KAJIMA CORPORATION

Robust and Reliable Earthquake Early Warning System for Engineering

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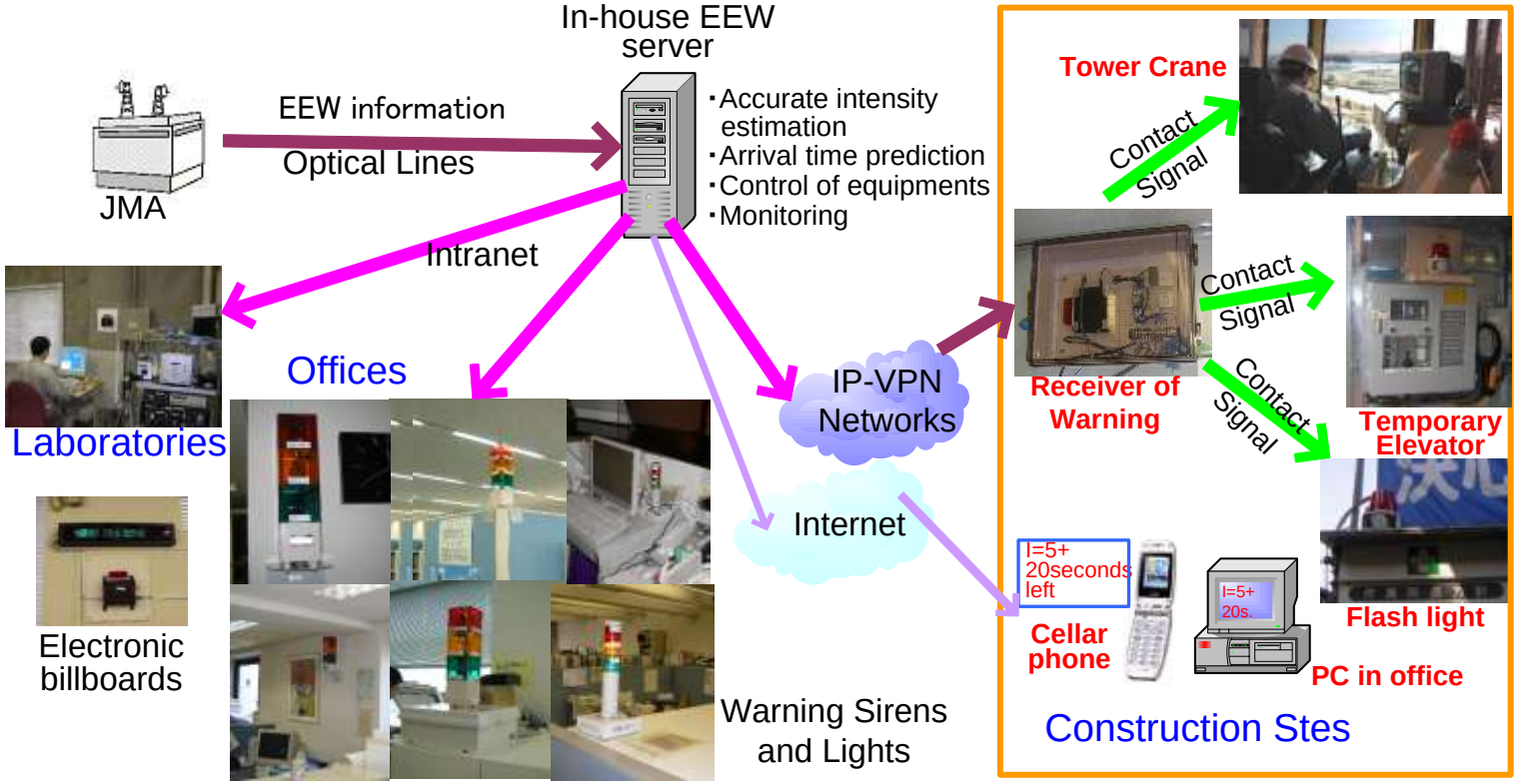
Outline

1. Practical Application of EEW Information from JMA
2. On-Site Warning System for Near-Field Earthquakes
3. Application to Construction Site against Aftershocks of the 2008 Iwate-Miyagi Inland Earthquake
4. Integrated System to Apply to System Shutdown

