ACI 318-19 Updates

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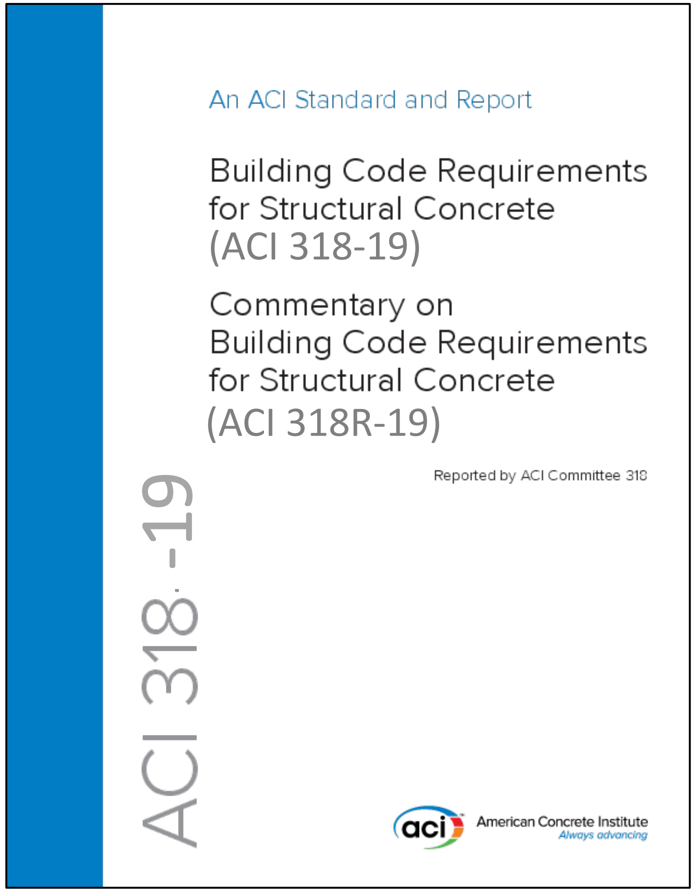
Always advancing



with thanks to Diego de Bedout and Prof. J.K. Wight

Disclaimer

The views expressed herein are based on those of the author and do not necessarily reflect those of the organization. The author drew information from the ACI 318-19 updates from the public comment version of the ACI 318-19 document.

ACI 318-19 Updates

- Introduction of high-strength reinforcement
- Modification of development length provisions
- Modification of hooked/headed bar provisions
- Simplified shear provisions for nonprestressed reinforcement
- Introduction of screw anchors and shear lugs
- Introduction of shotcrete provisions
- Extensive addition to foundations…

High-strength reinforcement

f_y = 80,000psi→100,000psi

- New definition of tension controlled limit, ε_t
- Modification of development length provisions to include a new Grade Factor ψ_g for high-strength steel
- Modification of hooked and headed bar develop length provisions for all grades of steel

New definition of ε_t associated with tension controlled limit (tcl)

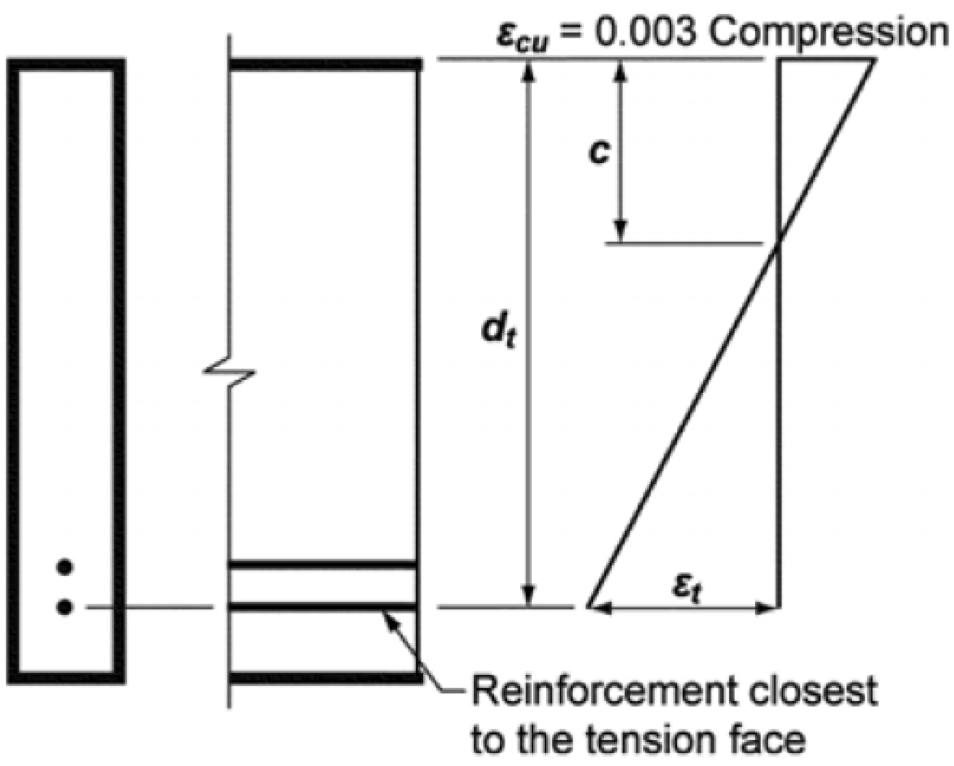


Figure 1 - Strain distribution and net tensile strain, ε_t, in a nonprestressed member.

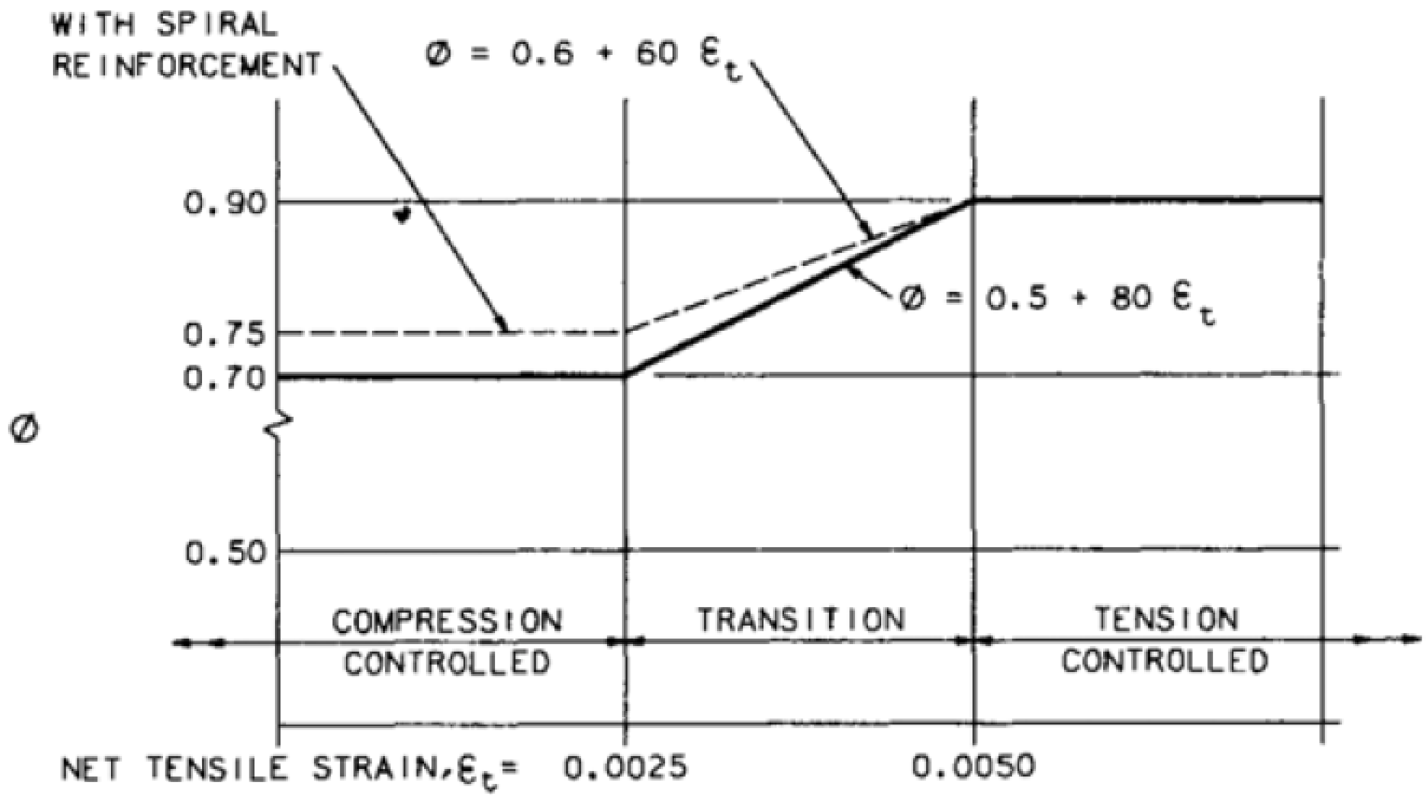


Figure 2 - Variation of ϕ with ε_t, from Mast (1992).

New definition of ε_t associated with tension controlled limit (tcl)

f_y = 80,000psi→100,000psi

- New definition of tension controlled limit, ε_t

Prior to 2019…

$\cancel{\varepsilon_t \geq 0.005}$ (for GR 60 this was equivalent to ε_{ty}+0.003)

In 2019…

$\varepsilon_t \geq (\varepsilon_{ty}+0.003)$ defines the limit on ε_t for tension-controlled behavior in Table 21.2.2 (based on Mast 1992)

New definition of ε_t associated with tension controlled limit (tcl)

f_y = 80,000psi→100,000psi

- New definition of tension controlled limit, ε_t

Prior to 2019…

~~$\varepsilon_t \geq 0.005$~~ (for GR 60 this was equivalent to ε_{ty}+0.003)

In 2019…

$\varepsilon_t \geq (\varepsilon_{ty}+0.003)$

GR 60 $\varepsilon_t \geq 0.00507$

GR 80 $\varepsilon_t \geq 0.00576$

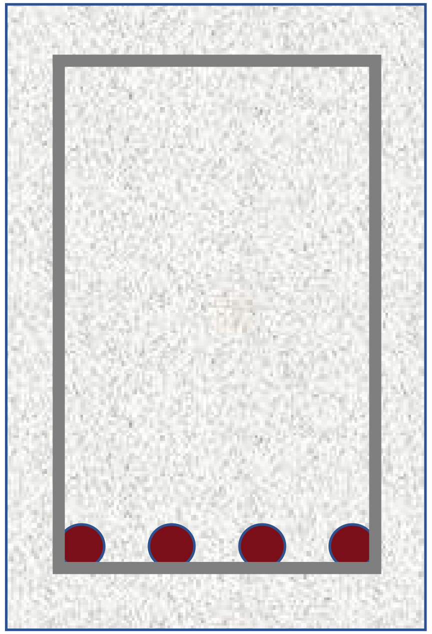
GR 100 $\varepsilon_t \geq 0.00645$

Reinforcement ratio, ρ_{tcl}

f'_c = 4ksi	f'_c = 10ksi
1.79%	3.42%
1.24%	2.37%
0.92%	1.75%

High-strength reinforcement comparison

Compare GR 60 to GR 100



12x20 in. beam

$f'_c = 4$ ksi

Grade 60

$A_{s,tcl} = 3.79 \text{ in}^2$

$M_{n,tcl} = 3370$ in-k

Grade 100

$A_{s,tcl} = 1.94 \text{ in}^2$

$M_{n,tcl} = 2960$ in-k

Approximately 50% of the reinforcement achieved 88% of the nominal moment

Reinforcement ratio, ρ_{tcl}

f'_c = 4ksi	f'_c = 10ksi
1.79%	3.42%
1.24%	2.37%
0.92%	1.75%

Straight bar development length

Modification of development length provisions to include:

- New Grade Factor ψ_g, and

$$\ell_d = \left(\frac{3}{40} \frac{f_y}{\lambda \sqrt{f'_c}} \frac{\psi_t \psi_e \psi_s \psi_g}{\left(\frac{c_b + K_{tr}}{d_b} \right)} \right) d_b$$

ψ_g = 1.0 for GR 40 or 60
1.15 for GR 80
1.3 for GR 100

$\ell_{d,\ GR\#} / \ell_{d,\ GR60}$
1.0
1.5
2.2

25.4.2.2 For bars with $f_y \geq$ 80,000 psi spaced closer than 6 in. on center, K_{tr} shall not be smaller than 0.5 d_b.

