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Analytics and Physical Chemistry Are Important in Litigation Technical Investigations

ACTIONABLE INSIGHT FOR LITIGATORS, INSURERS, AND CORPORATE COUNSEL

- Analytics coupled with physical chemistry uniquely addresses the challenges encountered in the scientific investigation of many types of failures and accidents.
- This case study is of a dispute that went to trial involved a road resurfacing technique
- A senior professor from a major research university conducted a typical investigation and concluded that aggregate deviating from civil engineering codes caused the failure.
- Dr. Fildes used analytics to analyzed almost 80 aggregate specifications from more than two dozen states and several major research studies to establish that the aggregate in this case fell in about the middle of the range that is used across the numerous states examined to produce a durable roadway surface.
- Dr. Fildes used physical chemistry principles with analytics to establish that the cause of this failure was due to poor adhesion between the binder and aggregate due to the used of a water intolerant organic binder and the presence of water in the aggregate at the time of the roadway resurfacing.
- The jury was able to more easily understand that Dr. Fildes's conclusions were reached by several semi-independent analyses, rather than having to understand complex scientific principles. The jury found for the defendant that hired Dr. Fildes. Dr. Fildes was the defense's only expert.

This content is based on Dr. Fildes' scientific experience, He is not an engineering or lawyer and does not practice engineering or the law.

INTRODUCTION

Analytics, which involves data mining and modeling, is likely not thought of as part of a litigation-related investigation, but it should be as indicated by Virginia Tech's College of Science having made analytics an overarching theme of its graduate degree programs. Accidents and product/structure failures do not happen in a lab under controlled conditions and the watchful eye of measurement instrumentation, and although there is often data, it is limited in its scope and amount and often contaminated with uncertainty and unrelated factors. Sometimes there is no evidence to inspect or test. Analytics provides highly effective tools to overcome these data challenges and is extremely powerful, but it requires specialized software, experience, and training in the applicable scientific principles, data mining, and modeling techniques.

Physical chemistry is the application of physics principles and mathematical methods to chemical systems that span all other sub-specialties of chemistry. Physical chemistry is an important and unique science because it provides the scientific basis for a vast variety of engineering disciplines such as: heat and moisture transfer that underlie chemical process engineering and building envelope science; the strength of materials such as composites used in aircraft; ceramics; chemical reactivity that underlies chemical process control; and electrochemistry that underlies corrosion. Physical chemistry provides proven principles and data to reliably estimate the

properties of a vast array of materials under a variety or conditions.

Analytics coupled with physical chemistry uniquely addresses the challenges encountered in the scientific investigation of many types of failures and accidents. An example is provided by the following case in which Dr. Fildes was an expert.

The Case Study

A case that went to trial involved a road resurfacing technique. The new surface had been installed in the summer on tens of miles of roadway and had failed with the onset of cold weather that same year. Hundreds of cars were damage by loose aggregate in addition to the roadway having to be resurfaced again, resulting in a damage claim of millions of dollars.

A senior professor from a major research university was used near the time of the failure by the installer of the new surface to investigate the cause of the failure. His opinion was that the aggregate did not meet the State's DOT specifications, and this caused the failure. Dr. Fildes was retained by the attorney who represented the aggregate supplier. The case went to trial by a jury in the county where the failure occurred. Dr. Fildes was the only expert for the defendant and one of only a few witnesses called by the defense. The trial resulted in a full verdict for the defense. The jury contained a retired engineer who was knowledgeable of roadway resurfacing and the State's roadway specifications.

The Role of Analytics in Litigation

In the Supreme Court's Daubert decision Justice Blackmun emphasized that science is a process in which an inference or assertion must be derived by the scientific method, which he described as a validation technique. Analytics is inherently a validation technique that fully utilizes the scientific method.

Litigation is an adversarial process in which attorneys sometimes try to draw distinctions between engineers and scientists, but the U.S. Supreme Court did not do so. Justice Breyer in his Introduction to the *Reference Manual on Scientific Evidence*, 3rd. Edition, National Academies Press, writes "All of the justices of the Supreme Court, in an opinion by Justice Breyer, held that the trial court's gatekeeping obligation extends to all expert testimony,37 and unanimously rejected the Eleventh Circuit's dichotomy between the expert who "relies on the application of scientific principles" and the expert who relies on "skill- or experience-based observation. 38." The National Academy of Engineering (NAE) noted in its Amicus Curiae brief to the U.S. Supreme Court in the Kumho Tire Case that science focuses on understanding nature and engineering focuses on modifying nature. Engineering modifies nature through the application of scientific principles guided by codes, standards, and design procedures. This is seen in the NAE's Brief, which noted that "…science provides the foundation for the engineer's work."

