



CONCRETE FOUNDATIONS ASSOCIATION

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ACI 332 - Past Chair ('04, '08, '10)
ACI 332-D Chair
ACI 380 Chair
ACI 551 Secretary
ACI C-655 Chair

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International Residential Code

National Standard
Chapter 4, 2021 Edition
Basic prescriptive standards
Requirements standardized for a broad market
Limited Design Variety

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An ACI Standard
Code Requirements for Residential Concrete (ACI 332-20) and Commentary
Referenced by ACI Committee 332

ACI 332-20

ACI 332-20

ACI 332 Standard

Referenced by the International Residential Code (IRC)

"...or comply with the applicable standards of ACI 318 or ACI 332..."

Section R402.2 (Materials)
Section R403.1 (Footings)
Section R404 (Walls)

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docs.legis.wisconsin.gov

Chs. SPS 320-325; Wisconsin Uniform Dwelling Code

- Statewide building code for one- and two-family dwellings
- Structures built since June 1, 1980.
- The Industry Services Division provides consultation and education concerning UDC construction standards and inspection procedures.
- Building materials are evaluated for conformance with standards.
- UDC inspection and contractor credentials are administered.
- The UDC is enforced in all Wisconsin municipalities.
- 2018 version > ACI 332-14 for concrete prescription

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An ACI Standard

Code Requirements for Residential Concrete (ACI 332-20) and Commentary

Reported by ACI Committee 332

ACI 332 Advantages


References for:

- Cold weather placement
- Footing excavations
- Wall jumps – footing discontinuity
- Footing spans
- Integrated footings
- Consolidation of wall requirements
- Increased design flexibility

and more...

ACI 332-20

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MEMBER INTEREST EDIT

	<u>Interest</u>	<u>Percent</u>
Academic/Educator		2%
Consultant		15%
Contractor		5%
Designer		23%
General Interest		12%
Producer		30%
Researcher		2%
User		7%

Committee 332 – Residential Concrete Work

- **Who we are**
- **50 members:**
 - 43 voting
 - 7 consulting

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We've been doing this for a while

- Code
- Mandatory language
- 2004 – 26 pages
- 2008 – 31 pages
- 2010 – 34 pages
- 2014 – 58 pages
- 2020 – 74 pages

- Guide
- Not mandatory language
- 1984 – 38 pages
- 2006 – 52 pages
- 2018 – 68 pages

Intent of Codes

R101.3 Intent. ...to establish minimum requirements to safeguard the public safety, health and general welfare through affordability, structural strength, means of egress facilities, stability, sanitation, light and ventilation, energy conservation and safety to life and property from fire and other hazards attributed to the built environment, and to provide safety to fire fighters and emergency responders during emergency operations.

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2020 Code Scope

- Most Significant Changes
 - Concrete requirements
 - Design of structural concrete
 - Footings
 - Foundation walls
 - Above-grade walls
 - Lintels
- Complements the prescriptive design

ACI 332-20

Material Interaction: Rebar Contaminants

- 4.2.4 Surface conditions of reinforcement—At the time concrete is placed, deformed bar and welded wire reinforcement shall be **free of materials deleterious to development of bond** strength between the reinforcement and the concrete.

R4.2.4 Common surface contaminants such as **concrete splatter, rust, form oil, or other release agents** have been found not to be deleterious to bond

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Table 5.1.1—Exposure categories and classes

Category	Severity	Class	Condition	Exposure class	
				RF freezing and thawing	RC protection of reinforcement
RF freezing and thawing	Not applicable	RF0	Concrete not exposed to freezing-and-thawing cycles		
	Moderate	RF1	Concrete exposed to moisture but not likely to be in a saturated condition when exposed to freezing-and-thawing cycles		
	Severe	RF2	Reinforced concrete exposed to moisture and with the potential of being in a saturated condition when exposed to freezing-and-thawing cycles		
	Very severe	RF3	Plain concrete exposed to moisture and deicing chemicals with the potential of being saturated when exposed to freezing-and-thawing cycles		
RC protection of reinforcement	Most severe	RF4	Reinforced concrete exposed to moisture and deicing chemicals with the potential of being saturated when exposed to freezing-and-thawing cycles		

Depending on exposure conditions, garage floors can be classified as RF0 to RF3, but not RF4.

