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A Study of Deriving Fragility Curves by Using GPS Data at Control Points Before and After Chi-Chi Earthquake

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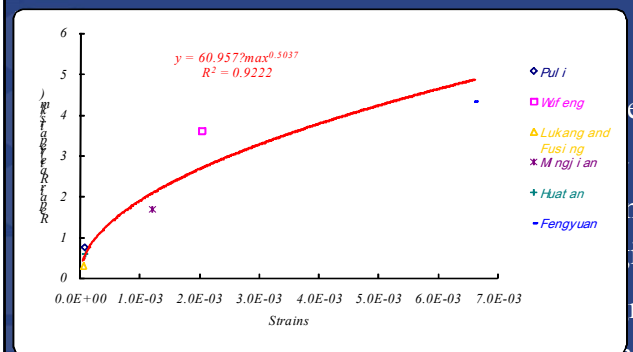
Introduction



estic water for 90.4%

easily by earthquake。

nd Deformation (PGD) as

ility curves.

ression analysis which

was performed by repair rate and ground strain that was calculated by PGD applied Strain Gage Rosettes method and Mohr's circle.

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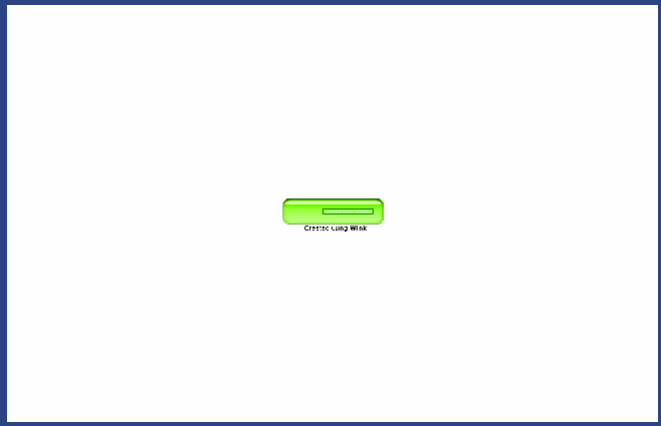
Study Area



Sweden to Taiwan

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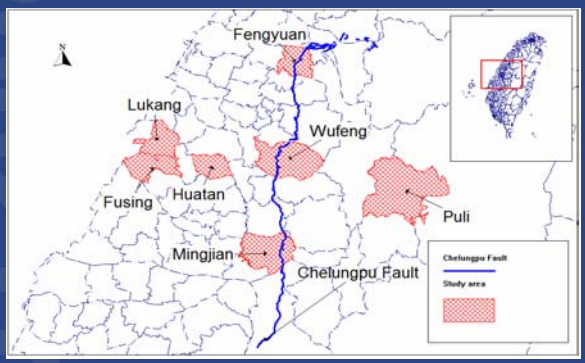
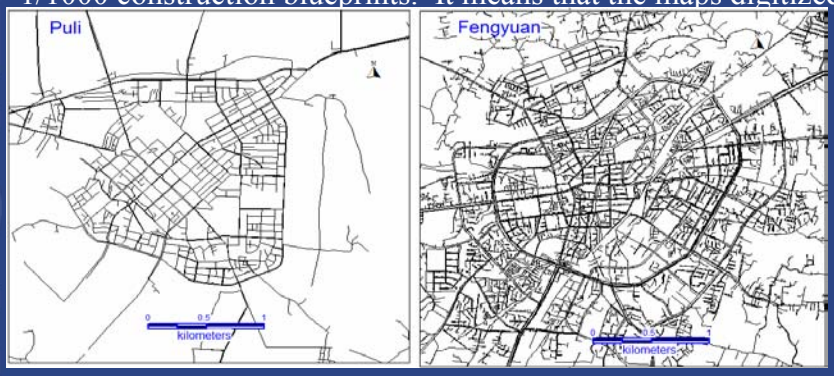
Study Area



- The 7 cities in central Taiwan was chosen as study area, which were Fengyuan, Wufeng, Mingjian, Huatan, Lukang and Fusing.
- Fengyuan, Wufeng and Mingjian were passed through by Chelungpu Fault.