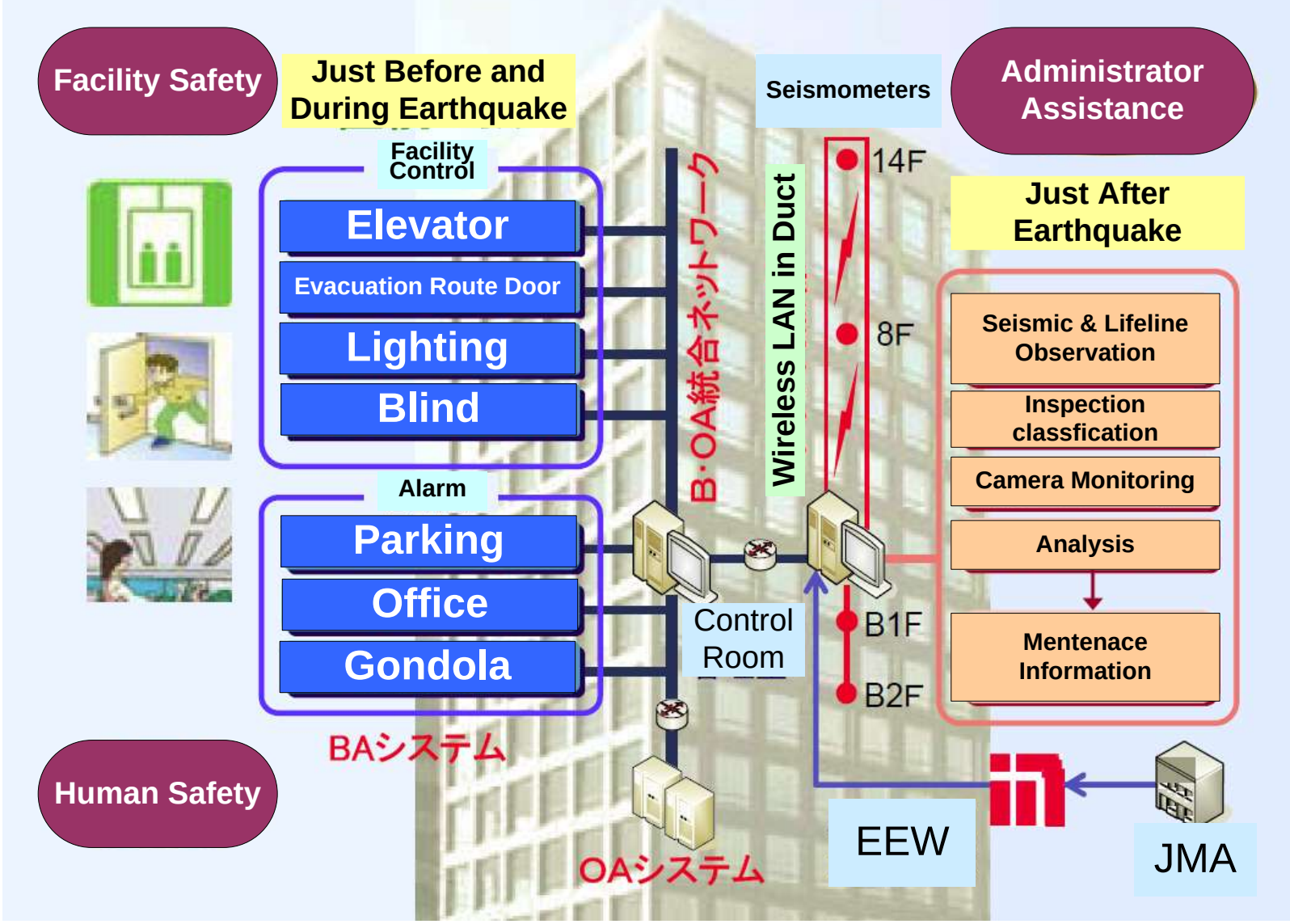
1 Practical Application of EEW Information from JMA in Construction Company

System Configuration for EEW information from JMA in Construction Company

- Integrated server can intensively receive and process EEW information from JMA and can extensively deliver it to whole company.
- EEW information can be transmitted through company networks to offices, laboratory and construction sites for about 1 second.



