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1 **Using System Archetypes to identify safety behaviours within the**
2 **Malaysian construction industry**

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12 **Using System Archetypes to identify safety behaviours within the**
13 **Malaysian construction industry**

14 **ABSTRACT**

15 The construction industry, particularly in Asia, experiences disproportionately high numbers
16 of occupational injuries and fatalities. Malaysian construction fatality rates are more than
17 double those in developed nations. Systems thinking has previously been used to identify
18 ‘archetypal’ casual structures underpinning safety-related construction behaviours via a
19 Grounded Theory analysis of interview data from construction safety professionals in New
20 Zealand (Guo et al. 2015). This paper partially replicates the method of this prior work within
21 a different cultural context in order to further validate the method and evaluate the extent to
22 which the previously identified structures are indeed archetypal. Seven interviews were
23 conducted with Malaysian construction industry professionals. Three potential archetypal
24 structures were identified concerning: (1) effects of a migrant workforce, (2) corporate
25 accountability and profit driven business culture, and (3) issues in the regulatory system. The
26 structure of behavioural systems in Malaysian construction is depicted providing a view into
27 the failings of construction safety management systems and the interventions to address them.
28 Contractors’ drive for profit was determined as a primary contributing factor in most causal
29 relationships identified. The method is shown to be useful and evidence produced to suggest
30 at least one of the previously proposed causal structures is archetypal.

31
32 **KEYWORDS:** Construction safety, systems thinking, archetypes, Malaysian construction,
33 systems dynamics

34

35

36

37 **1. Introduction**

38 Construction is a hazardous sector (Im et al., 2009; Razak, Ibrahim, Roy, Ahmed, & Imtiaz,
39 2010; Ringen, Seegal, & Englund, 1995). It experiences a disproportionately large number of
40 injuries and fatalities for the number of people employed, compared to other industries (Chong
41 & Low, 2014; Ringen et al., 1995; Waehrer, Dong, Miller, Haile, & Men, 2007). Fatal
42 occupational accidents occur much more regularly in Asian countries than more established
43 market economies of the European Union, North America and Australasia (Hämäläinen,
44 Takala, & Saarela, 2006; Takala, 1999). Two economically and culturally different countries
45 are central to the study described here, Malaysia and New Zealand. Comparing these two in
46 terms of construction industry fatalities shows Malaysia recorded a rate 2.6 times higher than
47 that of New Zealand over the period between 2013 and 2017 (see Table 1).

48

49

50

TABLE 1

51

52

53 The danger of construction can be attributed to a variety of factors. For example, the transient
54 nature of the workforce (often referred to as ‘mobility’) results in low skill workers being
55 constantly introduced to the industry and moving from project to project (Fang, Chen, & Wong,
56 2006; Guo, Yiu, & González, 2015; Lunt, Bates, Bennett, & Hopkinson, 2008; Sawacha,
57 Naoum, & Fong, 1999). This can inhibit the cultivation of a strong safety culture. Establishing
58 a strong, positive safety culture can be a crucial tool to assist organisations with improving
59 safety performance (Choudhry, Fang, & Mohamed, 2007; Cooper, 2000). Cooper (2000)
60 defines safety culture as the “observable degree of effort by which all organizational members
61 directs their attention and actions toward improving safety on a daily basis”. It has become a

62 staple in the vocabulary of those concerned with construction related accidents, due to its ability
63 to encompass behavioural, psychological, and management factors into a single management
64 designation (Choudhry et al., 2007).

65 This mobility is compounded by issues arising from “decentralization” (Fang et al., 2006) in
66 the construction industry. This is a concept that suggests as employees are often distributed
67 and separated by site, they are dissociated from the regulation and planning that governs them,
68 which, in combination with the often complex and novel working conditions present, leads to
69 workers having to make autonomous decisions (Fang et al., 2006; P. T. Mitropoulos & Cupido,
70 2009; Sawacha et al., 1999). Letting workers make autonomous decisions assumes that they
71 are properly trained in their field and are skilled enough to make such choices - which is not
72 always the case. This combination of work conditions and pressures, as well as construction
73 crews themselves determining how work is structured and coordinated, increases the likelihood
74 of errors arising (P. T. Mitropoulos & Cupido, 2009; Sawacha et al., 1999). Thus, due to the
75 nature of construction, it is difficult for organisations to tackle safety with an organisational,
76 systemic approach (Guo et al., 2015; Lunt et al., 2008).

77 This paper explores the use of networks of cause and effect to describe construction safety
78 behaviour, evaluating and developing the work of Guo et al. (2015) to determine whether these
79 structures are archetypal across cultural differences.

80

81 **2. Background**

82 System Archetypes are the name given to a set of generic structures of cause and effect
83 feedback loops popularised by Senge (1990). They can be used to explain and describe the
84 common behaviours of a system (which in the context of this paper could include a construction
85 site, company, or whole industry). Senge argues that these cause and effect feedback structures

86 can be so influential on a system's behaviour that almost any human actor placed in a system
87 where those structures are present will produce the same results.

88 Guo et al.'s (2015) research led to the fabrication of 8 System Archetypes specific to
89 safety-related behaviours observed in the construction sector. These were based on data
90 collected from construction professionals in New Zealand, blended with the 8 general System
91 Archetypes created by Senge (1990). However, Guo et al. recognised that for these structures
92 to be truly archetypal, their research must be consolidated through "future research in different
93 cultural settings" (Guo et al., 2015). This paper attempts to validate and develop their prior
94 research using a similar methodology within the Malaysian construction industry.

95

96 ***2.1 Malaysian & New Zealand culture***

97 Before proceeding it is necessary to establish whether New Zealand and Malaysia do indeed
98 provide different cultural settings. Malaysia's national culture features a melting pot of
99 different ethnicities and religions, contributing to a unique and diverse culture (Ahmad, 1997).
100 Malaysian culture can be constructed from its main constituent cultures - Malay, Chinese, and
101 Indian. Religion is an acknowledged descriptive aspect of culture (Herskovits, 1949), therefore
102 culture can be further derived from the main religious ideologies practiced by these groups.
103 Table 2 shows the contrast between the religions practiced by Malaysia and New Zealand.
104 While there are many alternative dimensions on which to differentiate cultures, based on the
105 aforementioned use of practiced religion as a proxy gauge of culture, it can be justified for the
106 intentions of this paper that New Zealand and Malaysian cultures are significantly different.

107

108

109

110

TABLE 2

111 A study by Goodwin and Goodwin (1999) invokes a framework devised by Hofstede (1980,
112 1983) to compare the cultures of New Zealand and Malaysia. They note the difficulty in
113 assessing Malaysia's culture due to its diverse ethnic mix. Hofstede's framework has five
114 cultural dimensions: (i) expectations of equality and willingness to challenge superiors; (ii)
115 comfort with uncertainty and adherence to rules; (iii) individualism vs collectivism; (iv)
116 aggressive vs supportive behaviour, and; (v) long term vs short term thinking. Hofstede found
117 that Malaysia has considerably lower expectations of equality and willingness to challenge
118 superiors when compared to New Zealand, a slightly higher tendency towards uncertainty
119 avoidance and a marginally more collectivist and supportive society. Malaysia's long-term vs
120 short-term thinking was not included in the study. Goodwin and Goodwin's study found that
121 there were differences in responses to ethical issues among students between New Zealand and
122 Malaysia

123

124 ***2.2 The Malaysian construction industry***

125 Malaysia has a diverse construction workforce, being the most reliant on foreign workers in
126 Asia (Pillai, 1999). 15.6% of the total Malaysian labour force is made up of immigrant workers
127 (Department of Statistics Malaysia, 2017b). These workers contribute to 69% of the labour
128 used in the construction industry (Abdul-Rahman, Wang, Wood, & Low, 2012). This is a
129 considerably higher proportion of foreign workers than the approx. 11% active in UK
130 construction (Office for National Statistics, 2017) and approx.19% in New Zealand (McLeod
131 & Mare, 2013). This 69% is suspected to be much higher due to construction industry growth
132 in Malaysia, and the undocumented arrival of at least one million illegal immigrants (Abdul-
133 Rahman et al., 2012; Garcés-Mascareñas, 2010; Khan, Liew, & Ghazali, 2014; Salleh et al.,
134 2014). The majority of immigrants (62%) are Indonesian (Salleh et al., 2014).

135 The presence of a vast foreign workforce presents a set of unique problems. These include, but
136 are not limited to: the use of unskilled labour, repression of wages for local workers,
137 commonplace practice of illegal activities, communication issues, and social problems (Abdul-
138 Rahman et al., 2012).

139

140 ***2.3 The need and use of Safety Management Systems***

141 The need to effectively manage construction safety is imperative due to the potential impact on
142 human life. For some, keeping workers safe is as much about the economic impacts associated
143 with the increasing costs of medical treatment, as it is the moral responsibility and duty of care
144 placed on them (Hinze, Pedersen, & Fredley, 1998). Frequent and grave accidents can also
145 have a serious impact on a construction company's operations, thus again it becomes economic
146 as well as ethical to manage safety properly (Wilson & Koehn, 2000).

