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MISTAKES HAPPEN – THEN WHAT?

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SUMMARY

Structural engineering is a demanding 'learning' profession that is part art and part science. The science has little margin for error of application, whilst the art is subjective and creative. Acknowledging that structural engineers are human and "nobody is perfect", mistakes happen. The challenge is 'how to react to our mistakes' and 'how to deal with them'. This paper gives some perspective on how admitting mistakes, is not fun and takes courage. However, it is necessary as a professional to own any mistakes and provided you (and the profession) learns from them, it ultimately makes you (and the profession) better engineers.

INTRODUCTION

Mistakes, errors, and omissions are part of life – they happen. The mistake aftermath sometimes affects the reputation, mental health, and even the revenue of the individual or company. On the other hand, improvement and learning is sometimes not possible without failure.

Traditionally, mistakes are viewed as something bad or embarrassing. The fear of failure, constant worrying of not meeting expectations, and the feeling of being rejected are hindering our ability to embrace mistakes and learn from them.

In structural engineering we have quality assurance systems in place to catch mistakes and ensure the consequences of them are minimised. The Building Regulatory System that we are familiar with in our daily work is an example. Producer statements, design peer review, and construction monitoring provide us with some control over mistakes.

In the opinion piece that follows, the authors start from the premise that mistakes happen and as a profession and individuals, it is how we deal with them that is important. The purpose of this opinion piece is to have you critically think about your actions throughout your career and learn from any mistakes. Even better learn from someone else's mistake!

TYPES OF MISTAKES

Let's consider the types of mistakes, errors, omissions that can and do occur in structural engineering. If you subscribe to the concept that structural engineering is both an art and a science practised by humans, then you can group mistakes into science, art, and human categories. Table 1 below is not exhaustive and is opinion based on experience.

Table 1 – Types of mistakes

Science-based Mistakes	Art-based Mistakes	Human-based Mistakes
• Changing technology • Wrong source information/assumptions • Software glitch • Drawing/documentation not adequately describing the design	• Wrong load path • Details inconsistent with analysis assumptions • Using design effort on the wrong components i.e. not designing a critical component	• Omission • Arithmetic errors • Confirmation bias/interpretation • Brain fatigue due to repetitive task • Miscommunication

As an individual, the human-based mistake is the most likely controlled yet the study has shown that this is the most common cause of structural failure (Johan de Haan, 2012). Furthermore, the study has classified the cause of human-based mistakes in three levels of organisations:

- Micro-level: cause by mistake or insufficient knowledge of individual
- Meso-level: cause arising from the project organization or the management
- Macro-level: cause arising from the regulation, the culture of the sector and other external circumstances.

It could be argued that the human-based mistakes are much more complicated than the science and art-based mistake. Healthy communication is key to avoid human-based mistake.

Micro-level mistakes can be largely addressed by the individual through the right type of experience. However, Meso and Macro level mistakes require organisational or professional change. Think about design offices with a bad culture that repeatedly use products that are known not to perform as a Meso Level issue. On a Macro level think about leaky homes and untreated timber or floor diaphragms that were never designed.

The authors would like the reader to critically question both their own and their professions/organisations decisions against these three human based categories. Further we point out that as humans, confirmation bias is something that takes great self-awareness to recognise.

Consequences of Mistakes

Just as there are many sources of mistakes, the consequences of mistakes can range from negligible to catastrophic. The authors propose that the consequences of a mistake can be thought about as a continuum ranging from “acceptable imperfections” through to “unacceptable errors”. However, it is also worth noting that when there is a failure you normally find multiple mistakes, many of which are classed as “unacceptable errors”. An unacceptable error such as design error can cause severe consequences such as building collapse, economic hardship, and social issues.

PROFESSIONAL RESPONSIBILITIES

We are often being asked to act professionally but the description of being a professional is very subjective. Being a professional suggests things such as being qualified (however defined) and practising in a definable area, having expertise based on a deep level of knowledge, and having a commitment to the area of practice - possibly (but not necessarily) through being a member of a relevant professional body (Stan, 2015).