Headquarter Offices



Ceiling Alarm Lamps in Offices

Other Displays and Alarm Lights

Tricolor Desktop Display

Desktop Small Display

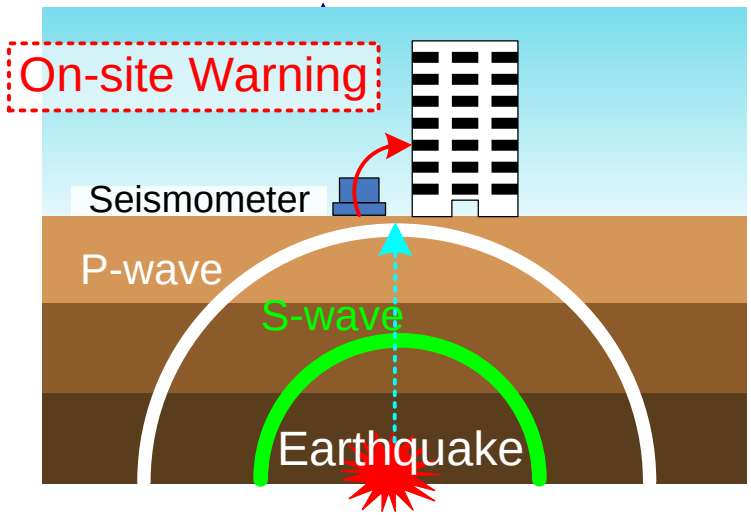
Good Design Award in 2008

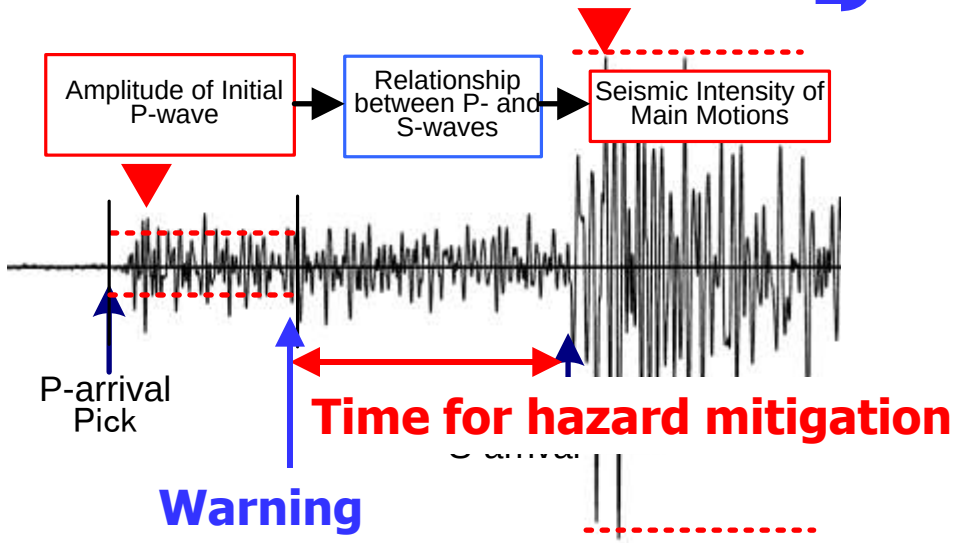
Desktop Large Display

Tricolor Alarm Lights

2 On-Site Warning System for Near-Field Earthquakes

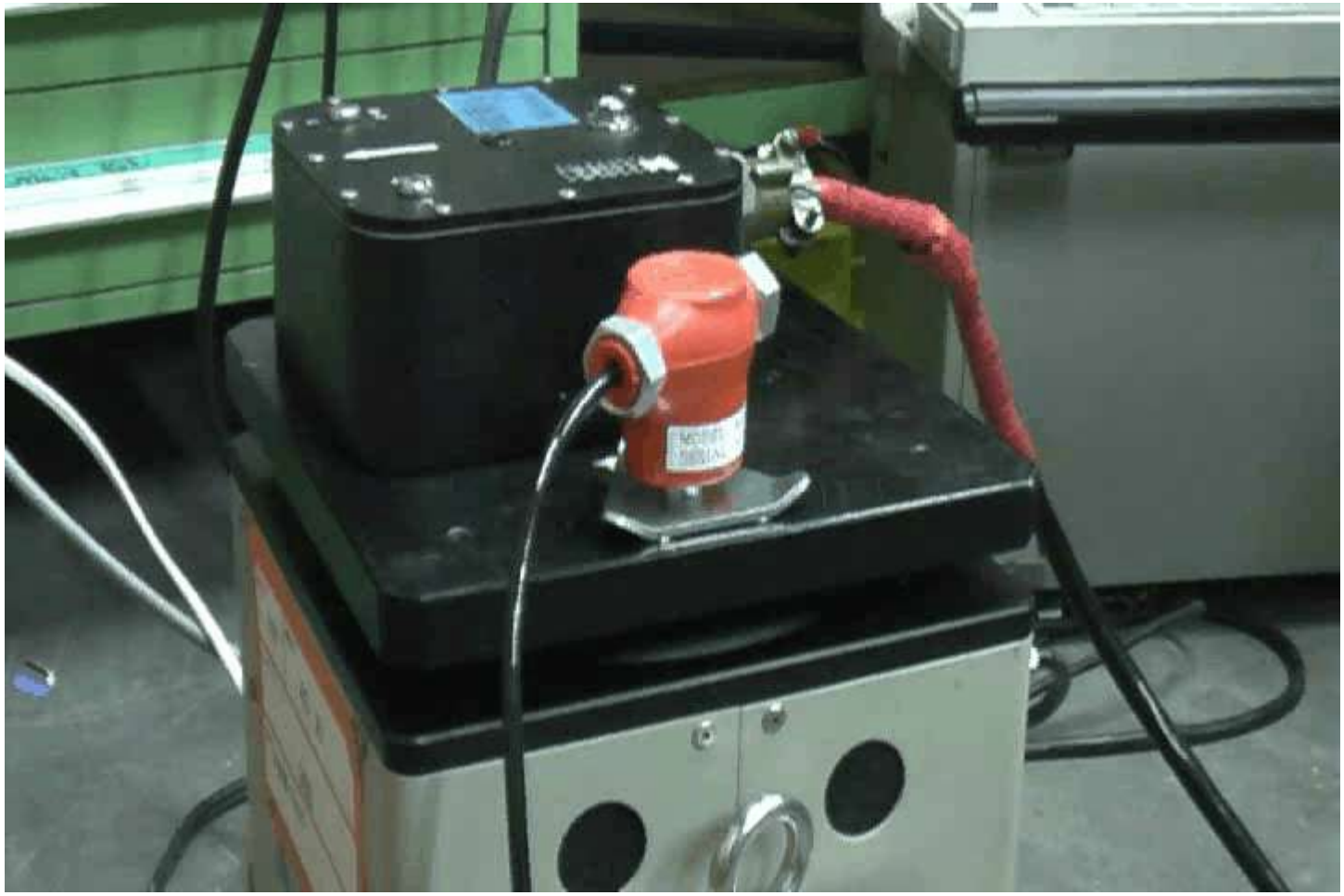
Concept of On-site Warning





