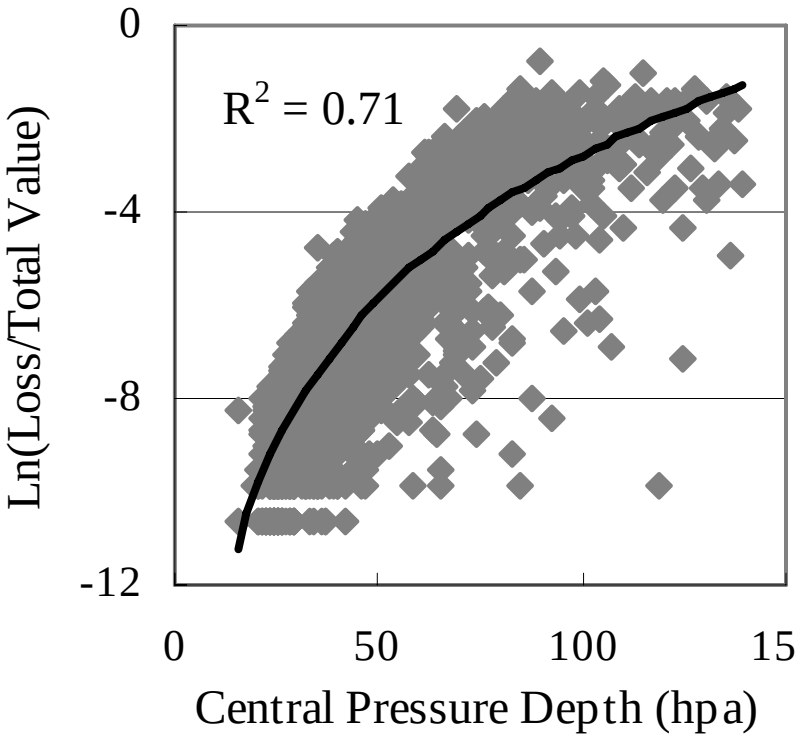


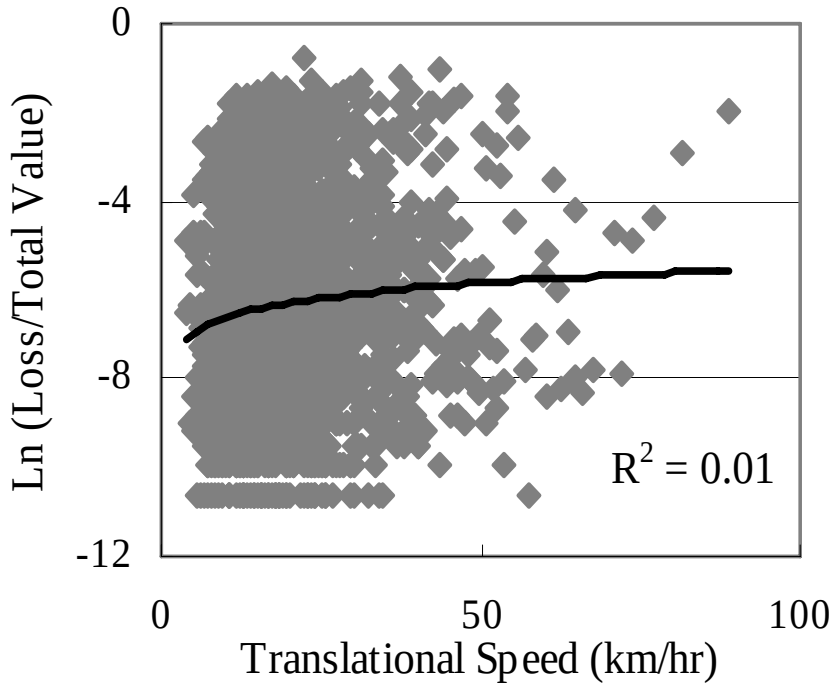
Type of Vulnerability Curve	Structure	Value	Number of Buliding	Total Value
A2	Unburned Brick Wall/ Sloping Roof	100	50	5,000
A3	Stone Wall / Flat Roof	100	50	5,000

Risk Curves for Portfolio



Expected Loss / Cyclone Parameter's Relation





From the relation between the expected loss and the cyclone parameter, we can design the CAT bond with central pressure trigger.

Conclusions

In this study, we developed the probabilistic cyclone risk analysis model based on historical cyclone data and existing research works. Using the model, we tried to study the parametric trigger that is used for cyclone risk securitization.

The result of study was summarized as follows;

- Due to lack of enough statistical observation data to analysis the cyclone risk, we developed the probabilistic cyclone risk analysis model to estimate the gust wind speed and the consequence of the intense wind.
- The characteristics of the cyclone parameters; center pressure depth, translational speed, frequency, angle is clearly described through the historical cyclone data.
- No correlation between each parameters was observed.
- The validation study shows that the estimated gust wind speed was highly matched with the hazard map developed by Gjurart State.
- Risk curve was obtained by the vulnerability curves for the building based on the previous research applied to the assumed portfolio.
- For setting the parametric trigger, we examined the relation between the cyclone parameters and the estimated loss.