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# Identifying the factors of trust in new seismic-proofing technologies in New Zealand

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## ABSTRACT

Earthquakes have caused serious damages to the economy of New Zealand. Numerous innovative methods and technologies are introduced to the New Zealand construction industry with the aim of reducing the consequences of earthquake damages and the aftermath repair costs. However, the low level of trust towards these new technologies poses a significant challenge in their application. An enhanced understanding of the factors that affect the trust in the newly introduced seismic proofing technologies can support design policies to leverage their adoption. This study explores the cost and market-related factors that determine the trust level. A specific innovative seismic-proofing technology, namely the Resilient Slip Friction Joint (RSFJ), has been adopted as a case study. This technology has been introduced to the industry in 2016. It provides seismic energy dissipation and the ability to return the structure to the pre-earthquake position after the event in one compact package.

The data collection step of this study involved an online survey of different industry groups including clients, contractors, and consultancies. The survey questions were designed to approach the trust factors from different perspectives, such as cost, market and bidding, as well as the project characteristics. The methods used, the challenges encountered and the significant factors that affect the trust level in a new seismic proofing technology are reported. The findings can help to develop a pathway to significantly improve the uptake of new seismic-proofing technologies in the construction industry.

## 1 INTRODUCTION

Failing to meet owners' demands has become one of the biggest concerns in the construction industry. Projects frequently fail to meet the expectations indicated by time, cost and quality (Construction Users Roundtable 2007). A wide range of innovative technologies from new software to new equipment devices, materials and methods are introduced to address these failings. Seismic-proofing technologies and methods have been an integral part of this endeavour with the main aim of maintaining the life-safety criteria and reducing the damage that provides the possibility of post-event functionality. However, the adoption of the innovations has always faced resistance from the industry. Governmental studies have demonstrated a strong tie between such resistance and a lack of trust in the industry (Bruneau and MacRae 2017; WEF 2017). It is, therefore, important to explore the determinants of trust within the industry and to get a clear picture of how the actors in this sector perceive these determinants and their interactions.

## 2 TRUST

### 2.1 Definition and role

Trust is a complex concept linked with various meanings, depending on the situations and context. Rousseau et al. (1998) provided a collective definition where "trust is a disposition and attitude concerning the willingness to rely upon the actions of or be vulnerable towards another party, under circumstances of contractual and social obligations, with the potential for collaboration". The definition proposed by McKnight et al. (2011) established a connection between trust and technology adoption. According to them, trust refers to "a belief that a specific technology has the attributes necessary to perform as expected in a given situation in which negative consequences are possible."

### 2.2 Determinants of trust to new technologies in the construction industry

The construction industry is frequently pledging for change, and this has been constantly reflected through many reports and studies over the recent decades (Antunes and Poshdar 2018; Latham 1994; Overduin 2012). Trust has been acknowledged as an important aspect in such dynamic environment (Cheung et al. 2014; Pinto, Slevin, and English 2009; Wong et al. 2008; Wong, Then, and Skitmore 2000). There are several indications that the lack of trust in the construction industry can severely harm the projects (Gonzalez, Pavez, and Poshdar 2015).

Davidson and McFetridge (1985) tested the relationship between international technology adoption and the characteristics of the individual technology, parent corporation, and the host country involved in the transfer. A sample of 1226 technology transfers was studied that strongly supported the effects of technology and parent characteristics on its adoption. The effects of the characteristics of the host country were demonstrated to have a weaker influence on the transfer patterns. Akintoye (2000) studied the perspectives of contractors in the United Kingdom. They identified the complexity of design and construction, scale and scope of construction, method of construction, tender period and market condition, site constraints, client's financial situation and budget, type of client, buildability, the location of the project, and availability and supplies of labour and materials, as cost-related factors of trust.

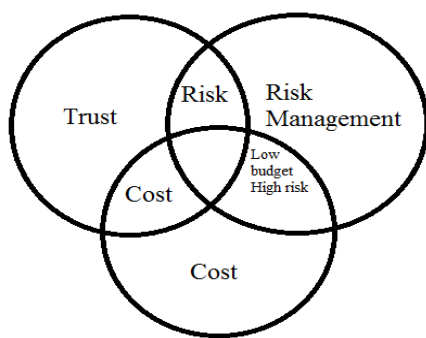
Cui et al. (2006) explored the effects of market and cultural factors on international technology trust and resultant performance. They examined the relative influence of market and cultural environments. The market environment was linked to two factors including competitive intensity and market dynamism. The cultural environment was related to national cultural distance and organisational cultural distance. The results indicated a higher influence from market dynamism compared to the competitive intensity. Similarly, organisational cultural distance found to have a higher influence on trust than the national cultural distance.