- **P-wave pick-up sensors are installed on the soil surface at a site or on the basement of a building.**
- **The warning can be issued before S-wave arrival taking advantage of the difference between the velocities of P and S waves.**
- **The intensity estimation method is based on the empirical amplitude relationship between P and S waves.**

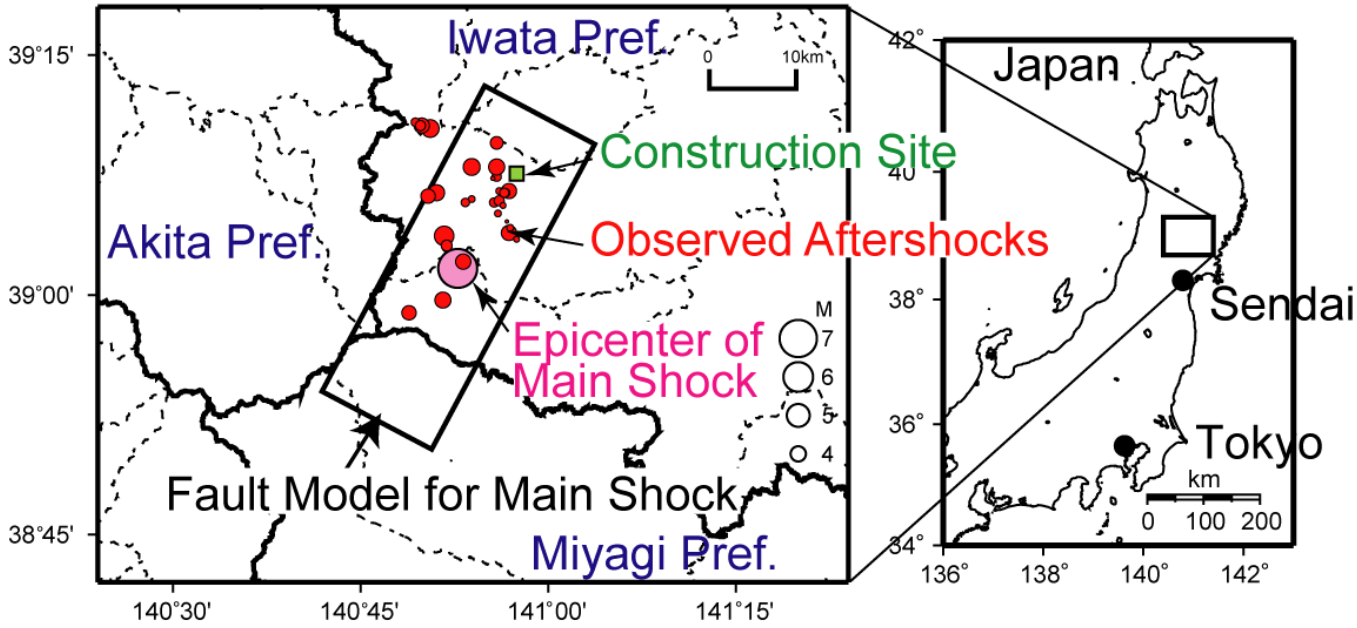
Vibration Test of Developed On-site Warning System