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ACI 332-20 Minimum Concrete Provisions

ACI 332-20 CONCRETE AND SOILS COMMENTARY

Table 5.3.2—Concrete design requirements for exposure categories and classes

Exposure class	Maximum w/c	Minimum f_c' , psi	Additional minimum requirements
RF0	N/A	2500	Air content N/A
RF1	0.55	3000	Table 5.4.1 N/A
RF2	0.45	4500	Table 5.4.1 N/A
RF3	0.45	4500	Table 5.4.1 Table 5.4.2
RF4	0.40	5000	Table 5.4.1 Table 5.4.2

ACI 332-14

Table 5.3.2—Exposure categories and classes

Exposure class	Maximum (lb/m ³)	Minimum f_c' , psi	Notes
RF0	6	2500	
RF1	5	3000	
RF2	5	3500	
RF3	4	4000	

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Code Influence: Material Performance

Cold weather means the need for protection and the opportunity for better quality concrete.

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Code Influence: Material Performance

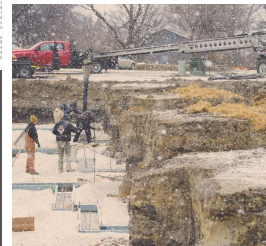
- 6.6.1 During anticipated ambient temperature conditions of 35 °F or less, concrete temperature shall be maintained above a frozen state until a concrete compressive strength of 500 psi has been reached.
- Frozen concrete wall (MN)




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Code Influence: Material Performance

- 6.6.2 – Concrete materials, reinforcement, forms, and any earth with which concrete is to come in contact shall be free from ice, snow and frost.
- 6.6.3 Frozen materials or materials containing ice shall not be used.



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Snow Insulates?

Contractor felt the snow would be melted from the forms...instead, it was pushed to one mound.

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Concrete Foundations Association of North America
Cold Weather Research Report 2004

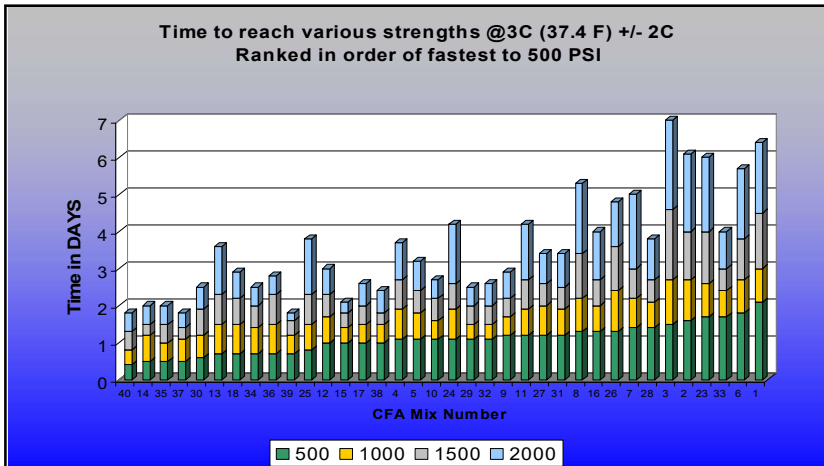


Cold Weather Research

- Referenced by ACI 332
- Referenced by ACI 306
- Only research specifically conducted on residential concrete foundation walls
- Validates mix design options
- Encourages use of Maturity

Research conducted by the Concrete Foundations Association (CFA) sheds new light on how foundation walls can be constructed in cold weather while addressing concerns for poor concrete performance.

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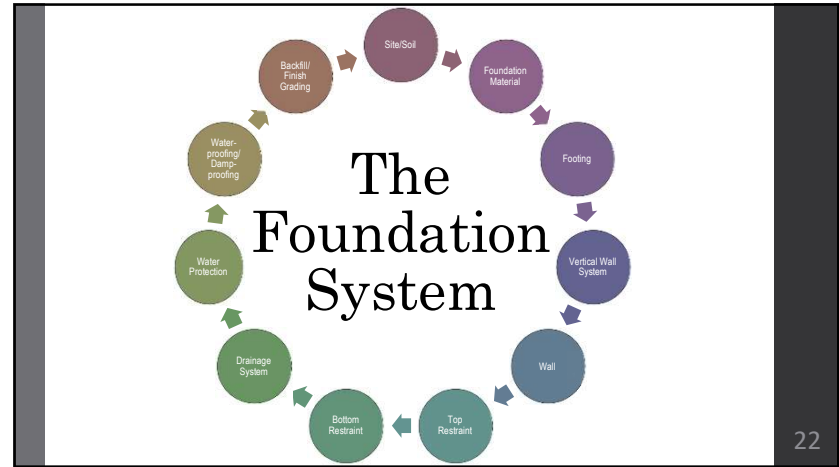


