Quality Assurance: The Perils of Doing Too Much

Sriram Kalaga[1]

Abstract

Quality Assurance and Quality Control are integral to the successful implementation of any design. In engineering, the importance of the two processes grows exponentially with the size and extent of a project and the number of deliverables involved. However, in many cases, it is being overdone to the degree where general project efficiency is affected. This article examines the perils of doing too much QA with specific reference to transmission line structural engineering analysis. Several examples are presented and their overall influence on project timelines, budgets and efficiency are discussed. Suggestions for process improvement are made.

Keywords: *assurance, control, engineering, quality, management, transmission*

[1] *Civil-Structural Engineer, USA.*

Introduction

All engineering projects usually consist of analysis and design phases followed by the fabrication and construction phases. The analysis phase involves visualization, computer modeling and simulation of the intended structure or system subject to a set of code-mandated loads and load effects. The results of the analysis then form the basis for designing/sizing of system components to satisfy a given set of design strength and stiffness requirements. Finally, the various components are fabricated to the specified dimensions, shipped to the construction site, assembled and installed at the given location(s). Thus, the overall project quality involves assuring the quality of not only the process (analysis, design, fabrication and construction) but also controlling the quality of the product or materials used in various components of the system (Figure 1).

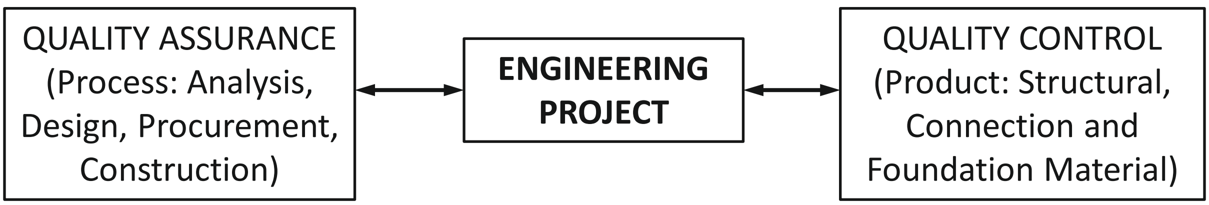


Figure 1. Typical Engineering QA/QC

The definitions of Quality Assurance (QA) and Quality Control (QC) are stated as follows (IEEE 751, 1991; PMI, 2011):

QA: A program applying technical and managerial skills to accomplish the objectives of a particular design. It is the responsibility of the system's Owner to design a program or process that provides an adequate design, adequate materials and adequate field workmanship to meet the requirements of the project. The goal of a comprehensive QA program is to ensure that all processes are defined and appropriate to secure an economical and reliable design.

QC: A process of comparing the properties and characteristics of the project's component parts (materials, hardware, drawings) with the design assumptions. This is usually achieved through the media of specifications, standards and/or testing. It is the responsibility of the Owner to provide specifications for the component parts and it is the Provider's responsibility to comply with the given specifications.

Quality Assurance (QA) and Quality Control (QC) are integral to the successful completion of any engineering project. The larger the project, the larger the scope of QA and QC. Both have a time component and a money component. The former affects the project schedule and the latter, the cost schedule. These costs are passed on to the Owner by the Consultant or Service Provider. Therefore, excessive QA/QC will invariably lead to increased time and project costs.

Transmission line projects generally comprise several miles of high-voltage systems (poles, towers, conductors, insulators, guy wires, anchors, hardware and foundations) and contain dozens of areas critical for QA/QC (Kalaga and Yenumula, 2016). Figure 2 shows the typical features of a high voltage transmission line project and the various processes and products. Design aspects – each focused on a specific item – occupy a significant portion of QA. This paper deals with QA referring to one process, namely, Structure Design.

Design Documentation for QA

This generally involves assembling and saving the various calculations associated with the analysis and design process. The manner in which this is done varies from company to company, depending upon the requirements of the particular project. A typical design calculation includes a physical record of the input criteria, sketches, manual calculations, computer output supplemented by a discussion of the basis and assumptions made, if any, for the process.