3 Application to Construction Site in Aftershock Area of Inland Event

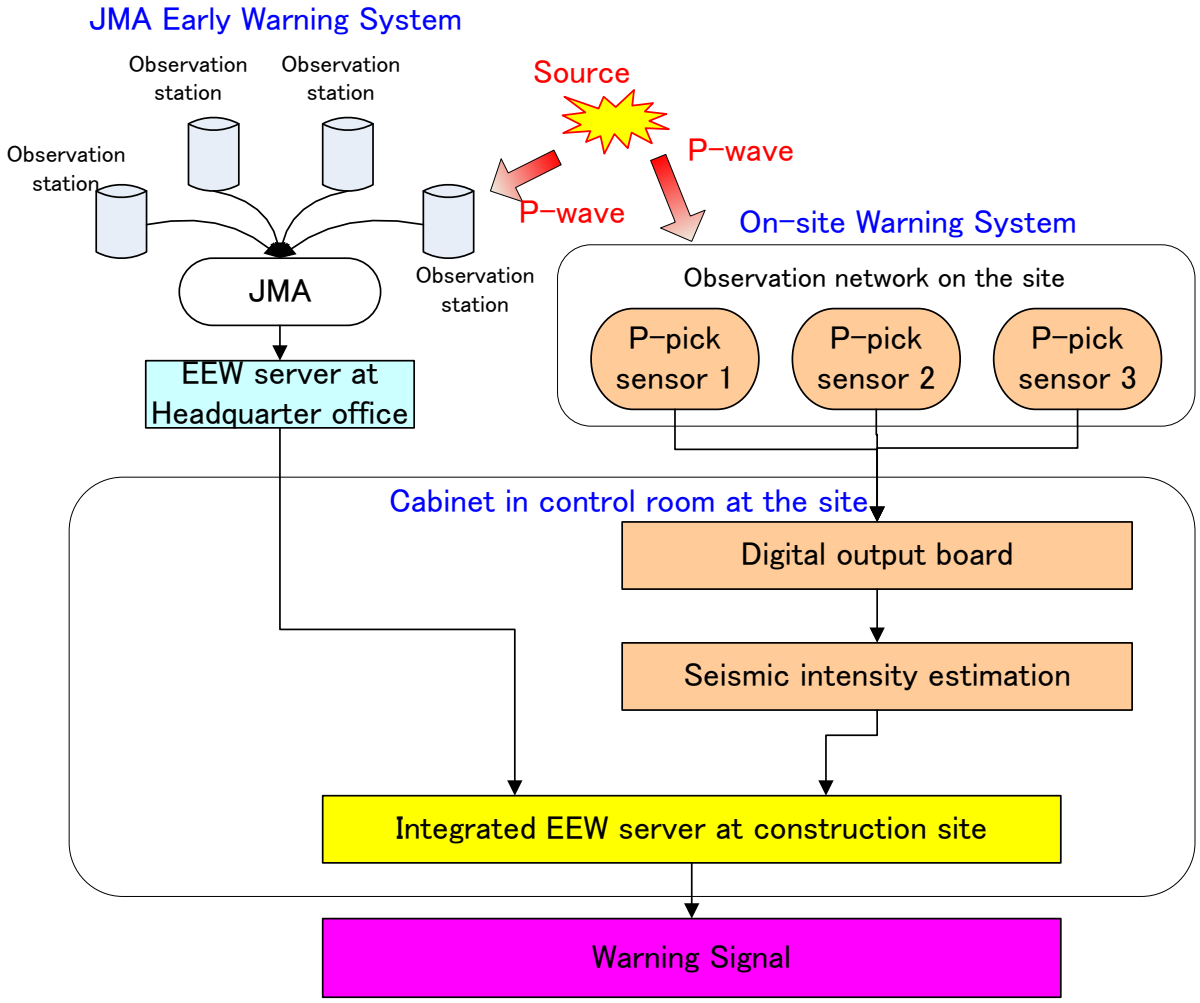
Application to construction site

Measures against aftershocks of the 2008 Iwate-Miyagi Inland Earthquake



- **EEW from JMA which had been operating since 2007 was output to the site after the arrival of the S-wave in the main shock.**
- **Since the aftershocks were quite active, we installed the on-site warning system and modified EEW to integrated warning system.**

