PDHonline Course G485 (2 PDH)

The Rule of Thumb

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THE RULE OF THUMB

Ruben A. Gomez, P.E.

1.0 FOREWORD

Although filled with hard work and sometimes being the target of adverse criticism, the practice of professional engineering is also filled with rewarding satisfaction and rich experiences. Few professions have such open doors to ingenuity and creativity, for the accomplishment derived from the creation of an idea out from thin air is unsurpassed by any other human activity or endeavor.

We engineers all share, or at least should, that sense of pride for what we do. As a good example and testimonial on the above statement, we can go back to that afternoon of November 1962 as we were in an auditorium at the University of Columbia listening to a very interesting lecture presented by a great engineer and architect named Mario G. Salvadori. He started his speech by saying that he had hoped that his words had an impact on those “who loved beautiful buildings and always wondered what kept them standing up, as well as those others who had designed beautiful buildings and were marveled to know they were still standing up”. Then, he went on to saying that in his experience although “correctness in engineering could often lead to architectural balance and beauty, however, such state of correctness was not necessarily sufficient to satisfy or guarantee architectural beauty”.

After listening to those statements coming from such a seasoned engineer-architect, one cannot help but conclude that knowledge of engineering on the part of the architect may well end up enhancing his work product. Moreover, those riddles and the sense of irony and doubt that they may encompass, validate the ever eternal conflict between design and performance, as well as between theory and practicality.

Later in 1980, while practicing professional engineering in Fort Lauderdale, Florida, a loyal client called our office to request a particular service. His timing could not have been any more displeasing. It was a Friday afternoon; the client himself was a known mechanical engineer and part owner of a wheat mill complex in the Greater Miami area. He had enlarged and expanded his production assembly line and needed a specific design dealing with the expansion of his vacuum lines into a nearby building across the street. According to his own words, he was actually looking for a “quick-and-dirty” design and solution to get him out of the “bind” he was in.

“Quick-and-dirty” seemingly meant to him, an improvised and precipitous design as result of applying plenty of short-cuts and rule-of-thumbs conducive to achieve a fast completion. Unfortunately, to many of us in the office and to our families as well, it also meant another spoiled weekend of long work hours.

Regarding "the rule of thumb" saying this course has been titled after, it is much like the principles and beliefs so celebrated by Mark Twain "everybody used them all the time but nobody knew what they were". As a student, the minute you entered engineering school you heard about the so called "rule of thumb" that everybody was talking about, seemingly as part of the *holy grail* of *common wisdom*. The dictionary defined it as "any rough process of operation, like that of using the thumb as a rule in measuring; hence, it could further be defined as personal judgment and practical experience as distinguished from scientific knowledge". So in a nutshell, that was indeed the request and expectation of our client.

Then it came along the dreaded Monday morning and our embattled client showed up at our door. Needless to say, we were not near finished and he was quite disappointed because we were incomplete and "still monkeying around with wind design" rather than following his advice of taking whatever the "necessary" short-cuts. He talked as if that was some kind of protection, shield or even antidote against malpractice charges. At that point we came to wish we knew about some miraculous "rule of thumb" which could have given us the solution at the snap of our fingers.

You must expect to read much more about these concepts of empirical knowledge and rules of thumb as you make progress along the paragraphs of this course.

2.0 SCOPE OF THE WORK

As result of his procrastination, our client had wasted precious time trying to decide what to do and as the demands of his production schedule became unsustainable, he had made his sense of urgency to become ours, however, he was the kind of client whom we could not have turned our backs to, therefore we had no choice but to oblige.

Figure 2.1 shows his basic predicament; he needed to extent his vacuum lines from the grain warehouse (Bldg. 102) to the production facilities (Bldg. 202). He had a 12 inch and 6 inch diameter vacuum ducts to be extended over the eighty (80) feet separation between the two buildings, as well as an 8 inch spare line. The center of the proposed alignment has been shown on the same figure.

The "wish list" given by the client had several requirements that needed to be complied with as part of our design assignment features:

a. the road had to be kept open at all times,

b. the solution had to be pleasant, compatible and well blending with the surroundings,

c. having no intermediate support(s) which could affect circulation or view,

d. clearances needed to comply to those specified by AASHO* 1.1.7(B).

e. he wanted a flat surface facing the road to install their business name affixed to it, as well as extra room for displaying miscellaneous instructional texts,

f. the design process, preparation, installation and completion time had to be the shortest possible.

g. last but not least, the cost had to be streamlined to the minimum.

With all that in mind, we went to work seeking for the most reasonable solution to meet our client's needs. As we go now over the preliminary process, it would be a good mental exercise for you the reader, to try to come up with a solution of your own before you get to ours. In a case as the one herein described what would you do? Please take a 10 minute break and "burn the midnight oil".

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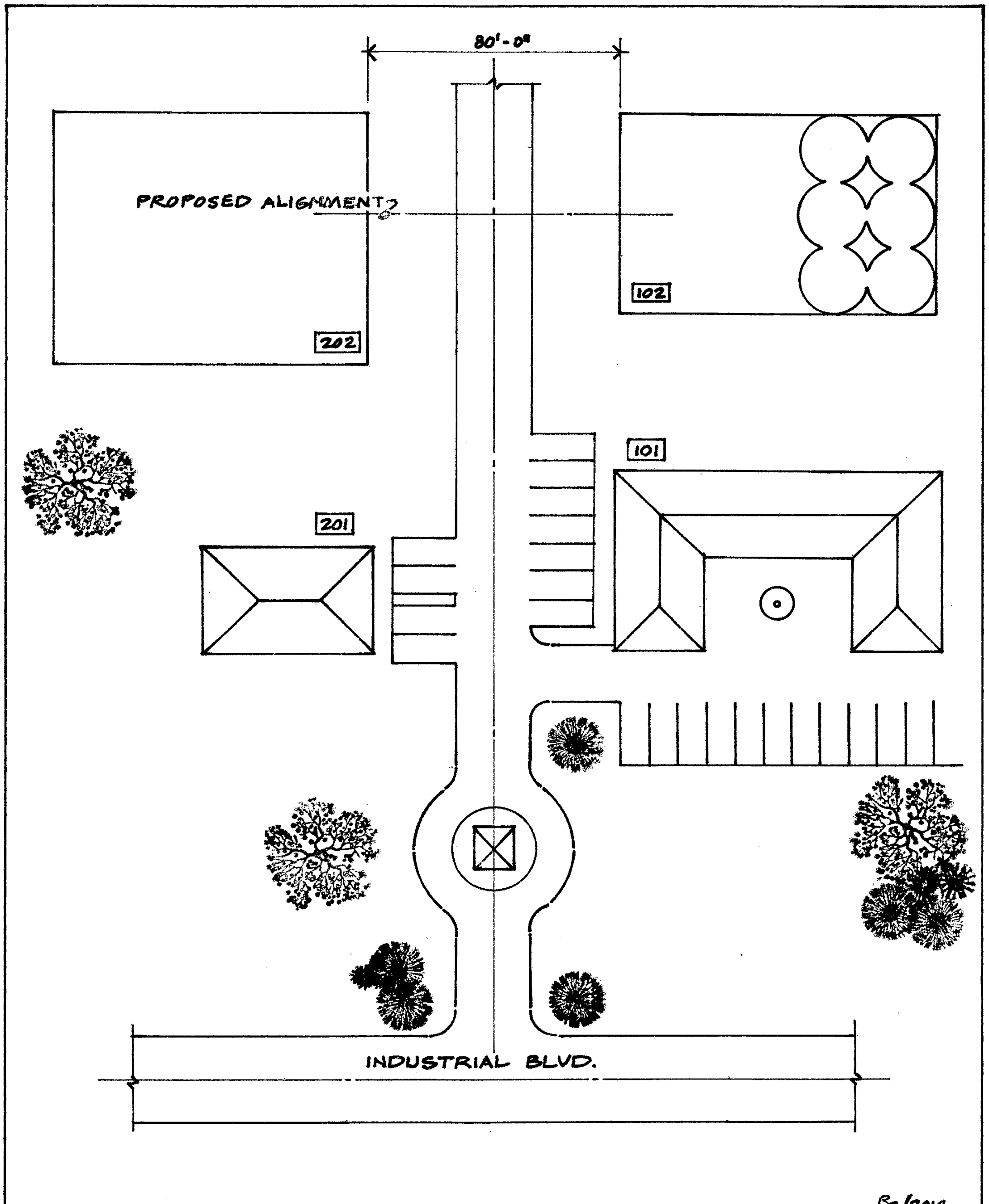
*American Association of State Highway Officials.