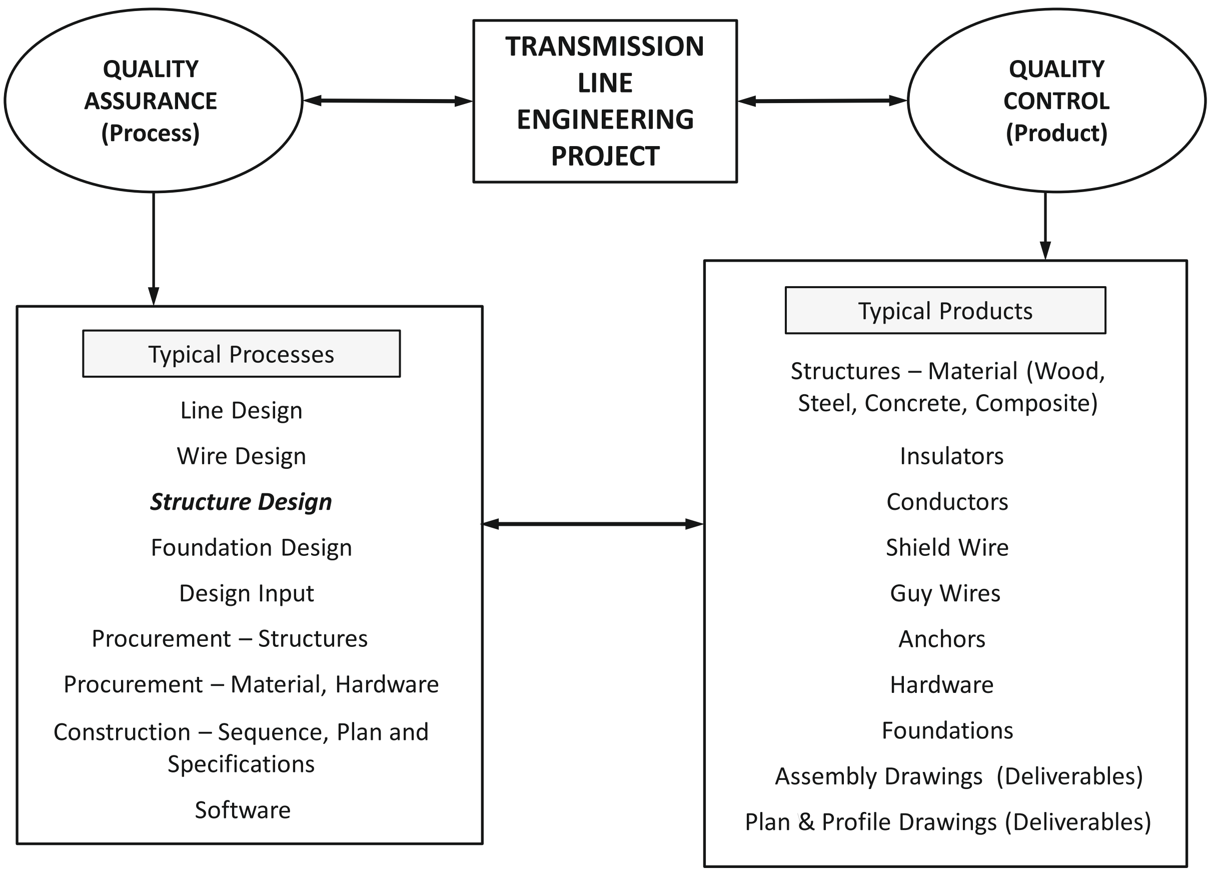


Figure 2. Typical Transmission Line QA/QC Features

However, in the process of doing detailed QA, efficiency is often sacrificed in the name of requiring too much documentation. This is prevalent more in the area of structural analysis and design. A bulky, and sometimes unnecessary or extraneous, set of supplementary forms are often attached to a simple set of calculations. These extra forms are often defined as mandatory or standard QA forms. Then there is the issue of how and *where* these documents are made available for users (see Figure 5 and Example 3).

The objective of this paper is to discuss how too much QA affects the timeline and budget of projects. Specifically, the paper aims to:

1. Provide examples of design and documentation with excessive paperwork
2. Provide suggestions of how to avoid the pitfalls

EXAMPLE 1

Figures 3a and 3b shows the calculation of base bending moment on a cantilever beam. The actual calculation is expected to take about 5 minutes whereas the additional documentation consumes over 1½ hours. That is, 18 times! (Note that all times – engineer, reviewer/supervisor – are billed to the client. In this example, there is no specific approver per se; the supervisor is also the approver.) So, instead of the items of Step 2, if the supervisor/reviewer mark up their notes on the original calculations sheet itself – in person, in the presence of the engineer – it would be time-saving and economical. A simple signed attestation as follows would be sufficient:

"The above calculations are checked and are found to be correct, consistent and correlate well with the design parameters of the problem. Approved for project documentation."