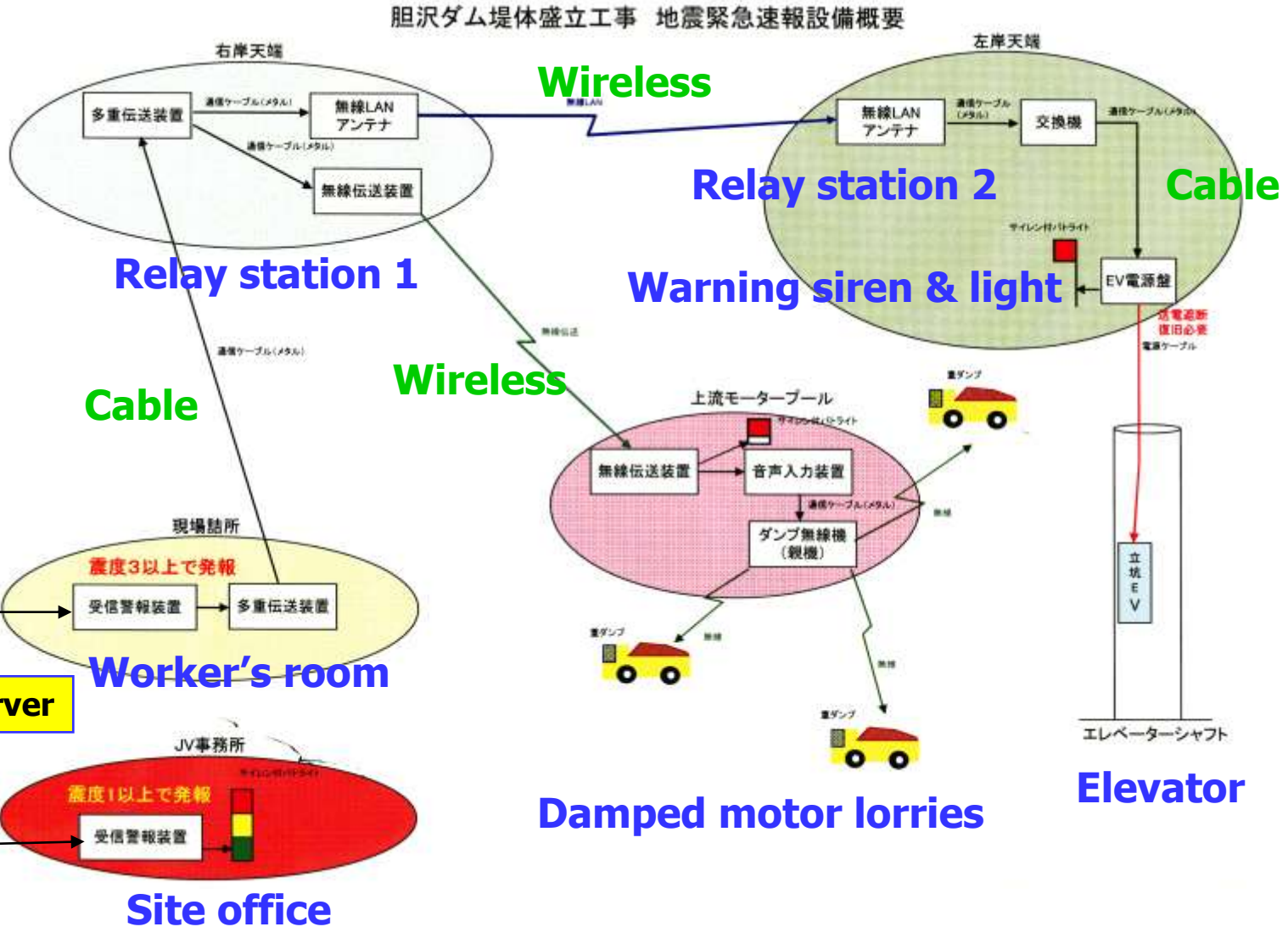
Configuration of EEW System at Construction Site