Hooked bar development length

25.4.3 *Development of standard hooks in tension*

25.4.3.1 Development length ℓ_{dh} for deformed bars in tension terminating in a standard hook shall be the greater of (a) through (c):

(a) ~~$\left(\frac{f_y \psi_e \psi_c \psi_r}{50\lambda\sqrt{f'_c}}\right)d_b$ with ψ_e, ψ_c, ψ_r, and λ given in 25.4.3.2.~~ $\left(\frac{f_y \psi_e \psi_r \psi_o \psi_c}{55\lambda\sqrt{f'_c}}\right)d_b^{1.5}$ with ψ_e, ψ_r, ψ_o, ψ_c, and λ given in 25.4.3.2

[CB601]

(b) $8d_b$

(c) 6 in.

- New ψ_o factor
- ψ_r , confining reinforcement factor is redefined
- ψ_c is now concrete strength factor

Hooked bar development length

25.4.3.2 For the calculation of ℓ_{dh}, modification factors ψ_e, ψ_r, ψ_o, ψ_c, and λ shall be in accordance with Table 25.4.3.2. ~~Factors ψ_c and ψ_r shall be permitted to be taken as 1.0.~~ At discontinuous ends of members, 25.4.3.~~3~~ 4 shall apply. For $f_y \geq$ 80,000 psi, **25.4.3.3** (a) through (~~c~~b) shall be satisfied.

[~~CR014~~CB601][CR014]

Table 25.4.3.2—Modification factors for development of hooked bars in tension

Modification factor	**Condition**	**Value of factor**
Lightweight λ	Lightweight concrete	0.75
	Normalweight concrete	1.0
Epoxy ψ_e	Epoxy-coated or zinc and epoxy dual-coated reinforcement	1.2
	Uncoated or zinc-coated (galvanized) reinforcement	1.0

Hooked bar development length

Confining reinforcement ψ_r ~~[2]~~	~~the bend within ties or stirrups[1] perpendicular to ℓ_{ext} at $s \le 3d_b$~~	~~0.8~~
	~~For 180 degree hooks of No. 11 and smaller bars enclosed along ℓ_{dh} within ties or stirrups[1] perpendicular to ℓ_{dh} at $s \le 3d_b$~~	
	For No. 11 and smaller bars with $A_{th} \ge 0.4 A_{hs}$ or s[1] $\ge 6d_b$[2]	1.0
	Other	1.~~0~~6

[1]*s* is minimum center-to-center spacing of hooked bars

[2]d_b is nominal diameter of hooked bar

Hooked bar development length

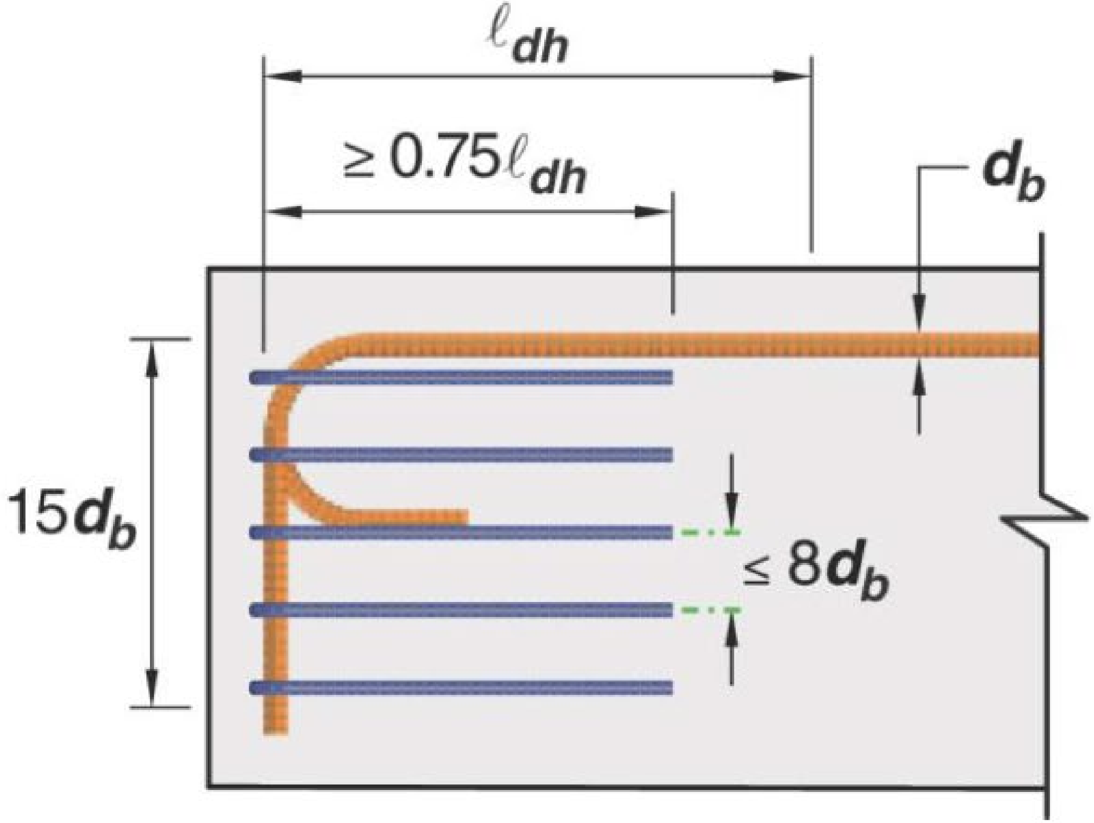


Fig. R25.4.3.3a—Confining reinforcement placed parallel to the bar being developed that contributes to anchorage strength of both 90- and 180-degree hooked bars.
[CB601]

Hooked bar development length

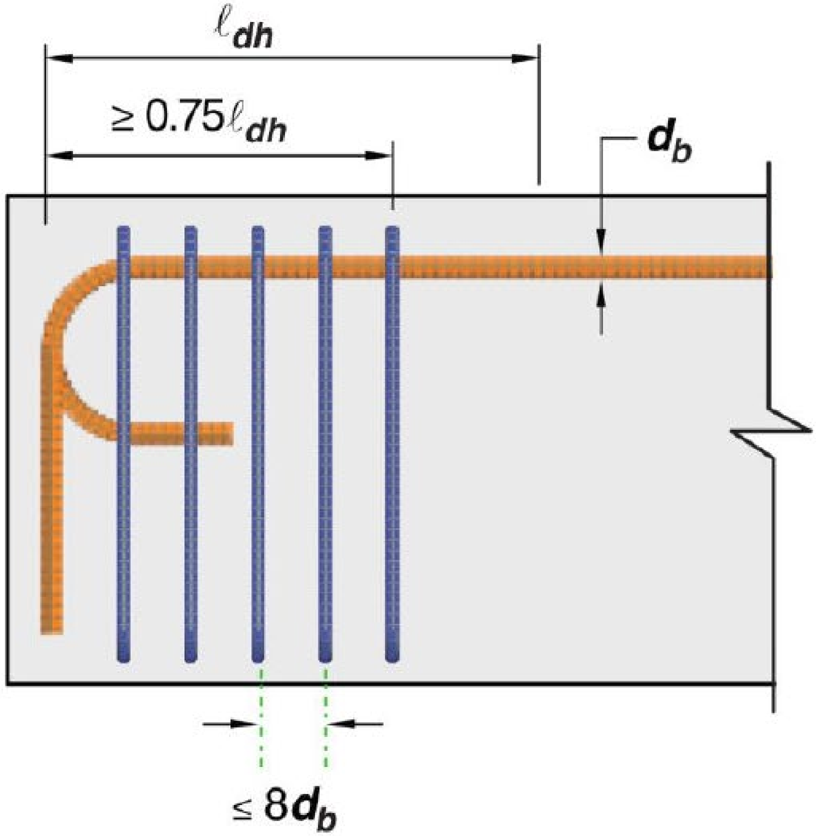


Fig. R25.4.3.3b—Confining reinforcement placed perpendicular to the bar being developed, spaced along the development length ℓ_{dh}, that contributes to anchorage strength of both 90- and 180-degree hooked bars.
[CB601]

Hooked bar development length

Location ψ_o	For No. 11 and smaller diameter hooked bars (1) terminating inside column core with side cover normal to plane of hook ≥ 2.5 in., or (2) with side cover normal to plane of hook ≥ $6d_b$	1.0
	Other	1.25
Concrete Strength ψ_c	For f'c < 6000 psi	$\frac{f_c'}{15000} + 0.6$
	For f'c ≥ 6000 psi	1.0

Headed bar development length

25.4.4.2 Development length ℓ_{dt} for headed deformed bars in tension shall be the ~~greatest~~ longest of (a) through (c):

(a) $\left(\frac{f_y \psi_e \psi_p \psi_o \psi_c}{75\sqrt{f_c'}}\right) d_b^{1.5}$ with ψ_e, $\psi_{\cancel{csp}}$, ψ_o, and ψ_c, $\cancel{\left(\frac{0.016 f_y \psi_e}{\sqrt{f_c'}}\right) d_b}$~~, with ψ_e~~ given in 25.4.4.3 ~~and value of f_c' shall not exceed 6000 psi~~

[CB601]

(b) $8d_b$

(c) 6 in.

Headed bar development length

Table 25.4.4.3—Modification factors for development of headed bars in tension

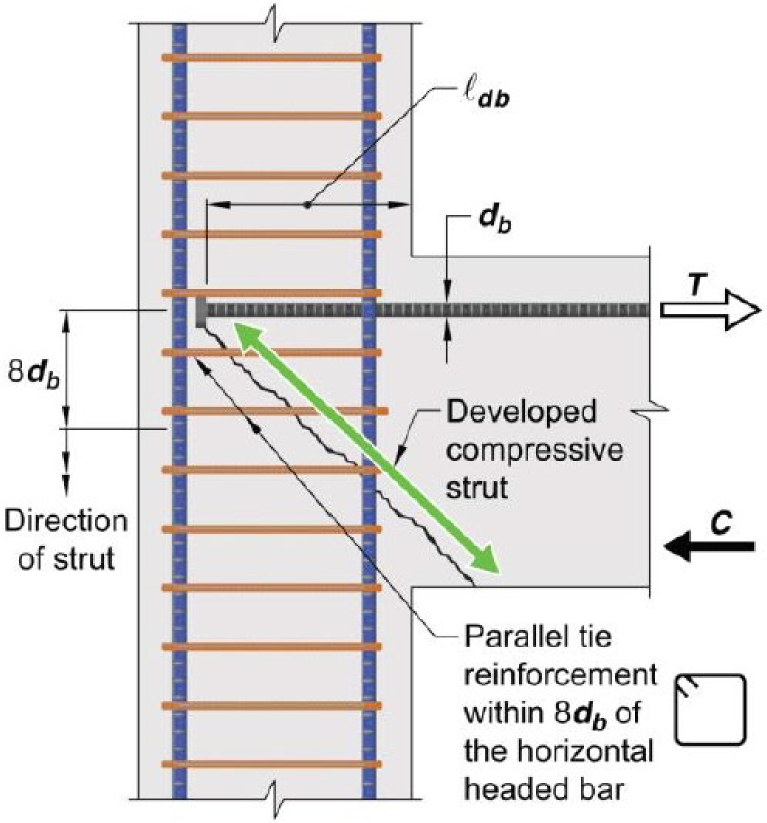
Modification Factor	Condition	Value of Factor
Epoxy ψ_e	Epoxy-coated or zinc and epoxy dual-coated reinforcement	1.2
	Uncoated or zinc-coated (galvanized) reinforcement	1.0
Parallel Tie Reinforcement ψ_p	For No. 11 and smaller bars with $A_{tt} \geq 0.3\ A_{ts}$ or s[1] $\geq 6d_b$[2,3]	1.0
	Other	1.6

25.4.4.4 For beam column joints, the total cross-sectional area of parallel tie reinforcement A_{tt} shall consist of ties or stirrups oriented parallel-to ℓ_{dt} and located within $8d_b$ of the centerline of the headed bar toward the middle of the joint, where d_b is the nominal diameter of the headed bar.

