

# On-line Model Updating for Advanced Hybrid Simulation

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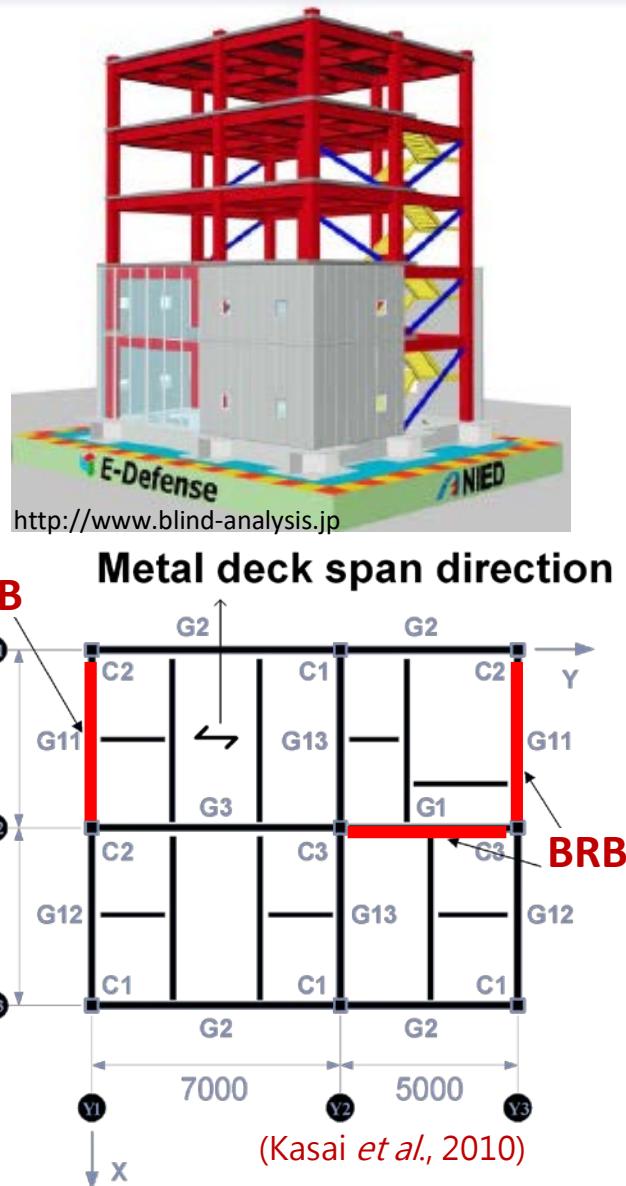
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The hybrid simulation can offer  
a cost-effective alternative to the shake table test.

Real time and model updating techniques  
are required!

