REHABILITATION and RETROFIT of EXISTING STEEL STRUCTURES

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RESOURCES
Chapter 34 provides information related to Existing Buildings and Structures.
Appendix 5 provides information related to Evaluation of Existing Structures.
RESOURCES
WELDING TO EXIST. STRUCTURES

• Field Welding to Existing Steel Structures - Ricker – EJ 1st Qtr. 1988
• Welding to Existing Structures - Garlich, - 2000 NASCC
• Reinforcing Steel Members and the Effects of Welding - Tide – EJ 4th Qtr. 1990
• AISC Design Guide 15 - Rehabilitation and Retrofit Guide
• AISC Design Guide 21 - Welded Connections
RESOURCES
HEAT STRAIGHTENING

• What You Should Know About Heat Straightening Repair of Damaged Steel – Avent and Mukai – EJ 1st Qtr. 2001
RESOURCES
STRENGTHENING

• Reinforcing of Steel Joist - Fisher – 2004 NASCC
• The Reinforcement of Steel Columns - Tall – EJ 1st Qtr. 1989
• Reinforcing Steel Members and the Effects of Welding - Tide – EJ 4th Qtr. 1990
MATERIAL PROPERTIES
MATERIAL PROPERTIES TESTING

Acceptable Sources:

- Certified material test reports
  - ASTM A6 or A568

- Bolt Markings
## MATERIAL PROPERTIES TESTING

### Bolt Head Markings:

<table>
<thead>
<tr>
<th>Material</th>
<th>Diagram</th>
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<tbody>
<tr>
<td>A307</td>
<td><img src="image1" alt="A307 Diagram" /></td>
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<tr>
<td>A325</td>
<td><img src="image2" alt="A325 Diagram" /></td>
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<tr>
<td>A490</td>
<td><img src="image5" alt="A490 Diagram" /></td>
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<tr>
<td>A449</td>
<td><img src="image7" alt="A449 Diagram" /></td>
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</tbody>
</table>
MATERIAL PROPERTIES
TESTING

Tests:

• ASTM A370 – tensile tests
• ASTM A751 – chemical composition
  – Welding
• Charpy V-notch toughness
  – tension splices in heavy shapes
• ASTM F606 - Bolts
Acceptable Assumptions:

• Bolts – A307
• Rivets - ASTM A502, Grade 1
MATERIAL PROPERTIES
TESTING

Strength of Existing Welds

• Chemical analyses
• Mechanical tests
• Magnitude and consequences of imperfections
DIMENSIONAL DATA

Obtained from:

• Design or shop drawings - Analysis
  – verify critical dimensions

• Field Survey – A must for construction
WELDING
Easy Fixes:
• Check actual leg size
• Directional strength increase
• Try inelastic design
WELDING

Considerations:

• Combustion
• Reduction in Properties
• Weldability
WELDING

Combustion (You may start a fire)
• Welding itself
• Preheating torches
• Circuit – work lead should be attached as close as possible to area being welded.
WELDING

Reduction in Properties

- Loss of strength and stiffness as steel is heated
- Negligible loss to about 650 °F – Welding interpass temperature should not generally exceed 550 °F
- Small portion experiences reduction at a time
WELDING

Only a small area experiences reduction at a time

Temperature

Distance from weld from Lambert Tall

4x1/2 PI Edge Weld

time = 0

time = 25s

time = 50s
WELDING

Reduction in Properties
• Welding parallel to stress preferred over transverse – effects less of cross-section
WELDING

Weldability

• Representative chemistry
• Simple field tests
WELDING

Weldability - Cast iron

• Should not be structurally welded
• Cosmetic welding okay
WELDING

Weldability - ASTM - A7

• 1900-1967
• must be evaluated on a case-by-case basis
• late 1950s+ historically weldability was good
WELDING

Weldability - ASTM – A9

- 1900-1939
- must be evaluated on a case-by-case basis
- Only existed prior to popular welding
WELDING

Weldability - ASTM – A373

• 1958-1965
• Generally good weldability
WELDING

Weldability - ASTM – A242

- 1963-Current
- Weathering Steel
- No limit of phosphorous
- Not prequalified
THERMAL CUTTING
THERMAL CUTTING

- Shoring recommended
- Care needed especially for tension members
BOLTING

Easy Fixes:

• Are bolts designed as SC but can be bearing?
• Are bolts designed as N but really X?
• Substitute A490s for A325s
• End-loading?
BOLTING

New Holes:
• Black A325 bolts can be reused
• Spec. Part M allows thermal cutting of holes - Intended for shop plasma cuts
• Magnetic drill
BOLTS & WELDS COMBINED
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• Generally it is a bad idea to combine the strengths of bolts and welds
• When making alterations can be combined:
  – SC connections can resist existing load.
BOLTS & WELDS COMBINED

Bolt - Weld Compatibility

- 7/8" A325-X
- (2)-5/16" Welds 3" Long

Force, kips

Deformation, in.
OTHER COMPATIBILITY ISSUES
OTHER COMPATIBILITY ISSUES

Though the Spec. only addresses compatibility of welds and bolts, compatibility must be considered in many retrofit situations.
OTHER COMPATIBILITY ISSUES

The beam reaction has increased.
OTHER COMPATIBILITY ISSUES

One commonly proposed solution is to add a seat designed to carry the additional load.
OTHER COMPATIBILITY ISSUES

NEW SEAT REQUIRES SIGNIFICANT DEFORMATION TO PICK UP LOAD
OTHER COMPATIBILITY ISSUES

EXISTING SHEAR TAB WILL BE STIFFER AND WILL CARRY MOST OF THE LOAD
A haunch provides a more compatible solution.
STRENGTHENING
FLOORS
STRENGTHENING FLOORS

1. Add intermediate support
2. Inserting new beams, parallel to the existing ones
3. Add steel reinforcement to bottom flanges of existing beams
4. Add pre-tensioned steel cables to beams
5. Add shear connectors.
Add steel reinforcement to bottom flanges of existing beams.
STRENGTHENING FLOORS

Pre-tensioned steel cables to beam
STRENGTHENING FLOORS

Add shear connectors

• Cored holes of a diameter sufficient to allow stud placement and grouting.
• Shrink-compensating grout with strength at least equal to the existing slab.
• The strength of the resulting beam is independent of the initial load present.
Generally the strength of the reinforced beam is assumed to be the same whether the existing load is removed (supported) during reinforcement or left in place.
Steel is ductile and will redistribute stress to maximize the strength of the section.
This redistribution will involve plastic deformation of some elements of the section.
This plastic redistribution will not adversely affect strength, but does have to be taken into account when evaluating deflections.
Texts on Plastic Methods provide procedures to calculate deflections of yielded members, but it is common to instead remove all or some of the load during reinforcing when deflections are a concern.
REINFORCING COLUMNS
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Two schools of thought concerning reinforcing columns under load:

1. The strength is the same as an unloaded reinforced column – Lambert (EJ 1989), Tide (EJ 1990)

2. The strength of the reinforcement is limited due to the stress already present in the existing column – Brown (EJ 1988), Ricker (EJ 1988)
I believe there is ample evidence to assume that the strength of a column reinforced under load is identical to the strength of a column reinforced without load.

In practice the loaded case may have somewhat greater strength due to the realignment of residual strength.
A tapered column will have nearly the same strength as a prismatic column.

Reinforcing can often be terminated clear of the connections.
REINFORCING COLUMNS

A practical approach to the non-prismatic column strength can be found in:

QUESTIONS???

THE STEEL SOLUTIONS CENTER

www.AISC.org

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