[CB601]

25.4.4.5 For anchorages other than in beam-column joints, tie reinforcement, A_{tt}, shall not be considered, and ψ_r shall be taken as 1.0 provided the spacing is at least $6d_b$.

[CB601]



Headed bar development length

Location ψ_o	For headed bars (1) terminating inside column core with side cover to bar ≥ 2.5 in. , or (2) with side cover to bar ≥ $6d_b$	1.0
	Other	1.25
Concrete Strength ψ_c	For f'c < 6000 psi	$\frac{f_c'}{15000}+0.6$
	For f'c ≥ 6000 psi	1.0

Simplified shear provisions for nonprestressed members

Updated 1-way shear for nonprestressed beams and
Updated 1- and 2-way shear for nonprestressed slabs

As an example, review

- One-way beam shear equations for nonprestressed concrete

- ACI 318-14: Sections 22.5.1 and 9.6.3.1 ($A_{v,min}$ in beams)
  V_c Eqns. in 22.5.6-22.5.7

Review of ACI 318-14 Code Provisions

22.5—One-way shear strength

22.5.1 *General*

22.5.1.1 Nominal one-way shear strength at a section, V_n, shall be calculated by:

$$V_n = V_c + V_s \qquad (22.5.1.1)$$

22.5.1.2 Cross-sectional dimensions shall be selected to satisfy Eq. (22.5.1.2).

$$V_u \leq \phi(V_c + 8\sqrt{f_c'}b_w d) \qquad (22.5.1.2)$$

22.5.1.3 For nonprestressed members, V_c shall be calculated in accordance with 22.5.5, 22.5.6, or 22.5.7.

Review of ACI 318-14 Code Provisions

9.6.3 *Minimum shear reinforcement*

9.6.3.1 A minimum area of shear reinforcement, $A_{v,min}$, shall be provided in all regions where $\boxed{V_u > 0.5\phi V_c}$ except for the cases in Table 9.6.3.1. For these cases, at least $A_{v,min}$ shall be provided where $V_u > \phi V_c$.

Table 9.6.3.1—Cases where $A_{v,min}$ is not required if $0.5\phi V_c < V_u \leq \phi V_c$

Beam type	Conditions
Shallow depth	$h \leq 10$ in.
Integral with slab	$h \leq$ greater of $2.5t_f$ or $0.5b_w$ and $h \leq 24$ in.
Constructed with steel fiber-reinforced normalweight concrete conforming to 26.4.1.5.1(a), 26.4.2.2(d), and 26.12.5.1(a) and with $f_c' \leq 6000$ psi	$h \leq 24$ in. and $V_u \leq \phi 2\sqrt{f_c'} b_w d$
One-way joist system	In accordance with 9.8

V_c without axial force

22.5.5 $\mathbf{V_c}$ *for nonprestressed members without axial force*

22.5.5.1 For nonprestressed members without axial force, V_c shall be calculated by:

$$\boxed{V_c = 2\lambda\sqrt{f_c'}b_w d} \qquad (22.5.5.1)$$

unless a more detailed calculation is made in accordance with Table 22.5.5.1.

Table 22.5.5.1—Detailed method for calculating V_c

V_c		
Least of (a), (b), and (c):	$\left(1.9\lambda\sqrt{f_c'} + 2500\rho_w \frac{V_u d}{M_u}\right) b_w d$ [1]	(a)
	$(1.9\lambda\sqrt{f_c'} + 2500\rho_w) b_w d$	(b)
	$3.5\lambda\sqrt{f_c'} b_w d$	(c)

[1] M_u occurs simultaneously with V_u at the section considered.

V_c without axial compressive force

22.5.6 **V_c** *for nonprestressed members with axial compression*

22.5.6.1 For nonprestressed members with axial compression, V_c shall be calculated by:

$$V_c = 2\left(1+\frac{N_u}{2000A_g}\right)\lambda\sqrt{f_c'}b_w d \qquad (22.5.6.1)$$

unless a more detailed calculation is made in accordance with Table 22.5.6.1, where N_u is positive for compression.

Table 22.5.6.1—Detailed method for calculating V_c for nonprestressed members with axial compression

V_c		
Lesser of (a) and (b):	$\left(1.9\lambda\sqrt{f_c'}+2500\rho_w\dfrac{V_u d}{M_u - N_u\dfrac{(4h-d)}{8}}\right)b_w d$ [1] Equation not applicable if $M_u - N_u\dfrac{(4h-d)}{8} \le 0$	(a)
	$3.5\lambda\sqrt{f_c'}b_w d\sqrt{1+\dfrac{N_u}{500A_g}}$	(b)

[1] M_u occurs simultaneously with V_u at the section considered.

V_c with axial tensile force

22.5.7 **$\mathbf{V_c}$** *for nonprestressed members with significant axial tension*

22.5.7.1 For nonprestressed members with significant axial tension, V_c shall be calculated by:

$$V_c = 2\left(1 + \frac{N_u}{500A_g}\right)\lambda\sqrt{f_c'}b_w d \qquad (22.5.7.1)$$

where N_u is negative for tension, and V_c shall not be less than zero.

New ACI 318-19 Code Provisions

Reasons for updating V_c equations:

- Account for size effect
- Account for low longitudinal reinforcement ratios for members without shear reinforcement
- Simplification (8 equations → 3 equations)

Size Effect

Measured shear strength, attributed to concrete *(V_c)* does not increase in direct proportion with member depth. Beam that is twice as deep, may fail at less than twice the shear of shallower beam, even though ACI 318-14 implies that shear should scale with depth. (Sneed and Ramirez, 2010).

ACI 318-14 $$V_c = 2\lambda\sqrt{f_c'}b_w d \qquad (22.5.5.1)$$

Size Effect – Experimental Evidence

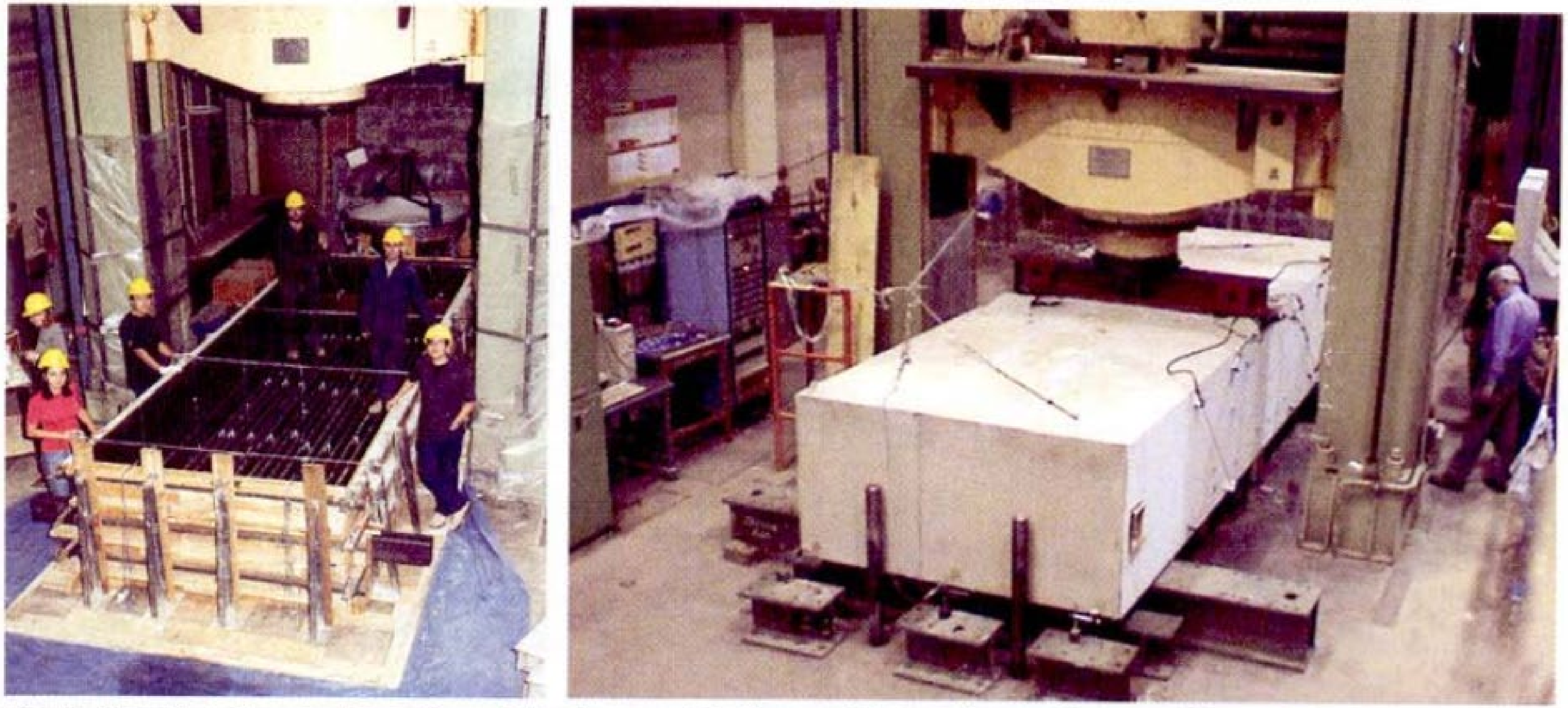


Fig. 8: Construction and loading of the large, wide beam, AT-1 under testing machine at the University of Toronto

Size Effect – Experimental Evidence

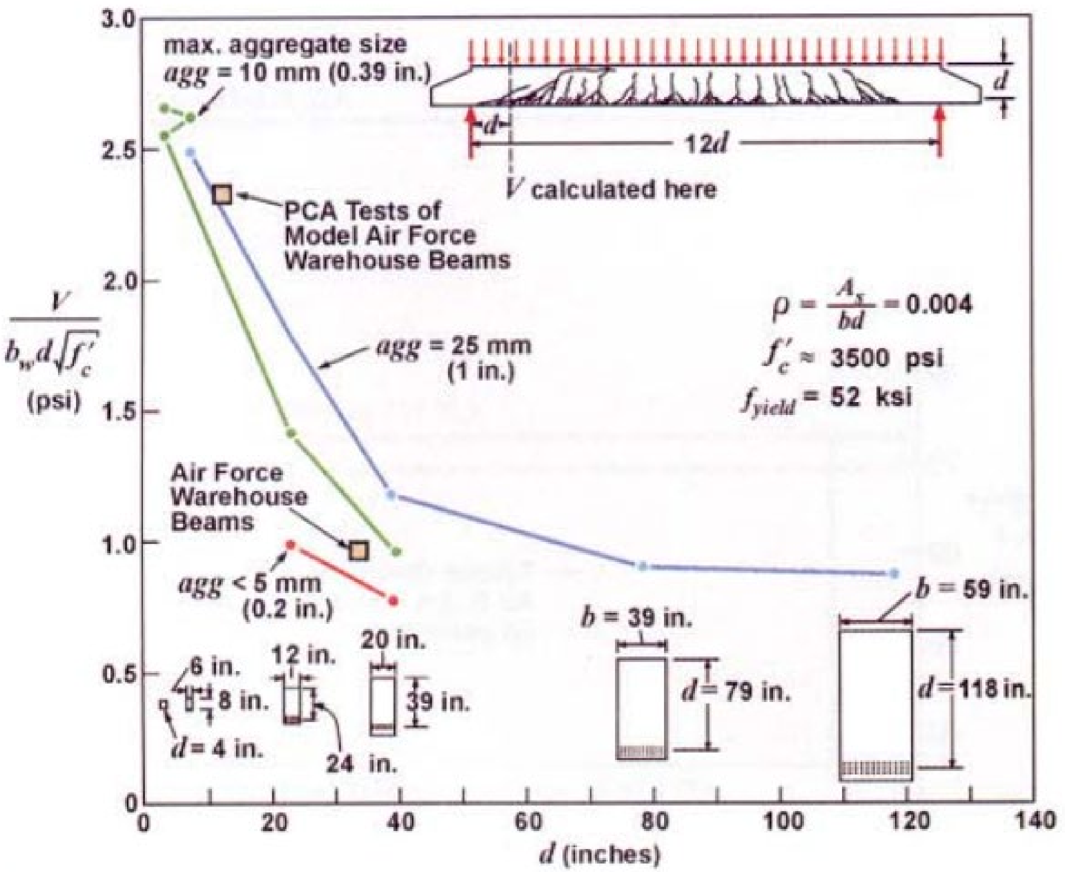


Fig. 5: Influence of member depth and maximum aggregate size on shear stress at failure (tests by Shioya et al.[9] and Shioya[10]) (1 in. = 25.4 mm; 1 ksi = 6.89 MPa; 1 psi = 6.89 kPa)