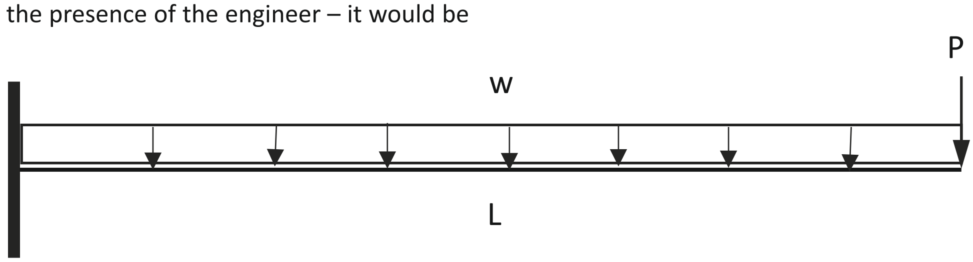


Figure 3a. Cantilever Beam subject to Loading

<u>Given</u>: L = 10'-8" (3.25 m)
w = 100 pounds / foot (1.488 kg/meter)
P = 500 pounds (227 kg)

<u>Determine</u>: Bending Moment at the Fixed End

<u>Solution</u>: M = (P)(L) + (w)(L^2)/2 (Eqn.1)
= (500)(10.66) + (100)$(10.66)^2$/2
= 5,333 + 5,682
= 11,015 pound-feet (1523.4 kg-meter) (time ≈ 5 min)

<u>Additional QA Documentation</u>:

Step 1

1. Check units for P
2. Check units for w
3. Check units for L
4. Check units for M
5. How did you measure L?
6. Give source for formula used
7. Engineer gives Reviewer the Calculations package (online)

Step 2

1. Reviewer reviews (online)
2. Sends it back to the Engineer (online)
3. Engineer incorporates changes (if any)
4. Sends it back to Reviewer (online)
5. Reviewer sends to Approver (online)
6. Approver approves, signs off (online)
7. Calculations Package is final for File Storage (Total time > 1½ hours!)

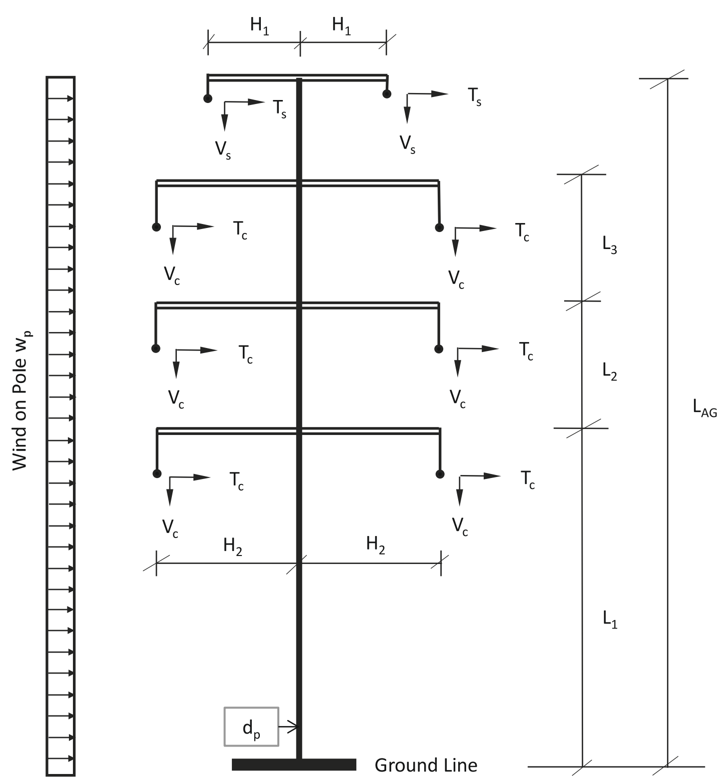
Figure 3b. Calculations for Cantilever Beam