147 Accidents are controlled using safety management systems which are implemented through
148 "policies, plans, procedures and processes" (Wachter & Yorio, 2014). Examples of these
149 practices include, but are not limited to: guidelines, instructions, rules, safety toolbox talks,
150 safety training, hazard management, safety inspections, devolving power to safety officers,
151 daily communication between supervisors and workers regarding safety, declaring safety a
152 priority, greater engagement from senior management in safety, and thorough accident
153 investigation procedures (Guo et al., 2015; Vinodkumar & Bhasi, 2010). Koh and Rowlinson
154 (2012) argue that these control-based practices are inadequate as they rely on error prevention
155 and normative compliance. Furthermore, they suggest that focus on procedure compliance is
156 at the expense of understanding the system holistically; such processes omit or overlook the
157 key dynamic interactions between workers and their tasks in a wider context.

158

159 ***2.4 Systems Thinking in safety***

160 Systems thinking is the general name given to an approach for managing problem situations
161 that is different from, but complementary to the dominant approach. There are many
162 definitions and explanations of what constitutes systems thinking, but they are all similar in
163 essence. Von Bertalanffy (1968, p18) described the rise of the approach as a reaction to
164 problems that were not suited to classical analysis. He noted that the more traditional
165 approaches required the interactions between parts to be negligible and the relations between
166 the parts to be linear. Modern complex systems did not fit these requirements. Thus, methods
167 which broke entities or issues into their simpler parts in order to study them in relative isolation
168 under the assumption an understating of the whole could be extrapolated from this, were not
169 suitable for these complex issues (Ackoff, 1979, 2001). The Royal Academy of Engineering
170 explains: “A system is a set of parts which, when combined, have qualities that are not present
171 in any of the parts themselves. Those qualities are the emergent properties of the system” (The
172 Royal Academy of Engineering 2007). Systems thinking, embodied in various tools and
173 methods, is therefore an approach for thinking about complex entities and issues as if they are
174 a single intricate system with associated interconnections, emergent properties and non-linear
175 behaviours.

176 Early accident causation theory developed by Heinrich (1931) through his ‘domino’
177 theory suggests accidents are linear sequences of discrete actions, one causing the next, and
178 that most accidents are rooted in human error. Reason (1997) significantly advanced the
179 dominant model of accident causation to better encompass organisational accidents, through
180 his ‘Swiss Cheese Model’ (SCM). The SCM improved on previous developments as it took
181 into account the effects of holistic factors in a larger system as well as including the idea of
182 organisational defence layers (Reason, 1997). The model imagined defence layers as barriers
183 between loss-causing hazards, with ‘holes’ in the defences allowing for accidents to occur. The
184 SCM included the consideration of these holes forming due to “active failures” (mostly human

185 factors) and “latent conditions” (mostly organisational factors). This more advanced model is
186 limited, as pointed out by Reason himself, in that it is not sufficiently dynamic (Reason, 1997).
187 The model is better represented by moving defence layers, which change on local conditions,
188 and holes constantly changing in size - representing the ever-changing risks and contributing
189 factors to accidents.

190 Leveson (2011) suggested that such models are limited by their linear nature and
191 presumption of a “root cause”. The inadequacy of assuming a root causes for an accident is
192 that the choice of an “initial event” is subjective and thus a human decision, deeming activities
193 preceding the “initial event” as irrelevant, has to be made (Leveson, 2011). Leveson also states
194 that as real-life systems are constantly changing, linear models are not suitable as they have no
195 provision for dynamic changes – they are not capable of capturing the complex nonlinear
196 interactions between components in advanced socio-technical systems (Qureshi, 2007). For
197 example, a supervisor instructing a worker to perform a task, then reviewing the progress of
198 the task so that they can further instruct the worker creates a simple feedback loop that would
199 not be adequately captured by these linear cause and effect models.

200 Systemic accident analysis (SAA) arose from these acknowledged shortfalls in the form
201 of various systems analysis methods. Examples such as Systems Theoretic Accident Modelling
202 and Processes (STAMP) (Leveson, 2011), Functional Resonance Analysis Method (FRAM)
203 (Hollnagel & Goteman, 2004) and Accimapping (Rasmussen, 1997) have been said to avoid
204 some of the limitations of these more traditional approaches (Underwood & Waterson, 2013).
205 Crucially, SAA views accidents as an “emergent phenomena”, resultant of the complex
206 interaction of systems components (Qureshi, 2007), thus understanding the dynamic interacting
207 nature of factors within these incidents is critical.

208 STAMP is a control based theory that examines interactions between system
209 components and views accidents as a result of inadequate control of these components

210 (Leveson, 2011). FRAM constructs a network of interrelating subsystems, with the behaviour
211 of any one system component able to ‘resonate’ with that of others. Such resonance within
212 components can result in dramatic system-level variation that pushes it out of control and to
213 the point where an accident develops (Hollnagel, 2012). Accimap is a model that links failures
214 across six socio-technical system levels (Salmon, Cornelissen, & Trotter, 2012), based on
215 Rasmussen’s socio-technical framework (Rasmussen, 1997). A cause-consequence chart is
216 used to analyse cause events and link different factors across the various system levels
217 (Qureshi, 2007). While these SAA methods are widely used in accident analysis (specifically
218 STAMP and Accimap) (Salmon et al., 2012), they are considered as “resource intensive” as
219 well as requiring “considerable amounts of domain and theoretical knowledge to apply”
220 (Underwood & Waterson, 2013).

221 System dynamics was first pioneered by Forrester (Forrester, 1961) and was developed
222 into a methodology for understanding “the structure and dynamics of complex systems”
223 (Sterman, 2000). It embodies, and is to some synonymous with, systems thinking. The notion
224 that systems thinking can be used to interpret intricate systems was echoed by Checkland
225 (1981), who stated that systems thinking was “the use of a particular set of ideas, systems ideas,
226 in trying to understand the world’s complexity” (Checkland, 1981). Furthermore, system
227 dynamics related methods – namely causal loop diagrams (see Figure 1a and Figure 1b) – may
228 be better suited for the problems associated with traditional accident models as they emphasise
229 the circular nature of complex systems - there is “no difference between cause and effect” (Goh,
230 Brown, & Spickett, 2010). Causal loop diagrams can be used to create generic and frequently
231 occurring system structures to describe common behaviours, called system archetypes, which
232 are useful to identify points of leverage for change (Goh et al., 2010). These system archetypes
233 can be viewed as “classifying structures responsible for generic patterns of behaviour over
234 time” (E F Wolstenholme, 2003).

235 Systems thinking is suitable to understand the complexity (Checkland, 1981; Maani &
236 Maharaj, 2004; Sterman, 2000) presented by construction accidents while system archetypes
237 provide a concise way to visualise the complexity (Goh et al., 2010).

238

239 *2.5 Study aims*

240 As outlined in the previous section, the of use systems thinking in relation to safety is an
241 effective way to conceptualise the complex issues present. It also provides a platform from
242 which further safety improvements in the construction sector can be made (P. Mitropoulos,
243 Abdelhamid, & Howell, 2005). Guo et al. (2015) asserted the pertinent point of needing to fully
244 understand the interdependence of system factors, through the exploration of the linking
245 behavioural system components that make them up.

246 Guo et al.'s (2015) research consisted of the creation of 8 'system archetypes' describing
247 behaviour patterns characteristic of construction safety. Following the dictionary definition of
248 an archetype being "something that is considered to be a perfect or typical example of a
249 particular kind of person or thing, because it has all their most important characteristics"
250 (Collins English Dictionary, 2018), it is inferred that the system archetypes proposed by Guo
251 et al. (2015) should be applicable in any context. Guo et al. (2015) recognised the limitations
252 of claiming to have identified archetypes, in that future research would be needed to establish
253 their presence in "different cultural settings" for this to truly be the case. Thus, the aims of this
254 study therefore are:

- 255 1. Establish the main factor or factors that contribute to construction accidents in
256 Malaysia.
- 257 2. Evaluate and validate the grounded theory method devised by Guo et al. by utilising it
258 in a new context.

259 3. By applying the method, independently develop and test potential archetypes present
260 in the ‘different cultural context’ of the Malaysian construction industry. Doing so
261 will potentially identify new archetypes, as well confirm whether Guo et al.’s models
262 are truly archetypal.

263

264 **3. Method**

265

266 *3.1 Creating construction safety archetypes*

267 System archetypes can be represented through causal feedback loops. These are visual
268 representations of the causal influences between contributing factors. The causal influences
269 are represented by arrows between named variables. The arrows between the variables in
270 feedback loops are marked either positive (+) or negative (-). A positive arrow (positive
271 polarity) means that the linked variables change in the same direction (e.g. if the parent variable
272 decreases, the child variable will also decrease or if the parent variable were to increase, it
273 would cause the child variable to increase). A negative arrow (negative polarity) describes a
274 relationship between variables such that they are opposed (e.g. if the parent variable increases,
275 the child variable will decrease and vice-versa). These two types of causal connection can
276 combine to form two types of feedback loop representing either reinforcing or balancing
277 relationships. Reinforcing loops (Figure 1a) act to exponentially increase (for an ascending
278 trend) or decrease (for a descending trend) the effects of a phenomenon, with the rate of
279 increase also inflating exponentially. Balancing loops (Figure 1b) act to close the gap between
280 the current state and the desired state via some process or action (Guo et al., 2015), resisting
281 change and attempting to maintain the status quo.

282

283

FIGURES 1a & 1b

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Senge (1990) used this modelling approach to represent archetypal causal structures that underpin organisational issues, subsequently reinterpreted and developed by Marais et al (2006) into system safety-specific archetypes. Such system archetypes are fundamental to system dynamics modelling (Eric F. Wolstenholme, 2004). Construction safety archetypes then are simply system safety archetypes applied in the context of construction. They are intended to describe the causal structures that result in individual safety issues, rather than the whole system.