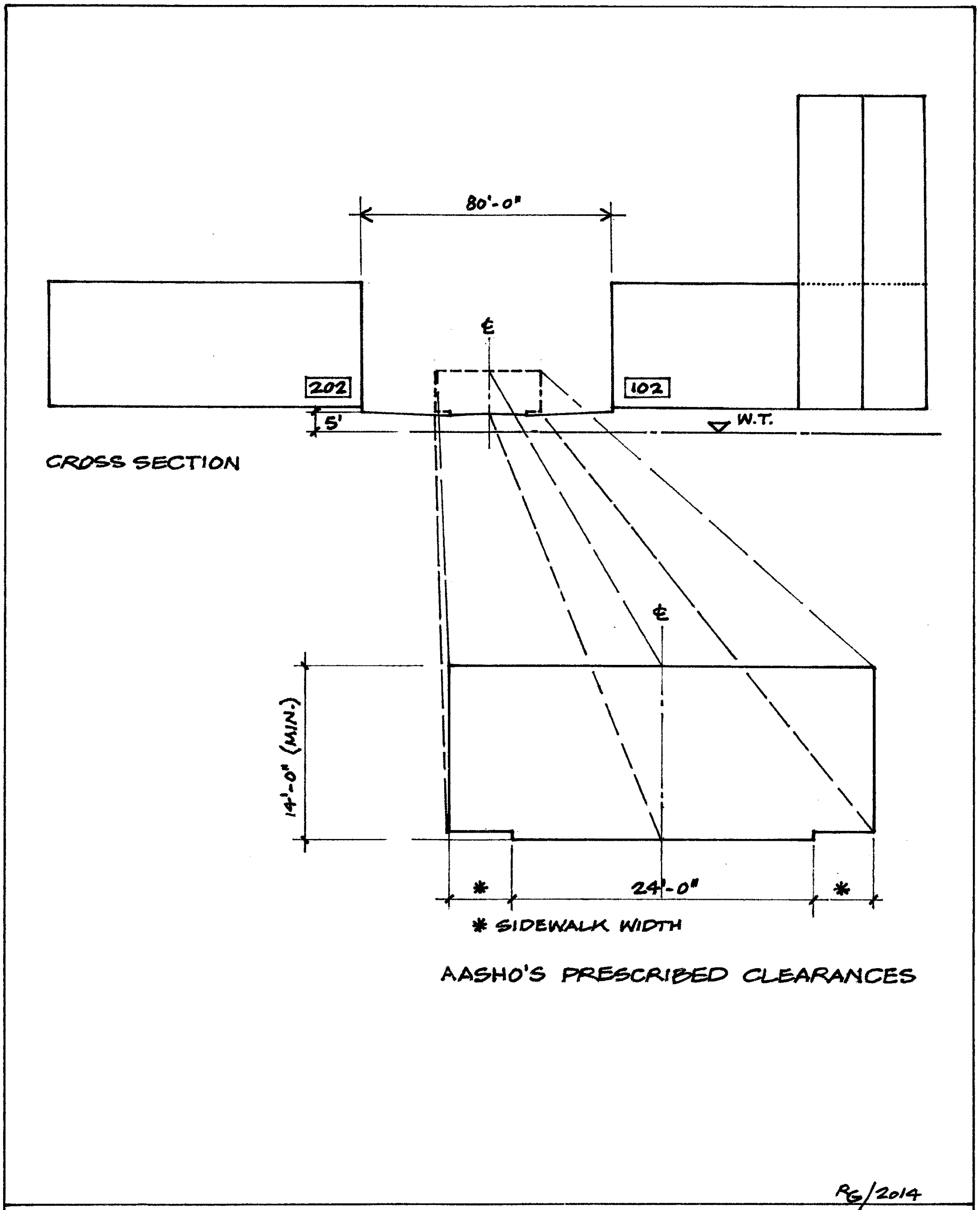
PARTIAL SITE PLAN SHOWING PREVAILING JOB CONDITIONS
FIGURE 2.1

3.0 EXPLORING THE ALTERNATIVES

The possibility of having the lines in a water-tight enclosure and placed underground in a dug up trench across the road was ruled out due to the shallow water table typical of the region, as can be noticed from a close examination of Figure 3.1. On that same figure, in addition to the relative position of buildings 102 and 202 we have shown the proposed suction lines location. Accordingly, we have also indicated the AASHO's prescribed clearances, of which, the most relevant item applicable to our case was the minimum required clear height of 14 feet.

As a second alternative, we gave due consideration to the possibility of installing a set of twin trussed girders spanning the eighty feet across the road. The idea was shortly abandoned because the needed girders were too deep for the purpose and rather too unpleasant and mundane as well.

The solution that became obvious during our process of selection was that consisting of an over-passing cable suspended structure. That solution was the one finally selected as most suitable to meet the client's assignment list. Consequently, the suspended cable structure will be the solution shown from now on in this course and for the remaining of the text and the accompanying graphics.



