What You Are Not Taught In College !!

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Definition

"Structural engineering is the art of molding materials we do not wholly understand, into shapes we cannot fully analyze, so as to withstand forces we cannot really assess, in such a way that the community at large has no reason to suspect the extent of our ignorance."

... Dr. E. H. Brown, 1967

Materials We Do Not Wholly Understand

- ✓ Archeologists have discovered concrete dating to 6500 BC.
- ✓ That concrete was cracked.
- ✓ Today, more than 8,500 years later, concrete still cracks.
- ✓ We can't yet accurately calculate creep or shrinkage.
- ✓ The use of reinforced concrete dates back to 1848.
- ✓ For 170 years, we have struggled to define rebar development length.
- ✓ The criteria change and become more complex with every code cycle.
- ✓ A single page in 1963 has grown into 30+ pages today.

Shapes We Cannot Fully Analyze

- ✓ Before computers, practicing engineers assumed that connections were either rigid or pinned.
- ✓ With computers, practicing engineers still assume that connections are either rigid or pinned.
- ✓ In reality, nearly all connections are semi-rigid, meaning that some joint deformation takes place.
- ✓ Except in research, joint deformation is usually ignored.

Forces We Cannot Really Assess

- ✓ Prescriptive live loads vary widely from actual live loads.
- ✓ The most enigmatic loads are caused by environmental conditions.
- ✓ We mostly use static approximations for these dynamic phenomena.
- ✓ 50 years ago, codes addressed all loads in just a few pages.
- ✓ For example, wind loads were addressed in just 2 pages.
- ✓ Today, ASCE-7 is 600+ pages, with about 120 pages on wind.
- ✓ Engineers are taught to follow the code criteria to the letter.
- ✓ Mother Nature continues to ignore the code criteria.

The Extent Of Our Ignorance

- ✓ How many digits are truly significant?
- ✓ Slide rules allowed calculations to only 3 digits.
- ✓ Today, computers provide calculations with very high precision.
- ✓ Nevertheless, only 3 digits are significant today.
- ✓ For example: f'_c = 4 Ksi, U = 1.2D + 1.6L, and Ø = 0.90

Preparing For SE Practice

- ✓ Polish your verbal and written communication skills.
- ✓ Master the core analysis and design courses … avoid shortcuts.
- ✓ Gain some applicable experience as an intern.
- ✓ Earn a Masters Degree before leaving college.*
- ✓ Pass the FE Exam and the 16-Hour SE Exam.*
- ✓ Thoroughly evaluate your career and employment options.

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Advice For Young Engineers

- ✓ Mind the gap.*
- ✓ Ensure stability.*
- ✓ Design first, then compute.
- ✓ Be a sponge.
- ✓ Spend time at the jobsite.
- ✓ Own your work.
- ✓ Love your profession.

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Load Paths

- ✓ Load paths define how your carefully calculated vertical and lateral loads find their way to the foundation of your structure.
- ✓ Structures can and do fail due to gaps in load paths.
- ✓ Track your load paths manually, not on your computer.
- ✓ It is all about first principles, not codes and standards.
- ✓ Code compliance alone is not always adequate.
- ✓ Unlike humans, Mother Nature always chooses the path of most resistance (regardless of your design intent).