The first step in developing such representation involves the identification of the themes relating to an issue; the key variables associated with each theme or problem are also established (Guo et al., 2015). The second step requires the generalisation of these variables such that they are no longer event-specific, instead describing a generic pattern of behaviour, by exploring their causal affiliation with each other (Guo et al., 2015).

3.2 Grounded Theory for data collection

Grounded Theory, conceived by Glaser and Strauss (1967), is a methodology for creating theory that is “grounded in data systematically gathered and analysed” (Strauss & Corbin, 1994). As part of the process, Grounded Theory stipulates an analysis of constant comparison of data sources and of theory to data in order to identify emergent concepts (Glaser & Strauss, 1967). Thus, based on Grounded Theory, concurrent data collection, data analysis, archetype development, and constant comparison of data and models is performed. The data, in this case from interviews, is analysed and progressively abstracted such that it is described in terms of higher-order categories. The process as applied here is described in the subsequent sections.

309

310 *3.3 Interview structure, sample strategy, and sample participants*

311 Seven semi-structured interviews were conducted (i.e. there was a predefined set of questions,
312 but participants were able to deviate from those and talk freely). Semi-structured interviews
313 are “particularly effective” as a method of gathering data when developing causal diagrams
314 (Sterman, 2000). Interviews focused on identifying the main safety themes through broad
315 questions, spanning a multitude of topics. When a new theme revealed itself, further questions
316 were directed on that specific line of thought. Due to the concurrent nature of data collection
317 and analysis when utilising Grounded Theory, pointed questions were formulated between
318 interviews, based on previous respondents, about specific safety topics. These questions were
319 then asked to subsequent interviewees after they had referenced the relevant topic.

320 The precedent in Grounded Theory sampling is to employ sampling techniques
321 sequentially (known as directed sampling) as data is collected and the theoretical model
322 becomes focused (Bryant, Charmaz, & EDITORS, 2010). The techniques that are typically
323 employed are (sequentially): convenience sampling, purposeful sampling, and theoretical
324 sampling (Bryant et al., 2010). However, due to the time constraints of this study, only
325 convenience sampling was carried out. This meant that participants were selected on the basis
326 of accessibility, but did provide a large wealth of knowledge based on their considerable
327 collective experience. Bryant et al. (2010) state the necessity of having “excellent participants
328 to obtain excellent data”. An excellent participant must: have experience of the phenomena
329 under study, be willing to participate, give enough time to fully explain their experience, and
330 be articulate and reflective (Bryant et al., 2010). The participants of this study fulfil those
331 criteria. All participants were fluent in English, and willingly volunteered at least 30 minutes
332 of their time (mean interview length: 45 minutes). Only one interview was not conducted face-
333 to-face, this interview was conducted via Skype.

334

335

336

TABLE 3

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338

339 ***3.4 Data analysis – Inductive System Diagrams***

340 Inductive system diagram (ISD) methodology is one in which causal loop diagrams can be
341 constructed through concept development of field data (Burchill & Fine, 1997). It utilises the
342 grounded theory method to develop key variables that are closely linked to the data. Following
343 this, the ISD methodology allows for these key variables to be causally linked via causal loop
344 diagrams (Burchill & Fine, 1997). Thus, the causal loop diagrams (and resulting archetypes)
345 are markedly ‘grounded’ in the data collected, lending to their validity. The development
346 process of ISD methodology, adapted for the creation of a system archetype, is outlined in
347 Figure 2.

348

349 ***3.5 Coding techniques***

350 The standard grounded theory method for processing interview data was followed. This
351 consisted of three ‘coding’ stages. The first was ‘open coding’, in which interview
352 transcriptions were processed line-by-line, tagging data as ‘nodes’. Nodes can be thought of as
353 folders representing an event, theme, or behaviour, which were filled with quotes taken from
354 the raw data. These quotes are ‘coded’ under a specific node. Nodes describing similar events,
355 variables, or topics were then grouped to form key themes – this allowed for the main safety
356 themes to be identified. As this process was carried out, memos were taken as insight into the
357 topic was gained and new theories began to formulate.

358 Upon the initial identification of a safety theme the second stage - ‘selective coding’ -
359 was performed. Interview data was analysed by studying the events and ideas mentioned by
360 participants to understand the behaviour patterns that they were speaking about, and determine
361 under which themes these behaviours occur. This also allowed the determination of causal
362 relationships between variables by utilising an adjacency matrix, which explored the affiliation
363 between variables and whether the effect one had on another was positive or negative. Based
364 on these causal links, word-arrow diagrams and self-contained causal loops were created.

365 ‘Theoretical coding’ is the final stage of the process. Theoretical coding allowed for the
366 fabrication of safety archetypes by consolidating the feedback loops created in selective coding.
367 Related feedback loops were gathered under a single safety theme, creating a generic causal
368 loop describing a set of patterns of behaviour – a safety archetype. The safety archetypes were
369 validated against the collected data through constant comparison. All coding was performed
370 using the software package NVIVO, developed for such analysis.

371

372

373

FIGURE 2

374

375

376 ***3.6 Establishing causal relationships from data***

377 Exemplification of the process carried out in creating causal loop diagrams from interview data
378 is outlined in Table 4. Open coding was used to tag the quotes shown under various themes
379 (quotes can be tagged under more than one theme). Selective coding then allowed for the causal
380 relationship between these themes to be explored, and the creation of causal links following
381 that.

382

383

384

TABLE 4

385

386

387

388 Selective coding is used to combine the causal links shown in Table 4 to form a causal loop, as
389 seen in Figure 3. Multiple feedback loops like this are then integrated together to create a
390 system archetype by utilising theoretical coding. The quotes shown in Table 4 did not all come
391 from the same source, highlighting the complex nature of construction behaviour and the lack
392 of holistic knowledge possessed by members in the system. Causal arrows bisected by two
393 parallel lines show a relationship that has a delay.

394

395

396

FIGURE 3

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398

399 **4. Results**

400

401 The interviews and open coding processes revealed a multitude of behaviours, which were
402 grouped into nodes, safety themes, and then eventually combined to form safety archetypes as
403 shown in Table 5.

404

405

406

TABLE 5

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408

409 Each of the archetypes mentioned above will be explored in-depth, and leverage points (places
410 to intervene in the system to counter unwanted behaviour) identified. Quotes from interviewees
411 are included in italics.

412

413 ***4.1 Effects of a migrant workforce***

414 Figure 4 shows a construction safety archetype relating to the workforce employed in
415 Malaysian construction. A main safety theme of this archetype is the inadequacy of the
416 workforce (S2); generally speaking, workers struggle to safely carry out a variety of
417 construction activities. Another contributing factor is the unique communication challenges
418 introduced by the use of a foreign workforce.

419

420

421

FIGURE 4

422

423

424 The prevalence of a foreign workforce is the consequence of various factors, including a
425 shortage of local labour (Salleh et al., 2014) and the perception among Malaysians of
426 construction industry being “dirty, difficult and dangerous” (Wong & Yazdanifard, 2015).

427 However, labourers in this workforce are often untrained, as multiple interviewees echoed the
428 sentiment of the following quote: “*A general worker on a construction site – they have no*
429 *training*”. The ‘communication issues in training’ (R3) reinforcing loop has a direct effect on

430 the ‘unforeseen impacts of communication issues’ (R4) reinforcing loop. Due to the

431 communication issues presented by a foreign workforce, it is significantly harder to train them.

432 This has a reinforcing effect as training would reduce the communication problems

433 experienced. Many interviewees noted both the contractor's and client's overriding drive for
434 profit - "*The majority of contractors within Malaysia ... they don't really care about the*
435 *workers, it's about turnover profit and margins*". This means that training is often ignored as
436 it is perceived cheaper to continuously hire new workers as compared to training the whole
437 workforce. However, this perception is incorrect as noted by an interviewee: "*training people*
438 *to do the job means that they will do the job more safely and more quickly*". This is depicted
439 by the 'creation of an unskilled workforce' (R2) loop; untrained staff are more likely to be
440 involved in accidents, after which they are replaced by new, similarly unskilled workers –
441 perpetuating the cycle. The 'disregard for safety procedure' (R1) reinforcing loop shows a
442 common vicious cycle that is cultivated in Malaysian construction. Schedule delays are
443 inevitably incurred when accidents happen, resulting in slowed progress. The stagnation of
444 production progress generates an increased cost to the contractor which, as previously
445 discussed, is the antithesis to their project goal - make the most money possible. This means
446 that the production pressure on site is increased to try to make up for this lost time. Increased
447 production pressure then often leads to safety practices being ignored in favour of quicker
448 work, which inevitably results in more unsafe behaviours and accidents - "*[upon the*
449 *occurrence of delays, site managers] scream at their workers, who are just general workers,*
450 *and health and safety goes out the window*".

451

452 *Leverage points*

453 Moving Malaysia away from an unskilled foreign workforce would help to alleviate a number
454 of construction safety issues in the country. However, the problem of the migrant workforce is
455 not one that can be solved quickly nor easily, and for broader national and industry factors may
456 not even be feasible, thus it will be more suitable to focus on the training provided to these
457 labourers. Providing translated training courses and general communications training for

458 employees that are not proficient in the local language will reduce problems associated with
459 work orders and skills training. This will also reduce the reliance on a lingua franca with which
460 verbal exchange is often misinterpreted. These steps will help to combat the negative
461 behaviours of (R3) and (R4) reinforcing loops. Furthermore, the introduction of the balancing
462 loop shown in Figure 5 will aid in alleviating the negative impacts of the reinforcing loop (R1).
463 This loop could be practically implemented through the use of independent accident
464 investigators.