In New Zealand, Engineering New Zealand (2016), the professional body for engineers published a Code of Ethical Conduct . The judgement and decisions made by the engineer impacts not only themselves and the client but also the public. The Code of Ethical Conduct and the public expectation is that engineers keep their knowledge and skills up to date. There is a requirement to act competently, which could include not making any serious errors. Known as the Dunning-Kruger, people can show bias and overestimate their ability. (Dunning, Kruger, 1999). As above, maturity and self-awareness are required to overcome this.

The authors propose that in order to be classed as a professional you must demonstrate self-awareness and maturity.

Mistakes occur for various reasons, therefore different actions are needed to prevent or avoid the different sorts of error experienced in construction and engineering (Love, Lopez, Goh, & Tam, 2011).

The engineering profession acknowledge mistakes happen for a number of reasons and many studies have been done on preventing engineering failures. In order to illustrate the accident/failure causation, it is generally accepted that a system-based approach is a useful model. Two common models for system-based failure are the Domino and Swiss Cheese models.

The Domino model shows that the failure occurs as the result of a chain of events. The chain follows the given sequential factors. This model believes that removing one of the factors may prevent the failure. Hudson (2010) shows this model is more accurate when the mistakes are deterministic.

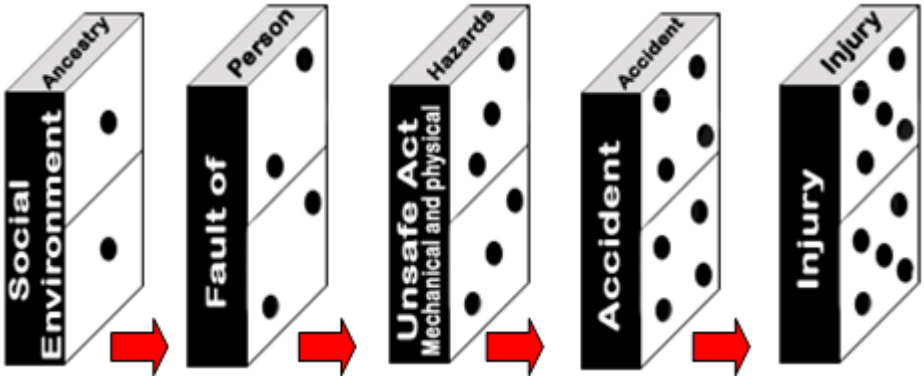

Figure 1 – Domino Theory (Hudson, 2010)

The Swiss Cheese model on the other hand shows that failure may occur when the hazard passes through the flaws of each system. The flaw of each system is likened to multiple slices of Swiss cheese where the hole location varies to mitigate the risk of a threat becoming a loss.

In the structural engineering profession, we are dealing with material strength, loading and workmanship, they are all based on statistics and probability. Therefore, the Swiss Cheese model may represent the system-based failure more appropriately. Some controls that we are familiar in our daily work are internal QA processes, producer statements, design peer review, consenting process, and construction monitoring. These could all be represented by slices of Swiss cheese, and collectively these form part of the building regulatory system.

The building regulatory system is in place hoping that the “unacceptable errors” are being sieved/filtered in the first two layers of the system. However, as perfect as it seems, when the holes are stacked together, the loss is still likely to happen. This shows there is no perfect model system to prevent loss.