# E-defense Shake Table Tests in Japan in 2009

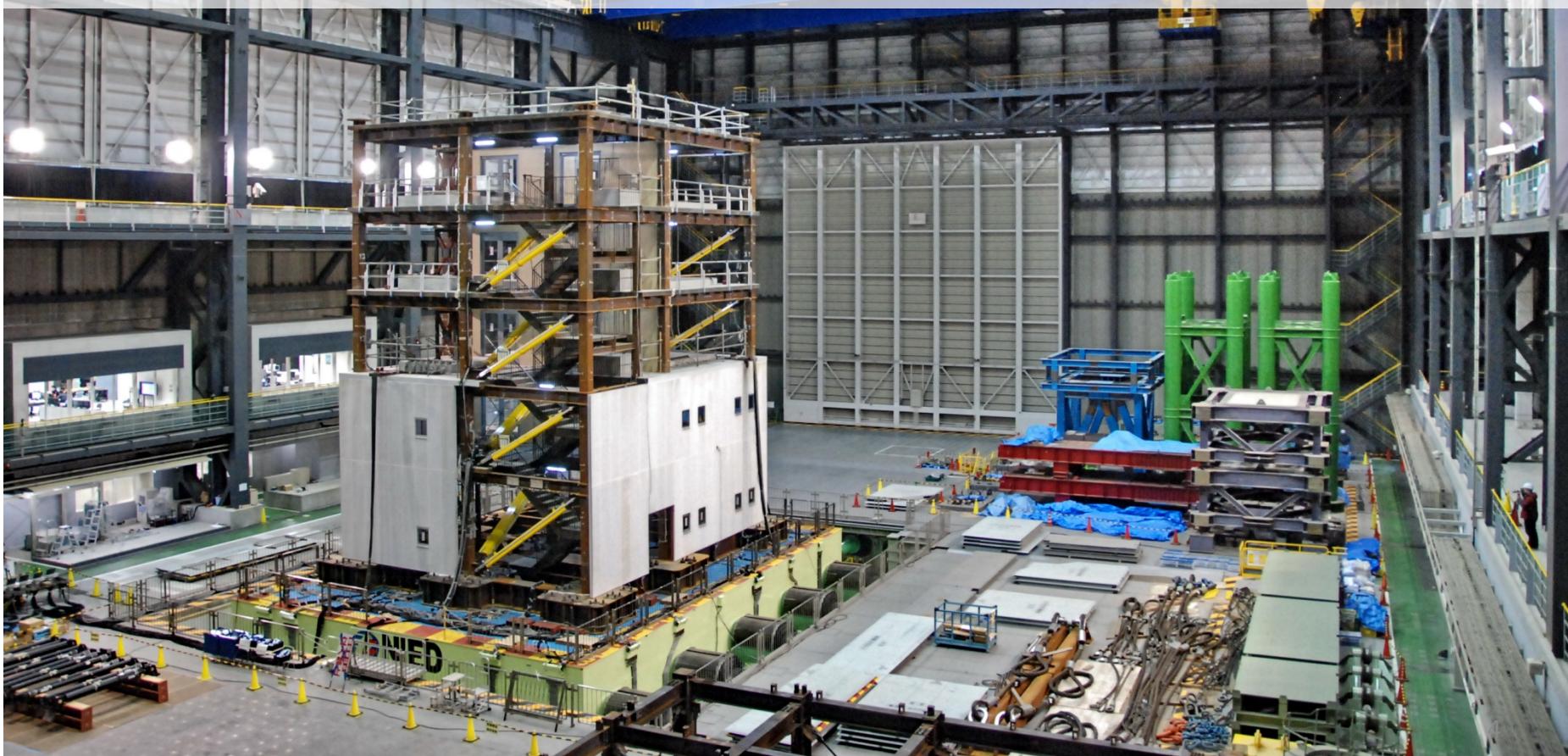


- 5 -story steel frame  
for 2009 blind analysis contests
- 4 stories equipped with BRBs
- 3 -dimensional shaking  
with Takatori ground motion with  
progressively increasing scale factor
- 2 bays  
in the X direction ( $5+5 = 10$  m)  
in the Y direction ( $7+5 = 12$  m)
- 1 sample BRB component test  
for off-line model fitting

# E-defense Shake Table Tests in Japan in 2009

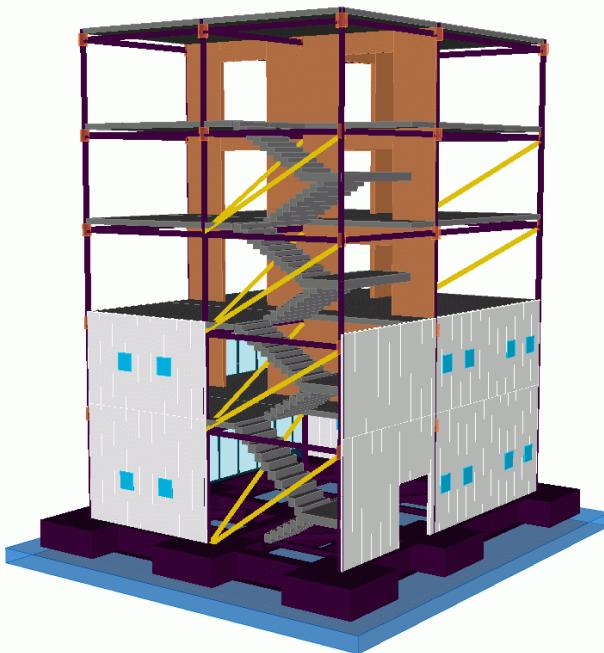
ありがとうございました

Big thanks go to Kasai sensei and his team for sharing the valuable test results of the 5 story BRBF

