Conditional Probability in Expert Opinion

By Patrick Irwin, Forensic Structural Engineer

This article questions the validity of expert opinions based on multiple factors and uncertainty.

Introduction

In most civil cases, courts and tribunals are required to reach a *balance of probability* opinion of the ultimate issue. This criteria does not strictly apply to expert opinion and an expert's opinion is often not the only evidence the court or tribunal weights. However, in most cases an expert should seek to at least reach a balance of probability opinion. Ideally a higher level of certainty. There are cases where this is not required such as when an expert is exploring possible doubt but this article is limited to the case of an expert attempting to reach a positive view with some uncertainty.

To express a positive opinion, the expert must be more than 50% confident of their opinion being correct rather than incorrect. This is distinct from being *certain.* When considering past and future events and conditions unseen *certainty* is rare. For example opining causation when one was not witness to events is likely to have some uncertainty.

Where an expert's opinion is based on being satisfied of a sequence of events or circumstances, reaching a balance of probability view is often more exacting than it appears and some consideration of probability can be useful.

To take a simple example if an expert was to opine the probability of having rolled a double six at dice, the calculation is simply 1/6 x 1/6 or 1/36, around 3%. Much less than the 50% required for a balance of probability opinion. If one was to opine the probability of *not* having rolling a six twice in a row the calculation is 5/6 x 5/6 or 25/36, just under 70%, well over balance of probability.

Dice are a useful example as the rolls are independent or unrelated events. It doesn't matter what the first throw turns up, the probability of rolling any given number for the second throw is always 1/6. The balance of this thesis concerns similarly independent events or, for practical purposes, events with no material relationship.

For example, if one is opine whether damage has been caused by an event, the occurrence of the event and it causing the damage must be established. This is an example of *conditional probability* where consecutive occurrences depend upon those prior. If one is 60% certain of an event occurring and 70% certain that the damage occurred as a result, the probabilities multiply together (as in the dice example) and causation is 42% likely (60% x 70%). This is less than 50% and thus a balance of probability opinion of causation of the damage cannot be reached. This kind of assessment sometimes arrises in investigation of suspected earthquake damage to buildings. In such cases it may still be informative to a court or tribunal to know the expert's view of the probability as other factors may also inform the decision. For example the expert's opinion combined with an eye witness account.

Practical Examples

Some of my work is in building disputes where foundation movement is at issue. In most cases there are multiple factors to consider some of which are independent. The question may be whether a cause or causes has resulted in movement and damage and whether this requires remedial works. Usually there are other essential inputs that are not known with certainly such as ground conditions. A decision table may look like this:

Input	Probability	Cumulative probabilty
Built works below ground as expected.	**95%**	95%
Foundation conditions as expected.	90%	0.95 x 0.9 = 86%
Plumbing leak has occurred causing significant flow into ground.	80%	0.86 x 0.8 = 68%
Foundation has expanded.	**95%**	0.68 x 0.95 = 65%
Building damage has resulted.	**95%**	0.65 x 0.95 = 62%
Specific repairs are required.	80%	0.62 x 0.80 = 49%

This example serves to illustrate that, in a case with several conditional inputs, very high probabilities are required for the inputs to result in a positive balance of probability result. Few experts apply this kind of rigour, they tend to skip through the high probability events as if they were 100% certain. In the above case if we attribute 100% to each probability above 90% we get a net 58%, a very different position to 49%.

I have a matter at present where in ground conditions are essential to the plaintiff's experts reaching their opinions. None of them have

examined, tested, seen or otherwise investigated the in ground conditions. Reports present as if those conditions are known with certainty, which is clearly not the case.

A Rational Probabilistic Approach

The example above is a simplification and assumes we can assess probabilities reasonably accurately. In practice this will rarely be the case. However, even attributing a range of probability values may assist consideration, even if it is not for publication in a final report. It may, for example assist identifying critical inputs. Returning to the above example, a decision table may look like this:

Input	Probability range	Cumulative probability range.
Built works below ground as expected	80 to 100%	80 to 100%
Essential foundation conditions as expected	70 to 90%	56 to 90%
Plumbing leak has occurred causing significant flow into ground	50 to 90%	28 to 81%
Foundation has expanded	**95%**	27 to 77%
Building damage has resulted	**95%**	25 to 73%
Specific repairs are required.	80%	**20 to 55%**

These results suggest that further investigation of the built works below ground, foundation conditions and plumbing leak are required to reach a positive opinion of the suspected causation. Convincing results would be required from all three. Such a conclusion, although tentative, may be informative for a party considering further investigations in pursuit of a more certain opinion.

Assumptions and Instructions

Where experts are instructed to accept that, for example, certain initial conditions existed, this should be accepted as 100% likely and need not form part of the decision process, above. It may be for others to argue the merits of the assumption but, if we accept an instruction we should generally accept it unconditionally. However, it may be worth mentioning in a report that if an assumption was uncertain one's opinion may differ.

Some of the inputs in the above example are the kind we may identify as assumptions in our reports. For example, I commonly assume that works are built as specified unless there is evidence otherwise. Ideally this assumption could be given a probability, as above. That is it is assumed as very likely but not certain. It is up to the individual expert to decide how to rationalise his own assumptions.

Causations and Consequences

The first example above demonstrates a balance of probability being reached that the building damage had resulted but not that it required the specific repairs under consideration. I suspect that this position arises more often than it is identified. There can be a tendency to accept the opinion of causation, put doubt aside and move on to remedial works. As practice notes and codes require us to discuss alternatives the opportunity is there for experts to also opine how likely they believe a scope of works is to be appropriate or effective.

Conclusions

To experts, consider how certain you are, on a % basis, even if only for your own evaluation. Caution about reaching a balance of probability opinion when several independent events are required is suggested. For practical purposes if there are three or more inputs you must be virtually certain of each to reach a positive view.

For those questioning experts' opinions it can be useful to identify the key independent events and question how certain the expert is of each.