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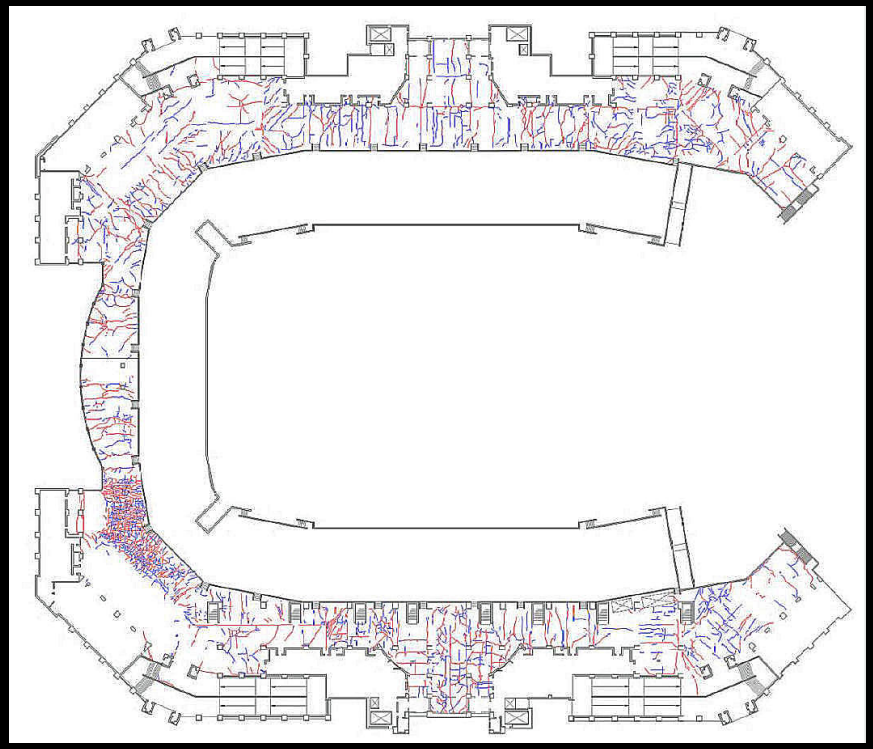