EXAMPLE 2

Figures 4a and 4b show the calculation of ground line bending moment for a double-circuit transmission pole given the vertical and transverse loads at wire points and various attachment dimensions (see Notation for definition of parameters.) The actual calculation is expected to take less than 15 minutes whereas the additional documentation consumes over 3 hours. That is, 12 times! (Note that all time charges – engineer, reviewer and approver – are billed to the client.) However, instead of the items of Step 2, if the reviewer/approver mark up their notes on the original calculations sheets themselves – in person with the engineer – it would be time-saving and economical. A simple signed attestation as follows would be sufficient:

"The above calculations are checked and are found to be correct, consistent and correlate well with the specified design parameters of the problem. Approved for project documentation."

A typical high-voltage transmission line may contain up to 8 to 10 structures per mile and the documentation costs increase proportionately. Therefore, it is advisable to reduce the paperwork and reviewer/approver time. This benefits both the engineer and the Owner.



Given:

L_{AG} = 70' (21.34 m)
H_1 = 5' (1.52 m), H_2 = 10' (3.048 m)
L_1 = 45' (13.72 m), L_2 =10' (3.048 m), L_3 = 10 (3.048 m)
w_p = 20 pounds / foot (0.298 kg/meter)
d_p = 1' (0.3048 m)
V_s = 500 pounds (227 kg)
T_s = 1,000 pounds (454 kg)
V_c = 1,000 pounds (454 kg)
T_c = 2,500 pounds (1135 kg)

Figure 4a. Transmission Pole subject to Loading

Determine: Bending Moment at the Ground Line

Solution:

$$GLM = (2)(V_s)(H_1) + (2)(T_s)(L_{AG}) + (2)(3)(V_c)(H_2) + (2)(T_c)(3L_1 + 2L_2 + L_3) + (w_p)(L_{AG})^2(d_p)/2 \quad \text{(Eqn.2)}$$

$$= (2 \times 500 \times 10) + (2 \times 1000 \times 70) + (6 \times 1000 \times 10) + (5000 \times 165) + (20 \times 70^2 \times 1/2)$$

$$= 10{,}000 + 14{,}000 + 60{,}000 + 825{,}000 + 49{,}000$$

$= 958{,}000$ pound-feet (132,491.4 kg-meter) (time ≈ 15 min)

Additional QA Documentation:

Step 1

1. Check value and units for H_1, H_2
2. Arm Lengths measured from face or centerline of pole?
3. Check value and units for L_1, L_2, L_3 and L_{AG}
4. Check values and units for all loads
5. Attach Reference for Loads used
6. Attach Reference for Pole Geometry
7. Attach Reference for Formula Used
8. Check value and units for GLM
9. Engineer gives Reviewer the Calculations package (online)

(Some firms require all numbers up to second decimal place even though that rarely affects the final result)

