

## **DEVELOPMENT OF LARGE TUNED MASS DAMPER WITH STROKE CONTROL SYSTEM FOR SEISMIC UPGRADING OF EXISTING HIGH-RISE BUILDING**

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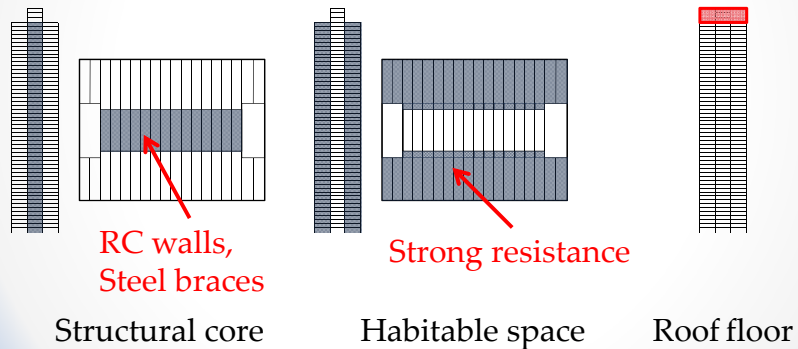
### **2011 Great East Japan Earthquake**

Demands for seismic upgrading against long-period earthquakes.

- High-rise buildings continued shaking with large amplitude and long duration.
- Residents felt scary and uneasy.
- Unknown long-period earthquake is expected in near future.

## 2011 Great East Japan Earthquake

Space to install devices

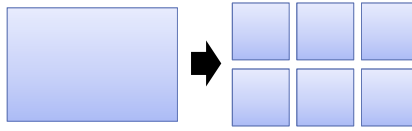


## TMD for Large Earthquakes

- PROBLEM No.1 : HUGE weight.  
Several hundred tons of weight is required.
- PROBLEM No.2 : LARGE Movement.  
Weight sways within several meters.  
Must be SAFE under unexpected earthquakes.

## TMD for Large Earthquakes

### Solution 1



Simple suspended support with wires.  
Weight is divided into several pieces.

### Solution 2



New oil damper with unique hydraulic circuit.