ACI 332 – Lateral Soil Load

- *The definition and classification of soil materials shall be in accordance with ASTM D2487.
- †Design lateral soil loads are given for moist conditions for the specified soils at their optimum densities. Actual field conditions shall govern. Submerged or saturated soil pressures shall include the weight of the buoyant soil plus the hydrostatic loads.
- ‡For relatively rigid walls, as when braced by floors, the design lateral soil load shall be increased for sand and gravel type soils to 60 psf per foot of depth. Basement walls extending not more than 10 ft below grade and supporting light floor systems are not considered as being relatively rigid walls.
- §Unsuitable as backfill material.

Description of backfill material	Unified soil classification	Design lateral soil load, lb./ft ² of depth	
		Active pressure [†]	At-rest pressure
Well-graded, clean gravels; gravel-sand mixtures	GW	30	60
Poorly graded clean gravels; gravel-sand mixtures	GP	30	60
Silty gravels, poorly graded gravel-sand mixtures	GM	40	60
Clayey gravels, poorly graded gravel-sand-silt mixtures	GC	45	60
Well-graded, clean sands; gravelly sand mixtures	SW	30	60
Poorly graded clean sands; sand-gravel mixtures	SP	30	60
Silty sands, poorly graded sand-silt mixtures	SM	45	60
Sand-silt clay mixture with plastic fines	SM-SC	45	100
Clayey sands, poorly graded sand-clay mixtures	SC	60	100
Inorganic silts and clayey silts	ML	45	100
Mixture of inorganic silt and clay	ML-CL	60	100
Inorganic clays of low to medium plasticity	CL	60	100
Organic silts and silt-clays, low plasticity	OL	§	§
Inorganic clayey silts, elastic silts	MH	§	§
Inorganic clays of high plasticity	CH	§	§
Organic clays and silty clays	OH	§	§

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Residential Concrete (ACI 332-20) and Commentary
Reported by ACI Committee 332

332-20

Footing Design & Construction

Isolated pads, continuous strip, trench, integrated slab, piers and pilings...a complicated system.

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24 RESIDENTIAL CODE REQUIREMENTS FOR STRUCTURAL CONCRETE (ACI 332-14) AND COMMENTARY

CODE COMMENTARY

Table 72.11.1 - Minimum exterior footing width for clear span and interior supported footing

Wall height capacity, psf	Roof live load, psf			
	20	30	50	70
1500	16	9.5	10	11
	24	9.5	10	11
	32	11	12	14
	40	11	12	14
3000	16	9.5	9.5	10
	24	9.5	9.5	10
	32	9.5	9.5	10
	40	9.5	9.5	10
4000	16	9.5	9.5	10
	24	9.5	9.5	10
	32	9.5	9.5	10
	40	9.5	9.5	10

Table 72.11.2 - Minimum exterior footing width for clear span and interior supported footing

Wall height capacity, psf	Roof live load, psf			
	20	30	50	70
1500	16	12	13	14
	24	14	15	16
	32	15	16	17
	40	15	16	17
3000	16	10	11	12
	24	10	11	12
	32	12	13	14
	40	12	13	14
4000	16	9.5	9.5	10
	24	9.5	9.5	10
	32	9.5	9.5	10
	40	9.5	9.5	10

