March 8, 2011

Chuck Wilson
Manager
ICF Construction LLC

Dear Chuck:

Attached are engineering calculations for alternative designs using Helix rather than rebar in the ICF walls, retaining walls and footings designs you sent. This letter contains all the required calculations and supporting data. The side-by-side calculations show the advantages of using Helix versus rebar for 1) Peak strength, and 2) Bending Strength. Each sheet also shows the Helix dosage required to replace the currently specified rebar.

Dowels are still required at cold joints. Lintel reinforcement could be removed by applying a higher dosage of Helix, keeping this reinforcement and a lower dosage of Helix in the rest of the structure provides a more economical solution.

The details of the calculations are attached and an added resistance factor has been added to assure a conservative design. Please contact me with any questions you may have at 734-322-2114 x 60 or luke@helixsteel.com.

Sincerely,

Luke R Pinkerton

Luke Pinkerton, PE

Enclosure:

Side-by-Side Summary Calculations
Sample Calculation Details

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# Side By Side Performance – US Units

| | |
|---|---|
| Date: | Mar 8, 2011 |
| Project Name: | House where 6” wall Required |

| Input | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 6” wall with #5@18” Vertical ,#5@24” Horizontal | 6” wall 22.5 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 6 | 6 |
| Helix Dosage, Dos | $lb/yd^3$ | | **22.5** |
| Helix Resistance Factor | | | 0.72 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | $in^2$ | 0.310 | |
| Spacing, s (non zero) | in | 18 | |
| Depth, d | in | 4 | |
| Number of Layers | | 1 | |
| Yield Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| Output | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **43.1** | **44.0** |
| Percent Increase | | | 2% |
| **First Crack Strength** | **kip-in** | **37.8** | **48.8** |
| Percent Increase | | | 29% |
| **Durability** | **lb-in** | **234** | **818** |
| Percent Increase | | | 249% |
| **Shear Strength** | **kip** | **7.7** | **13.0** |
| Percent Increase | | | 67% |

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## Side By Side Performance – US Units

Date: Mar 8, 2011

Project Name: House where 8” wall Required

| **Input** | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 8” wall with #5@18” Vertical , 2#4@24” Horizontal | 8” wall 15 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 8 | 8 |
| Helix Dosage, Dos | $lb/yd^3$ | | **15** |
| Helix Resistance Factor | | | 0.72 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | $in^2$ | 0.400 | |
| Spacing, s (non zero) | in | 24 | |
| Depth, d | in | 4 | |
| Number of Layers | | 1 | |
| Yield Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| **Output** | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **41.8** | **57.2** |
| Percent Increase | | | 37% |
| **First Crack Strength** | **kip-in** | **67.2** | **80.8** |
| Percent Increase | | | 20% |
| **Durability** | **lb-in** | **242** | **1061** |
| Percent Increase | | | 338% |
| **Shear Strength** | **kip** | **10.3** | **16.9** |
| Percent Increase | | | 64% |

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## Side By Side Performance – US Units

Date: Mar 8, 2011

Project Name: Retaining Wall 100 PSF 2

| **Input** | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 8” wall with #5@15” Vertical , #4@10” Horizontal | 8” wall 22.5 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 8 | 8 |
| Helix Dosage, Dos | lb/yd$^3$ | | **22.5** |
| Helix Resistance Factor | | | 0.72 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | in$^2$ | 0.310 | |
| Spacing, s (non zero) | in | 15 | |
| Depth, d | in | 5.69 | |
| Number of Layers | | 1 | |
| Yield Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| **Output** | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **74.0** | **78.2** |
| Percent Increase | | | 6% |
| **First Crack Strength** | **kip-in** | **67.2** | **86.8** |
| Percent Increase | | | 29% |
| **Durability** | **lb-in** | **403** | **1455** |
| Percent Increase | | | 261% |
| **Shear Strength** | **kip** | **10.3** | **17.3** |
| Percent Increase | | | 67% |