CROSS SECTION SHOWING PREVAILING JOB CONDITIONS
FIGURE 3.1

4.0 ANALYSIS AND DESIGN

Although the calculations found in our files were dated back to the year 1980, we have checked, shortened and updated some of the math, the procedural flow as well, and finally added new graphics to improve comprehension as we progress in our description of the analysis. In the same way, any discrepancies, code changes or deviations found along the way were noted and compared accordingly. We have also prepared Figure 4.1 with all its mosaic of conditions to assist and enhance our descriptive attempt.

Before going any further, one important point needs to be stated without ambiguity, cable suspension systems are a kind of their own and so are their analysis and design routines. It is also important to keep in mind that we were dealing with a cable structure which unlike tridimensional structures was a *planar* assembly by itself and unable to transmit bending or shear in any form, therefore, its structural capacity and stability was entirely dependent on its ability to convey tension forces from one point to another. We also needed to remember that when a cable was suspended between two points and under the influence of its own weight, or under the effect of a given uniform load for that matter, it adopted the shape of a *parabola*. However, when the same cable was under the effect of a system of concentrated loads, it adopted the shape of a *funicular polygon* as it followed along its path the position of those loads.

It is also important to also note now that the system of loads, whether such system is of uniform or concentrated nature, needs to occur within the same vertical plane that contains the cable's curve. However, because of the practical reasons as being explained below, and because of the nature of the gravity (vertical) and lateral loads (horizontal), we found necessary to introduce variations to that reasoning and train of thought.

Fortunately, there is a factor that puts simplicity on our side, both the parabola and the polygonal funicular can be defined and constructed on the basis of three given points, which happen to equal in number to the three conventional equations of equilibrium given by statics. For the purpose of drawing the curve, we will be using as the required three points, the two end bearing points as you might expect, and the mid-span point.

Figure 4.1(a) shows the configuration of the suspended structural box containing the owner's requested three-duct assembly. The box is basically formed by a series of square steel channel frames welded together and with trussed members in the longitudinal direction. Said box is enclosed by using galvanized steel ribbed panels spot welded to the frame. The net inside dimensions are also shown as part of the same figure.

Again, for practical reasons related to maintenance, the top of the box was provided with a non-slip metal surface so to allow a service-providing technician to walk over from one end to the other. In order to facilitate proper width for circulation, the suspension cables were placed at an angle of 18 degrees about the vertical plane and a security railing was installed accordingly as shown in Figure 4.1(b). Both the cable hangers and the railing supports were attached to the box by means of welded brackets as shown in the corresponding figures.

Taking into consideration the fact that the so described security railing could not span the eight (8) feet between cable hangers, it was necessary to add an intermediate support for the railing as shown in Figure 4.1(c). Such support was designed with enough built-in flexibility as to be compatible with the inherent flexibility of the entire system.

As hinted above, we had to face treating the analyzed and so resulting set of loads and forces as contained in three different planes: the gravity loads in the vertical plane, the wind loads in the horizontal plane and a third plane actually containing the cable's curve, as well as all the system of combined resultant loads as shown in Figure 4.1(d). We will resume with this topic somewhere below after completing the gravity load analysis.

One more point needs to be made now to help pave the way for the coming analysis. Although the most economical sag equals to one-half of the span, when it comes to the cable stress efficiency ideal, there is a "golden" *rule of thumb* predicating that the optimal sag-to-span ratio should be maintained at or close to one-third. In our present example, since the existing distance between the two buildings and therefore the span of the proposed structure was eighty-feet (80 ft.). If we had followed such "golden rule" the sag should have been 26.67 ft. and thus the needed building height should have been: 15+2+3+1+26.67 = 47.67′ (we took 15 as the *safe* clear height).

However, in reality both buildings 102 and 202 happened to have had a height of 40′- 0″ to the top of their roof parapets, some 7′- 8″ short of the ideal dimension. Therefore, to avoid having to build two support piers at an extra cost, we had to compromise for a lower sag so to meet the existing site conditions.

Figure 4.2 graphically describes the characteristics of the final assembly in both ways, functionally and dimensionally. In the same manner, said figure also serves as a cross reference to the rest of details that follow in Section 5.0.

LOAD ANALYSIS

a. Gravity Loads (vertical plane)

¼″ non-slip steel plate: 2′ x 80′ x 11.26 =		1,802 lbs
22 ga. steel ribbed siding: 6′ x 80′ x 1.73 =		830
Steel framing		
C3x5: 21 x 8′ x 5 =	840 lbs	
C3x5: 20 x 9′ x 5 =	900	
2 x 2″ angle: 4 x 80′ x 2.44 =	781	2,521 lbs
Handrails		
1¼ I.D. Galv. Pipe: 2 x 80′x 2.30 =	368 lbs	
Intermediate supports: 20 @ 16 =	320	
Brackets & straps:	210	898 lbs

Cables (allowance) 2 x 476 = 952

Vacuum Ducts
12 in. diameter
Metal: 3.1416 x 80 x 2.0 = 503 lbs
Wheat: 0.785 x 80 x 50 = 3,140
6 in. diameter
Metal: 1.57 x 80 x 1.5 = 188
Rice: 0.20 x 80 x 40 = 640
8 in. diameter
Metal: 2.10 x 80 x 1.50 = 252
Spare: 0.35 x 80 x 50 = 1,400
(Ducts add up to 6,123 lbs., which multiplied by a dynamic factor of 1.20) = 7,348 lbs
Total Dead Loads: 14,351 lbs

(The International Building Code requires a "cat-walk" load of 40 psf)
Live Load: 2 x 80' x 40 = 6,400
Total (DL+LL) on vertical plane: 14,351 + 6,400 = 20,751 lbs

Unit Load (on the vertical plane): 20,751/80 = 259.39 lbs/lin. ft.

Concentrated Loads @ suspension points (each side): 2,075/2 = 1,038 lbs

b. Wind Loads (horizontal plane)

At the time the original design was prepared, we followed the requirements of the then South Florida Building Code. The wind pressure applicable at the time was 24 pounds per square foot (psf). We have now reviewed and updated the calculations to reflect the standards recommended by the American Society of Civil Engineers (ASCE-7). The revised wind pressure after using their formula:

$$q_z = 0.00256\ (K_z)\ (K_t)\ (K_d)\ (V^2)\ (I)$$

Where:

$K_z = 0.70$
$K_t = 1.0$ (topography of terrain)
$K_d = 0.85$ (directional factor)
V = 146 mph (regional wind velocity)
I = 0.77 (importance factor)

Resulting in the following wind pressure:

$$q_z = 0.00256\ (0.70)\ (1.0)\ (0.85)\ (21{,}316)\ (0.77) = 25 \text{ psf}$$

Wind Up-lift Forces:

To verify up-lift safety it is necessary to consider dead loads only, that means from the above load analysis we need to subtract all live loads and grain weight. Consequently, the total dead load adds up to: 7,946 lbs.