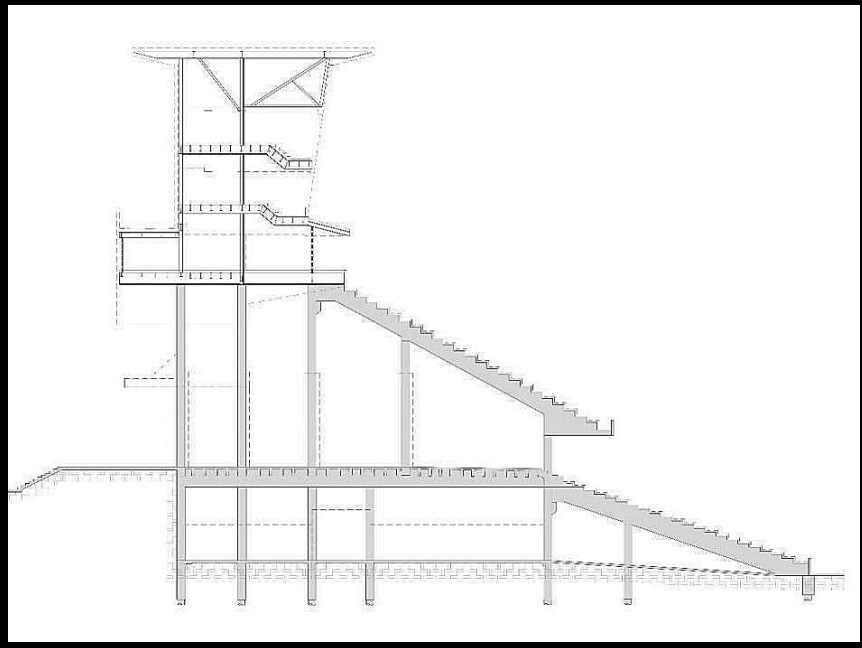
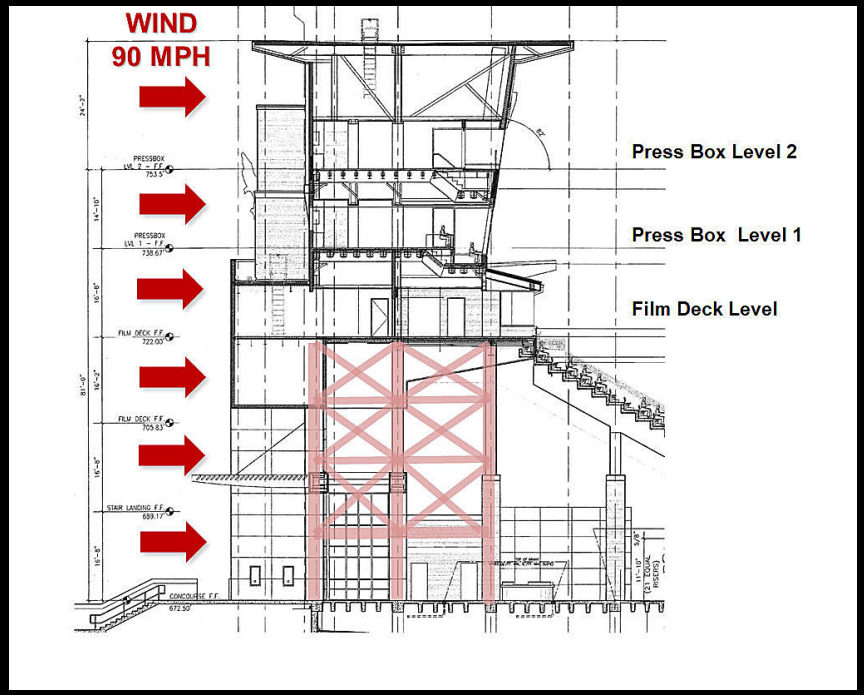