ACI 332-20: Tables 8.6.1.a – f

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		Soil bearing capacity, psf															
		1500				2000				3000				4000			
		Maximum roof load: live load or snow load, psf															
		20 and below	21 to 30	31 to 50	51 to 70	20 and below	21 to 30	31 to 50	51 to 70	20 and below	21 to 30	31 to 50	51 to 70	20 and below	21 to 30	31 to 50	51 to 70
		Footings supporting roof only															
Plain ¹	L	2'-4"	2'-6"	2'-9"	3'-1"	2'-0"	2'-2"	2'-5"	2'-8"	1'-8"	1'-10"	2'-0"	2'-2"	1'-5"	1'-6"	1'-9"	1'-11"
	W	2'-4"	2'-6"	2'-9"	3'-1"	2'-0"	2'-2"	2'-5"	2'-8"	1'-8"	1'-10"	2'-0"	2'-2"	1'-5"	1'-6"	1'-9"	1'-11"
	D	1'-2"	1'-3"	1'-5"	1'-7"	1'-0"	1'-1"	1'-3"	1'-4"	1'-5"	1'-5"	1'-0"	1'-1"	1'-0"	1'-3"	0'-11"	1'-6"
	R ²	(2)-#3	(2)-#3	(3)-#3	(3)-#3	(2)-#3	(2)-#3	(2)-#4	(2)-#3	(2)-#3	(3)-#3	(2)-#3	(2)-#3	(2)-#3	(2)-#3	(2)-#3	(2)-#3
Reinforced	L	2'-4"	2'-6"	2'-9"	3'-1"	2'-0"	2'-2"	2'-5"	2'-8"	1'-8"	1'-10"	2'-0"	2'-2"	1'-5"	1'-6"	1'-9"	1'-11"
	W	2'-4"	2'-6"	2'-9"	3'-1"	2'-0"	2'-2"	2'-5"	2'-8"	1'-8"	1'-10"	2'-0"	2'-2"	1'-5"	1'-6"	1'-9"	1'-11"
	D	0'-8"	0'-9"	0'-9"	0'-10"	0'-8"	0'-9"	0'-10"	0'-8"	0'-9"	0'-9"	0'-9"	0'-9"	0'-8"	0'-8"	0'-9"	0'-9"
	R ²	(2)-#3	(2)-#3	(3)-#3	(3)-#3	(2)-#3	(2)-#3	(2)-#4	(2)-#3	(2)-#3	(3)-#3	(2)-#3	(2)-#3	(2)-#3	(2)-#3	(2)-#3	(2)-#3
		Footings supporting roof and single floor															
Plain ¹	L	3'-2"	3'-4"	3'-7"	3'-9"	2'-9"	2'-11"	3'-1"	3'-3"	2'-3"	2'-5"	2'-6"	2'-8"	1'-11"	2'-1"	2'-2"	2'-4"
	W	3'-2"	3'-4"	3'-7"	3'-9"	2'-9"	2'-11"	3'-1"	3'-3"	2'-3"	2'-5"	2'-6"	2'-8"	1'-11"	2'-1"	2'-2"	2'-4"
	D	1'-7"	1'-8"	1'-10"	1'-11"	1'-5"	1'-6"	1'-7"	1'-8"	1'-2"	1'-3"	1'-3"	1'-4"	1'-0"	1'-1"	1'-1"	1'-2"
Reinforced	L	3'-2"	3'-4"	3'-7"	3'-9"	2'-9"	2'-11"	3'-1"	3'-3"	2'-3"	2'-5"	2'-6"	2'-8"	1'-11"	2'-1"	2'-2"	2'-4"
	W	3'-2"	3'-4"	3'-7"	3'-9"	2'-9"	2'-11"	3'-1"	3'-3"	2'-3"	2'-5"	2'-6"	2'-8"	1'-11"	2'-1"	2'-2"	2'-4"
	D	0'-10"	0'-10"	0'-10"	0'-9"	0'-9"	0'-10"	0'-10"	0'-9"	0'-10"	0'-10"	1'-0"	0'-9"	0'-10"	0'-10"	0'-10"	0'-10"
		Footings supporting roof and two floors															
Plain ¹	L	3'-6"	3'-7"	3'-9"	3'-11"	2'-10"	2'-11"	3'-1"	3'-3"	2'-6"	2'-7"	2'-8"	2'-9"				
	W	3'-6"	3'-7"	3'-9"	3'-11"	2'-10"	2'-11"	3'-1"	3'-3"	2'-6"	2'-7"	2'-8"	2'-9"				
	D	1'-11"	1'-11"	1'-11"	1'-11"	1'-11"	1'-11"	1'-11"	1'-11"	1'-11"	1'-11"	1'-11"	1'-11"				
Reinforced	L	3'-6"	3'-7"	3'-9"	3'-11"	2'-10"	2'-11"	3'-1"	3'-3"	2'-6"	2'-7"	2'-8"	2'-9"				
	W	3'-6"	3'-7"	3'-9"	3'-11"	2'-10"	2'-11"	3'-1"	3'-3"	2'-6"	2'-7"	2'-8"	2'-9"				
	D	0'-10"	0'-10"	0'-10"	0'-9"	0'-9"	0'-10"	0'-10"	0'-9"	0'-10"	0'-10"	1'-0"	0'-9"	0'-10"	0'-10"	0'-10"	0'-10"