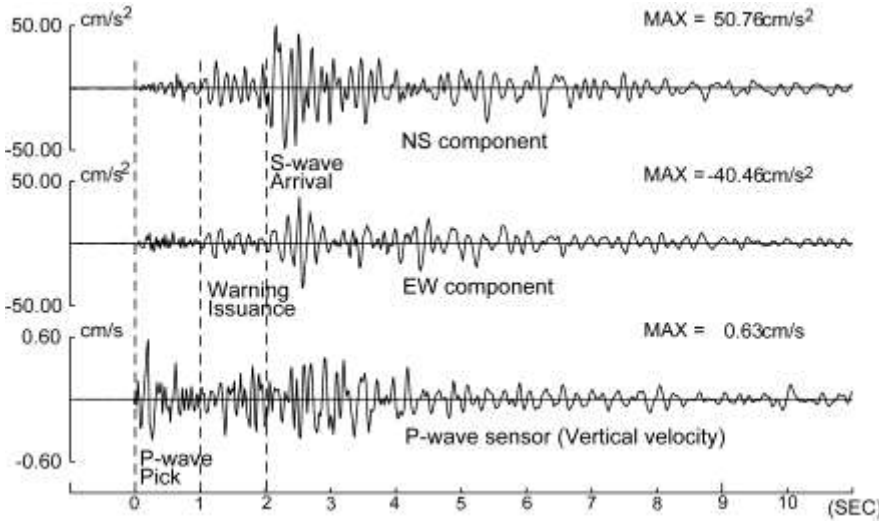
Alarm devices in construction site office

→Dam construction site (more than I=3)
Field workers
Damped motor lorries
Elevators

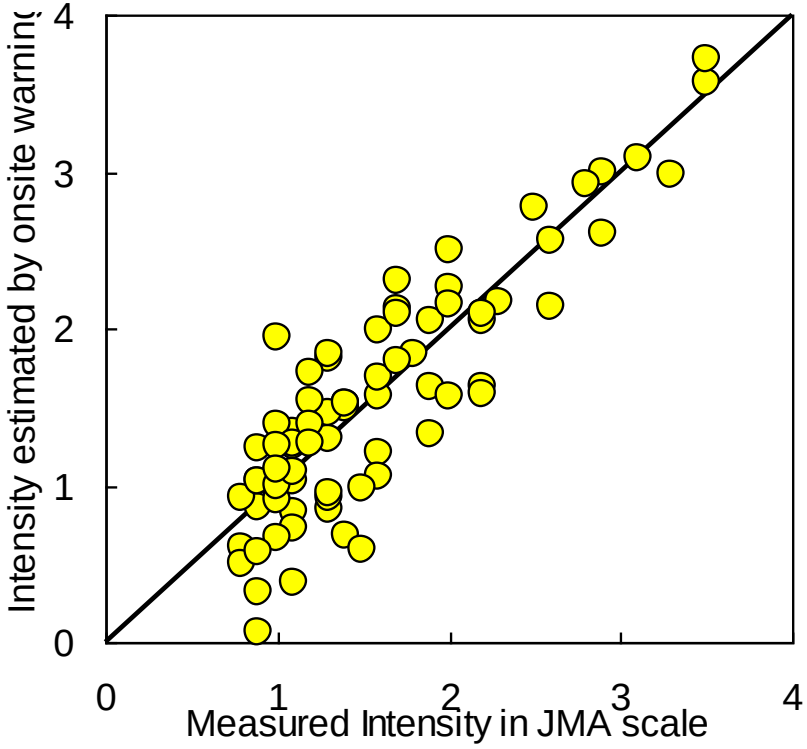
Warning Signal Flow at Dam Construction Site



Results of on-site warning against aftershocks of 2008 Iwate-Miyagi inland earthquake

