



High Strength Welded Wire Reinforcement for High Performance Concrete

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Spring Convention April 17-21, 2016
Hyatt & WI Centre C-202E– Milwaukee, WI
Tue. 4-19-2016 1:30-3:30 PM Session



Overview – Learning Objectives

- Brief History of High Strength Welded Wire Reinforcement
- How is HS WWR Made
- Why the recent need/interest in HS Reinforced Materials
- Details and uses of HS WWR
- Where we are headed with HS WWR.



Brief History Wire & HS

- FIRST PATENT'S ISSUED FOR WWF/WWR 1901.
- EXTENSIVE USE IN BUILDING FLOORING SYSTEMS OF MANY SKYSCRAPERS IN Early to Mid-1900's.
- MUCH USE OF IN BUILDING INTERSTATE HIGHWAY SYSTEM OF THE 1950's, & 1960's.
- BEGAN RESEARCH & TESTING OF HIGHER STRENGTH WIRE IN THE 1950's & 1960's [PCA research, ...others]?!]
- FIRST APPEARING IN CODE AS (Grd. 80 ksi) in 1977 ACI 318 CODE. & IN ASTM CODES IN 1970's.

How is HS WWR Made

- We can get multiple grades from the same rod size (Grd. 60, 65, 70, 75, 80, etc.).
- With more cold working (drawing), the more reduction in area, the higher the wire strength.
- The Mfg. limits the amount of cold working – draw down – we can do to a %(25-50) in area of original wire rod.



VIDEO OF ROD ROLLING – ~120s~4400 LBS.



PLOT AS IN ACI-'WWR GUIDE'

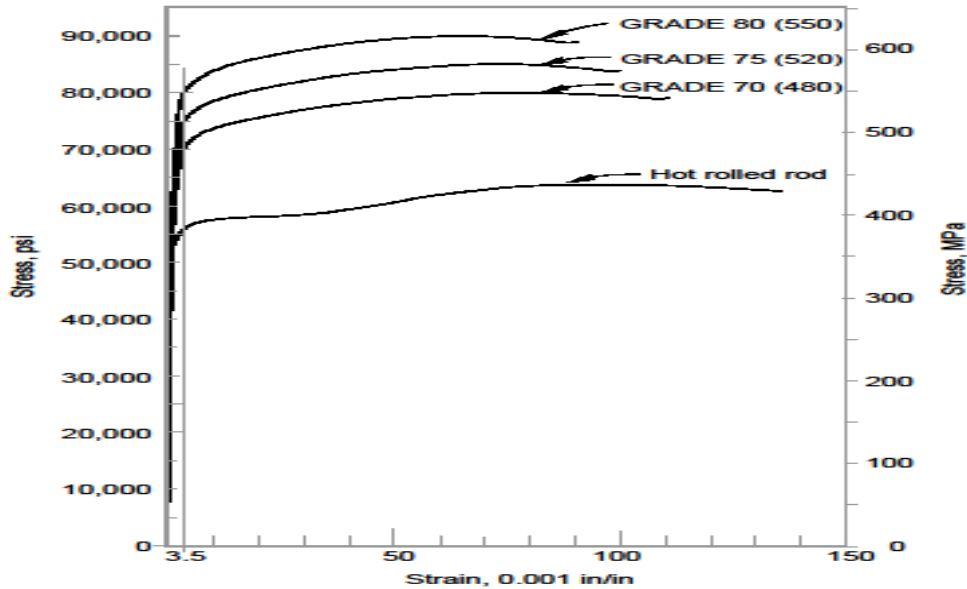


Figure 3.2 Idealized stress-strain curves for ASTM A 1064 / ASTM 1064M wire



Chart/plot to illustrate this -!