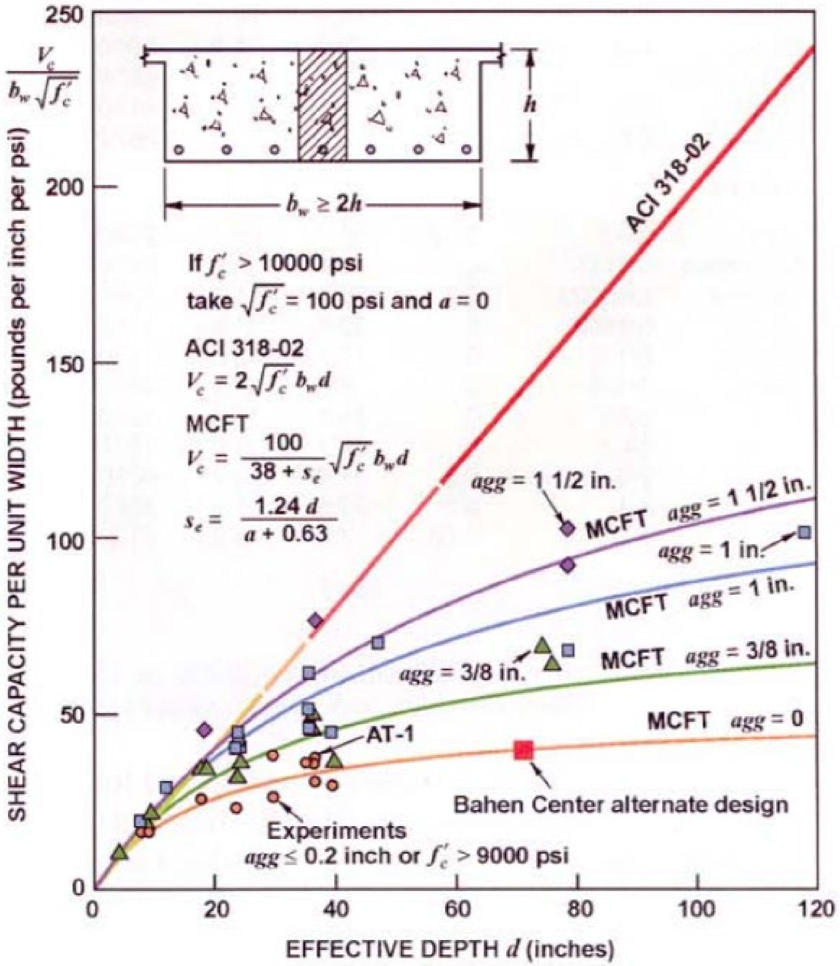


Fig. 13: Safety of ACI shear design procedure for large, wide beams (1 in. = 25.4 mm; 1 lb/in./psi = 0.025 kN/m/kPa; and 1 psi = 6.89 kPa)

New ACI 318-19 Code Provisions

22.5—One-way shear strength

22.5.1 *General*

22.5.1.1 Nominal one-way shear strength at a section, V_n, shall be calculated by:

$$V_n = V_c + V_s \quad (22.5.1.1)$$

22.5.1.2 Cross-sectional dimensions shall be selected to satisfy Eq. (22.5.1.2).

$$V_u \leq \phi(V_c + 8\sqrt{f_c'}b_w d) \quad (22.5.1.2)$$

22.5.1.3 For nonprestressed members, V_c shall be calculated in accordance with 22.5.5~~, 22.5.6, or 22.5.7~~.

Reduce # of Eqns.
8→3

New ACI 318-19 Code Provisions

22.5.5 V_c *for nonprestressed members without axial force*

22.5.5.1 For nonprestressed members ~~without axial force~~, V_c shall be calculated by~~:~~

$$\cancel{V_c = 2\lambda\sqrt{f'_c}b_w d \qquad (22.5.5.1)}$$

[CE025]

~~unless a more detailed calculation is made in accordance with~~ Table 22.5.5.1 and 22.5.5.1.1 through 22.5.5.1.3.

[CE025]

Table 22.5.5.1 – V_c for nonprestressed members

Criteria	V_c		
$A_v \geq A_{v,min}$	Either of:	$\left[2\lambda\sqrt{f'_c}+\frac{N_u}{6A_g}\right]b_w d$	(a)
		$\left[8\lambda(\rho_w)^{1/3}\sqrt{f'_c}+\frac{N_u}{6A_g}\right]b_w d$	(b)
$A_v < A_{v,min}$	$\left[8\lambda_s\lambda(\rho_w)^{1/3}\sqrt{f'_c}+\frac{N_u}{6A_g}\right]b_w d$		(c)

Notes: 1. Axial load, N_u, is positive for compression and negative for tension.

2. V_c shall not be taken less than zero.

Notes:

- Reduction of equations
- Size effect factor, λ_s, for $A_v<A_{v,min}$
- f(Longitudinal reinforcement ratio)

New ACI 318-19 Code Provisions

22.5.5.1.1 V_c shall not be taken greater than $5\lambda\sqrt{f'_c}\,b_w d$.

[CE025]

22.5.5.1.2 In Table 22.5.5.1, the value of $N_u/6A_g$ shall not be taken greater than $0.05f'_c$.

[CE025]

22.5.5.1.3 The size effect modification factor, λ_s, shall be determined by

$$\lambda_s = \sqrt{\frac{2}{(1+d/10)}} \quad \cancel{\lambda_s = \frac{1.4}{\sqrt{1+d/10}}} \quad \le 1.0 \qquad (22.5.5.1.3)$$

λ_s = Factor used to modify shear strength based on the effects of member depth, commonly referred to as the size effect factor.

New ACI 318-19 Code Provisions

Size effect factor, λ_s

- Consistent with fracture mechanics theory for RC
- Proposed by ACI Committee 446 (fracture mechanics)
- Power law, proportionality to $d^{-1/2}$
- General form verified for many geometries and quasi-brittle materials

New ACI 318-19 Code Provisions

9.6.3 *Minimum shear reinforcement*

9.6.3.1 ~~A~~ For nonprestressed beams, minimum area of shear reinforcement, $A_{v,min}$, shall be provided in all regions where $V_u > \phi\lambda\sqrt{f'_c}b_w d$ ~~$V_u > 0.5\phi V_c$~~ except for the cases in Table 9.6.3.1. For these cases, at least $A_{v,min}$ shall be provided where $V_u > \phi V_c$.

[CE025]

Equivalent to previous $V_u > 0.5\phi V_c$

Table 9.6.3.1—Cases where $A_{v,min}$ is not required if $V_u \le \phi V_c$ ~~if $0.5\phi V_c < V_u \le \phi V_c$~~
[CE025]

Beam type	**Conditions**
Shallow depth	$h \le 10$ in.
Integral with slab	$h \le$ greater of $2.5t_f$ or $0.5b_w$ and

Background of ACI 318-19 Code Provisions

Comparison of Statistical Values

	No Net Axial Compression						With Net Axial Compression*								
	no Av			With Av			No Av			With Av			Columns Cyclic		
Method	Mean	COV	5%	Mean	COV	5%	Mean	COV	5%	Mean	COV	5%	Mean	COV	5%
ACI318-14 Simplified	1.51	0.38	0.88	1.47	0.24	1.08	2.25	0.36	1.65	1.57	0.26	1.02			
ACI318-14 Detailed at "d"	1.10	0.30	0.61	1.21	0.21	0.87	1.27	0.33	0.56	1.19	0.20	0.86			
ACI318-14 Detailed at "a/2"	1.25	0.30	0.76	1.31	0.21	0.97	1.49	0.26	1.05	1.41	0.16	1.14			
ACI318-14 Detailed at "a-d/2"	1.36	0.32	0.83	1.39	0.22	1.03	1.92	0.25	1.51	1.81	0.19	1.49			
Proposal	1.44	0.22	1.09	1.33	0.20	1.00	1.95	0.29	1.47	1.50	0.20	1.17	1.35	0.31	0.84

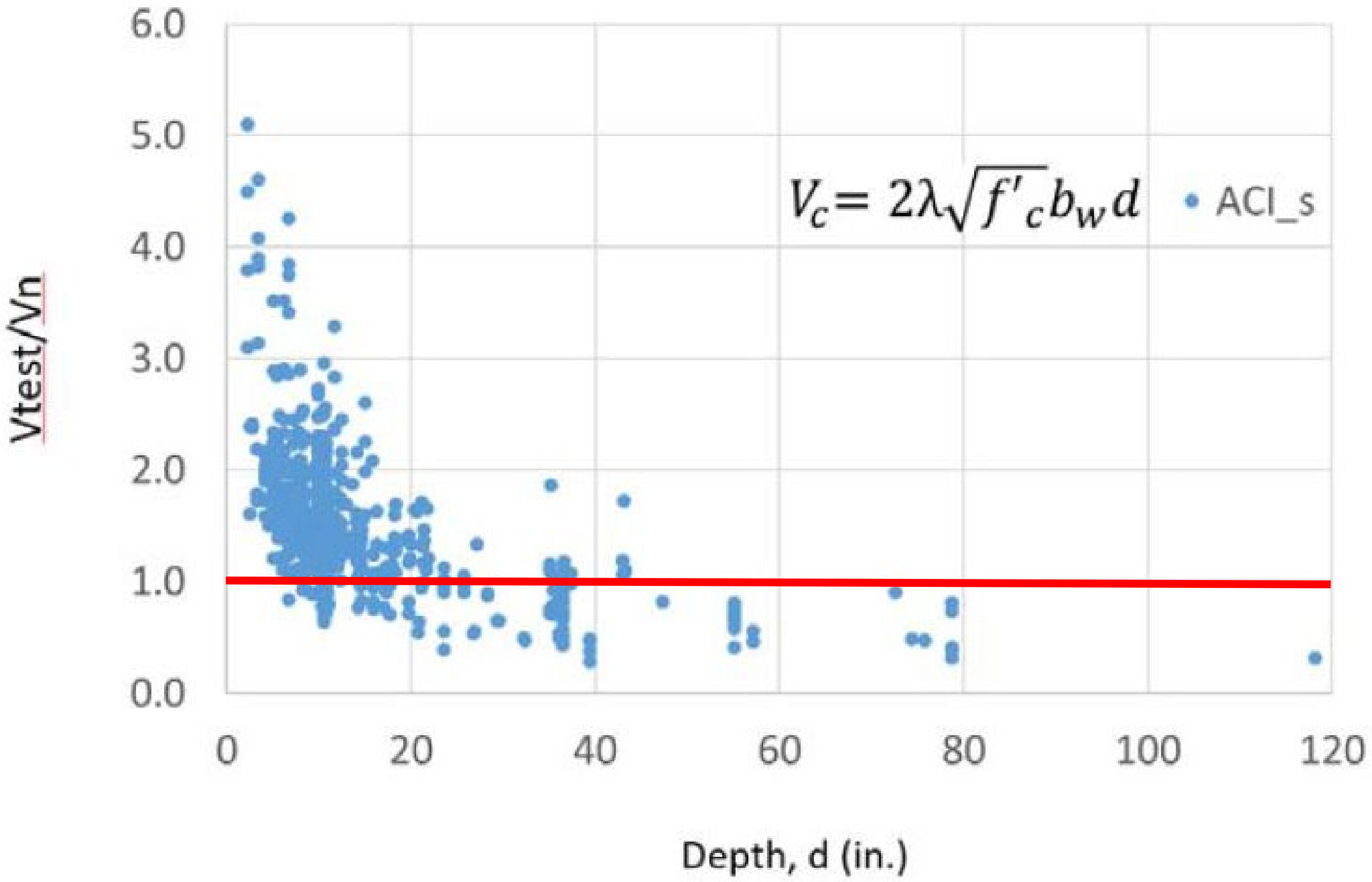
*Database consists of prestressed concrete members

Note: Comparison of statistical values (Mean Strength Ratio, COV, and 5% Fractile Value) for ACI318-14 provisions and the method of the change proposal.