The Use of Data Mining in Examining Codes and Standards

Data mining uses specialized, sophisticated software to visualize and identify patterns in the data that is available. Plotting data in different coordinate systems, or first transforming the data, can reveal systematic trends. Mathematically transforming data can make trends more obvious. The ways in which the data is plotted or transformed is sometimes suggested by the underlying scientific principles and sometimes by data analysis methodologies for discovering trends in the data that are not easily seen.

The data can also be characterized statistically to establish the variability of the data, which can be used to identify what portion of the available data comes from the same population and is therefore similar and related to the same underlying scientific principles. Treating the data, especially data collected at different times, as vectors allows cluster analysis by statistical

methods or by newer and potentially more effective neural network techniques, which provides another way to identify which samples of data are similar and which are different.

Accidents and failures happen because scientific principles are violated. In this road resurfacing case study, the plaintiff's expert opinion was that the aggregate supplied did not meet the State's codes and this caused the failure of the new roadway surface. A careful reading of the codes and of the several tests that had been conducted of the aggregates size distribution did not clearly support this opinion, plus not adhering to a code does not necessarily cause a failure.

Since codes and standards are often established by consensus and in the case of civil and building codes have to represent the nature of materials that are locally available, Dr. Fildes used data mining of many states' codes and standards to establish the range of aggregate size distribution that would result in a durable road surface from the road resurfacing technique involved in this case. He identified relevant data and analyzed almost 80 aggregate size distribution specifications, the majority of which came from more than two dozen states with the rest coming from several major research studies. This analysis clearly established that the aggregate size distribution in this case fell in about the middle of the range that is used across the numerous states examined to produce a durable roadway surface.

Although data mining is powerful in the insight it can produce, it is common for significant gaps to still exist in the data.

The Use of Data Modeling in Examining Codes and Standards

Modeling addresses the issue of gaps in the available data by using trends discovered by data mining, fundamental scientific principles, and known properties of materials to estimate the data needed to fill the gaps. A significant amount of data is available from academic research and industrial R&D, and although this data is often valuable, it is usually not generated specifically for the situation under investigation and needs to be adapted, which requires skill by the investigator to both see the utility of the data and to adapt it. The estimates produced by modeling are tested and validated by estimating data that already exists.

The fundamental scientific principles that are used come (to a substantial degree) from: thermodynamics, which determines which processes can happen; chemical reactivity, which determines the rate at which a process happens; chemical bonding and adhesion, which relates to the strength of materials and a material's susceptibility to degradation; solid state physics, which determines the properties of semiconductor materials and devices; and general physics, which underlies mechanical properties. Dr. Fildes has formal training and experience in these disciplines and has used analytics to investigate the strength and fracture of materials, corrosion, thermal degradation, chemical compatibility, vaporization and evaporation, adhesives, expansion/contraction of wood and laminates, and many others.

In this case, Dr. Fildes identified several model-based design tools developed by the Federal Government and several states and that are utilized by several states to guide their use of this road resurfacing technique. Dr. Fildes applied each of these models and combined their results to establish the range of aggregate size distributions that would provide a durable roadway surface using the road resurfacing technique that was investigated in this case. The results of this data modeling not only further validated the data mining results described above, but also provided scientific insight as to what factors of an aggregate's size distribution are important to obtain a durable roadway surface. These factors further confirmed that the aggregate used in this case would be expected to provide a durable roadway surface, which was more easily understood by the jury.

The Use of Data Mining and Data Modeling in Broadening the Scope of an Investigations

Data mining and data modeling also uncovered important insight about what other factors could cause a roadway that was resurfaced with this technique to fail within a few months as the temperature dropped. The model-based resurfacing design techniques coupled with fundamental chemical principles and patent literature on the binder used established a failure mechanism due to lack of adhesion between the binder and aggregate because of excessive moisture. This failure mechanism was validated by showing how it matched observations made during the resurfacing and the manner in which the surface failed.

The Importance of Analytics in Deposition and Trial Testimony

Non-technical people may not fully understand the details of complex scientific concepts, but they do comprehend the confidence that is imparted by same conclusion being reached by different methods, data mining and data modeling, and they appreciate that a material that works in a similar use in other localities means that the failure here is due to something other than that material.