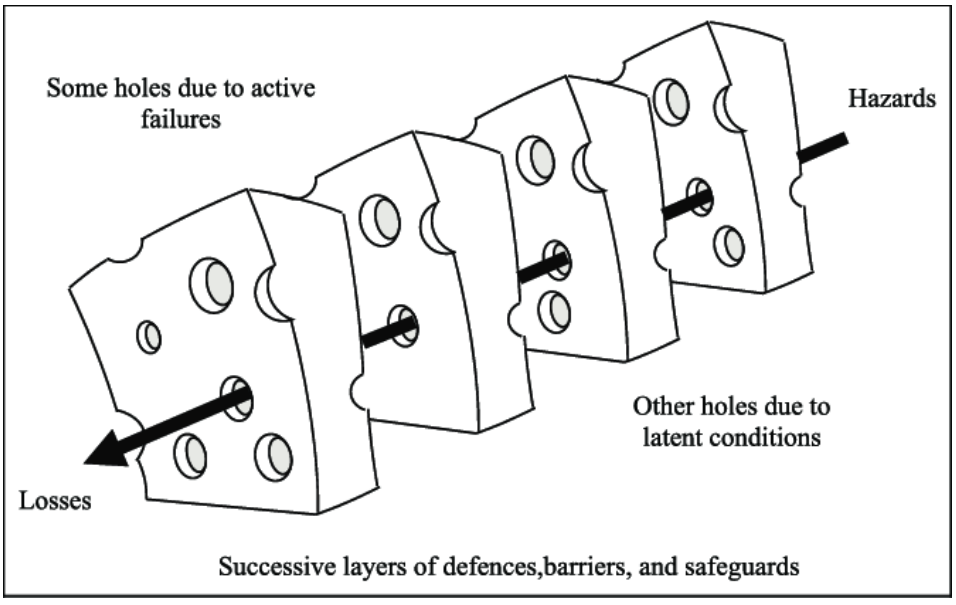

Figure 2 – Swiss Cheese Model (Reason, 1997)

Owning Mistakes

There are usually four psychological stages that happen after making a mistake:

- Embarrassment

  We are usually convinced that people will remember the mistakes for the rest of our lives. In reality, mistakes don't have to leave a permanent mark on our career. Instead, our response to the mistakes will be remembered and can even enhance our reputation.

- Denial

  There is a tendency to deny mistakes, make excuses, or even blame others. However, as a professional, this is not an option. It is also important to truly listen to others without defensiveness.

- Regret

  Regretting is the first step to acknowledging the mistake. Regret is a process in which we may remember our mistakes forever. However, it is important to not stress to the point that it affects your mental health. This process is not fun and takes courage to move on. You can however learn and grow through the process.

- Acceptance/ownership

  Reminding ourselves that 'we are only human', only we really mean it this time. However, as a professional, the best apology is not by words but the commitment and willingness to fix the error.

Fixing Mistakes

As mentioned previously, our willingness to fix the error is very important. The basic principle to fix a mistake is acknowledging your limitation and asking for expert help. The help can be from simple questions to complicated laboratory testing.

Learning from Mistakes

Failure can be seen as an asset, an investment for future breakthrough and innovations. This is simply because such a failure can raise a question on how to fix or what solution can be used in the future. The willingness to bounce back and not make the same mistake again is a professional obligation as an engineer.

As part of an organisation and profession, it is important to shift others from a blame culture toward being a learning culture. Perfectionism and overthinking may not lead to improvement in the near future.

Professional Indemnity Insurance (PI) protects from financial loss, however, it often hinders the profession from learning opportunities. With settlements covered by confidentiality it is difficult to publicise and let others learn.

CASE STUDY EXAMPLE

In 1981, the hanging walkway at the Hyatt Regency Hotel in Kansas City suddenly collapsed onto an ongoing tea dance party on the lobby floor. This resulted in 114 deaths and 216 people injured.

The hanging walkway was the main feature of the multi-storey atrium of Hyatt Regency Hotel. The walkway comprises three suspended walkways with the fourth-floor walkway spanning directly above the second-floor walkway. The fourth storey walkway fell completely onto the second storey before both walkways fell onto the lobby floor.

Figure 2 – The collapsed walkway (https://timeline.com/hyatt-regency-skywalk-failure-8240bff34fa6?gi=4582a0896730)

The investigation team found the failure of connections of the hanger rods that supported the two-storey walkways was the issue. The investigation revealed the discrepancy between the original design sketches and the installed connection.