- Four one-way shear experimental databases (ACI 445, shear and torsion)
- The prestressed concrete databases were used to investigate axial load effects
- Data presented as V_{test} / V_n

Background of ACI 318-19 Code Provisions

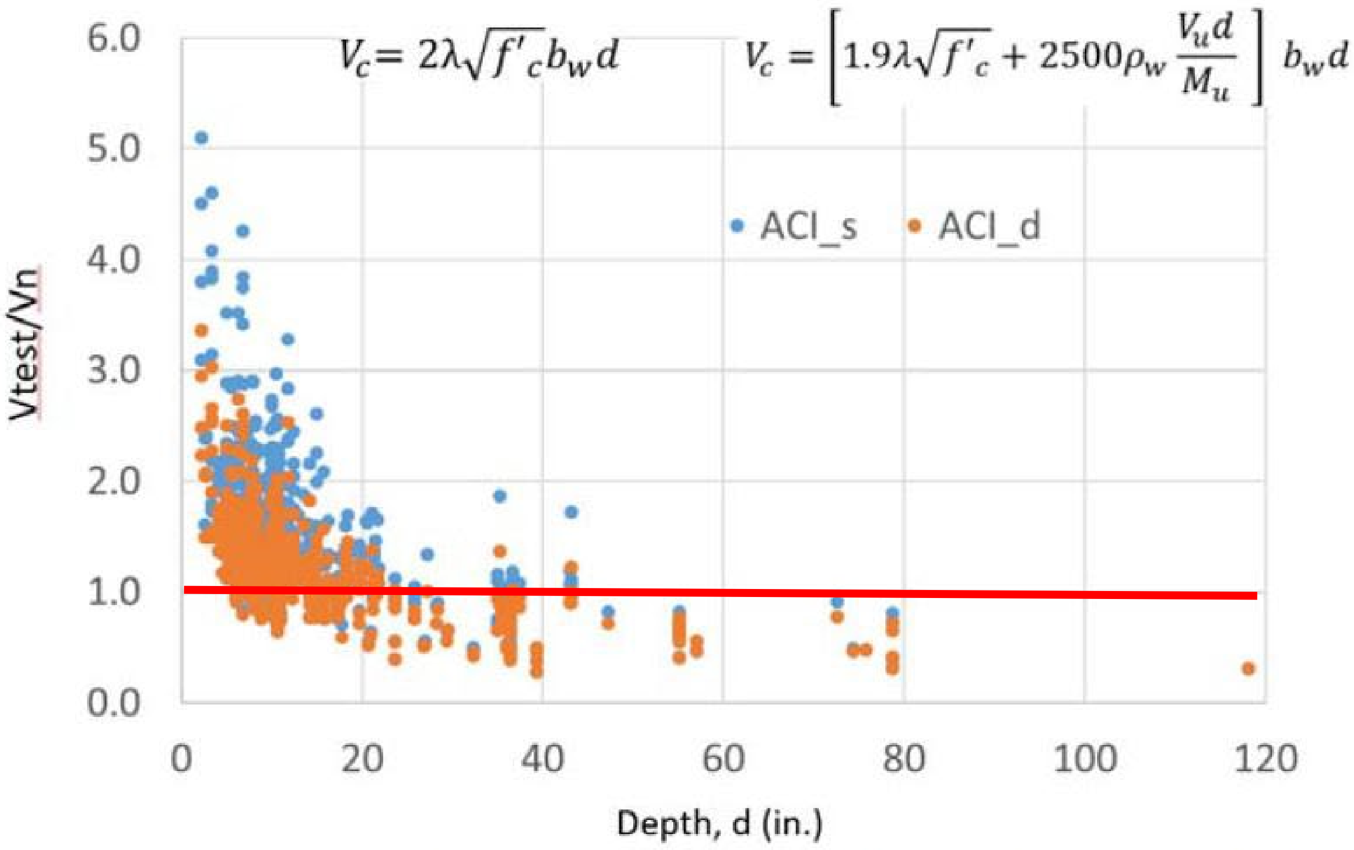
Strength ratio V_{test} / V_n (ACI 318-14 Simplified Eqn)
Nonprestressed members, No axial load, No shear reinforcement



Note:
- Plot against *d*
- Unconservative for large depths
- Problems at lower depths too

Background of ACI 318-19 Code Provisions

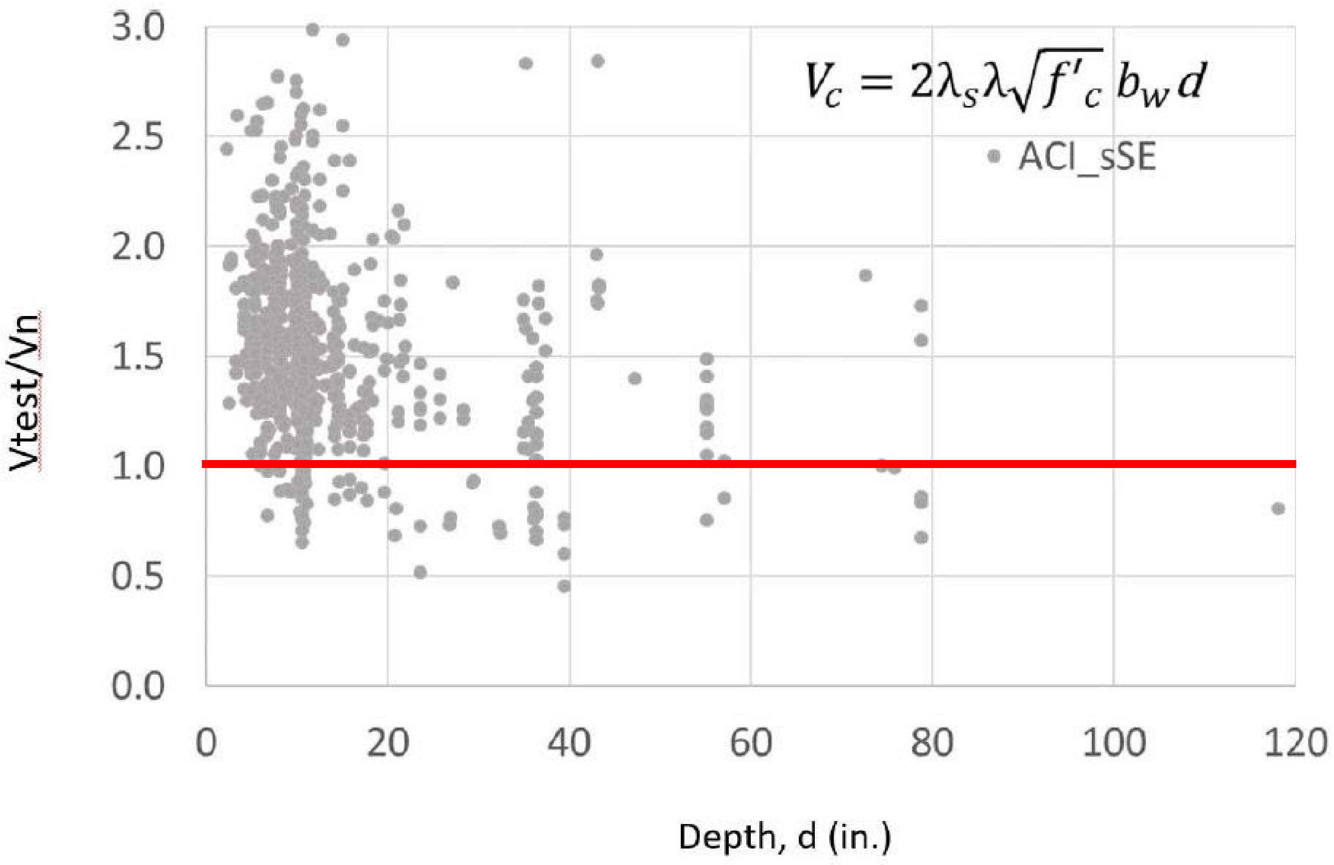
Strength ratio V_{test} / V_n (ACI 318-14 Eqns)
Nonprestressed members, No axial load, No shear reinforcement



Note:
- Plot against *d*
- Detailed provisions more unconservative

Background of ACI 318-19 Code Provisions

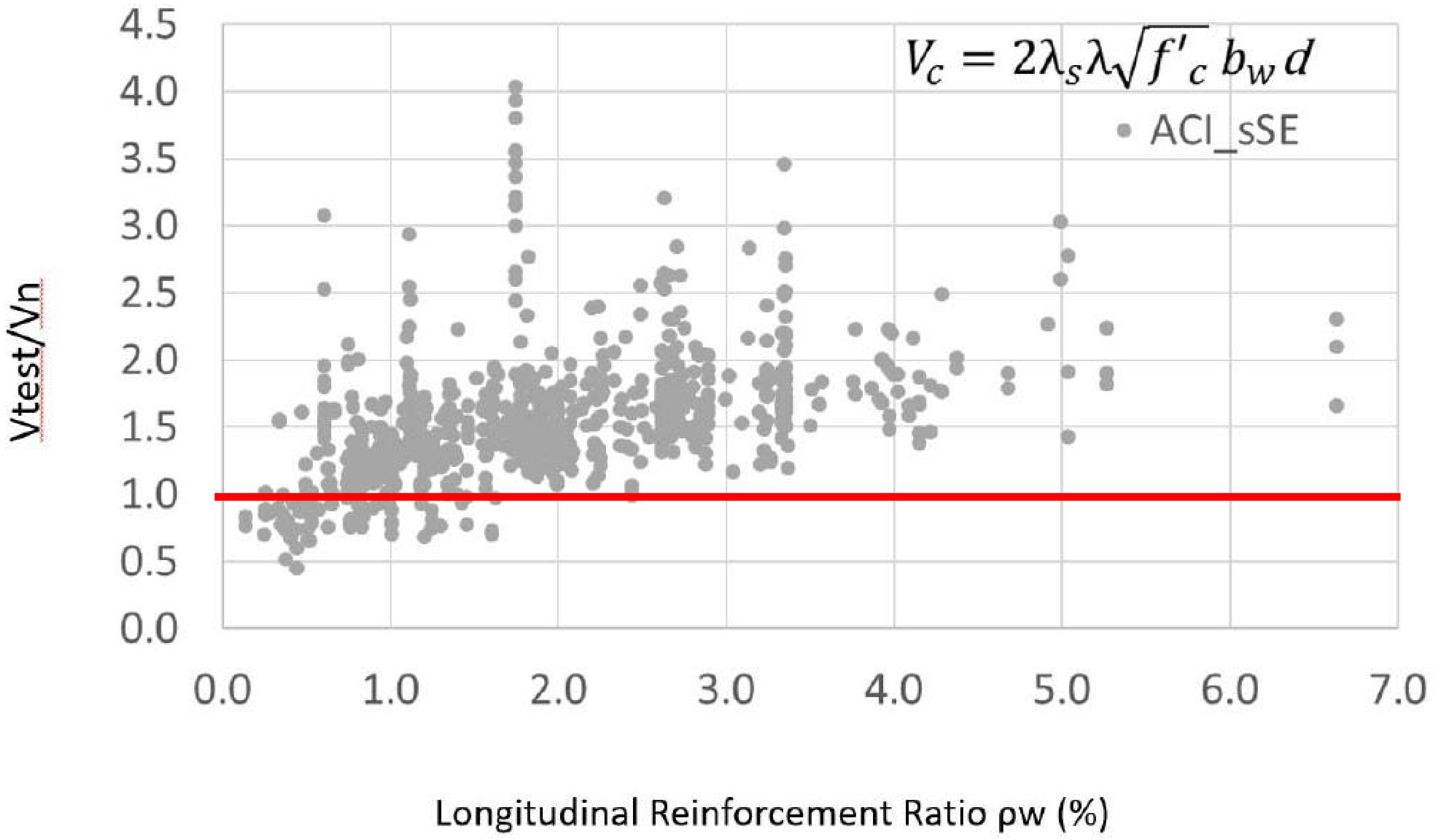
Strength ratio V_{test} / V_n (ACI 318-14 Simplified Eqn with λ_s)
Nonprestressed members, No axial load, No shear reinforcement



Note:
- Plot against *d*
- Size effect added
- Still unconservative results along all depths
- Other parameter(s) affect strength ratio