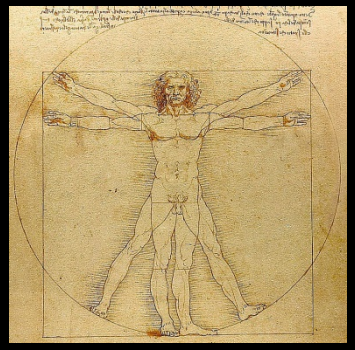


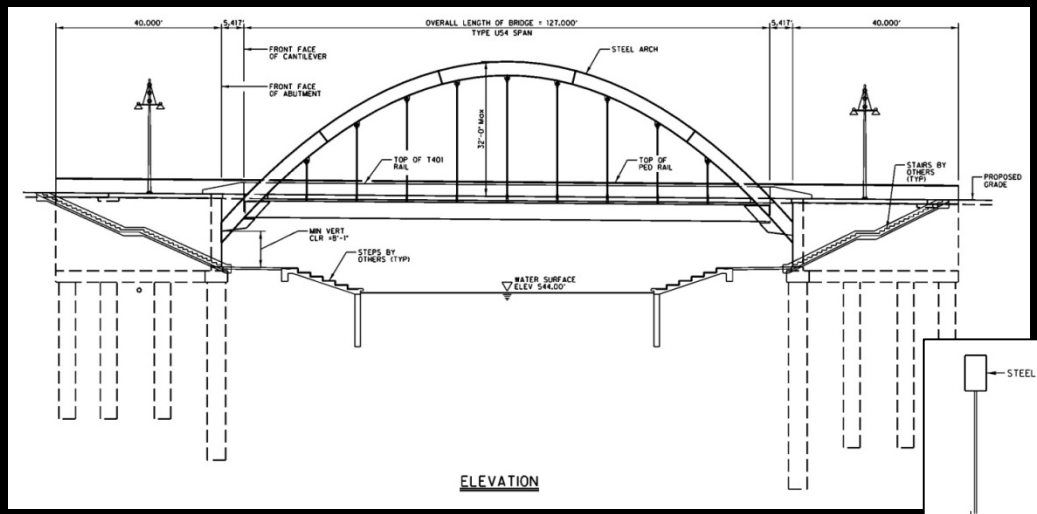

WIND
90 MPH
Press Box Level 2
Press Box Level 1
Film Deck Level

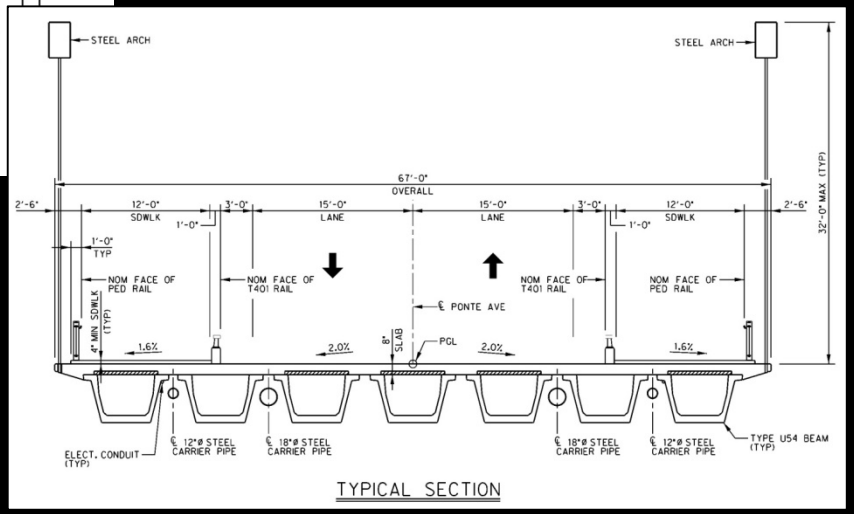

PLAY LIKE A

Vitruvius: 75 BC – 15 BC

- ✓ Roman author, architect, civil and military engineer
- ✓ Wrote a multi-volume book,
- ✓ *De Architectura*
- ✓ Discussed perfect proportion in structures and the body




40.000'
5.417'
OVERALL LENGTH OF BRIDGE = 127.000'
TYPE U54 SPAN
5.417'
40.000'
FRONT FACE OF CANTILEVER
FRONT FACE OF ABUTMENT
STEEL ARCH
32'-0" Max
TOP OF T401 RAIL
TOP OF PED RAIL
STAIRS BY OTHERS (TYP)
PROPOSED GRADE
MIN VERT CLR =15'-1"
STEPS BY OTHERS (TYP)
WATER SURFACE ELEV 544.00'
ELEVATION


STEEL ARCH
STEEL ARCH
67'-0"
OVERALL
2'-6"
12'-0"
SDWLK
1'-0"
3'-0"
15'-0"
LANE
15'-0"
LANE
3'-0"
1'-0"
12'-0"
SDWLK
2'-6"
32'-0" MAX (TYP)
1'-0"
TYP
NOM FACE OF PED RAIL
NOM FACE OF T401 RAIL
℄ PONTE AVE
NOM FACE OF T401 RAIL
NOM FACE OF PED RAIL
4" MIN SDWLK (TYP)
1.6%
2.0%
8" SLAB
PGL
2.0%
1.6%
ELECT. CONDUIT (TYP)
℄ 12"ø STEEL CARRIER PIPE
℄ 18"ø STEEL CARRIER PIPE
℄ 18"ø STEEL CARRIER PIPE
℄ 12"ø STEEL CARRIER PIPE
TYPE U54 BEAM (TYP)
TYPICAL SECTION

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Stability

- ✓ Structures can and do fail due to instability.
- ✓ Instability can take many forms, in steel structures and also in concrete structures.
- ✓ Instability can cause failures during or after construction.

