### GENERAL INFORMATION

**Index Building Taxonomy String:**

1. Main structural system: _____________________________
2. Height range: _____________________________ Low (LR) X
3. Seismic design level: _____________________________ Poor (PD) X
4. Diaphragm Type: _____________________________ Flexible (FD) X
5. Structural Irregularity: _____________________________ No (NI) X
6. Wall Panel Length: _____________________________ Short (SP) X
7. Wall Openings: _____________________________ Small (SO) X
8. Foundation Type and Flexibility: _____________________________ Flexible (FF) X
9. Seismic Pounding Risk: _____________________________ No (NP) X
10. Seismic Retrofitting: _____________________________ Original (OS) X
11. Structural Health Condition: _____________________________ Poor (PC) X
12. Non-Structural Components: _____________________________ Vulnerable (VN) X

### INTRINSIC CHARACTERISTICS

**General Geometry:**

- Building Plan Area (m²): 37
- Building Total Floor Area (m²): 37
- Number of Stories: 1
- Story Height (m): 2.3
- Number of Spans in X Direction: 4.5
- Number of Spans in Y Direction (m): 4
- Wall Thickness (mm): 420
- Wall Construction: Running Bond
- No. of Wythes: Two

**Material Properties of Masonry:**

- Unit Weight, γ (kg/m³): 2200
- Modulus of Elasticity, E (MPa): 240
- Shear Modulus, G (MPa): 96
- Compressive Strength, f'm (MPa): 1.8
- Cohesion, c (MPa): 0.048
- Tensile Strength, f_t (MPa): 0.048
- Friction Coefficient, µ: 0.5

### SEISMIC BEHAVIOR

- Seismic Weight of IP Walls (kN): 380
- Fundamental Time Period of IP Walls (sec): 0.29
- Seismic Weight of OOP Walls (kN): 380
- Fundamental Time Period of OOP Walls (sec): 0.31

### MODELLING PARAMETERS

#### 3D Model

**Modelling Consideration:**

- Numerical Model Type: 3-D Element-by-Element
- Masonry Modelling Approach: Simplified Micro-Modelling

**Loads:**

- Roof Dead Load (D) (kN/m²): 0.9
- Design Live Load (L) (kN/m²): 0.0
- Load Combination for Seismic Analysis: D+0.25L

**Analysis Considerations:**

- Global P-Delta Effects: Yes X No
- Analysis Direction: X X Y (+) (-) X

**Pushover Curve with Damage State Thresholds:**

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**Index Building in Mud Mortar (UCM-URM2):**

- Rubble Stone in Mud Mortar Masonry (UCM-URM2)
- Medium (MR) X Low (LD) X Medium (MD) X High (HD) X
- Horizontal (HI) X Long (LP) X Vertical (VI) X Both (HV) X
  - Vulnerable (VN) X Non Vulnerable (NN) X
### Damage (Crack Pattern, Width and Extent) Progression

<table>
<thead>
<tr>
<th>IP Wall Behavior</th>
<th>OOP Wall Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="IP Wall Behavior Image" /></td>
<td><img src="image2.png" alt="OOP Wall Behavior Image" /></td>
</tr>
<tr>
<td><strong>OP Threshold</strong>: Hairline cracks (blue) of maximum width 0.1 mm appeared at few corners of doors and windows and in some areas of the wall.</td>
<td><strong>OP Threshold</strong>: Hairline cracks (blue) appeared at the connection with the in plane walls. Max crack width 0.1 mm.</td>
</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>IO Threshold</strong>: Hairline to minor cracks (blue) of maximum width 0.5 mm developed at most of the corners of the openings, few piers and spandrels start to develop shear and flexural cracks, respectively.</td>
<td><strong>IO Threshold</strong>: Minor cracks (blue) start to extend upward at the IP connection, max crack width 1 mm.</td>
</tr>
<tr>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>LS Threshold</strong>: Left most pier starts to damage in flexure with major cracks (red) of 5 mm maximum width. Other piers also start to develop shear and flexural cracks.</td>
<td><strong>LS Threshold</strong>: Major cracks (red) of 4 mm maximum width at the IP walls connection at the bottom. A horizontal crack of maximum opening 1 mm at the bottom appears.</td>
</tr>
<tr>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>CP Threshold</strong>: Most piers and spandrels start to damage in shear/flexure with extensive crack (red) width of more than 5 mm.</td>
<td><strong>CP Threshold</strong>: Wall on the verge of collapse. Connection with the IP wall damaged with extensive cracks (red) of width more than 5 mm. Horizontal bottom crack (red) extends to full length with a maximum opening of 4 mm.</td>
</tr>
<tr>
<td><img src="image9.png" alt="Image" /></td>
<td><img src="image10.png" alt="Image" /></td>
</tr>
</tbody>
</table>
FRAGILITY/VULNERABILITY ASSESSMENT

RUBBLE STONE MASONRY IN MUD MORTAR INDEX BUILDING

SEISMIC PERFORMANCE ASSESSMENT

Analysis Considerations:
- Analysis Methodology: Static Analysis (N2 Method)
- Engineering Demand Parameter (EDP): Roof Drift

Seismic Ground Motions:
- Ground Motion Suite: FEMA P695 - 22 Far Field Ground Motions
- Intensity Measure (IM): PGA (g)
- Scaling Factor: 0.1
- Minimum IM: 0
- Maximum IM: 2g

Bilinear Idealization:

EDP Calculation:

FRAGILITY ASSESSMENT

Integration Methodology: Least Square Method

Fragility Functions:

<table>
<thead>
<tr>
<th>PGA</th>
<th>OP</th>
<th>IO</th>
<th>LS</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.01</td>
<td>0.09</td>
<td>0.13</td>
<td>0.38</td>
</tr>
<tr>
<td>1.5</td>
<td>0.28</td>
<td>0.29</td>
<td>0.47</td>
<td>0.74</td>
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</table>

<table>
<thead>
<tr>
<th>PGA</th>
<th>OP</th>
<th>IO</th>
<th>LS</th>
<th>CP</th>
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<tbody>
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<tr>
<td>1.5</td>
<td>0.30</td>
<td>0.30</td>
<td>0.39</td>
<td>0.82</td>
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IB3_LBM_UCM-URM2_LR_PD
VULNERABILITY ASSESSMENT

Damage to Loss Function:

<table>
<thead>
<tr>
<th>OP (%)</th>
<th>IO (%)</th>
<th>LS (%)</th>
<th>CP (%)</th>
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<tbody>
<tr>
<td>2</td>
<td>10</td>
<td>43.5</td>
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Vulnerability Function:

![Building Vulnerability Curve](image)

GLOSARY

<table>
<thead>
<tr>
<th>IP</th>
<th>OOP</th>
<th>OP</th>
<th>IO</th>
<th>LS</th>
<th>CP</th>
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<tbody>
<tr>
<td>In Plane</td>
<td>Out of Plane</td>
<td>Operational</td>
<td>Immediate Occupancy</td>
<td>Life Safety</td>
<td>Collapse Prevention</td>
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<tr>
<td>IM</td>
<td>EDP</td>
<td>ADRS</td>
<td>Sa</td>
<td>Sd</td>
<td>PGA</td>
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<td>Engineering Demand Parameter</td>
<td>Acceleration Displacement Response Spectra</td>
<td>Spectral Acceleration</td>
<td>Spectral Displacement</td>
<td>Peak Ground Acceleration</td>
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<td>Time (second)</td>
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<td>FUNVUL (<a href="http://www.ecapra.org">www.ecapra.org</a>)</td>
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