ACI 332-20:
Tables 8.6.1.g – h

Detailing Footings:

ACI 332 8.2.4 – Unsupported Footings

8.2.4.1 Trenches under footings shall be backfilled to prevent movement of the adjacent soil and compacted to match the adjacent soil conditions

8.2.4.2 Where an unsupported wall footing section does not exceed a 3 ft span, at least two No. 4 reinforcing bars shall be securely positioned in the bottom of the footing and extend at least 18 in. into the supported sections on both sides. Reinforcing bars shall have a cover as specified in 5.6.4.

Fig. 4.3.8.1b—Footing splicing gap. (Note: 1 in. = 25.4 mm.)

Fig. 4.3.8.1c—Penetration or reduced thickness of a concrete footing and required reinforcement. (Note: 1 in. = 25.4 mm.)

Continuous Footings:

- IRC – R403.1 – All exterior walls shall be supported on continuous solid...concrete footings.
- ACI 332 – 8.2.5

ACI 332-20 Footing Requirements

8.2.5 Maximum length of discontinuity 4 feet

The walls must be designed for the span

The footing around the discontinuity shall bear on at least 4 feet of undistributed soil

Typical additional discontinuity wall reinforcement:

- 2 - #4 reinforcement bars across the bottom
- 1 - #4 reinforcement bars across the top

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Code Requirements for Residential Concrete (ACI 332-20) and Commentary

Reported by ACI Committee 332

ACI 332-20

ACI 332-14 Foundation Wall Structure:

9.2.7 - Horizontal Reinforcement

- All walls must have horizontal reinforcement.
- Vertical rebar is placed on the inside.
- 3 horizontal bars are needed if the wall 8 feet or less in height
- 4 horizontal bars if the wall is more than 8 feet high
- 1 bar in the upper 24 in. and 1 bar in lower 24 in., except SDC D, E and F (2 in upper 24 in.)

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ACI 332 – Wall Design Tables

Combined tables for plain and reinforced originated in 2004 edition

- Ten (10) tables for concrete strengths from 2,500 psi to 4,500 psi at steel strengths of 40 and 60 ksi
- Significant departure from IRC design tables
- Wall heights up to 10-ft.

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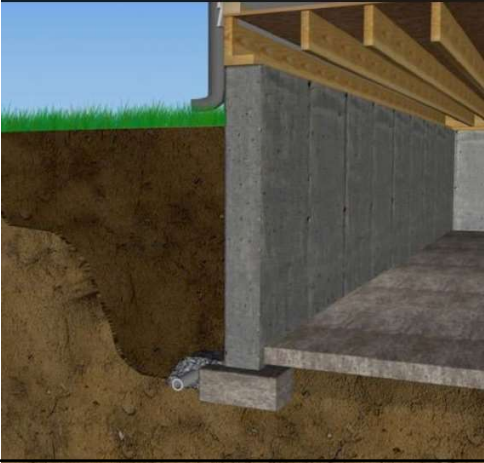
Wall Design Tables:

2,500 psi 4,500 psi

Reinforcing bar spacing for solid concrete foundation walls

Maximum clear wall height, ft	f'c (psi) = 2500	Maximum equivalent fluid pressure of soil, psf-ft											
		Wall thickness, in						Wall thickness, in					
		30		45		60		45		60			
1	50,000	Reinforcing bar spacing, in											
		8	10	12	8	10	12	8	10	12	8	10	12
3	50,000	Reinforcing bar spacing, in											
		8	10	12	8	10	12	8	10	12	8	10	12
5	50,000	Reinforcing bar spacing, in											
		8	10	12	8	10	12	8	10	12	8	10	12
7	50,000	Reinforcing bar spacing, in											
		8	10	12	8	10	12	8	10	12	8	10	12
9	50,000	Reinforcing bar spacing, in											
		8	10	12	8	10	12	8	10	12	8	10	12