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# Side By Side Performance – US Units

Date: Mar 8, 2011

Project Name: Retaining Wall 100 PSF 1

| **Input** | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 8" wall with #4@18" Vertical , #4@10" Horizontal | 8" wall 18 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 8 | 8 |
| Helix Dosage, Dos | $lb/yd^3$ | | **18** |
| Helix Resistance Factor | | | 0.72 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | $in^2$ | 0.200 | |
| Spacing, s (non zero) | in | 12 | |
| Depth, d | in | 5.69 | |
| Number of Layers | | 1 | |
| Yield Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| **Output** | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **60.0** | **65.6** |
| Percent Increase | | | 9% |
| **First Crack Strength** | **kip-in** | **67.2** | **83.2** |
| Percent Increase | | | 24% |
| **Durability** | **lb-in** | **334** | **1219** |
| Percent Increase | | | 265% |
| **Shear Strength** | **kip** | **10.3** | **17.0** |
| Percent Increase | | | 65% |

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## Side By Side Performance – US Units

| | |
|---|---|
| Date: | Mar 8, 2011 |
| Project Name: | Retaining Wall No Surcharge 7 |

| **Input** | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 8" wall with #6@6" Vertical , #4@10" Horizontal | 8" wall 65 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 8 | 8 |
| Helix Dosage, Dos | $lb/yd^3$ | | **65** |
| Helix Resistance Factor | | | 0.9 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | $in^2$ | 0.440 | |
| Spacing, s (non zero) | in | 6 | |
| Depth, d | in | 5.5 | |
| Number of Layers | | 1 | |
| Yield Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| **Output** | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **233.7** | **240.6** |
| Percent Increase | | | 3% |
| **First Crack Strength** | **kip-in** | **67.2** | **120.6** |
| Percent Increase | | | 79% |
| **Durability** | **lb-in** | **1202** | **3688** |
| Percent Increase | | | 207% |
| **Shear Strength** | **kip** | **10.3** | **19.4** |
| Percent Increase | | | 88% |

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## Side By Side Performance – US Units

Date: Mar 8, 2011

Project Name: Retaining Wall No Surcharge 6

| **Input** | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 8” wall with #6@9” Vertical , #4@10” Horizontal | 8” wall 45 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 8 | 8 |
| Helix Dosage, Dos | $lb/yd^3$ | | **45** |
| Helix Resistance Factor | | | 0.9 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | $in^2$ | 0.440 | |
| Spacing, s (non zero) | in | 9 | |
| Depth, d | in | 5.69 | |
| Number of Layers | | 1 | |
| Yield Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| **Output** | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **167.9** | **174.6** |
| Percent Increase | | | 4% |
| **First Crack Strength** | **kip-in** | **67.2** | **104.7** |
| Percent Increase | | | 56% |
| **Durability** | **lb-in** | **873** | **2637** |
| Percent Increase | | | 202% |
| **Shear Strength** | **kip** | **10.3** | **18.4** |
| Percent Increase | | | 78% |

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## Side By Side Performance – US Units

Date: Mar 8, 2011

Project Name: Retaining Wall No Surcharge 5

| **Input** | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 8” wall with #5@10” Vertical , #4@10” Horizontal | 8” wall 30 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 8 | 8 |
| Helix Dosage, Dos | $lb/yd^3$ | | **30** |
| Helix Resistance Factor | | | 0.9 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | $in^2$ | 0.310 | |
| Spacing, s (non zero) | in | 10 | |
| Depth, d | in | 5.69 | |
| Number of Layers | | 1 | |
| Yield  Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| **Output** | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **109.3** | **123.5** |
| Percent Increase | | | 13% |
| **First Crack Strength** | **kip-in** | **67.2** | **92.8** |
| Percent Increase | | | 38% |
| **Durability** | **lb-in** | **580** | **1849** |
| Percent Increase | | | 219% |
| **Shear Strength** | **kip** | **10.3** | **17.6** |
| Percent Increase | | | 71% |