Khalfan et al. (2007) found three major factors influencing trust in construction projects: honest communication, reliance and the delivery of outcomes. By honest communication between people involved in a construction project, better delivery of the final project can be guaranteed. Reliance means people have to trust their co-workers within the construction projects and believe they will deliver the project by the expected standard. The outcome of a project should be delivered as a functional product to the client.

(Montague and Asan 2012) asserted that the appropriate/inappropriate use of technology plays a significant role in building trust. Jafarzadeh (2012) studied building characteristics and local site condition as the two important cost-related factors. Kai Lu et al. (2016) investigated the processes that foster trust and the way they are influenced by contractual control and managers' propensity to trust. They collected survey data on 260 architect–contractors in China. The results showed a positive relationship between the contractual control and the project manager's propensity to trust, and the managers' trust in their partners. Zuppa et al. (2016) surveyed the top 400 contractors that are members of the American Engineering News Record to identify the determinants of trust and their impact on a construction project. The findings indicated the on-time payment, competency, reliability and effective collaboration as the most important factors. Face-to-face communication, electronic documentation, besides timely and adequate feedbacks to requests for information were also found to be imperative. On the other hand, the presence of construction managers on construction projects and corrective change orders from neutral third parties were specified to weaken the trust. Trust was found to assist leadership, team building, communication and information sharing.

Johnson et al. (2016) investigated the cost-related risk aspects of trust including contract condition, procurement system, inflation, change in owners requirement, type of cost, underestimation and type of bidding. Adafin and Johnson (2017) identified change in an owner's requirements, the complexity of design and construction, quality of information and flow requirements, availability of design information, and the expertise of consultants, market condition, and project team's experience of the construction type, site investigation and inadequate tender documentation as the most important cost-related factors of trust.

Figure 1 summarises the existing literature on the determinants factors in a global context.



*Figure 1: Relationship between trust, cost and risk factors*

### **2.3 Determinants of trust to new technologies in New Zealand**

Figure 1 gives an insight into the trust factors that can influence the adaptation process to new methods and technologies in construction. Given the unique culture and characteristics of the New Zealand construction industry, the nature or relative level of importance of the trust determinants may vary from other countries. This study explores and prioritises the importance of the factors in the New Zealand context. It specifically focuses on cost- and risk-related trust factors inherent in the construction projects.

### 3 METHODOLOGY

A case study was conducted to assess the relative importance of the 24 determinant factors collected from the literature review (Table 1).

*Table 1: Summary of the significant determinants of trust*

Type of client	Availability of labour
Type of cost	Availability of material
Type of project	Procurement system
Type of market	Buildability
Type of bidding	Building characteristics
Location of the project	Site access
Change in owners requirement	Method of construction
The scale of the project	Market condition
The complexity of design and construction	Tender period
The expertise of consultants	Inflation
Availability of design information	Availability of material
Site investigation information	Contract condition

The Resilient Slip Friction Joint (RSFJ) (Zarnani and Quenneville 2015) was used as the technology sample for the case study. It is a new generation of resilient seismic technologies that offer a significant damage reduction in the structural and non-structural elements in the building (Hashemi 2017), introduced to the market in 2016. It provides a possibility of immediate occupancy after the seismic event (Zarinkamar, Wilkinson, and Quenneville 2018). A questionnaire survey was conducted with the construction field experts to assess the relative importance of the factors listed in Table 1 for the New Zealand market when adopting RSFJ. A link to a webpage on Survey Monkey was emailed to a total of 200 construction professionals from New Zealand. Hundred-thirty responses received, with 81 complete and valid. The questionnaire was composed of four sections. The first three sections collected the demographic information of the respondents including their role, years of experience and their geographic location; the type of their organisation (public or private); and finally, the type of the construction they have been involved. The respondents could assign themselves to one of the five main professional groups in construction including architects, structural engineers, planners, quantity surveyors and project managers. The ones that did not belong to any of these pre-defined categories were provided with an option to add their role.