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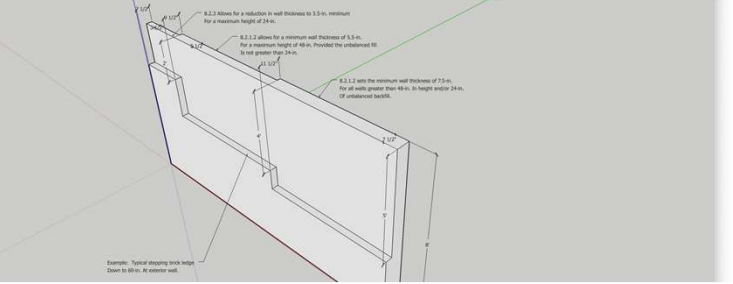


ACI 332 -20
Wall
Detailing



Reduced Wall Thickness:
Getting brick to grade for the homeowner.

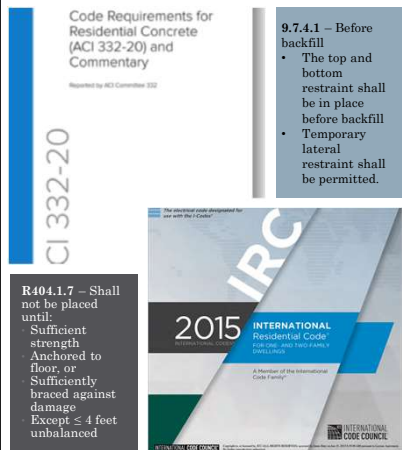
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ACI 332-14

- Increasing Reduced Wall Thickness Height

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Code Requirements for Residential Concrete (ACI 332-20) and Commentary

9.7.4.1 – Before backfill

- The top and bottom restraint shall be in place before backfill
- Temporary lateral restraint shall be permitted.

Backfill:



R404.1.7 – Shall not be placed until:
Sufficient strength
Anchored to floor, or
Sufficiently braced against damage
Except ≤ 4 feet unbalanced

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Code Requirements for Residential Concrete (ACI 332-20) and Commentary
Reported by ACI Committee 332

332-20


Surface Irregularities:

9.7.3 – fins or projections greater than 0.5 in. shall be removed to prevent interference with waterproofing systems or interior finishes.

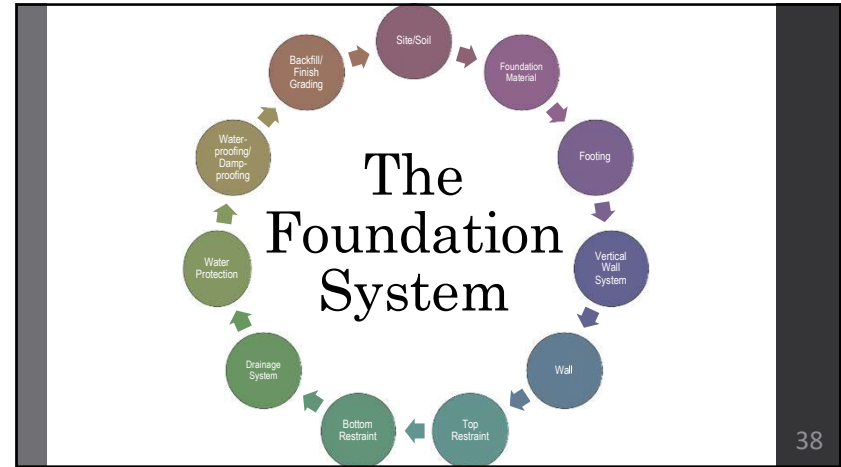
R9.7.3 Remove fins or other projections

- to prevent interference with dampproofing and waterproofing systems
- to prevent interference with interior finish systems where the wall surface encloses occupied space.

IRC does not address irregularities.



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Final Questions?

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