Background of ACI 318-19 Code Provisions

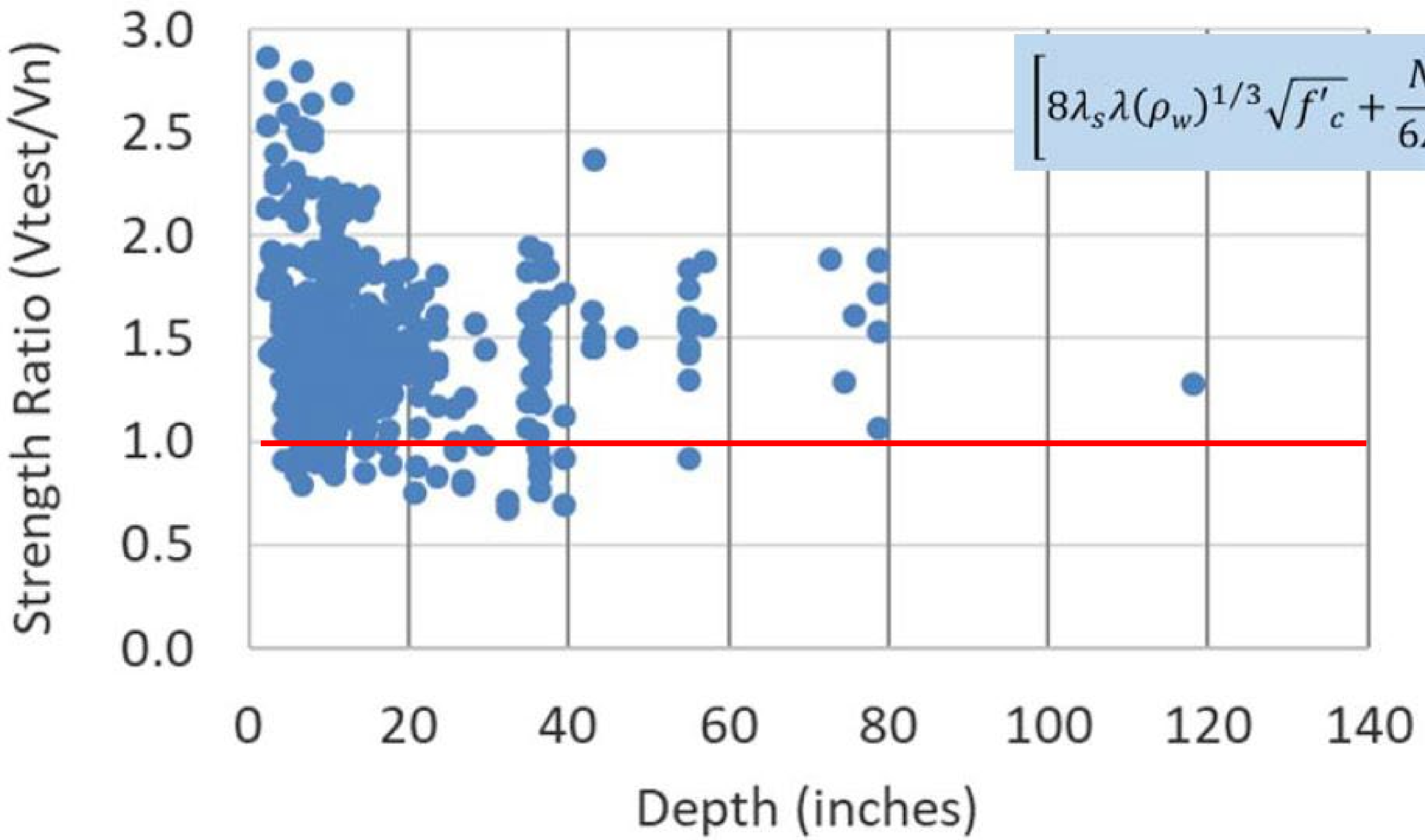
Strength ratio V_{test} / V_n (ACI 318-14 Simplified Eqn with λ_s)
Nonprestressed members, No axial load, No shear reinforcement



Note:
- Plot against ρ_w
- Unconservative results at low ρ_w

Background of ACI 318-19 Code Provisions

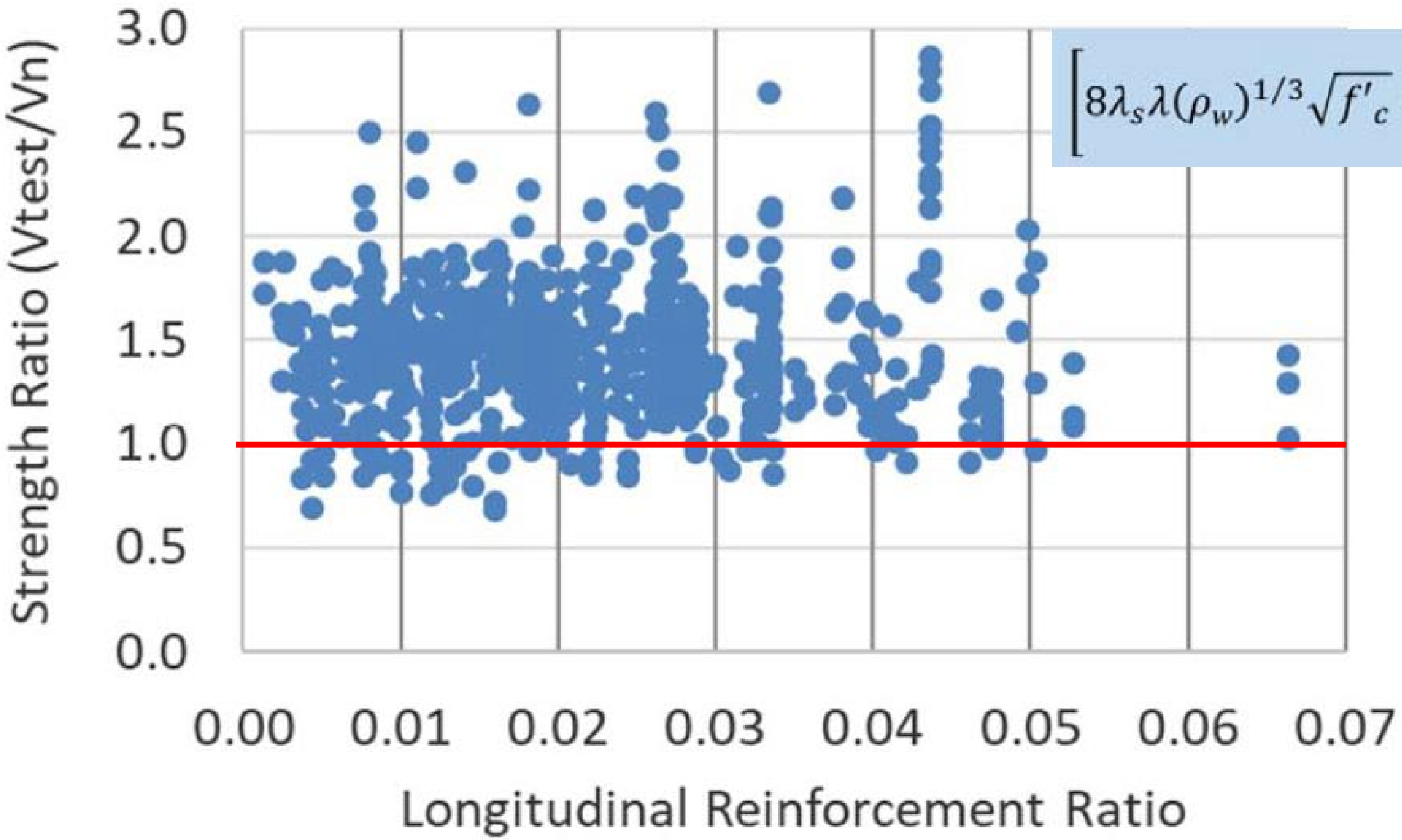
Strength ratio V_{test} / V_n (ACI 318-19 Eqn considering λ_s and ρ_w effects)
Nonprestressed members, No axial load, No shear reinforcement



Note:
- ACI 318-19 Eq.
- Plot against *d*
- Depth impact minimized (no appreciable trend)

Background of ACI 318-19 Code Provisions

Strength ratio V_{test} / V_n (ACI 318-19 Eqn considering λ_s and ρ_w effects)
Nonprestressed members, No axial load, No shear reinforcement



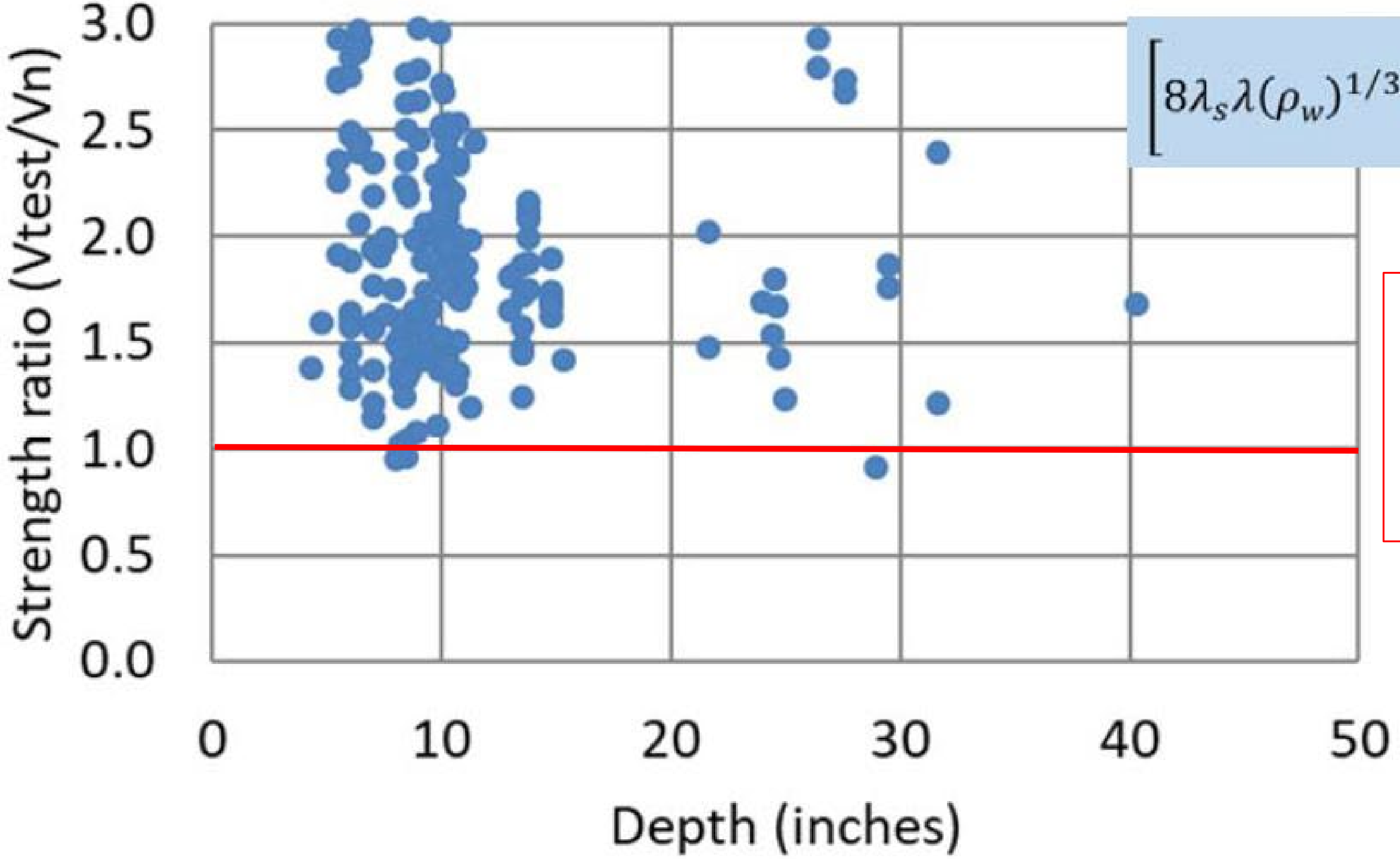
$$\left[8\lambda_s\lambda(\rho_w)^{1/3}\sqrt{f'_c}+\frac{N_u}{6A_g}\right]b_w d$$

Note:

- ACI 318-19 Eq.
- Plot against against ρ_w
- ρ_w impact minimized (no appreciable trend)
- $\rho_w^{1/3}$A originally proposed by Zustty ('71) and adopted in Eurocode ('91)