On the other hand, the total up-lift force would be:

$$80' \times 2' \times 25 = 4{,}000 \text{ lbs}$$

And the safety factor:

$$7{,}946/4{,}000 = 1.99$$

This gives us an adequate value. However, if an increase in the safety factor would be desired, one of the following two alternatives would have to be implemented:

a. adding dead weight to the structure (not recommended in this case), or

b. adding safety features, such as bucket sliders at both of the supports.

GRAVITY LOADS ACTING ON THE VERTICAL PLANE

P_1 = 1,038 lbs ($p \approx$ 130 lbs/lin. ft.)
f = 20 ft.
80 ft. span

$V_A = V_B = ½ \times 1{,}038 \times 10 = 5{,}190$ lbs (5.19 kips)

$H_A = H_B = 130 \times 80^2/(8 \times 20) = 832{,}000/160 = 5{,}200$ lbs (5.20 kips)

Therefore, the tension on the suspended cable can be determined as:

$T' = \sqrt{(V^2 + H^2)} = v(27.04 + 26.94) = 7.35$ kips

Sag-to-span ratio: 20/80 = ¼ (less than the conventional "rule of thumb")

Stress on steel box top and bottom chords:

p = 130 lb/ft; span: 8 ft; $M_o = 0.10 \times 130 \times 64 = 832$ ft-lbs

C3x5: D = 21 in.; d = 20 in.; $A_s = 1.47$ in^2

Tension Force: $(832 \times 12)/20 = 499.20$ lbs

Unit Stress: f = 340 psi

WIND LOADS ACTING ON THE HORIZONTAL PLANE

We have now the same span of 80 ft. However, the sag projection has been reduced to 6.5 ft:

$$V'' = 25 \times 40 = 1{,}000 \text{ lbs } (1.0 \text{ kips})$$
$$H'' = (25 \times 80^2)/(8 \times 6.5) = 160{,}000/52 = 3{,}077 \text{ lbs } (3.08 \text{ kips})$$

And the tension force:

$$T'' = \sqrt{(1.0^2 + 3.08^2)} = 3.24 \text{ kips}$$

RESULTANT LOADS ACTING ON THE INCLINED PLANE

Having found: T′ = 7.35 kips and T″ = 3.24 kips

Also,

Cos 18° = 0.95
Cos 72° = 0.31

Designating the tension force projections as X_1 and X_2, then:

$X_1 = 7.35/0.95 = 7.74$ kips
And,
$X_2 = 3.24/0.31 = 10.45$ kips

By using the load combination: DL + LL + W we get the resultant tension force on the suspension cable as:

$$T = X_1 + X_2 = 7.74 + 10.45 = 18.19 \text{ kips}$$

By doubling that value we get the ultimate load on the suspension cable as:

$$T_u = 18.19 \times 2 = 36.38 \text{ kips}$$

For that load, Table A in the Appendix gives us a cable size of 5/8 in. diameter.

CABLE ELONGATION

In consideration of the following values:

H = 5,200 lbs	l = 80 ft
$A = 0.182$ in^2	n = 20/80 = 0.25
E = 24,000,000 psi	$n^2 = 0.0625$
$\xi = 0.00065$ (for 100° temp. diff.)	$\Delta t = 60°$

a. elongation due to the axial force:

$\Delta L' = [(5{,}200 \times 80 \times 12)/(0.182 \times 24{,}000{,}000)]\ 1.333 = 1.52$ in

b. elongation due to the temperature differential:

$\Delta L'' = (0.00065 \times 0.60 \times 80)\ 1.167 = 0.48$ in

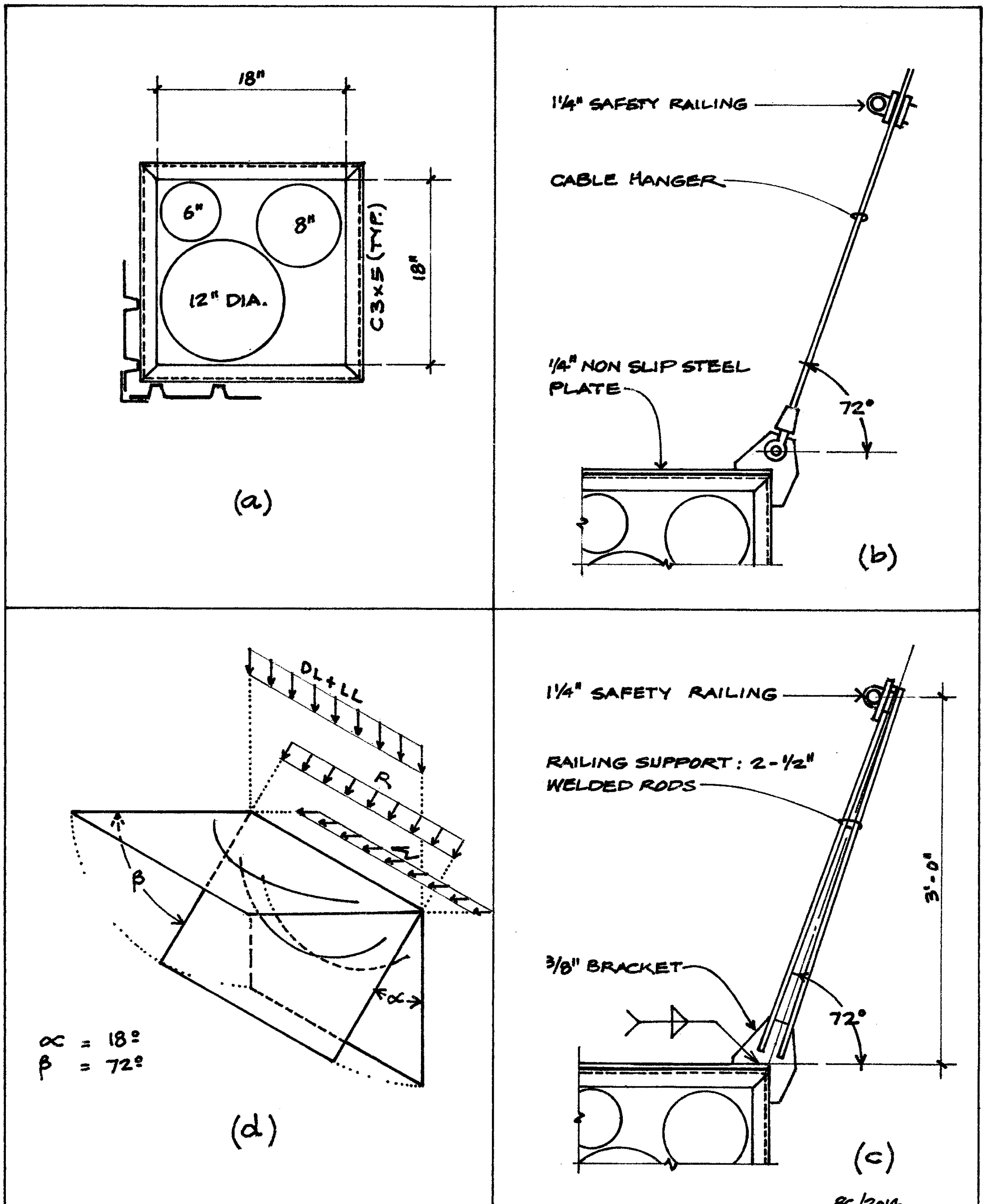
$\Delta L = \Delta L' + \Delta L'' = 2$ in

