Cyclic Load Testing for the Safety Assessment of Reinforced Concrete Structures according to ACI-437: recent developments and case studies

Antonio Brancaccio (Experimentations Srl) - Antonio Nanni (University of Miami)
EXPERIMENTATIONS operates since 1985 as a leading company in the field of innovative services for experimental engineering, providing laboratory and site testing of construction materials and soils, inspections and surveys, structural assessment and diagnosis, long-term monitoring and control of structures and infrastructures.

EXPERIMENTATIONS is an Independent Laboratory accredited by:

- Italian Ministry of Infrastructures
- Italian Ministry of Economic Development

EXPERIMENTATIONS is accredited laboratory according to the Italian art.59 of D.P.R. 380/2001 in the following sectors:

- Construction Materials - (Law n. 1086/71) with Decree n.38194 (14/01/1994) and followings;
- Soils - with Decree n. 54349 (16/02/2006) and followings.

EXPERIMENTATIONS is also Inspection, Testing and Certification Body for the construction products and assemblies industry - (European Notification N. 1676) according to the law 156/2003 and D.P.R. n. 246 (21/04/1993).
**CYCLIC LOAD TESTING:**

**Target:** assess the actual behavior of structural elements (slabs, beams, cantilevers, stairs, etc.)

**Tools:** Application of successive loading and unloading cycles through the use of hydraulic jacks and LVDTs to monitor deflections and acceptance criteria.

---

**When is it useful to perform load testing on structures?**

- **New Structures**
  - When the construction is completed to check the compliancy with design specifications and code requirements

- **Existing Structures**
  - To assess the structural behavior of damaged/deteriorated elements and estimate the load carrying capacity

- **Existing Strengthened Structures**
  - To verify and quantify the efficiency of a repair strengthening system

---

**MAJOR INTEREST:** Public Authorities, Developers, Owners, Building managers, Forensic Engineers, Insurance Companies, etc.
CYCLIC LOAD TEST: Load Application Method and Test Set-Up

The application of test loads is provided by using displacement-controlled hydraulic jacks.

The use of such equipment rather than uniformly distributed dead loads (water, cement bags, etc.), allows for:

- faster and more controlled application of test loads (softening post peak behavior)
- the test load can be removed almost instantaneously in case of impending failure.
CYCLIC LOAD TEST: Load Application Method and Test Set-Up

There are several ways to provide reactions to the hydraulic jacks and based on the type of reaction we can identify:

(1) pull set-up and (2) push set-up configurations:
**CYCLIC LOAD TEST: Loading Procedure**

In the cyclic loading procedure, the loads are applied in loading-unloading cycles of increasing magnitude using hydraulic jacks that are controlled by hand or electric pumps. The structure will be initially loaded and unloaded at low levels, allowing the engineer the ability to better understand end fixity and load transfer characteristics of the tested member by comparing actual deflection responses with calculated deflection responses.

The total load test duration should be approximately minimum 2 hours, with each loading/unloading cycle lasting approximately 20 minutes.
CYCLIC LOAD TEST: Acceptance Criteria

➢ **DEVIATION FROM LINEARITY:** It represents the measure of the nonlinear behavior of a member being tested at any time after a given threshold that typically corresponds to its service load level.

\[ I_{DL} = 1 - \frac{\tan(\alpha_i)}{\tan(\alpha_{ref})} \quad < 25\% \]

➢ **PERMANENCY:** it represents the amount of permanent change displayed by any structural response parameter during the second of two identical load cycles. If the level of permanency of the second of two repeated cycles is higher than 10%, it may be an indication that the repeated loading has damaged the structural member further and nonlinear effects are taking place.

\[ I_{pr} = \frac{I_{p(i+1)}}{I_{pi}} \quad \text{and} \quad I_{pi} = \frac{\Delta^i}{\Delta_{max}} \quad < 10\% \]

➢ **RESIDUAL DEFLECTION:** The residual deflection measured at least 24 hours after removal of the load at the completion of the load test.

