

Accommodating Deterioration In Load Rating Analysis

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Load Rating For Deterioration

- **Rating Elements To Discuss**
 - Steel Beams
 - Reinforced Concrete Beams and Slabs
 - Prestressed Concrete Beams
 - Trusses
 - Substructures
 - Concrete Bridge Decks
 - Other??



Load Rating For Deterioration

○ Steel Beams

- Section Loss of Tension Flange
 - Input loss of thickness in BrR
- Section Loss of Compression Flange
 - Input loss of thickness in BrR
- Crack in Flange
 - Options
- Collision Damage of Flange / Web



Load Rating For Deterioration

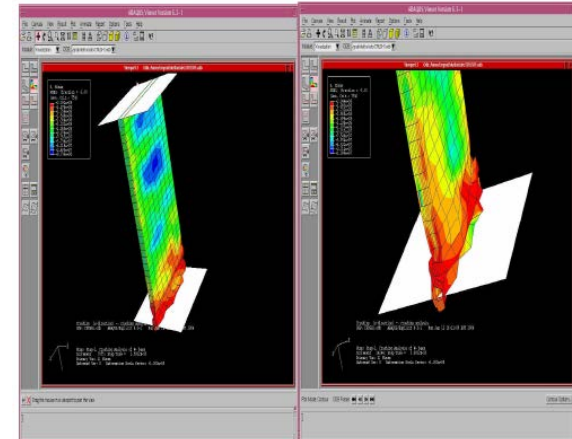
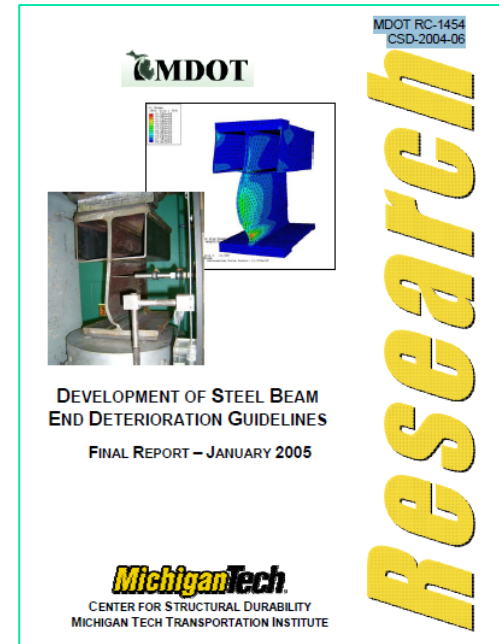
- **Steel Beams**

- Section Loss of Web

- Input loss of thickness in BrR as average web thickness

- MDOT RC 1454 (Michigan Tech Study)

- Provides tables correlating web loss to residual capacity for W-Beams



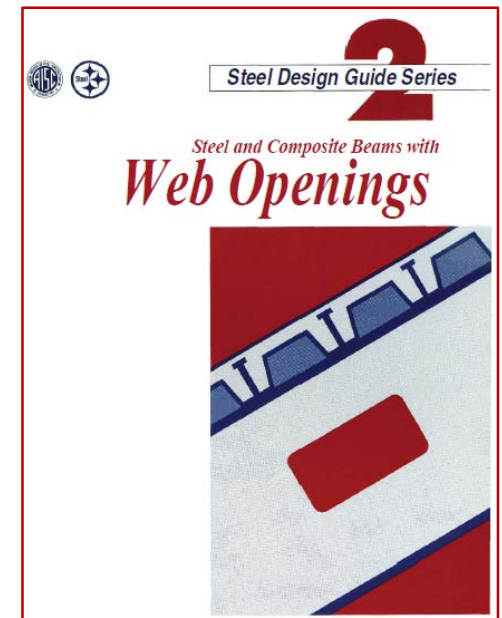
Load Rating For Deterioration

- **Steel Beams**

- Holes in Web

- Input reduced average web in BrR

- AISC Design Guide 2 (Dr. David Darwin, Univ. of Kansas)



Load Rating For Deterioration

- **Reinforced Concrete Beams and Slabs**
 - Spalling / reinforcing section loss
 - Reduce area of reinforcing based on section loss
 - Concrete Deterioration in Compression Zone
 - Testing
 - Reduce compressive strength in BrR
 - Use Condition Reduction Factors from MBE



Load Rating For Deterioration

- **Prestressed Concrete Beams**
 - P/S Box Beams
 - Exposed Strands
 - Remove visible and adjacent strands
 - Top Flange Concrete Deterioration
 - Testing
 - Reduce compressive strength in BrR
 - Use Condition Reduction Factors from MBE
 - Cracked Bottom Flange due to Ice expansion inside void