CABLE DEFLECTION

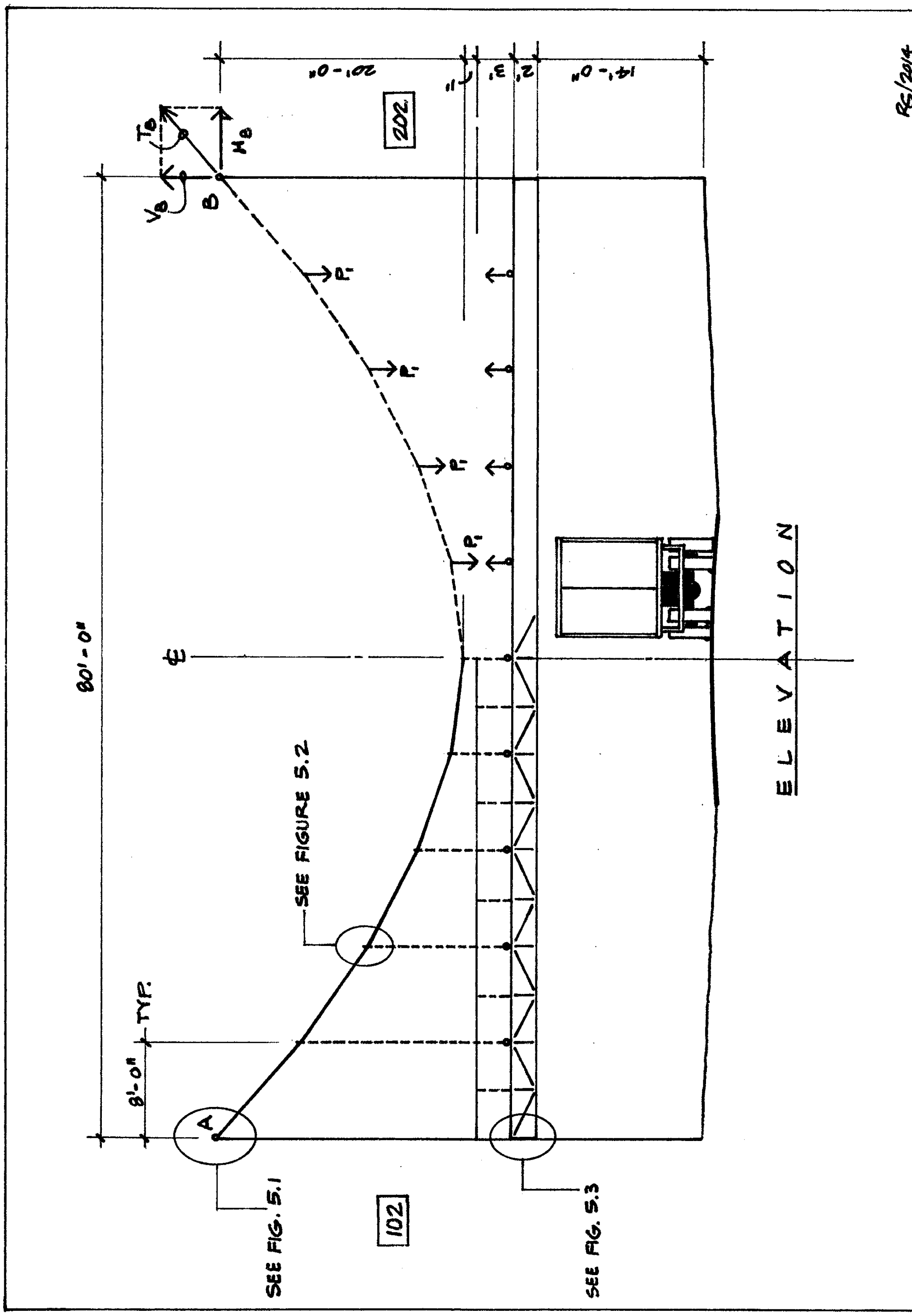
$$\Delta L = (1.067)\ n\ (5\text{-}24n^2)\ \Delta f = 0.934\Delta f$$

Thus,

$$\Delta f = (\Delta L)/0.934 = 2.14 \text{ in}$$



CONDITIONS & ASSUMPTIONS
FIGURE 4.1



FULL VIEW OF ASSEMBLY
FIGURE 4.2

5.0 THE FINAL CONCEPTION & DETAILS

A half-plan view of the assembly is depicted in Figure 5.1. Here again, rather than the main cable following a straight-line *trace* and because of the pull exerted by the hangers it tended towards the pattern of a free polygon. Please notice that, as the main cable separation flared up from 5 ft. at the center of the span to 18 ft. at the supports, such configuration helped to improve performance and resistance against wind forces. Furthermore, considering that the parapets were built of reinforced masonry as an extension of the building bearing walls, we found them adequate to resist the pulling forces transmitted by the main cable; consequently, what it was needed for anchorage purposes was the placing of a steel spreader as shown by the same figure.

Figure 5.2 provides a detail of how to connect the cable hangers to the main cable. Please notice that the wrap-around *loop* from the cable hangers had to be made with both cable ends flat together with no slack in between. As an alternate to such method there is a commercially available combined clamp-socket device which greater simplifies the installation, however, it must be factory made to fit the conditions and therefore much less forgiving for the installer.

Finally, Figure 5.3 graphically describes one of the end conditions as the vacuum ducts typically penetrated through the existing walls. An opening needed to be cut large enough not only to provide room for the passing ducts, but also to allow anchorage for the supporting hardware and rainwater protection. The end of the steel box was fully supported by means of a 4" x 4" x ½" steel angle fastened with steel anchors embedded in the supporting concrete block. In order to allow for expansion, contraction and the consequential sliding, a ¾" thick layer of neoprene was installed between the two steel surfaces. The anticipated movement at the joint was calculated in the following manner:

Coefficient of linear expansion for a temperature differential of 100°F:

$$\xi = 0.00065$$

(This coefficient should be tripled when applied to volumetric changes.)