\[ \Delta_i \leq \frac{l_i}{180} \]
CASE STUDIES

1) Assessment and Repair of fire damaged structure
2) Serviceability assessment of exposed hotel building
3) Strength evaluation of a slab due to a new load configuration
CASE STUDY: Fire-damaged Industrial Warehouse
CASE STUDY: Fire-damaged Industrial Warehouse

DAMAGE ASSESSMENT TESTING CAMPAIGN: Cyclic Load Testing of slabs
CASE STUDY: Fire-damaged Industrial Warehouse
CASE STUDY: Fire-damaged Industrial Warehouse

DAMAGE ASSESSMENT TESTING CAMPAIGN: Cyclic Load Testing of slabs

TEST FAILED
1. Deep concrete spalling, reinforcing steel exposure and deterioration was found.

2. Structural elements resulted to be complying with shop drawings.

3. NDT surveys gave evidence of the amount of damage experienced by the structure.

4. Laboratory mechanical and chemical tests reviled affected material properties.

5. Maximum temperature experienced = 600 °C

- The rise in temperature generated by a fire a decrease in the strength and modulus of elasticity of the constituent materials, both concrete and steel reinforcement.

- The rate at which the strength and modulus decrease depends on the rate of increase in the temperature of the fire and the insulating properties of concrete.

- The ductility of the structure decreases reducing the overall safety factor which it has been designed for.

OVERALL STRENGTH REDUCTION = 25%
STRENGTHENING SYSTEM SOLUTION: FRP High Strength Steel Fibers + Carbon Fibers

FLEXURAL RETROFITTING:
1 LAYER OF HIGH STRENGTH STEEL FIBER SHEET - MEDIUM DENSITY - BRASS COATED FIDSTEEL 3x2 - B 12-12-500.
STRIPS 30cm WIDE @1m

FLEXURAL RETROFITTING:
1 LAYER OF HIGH STRENGTH STEEL FIBER SHEET - MEDIUM DENSITY - BRASS COATED FIDSTEEL 3x2-B 12-12-500,
STRIPS 45cm WIDE @1m
STRENGTHENING SYSTEM SOLUTION: FRP High Strength Steel Fibers + Carbon Fibers
CASE STUDY: Fire-damaged Industrial Warehouse

POST-RETROFIT EXPERIMENTAL CAMPAIGN:

1. Pull-out test on FRP
2. Ultrasonic survey
3. Thermographic survey
4. CYCLIC LOAD TESTS
CASE STUDY: Fire-damaged Industrial Warehouse

**TIME-DISPLACEMENT DIAGRAM**

**HYSTERESIS DIAGRAM - TRASDUCER T2**

**TEST LOADS**
- MAXIMUM POINT LOAD: 26187 daN
- EQUIVALENT UNIFORMLY DISTRIBUTED LOAD: 2054 daN/m²

**ACCEPTANCE CRITERIA**

**REPEATABILITY INDEX (Iₚ)**

<table>
<thead>
<tr>
<th>CYCLE</th>
<th>VALUE</th>
<th>ACCEPTANCE CRITERIA (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Iₚ = 100.9 %</td>
<td>95% &lt; Iₚ &lt; 105%</td>
</tr>
<tr>
<td>3-4</td>
<td>Iₚ = 101.6 %</td>
<td></td>
</tr>
<tr>
<td>5-6</td>
<td>Iₚ = 101.1 %</td>
<td></td>
</tr>
</tbody>
</table>

**PERMANENCY INDEX (Iₚ)**

<table>
<thead>
<tr>
<th>CYCLE</th>
<th>VALUE</th>
<th>ACCEPTANCE CRITERIA (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Iₚ = 0.0 %</td>
<td>Iₚ &lt; 10%</td>
</tr>
<tr>
<td>4</td>
<td>Iₚ = 1.1 %</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Iₚ = 1.8 %</td>
<td></td>
</tr>
</tbody>
</table>

**DEVIAITON FROM LINEARITY (I_DL)**

<table>
<thead>
<tr>
<th></th>
<th>I_DLmax = 17.7 %</th>
<th>ACCEPTANCE CRITERIA (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I_DL &lt; 25%</td>
<td></td>
</tr>
</tbody>
</table>
### POST-RETROFIT EXPERIMENTAL CAMPAIGN