465

466

467

FIGURE 5

468

469

470 ***4.2 Corporate accountability and profit driven business culture***

471 Figure 6 shows a construction safety archetype describing behaviours exhibited by clients and
472 contractors at the highest levels of Malaysian construction. One of the main themes of this
473 archetype is that the foreign workforce is held with such little regard (S2) that it is almost
474 viewed as dispensable. This means that even when accidents occur, they have little to no effect
475 on contractors and clients.

476

477

478

FIGURE 6

479

480

481 The ‘person approach’ (B1) and ‘side effect of person approach’ (R1) are loops forming the
482 “Blame on workers” archetype devised by Guo et al. (2015). Blaming workers reduces unsafe

483 behaviours in the short term as it prevents minor transgressions and promotes procedural
484 adherence. However, it also means more fundamental root causes and latent failures in the
485 system go unidentified, as well as the procedures that prompted the transgressions – ultimately
486 leading to the accident rate increasing. This archetype was determined to also occur in
487 Malaysian construction but as can be seen, has an array of other feedback loops associated with
488 it that are not present in Guo et al.’s research.

489 Furthermore, the tendency to blame workers is facilitated by the nature of the
490 workforce; being made up of a migrant (often illegal) majority whom are offered little
491 protection, particularly in the case of illegal workers – *“you often hear: “it was the dumb
492 migrants fault, he didn’t listen to me, and that’s why this accident has happened”. They’ve
493 become the scapegoat, so there’s no accountability.”* This leads into the ‘value placed on
494 workforce’ (R2) reinforcing loop, in which limited accountability for accidents leads to the
495 propensity of disregarding the safety of the foreign workforce. Interview data has indicated that
496 foreign workers are already held in low regard by the contractors managing them – *“the
497 Indonesians are just looked down on by everybody, same with the Bangladeshis, and same with
498 the Pakistanis”* due to a myriad of culture factors (not featured in the archetype). This allows
499 contractors to *“get away with accidents”*, further lowering the value placed on the workforce.
500 Intuitively this will influence the safety culture on site, which will affect the unsafe behaviours
501 (and therefore accidents) that occur. The ‘no training for workers’ (R3) reinforcing loop shows
502 the ease at which workers are terminated from Malaysian construction sites. Blaming workers
503 for accidents increases the workforce turnover, which leads to a decrease in training as
504 contractors don’t believe in investing in a workforce that is quick to turnover – *“the turnover
505 of staff reduces the willingness of contractors to train them – it’s money down the drain”*.

506

507 *Leverage points*

508 The common practice of blaming workers to reduce unsafe behaviours is clearly shown to be
509 an ineffective safety management strategy; the loops (R1), (R2), and (R3) exhibit the ways in
510 which this method is flawed. The simplest way to mitigate the negative impacts of these loops
511 would be to eliminate the practice of blaming workers. This may be difficult to achieve due to
512 construction management’s reluctance to take ownership of accidents, as it is often easier and
513 cheaper to terminate workers than to change working procedures and pay accident related fines.
514 A change in regulation to allow more blame to be attributed to employing organisations, and
515 heavier fines for infractions, would force a shift in the priorities held by construction managers.
516 However, the problems associated with increased regulation (discussed in section 4.3) would
517 have to be addressed.

518

519 *4.3 Issues in the regulatory system*

520 Figure 7 shows a construction safety archetype describing behaviour shown by Malaysian
521 regulators and legislators. It is a modified version of Senge’s “fixes that fail” archetype (Senge,
522 1990). The main theme of this archetype is the effect that enforcement has on safety
523 performance. Analysis has suggested that enforcement of regulation is extremely poor in
524 Malaysia, to the extent that contractors are comfortable in taking risk to avoid compliance with
525 regulation in an attempt to save cost.

526

527 -----

528 FIGURE 7

529 -----

530

531 The ‘penalisation inducing corruption’ balancing loop (B3) demonstrates the ability of
532 contractors/clients to avoid penalisation for noncompliance. This is enabled by the

533 susceptibility of governmental agents to bribes and pressure from those in positions of power.
534 “Corruption is rife, and with that there’s always the opportunity for something to be covered
535 up or paid off”. The construction industry has been identified as “the most corrupt sector in the
536 world” (de Jong, Henry, & Stansbury, 2009); coupling this with Malaysia’s reputation as a
537 place rife with corruption (Alam Siddiquee, 2006), it is no surprise that corruption plays a large
538 role in the Malaysian construction industry. The ability to avoid penalties is exploited by
539 contractors as a way to evade costly compliance with regulation, as they know that they will
540 not be penalised; “Inspectors can be paid off if they do go and find something”. This effect is
541 carried into the ‘effect of penalty on safety performance’ (B2) balancing loop in which the
542 avoidance of penalties induces a lower level of safety motivation and then performance -
543 leading to more accidents. The ‘performance reducing budget’ (B1) balancing loop shows the
544 delayed effect that safety performance has on budgeting. However, safety budget is often cut
545 regardless of performance in an attempt to gain better profit margins – “The contractor is
546 always trying to look for ways to get higher profit, so they tend to cut, cut, cut safety budget.”
547 – thus further impacting loop (B2). The ‘safety performance’ (B4) balancing loop shows the
548 interconnected nature of performance and legislation. However, it must be noted that
549 interviewees have detailed a marked inflexibility in government regarding the change of
550 legislation, meaning that causal link between safety performance and legislation is weak – “To
551 actually make that [legislative] change would take an additional workload for somebody, are
552 they willing to do that? From what I’m seeing, I don’t see a willingness to change”

553

554 *Leverage points*

555 The problem of legislative enforcement is one that was often mentioned by interviewees. As
556 mentioned above, corruption is a large contributing factor to the lack of enforcement, however
557 it is also affected by Malaysia’s low governmental safety budget. In combination, these factors

558 lead to a void in the enforcement of regulation, which is exploited by contractors to cut corners
559 and utilise unsafe practices. To reduce these practices, loop (B3) needs to be opposed. This
560 could be done through the introduction of policies that improve the transparency of
561 construction transactions, particularly those paid to governmental agencies. Transparent
562 actions would discourage government officials from accepting bribery payments as it would
563 be easier to recognise corrupt activities.

564

565 **5. Discussion**

566 The three ‘construction safety archetypes’ detailed indicate patterns of behaviour, and the
567 causal structures that produce them, at different hierarchical levels of the Malaysian
568 construction industry.

569 The ‘effects of a migrant workforce’, ‘corporate accountability and profit driven
570 business culture’, and ‘issues in the regulatory system’ archetypes show behaviour at site
571 management, senior management, and governmental levels, respectively – each subsequent
572 model serves to contextualise the previous one. These models describe the underlying
573 behavioural structures found in Malaysia, indicating why certain construction behaviours are
574 observed. Using systems thinking in this context allows for a greater understanding of the
575 complex interconnectivity of management decisions and systems throughout hierarchical
576 levels. Furthermore, these archetypes reveal causal relationships that are not obvious, allowing
577 for an analysis of procedures and their effects that would have otherwise thought to be unrelated
578 or counterintuitive. For example, the ‘effects of a migrant workforce’ archetype reveals an
579 unlikely causal link in which the communication issues presented by a foreign workforce
580 eventually leads to more foreign workers being hired (reinforcing loop ‘unforeseen impacts of
581 communication issues’ (R4)). This example shows the strength of dynamic system analysis to
582 fully identify all of a systems characteristics.

583 Rasmussen (1997) attributed certain major accidents to a “systematic migration of
584 organisational behaviour toward accident under the influence of pressure toward cost-
585 effectiveness in an aggressive, competitive environment”. This was developed by Dekker
586 (2016) who coined the concept of “drift into failure” in which organisations develop routines
587 based on balancing productivity and safety, such that failures become a by-product of the
588 system itself, rather than based on the decisions of individuals within the system (Dekker,
589 2016). These concepts are exhibited in the archetypes, particularly in the loops ‘disregard for
590 safety procedure’ (R1), ‘value placed on workforce’ (R2), and ‘penalisation inducing
591 corruption’ (B3) from each archetype respectively. These loops show routine behaviour that is
592 not internally viewed as a contributing factor to unsafe behaviour, but undoubtedly has an
593 effect.

594 The archetypes support Guo et al.’s (2015) assertions that safety management systems
595 are unable to cope with the dynamic nature of the problem, and that safety considerations need
596 to be integrated into all areas of a business. This is exemplified by the ‘no training for workers’
597 (R3) reinforcing loop in which there is no consideration of potential employees’ skills when
598 hiring new staff. However, in addressing study aim 3, Guo et al.’s (2015) archetypes have been
599 proven to not be truly archetypal - they do not apply in all contexts. The archetype ‘corporate
600 accountability and profit driven business culture’ demonstrates this. Whilst it shares the
601 characteristics of the ‘person approach’ (B1) and ‘side effect of person approach’ (R1) loops
602 with the identically named loops of Guo et al.’s (2015) “Blame on workers” archetype, the
603 “Blame on workers” archetype excludes novel factors that occur outside of New Zealand. The
604 presence of a lowly-valued migrant workforce presents a new dynamic effect for the variable
605 ‘blame on workers’, in which workers are dispensable, thus raising issues of accountability that
606 could only arise in such a context.