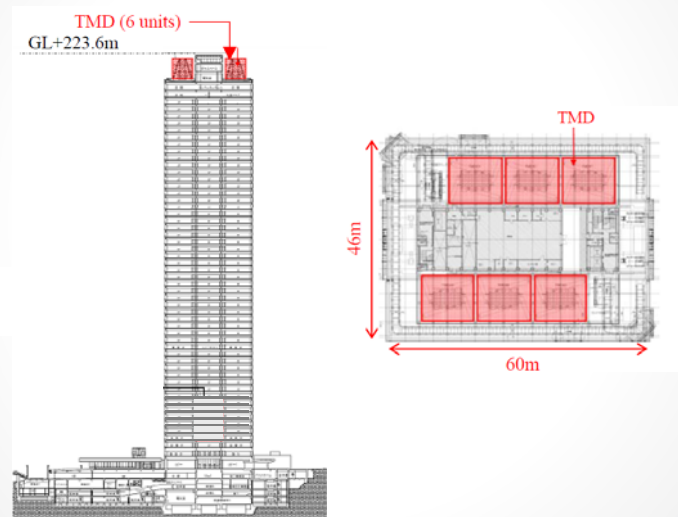
## Outline of Seismic Upgrading

### Target Building

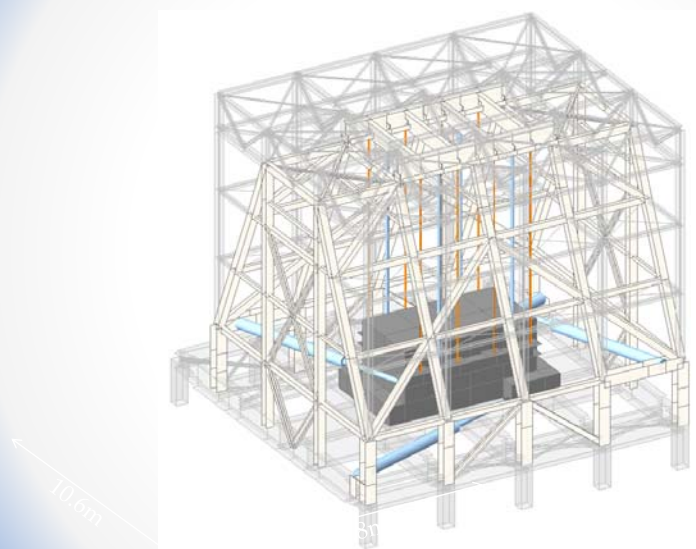
- Sinjuku Mitsui Building
- Located in Shinjuku area, Tokyo
- Built in 1974
- Office, Shop, Parking.
- Site area : 14,450m<sup>2</sup>
- Building area : 9,820m<sup>2</sup>
- Total floor area : 179,600m<sup>2</sup>
- 223m-high, 55 stories
- Typical floor height : 3.68m
- Steel-frame with huge diagonal truss and RC slit wall.
- Construction duration : 21months