<table>
<thead>
<tr>
<th></th>
<th>Concentrated Force</th>
<th>Distributed Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-retrofit</td>
<td>11,000 daN</td>
<td>500 daN/sqm</td>
</tr>
<tr>
<td>Post-retrofit</td>
<td>26,000 daN</td>
<td>2,000 daN/sqm</td>
</tr>
</tbody>
</table>

#### Graph:

- **Load F [daN]**
- **Displacement [mm]**

- Blue line: Load test before strengthening
- Red line: Load test after strengthening
CASE STUDY: Exposed Hotel Building - Dubai

**Project:** Exposed Hotel Building  
**Location:** Jumeirah Village - Dubai (UAE)  
**Objective:** Load testing of cracked slabs  
**Target:** Serviceability assessment: check structural performance compliance with design previsions
CASE STUDY: Exposed Hotel Building - Dubai

Slab n.1

Slab n.2
CASE STUDY: Exposed Hotel Building - Dubai

Cyclic Load Test n.1

<table>
<thead>
<tr>
<th>Design and Test Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ds = 2.6 kPa</td>
</tr>
<tr>
<td>L = 4 kPa</td>
</tr>
<tr>
<td>TLM* = 9.26 kPa = 926 daN</td>
</tr>
</tbody>
</table>

*excluded dead weight already in place

COMPUTATION OF THE EQUIVALENT DISTRIBUTED LOAD (Qeq)

\[
F_{\text{Target}} = 2 F = 16300 \text{ [daN]} \]

\[
\text{Span} = 8.90 \text{ [m]} \]

\[
Q_{\text{eq}} = \frac{8 \times F_{\text{Target}}}{3 \times S \times C^2} = 950 \text{ [daN/m²]} \]

HYSTERESIS DIAGRAM - TRASDUCER T2

TIME-APPLIED LOAD DIAGRAM

TIME-DISPLACEMENTS DIAGRAM
CASE STUDY: Exposed Hotel Building - Dubai

Cyclic Load Test n.2

### Design and Test Loads

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_s$</td>
<td>2.8 kPa</td>
</tr>
<tr>
<td>$L$</td>
<td>5 kPa</td>
</tr>
<tr>
<td>TLM*</td>
<td>11.08 kPa = 1108 daN</td>
</tr>
</tbody>
</table>

*excluded dead weight already in place

### Computation of the Equivalent Distributed Load ($Q_{eq}$)

$$F_{target} = 2F = 18723 \text{ [daN]}$$

$$\text{Span} = 8.50 \text{ [m]}$$

$$Q_{eq} = \frac{F_{target}}{L \times C_1 \times C_2} = 1108 \text{ [daN/m²]}$$

---

**Hysteresis Diagram - Trasducer T2**

**Time-Applied Load Diagram**

**Time-Displacements Diagram**

Legend:
- T0
- T1
- T2
- T3
- T4
- T5
- T6
### Results Cyclic Load Test n.1

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Repeatability Index ($I_R$)</th>
<th>Acceptance Criteria ($^\circ$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>98,7%</td>
<td></td>
</tr>
<tr>
<td>3-4</td>
<td>99,9%</td>
<td></td>
</tr>
<tr>
<td>5-6</td>
<td>101,2%</td>
<td></td>
</tr>
</tbody>
</table>

#### Deviation

$\text{I}_{DL\text{ max}} = 9,1\%$

### Results Cyclic Load Test n.2

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Repeatability Index ($I_R$)</th>
<th>Acceptance Criteria ($^\circ$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>97,9%</td>
<td>95% &lt; $I_R$ &lt; 105%</td>
</tr>
<tr>
<td>3-4</td>
<td>99,6%</td>
<td></td>
</tr>
<tr>
<td>5-6</td>
<td>100,5%</td>
<td></td>
</tr>
</tbody>
</table>