Failure Mode	AISC Code	Required (A)	Provided (B)	Ratio 24" Soil (A/B)	Ratio 36" Soil (*)
Lateral-Torsional	LRFD	251 FK	190 FK	1.32	1.65
Buckling	ASD	51 Psi	33 Psi	1.54	1.96
Flange: Local	LRFD	210 K	76.1 K	2.76	3.45
Bending	ASD	162 K	50.6 K	3.20	4.06
Web: Local	LRFD	210 K	152 K	1.38	1.73
Yielding	ASD	162 K	101 K	1.60	2.03
Web: Local	LRFD	210 K	140 K	1.50	1.88
Crippling	ASD	162 K	93.1 K	1.74	2.21
Web: Local	LRFD	210 K	64.7 K	3.25	4.06
Compression Buckling	ASD	162 K	43.1 K	3.76	4.78

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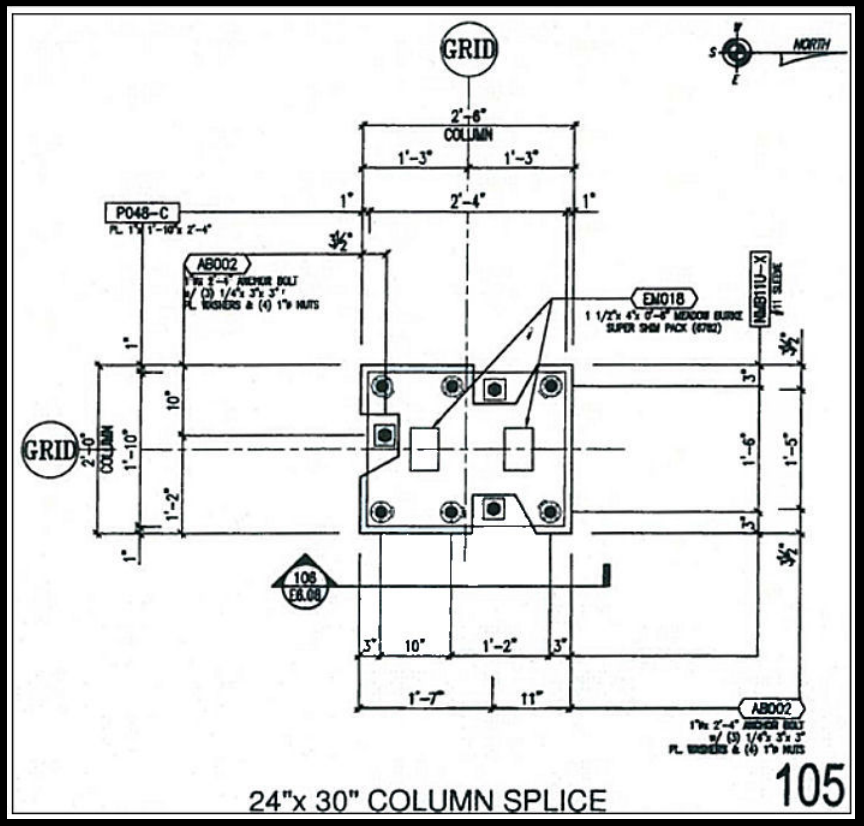
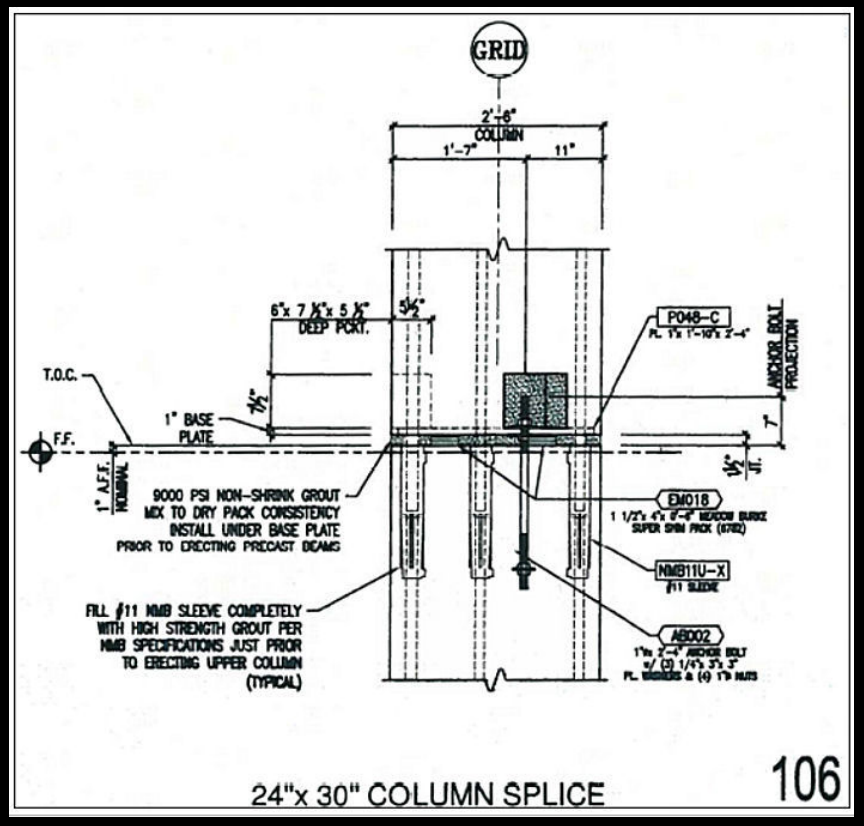
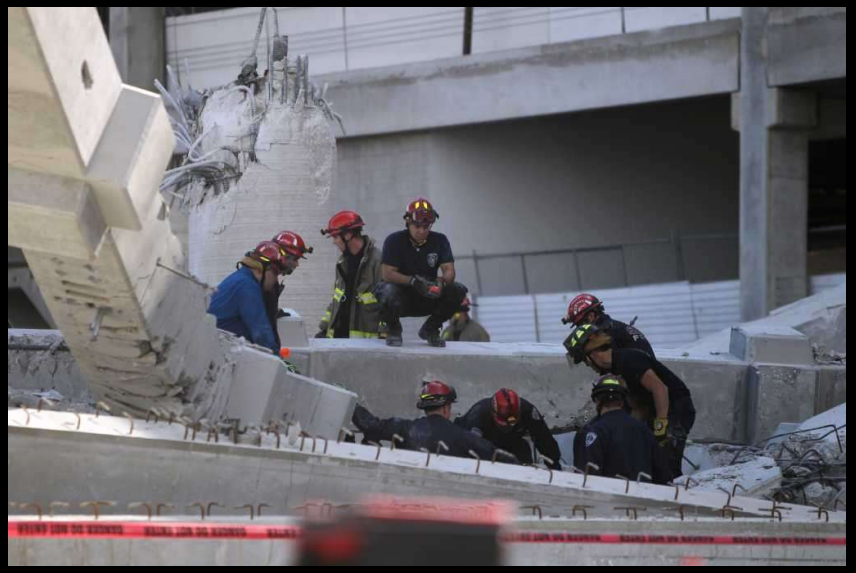