607 The grounded theory method proved to be effective in data collection and analysis. The
608 utilisation of constant comparison allowed for theory to naturally emerge from the data and
609 helped to direct questioning in further interviews, contributing to underdeveloped areas in the
610 theory. Furthermore, grounded theory facilitated the creation of models that were directly
611 related to the data collected, lending to their validity.

612 ***5.1 Malaysian Construction Behaviour***

613 The client and contractors overriding drive for profit, through cost-cutting and progress
614 motivated working procedures, was a principal factor that was unanimously mentioned by
615 interviewees, but was not included explicitly in the archetypes themselves. It was excluded
616 because it was intrinsic in the majority of variables, meaning that its inclusion would lead to
617 its effect being double counted. The bulk of decisions taken by contractors are in regard to this
618 sole interest, presenting the systemic, cultural problem that faces Malaysian construction. This
619 behaviour is facilitated by a myriad of factors that occur in the Malaysian construction industry,
620 including the ability to disregard the lives of foreign workers. A phrase that was often used by
621 interviewees, in reference to labourers, was that of “life is cheap” - *“I think life is cheap because*
622 *its immigrant labour – it’s not as close to heart”*. Other factors that allow for the uncontentious
623 ethos of profit driven business to thrive include, but are not limited to: the ability to corrupt
624 government officials, the lack of enforcement of safety regulation, the availability of new
625 migrant labourers, the lack of accountability for accidents at the management level, the
626 weakness of safety regulation (*“[after a fatal accident] a RM50,000 fine. That’s the price of a*
627 *human here. A slap on the wrist and off you go.”*), high risk projects, and the use of unskilled
628 labourers. A systemic moral permutation away from the industry’s profit related objectives -
629 into goals that have a recognition of the distinct social responsibilities the industry carries - is
630 required to combat these issues.

631 These views must also be considered in the broader context of Malaysian culture, and
632 in relation to the aims of this study, its comparison to New Zealand culture. Despite arguing
633 that their cultures are different, an archetypal causal structure appears to have been identified
634 that is present in both. This invites further consideration of the similarities and differences
635 between their cultures. The detail of this ethnography is beyond the scope of the paper and
636 indeed the expertise of its authors. It is therefore recommended as further work in addition to
637 the discussions in following sub-section.

638 Nevertheless, it is interesting to briefly reflect on the differences in customs and other
639 social behaviours that might warrant further investigation. Building on the point above, the
640 statistical value of a life has been estimated through meta-study (Miller, 2000) at around \$1.6m
641 (baselined to 1995 values) in New Zealand and \$600,000 in Malaysia. This is approximately
642 \$2.7m and \$1m today. Worksafe, the New Zealand health and safety regulator recently fined a
643 construction company NZ\$351,563 and NZ\$177,735 reparations. In total this is approximately
644 RM1.4m or 28x the reported Malaysian fine.

645

646 ***5.2 Limitations and future research***

647 This research has various limitations. Firstly, it was not feasible in this study to carry out fully
648 exploratory Grounded Theory. Data collection was limited to 7 interviews, less than the 20-30
649 participants recommended for Grounded Theory (Creswell, 2007), but not dissimilar to the
650 number of participants used in other studies to produce safety-related causal loop models (e.g.
651 the 7 interviewees of Kwesi-Buor, Menachof, & Talas, 2019). Nor is it dissimilar to the number
652 of participants in the more common group model building mode (e.g. the average of 7
653 participants found in 15 qualitative and 19 quantitative studies by Rouwette, Vennix, &
654 Mullekom, 2002). It does however mean that, similar to Guo et al. (2015), the ‘archetypes’
655 formulated in this paper may not be truly archetypal, as under the Grounded Theory approach

656 data collection did not reach the point of saturation. Furthermore, no interviews were
657 conducted with labourers themselves, only management staff. Whilst this gave perspective to
658 behaviours beyond the ‘coalface’, it excludes the unique viewpoint of the migrant workforce.
659 However, the paper aimed to independently develop casual loop models within a different
660 cultural context in order to test whether Guo et.al.’s models were truly archetypal. With the
661 discovery of the of the ‘corporate accountability and profit driven business culture’ model the
662 study is able to provide evidence to support their claim even with a smaller sample size. Hence
663 the smaller number of participants is not a limitation on this aim. Nor is it a limitation on the
664 ability to achieve the study’s humbler aim of verifying that the process can produce such
665 structures. The limited number of participants *does* limit the ability to claim that the two
666 additional structures are archetypal or even complete, however the fact that they emerged from
667 interviews with the seven participants still suggests that other structures other causal loop
668 structures and indeed other archetypes may exist. This would require a larger sample size.

669 It is stated that, for Grounded Theory, “the investigator needs to set aside [...]
670 theoretical ideas or notions so that the analytic, substantive theory can emerge” (Creswell,
671 2007). However, due to the nature of this study – developing Guo et al.’s (2015) theory – there
672 may have been pre-existing theoretical notions based on the prior research influencing the
673 method.

674 As the construction safety archetypes created in this paper are partially informed by
675 Senge’s (1990) generic archetypes, criticism that is placed on Senge’s work can also be
676 applicable to this research. It can be scrutinised according to analytical flaws; Senge relies on
677 an inadequate definition of structure that “cannot explain the organizing practices and learning
678 processes by which systems as feedback structures come into being and change” (Caldwell,
679 2012).

680 Future research within the Malaysian (and other nations) construction industry is
681 needed to identify further construction safety archetypes. Furthermore, future research could
682 focus on a different method of archetype construction/data collection, rather than the Grounded
683 Theory based approach employed here.

684

685 **5.3 Conclusions**

686 This paper sought to identify the main factors affecting the safety of the construction industry
687 in Malaysia. A series of interviews, and subsequent data analysis, illuminated the role of the
688 migrant workforce, safety procedures, and governance of a profit driven industry. The
689 Grounded Theory approach used by Guo et al. (2015) was partially validated in that it allowed
690 for the underlying behavioural structures in the construction industry to be revealed and
691 articulated as causal loops. It was also possible to identify corrective leverage points from
692 these structures, establishing potential methods to reduce the unwanted behaviours displayed.

693 The ‘corporate accountability and profit driven business culture’ archetype revealed a
694 similar structure to the “Blame on workers” archetype created by Guo et al., suggesting that
695 this may indeed be archetypal. This study was also able contextualise the ‘corporate
696 accountability and profit driven business culture’ archetype in the broader issues of the
697 Malaysian construction industry.

698 The other structures identified in this study differed significantly from those created by
699 Guo et al. This does not suggest that Guo et al.’s structures are not truly archetypal but indicates
700 that additional construction safety archetypes may exist.

701

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705

706 **REFERENCES**

707

708 Abdul-Rahman, H., Wang, C., Wood, L. C., & Low, S. F. (2012). Negative impact induced
709 by foreign workers: Evidence in Malaysian construction sector. *Habitat International*,
710 36(4), 433–443. <https://doi.org/10.1016/j.habitatint.2012.03.002>

711 Ackoff, R. L. (1979). The Future of Operational Research is Past. *The Journal of the*
712 *Operational Research Society*, 30(2), 93–104. Retrieved from
713 <http://www.jstor.org/stable/3009290>

714 Ackoff, R. L. (2001). Fundamentalism and Panaceas. *Systemic Practice and Action Research*,
715 14(1), 3–10. <https://doi.org/10.1023/a:1009527509074>

716 Ahmad, Q. (1997). The Question of National Culture in Multi-Ethnic Malaysia.

717 Alam Siddiquee, N. (2006). Public management reform in Malaysia: Recent initiatives and
718 experiences. *International Journal of Public Sector Management*, 19(4), 339–358.
719 <https://doi.org/https://doi.org/10.1108/09513550610669185>

720 Bryant, A., Charmaz, K., & EDITORS, T. A. T. (2010). *The SAGE Handbook of Grounded*
721 *Theory*. Sage Publications Ltd.

722 Burchill, G., & Fine, C. H. (1997). Time Versus Market Orientation in Product Concept
723 Development: Empirically-Based Theory Generation. *Management Science*, 43(4), 465–
724 478. <https://doi.org/10.1287/mnsc.43.4.465>

725 Burchill, G., & Kim, D. (1993). *Inductive System Diagrams: An Empirically Based Theory*
726 *Generation Technique*. Cambridge, MA: Massachusetts Institute of Technology.

