ANALYSIS OF A SCHOOL BUILDING AGAINST TYPHOON HAIYAN STORM SURGE FORCES

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In 2013 Typhoon Haiyan dealt strong winds and storm surges to Tacloban City, Philippines. Widespread damages to structures were observed, including public school buildings that are usually used as evacuation centers. The National Structural Code of the Philippines (NSCP) was then updated in 2015. The Department of Public Works and Highways (DPWH) used the dead, live, wind, and earthquake load provisions of the 2015 NSCP in designing the standard reinforced concrete public school buildings. It is important to analyze if the designed school buildings can resist failure against another Typhoon Haiyan storm surge event.

TYPHOON SIMULATION

Typhoon Haiyan was simulated with the Global Forecast System (GFS) meteorological data using the Weather Research and Forecasting (WRF) Model (Skamarock et al. 2008). A two-way nested domain with a simulation period of 108 hours was performed. Using the Japan Meteorological Agency (JMA) observed data, the Tropical Cyclone (TC) Bogussing scheme was employed to significantly improve the intensity and track simulations (Figure 1).

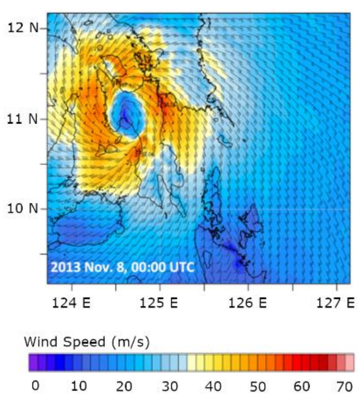

Figure 1 - Simulated Wind Field of Typhoon Haiyan

STORM SURGE SIMULATION

The wind and pressure data from the WRF simulation was then used in the Finite Volume Community Ocean Model (FVCOM) (Chen et al. 2003). An unstructured triangular mesh system was generated to simulate the storm surge at San Pedro Bay and inundation at Tacloban City. The FVCOM results were validated (Figure 2) using water mark data of post-Haiyan field survey data from Mikami et al. (2016). The time-history data of inland wind speed, flood horizontal speed, and flood depth at the location of San Jose National High School (11°12'18"N, 125°01'20"E) were obtained from the inundation simulation. The horizontal wind, hydrostatic, and hydrodynamic forces were then calculated based on the tsunami load provisions of the ASCE 7-16 Standard.

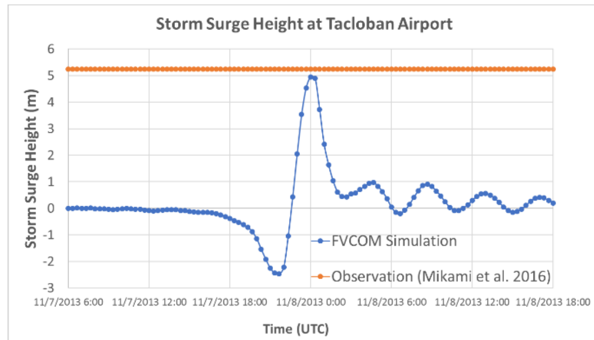

Figure 2 - Validation of Storm Surge at Tacloban Airport

STRUCTURAL ANALYSIS

The two-storey standard public school building was then modelled in STAAD.Pro (Bentley Systems 2019). The load combinations were applied on the structural frame. The maximum shear forces and bending moments in the 300 beams and columns were quantified and compared to its capacity (Table 1).

Table 1 - Shear Force Comparison of Corner Columns

MEMBER	DESIGN CAPACITY Vu (kN)	TYPHOON HAIYAN		% change with SURGE	PASS/ FAIL
		WIND ONLY, Vw (kN)	WITH SURGE, Vs (kN)		
1 (corner GF Column)	412.48	19.41	32.14	65.53	PASS
7 (corner 2F Column)	341.20	34.05	33.24	-2.38	PASS
144 (corner 2F Column)	208.74	12.80	26.49	106.91	PASS

The ground floor (GF) columns experienced a significant increase in the applied shear forces and bending moments due to the flood loads. However, all beams and columns were determined to have sufficient strength to resist failure against the Typhoon Haiyan storm surge forces. Overall, the results showed the capability of the weather-surge-structure numerical model to calculate the storm surge forces applied on a specific structure.

REFERENCES

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