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From The Castle

RUNKLE CONSULTING INC.

What They Don't Teach In School

In this issue, we're going to look at three theories of engineering, Lowest Common Denominator Design, The Theory of Many Sticks, and Hell For Stout. These aren't exactly theories in that no one put forth a hypothesis, tested it, and put it up for peer review in some obscure journal that no one could understand. These are theories that we see in day to day life and certainly have some validity.

While they may not hold up to peer review, and I certainly couldn't write a thesis on any of these three theories in school and expect to pass, most of us that actually work in construction will agree they are real, and have to be considered on every job.

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Engineering Theories From Real Life

Lowest Common Denominator Design

There are different levels of complexity to everything you build. I think it was in the Air Force that I first heard the expression, "we're not building the Space Shuttle". We used this whenever someone would get into too much detail about how to do something mundane, like put in a new toilet. When airplanes, rockets, computers, and even diesel engines are built, the precision required is extreme, and the actual plans to build them are very complex. The assembly is done by highly trained people in controlled environments.

In construction, especially residential construction, there can be no high precision. Much of the labor force has limited formal education, and since you are moving from small jobsite to small jobsite, it's difficult to control the environment. Unlike large construction projects, there isn't a lot of supervision on the individual jobsites, and since the pay is lower, the skill level is also lower. So, when developing plans for residential jobs, all of this has to be brought into consideration. So, here are my own informal rules for residential structural design:

1. For Concrete:

a. Stick to small rebar that can be bent in the field and is easy to handle, use #4 (1/2") wherever possible, and never go larger than #5 (5/8"). Try to avoid varying rebar sizes in the same wall.

b. Never make a concrete wall less than 10" thick, otherwise you risk the rebar not being placed right, and the concrete not going properly into the forms (since vibrators are rarely if ever used on residential sites).

c. Use 3000 psi concrete. It's easier to work with, and it's likely if you go stronger in the design, they will still order 3000 psi concrete.

d. Allow some leeway in the design so if rebar is placed slightly wrong the concrete won't fail.

e. Don't design in any fancy hooks in the rebar, and absolutely nothing in the rebar that requires shop fabrication.

2. For Framing:

a. Try to keep the beams on a job the same size so that the wrong ones won't go in the wrong places.

b. Keep the floor system the same size and spacing. Again, the wrong joists will go to the wrong places, and the spacing will be all jacked up otherwise.

c. Try to keep roof bracing to a minimum. It's too easy to place roof braces in the wrong location.

d. Avoid steel. If steel can't be avoided, keep the members small so they can be fairly easily placed.

e. Avoid welded connections.

f. Don't design roofs to be dependent on cross ties to keep them from arching, it's too easy to put them in wrong.

Of course in more difficult structures the above rules have to be broken. However, from my own informal observance of construction in 30 years, following the above can help you avoid errors, and the material costs will be more than outweighed by the labor savings. It's designing for the lowest common denominator, and the lowest chance of screwing something up.

The Theory of Many Sticks

I heard about this theory from an Architect,

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The deck below has many things wrong with it, and should have fallen down. The Theory of Many Sticks is allowing it to stand, for now.

It's not braced for sidesway, it is not attached to the posts correctly, it's beams are over spanned, it is not attached to the house securely, and the stair stringers aren't properly supported.

who heard it from an old carpenter. A real life example is the best illustration. About a year ago a builder I was doing work for asked me to go with him into a house that was having problems. The homeowner said his floors were sagging. The builder wanted me to look over the situation with him to see if there was something obvious. Well, we went into the house, and it was obvious why the floors were sagging. The homeowner had removed every load bearing wall in the basement. I actually stepped backwards after going in the basement, and positioned myself next to the exterior walls so it would be easier to find my body if the house collapsed while I was in it.

In theory, the whole house should have imploded. Why didn't it? Well, as the old carpenter said, the "Theory of Many Sticks" came into play. Because wood is so flexible, everything started to work as part of the structure as the system started to fail. The floor sheathing started to carry loads, the walls started to act as beams, and the oak flooring did its part to help hold the house up. Even the wall paper and paneling will kick in as the house starts to move. This theory is what keeps people from killing themselves with their ill-advised home projects. It also kept a house that I went to from falling in when the HVAC contractor decided to give his brother-in-law a chance and hired him (you know something bad happened, don't you?). It became obvious why the brother-in-law can't keep a job; he cut away the main support beam in the house to run ductwork. The house stood long enough for us to fix it with a steel beam.

The Theory of Many Sticks is very helpful in residential construction. Not only does it protect us from our own stupidity, and the stupidity of others, but it can help in natural disasters too. Unlike other countries where houses are built from masonry, houses here can stay standing after high windstorms, earthquakes, tornadoes, and other disasters. They may be uninhabitable, but they don't pancake and squish everyone inside.

There is a catch to the Theory of Many Sticks. It can't be counted on; otherwise another law will jump in – Murphy's Law. If you do something wrong, and figure the Many Sticks Theory saving you, the law that "Anything That Can Go Wrong Will Go Wrong" will go into play, and everything will fall down on you. The Theory of Many Sticks is good to know, but can't be used on purpose.

Hell For Stout

I heard this theory from an engineer that used to design locomotives. It can be confused with the Lowest Common Denominator Theory, but it's concept is totally different. Many parts of a locomotive are hard, if not impossible to analyze structurally. In the days before computers, you would have to spend a lot of time to analyze things like couplings and other oddly shaped items, and it wasn't worth it. So, the idea was to design "Hell For Stout". Make the item massive, and use lots of steel. That way it wouldn't fail, and you didn't have to spend weeks in tedious calculations.

When I see buildings put up by the ancients, I see the same engineering theory used. The reason is simple. The Romans, Egyptians, Babylonians, and others didn't have computers, or even hand calculators to do design calculations. They didn't have a way of testing their mortar and concrete (Romans by the way made excellent concrete, you should see the Parthenon). Worse yet, building failures didn't result in lawsuits; they often executed people that built buildings that fell down. Also, material costs (rock) were fairly cheap and labor most of the time was probably pretty cheap too. Add that all up, and you would tend to build things massively to avoid any problems.

I see the same thing happening today in construction, and I don't like it. I've seen designs where the engineers called out massive beams, put in huge foundations, and subwalls with too much concrete and too much reinforcing. When I see that, I realize the engineer was either too lazy or lacked the knowledge to do proper calculations. Not only does this type of "design" waste material and labor, it can lead to failure too. If the engineer just guesses how big to make something, how does he or she know it's big enough? Also, how does making something ridiculously big affect the rest of the structure?

When the Romans used "Hell For Stout" theory, they had experience of what worked and what didn't. If somebody built something that didn't work, it was remembered because that guy was fed to the lions. I've personally known engineers that just guessed what they thought was a suitably large design for whatever they were putting on paper. There was no experience involved, or knowing what did or didn't work. It was just sloppy engineering that added to the job cost, and sometimes led to failure.

In my opinion there is no excuse today for using "Hell For Stout" design. Possibly if I'm designing a locomotive, and I need to design an obscure connection for a railing it might make sense. It also might make sense if someone wants to live in a stone house that is built like a pyramid. However, since we are using concrete, wood, and steel to build with, the Residential Code is full of handy tables, and computers are cheap, this is a design theory that needs to be history.

The Romans didn't have the benefit of computers when they built this aqueduct, so they had to make it massive to be sure it wouldn't fall down. Still, they made use of arches to make a more elegant design, unlike what we see today when people guess and just make things big.