727 Caldwell, R. (2012). Systems Thinking, Organizational Change and Agency: A Practice
728 Theory Critique of Senge's Learning Organization. *Journal of Change Management*,
729 12(2), 145–164. <https://doi.org/https://doi.org/10.1080/14697017.2011.647923>

- 730 Checkland, P. (1981). *Systems thinking, systems practice*. Chichester: Wiley.
- 731 Chong, H. Y., & Low, T. S. (2014). Accidents in Malaysian Construction Industry: Statistical
732 Data and Court Cases. *Journal of Occupational Safety and Ergonomics*, 20(3), 503–513.
733 <https://doi.org/10.1080/10803548.2014.11077064>
- 734 Choudhry, R. M., Fang, D., & Mohamed, S. (2007). Developing a Model of Construction
735 Safety Culture. *Journal of Management in Engineering*, 23(4), 207–212.
736 [https://doi.org/10.1061/\(ASCE\)0742-597X\(2007\)23:4\(207\)](https://doi.org/10.1061/(ASCE)0742-597X(2007)23:4(207))
- 737 Collins English Dictionary. (2018). Definition of “archetype.”
- 738 Cooper, M. D. (2000). Towards a model of safety culture. *Safety Science*, 36(2), 111–136.
739 [https://doi.org/10.1016/S0925-7535\(00\)00035-7](https://doi.org/10.1016/S0925-7535(00)00035-7)
- 740 Creswell, J. W. (2007). *Qualitative Inquiry and Research Design: Choosing Among Five*
741 *Approaches*. Book (Vol. 2nd ed). Thousand Oaks: Sage Publications Ltd.
742 <https://doi.org/10.1016/j.aenj.2008.02.005>
- 743 de Jong, M., Henry, W. P., & Stansbury, N. (2009). Eliminating Corruption in Our
744 Engineering/Construction Industry. *Leadership and Management in Engineering*, 9(3),
745 105–111. [https://doi.org/10.1061/\(ASCE\)1532-6748\(2009\)9:3\(105\)](https://doi.org/10.1061/(ASCE)1532-6748(2009)9:3(105))
- 746 Dekker, S. (2016). *Drift into failure: From hunting broken components to understanding*
747 *complex systems*. CRC Press.
- 748 Department of Occupational Safety and Health. (2017). Archive Statistics (2016).
- 749 Department of Statistics Malaysia. (2011). Population Distribution and Basic Demographic
750 Characteristic Report 2010.
- 751 Department of Statistics Malaysia. (2017a). Economic Census 2016 - Construction.
- 752 Department of Statistics Malaysia. (2017b). Principal statistics of the labour force, Malaysia,
753 1982–2016.
- 754 Fang, D., Chen, Y., & Wong, L. (2006). Safety climate in construction industry: A case study

755 in Hong Kong. *Journal of Construction Engineering and Management*, 132(6), 573–
756 584. [https://doi.org/10.1061/\(ASCE\)0733-9364\(2006\)132:6\(573\)](https://doi.org/10.1061/(ASCE)0733-9364(2006)132:6(573))

757 Forrester, J. W. (1961). *Industrial Dynamics*. Cambridge, Mass.: MIT Press.

758 Garcés-Mascareñas, B. (2010). Legal production of illegality in a comparative perspective.
759 The cases of Malaysia and Spain. *Asia Europe Journal*, 8(1), 77–89.
760 <https://doi.org/10.1007/s10308-010-0249-8>

761 Glaser, B. G., & Strauss, A. (1967). *Discovery of Grounded Theory: Strategies for*
762 *Qualitative Research*. Aldine.

763 Goh, Y. M., Brown, H., & Spickett, J. (2010). Applying systems thinking concepts in the
764 analysis of major incidents and safety culture. *Safety Science*, 48(3), 302–309. Retrieved
765 from [http://www.sciencedirect.com/science/article/B6VF9-4XX26CD-](http://www.sciencedirect.com/science/article/B6VF9-4XX26CD-2/2/b945a63ad65524406659c7e1e326303f)
766 [2/2/b945a63ad65524406659c7e1e326303f](http://www.sciencedirect.com/science/article/B6VF9-4XX26CD-2/2/b945a63ad65524406659c7e1e326303f)

767 Goodwin, J., & Goodwin, D. (1999). Ethical Judgments Across Cultures: A Comparison
768 between Business Students from Malaysia and New Zealand. *Journal of Business*
769 *Ethics*, 18(3), 267–281. <https://doi.org/10.1023/A:1005785020162>

770 Guo, B. H. W., Yiu, T. W., & González, V. A. (2015). Identifying behaviour patterns of
771 construction safety using system archetypes. *Accident Analysis & Prevention*, 80, 125–
772 141. <https://doi.org/10.1016/j.aap.2015.04.008>

773 Hämäläinen, P., Takala, J., & Saarela, K. L. (2006). Global estimates of occupational
774 accidents. *Safety Science*, 44(2), 137–156. <https://doi.org/10.1016/J.SSCI.2005.08.017>

775 Herskovits, M. J. (1949). *Man and His Works: The Science of Cultural Anthropology*. New
776 York: Knopf.

777 Hinze, J., Pedersen, C., & Fredley, J. (1998). Identifying Root Causes of Construction
778 Injuries. *Journal of Construction Engineering and Management*, 124(1), 67–71.
779 [https://doi.org/10.1061/\(ASCE\)0733-9364\(1998\)124:1\(67\)](https://doi.org/10.1061/(ASCE)0733-9364(1998)124:1(67))

780 Hofstede, G. (1980). *Culture's consequences : international differences in work-related*
781 *values*. Sage Publications.

782 Hofstede, G. (1983). Dimensions of national cultures in fifty countries and three regions. In J.
783 B. & S. D. and R. C. A. (eds. . Deregowski (Eds.), *Expiscations in Cross-cultural*
784 *Psychology: Selected 280 J. Goodwin and D. Goodwin Papers from the Sixth*
785 *International Congress of the International Association for Cross-cultural Psychology*
786 *Held at Aberdeen, July 20–23 1982*. Retrieved from
787 [https://www.semanticscholar.org/paper/Dimensions-of-national-cultures-in-fifty-](https://www.semanticscholar.org/paper/Dimensions-of-national-cultures-in-fifty-countries-Hofstede/55b55595f5043c485acfd01742cc537582e6eb9e)
788 [countries-Hofstede/55b55595f5043c485acfd01742cc537582e6eb9e](https://www.semanticscholar.org/paper/Dimensions-of-national-cultures-in-fifty-countries-Hofstede/55b55595f5043c485acfd01742cc537582e6eb9e)

789 Hollnagel, E. (2012). *FRAM: The Functional Resonance Analysis Method*. London: Taylor &
790 Francis Group.

791 Hollnagel, E., & Goteman, O. (2004). The functional resonance accident model. *Proceedings*
792 *of Cognitive System Engineering in Process Plant, 2004*, 155–161.

793 Im, H.-J., Kwon, Y.-J., Kim, S.-G., Kim, Y.-K., Ju, Y.-S., & Lee, H.-P. (2009). The
794 characteristics of fatal occupational injuries in Korea's construction industry, 1997–
795 2004. *Safety Science*, 47(8), 1159–1162. <https://doi.org/10.1016/j.ssci.2008.11.008>

796 Khan, R. A., Liew, M. S., & Ghazali, Z. Bin. (2014). Malaysian Construction Sector and
797 Malaysia Vision 2020: Developed Nation Status. *Procedia - Social and Behavioral*
798 *Sciences*, 109, 507–513. <https://doi.org/10.1016/j.sbspro.2013.12.498>

799 Kwesi-Buor, J., Menachof, D. A., & Talas, R. (2019). Scenario analysis and disaster
800 preparedness for port and maritime logistics risk management. *Accident Analysis &*
801 *Prevention*, 123, 433–447. <https://doi.org/10.1016/J.AAP.2016.07.013>

802 Leveson, N. (2011). *Engineering a safer world: Systems thinking applied to safety*. MIT
803 Press.

804 Lunt, J., Bates, S., Bennett, V., & Hopkinson, J. (2008). *Behaviour change and worker*

805 *engagement practices within the construction sector.*

806 Maani, K. E., & Maharaj, V. (2004). Links between systems thinking and complex decision
807 making. *System Dynamics Review*, 20(1), 21–48. <https://doi.org/10.1002/sdr.281>

808 Marais, K., Saleh, J. H., & Leveson, N. G. (2006). Archetypes for organizational safety.
809 *Safety Science*, 44(7), 565–582. Retrieved from
810 [http://www.sciencedirect.com/science/article/B6VF9-4JCCJP7-](http://www.sciencedirect.com/science/article/B6VF9-4JCCJP7-1/2/7ea0cdf75ef7745a43de039255842119)
811 1/2/7ea0cdf75ef7745a43de039255842119

812 McLeod, K., & Mare, D. (2013). *The rise of temporary migration in New Zealand and its*
813 *impact on the labour market: Ministry of Business, Innovation and Employment.*
814 Retrieved from [http://www.mbie.govt.nz/publications-research/research/migrants---](http://www.mbie.govt.nz/publications-research/research/migrants---economic-impacts/riseof-temporary-migration-in-NZ-and-its-Impact-on-the-Labour-Market2013.pdf)
815 economic-impacts/riseof-temporary-migration-in-NZ-and-its-Impact-on-the-Labour-
816 Market2013.pdf

817 Miller, T. R. (2000). Variations between Countries in Values of Statistical Life. *Journal of*
818 *Transport Economics and Policy*, 34, 169–188. <https://doi.org/10.2307/20053838>

819 Ministry of Business Innovation & Employment. (2013). *New Zealand Sectors Report 2013 -*
820 *Construction.*

821 Mitropoulos, P., Abdelhamid, T. S., & Howell, G. A. (2005). Systems Model of Construction
822 Accident Causation. *Journal of Construction Engineering and Management*, 131(7),
823 816–825. Retrieved from <http://link.aip.org/link/?QCO/131/816/1>

824 Mitropoulos, P. T., & Cupido, G. (2009). The role of production and teamwork practices in
825 construction safety: A cognitive model and an empirical case study. *Journal of Safety*
826 *Research*, 40(4), 265–275. <https://doi.org/10.1016/j.jsr.2009.05.002>

827 Office for National Statistics. (2017). International immigration and the labour market, UK:
828 2016.

829 Pillai, P. (1999). The Malaysian State’s Response to Migration. *SOJOURN: Journal of Social*

830 *Issues in Southeast Asia*, 14, 178–197.