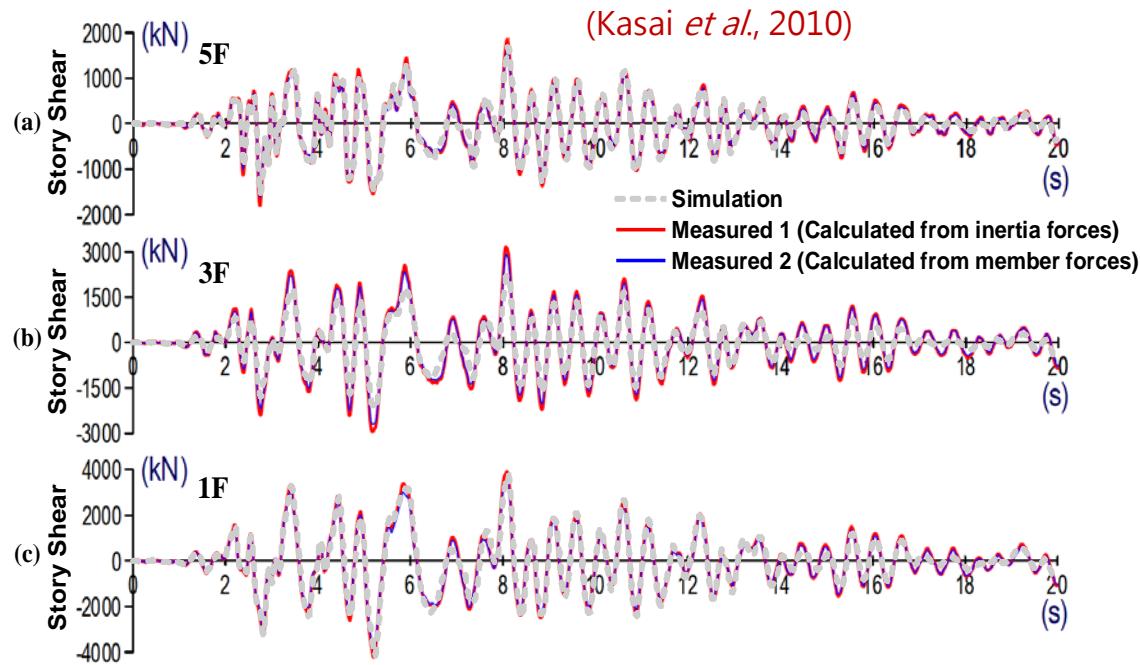


# Numerical Model Verified with Test Results

PISA3D model as the reference model



Accuracy can be verified with the test results  
(under Takatori ground motion)



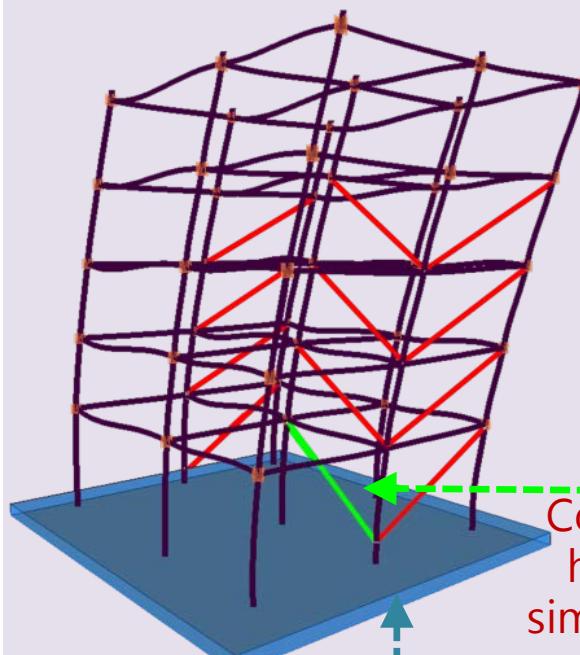
Calibrated Numerical Model

Accurate Simulation

Reasonably good Prediction

# Advanced Hybrid Simulation with Model Updating

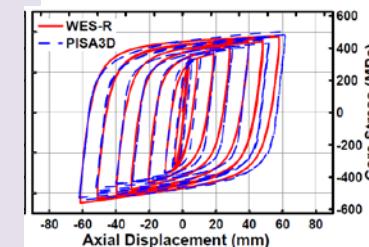
Numerical  
substructure  
(NS)



Physical  
substructure (PS)



Auxiliary  
numerical  
model (ANM)