Analytics helps make abstract concepts real by changing the focus from the concept to how the situation is similar to others where no failure occurs. Without use of analytics, this similarity may not have been uncovered and would have made the testimony more about having to explain the complex scientific concepts in abstract terms.

Analytics Is an Important Tool in All Technical Investigations Including Litigation-Related Ones

Some attorneys and even some experts may not appreciate the importance of analytics in litigation-related technical investigations and using analytics is challenging. Analytics requires a deep knowledge of scientific principles so that they can be applied in the unusual situations that accidents and failures often present. In this case for example, Dr. Fildes not only understood the science of adhesion and composite materials, but he also is experienced with how technology including civil and building construction is developed and disseminated and how codes are established. His broad chemistry and physics background enable him to apply analytics in almost any materials related situation.

Analytics also requires extensive knowledge of statistics, data modeling, and increasingly of artificial intelligence methods, with which one has to be sufficiently experienced to apply in a practical way. Analytics also requires comprehensive searching for relevant data and the experience to select meaningful subsets of data during the exploratory screening phase so as to make the time required practical. This is a demanding combination of skills and experience that some experts may lack. Dr. Fildes has used analytics in numerous situations starting with his Ph.D. dissertation research and continuing throughout his R&D career, and now in conducting litigation-related investigations.

The importance and value of using analytics in some litigation investigations, especially ones that are more complex and multidisciplinary, cannot be overstated. A message from the Dean of Virginia Tech's College of Science stated "At the Virginia Tech College of Science, we have reimagined scientific research…. We are focused not on data itself, but amplifying the relevance of that data with analysis, modeling, and interpretation." (Va. Tech Science, Fall 2019)

Combining empirical trends in the data uncovered by data mining in litigation-related technical investigations with estimates made from modeling based on fundamental scientific principles using data generated by academia and industry not only fills gaps in the limited data available from the accident or failure but is also uniquely able to provide insight as to what scientific principles were violated and why they

were violated, resulting in the accident or product failure.

Testing the hypotheses made in an investigation is also inherent in this approach, which is extremely valuable since testing hypotheses is an essential aspect of the scientific method that guides the normal conduct of scientific investigations and that is also fundamental in litigation-related technical investigations to meet the rules of evidence.

Bio for John Fildes, Ph.D.

Dr. Fildes' experience for conducting the type of work described above is extensive, spanning his entire career from graduate education to the present. He has a doctorate degree in physical chemistry and the concepts of thermodynamics underlying combustion and chemical reactivity, and of quantum mechanics underlying the strength of materials and failures provide the underpinnings of much of chemical, mechanical, materials, and electrical engineering. Statistical analysis, data mining, and modeling the properties of materials and chemical systems and making predictions based on those models was central to his Ph.D. dissertation and was used numerous times in conducting his over $27.5 million of funded R&D starting at Borg-Warner's Corporate Research Center, and continuing as Director of Sensors and Controls at IIT Research Institute, as a senior scientist and group leader at Northwestern University, as the founder and co-director of Northwestern University's Advanced Composite Materials Intelligent Materials Processing Center, and through his Army-funded work in tribology (the science of friction and wear).

Dr. Fildes has done extensive research using analytics in process control that was funded by the Gas Research Institute, the Army, the Navy, the State of Illinois, and the Great Lakes Composites Consortium. The Gas Research Institute (GRI) used him to help define their research agenda in combustion control. He was an invited workshop panel member for a report on Intelligent Process Control Systems for Materials Heat Treatment prepared by the National Materials Advisory Board of the National Research Council (National Academy Press) and an invited speaker on intelligent process control of chemical processes organized by the Defense Advanced Research Agency (DARPA). He led the process control activities for the Great Lakes Composites Consortium involving a team including Grumman, Northrop, and McDonnell Douglas. He was invited to provide a demonstration of intelligent process control to Congress, which he did provide. His work in materials processing and process control was the basis for establishing Northwestern University's federally funded Advance Composite Materials Intelligent Processing Center.

Although Dr. Fildes does not practice engineering, he has extensive experience with engineering. He served as a post-doctoral research associate in the Department of Chemical Engineering at Virginia Tech and instructed in a course on chemical process control. He led two substantial engineering companies licensed in Illinois as both Professional Engineering and Structural Engineering organizations, a not-for-profit materials science research institute, and a materials science group of 28 scientists and engineers at Northwestern University, which gives him much experience with the conduct, application, and principles of engineering. His oversight of major research labs also gives him broad experience with issues involving chemical and materials safety.