For an actual temperature differential of 60˚F and a length of 80 ft, the elongation should be:

$$\xi tl = 3\ (0.00065 \times 80 \times 60)/100 = 0.0936 \text{ ft} = 1.125 \text{ in}$$

See additional considerations further ahead in this section.

Two more important features have been included as part of that figure:

a) As the temperature changes took place, all components were bound to a perpetual back-and-forth sliding at the expansion joint, therefore, all items and components had to be furnished with the proper tolerance to movement, and that included the vacuum ducts which were provided with adjustable accordion connectors as shown.

b) A galvanized steel flashing was installed overlapping the upper cat walk surface to prevent rainwater penetration. Such flashing was also extended to the sides to disallow joint access to birds, insects and airborne contaminants.

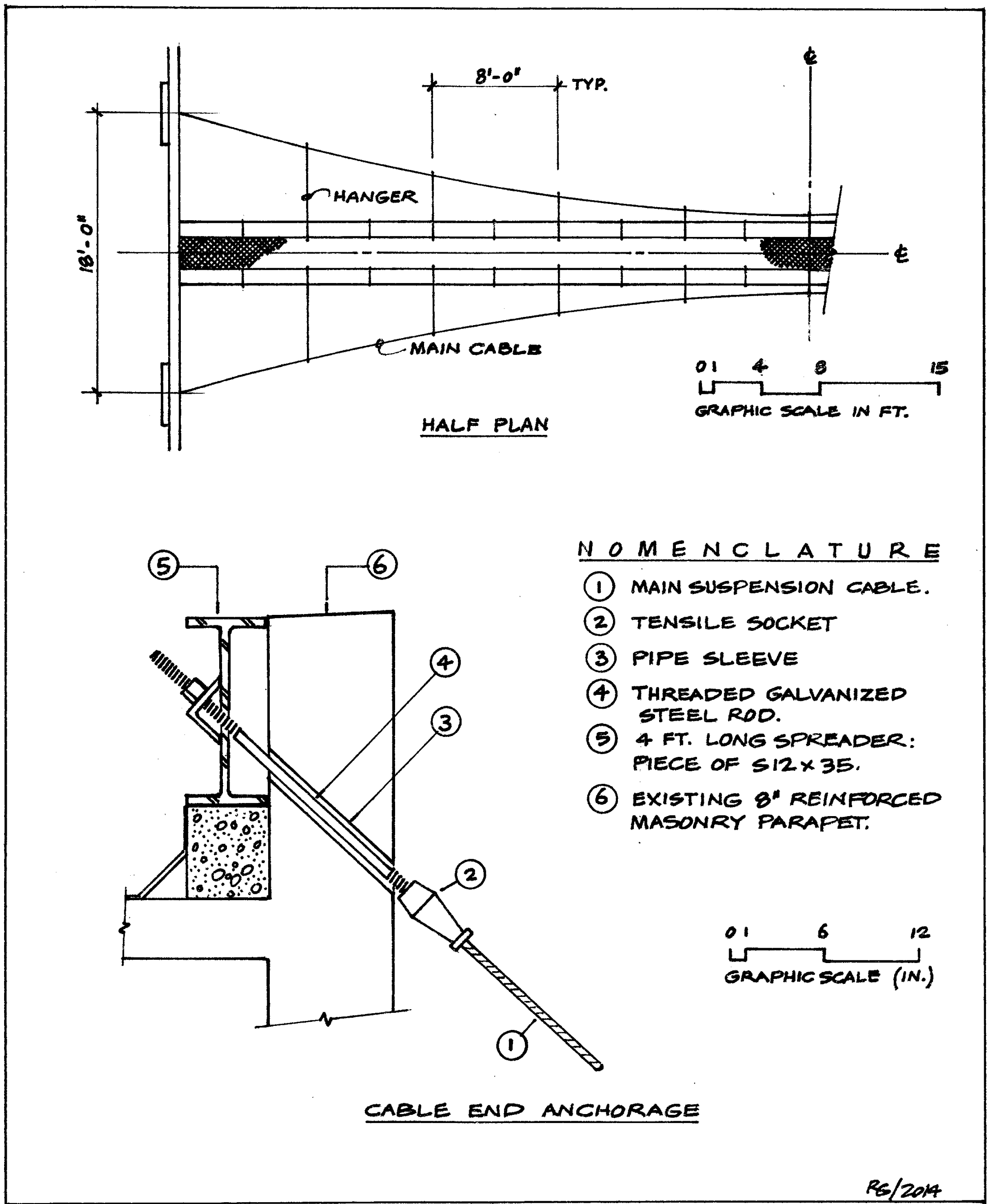
DEFLECTION & CAMBER

Due to the inherent flexibility of this assembly, a deflection substantially larger than one-and-a-half inch should be expected to take place at the midspan. In fact, the calculated deflection was determined above as 2.14 inches. Consequently, a conservative 2½ in. camber should be recommended in order to counteract the calculated deflection. During installation, that camber was in fact achieved by fabricating the box assembly as two identical halves, they were erected separately and all the cable hangers adjusted as needed before the final welding in the middle of the box assembly was completed.

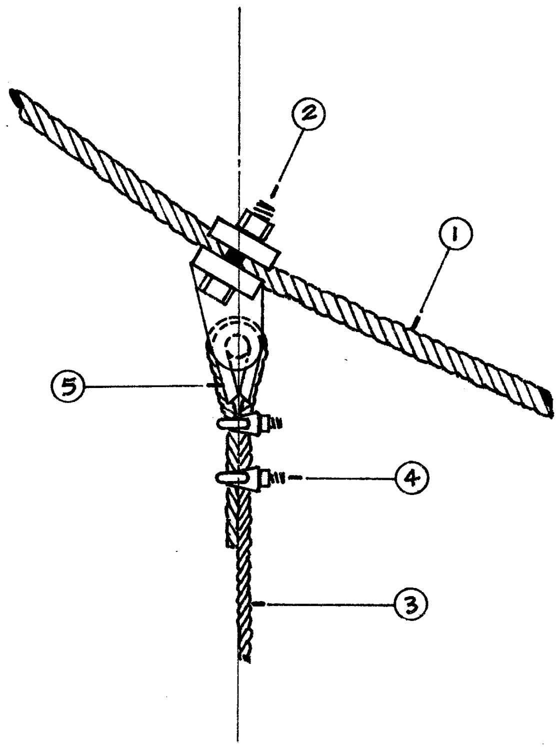
TEMPERATURE CHANGES

As we saw above, the predicted elongation due to temperature differentials was in the order of 1.125 in; therefore, provisions were made to allow joint movement of 1½ inches in both the steel structure and the suction ducts inside of it.

