Methods for Measuring Yield Stress

**Observed Yield Point (YP)**

- **Offset Method (OM)**

- **Extension Under Load (EUL)**

Symbols:
- \( R_y \) = Yield Stress
- \( O \) = Strain
- \( Om \) = Specified Offset
- \( Om = \) Specified Extension Under Load
When did ACI 318 first specify a method?

- ACI 318-63: “When reinforcement is used that has a yield strength, $f_y$, in excess of 60,000 psi, at a proof stress equal to the specified yield strength, $f_y$, the strain does not exceed 0.003.”
  - The “exception” can be associated with the progression to USD (ultimate strength design) because, in ACI 318-63, the “exception” applied only to members designed using the USD method.
- ACI 318-71: “For reinforcing bars with a specified yield strength, $f_y$, exceeding 60,000 psi, $f_y$ shall be the stress corresponding to a strain of 0.35 percent.”
  - This is based on the recommendations of a 1968 “Ad Hoc Group on Reinforcement.”
- ACI 318-14: Currently anticipated to be essentially the same.
  - However, a code change submittal currently under ballot proposes to change to the 0.2% offset method

Arguably, Code Provision is Obsolete

This provision first appeared about 50 years ago, and is based on actual stress-strain behavior of bars as manufactured in the 1960s.

Much has changed since then: manufacturing processes are different, and numerous other reinforcement products now included; these other products have differing stress-strain behaviors.

Time has come to change the yield method provisions within ACI 318.
Circa 1963 Actual Stress Strain Curves

- Grade 75 ASTM A431 bars never exhibited a distinct yield point
- Grade 60 ASTM A432 bars exhibited in-between stress-strain behavior
- Grade 40 ASTM A15 bars were always sharply-yielding materials

ACI 318 Ad Hoc Group on Reinforcement

- In early 2013, the records of “Ad Hoc Group on Reinforcement” were found in the committee correspondence archives at ACI headquarters
- The ad hoc group appears to have operated during 1966, 1967, 1968
- “DRAFT of a Report” issued March 8, 1967
- “Report” issued April 10, 1967
- 1967 and 1968: Interaction with ASTM committees and follow-up laboratory testing; ad hoc group expanded in size at that time to include steel producers and others
Circa 1960s measurement technology could explain why the Ad Hoc Group didn’t simply recommend using the 0.1% offset method. It would have required what was at that time specialty instrumentation to make offset strain measurements on rebar. Rebar rolling mills would quite likely not have that kind of instrumentation.

ACI 318-71

ACI 318-71: Representative behavior of actual bars from the era

GR80 not considered because of no commercial production

Ad-hoc group recommendation

ASTM spec method of 0.5%EUL was maintained because of shape of actual A615 GR60 stress-strain behavior

GR40 was always sharply yielding; ASTM spec method of Yield Point prevailed
Brief Historical Overview of Yield Strength Determination in ACI 318

October 20, 2013

ACI 318-08

Curves characterized on assumed coiled bar behavior

ASTM Specs during 2008 & 2009

ASTM Specs A615 and A706
[-08a, -08b, -09, -09a]
Never adopted into ACI 318 Code
Not shown here:
GR100 and GR120 measured at 0.2% offset;
Wire products measured at either 0.5%EUL or 0.35%EUL

ACI 318-14 Proposed Code Change CB006
“Roundhouse” only a few percent...

97% to 98% of circa 2013 steel bar reinforcement is sharply-yielding

Only 2% or 3% of steel bar reinforcement is “roundhouse”