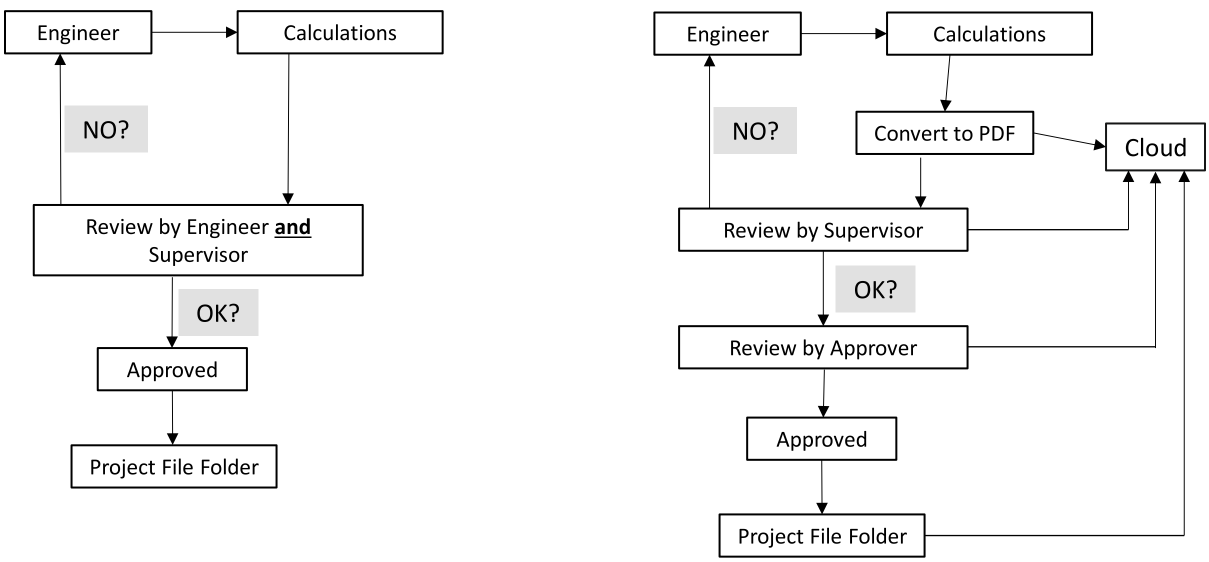
Step 2

1. Reviewer reviews (online)
2. Sends it back to the Engineer (online)
3. Engineer incorporates changes (if any)
4. Sends it back to Reviewer (online)
5. Reviewer sends to Approver (online)
6. Approver approves, signs off (online)
7. Calculations Package is final for File Storage (Total time > 3 hours!)

Figure 4b. Calculations for Transmission Pole

EXAMPLE 3

Figures 5a and 5b show two typical ways of filing the calculations for review and subsequent documentation. The merits of a simple process of (a) can be easily seen in comparison to the cumbersome process of (b). Eliminating the post of the Approver is time- and money- saving if a supervisor is deemed qualified to review an engineer's calculations.



(a) Simple Documentation Process

(b) Complex Documentation Process

Figure 5. Typical Documentation Process

Engineering Judgement

What does the foregoing discussion demonstrate? Timelines and budgets aside, such excess practices defeat the very goal of engineering. The art and purpose of engineering is to take a complex process and make it simple! This can be facilitated by recognizing and encouraging the element of engineering judgment, which is a qualified engineer's or Supervisor's ability to discern and eliminate redundancy. By education, training and experience, engineers can help identify and retain only necessary procedures, without recourse to a superficial set of QA forms.

Conclusions

In the preceding sections, a discussion on how too much QA affects the timeline and budget of projects is presented. Examples of design and documentation with excessive paperwork are provided along with suggestions of how to minimize the wastage of time and money. These are only a small set of examples and there could be hundreds of others that are possible under various aspects of a design regime. While it is not the author's intention to discount the importance of QA checks, it must be remembered that the goal here is saving time and money while simplifying the burden of reviewing, checking and documentation. Technology is no doubt facilitating QA on a wider format but still some old-fashioned common sense is sure useful.

References

IEEE Standard 751, "Trial Use Design Guide for Wood Transmission Structures", Institute of Electrical and Electronics Engineers (IEEE), New York, New York, USA, 1991.

Kalaga, S. and Yenumula, P., Design of Electrical Transmission Lines: Structures and Foundations, CRC Press (Taylor and Francis), 2016.

PMI, Project Management Book of Knowledge, Newton Square, PA, 2011.

NOTATION

d_p	=	diameter of pole (average)
w	=	uniform load on beam
w_p	=	wind load on pole
GLM	=	Ground Line Moment
H_1	=	Span of Davit Arm 1
H_2	=	Span of Davit Arm 2
L	=	Length of the Member
L_1, L_2, L_3	=	Distances from Ground to wire attachment points
L_{AG}	=	Pole Height above ground
M	=	Bending Moment of beam
P	=	Point Load at end of beam
T_s	=	Transverse Load - Shield Wire
V_s	=	Vertical Load- Shield Wire
T_c	=	Transverse Load - Conductor
V_c	=	Vertical Load - Conductor

Sriram Kalaga *is currently a consulting Civil-Structural engineer based in Baltimore, Maryland, USA. He has been involved in transmisison line structural design in the USA for over 18 years with overall experience as a Civil Engineer spanning 36 years. He has co-authored the first textbook on transmisison structures and foundations published in USA and Europe. In addition to being a Fellow of ASCE, he is also a Member of AISC, ACI, NSPE and IEEE. He served on the ASCE Committee on composite transmission structures. His research background includes finite elements, stability, nonlinearities, bolted connections, column end restraints, laterally-loaded piles, low-cost composites, foundations and reliability-based designs. He can be reached at drkalaga@hotmail.com*