Application of High Strength Reinforcing Bars in Earthquake-Resistant Structure Elements

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Introduction

conventional

400 MPa

VS

cost-effective

500 MPa

POSITIVE

1. Reduce amount of Reinforcing Steel Bars
2. Saves material, delivery, placement cost
3. Eliminate reinforcing bars congestion

NEGATIVE

Higher DEMAND for Shear & Bond Stress

How bad is it?
Objective:

Study the use of high strength reinforcement steel bars by comparing the post-elastic behavior between reinforced concrete (R/C) with conventional reinforcing steel bar and R/C with high strength reinforcing steel bars.
BEAM COLUMN JOINT
Specimen D16-400N

Diameter (mm): 16
fy (MPa): 420
fc' (MPa): 30

Normal Strength Reinforcing Steel Bars

Specimen D16-500N

Diameter (mm): 16
fy (MPa): 520
fc' (MPa): 30

High Strength Reinforcing Steel Bars

Specimen D19-500N

Diameter (mm): 19
fy (MPa): 520
fc' (MPa): 30

High Strength Reinforcing Steel Bars
# Mechanical Properties

**All Specimens**

<table>
<thead>
<tr>
<th>Material</th>
<th>Sectional Area (mm²)</th>
<th>Yield Str. (MPa)</th>
<th>Tensile Str. (MPa)</th>
<th>Young Modulus (Gpa)</th>
<th>Compressive Str. (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D16-400N</td>
<td>201.06</td>
<td>434.1</td>
<td>577.4</td>
<td>198.1</td>
<td>31.0</td>
</tr>
<tr>
<td>D16-500N</td>
<td>201.06</td>
<td>485.2</td>
<td>630.9</td>
<td>207.9</td>
<td>32.7</td>
</tr>
<tr>
<td>D19-500N</td>
<td>283.53</td>
<td>503.9</td>
<td>674.9</td>
<td>195.7</td>
<td>31.7</td>
</tr>
</tbody>
</table>
Instrumentation
Loading Protocol
According to ACI 374.2
Experimental Results
Analysis 1:

*Hysteretic Curve & Backbone Curve*
**Hysteretic Curve**

*Normal Strength*

**D16-400N**

- **Yield (Analysis)**
- **Spalling (Analysis)**
- **Yield SG**
- **Spalling**
- **First Crack**

![Hysteretic Curve Diagram](image-url)
Hysteretic Curve
High Strength

D16-500N

- Yield (Analysis)
- Spalling (Analysis)
- Yield SG
- Spalling
- First Crack

D19-500N
Backbone
All Specimens

Peak
35.18% ↑

Force (kN)

Drift Ratio (%)
Analysis 2:  
Energy Dissipation
Normalized Energy Dissipation vs. Displacement Ratio for different specimens.

**Backbone**

**All Specimens**

- Slightly No Difference

**Displacement Ratio**

33% ↓
Analysis 3:

Deformability
## Deformability

*According to ASCE 7.10*

<table>
<thead>
<tr>
<th>Specimen</th>
<th>$\delta_{\text{limit}}$ (mm)</th>
<th>$\delta_{\text{ultimit}}$ (mm)</th>
<th>Deformability</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>D16-400N</td>
<td>16.689</td>
<td>83.045</td>
<td>4.976</td>
<td>High</td>
</tr>
<tr>
<td>D16-500N</td>
<td>28.361</td>
<td>133.828</td>
<td>4.719</td>
<td>High</td>
</tr>
<tr>
<td>D19-500N</td>
<td>29.989</td>
<td>104.157</td>
<td>3.473</td>
<td>Limited</td>
</tr>
</tbody>
</table>


Analysis 4:  

**Stiffness**
Stiffness (Peak-to-Peak, Normalized by Initial Stiffness)

- D16-400N
- D16-500N
- D19-500N
Conclusions
Conclusions

1. Normalized energy dissipation for all specimens is relatively the same, but specimens with high strength reinforcing bars have smaller displacement ratio than that of specimens with normal strength reinforcing bars.

2. Specimens with high strength reinforcing bars tend to have smaller deformability than that of specimen with normal strength reinforcing bars.

3. Specimens with high strength reinforcing bars tend to have smaller stiffness degradation than normal strength reinforcing bars.

4. High strength reinforcing bars can be used as alternative for earthquake-resistant building.
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THANK YOU

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