831 Qureshi, Z. H. (2007). A review of accident modelling approaches for complex socio-
832 technical systems. *Proceedings of the Twelfth Australian Workshop on Safety Critical*
833 *Systems and Software and Safety-Related Programmable Systems - Volume 86*.
834 Adelaide, Australia: Australian Computer Society, Inc.

835 Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. *Safety*
836 *Science*, 27(2–3), 183–213. Retrieved from
837 [http://www.sciencedirect.com/science/article/B6VF9-3SWSK2N-](http://www.sciencedirect.com/science/article/B6VF9-3SWSK2N-8/2/e7910c755e1bd45acfb9d990ef561860)
838 [8/2/e7910c755e1bd45acfb9d990ef561860](http://www.sciencedirect.com/science/article/B6VF9-3SWSK2N-8/2/e7910c755e1bd45acfb9d990ef561860)

839 Razak, A., Ibrahim, B., Roy, M. H., Ahmed, Z., & Imtiaz, G. (2010). An investigation of the
840 status of the Malaysian construction industry. *Benchmarking: An International Journal*
841 *Structural Survey Structural Survey*, 12(2), 294–308.

842 Reason, J. (1997). *Managing the Risks of Organizational Accidents*. Ashgate.

843 Ringen, K., Seegal, J., & Englund, A. (1995). Safety and health in the construction industry.
844 *Annual Review of Public Health*, 16(1), 165–188.

845 Rouwette, E. A. J. A., Vennix, J. A. M., & Mullekom, T. van. (2002). Group model building
846 effectiveness: a review of assessment studies. *System Dynamics Review*, 18(1), 5–45.
847 Retrieved from <http://dx.doi.org/10.1002/sdr.229>

848 Salleh, N. M., Mamter, S., Lop, N. S., Farrita, I., Kamar, M., Aishah, N., & Hamdan, M.
849 (2014). The Escalating of Numbers of Foreign Workers in Construction Site. *MATEC*
850 *Web of Conferences*, 15. <https://doi.org/10.1051/mateconf/20141501026>

851 Salmon, P. M., Cornelissen, M., & Trotter, M. J. (2012). Systems-based accident analysis
852 methods: A comparison of Accimap, HFACS, and STAMP. *Safety Science*, 50(4),
853 1158–1170. <https://doi.org/10.1016/j.ssci.2011.11.009>

854 Sawacha, E., Naoum, S., & Fong, D. (1999). Factors affecting safety performance on

855 construction sites. *International Journal of Project Management*, 17(5), 309–315.

856 Senge, P. M. (1990). *The Fifth Discipline: The Art and Practice of the Learning*
857 *Organisation*. London: Century Business.

858 Stats NZ. (2014). 2013 Census QuickStats about culture and identity.

859 Sterman, J. D. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex*
860 *World*. McGraw-Hill.

861 Strauss, A., & Corbin, J. (1994). Grounded theory methodology: An overview. In *Handbook*
862 *of qualitative research* (Vol. 12, pp. 273–285). Sage Publications Ltd.

863 Takala, J. (1999). Global estimates of fatal occupational accidents. *Epidemiology-Baltimore*,
864 *10*(5), 640–646. <https://doi.org/10.1097/00001648-199909000-00034>

865 Underwood, P., & Waterson, P. (2013). Accident analysis models and methods: guidance for
866 safety professionals.

867 Vinodkumar, M. N., & Bhasi, M. (2010). Safety management practices and safety behaviour:
868 Assessing the mediating role of safety knowledge and motivation. *Accident Analysis and*
869 *Prevention*, 42(6), 2082–2093. <https://doi.org/10.1016/j.aap.2010.06.021>

870 Von Bertalanffy, L. (1968). *General System Theory: Foundations, Development*,
871 *Applications*. George Braziller. <https://doi.org/citeulike-article-id:1199862>

872 Wachter, J. K., & Yorio, P. L. (2014). A system of safety management practices and worker
873 engagement for reducing and preventing accidents: An empirical and theoretical
874 investigation. *Accident Analysis and Prevention*, 68, 117–130.
875 <https://doi.org/10.1016/j.aap.2013.07.029>

876 Waehrer, G. M., Dong, X. S., Miller, T., Haile, E., & Men, Y. (2007). Costs of occupational
877 injuries in construction in the United States. *Accident Analysis and Prevention*, 39(6),
878 1258–1266. <https://doi.org/10.1016/j.aap.2007.03.012>

879 Wilson, J. M. J., & Koehn, E. (2000). Safety management: Problems encountered and

880 recommended solutions. *Journal of Construction Engineering and Management*, 126(1),
881 77–79.

882 Wolstenholme, E. F. (2003). Towards the definition and use of a core set of archetypal
883 structures in system dynamics. *System Dynamics Review*, 19(1), 7–26. Retrieved from
884 <http://dx.doi.org/10.1002/sdr.259>

885 Wolstenholme, E. F. (2004). Using generic system archetypes to support thinking and
886 modelling. *System Dynamics Review*, 20(4), 341–356. <https://doi.org/10.1002/sdr.302>

887 Wong, M. W., & Yazdanifard, R. (2015). The Review of Challenges Foreign Workers Face
888 in Construction Industry of Malaysia. *Global Journal of Management and Business*
889 *Research*, 15(4).

890 Worksafe New Zealand. (2017). Workplace fatalities by focus area.
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894 **Table 1: Fatality rates for different countries/regions (Takala 1999, Ministry of Business**895 **Innovation & Employment 2013, Department of Occupational Safety and Health 2017,**896 **Department of Statistics Malaysia 2017a, Worksafe New Zealand 2017)**

Region	Annual average fatal occupational accident rate (per 100,000)	Country	Average construction fatality rate from 2013 to 2017 (per 100,000)
Asia and other islands	23.12	New Zealand	13.45
European Union	6.10	Malaysia	35.14

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899 **Table 2: Religions practiced in New Zealand and Malaysia (Department of Statistics**900 **Malaysia, 2011; Stats NZ, 2014)**

Country	Religion practiced (% of population)					
	Christianity	Islam	Buddhism	Hinduism	No Religion	Other
New Zealand	48	1.2	1.5	2.1	41.9	5.3
Malaysia	9.2	61.3	19.8	6.3	0.7	3.4

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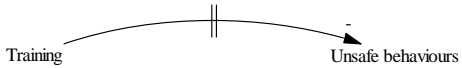
903 **Table 3: Participant occupation and experience**

Participant number	Job title	Years of experience in Asia (in Malaysia)
1	HSE Risk Professional - Southeast Asia	15 (3)
2	Head of HSE	13 (6)
3	Senior Project Manager	19 (1.5)
4	HSE Manager	17 (14)
5	CEO (of construction company)	16 (12)
6	Property Development Manager	5 (3)
7	Senior Project Manager	28 (16)

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Table 4: Process of fabricating causal links from interview data

Quote	Cause	Effect	+/-	Causal Links
<i>“The contactor, they always blame the workers.”</i>	Accidents	Blame on workers	+	
<i>“After an accident, the workers, they get canned straight away. The companies do that, the blame gets unfairly put on the workers.”</i>	Blame on workers	Turnover of staff	+	
<i>“High turnover definitely has an effect on a contractor’s willingness to train. Without a doubt. It’s money down the drain.”</i>	Turnover of staff	Training	-	
<i>“Training people to do the job means that they will do the job more safely and more quickly”</i>	Training	Unsafe behaviours	-	

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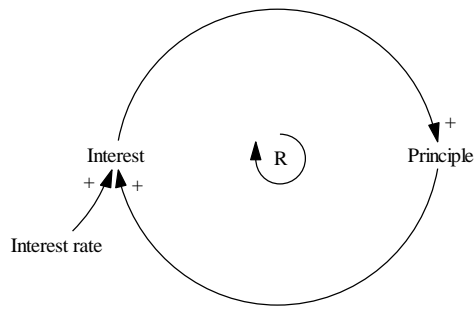
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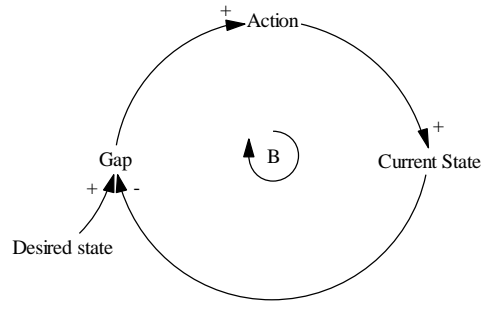
Table 5: The nodes and safety themes that the safety archetypes are composed of