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## Side By Side Performance – US Units

Date: Mar 8, 2011

Project Name: Retaining Wall No Surcharge 4

| **Input** | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 8” wall with #5@14” Vertical , #4@10” Horizontal | 8” wall 25 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 8 | 8 |
| Helix Dosage, Dos | $lb/yd^3$ | | **25** |
| Helix Resistance Factor | | | 0.72 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | $in^2$ | 0.310 | |
| Spacing, s (non zero) | in | 14 | |
| Depth, d | in | 5.69 | |
| Number of Layers | | 1 | |
| Yield Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| **Output** | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **79.1** | **85.2** |
| Percent Increase | | | 8% |
| **First Crack Strength** | **kip-in** | **67.2** | **88.8** |
| Percent Increase | | | 32% |
| **Durability** | **lb-in** | **429** | **1586** |
| Percent Increase | | | 270% |
| **Shear Strength** | **kip** | **10.3** | **17.4** |
| Percent Increase | | | 69% |

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## Side By Side Performance – US Units

Date: Mar 8, 2011

Project Name: Retaining Wall No Surcharge 3

| **Input** | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 8” wall with #5@16” Vertical , #4@10” Horizontal | 8” wall 20 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 8 | 8 |
| Helix Dosage, Dos | $lb/yd^3$ | | **20** |
| Helix Resistance Factor | | | 0.72 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | $in^2$ | 0.310 | |
| Spacing, s (non zero) | in | 16 | |
| Depth, d | in | 5.69 | |
| Number of Layers | | 1 | |
| Yield  Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| **Output** | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **69.5** | **71.2** |
| Percent Increase | | | 2% |
| **First Crack Strength** | **kip-in** | **67.2** | **84.8** |
| Percent Increase | | | 26% |
| **Durability** | **lb-in** | **381** | **1324** |
| Percent Increase | | | 247% |
| **Shear Strength** | **kip** | **10.3** | **17.1** |
| Percent Increase | | | 66% |

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## Side By Side Performance – US Units

Date: Mar 8, 2011

Project Name: Retaining Wall No Surcharge 1-2

| **Input** | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 8" wall with #4@18" Vertical , #4@10" Horizontal | 8" wall 18 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 8 | 8 |
| Helix Dosage, Dos | $lb/yd^3$ | | **18** |
| Helix Resistance Factor | | | 0.72 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | $in^2$ | 0.200 | |
| Spacing, s (non zero) | in | 12 | |
| Depth, d | in | 5.69 | |
| Number of Layers | | 1 | |
| Yield Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| **Output** | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **60.0** | **65.6** |
| Percent Increase | | | 9% |
| **First Crack Strength** | **kip-in** | **67.2** | **83.2** |
| Percent Increase | | | 24% |
| **Durability** | **lb-in** | **334** | **1219** |
| Percent Increase | | | 265% |
| **Shear Strength** | **kip** | **10.3** | **17.0** |
| Percent Increase | | | 65% |

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## Side By Side Performance – US Units

| | |
|---|---|
| Date: | Mar 8, 2011 |
| Project Name: | 10” Footing |

| **Input** | | Rebar/Mesh | Design 1 |
|---|---|---|---|
| Case Description | | 10” footing with #4@12 EW | 10” wall with 18 lb/yd Helix |
| Iterative Design Factors | | | |
| Section Thickness, h | in | 10 | 10 |
| Helix Dosage, Dos | $lb/yd^3$ | | **18** |
| Helix Resistance Factor | | | 0.72 |
| Concrete Strength,f'c | psi | 4000 | 4000 |
| Rebar/Mesh Input | | | |
| Type | | | |
| Cross Section Area, $a_b$ | $in^2$ | 0.200 | |
| Spacing, s (non zero) | in | 12 | |
| Depth, d | in | 9 | |
| Number of Layers | | 1 | |
| Yield Strength, fy | psi | 60000 | |
| Resistance Factor | | 0.9 | |
| Section Width, b | in | 12 | 12 |

| **Output** | | | |
|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **95.8** | **102.5** |
| Percent Increase | | | 7% |
| **First Crack Strength** | **kip-in** | **105.0** | **130.0** |
| Percent Increase | | | 24% |
| **Durability** | **lb-in** | **531** | **1904** |
| Percent Increase | | | 258% |
| **Shear Strength** | **kip** | **12.9** | **21.3** |
| Percent Increase | | | 65% |