24"x 30" COLUMN SPLICE 105



24"x 30" COLUMN SPLICE 106

Security Camera Video



SEs Love Computers

- ✓ 1970s: First to use computers for stress analysis
- ✓ 1980s: First to use computers for steel and concrete design
- ✓ 1990s: Among the first to transition to CAD
- ✓ 2000s: Emerged as leaders in BIM
- ✓ 2010s: Actively experimenting with paperless projects
- ✓ Then: Fully automated structural engineering services*
- ✓ Finally: Possible obsolescence for yet another profession*

Fully Automated SE Services

- ✓ Complete, seamless integration of:
- ✓ 3D design software with 3D CAD and 4D/5D BIM software;
- ✓ Cloud-based databases with site-specific code requirements, environmental loads, and real-time costs and schedules;
- ✓ And a relatively simple and intuitive user interface.
- ✓ Then, a "designer" can enter a few basic parameters, push the "Easy Button", and choose a preferred design from the results.

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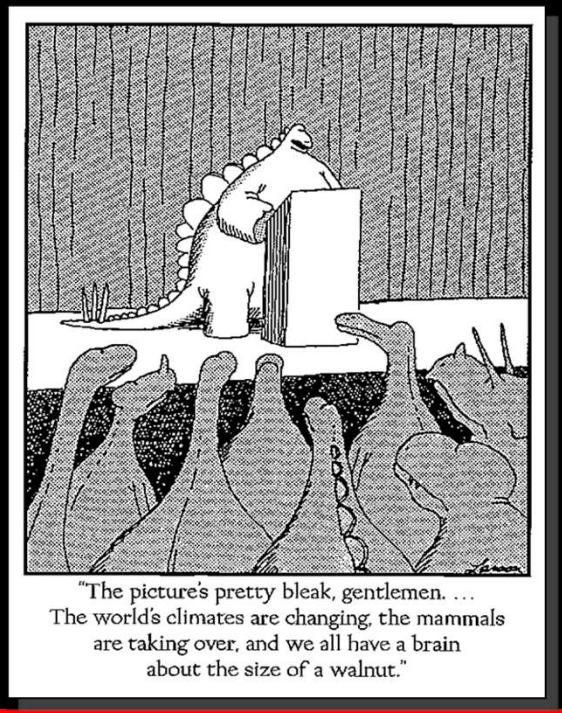
The Path To Obsolescence

- ✓ Today, most SEs spend their time designing beams, columns, frames, etc.
- ✓ They do not lead their project teams, their firms, the profession, or society.
- ✓ Being risk averse, they seldom innovate and believe that good, code-compliant design work is their highest calling.
- ✓ Within 20 years, these SEs will be just as obsolete as bank tellers, telephone operators, travel agents, and encyclopedia salesmen.
- ✓ Most traditional SE work will have been replaced by automation and/or outsourced to low-cost providers overseas.
- ✓ Without change, the SE profession in the USA is projected to shrink 80%.

Where Do We Go From Here?



"The picture's pretty bleak, ladies and gentlemen …
The construction business is changing, the computers
are taking over, and we all have a brain
about the size of a grapefruit."

The Path Forward

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The Vision For The Future

- ✓ The profession will be much smaller, and bifurcated.
- ✓ Top tier engineers will have SE licenses and MS degrees.
- ✓ They will become recognized leaders and innovators.
- ✓ They will be highly respected and well compensated.
- ✓ Lower tier engineers will have PE licenses and BS degrees.
- ✓ They will work mostly as para-professionals, or technicians.
- ✓ They will not be highly respected nor well compensated.

The First Code

"If a builder builds a house for a man and does not make its construction firm, and the house which he has built collapses and causes the death of the owner of the house, that builder shall be put to death."

... Code of Hammurabi, 1762 BC

The Evolution Of Codes

- ✓ Building and bridge codes have radically grown in size and complexity.
- ✓ There seemingly has been an effort to include every new equation.
- ✓ The codes have become highly prescriptive, much like recipes.
- ✓ SEs are generally required to follow the codes to the letter. They can no longer exercise the professional judgment inherent in their licenses.
- ✓ This is problematic, as the codes don't/can't address every situation.
- ✓ Some now view SEs as technicians that follow mathematical recipes.
- ✓ The emerging solution is performance-based design (PBD).
- ✓ PBD allows SEs to legally venture beyond code requirements.

My Favorite Technical Tips

- ✓ At sites with expansive clay soils, use void forms beneath grade beams, but never use void forms beneath structural floor slabs.
- ✓ Avoid rebar congestion, especially at connections. There must be space for the aggregate.
- ✓ Allow post-tensioned concrete members, especially slabs, to shorten due to compression, shrinkage, and creep.
- ✓ Pay attention to the drainage design and construction on low-pitched roofs, even though this is outside your scope of work.

Final Thoughts

"Ours is a great profession. There is the fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes to men. Then it elevates the standards of living and adds to the comforts of life. That is the engineer's high privilege."

… Herbert Hoover, 1954