#### Deviation

$\text{I}_{DL\text{ max}} = 1,6\%$

#### Permanency Index ($I_p$)

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Permanency Index ($I_p$)</th>
<th>Acceptance Criteria ($^\circ$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0,0%</td>
<td>$I_p &lt; 10%$</td>
</tr>
<tr>
<td>4</td>
<td>1,7%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0,0%</td>
<td></td>
</tr>
</tbody>
</table>

#### Deviation From Linearity ($I_{DL}$)

$\text{I}_{DL\text{ max}} = 1,6\%$

**TEST 2 SUCCESSFUL**
**CASE STUDY: THE MEYDAN HOTEL – DUBAI (UAE)**

**Project:** The Meydan Hotel  
**Location:** Dubai (UAE)  
**Objective:** New Load Configuration  
**Target:** Serviceability assessment, check structural performance compliance with design previsions and future load configuration
CASE STUDY: THE MEYDAN HOTEL – DUBAI (UAE)

Voids to be closed with a new steel slab connected to the concrete structure.

10, 20 m

13, 20 m
CASE STUDY: The Meydan Hotel – Dubai (UAE)

DEFINITION OF TLM

- **TEST BEAM 1**: \( \text{SDL} = 12.5 \text{ kN/m} + \text{SLL} = 25.0 \text{ kN/m} + \text{NS} = 53.0 \text{ kN/m} \Rightarrow \text{TLM} = 90.5 \text{ kN/m} 

- **TEST BEAM 2**: \( \text{SDL} = 5.80 \text{ kN/m} + \text{SLL} = 11.60 \text{ kN/m} + \text{NS} = 53.0 \text{ kN/m} \Rightarrow \text{TLM} = 70.4 \text{ kN/m} 

Test Beam 1:
- SDL = 12.50 kN/m
- SLL = 25.00 kN/m
- NS = 53.00 kN/m

Test Beam 2:
- SDL = 5.82 kN/m
- SLL = 11.62 kN/m
- NS = 53.00 kN/m

7th FLOOR EXISTING PLAN
CASE STUDY: The Meydan Hotel – Dubai (UAE)

Load Test 1: Load jacks are vertically positioned above the test beam and push down it using as reaction the above beam located at 8th floor, leading to a 2-point bending configuration at S/3, using n.2 hydraulic jacks at each section to transfer the required load.
EQUIVALENT PATCH LOAD

The equivalent patch load $F_{eq}$ is defined as: “the concentrated force applied at $L/3$ of the beam capable of inducing the same maximum bending moment provided by the uniformly distributed design load $q$.”

By equalizing the bending moments of schemes (1)–(2) and (3)–(4), given the design load $Q$, it is possible to derive the Equivalent Patch Load (2F) at $S/3$ sections:

\[ 2F = \frac{3}{8} \times (Q \times S) \]

<table>
<thead>
<tr>
<th>$S$</th>
<th>$Q$</th>
<th>$2F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.20</td>
<td>9050</td>
<td>34616</td>
</tr>
</tbody>
</table>
CASE STUDY: The Meydan Hotel – Dubai (UAE)

DEFINITION OF TEST SET-UP

HYSTERESIS DIAGRAM - TRASDUCER T2

TEST 1 SUCCESSFUL

APPLIED TOTAL LOAD (dF) 69232 daN
EQUIVALENT UNIFORMLY DISTRIBUTED LOAD 9050 daN/m

REPEATABILITY INDEX ($I_R$)

<table>
<thead>
<tr>
<th>CYCLE</th>
<th>VALUE</th>
<th>ACCEPTANCE CRITERIA ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>99.0</td>
<td></td>
</tr>
<tr>
<td>3-4</td>
<td>100.0</td>
<td>95% &lt; $I_R$&lt;105%</td>
</tr>
<tr>
<td>5-6</td>
<td>99.6</td>
<td></td>
</tr>
</tbody>
</table>

PERMANENCY INDEX ($I_P$)

<table>
<thead>
<tr>
<th>CYCLE</th>
<th>VALUE</th>
<th>ACCEPTANCE CRITERIA ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1.0</td>
<td>$I_P$&lt;10%</td>
</tr>
<tr>
<td>4</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.4</td>
<td></td>
</tr>
</tbody>
</table>