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## Side By Side Performance – US Units

| | |
|---|---|
| Date: | Mar 8, 2011 |
| Project Name: | 8” Wall |

| **Input** | | Rebar/Mesh | Design 1 | Design 2 |
|---|---|---|---|---|
| Case Description | | 8” wall with #4@12 Vertical & 2#4 @24 Horizontal | 8” wall with 15 lb/yd Helix | |
| Iterative Design Factors | | | | |
| Section Thickness, h | in | 8 | 8 | 8 |
| Helix Dosage, Dos | lb/yd³ | | **15** | **30** |
| Helix Resistance Factor | | | 0.72 | 0.63 |
| Concrete Strength,f'c | psi | 4000 | 4000 | 4000 |
| Rebar/Mesh Input | | | | |
| Type | | | | |
| Cross Section Area, $a_b$ | in² | 0.200 | | 0.2 |
| Spacing, s (non zero) | in | 12 | | 12 |
| Depth, d | in | 4 | | 2 |
| Number of Layers | | 1 | | 1 |
| Yield  Strength, fy | psi | 60000 | | 60000 |
| Resistance Factor | | 0.9 | | 0.9 |
| Section Width, b | in | 12 | 12 | 12 |

| **Output** | | | | |
|---|---|---|---|---|
| **Bending Moment Capacity** | **kip-in** | **41.8** | **57.2** | **96.7** |
| Percent Increase | | | 37% | 132% |
| **First Crack Strength** | **kip-in** | **67.2** | **80.8** | **92.8** |
| Percent Increase | | | 20% | 38% |
| **Durability** | **lb-in** | **242** | **1061** | **1849** |
| Percent Increase | | | 338% | 663% |
| **Shear Strength** | **kip** | **10.3** | **17.8** | **19.3** |
| Percent Increase | | | 73% | 87% |

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# Rebar / Mesh Strength and Durability

Calculated using internationally recognized standards ACI 318-08

Concrete Input

| | | | | |
|---|---|---|---|---|
| Section Thickness, h | 8 | in | | |
| Section Width, b | 12 | in | | |
| Concrete Strength, $f'_c$ | 3000 | psi | | |

Rebar/Mesh Input

| | | | | |
|---|---|---|---|---|
| Rebar Mesh Type: | #4@12 | | | |
| | Flexural | | Shear | |
| Cross Section Area, $a_b$ / $a_{sv}$ | 0.200 | $in^2$ | | $in^2$ |
| Spacing, s / $s_v$ | 12 | in | | in |
| Depth, d | 4 | in | | |
| Number of Layers, nl | 1 | | | |
| Steel Strength, $f_y$ / $f_{yv}$ | 60000 | psi | | psi |
| Steel Resistance Factor, φ / $φ_v$ | 0.9 | | | |

Calculations

| | | | |
|---|---|---|---|
| Equivalent Steel Area, $a_s$ | 0.2 | $in^2$ | $a_s = a_b \times b / s$ |
| Factored Yield Strength, φ $f_y$ | 54000 | psi | $\varphi f_y = \varphi \times f_y$ |
| Stress Block Constant, β | 0.90 | | $\beta = 1.05 – 0.05 F'_c/1000$ |
| Neutral Axis Depth, c | 0.4 | in | $c = ( a_s \times \varphi f_y) / (0.85 F'_c \times b \times \beta)$ |
| Stress Block Depth, a | 0.35 | in | a=β x c |
| Concrete Compression | 10.8 | kip | $Cc=0.85 \times f'_c \times (b \times a) / 1000$ |
| Rebar/Mesh Tension | 10.8 | kip | $Ts=a_s \times \varphi f_y / 1000$ |