Safety Archetype (A)	Safety Theme (S)	Nodes (N)
Effects of a migrant workforce (A1)	Foreign workers (S1)	Use of foreign workers (N1) Illegal workforce (N2) Communication issues (N3)
	Inadequate workforce (S2)	Uneducated workforce (N4) Lack of training (N5) Poorly paid workforce (N6) Unskilled workforce (N7) Inexperienced workforce (N8) Undisciplined behaviour (N9)
	Construction industry factors (S3)	Workers' top priority is income (N10) Subcontractor driven market (N11) Site factors (N12)
Corporate accountability and profit driven business culture (A2)	Emphasis on health and safety (S4)	Health and safety is not a priority (N13) Lack of safety culture (N14) Life is cheap (N15) Health and safety is simply 'box ticking' (N16)
	Organisational practices/views on health and safety (S5)	Poor accepted practices (N17) Reactive organisational culture (N18) Lack of training (N19) Desire to avoid regulation (N20) Lack of risk awareness by management (N21) Poor construction equipment (N22)
	Lack of caring culture (S6)	(Client/contractor) Drive for profit (N23) No regard for foreign workers (N24) Life is cheap (N15) Cultural factors (N25) Accountability of client/contractor (N26) Blame on workers (N27)
Issues in the regulatory system (A3)	Legislation and enforcement issues (S7)	Poor enforcement of regulation (N28) Lack of budget for health and safety authorities (N29)

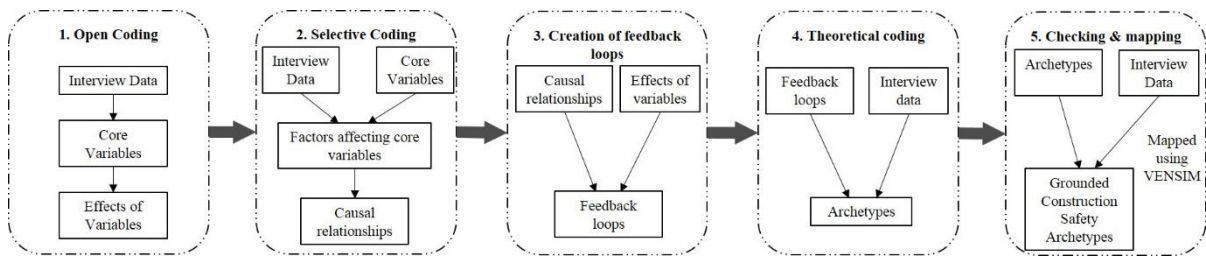
		Poor legislation (N30)
		No desire to change legislation (N31)
	Poor governmental leadership (S8)	Corruption (N32)
918		Reactive decisions (N33)
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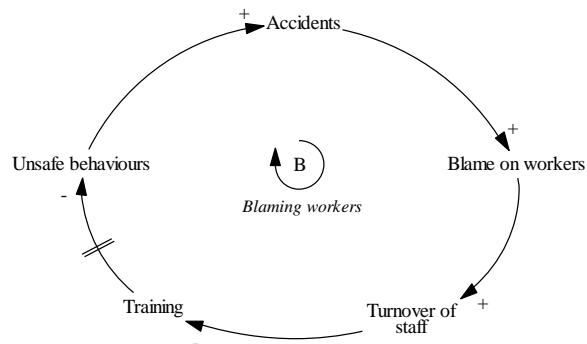
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921 **Figure 1a: Example reinforcing loop**



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923 **Figure 1b: Example balancing loop**



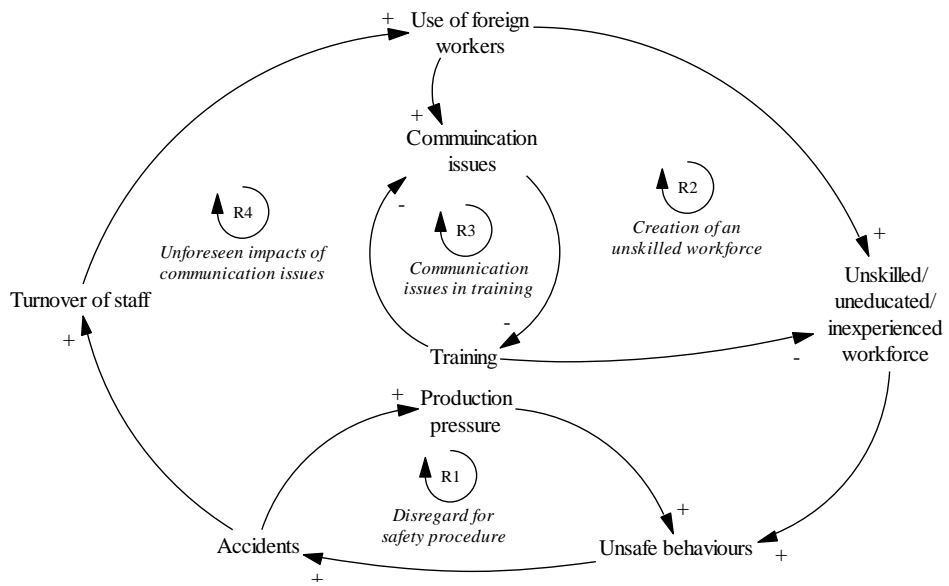
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925 **Figure 2: Process of data analysis (adapted from (Burchill & Kim, 1993; Guo et al.,**
926 **2015))**



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930 **Figure 3: Amalgamation of causal links into a causal loop diagram**

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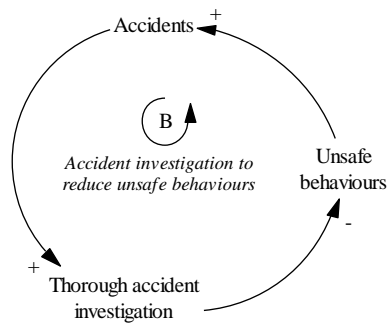
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Figure 4: 'Effects of a migrant workforce' archetype

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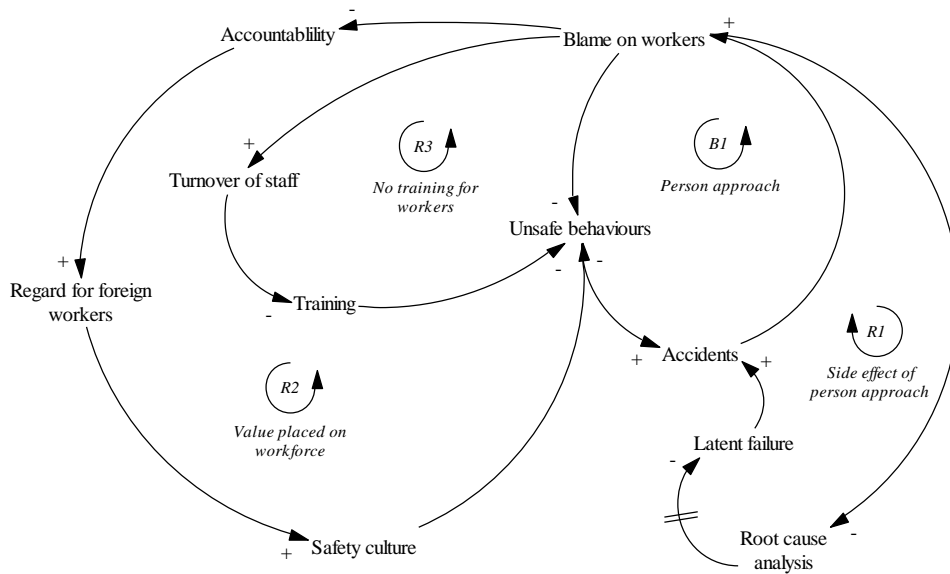
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Figure 5: 'Accident investigation to reduce unsafe behaviours' balancing loop

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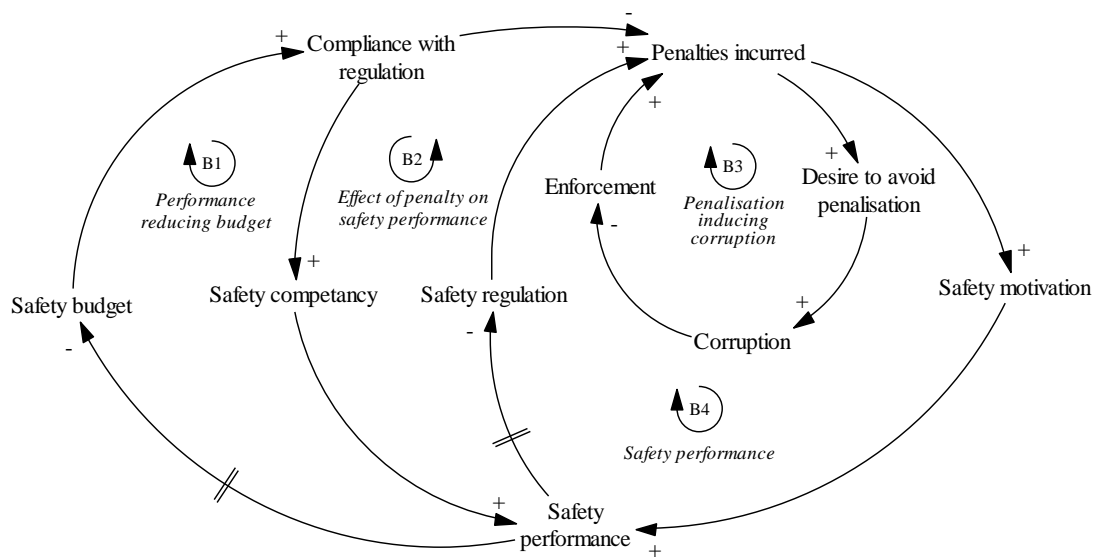


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942 **Figure 6: 'Corporate accountability and profit driven business culture' archetype**

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946 **Figure 7: 'Issues in the regulatory system' archetype**

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