Load Rating For Deterioration

○ Trusses

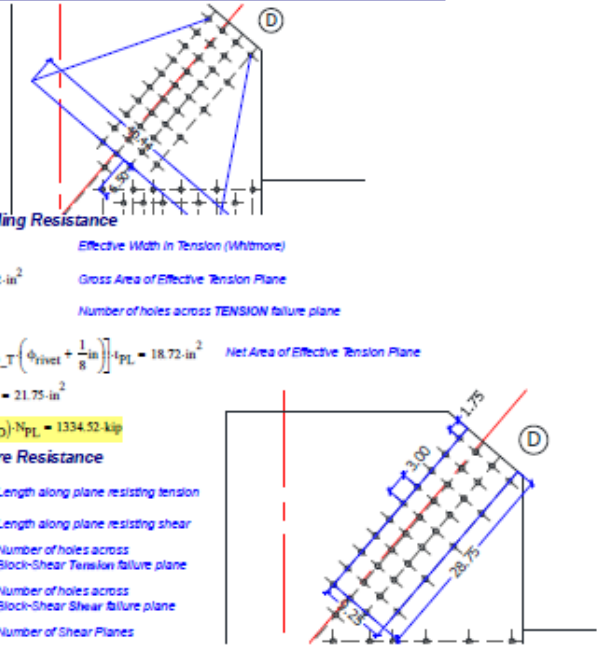
- Tension Member Section Loss
 - Input Reduced Member Capacity in BrR
- Compression Member Section Loss
 - Input Reduced Member Capacity in BrR
- Compression Member Distortion
 - Thresholds for reduction
- Rivet Head Section Loss



Load Rating For Deterioration

- Trusses
 - Gusset Plate Deterioration
 - Calculate Capacity Reduction
 - Input Capacity in BrR

IFR: CHECK TENSION RESISTANCE OF GUSSET PLATE (Member D)



Gross Section Yielding Resistance

$L_{wD} = 40.44$ in Effective Width in Tension (Witmore)

$A_{gD} = L_{wD} \cdot t_{PL} = 20.22$ in² Gross Area of Effective Tension Plane

$N_{holesD_T} = 3$ Number of holes across TENSION failure plane

$A_{nD} = [L_{wD} - N_{holesD_T} \left(\phi_{rivet} + \frac{1}{8} \right)] t_{PL} = 18.72$ in² Net Area of Effective Tension Plane

$A_{eD} = A_{nD} + 0.15 \cdot A_{gD} = 21.75$ in²

$P_{r_D} = F_y \cdot \min(A_{eD}, A_{gD}) \cdot N_{PL} = 1334.52$ kip

Block Shear Rupture Resistance

$L_{tD} = 9.25$ in Length along plane resisting tension

$L_{vD} = 28.75$ in Length along plane resisting shear

$N_{holesD_Tbs} = 2.5$ Number of holes across Block-Shear Tension failure plane

$N_{holesD_Vbs} = 9.5$ Number of holes across Block-Shear Shear failure plane

$N_{vp_D} = 2$ Number of Shear Planes

$A_{nD} = t_{PL} \left[L_{tD} - N_{holesD_Tbs} \left(\phi_{rivet} + \frac{1}{8} \right) \right] = 3.38$ in²

$A_{vD} = N_{vp_D} \cdot t_{PL} \left[L_{vD} - N_{holesD_Vbs} \left(\phi_{rivet} + \frac{1}{8} \right) \right] = 19.25$ in²

$A_{gD} = t_{PL} \cdot L_{tD} = 4.62$ in²

$A_{vD} = N_{vp_D} \cdot t_{PL} \cdot L_{vD} = 28.75$ in²

$0.58 \cdot A_{vD} = 11.16$ in²

$R_{r_D} = \min \left[A_{nD} > 0.58 \cdot A_{vD}, 0.85 \cdot (0.58 \cdot F_y \cdot A_{vD} + F_u \cdot A_{nD}), 0.85 \cdot (0.58 \cdot F_u \cdot A_{vD} + F_y \cdot A_{gD}) \right] \cdot N_{PL} = 1398.29$ kip

Load Rating For Deterioration

- **Miscellaneous Items**
 - Concrete Bridge Deck

- Substructure
 - Loss of Bearing Area
 - Exposed Pile Deterioration



Load Rating For Deterioration

- **Outstanding Issues**

- Lack of Codified Guidance

- Design Code and MBE vs Analytical Methods for Natural Deterioration

- Research Needs