Background of ACI 318-19 Code Provisions

Strength ratio V_{test} / V_n (ACI 318-19 Eqn considering λ_s and ρ_w effects)
With net axial compression, No shear reinforcement



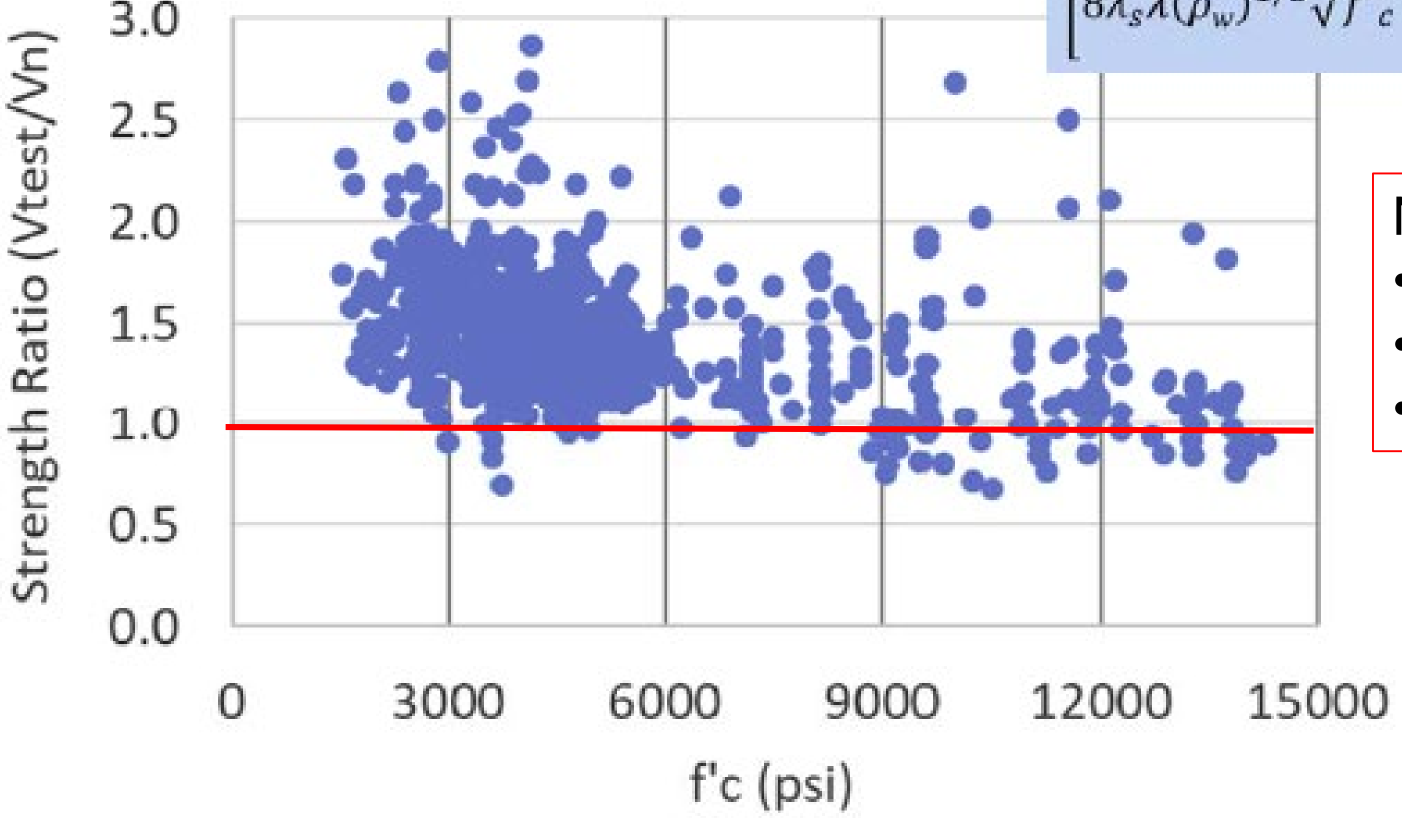
$$\left[8\lambda_s\lambda(\rho_w)^{1/3}\sqrt{f'_c}+\frac{N_u}{6A_g}\right]b_w d$$

Note:
- ACI 318-19 Eq.
- Plot against against d
- Axial compression

Background of ACI 318-19 Code Provisions

Strength ratio V_{test} / V_n (ACI 318-19 Eqn considering λ_s and ρ_w effects)
Nonprestressed members, No axial load, No shear reinforcement

$$\left[8\lambda_s\lambda(\rho_w)^{1/3}\sqrt{f'_c}+\frac{N_u}{6A_g}\right]b_w d$$



Note:

- ACI 318-19 Eq.
- Plot against against f'_c
- Unconservative as $f'_c\uparrow$

Background of ACI 318-19 Code Provisions

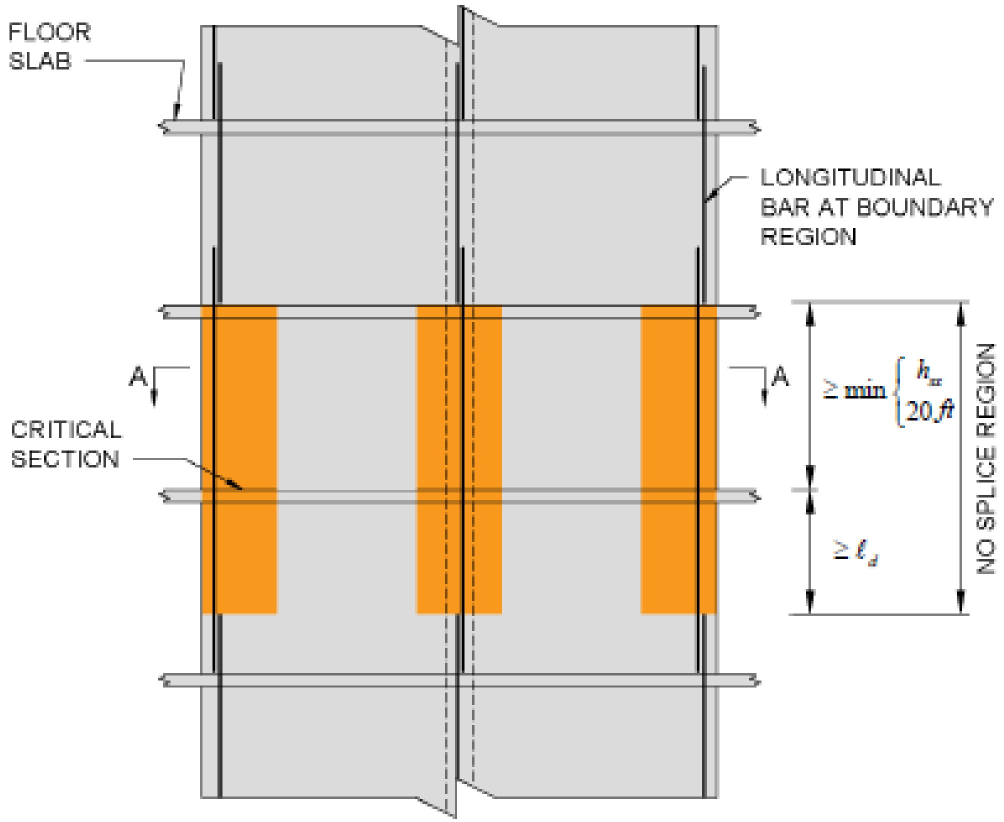
Also found that New Simplified Shear provisions for V_c work well for

- Varying amounts of shear reinforcement provided (A_V)
- Varying axial compressive stresses applied

Results showed that members with high concrete compressive strength can have unconservative shear strengths.

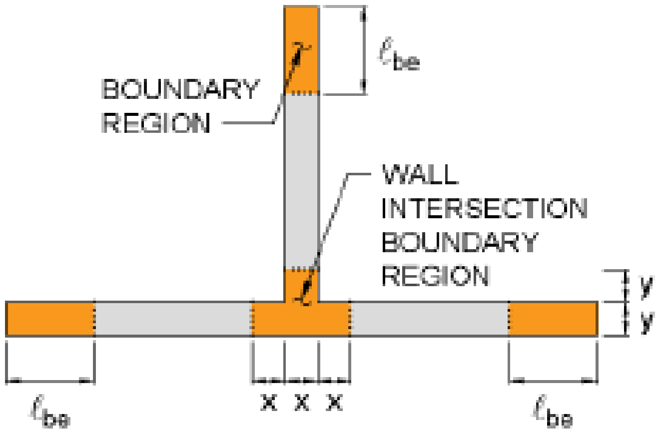
- ACI 318-19 still limits concrete strength for calculations at 10,000 psi for sections unless minimum transverse reinforcement is provided (22.5.3.1)

Restrictions on lap splices in special structural walls 18.10.2.3



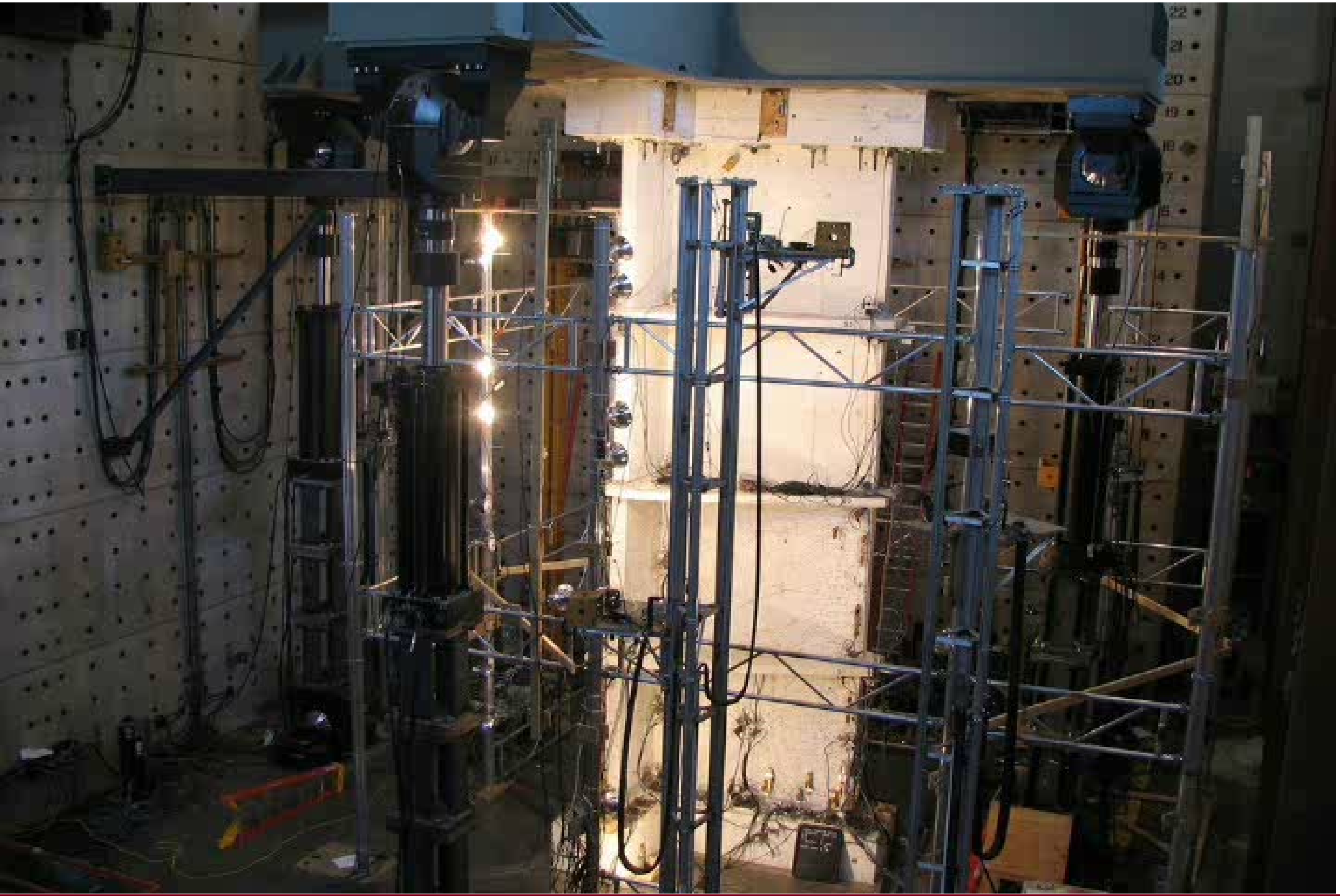
(a) Elevation

(c) Lap splices of longitudinal reinforcement shall not be permitted within boundary regions over a height equal to the shorter of 20 ft and one story height h_{sx} above and a minimum of ℓ_d to the closest end of the splice below critical sections where yielding of longitudinal reinforcement is likely to occur as a result of lateral displacements. Boundary regions include those within lengths specified in 18.10.6.4(a) and those within lengths not less than the wall thickness beyond the intersecting region in each direction.