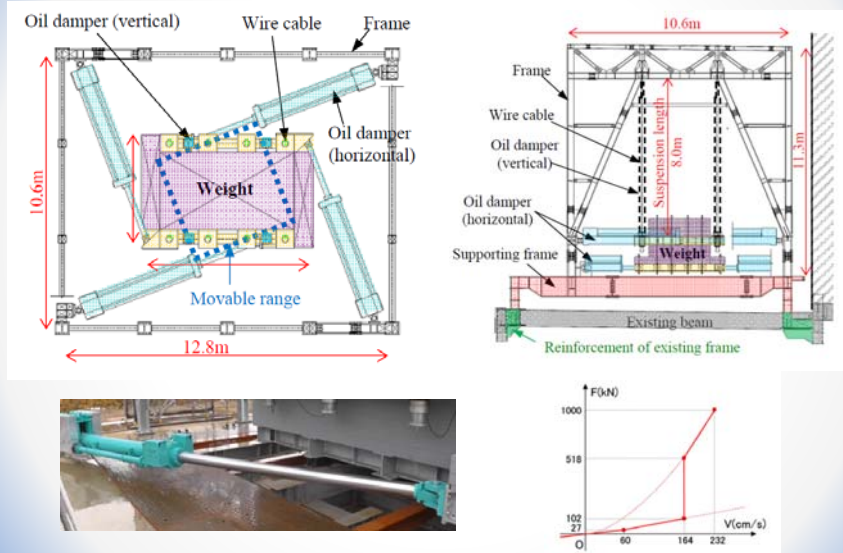
## Outline of Seismic Upgrading



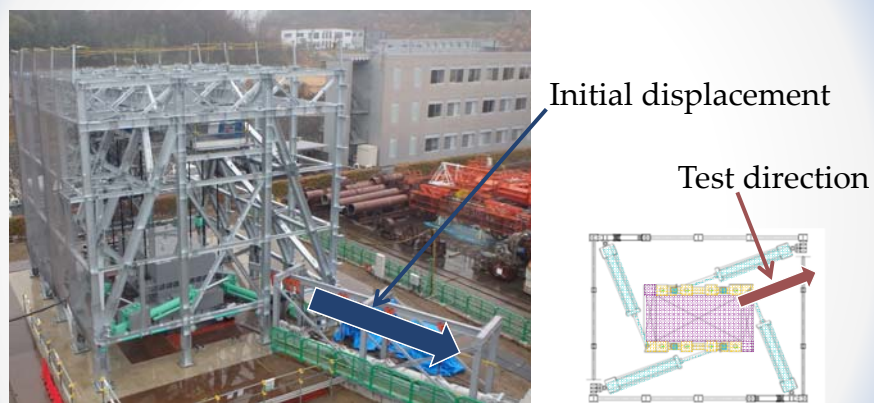
## Configuration of TMD



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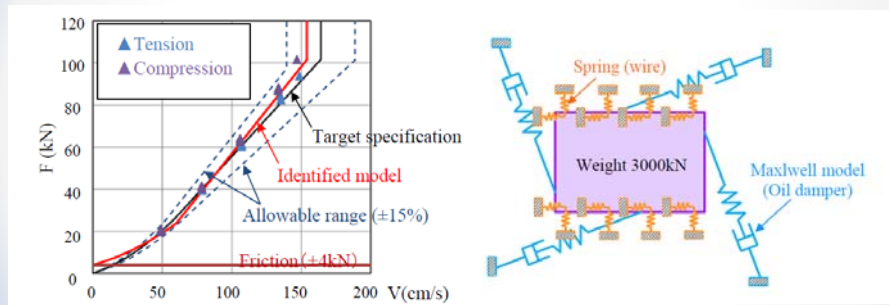


## Full scale experiment



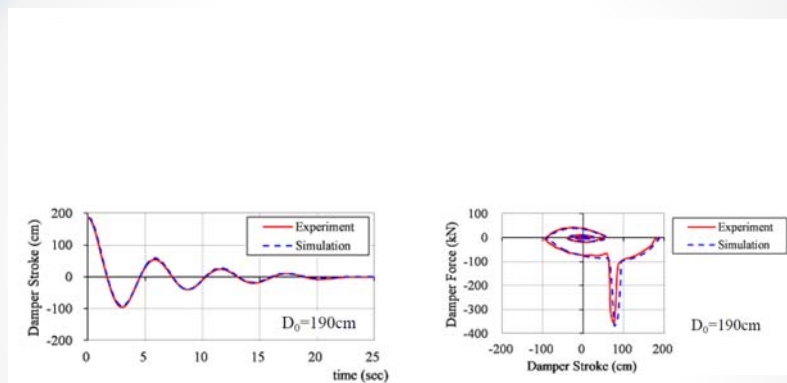
Free vibration test with initial displacement.

## Full scale experiment



Identified oil damper characteristics and analytical model of TMD

## Full scale experiment

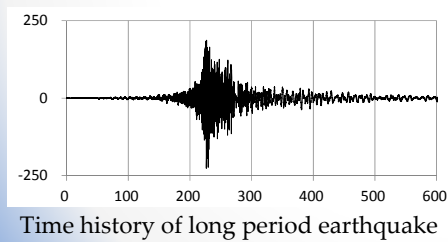
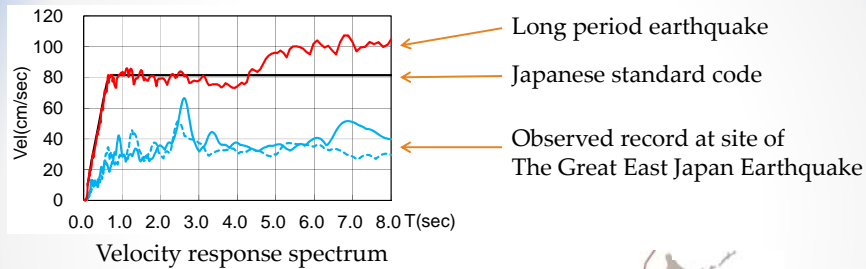