W-Rod Size-dia in (mm)	Rod Chemistry AISI/SEA 10XX	Rod Area/Dia. in ² /100 (mm ²)/ Dia., in (mm)	% elongation % reduction	WWR Grade-ksi (Mpa)
3/4" (19)	1012-1018	D31 (MD200) 0.625 (15.9)		100 (689) 80 (551) 70 (482) 60 (414)
5/8" (15.9)	(1008)			
11/16" (17.5)	1012-1018	D25 (MD161) 0.561 (14.25)		100 (689) 80 (551) 70 (482) 60 (414)
9/16" (14.3)				
5/8" (15.9)	1012-1018	D20 (MD130) 0.504 (12.8)		100 (689) 80 (551) 70 (482) 60 (414)
1/2" (12.8)	(1008)			
9/16" (14.3)	1012-1018	D15 (MD97) 0.437 (11.1)		100 (689) 80 (551) 70 (482) 60 (414)
7/16" (11.1)				
1/2" (12.8)	1012-1018	D11 (MD71) 0.374 (9.5)		100 (689) 80 (551) 70 (482) 60 (414)
3/8" (9.5)				
5/16" (7.9)	1012-1018	D4 (MD26) 0.226 (5.7)		100 (689) 80 (551) 70 (482) 60 (414)
1/4" (6.35)				

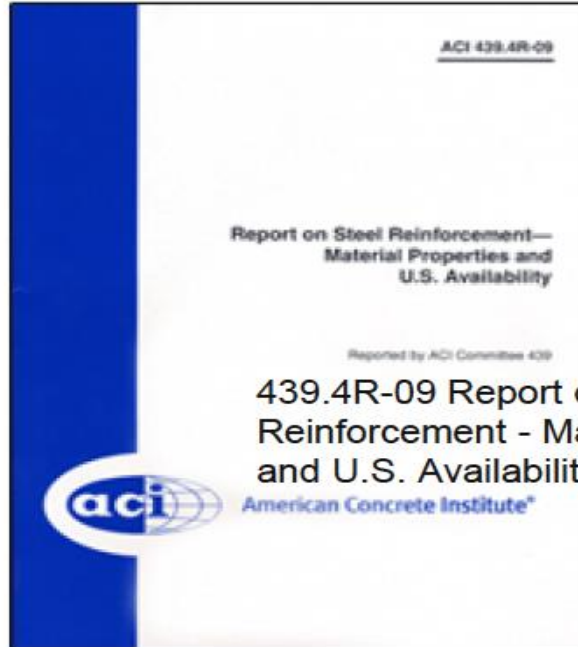
Cold working - Drawing

- Strength depends on chemistry, rod size, and amount of drawing going into rod...
- Limits from drawing of rod (wire)?!
 - For HS barbwire fencing 150-170 ksi (1045)
 - For Strand 250-270 ksi



Comparing Product Chemistry Reinforcing Products-all different

- Chemistry variably even bar, wire sizes.
- Ref. ACI 439.2R “Report on Steel Reinf. Material Properties & U.S. Availability”



439.4R-09 Report on Steel Reinforcement - Material Properties and U.S. Availability

American Concrete Institute®

[↓ Description\(Abstract\)](#)