Data processing of pipeline network

- The maps of pipeline network were digitized from 1/500 or 1/1000 construction blueprints. It means that the maps digitized

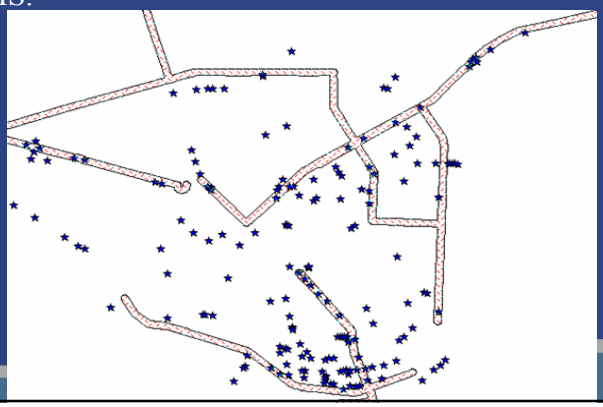


Data processing of damaged points

- The damaged points was digitized by address from repair work orders, it's hard to locate them at accurate location. Furthermore, the damaged points may be not located at pipleine.

Data processing of damaged points

- Considering the inaccuracy of digitizing, we selected the damaged points near the pipelines within a radius of 20m by using GIS.



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Data processing of damaged points

- The Figure shows the red lines are the pipelines over Ø250mm, and the asterisks are the damaged points selected by the processing. We can find out the asterisks are not belong to lager pipelines. Therefore, we also filtered this kind of damaged point manually.

Calculation of Ground Strain

- The Permanent Ground Deformation (PGD) can be calculated by the difference of coordinates before and after earthquake.
- There are 891 control points with coordinates before and after Chi-Chi Earthquake. The triangles can be made of every three points as triangle network.

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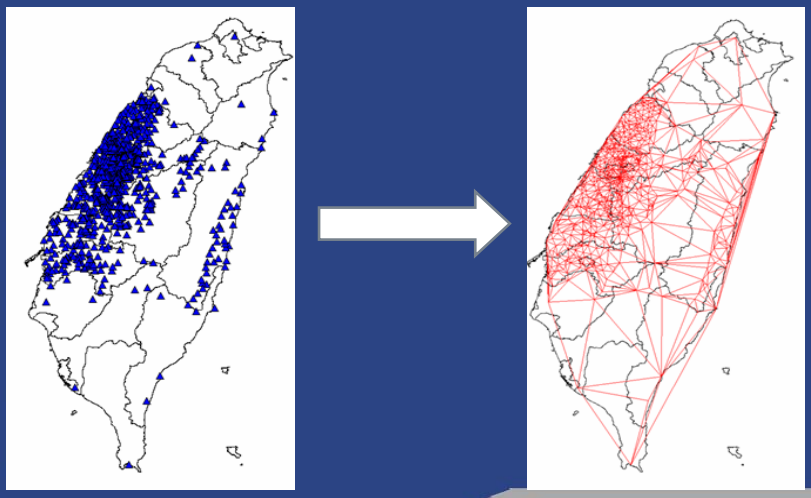


Apply Strain Gage Rosettes to Triangle Network

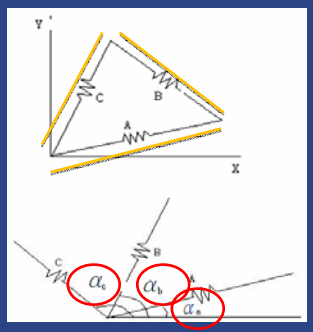
Earthquake

Apply Strain Gage Rosettes to Triangle Network

Strains

$$\begin{bmatrix} \varepsilon_A \\ \varepsilon_B \\ \varepsilon_C \end{bmatrix} = \begin{bmatrix} Cos^2\alpha_A & Sin^2\alpha_A & \frac{1}{2}Sin2\alpha_A \\ Cos^2\alpha_B & Sin^2\alpha_B & \frac{1}{2}Sin2\alpha_B \\ Cos^2\alpha_C & Sin^2\alpha_C & \frac{1}{2}Sin2\alpha_C \end{bmatrix} \begin{bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{bmatrix}$$

Angles



Maximum strain and shearing force

- The maximum strain and shearing force was calculated by Mohr's circle.

$$\varepsilon_{ave} = \frac{\varepsilon_x + \varepsilon_y}{2}$$

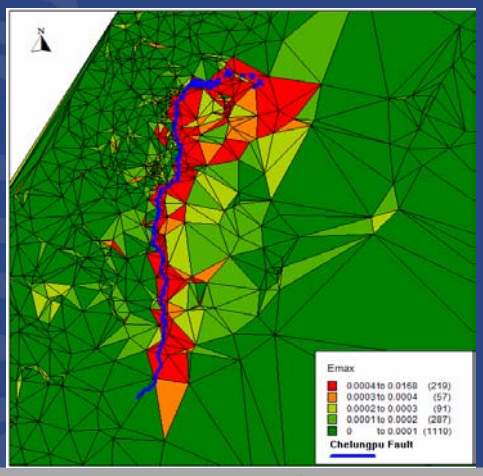
$$R = \sqrt{\left(\frac{\varepsilon_X - \varepsilon_Y}{2}\right)^2 + \left(\frac{\gamma_{XY}}{2}\right)^2}$$