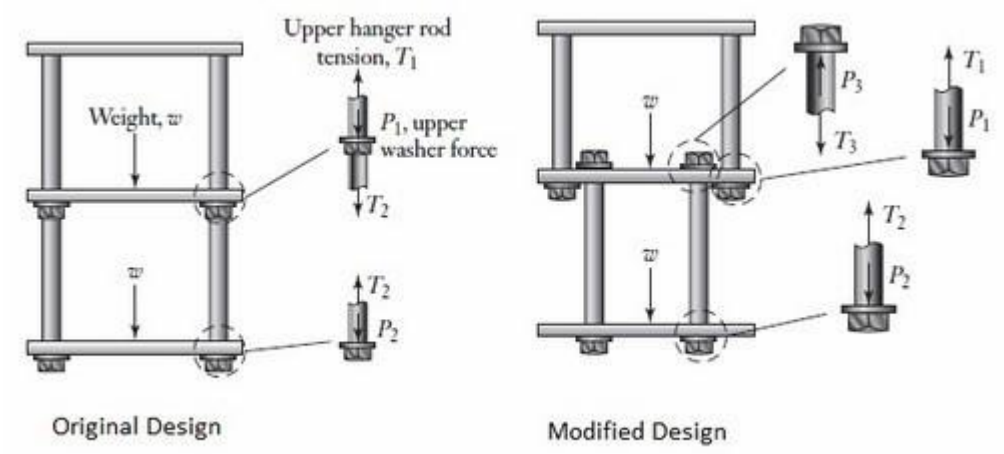

Figure 3 – Freebody diagram illustrating the difference between original and actual construction (https://www.indovance.com/knowledge-center/hyatt-regency-walkway-collapse-did-the-structural-analysis-go-wrong/)

Jack D. Gillum, the design engineer of record for the Hyatt project, contended that it was common practice in the industry for the structural engineer to leave the design of steel to steel connections to the fabricators and the structural engineer only provided the intended design through sketches (American Society of Civil Engineers, 2007). When the fabricator found that the connection design was not practicable on-site, they proposed an alternative connection and which the design engineer verbally approved the changes.

The modified connection generates concentrated load at the fourth-floor walkways such that the connection had to sustain double the original design intention. This meant that the hanging connection couldn't even sustain the walkway weight itself and led to collapse. This lack of communication and omission led to the deadly failure.

This tragedy left a significant impact on public confidence towards the engineering profession. The profession then responded by upgrading the culture and academic curriculum of engineering ethics and emergency management.

Jack claimed full responsibility and suggested that engineering societies to learn from his mistakes. He took his fault as a mission and teach the young engineer 'to scare the daylights out of them'. The takeaway from this disaster shows that as an individual, the smallest personal responsibility of an individual can impact the biggest project with the worst possible results.

What can we learn from this example?

The authors contend that this illustrates the Micro and Macro errors above. Micro for the design engineer to only provide sketches (that the contractor considered not practical). Macro for the common industry practice.

Further the authors admire how "Jack claimed full responsibility and suggested that engineering societies to learn from his mistakes. He took his fault as a mission and teach the young engineer 'to scare the daylights out of them'."

CONCLUSIONS

Admitting a mistake is not a fun process. it takes a lot of courage and a long process. However, the value of a mistake is not in the mistake itself but in what we can learn from it. Knowing that mistake is inevitable, it gives power to the individual to embrace themselves, try not blaming ourselves or others, instead learn together from the mistake.

Keep confidentiality of others' mistakes is also important and not to use other people's mistakes as a political football are also part of the Code of Ethics. The professional body has set the code of conduct and etiquette to help engineers keep in line with their responsibility. However, the importance of self-check and not relying on the system – supervision, verification, and peer review to catch the individual mistake, as a safety net.

ACKNOWLEDGEMENT

To all engineers who made or are going to make mistakes, we are in this together, how we fix our mistakes will be the reputation we earn.

We owe it to ourselves and the public to take our responsibility seriously and act with professionalism.

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