Allowing movement within the structure was an important design feature given the likely negative consequences of the alternative. Having the ends held fixed in position would have had undesirable and detrimental effect as result of the large generated shear as well as tensile and compressive stresses within the same structure. For more related information on this matter see the appendix at the end of this course.



MAIN SUSPENSION SYSTEM
FIGURE 5.1



NOMENCLATURE

1 MAIN SUSPENSION CABLE
2 SPECIAL CLAMP
3 CABLE HANGER
4 WIRE ROPE CLAMP
5 THIMBLE

CABLE TO CABLE CONNECTION

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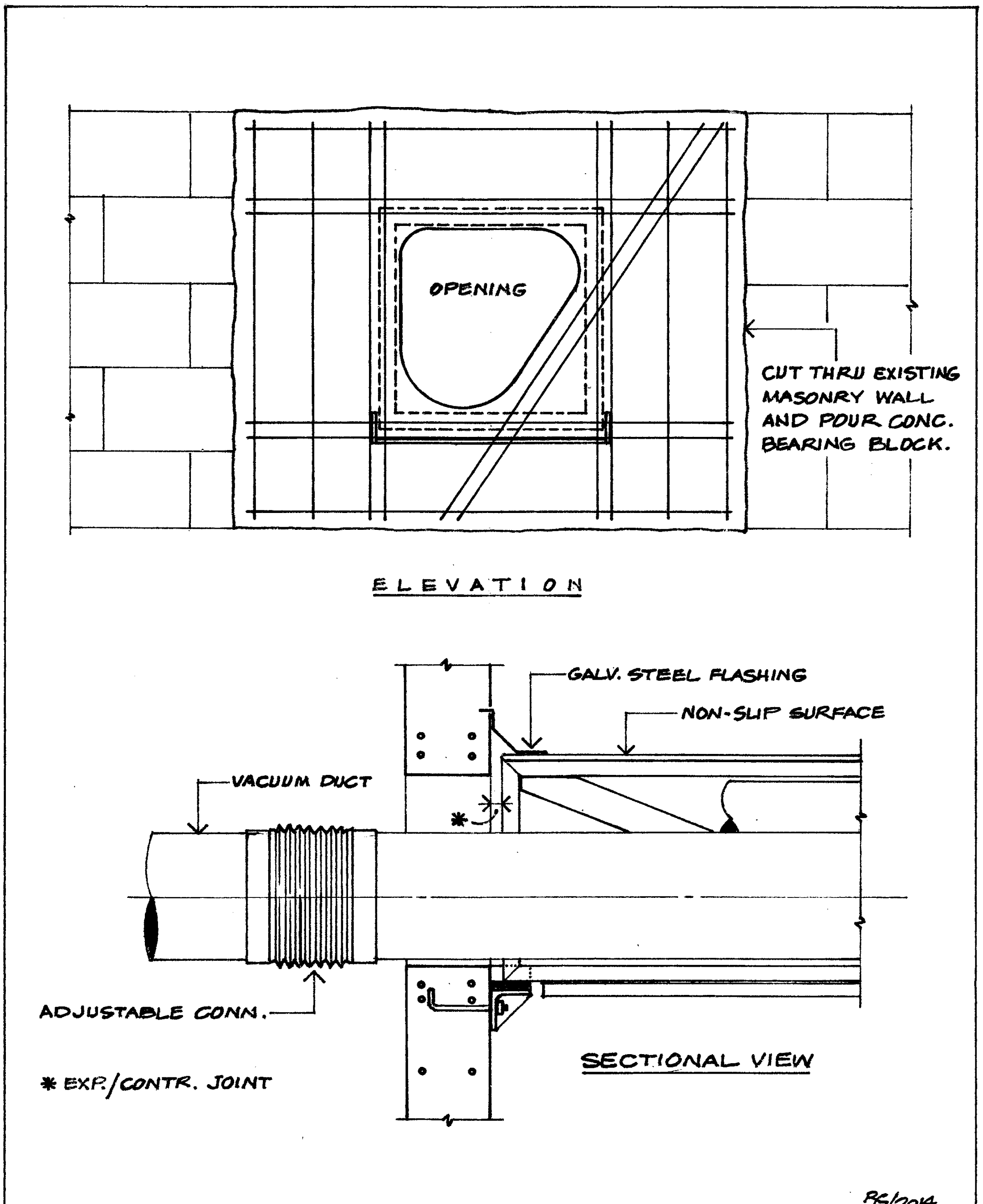
CABLE HANGER DETAIL
FIGURE 5.2



TYPICAL END CONDITION
FIGURE 5.3

6.0 CONCLUSION

Now that we have seen the consulting engineering process to evolve from the client's needs and wishes, to the logistic and intellectual stages in the mind of the design engineer, and finally to conception and completion of his work as a final product, for his creative abilities would have not much of a practical use for as long as it just remained on paper, rather than being applied and built as a materialization to his proposed solutions.

To put above statement in more practical terms and even though for the regular practitioner the safest job is the one that never gets built, in the real world when the engineer bids for work and makes a presentation of his credentials, he needs to include a list of his "projects that have actually been built". That takes us to the final and ultimate "rule of thumb" of them all, the one that has to do with the general public expectations from the practicing consulting engineer, for he has a fiduciary duty to his client to render a product that is suitable to his needs while being within the accepted methodology and common engineering practice. He also has the legal obligation to protect and preserve the public safety and welfare; finally and last but not any less important, during the discharge of his duties he has an obligation to himself, in such a way that he uses all his abilities and capabilities for his own satisfaction and the enhancement of his image and the profession's image as well.

APPENDIX

STORAGE WAREHOUSES
Grains*

Material	Weight per Cubic Foot
Bagged Beans	40
Cereals	45
Cocoa	35
Corn	44
Bagged Roasted Coffee	33
Bagged Green Coffee	39
Flour (in barrels)	40
Bagged Rice	58
Sugar (in barrels)	43
Sugar (in cases)	51
Wheat	50

*As recommended by the National Bureau of Standards, U.S. Department of Commerce.

STANDARD SPECIFICATIONS FOR STEEL STRANDS

These are the suggested specifications which can be used as a guide by the practicing engineer. They have been adjusted, condensed and reproduced from the standard version of the ASTM Specification A586.

BASE METAL
The base metal shall be carbon steel made by using one of the following methods: either open-hearth, basic-oxygen or electric-furnace process. The quality of the finished strand and the hard-drawn hot-dipped zinc coated wires shall have the characteristics and properties prescribed herein. The slab zinc shall also conform to ASTM Specification B6.

PHYSICAL REQUIREMENTS
The ultimate tensile strength and the stress at 0.7 percent extension under load shall be based on the actual cross-sectional area of the finished wire including the zinc coating. The zinc-coated wire surface shall be free from imperfections not consistent with good commercial practice. The zinc coating shall be continuous and of reasonably uniform thickness.