DEVIAITION FROM LINEARITY ($I_{DL}$)

<table>
<thead>
<tr>
<th>$I_{DL_{max}}$</th>
<th>ACCEPTANCE CRITERIA ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.3</td>
<td>$I_{DL}$&lt;25%</td>
</tr>
</tbody>
</table>
CASE STUDY: The Meydan Hotel – Dubai (UAE)

**Load Test 2:** Due to the absence of a suitable reaction frame, a push-down set-up with 1-point bending configuration was chosen, using n.4 hydraulic jacks to transfer the required load. The load application area was selected due to the presence of a drop beam at 8th floor used as reaction for the hydraulic jacks.
CASE STUDY: The Meydan Hotel – Dubai (UAE)

Load Test 2:
In this case, the load application point was located in an unusual position due to the absence of a proper reaction frame along the test beam. However, in accordance with the Consultant, since this beam is supported by two edge beams and not by columns, the idea at base of this choice is to test the entire structural system by measuring deflections and behavior also of the elements connected to the beam being tested.
CASE STUDY: The Meydan Hotel – Dubai (UAE)

EQUIVALENT PATCH LOAD

“the concentrated force applied at 2.5 m from the left end support of the test beam capable of inducing the same vertical reactions at supports provided by the uniformly distributed design load q”.

DISTRIBUTED LINEAR LOAD (INDICATED BY CONSULTANT)

\[ Q = 7044 \text{ daN/m} \]

SUPPORT REACTION \( V_B \) TO UNIFORMLY DISTRIBUTED LOAD (Q)

\[ Q = 7044 \text{ daN/m} \]

\[ S = 13.20 \text{ m} \]

\[ V_B = \frac{QS}{2} = 46490 \text{ daN} \quad (1) \]

SUPPORT REACTION \( V_B \) TO A CONCENTRED FORCE (4F)

\[ a = 10.70 \text{ m} \]

\[ b = 2.50 \text{ m} \]

\[ S = 13.20 \text{ m} \]

\[ V_B = 4Fa/S \quad (2) \]

EQUIVALENT PATCH LOAD

By equalizing the support reactions of schemes (1)=(2) it is possible to derive the Equivalent Patch Load (4F) in a section:

\[ 4F = \left( \frac{V_B x S}{a} \right) \]

\[ V_B = \frac{46490}{13.20} = 3520 \text{ daN} \]

\[ 4F = \frac{57352}{10.70} = 5352 \text{ daN} \]
CASE STUDY: The Meydan Hotel – Dubai (UAE)

TIME-APPLIED LOAD DIAGRAM

Applied Load of single hydraulic jack (F, daN)

<table>
<thead>
<tr>
<th>Time [s]</th>
<th>0</th>
<th>870</th>
<th>1740</th>
<th>2610</th>
<th>3480</th>
<th>4350</th>
<th>5220</th>
<th>6090</th>
<th>6960</th>
<th>7830</th>
<th>8700</th>
</tr>
</thead>
<tbody>
<tr>
<td>F  [daN]</td>
<td>13000</td>
<td>11000</td>
<td>9000</td>
<td>7000</td>
<td>13000</td>
<td>11000</td>
<td>9000</td>
<td>7000</td>
<td>13000</td>
<td>11000</td>
<td>9000</td>
</tr>
</tbody>
</table>

TIME-DISPLACEMENTS DIAGRAM

Displacements (mm)

<table>
<thead>
<tr>
<th>Time [s]</th>
<th>0</th>
<th>870</th>
<th>1740</th>
<th>2610</th>
<th>3480</th>
<th>4350</th>
<th>5220</th>
<th>6090</th>
<th>6960</th>
<th>7830</th>
<th>8700</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacements [mm]</td>
<td>16.00</td>
<td>14.00</td>
<td>12.00</td>
<td>10.00</td>
<td>16.00</td>
<td>14.00</td>
<td>12.00</td>
<td>10.00</td>
<td>16.00</td>
<td>14.00</td>
<td>12.00</td>
</tr>
</tbody>
</table>

HYSTERESIS DIAGRAM - TRASDUCER T4

Applied Total Load (4F) [daN]