Result of free vibration test



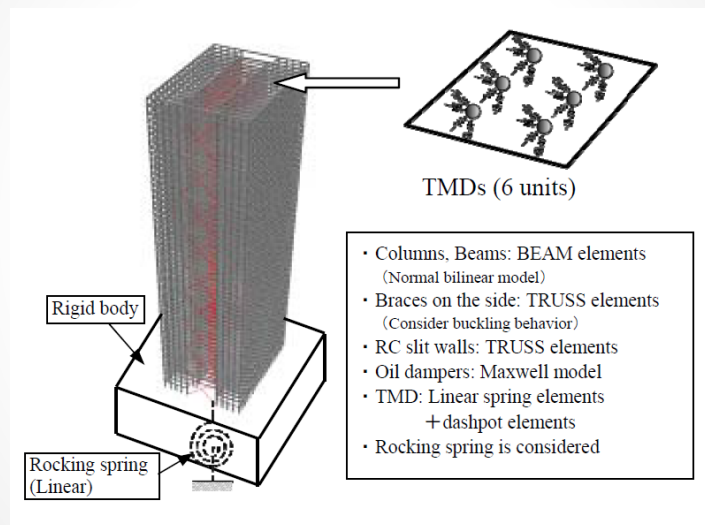
## Seismic design

### Design Earthquake



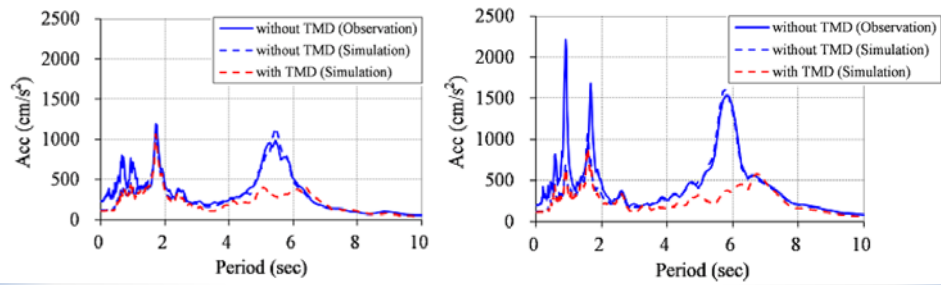
## Seismic design

### Model for Dynamic Response Analysis



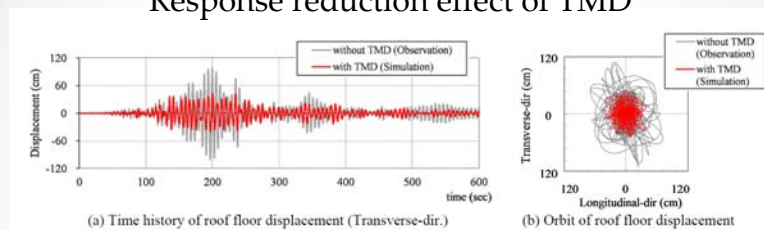
## Seismic design

### Acceleration response spectrum

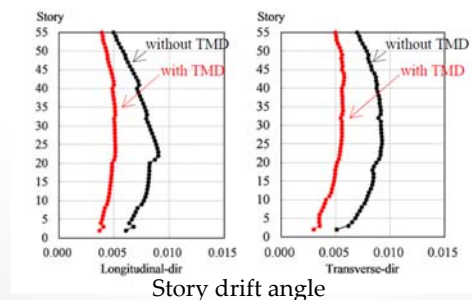


## Seismic design

### Response reduction effect of TMD



Response reduction effect to observed record in Great East Japan Earthquake





## Construction Procedure



1. Set Support Frame on existing beam



2. Set 2 tower cranes on support frame

## Construction Procedure



3. Set Weight and Horizontal Dampers



4. Build Steel Frame and Lift up weight

## Construction Procedure



5. Set Exterior Panels on the side



6. Set Exterior Panels on the roof

## Construction Procedure



7. Interior of the TMD unit



8. Exterior of the TMD units

## Aerial Photo (Before / After)



BEFORE



AFTER

## Conclusion

- A newly developed large tuned mass damper (TMD) for high-rise buildings adaptable to major earthquakes.
- Actual seismic upgrading project of an existing high-rise building.
- This TMD can be flexibly applied to any building regardless of its height or size without affecting habitable room space.