| | | | |
|---|---|---|---|
| **Bending Moment Capacity, $M_n$** | **41.3** | **kip-in** | $M_n$ = Cc x (d-a/2)/1000 x (1.05 for 2 layer<br>if $a_s$ = 0 then a is set to zero |
| **Durability, D** | **236** | **lb-in** | $D = (0.002 \times bh^2/12*8.3\sqrt{f'c})/2$<br>$+(0.08 \times 0.5 \times Mn/4 \times 1000 )/2$ |
| **Shear Strength, $V_n$** | **10.3** | **kip** | Vn =b x h 2 √f'c + asv x fyv/1000 x (h-d)/s |
| **First Crack Strength, MOR** | **58** | **kip-in** | $MOR = b \times h^2 \times 8.3\sqrt{f'c} / 6 / 1000$ |

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# Helix Strength and Durability

Calculated using internationally recognized standards - JSCE SF-4, JSCE SF-6, ACI 318-08

| | | | |
|---|---|---|---|
| **Inputs** | | | |
| Helix Dosage | 15 | lb/yd³ | *iterative* |
| Section Thickness, h | 8 | in | *iterative* |
| Compressive Strength, $F'_c$ | 4000 | psi | *specified* |
| Helix Safety factor, $H_\varphi$ | 0.72 | | *Polytorx ANOVA* |
| Width, b | 12.0 | in | *specified* |
| **Helix Properties (see page 4)** | | | |
| Residual Strength, $H_{F'_e}$ | 207.2 | psi | *JSCE SF-4* |
| Factored Residual Strength, $fH_{F'_e}$ | 149.2 | psi | $fH_{F'_e} = H_{F'_e} \times H_\varphi$ |
| Shear Strength, $H_V$ | 108.69 | psi | *JSCE SF-6* |
| Durability, $H_D$ | 88.4 | lb-in | *JSCE SF-4* |
| First Crack Strength, $H_{MOR}$ | 631.6 | psi | *JSCE SF-4* |
| **Calculations** | | | |
| Section Area, $a_g$ | 96 | in3 | $a_g = h \times b$ |
| Stress Block Constant, β | 0.85 | | $B = 1.05 – 0.05\ F'_c/1000$ |
| Neutral Axis Depth, c | 0.4 | in | $c=( fH_{F'_e} \times b \times h) / (0.85\ F'_c \times b \times \beta + fH_{F'_e} \times b)$ |
| Stress Block Depth, a | 0.33 | in | $a=\beta \times c$ |
| Concrete Compression, Cc | 14 | kip | $Cc=0.85 \times f'_c \times (b \times a) / 1000$ |
| Helix Tension, $T_h$ | 14 | kip | $T_h = fH_{F'_e} \times (h – c) \times b / 1000$ |

| | | | |
|---|---|---|---|
| **Bending Moment Capacity, $M_n$** | **57.2** | **kip-in** | $M_n = T_h \times (h – (h – c)/2)$ |
| Increase | **38%** | | |

| | | | |
|---|---|---|---|
| **Durability, D** | **1,061** | **lb-in** | $D = H_d \times (b/4in) \times (h/4in)^2$ |
| Increase | **350%** | | |

| | | | |
|---|---|---|---|
| **Shear Strength, $V_n$** | **17.8** | **kip** | $Vn = b \times h\ (2 \sqrt{f'c} + Phi \times Hv)$ |
| Increase | **73%** | | |

| | | | |
|---|---|---|---|
| **First Crack Strength, MOR** | **80.8** | **kip-in** | $MOR = b \times h^2 \times H_{MOR} / 6 / 1000$ |
| Increase | **39%** | | |