Structural Engineering Laboratory
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STATIC/PSEUDO STATIC/DYNAMIC TESTING

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INTRODUCTION

- Quasi-static loading test method
- Shake table testing method
- Pseudo-dynamic testing method
Open Loop Tests
**Quasi-static loading test method**

- a test specimen is subjected to slowly changing prescribed forces or deformations by means of hydraulic actuators.

- Inertial forces within the structures are not considered in this method.

- Purpose is to observe the material behavior of structural elements, components, or junctions when they are subjected to cycles of loading and unloading.

- Dynamic nature of earthquakes are not captured.
Static Tests

Gear Driven (or Screw Driven Machines)
- Crosshead speed
  - .001 to 500 mm/min
  - 1 to 20 mm/min for quasi static testing

Servo-Hydraulic Machines
- Crosshead speed
  - 1μm/h for creep/fatigue
  - 1 cycle/day to 200 cycles/s for cyclic tests
Static Tests Contd…

Load and Displacement Control modes

- Stress
- OR
- Load
- OR
- Strain
- OR
- Displacement

Stress
OR
Load
OR
Strain
OR
Displacement
Static Tests

Flexural Tests on RC Beams
Flexural Tests on Masonry Walls
Diagonal Shear Tests on Masonry Walls
Seismic Performance Evaluation

- Cyclic testing of structural elements & assemblies
- Post-ultimate strength and deformability up to failure
Cyclic Tests

Test set-up for cyclic tests on RC Beam-Column Joint
Typical Cyclic Loading History
Cyclic Test Facility
Shake table testing method

- test structures may be subjected to actual earthquake acceleration records to investigate dynamic effects
- inertial effects and structure assembly issues are well represented
- the size of the structures are limited or scaled by the size and capacity of the shake table
IITK Uni-axial Shake table

- Platform size 1.2x1.8 m
- Powered by 50 kN MTS servo-hydraulic actuator
- Velocities in the range of 1.5 m/s
Pseudo-dynamic testing Method

- Hardware Components

- Servo-Hydraulic Actuators

- Servo-Hydraulic Control Systems

- Measurement Instrumentation

- On-line computer
Pseudo-dynamic testing Method (Closed loop)
Hybrid Testing & Computing

- Pseudo-Dynamic Hybrid Testing System

Applies forces in substructure through actuators only – real time operation is a benefit but not a must.
Pseudo-dynamic testing Method

- applying slowly varying forces to a structural model
- motions and deformations observed in the test specimens are used to infer the inertial forces that the model would have been exposed to during the actual earthquake
- Substructure techniques
**Pseudo-dynamic testing Method**

Define a model of the structure system
Define the desired excitation - usually base acceleration
Calculate the expected response of structure - displacement
Use an actuator to apply the desired displacement in the structure
Measure the resistance force in the structure (or estimate it from measurements)
Repeat the above steps - start from second

\[ M\ddot{d}_i + C\dot{d}_i + R_i = f_i \]
**Pseudo-dynamic testing Method**

\[ a_{i+1} = \left( m + \frac{\Delta t}{2} c \right)^{-1} \left( f_{i+1} - r_{i+1} - cv_i - \frac{\Delta t}{2} c a_i \right) \]

\[ v_{i+1} = v_i + \frac{\Delta t}{2} (a_i + a_{i+1}) \]

\[ d_{i+2} = d_{i+1} + \Delta t v_{i+1} + \frac{\Delta t^2}{2} a_{i+1} \]
**Pseudo-dynamic testing Method**

Discretized equation of motion of the structure at time intervals \( t_i = i \Delta t \) for \( i = 1 \) to \( N \)

\[
M \ddot{d}_i + C \dot{d}_i + R_i = f_i
\]

Equation solved in computer step by step, with \( R_i \) as the reaction force measured from the specimen under test. Result is the displacement command of next step that will be applied to the specimen at each node of mass by actuators.
Pseudo Dynamic Test Facility @ IITK

- 20 Ton double girder crane
- Hydraulic hard lines - connected to existing laboratory equipment
- 1000 KN actuators (MTS) with stroke lengths up to 1000 mm
Pseudo-dynamic testing Facility @ IITK
Special Testing Facility for Forced Vibration studies of prototype buildings/structures
THANK YOU