TWI Report #1 - The Cause of All Infrastructure Failures

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Public infrastructure in the U.S. is wearing out faster than it is being replaced. The average age of U.S. infrastructure and the number of defects and failures increases every year. This is not sustainable if we expect to maintain our infrastructure and quality of life.

However, it is important to avoid making the same mistakes which caused the public infrastructure to be defective in the first place. If we want to fix broken infrastructure, then we should identify what is actually causing the problems. This report will demonstrate that there may be a more productive path going forward.

PROBLEM-SOLVING

One problem-solving technique involves dividing a complex problem into its constituent components or categories. By dividing a problem into progressively smaller components or categories, a portion of the problem becomes small enough that a partial-solution can be implemented right now. This is when the break-through occurs. A possible path forward has just been identified. Progress has been made towards solving the larger problem. An intelligent discussion about defects and failures in public infrastructure requires us to divide them into smaller components and categorize them. Let us begin.

All infrastructure defects and all infrastructure failures there have ever been (and ever will be) can be divided into the following three categories:

1. Old Age: Some public infrastructure was never supposed to last this long, so defects and failures are to be expected. The most proximate cause of the defect or failure could be aging infrastructure.

2. Day-One Defects: The most proximate cause of the defect or failure was built into the public infrastructure from the day it went into service. Although it can take years for the infrastructure to finally fail, this is a day-one defect.

3. Subsequent Damage: The public infrastructure may have met all applicable industry-standard criteria when it was placed in service, yet it still failed prior to the intended lifespan. In that case the most proximate cause is subsequent damage. The infrastructure would have provided a full service life, but a later event (or lack of a required event) damaged it.

OLD AGE

Most public works infrastructure should be designed to last a minimum of 50-75 years. The designer might use 50 years, 75 years, or another industry-standard duration depending on the design criteria applicable to that specific part of the infrastructure when it was designed. The 50-75 year duration is an economic assumption based on how long the selected materials are expected to provide adequate service. The designer should also account for what they do not know about the longevity of the materials.

The design life is usually built into the applicable standards for public infrastructure so it does not normally appear in the designer's calculations. These standards reduce the cost of design, reduce the cost of construction and maintenance, and help to insure that the public gets what they paid for. That is why such standards exist.

Minimum design durations have been used for longer than most infrastructure has been in service, but there are several exceptions: One exception would be replaceable and above-ground components which

do not need to last 50-75 years because they can be inspected, repaired, or replaced without requiring excavation or complete demolition of the adjacent infrastructure. Exceptions also include temporary structures which are specifically intended to last less than 50 years. Another exception would be life-safety critical components of highway bridges and flood control facilities where the required design life is more than 50-75 years.

The finer points of design-life are subject to interpretation. In fact, industry-standard publications identify a wide range of durations for the same infrastructure, but let's not get stuck in the weeds on design-life differences at this point. I assume that public works officials are aware of these requirements for the infrastructure which they manage. They should already be using this information to develop a plan and budget for future infrastructure replacements.

Public infrastructure should serve at least as long as its design life. Therefore, if public infrastructure fails prior to its industry-standard design life, then aging infrastructure cannot be the most proximate cause of the failure. The fact is: something else was wrong -- there was a more proximate cause of the failure – the public infrastructure should have lasted longer. Anyone who knows this should not be claiming that early failures were caused by aging infrastructure.

There are 100-year old brick sewers in Los Angeles, Boston, and other cities where the interior bricks are delaminating and falling to the floor. The cause is aging infrastructure. However, when public works infrastructure fails before its required design life, we are forced to look elsewhere for the cause. The other places we must look to explain the failures are obvious: day-one defects and subsequent damage.

DAY-ONE DEFECTS

Was the failure actually caused by a defect which was present from the time of construction, but it just took this long to reveal itself? If the answer is yes, then that defect is a "day-one" defect. Day-one defects include defective design, defective materials, and defective installation procedures. Of course, we can only claim a day-one defect if the infrastructure did not meet the design and construction standards which were in place at the time of the original design and construction. We do not expect older infrastructure to have been designed and constructed in accordance with current criteria. In many cases, we can still obtain the very standards which should have been applied. Those are the ones which are used to identify day-one defects.

SUBSEQUENT DAMAGE

Did the design, materials, and installation meet all applicable requirements at the time of construction, yet the infrastructure still failed prior to its minimum required design life? Then we must conclude that the most proximate cause was "subsequent damage". Subsequent damage consists of the following three sub-categories:

- Someone damaged the public infrastructure at some time after its initial construction.
- Someone failed to provide the required industry-standard maintenance of the public infrastructure. How was that ever supposed to work?
- A natural cause such as an earthquake, landslide, tsunami, or fire (sometimes) can be the most proximate cause of the damage, if the cause was greater in magnitude than the public infrastructure was supposed to be designed for.

Note that even if the public infrastructure was built by ancient Romans in 200 BC and had no specific design life at all, it would not materially change the case being presented here. If a Roman aqueduct was accidentally knocked down by a bulldozer today, would we still blame the failure on aging infrastructure? Now let me ask you this: how is that any different from cracking a 100-year-old sewer line in your city during subsequent watermain or storm drain construction? The resulting failure can only be

categorized as being caused by subsequent damage. It has nothing to do with the age of the infrastructure. (Side note: pay attention to how the damaged pipe is repaired. Many repairs of broken sewers are also defective from day-one).

THE PATH FORWARD

It is always possible for multiple causes to contribute to a failure of public infrastructure. However, **the most-proximate cause should always get the most blame for the failure**, because it is the one most responsible for the failure happening when it did. If not for the most-proximate cause, the infrastructure would probably have lasted many years longer, and none of the reports in this series would have been written.

It is dishonest to claim that our public infrastructure is failing from old age if you know there are more proximate causes of the failures built-into the infrastructure from day-one. It is also dishonest to claim that the infrastructure failed from old age if you know that the failures were actually caused by specific events, or by failures to perform the required maintenance.

In future reports, we will provide more information about correctly categorizing the defects and failures in public infrastructure, and the failures of public works in general. We will consider the mechanisms by which age gets blamed for so many defects and failures which have almost nothing to do with age.

This will point us in a new and more productive direction going forward. Until then, enjoy your infrastructure while it lasts.

ABOUT THE AUTHOR

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