(b) Section A-A

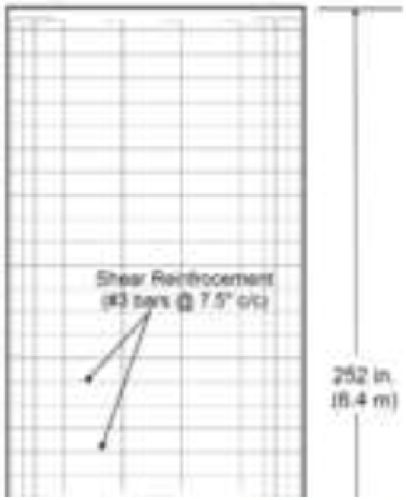
Restrictions on lap splices in special structural walls 18.10.2.3



Based on work conducted at UMN MAST Laboratory

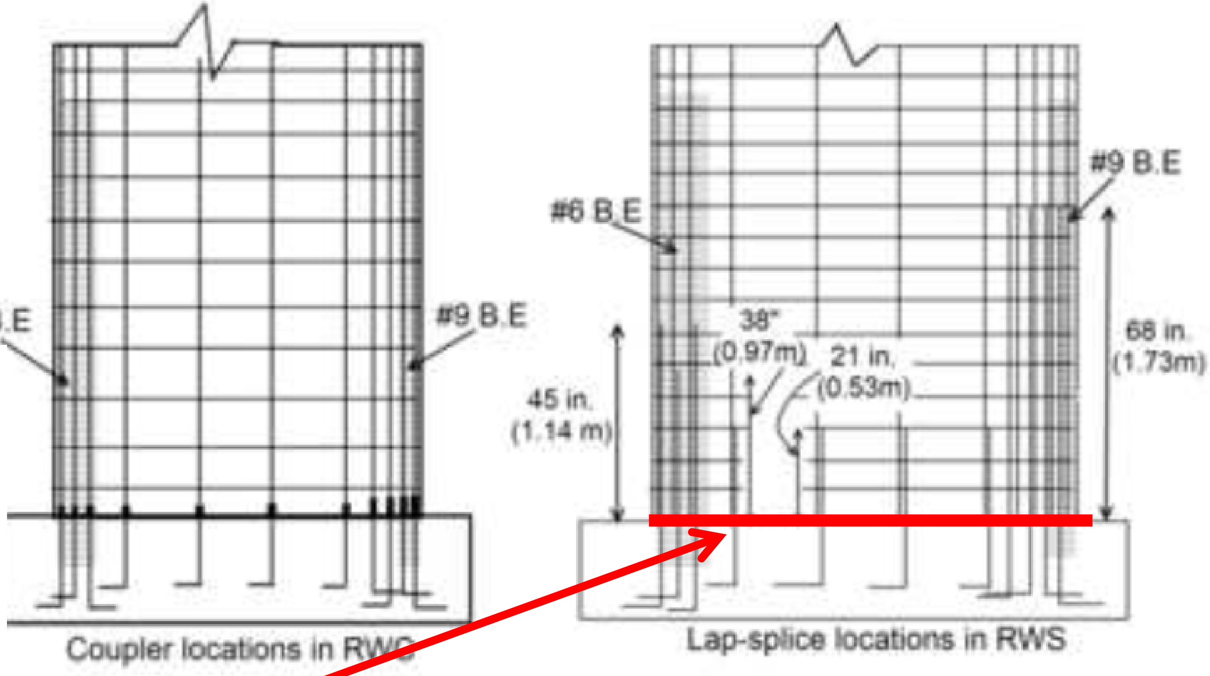
Restrictions on lap splices in special structural walls 18.10.2.3

Three details tested
- No splice
- Mechanical splice
- Lap splice



a) RWN b) RWC

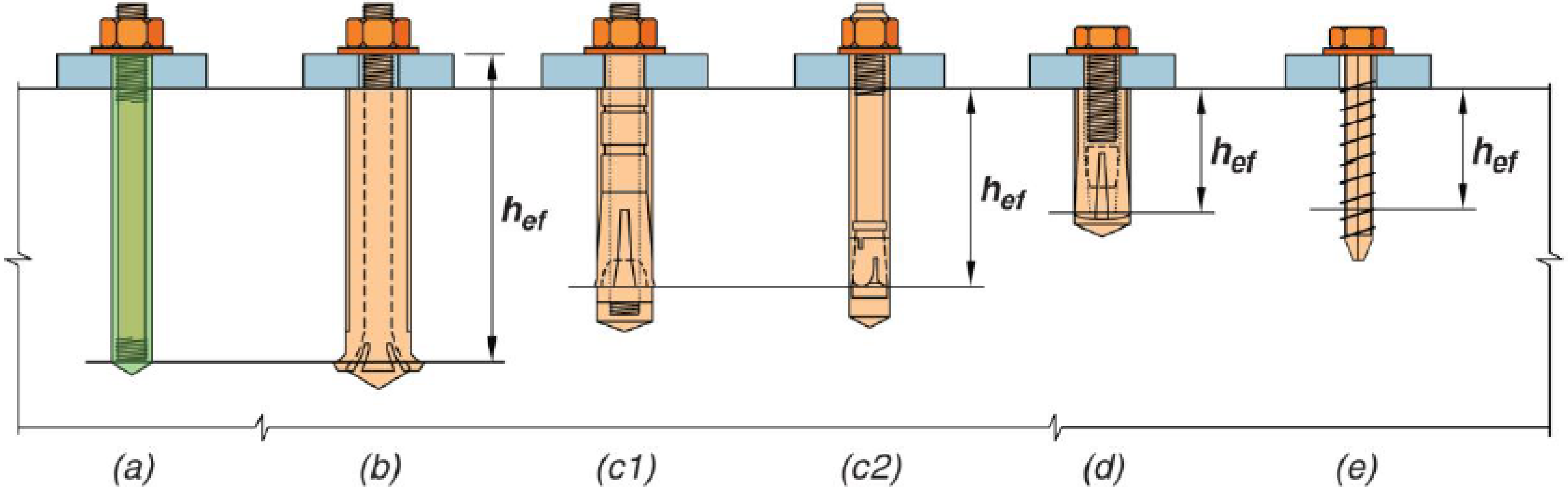
c) RWS



Note: B.E = boundary element

c) Coupler and Lap-splice details at the wall-to-foundation interface

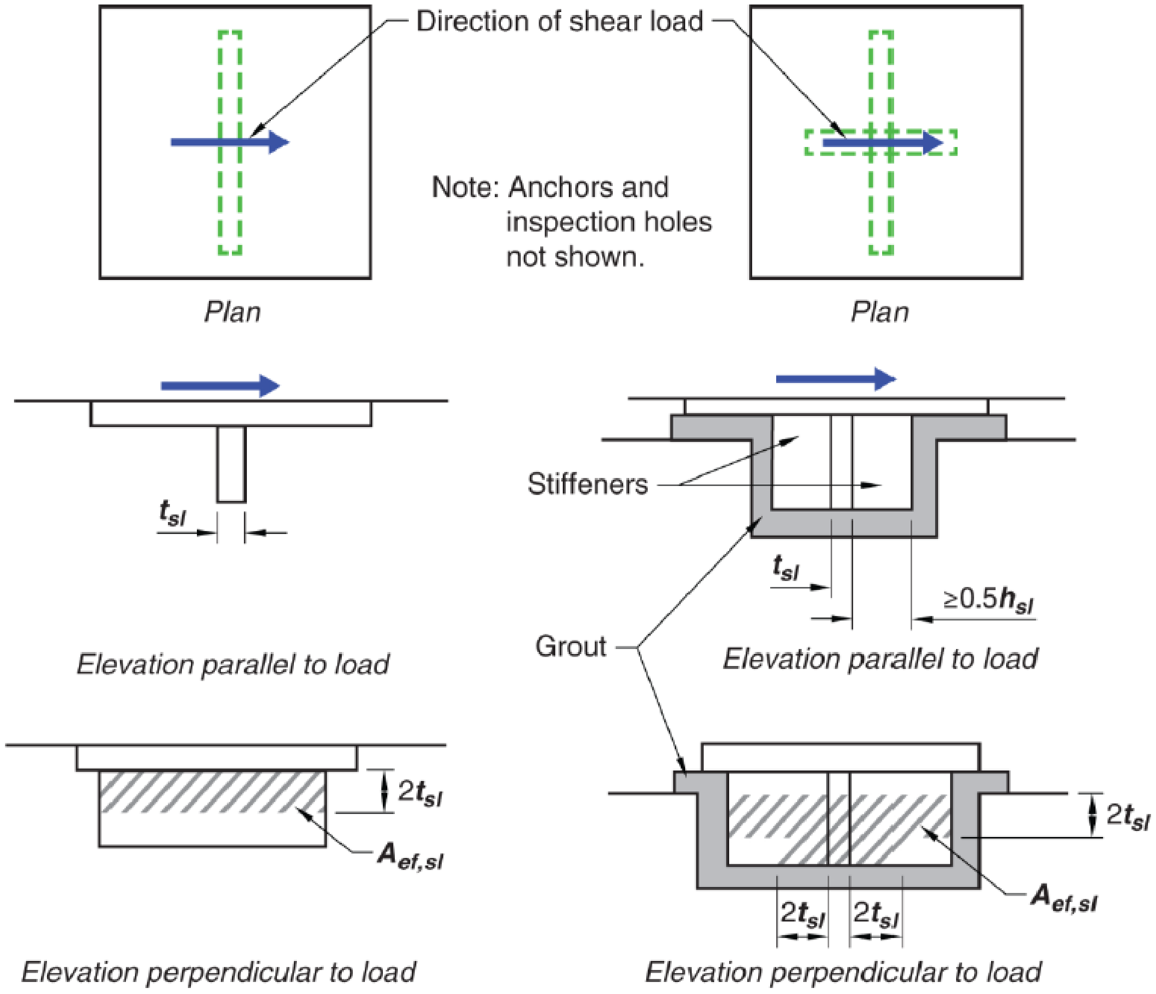
Chapter 17 Updates – Addition of screw anchors



(B) Post-installed anchors: (a) adhesive anchor; (b) undercut anchor;
(c) torque-controlled expansion anchors [(c1) sleeve-type and (c2) stud-type];
(d) drop-in type displacement-controlled expansion anchor; and (e) screw anchor.

Fig. R2.1—*Types of anchors.*

Chapter 17 Updates – Addition of shear lugs



(a) Shear lug without stiffeners

(b) Post-installed shear lug with stiffeners

ACI 318-19 Updates

- Effective Moment of Inertia (Bischoff & Scanlon 2008)

Table 24.2.3.5 – Effective Moment of Inertia, I_e

Service Moment	Effective Moment of Intertia, I_e, in.[4]	
$M_a \leq 2/3\, M_{cr}$	I_g	(a)
$M_a > 2/3\, M_{cr}$	$\dfrac{I_{cr}}{1-\left(\dfrac{2/3 M_{cr}}{M_a}\right)^2\left(1-\dfrac{I_{cr}}{I_g}\right)}$	(b)

[CC004]

Other ACI 318-19 updates

- Introduction of shotcrete provisions
- Extensive addition to foundations Chapter 13 (to provide consistency with ASCE7-16)
- Lightweight concrete, values for λ based on equilibrium density
- Modulus of Elasticity, E_c, can be specified for proportioning concrete
- Direct Design Method, Equivalent Frame Method removed from Code (textbook material)
- Chapter 27 Load testing procedures modified to be consistent with ACI 437.2
- Updates and clarifications to Strut and Tie Methodology (STM)
- etc.

Questions ?

with thanks to ACI, Diego de Bedout, and Prof. J.K. Wight