Displacement trasducer T4 [mm]

<table>
<thead>
<tr>
<th>Applied Total Load [daN]</th>
<th>0</th>
<th>1000</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
<th>5000</th>
<th>6000</th>
<th>7000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement [mm]</td>
<td>0.00</td>
<td>1.00</td>
<td>2.00</td>
<td>3.00</td>
<td>4.00</td>
<td>5.00</td>
<td>6.00</td>
<td>7.00</td>
<td>8.00</td>
</tr>
</tbody>
</table>

TEST LOADS

<table>
<thead>
<tr>
<th>APPLIED TOTAL LOAD (4F)</th>
<th>57352 daN</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQUIVALENT UNIFORMLY DISTRIBUTED LOAD</td>
<td>7044 daN/m</td>
</tr>
</tbody>
</table>

ACCEPTANCE CRITERIA

<table>
<thead>
<tr>
<th>REPEATABILITY INDEX (IR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYCLE</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>1-2</td>
</tr>
<tr>
<td>3-4</td>
</tr>
<tr>
<td>5-6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PERMANENCY INDEX (Ip)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYCLE</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEVIATION FROM LINEARITY (IPL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iplmax = 0,2%</td>
</tr>
</tbody>
</table>

EQUIVALENT PATCH LOAD

TEST 2 SUCCESSFUL
CASE STUDY: The Meydan Hotel – Dubai (UAE)

SUMMARY OF TEST RESULTS

✓ During the test, the beam showed no signs of impending failure, such concrete crushing or concrete cracking

✓ The maximum deflection of the member recorded at service load level (SDL+SLL) was 1.03 mm

✓ The maximum deflection of the member recorded at the sixth load cycle (during the application of TLM) was 3.22 mm

✓ The residual deflection of the member at the end of the test was 0.00 mm

✓ Maximum measured deflections did not exceed the permissible values given in Table 9.5 of ACI 318-11 for the various types of members, as stated by ACI 437.2-13 (§ R6.2.1)

✓ Maximum measured deflection and residual deflection did not exceed Equations 20-1 (4.16 mm) and 20-2 (1.04 mm) of ACI 318-11 (§ 20.5.2), allowing for not repeating the test

✓ During the test, the residual deflection of the member was less than 25% of the corresponding absolute maximum deflection immediately upon unloading

✓ During the test, the three main Acceptance Criteria were always within their limit range
CONCLUSIONS:

1. In the analysis and assessment of existing damaged structures, engineers are requested to thoughtfully understand the structure and therefore to achieve the maximum level of knowledge on material properties and structural behavior.

2. This goal is reached by characterizing materials with on-site testing activities but a very useful tool is represented by the cyclic load test to assess real performances of structures.

3. This test may be applied to:
   ✓ Give evidence to relevant authorities about compliance of performances of new structures before the project is delivered.
   ✓ Assess the structural behavior of damaged elements, check the compliance with the safety requirements of the code and eventually estimate load carrying capacity.
   ✓ Check quality and prove the efficiency of repair strengthening systems with satisfaction of all the parties involved in the project.

4. The reality is that structures are always more complex than the mathematical models we use to predict their performances. This is the reason why designers often choose load tests since previous attempts to predict performances failed to produce convincing or meaningful results. Accordingly, ACI 437 helps a lot to let consultants feel relaxed during the test.
THANKS FOR YOUR ATTENTION !!

PERUGIA (Italia)
Sede Legale, Uffici e Laboratori UNI EN ISO 9001
Via Y. Gagarin, 69/73 - 06070 S. Mariano di Corciano (PG) - Italy
Tel. (+39) 075.5170556 / 075.5179254 - Fax (+39) 075.5178146
info@sgmlaboratorio.com

VERONA (Italia)
Uffici e Laboratori certificati UNI EN ISO 9001
verona@sgmlaboratorio.com

MILANO (Italia)
Sede operativa

L’AQUILA (Italia)
Sede operativa

TRIPOLI (Libya)
Sede operativa

DUBAI (UAE)
Sede operativa

info@experimentations.it
www.experimentations.it