CHART SHOWING REINF. PRODUCTS VARIABLE CHEMISTRY

ACI 439.2R ksi (MPa) ASTM-spec.	AIS/SEA	Eng. (SI) size	Reinf. Chemistry Chemical Element Comp. (%)							App. X-X
			carbon	Manganese	phosphorus	Sulfur	Silicon	Nitrogen	Chromium	
A615,-M Bar 60,75,80 (420,520,550)		#3 (10)	0.38-0.45	0.85-0.95	0.035	0.045	0.2-0.3			
		#4 (13)								
		#5 (16)								
		#7 (22)	0.39 [Ni-0.13]	1 [Mo-0.038]	0.018 [Cu-0.39]	0.037 [CE-0.56]	0.39 [V-0.0]		0.2	
		#11 (36)								
A706,-M Bar 60,75,80 (420,520,550)		#3 (10)	.26-.30	1.2-1.3	0.035	0.045	0.2-0.3		0.19	
		#4 (13)								
		#5 (16)								
		#7 (22)	0.28 [Ni-0.09]	1.18 [Mo-0.02]	0.028 [Cu-0.29]	0.028 [CE-0.48]	0.17 [V-0.24]			
		#11 (36)								
A1064,-M Wire 60,75,80 (420,520,550)	1008	Welded grade	.06-.10	0.3-0.5	0.025	0.03	0.1-0.18	<0.012		
	1026	W/D4-W/D31	[Ni-<0.20]	[Cr-<0.20]	[Mo-<0.08]	[Cu-<0.80.]	[V-<0.002]			
	1008	Drawing grade	.06-.10 [Ni-<0.08]	0.3-0.5 [Cr-<0.08]	0.025 [Mo-<0.02]	0.03 [Cu-<0.75]	0.1-0.18 [V-<0.002]	<0.009		
A1035,-M Bar 100,120 (690,830)	91X0	#3 (10)	0.15	1.5	0.035	0.045	0.5	0.05	8.0-10.9	
	41X0	#4 (13)	0.2						4.0-7.9	
	21X0	#5 (16)	0.3						2.0-3.9	
		#8 (25)								
		#11 (36)								
Strand A416,+ 250,270 (1725,1860)										



Why The Recent Need/Interest in HS Reinforced Materials

- Higher Strengths of concrete mixes [>40 ksi].
 - in 1960's [>5 ksi]; thru 1980's [>10 ksi]; now [>20 ksi]. NC(3-10), HSC(10-20), UHPC(20-40+, 42).
- Need for greater load resistance at service conditions.
- More emphasis on performance and resiliency of finished product - LCC. Better maintenance & service life.
- Reduce congestion at critical sections (25%+)

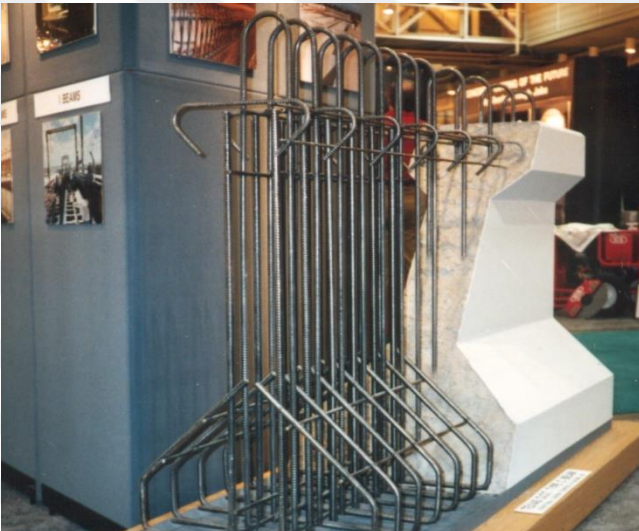
How Can HS WWR Help?

- Prefabricated cages – can help save time and labor cost in assembly [on site or precast]
- Higher strengths – where is the limit?!
- Reduce congestion – provide relief in tight areas
- Design Aids www.wirereinforcinginstitute.org

Details & Uses for HS WWR-Transp.