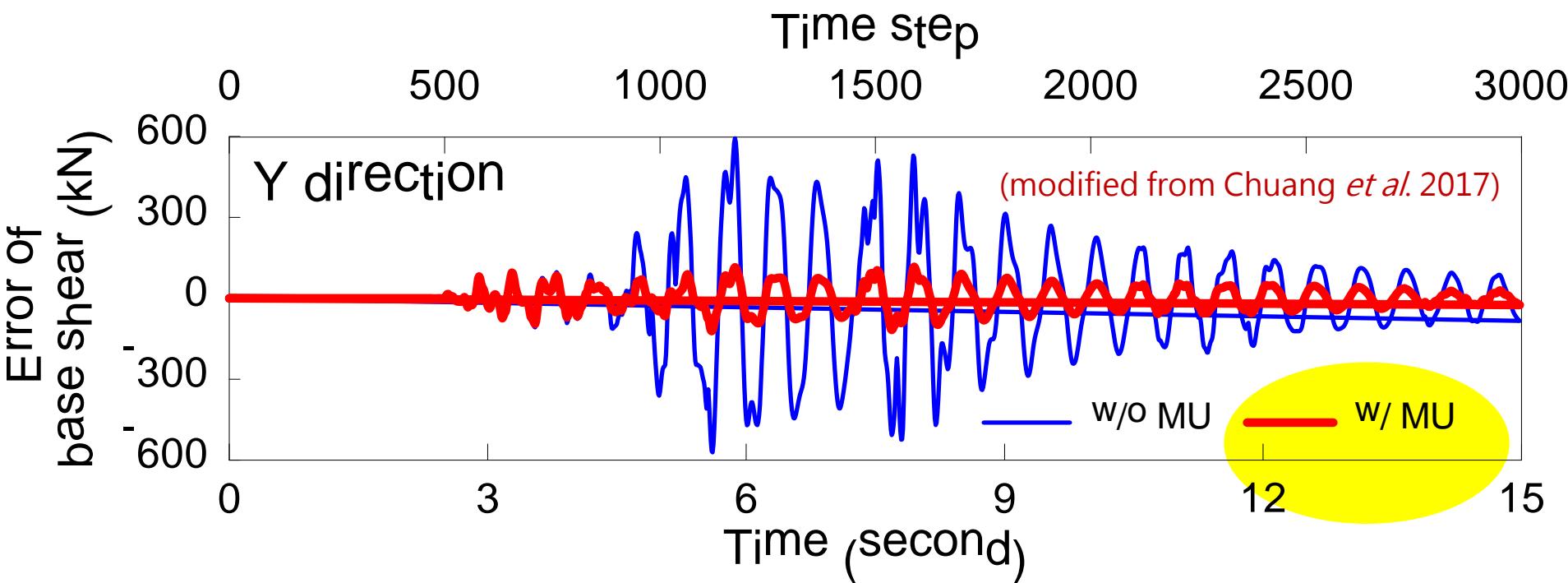
Conduct in-test  
parameter  
identification



On-line update relevant models

# Benefits of Model Updating in the Virtual HS

Compared with the reference model,

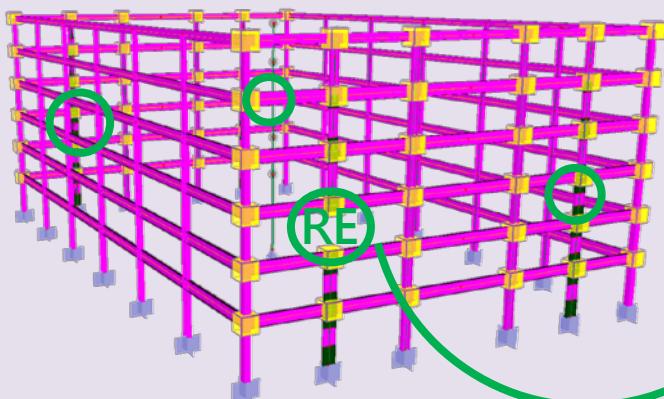


Error

Accuracy

# Hybrid Simulation with Model Updating on Steel Panel Damper Substructures Using MATS (April, 2017)

Numerical Substructure (NS) + Recdex Elements (REs)



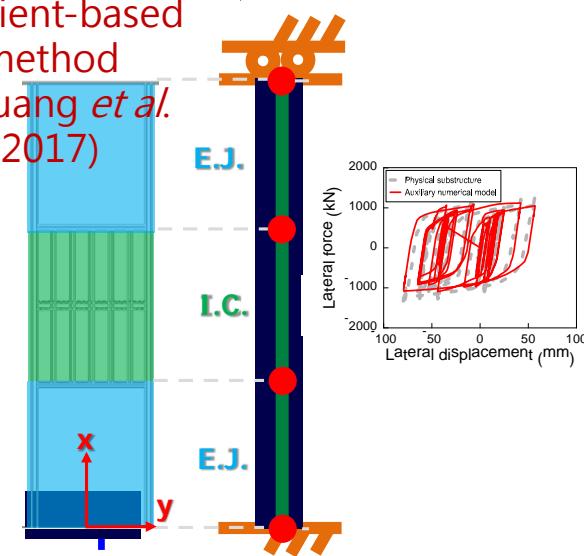
Conduct hybrid simulation

Physical Substructure (PS)



