Engineers Are from Aristotle

By Jon A. Schmidt, P.E., SECB

The January 2007 issue of STRUCTURE® included an "Outside the Box" article by Erik Anders Nelson entitled *Architects Are from Plato*. Nelson used the different philosophical priorities of Plato and Aristotle to highlight some of the distinctions between the typical approaches that architects and engineers take when carrying out their respective design tasks. I would like to elaborate on some key aspects of Aristotle's thought that I believe are especially relevant to engineering design.

Like Plato, Aristotle was concerned with resolving the tension between the permanence and change that we observe in the world around us. Which is more basic – the one or the many? Earlier philosophers tended to take sides – for example, Heraclitus argued that permanence is an illusion, and change is the universal feature of reality; while Parmenides advocated the opposite position, claiming that change is impossible, since everything that exists is just being itself. Plato sought to harmonize the two by developing an elaborate theory of "forms" – independently existing immaterial universals in which various individual material things participate.

Aristotle absorbed and adapted his mentor's teachings, adopting the notions of *act* and *potency* – what something *is* and what it has the capacity to *become* – and noting that potency must always be grounded in something actual. For example, that which is *actually* a steel billet (now) is *potentially* a wide flange beam (in the future). Aristotle also modified Plato's theory of forms, insisting that every physical object is an irreducible *composite* of matter and form. Matter without form is pure potency, and thus not actual; form without matter can exist only as an immaterial particular, such as an abstract concept in the mind.

Change occurs when something else causes an object's matter to transition from one form to another – to *transform* – actualizing a potency of that object. Aristotle identified four different types of causes, which are perhaps better characterized as types of explanations: material, formal, efficient, and final. As the terminology suggests, the first two correspond directly to matter and form; the last two concern how and why potency is actualized, respectively. Efficient causes are similar to what we mean by our most common current usage of the word "cause" – that which brings something about. Final causes are ends or goals – that for the sake of which something is brought about.

Aristotle believed that final causes are "the cause of causes" and took precedence over the other three kinds. Unless an object (material cause) is directed at producing certain effects (final cause) by virtue of its nature (formal cause), how can we be confident that the object is really the (efficient) cause of those effects? Notice that the final cause is not necessarily conscious or intentional; in fact, Aristotle viewed teleology as something that is present throughout the universe, not just confined to human endeavors. By contrast, modern philosophy largely abandoned both formal and final causes and is still struggling with the "problems" that this created.

What does any of this have to do with engineering design? Well, it seems to me that the role of an engineer is to select the formal, material, and efficient causes of an artifact in light of its final cause, which is often dictated primarily by non-technical factors (*The Social Captivity of Engineering*, May 2010). This is essentially what we mean when we use the verb "design", and the noun "design" roughly corresponds to the formal cause of the thing designed – the structure or pattern that *informs* the matter that ultimately constitutes the physical product or project (material cause), which serves a designated purpose (final cause) after it is assembled or built (efficient cause).

Of course, in the process of designing, an engineer must determine all four causes for various elements and subsystems – final (function), formal (configuration), material (specification), and efficient (construction). None of these component causes are inherent in the client's overall final cause, just waiting to be "discovered"; the engineer has to make *decisions* based on his/her knowledge of various feasible arrangements of appropriate materials and the corresponding fabrication and installation methods (*Engineering as Willing*, March 2010).

In summary, engineering design creates roadmaps for actualizing the potency of physical objects in order to satisfy real and perceived needs and desires. Aristotle taught that a good life was one that achieved *eudaimonia* – a Greek word usually equated with "happiness", but more accurately translated as "human flourishing". I would like to think that he would commend the engineers of today as enablers of *eudaimonia* for society as a whole.▪

Your Turn

Can Aristotle's concepts of act and potency, matter and form, and the four causes be reconciled with the modern "scientific" worldview? Are they relevant to our understanding of engineering and its place in our culture? Please submit your responses and see what others have had to say by clicking on the "Your Turn" button at **www.STRUCTUREmag.org**.

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