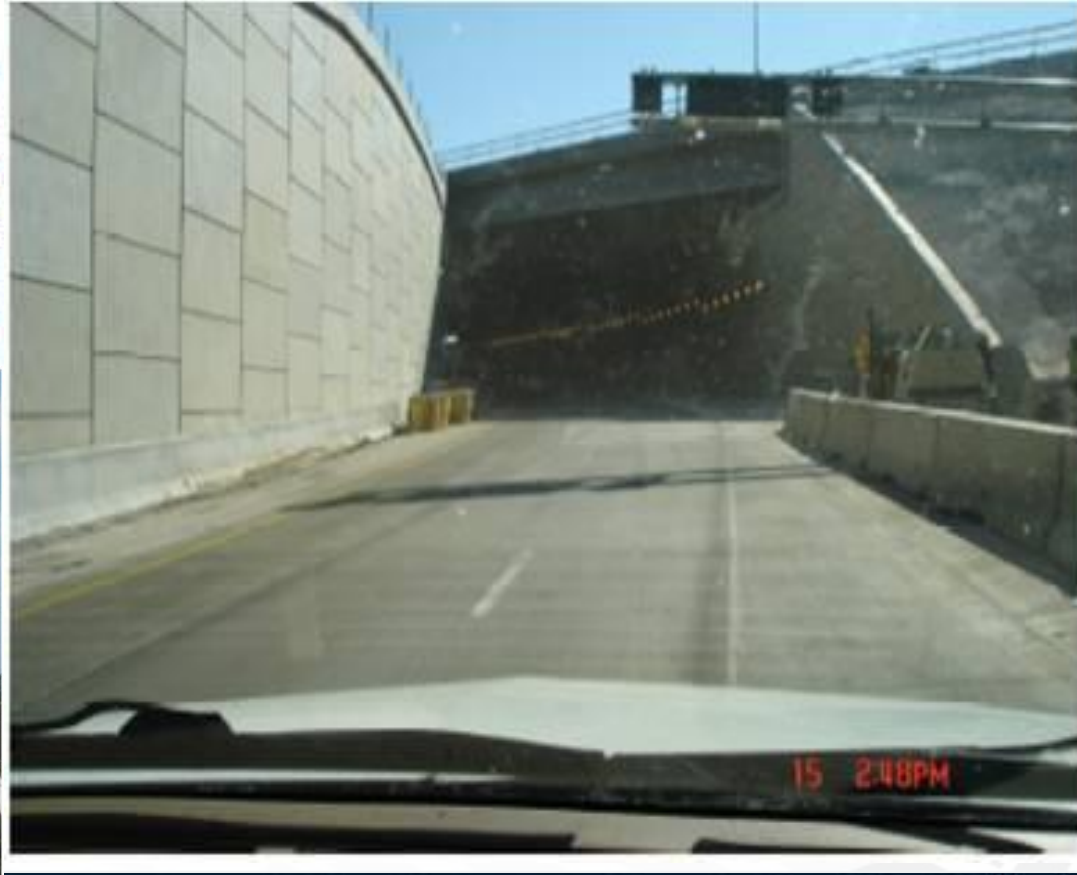
- In Precast Bridge Beams & Elements:
 - I-Beams or T-beams, box beams, etc.
 - Piers Sections, foundations
 - Retaining Walls, Abutments, MSE Walls
 - Precast Pavement Sections
- In Box Culverts or RC Pipe – CIP or Precast

Product Examples – P_C / CIP





Other Transportation photos



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and Exposition

Details & Uses for HS WWR Bldgs.

- In Precast Elements:
 - Inv.-T-beams, Dbl-T's, columns
 - Retaining Walls, MSE Walls
 - Precast Wall Panels – Facing panels, structural
 - Tilt-up Panels
- CIP components:
 - Foundations
 - Slabs, Elevated Decks, etc

Bldg. Photos ??



The Concrete Convention
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Where is HS WWR Headed?

- Testing to reach higher strengths...limits?!
- Updating on-line design aids at WRI website.
- ACI soon to publish 'WWR design/construction guide.' ACI 439.3R.
- Wire Specifications now all in a Standard
 - ASTM A1064 – 4 prior archived.
 - AASHTO – in process to combine into one.



Summary & Conclusions

- WWF/WWR has been around >110 yrs.
- HS WWR (~80 ksi) >50 yrs.
- Can be used in many products to expedite process and time to delivery.
- Beginning testing to determine limits of WWR.
- Updating Codes, Standards, Design Aids to assist concrete industry in building better products.



Thanks, Any Questions????

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