STRANDS
The zinc-coated strand shall consist of layers of wire about a center wire. The number of layers and number and size of wires in each layer shall be determined according to the

manufacturer's standards. The strand properties are shown in Table A below. The strand shall be pre-stretched under tension not to exceed 55% of the ultimate strength listed in the same table.

SAMPLING & TESTING
A test sample shall be taken from each manufactured length of strand and tested to the minimum ultimate strength. If it fails to meet the minimum ultimate strength listed, another test sample shall be cut from the same length and tested accordingly. Should it fail again, the manufactured length of strand shall be rejected.

PACKAGING & SHIPPING
Structural strands shall be packaged in coils or on reels unless otherwise specified. Strands shall be packaged and shipped in such a manner that no permanent damage or deformation of the wires in the strand will occur.

TABLE A
Properties of Zinc-coated Strands (Class A)

Nominal Dia. (in)	Net Cross-sectional Area (sq. in.)	Weight (lbs/ft)	Tested Ultimate Load (kips)
0.375	0.07	0.26	14
0.500	0.15	0.52	30
0.625	0.23	0.82	48
0.750	0.34	1.18	68
1.000	0.60	2.10	122
1.125	0.76	2.66	156
1.250	0.94	3.28	192
1.375	1.13	3.97	232
1.500	1.35	4.73	276

Modulus of Elasticity: E = 24,000,000 psi

STRESSES GENERATED BY TEMPERATURE CHANGES

When a structure is rigidly held in position without allowing the volumetric changes induced by temperature differentials to take place, in response, large and close to irresistible unit stresses will develop. Such tensile or compressive stresses, whether the ambient temperature increases or decreases, are defined by the expression:

$$Et\xi$$

Where,

E is the modulus of elasticity,
t is the temperature differential, and
ξ the coefficient of linear expansion.

POPULAR RULES OF THUMB

There is plenty of debate in reference to the origin of this phrase, however, it seems to have originated with the carpenters since the times they used to measure with their own thumbs, fingers and the palm of their hands, which although imprecise happened to be very handy and convenient.

Whether we may refer to thumbs, fists, hands or feet, they are resources that are always available to the user for being part of his body parts. The phrase "rule of thumb" or other similar ones have always existed in almost every known language. Some scholars have traced it back to 1782 when a British judge named Sir Francis Buller, also known as Judge Thumb, allegedly ruled that a man could legally beat his wife for as long as he used a stick not wider or thicker than his thumb. The verification of this claim we will leave to the historians.

In some Spanish and Portuguese speaking countries they still have *la regla del buen cubero,* which literally translates as "the rule of the good old bucket-man". It came from the not too distant times when the bucket (or pail) was an essential tool used in the construction industry, as it was the primary *poor-man's* means to carry liquids and mixes, consequently, rubber buckets became not only abundant, but a necessity at every construction site. As an example of its hand labor intensive use, to convey concrete mix to an elevated location, they would setup a strong long ladder from the place down on the ground where the concrete was being mixed, to the place up higher where it was going to be deposited, then arrange a row of men (as many as it took) standing on the rungs of the ladder and passing the filled buckets along on their way to the top. When emptied, the buckets were thrown back to the ground, which was why rubber became the ideal material to be used.

The following examples represent a few of the rules of thumb that were passed from mouth to mouth, culture to culture, and generation through generation. They were widely known and in some cases even accepted as matter-of-factly rules. Every "rule" presented here is followed by pertinent commentaries of our own.

#1- To be practical and workable the minimum concrete slab thickness should be four (4) inches.

Undoubtedly, this is a wise and practical rule, not because it has been imposed by the construction codes, for its concept existed before their inception, but because it is a good standard and accommodates the skilled laborer and the clumsy as well.

However, it does not mean that thinner slabs are wrong or improper; they just require more accurate design on part of the engineer and better skills and preparation on part of the builder himself. A 2½ in. thickness for a concrete shell is widely accepted and a 3 in. thickness for a suspended short-span slab is common place as well.

#2- The work output of two men (an operator and his helper) equals *four times* the output of a single man working alone.

We don’t know of any practical test or experimental study which has proven this point beyond argument, however, it is a well accepted fact that a man (or woman) working alone is the most inefficient work arrangement of them all.

On the other hand and to make it more convoluted, an Italian adage seems to contradict this entire concept: *Chi fa da se’, fa per tre,* meaning “he who works by himself does the work of three”.

#3- Time is money.

Somebody has defined the three relevant variables of work as time, money and effort. Therefore, if time equals money, then the equation is reduced down to two variables and can be solved by the simpler rules of algebra.

#4- The “perfect” is the enemy of the “good”.

This should be a lesson for the fanatics of quality control. While fastidious perfection may be a nuisance to some, it may be the “frost on the cake” to others.

#5- After the storm comes tranquility.

While in many cases that may be true, one needs to be watchful, for that tranquility may deceive and be just the temporary calm brought by the eye of the storm.

#6- There is a trick in every trade.

This principle is absolutely true, experience gained by constant repetition leads to the discovery of more and better ways to do things.

#7- When it comes to investments, to *approximately* determine the amount of time it would take to double the principal of an investment, just divide the numeral constant 72 by the percent interest rate.

We have just opened a small Certificate of Deposit paying a mere ½% annual interest. According to that rule of thumb it will take some 144 years for the balance to double. We are grateful to have both grandchildren and great grandchildren who could afford the waiting for such big event.

#8- The dimension around one's wrist is equal to twice the dimension around the last knuckle of one's thumb.

#9- The same rule of thumb applies between the neck and the waistline.

No one could sanely resist the temptation of verifying such a banality on both accounts. Tailors and seamstresses are generally very familiar with those two rules and could tell you more about them.

#10- When an airplane is full of fuel, which happens to be lighter than water, it will float. Providing its structural integrity and its water-tightness are unaffected.

Please keep that in mind the next time you fly and airplane. It may bring you some peace of mind.

#11- There is a solution to every problem, if you can find it.

The first part of the statement was extremely enlightening, but seemingly the author could not leave it alone.

#12- The cost of installing an electric power transmission line above ground is about $400 per linear foot, however, the cost of the same installed below ground is *ten times* as much.

No wonder there are so many aerial power transmission lines all over the place.

GENERAL CABLE ANALYSIS FORMULAE

Sag ratio:
$n = f/l$

Horizontal component:
$H = pl^2/8f$

Actual tension force on cable:
$T = \sqrt{(V^2 + H^2)}$

Cable elongation:
$\Delta L = [(Hl/AE)\,(6.33n^2)] + [(\xi t^\circ\, l)\,(3.67n^2)]$

Total deflection:
$\Delta f = \Delta L/[1.07n\,(5 - 24n^2)]$