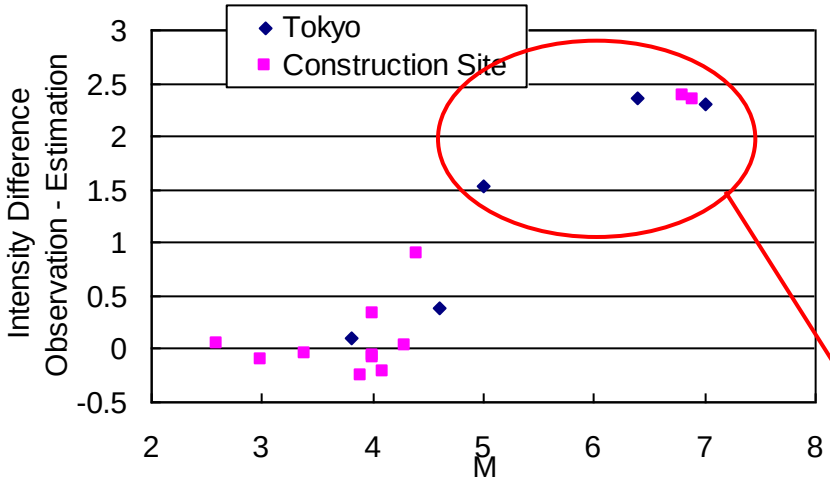


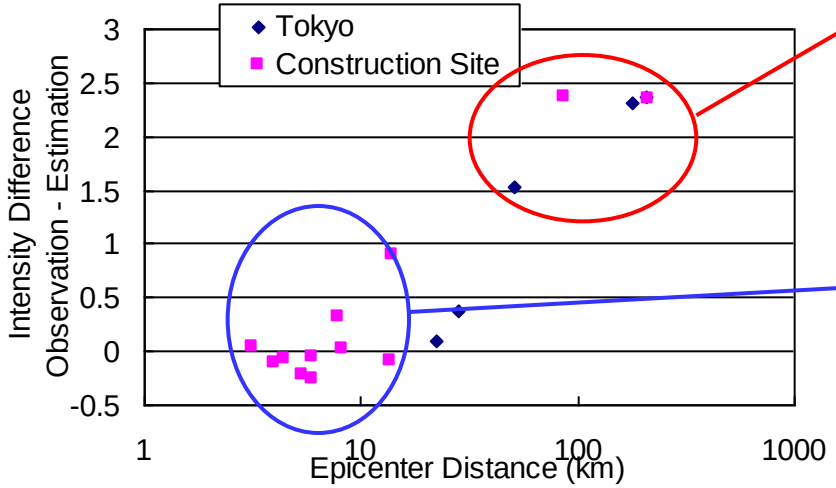
Example of time series observed on July 14, 2008



Accuracy of seismic intensity estimation (July – October)

Estimation Error ($I_{JMA} \geqq 2.5$) for Far & Large Events





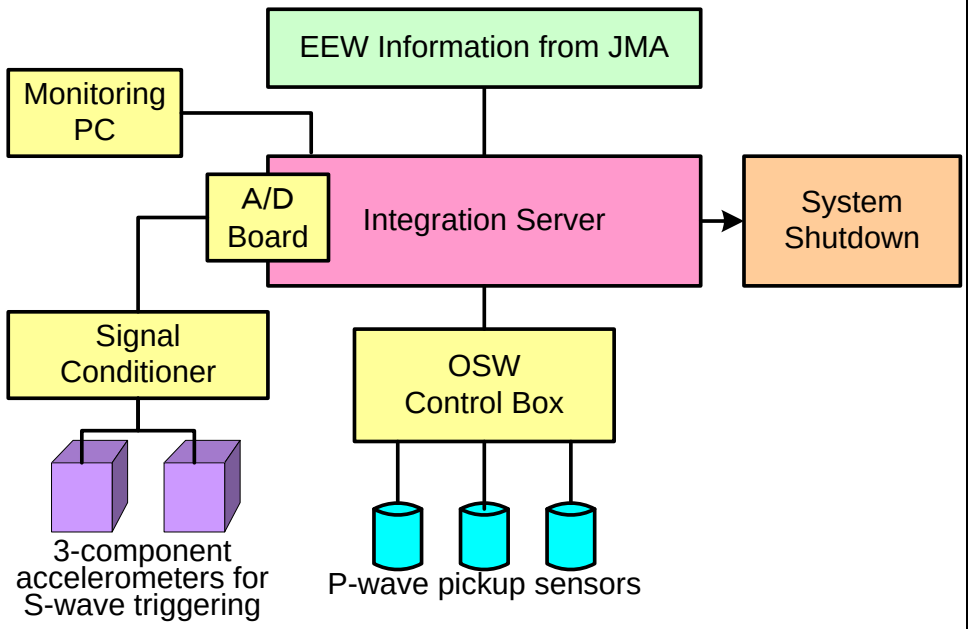
Far & Large Events

Aftershocks

Advanced System to Apply to System Shutdown

Robust and Reliable Earthquake Early Warning System

- The OSW is used for near-field earthquakes.
- The EEW information from JMA is used only for far large events.
- In case of underestimation by the OSW or EEW information from JMA, accelerometer installed on the target floor in a building is used as S-wave triggering.



For critical facilities such as precision machine and semiconductor factories

Conclusions

- Examples of practical application of EEW information from JMA were introduced.
- we have developed an on-site warning system especially for near-field earthquakes.
- We installed an on-site warning system combined with the EEW system from JMA at a construction site and verified the accuracy of seismic intensity estimation and the timing of warning.
- We have developed robust and reliable system to apply for shutdown of critical facilities.

Thank for your attention!