$$\varepsilon_{\max} = \varepsilon_{ave} + R$$

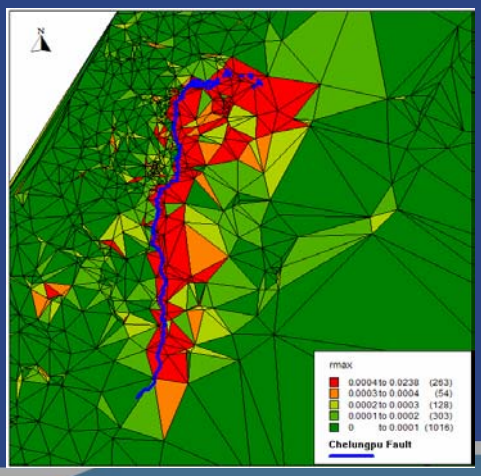
$$\varepsilon_{\min} = \varepsilon_{ave} - R$$

$$\gamma_{\max} = 2R$$

Maximum strain and shearing force



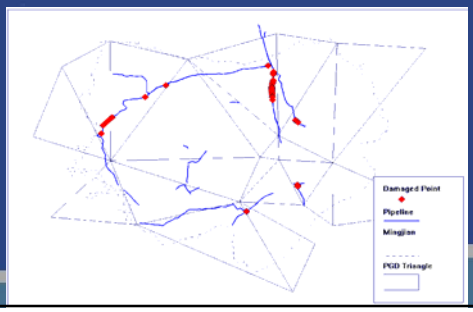
The triangle network of ε_{max}



The triangle network of γ_{max}

Regression Analysis

- The regression analysis was performed by repair rate and PGD applied Strain gage Rosettes method.
  - We summed the total damaged point numbers and total pipeline length of the triangles within the town by GIS to calculate the repair rate of each town.
  - The average and of each town can be also calculated by GIS.



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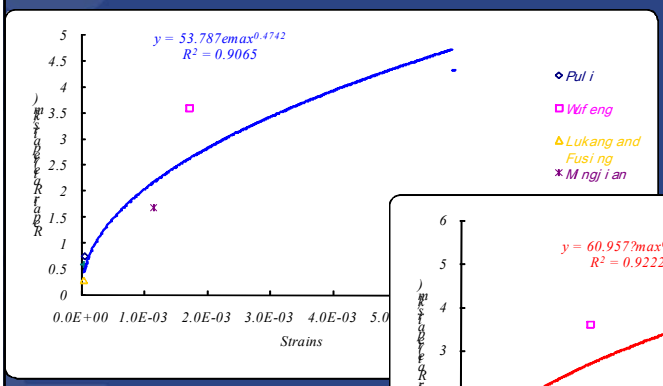
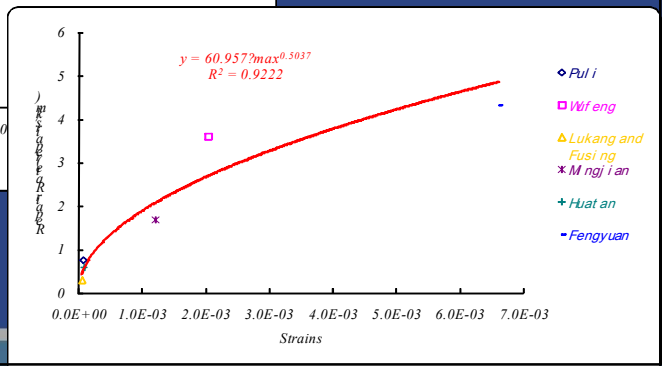
Regression Analysis





Conclusion

- After we applied Strain Gage Rosettes method to PGD, the result shown that the triangles passed through by Chelungpu Fault have larger ground strain. That means the process transfer PGD to ground strain is reasonable.
- The study chose the pipelines between Ø250mm and Ø500mm for regression analysis , because there was only one damaged point at pipeline over Ø500mm after data processing of pipeline networks and damaged points. All the data of pipelines and damaged points should be clarified and consistence.

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Conclusion

- The regression analysis use one town as a unit. The average repair rate and ground strain can be calculated for each town. The result showed that repair rate and ground strain have high correlation.


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Thank you