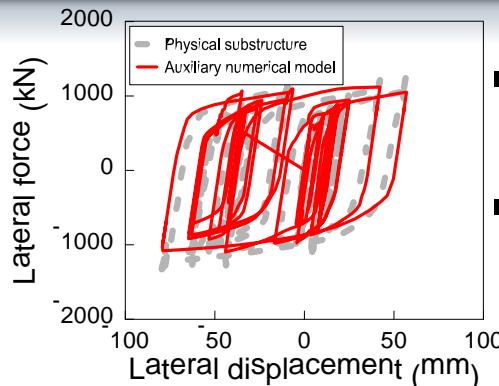
Auxiliary Numerical Model (ANM)

Parameter identification with the gradient-based method (Chuang et al. 2017)



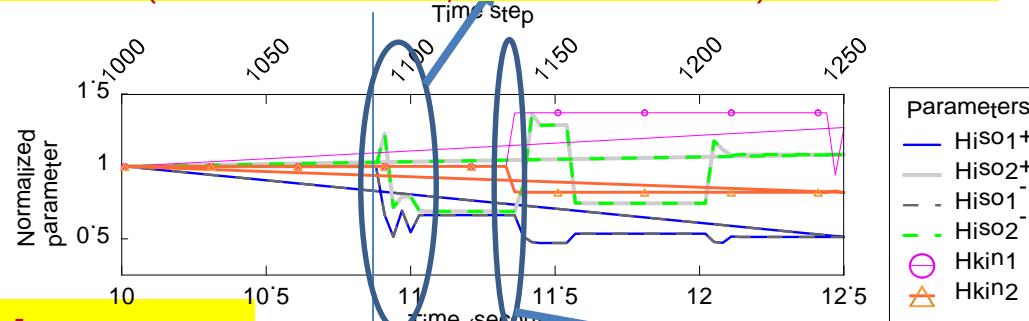
1. Update relevant models (8 SPD ICs of 1F and 2F)
2. Update the **12 x 12** stiffness matrix ( $K_t$ ) via static condensation

# Features of the Proposed Gradient-based Parameter Identification Method for Model Updating



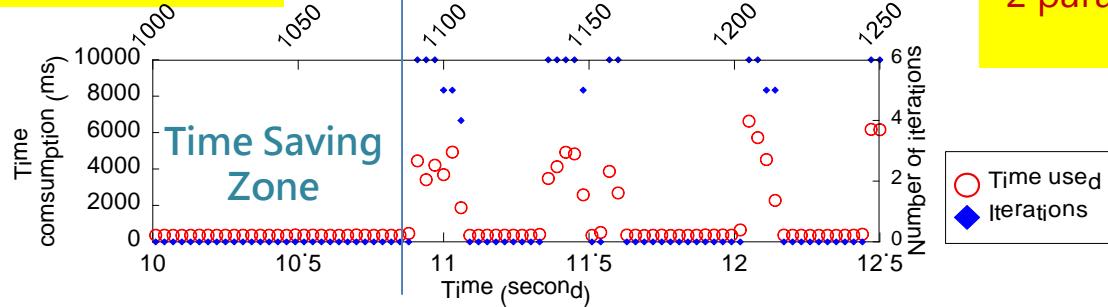
- The parameters to be identified are selected according to the stress state of the auxiliary numerical model.
- The parameter values are periodically identified at every 3 steps in the time stepping integration.

[Isotropic hardening]: 2 of 4 parameters to be identified  
( $Hiso1+ = Hiso1-$ ;  $Hiso2+ = Hiso2-$ )



[Elastic]:  
(No parameter to be identified)

[Kinematic hardening]:  
2 parameters to be identified  
( $Hkin1, Hkin2$ )



# On the Way to Advanced HS

- Verification for HS with MU using the Shake Table Tests
  - The full-scale tests of the **Shake Table@Tainan Lab.** will enrich the databank.
- Real Time Hybrid Simulation (RTHS)
  - Based on the experience from **MATS@Taipei Lab.**, the capacity of **BATS@Tainan Lab.** will enable development of RTHS.
  - Improvement of **efficiency** of **parameter identification**
- Parameter Identification and Model Updating
  - Proper constitutive model for **RC structure**
  - Feasibility of **sharing the identified parameter values** with the relevant models



The collage consists of four images: 1) A view of a large industrial or laboratory facility with multiple levels and structural supports. 2) A close-up of a concrete wall being tested, showing a red arrow pointing to a point of impact or damage. 3) Two people working at a desk with multiple computer monitors displaying data. 4) A laptop screen showing a 3D model of a bridge or similar structure, with a yellow hard hat resting on the desk next to it.

Thank you.