A short explanation on the RSFJ concept was included, and the respondents were requested to express their perception about the importance of each factor in Table 1 by ranking them on a five point-Likert scale from 'Extreme impact' to 'No impact'. The respondents could add any factor perceived to be missing from the list. A statistical analysis of the responses indicated the most imperative trust factors affecting the choice of RSFJ in a building project.

### 4 SAMPLING DEMOGRAPHICS

From the 81 respondents to the survey, 16% of them were clients, 9% were contractors, 68% were consultants, and the other 8% consist of surveyors, building controllers, regulator and structural designers (Figure 2(a)). The minimum working experience was five years, and the maximum was more than 20 years (Figure 2(b)). The statistical significance of the differences among the factors in each group was assessed

using an independent sample t-test. As shown in Table 2 the significance of the difference was close to zero, which confirmed the homogeneity of the samples in their groups.

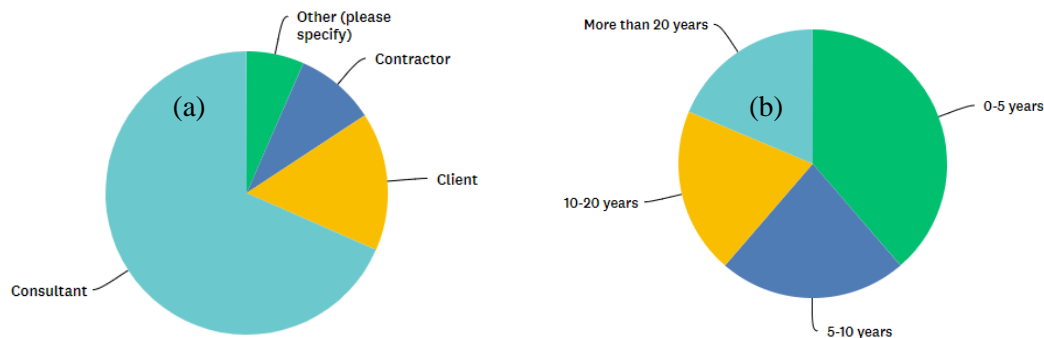


Figure 2: Respondents characteristics: (a) population (b) working experience

A T-test was conducted that indicated no significant anomaly in the responses from different groups (Table 2).

Table 2: t-test results

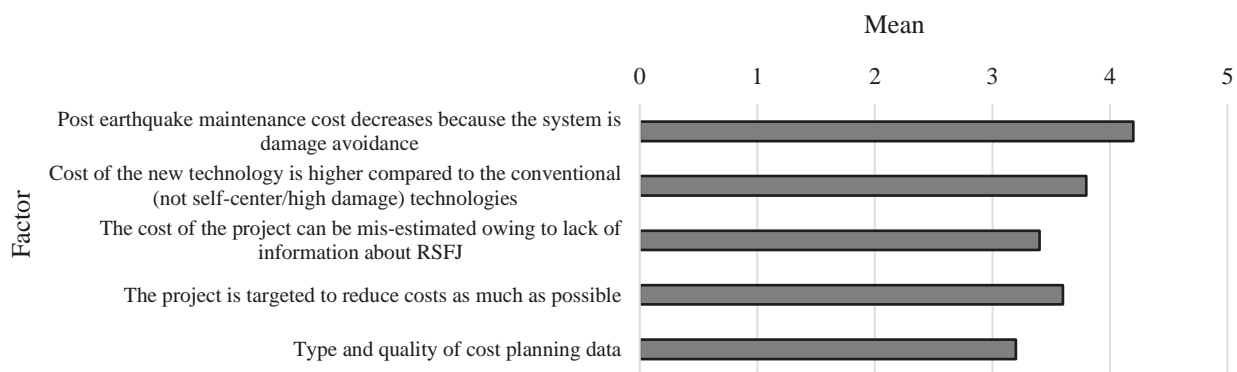
Factors affecting trust to new methods and new technologies in construction industry	Mean	t-value	SD	Significance (2-tailed)
<b>(I) Cost-related factors</b>				
Post-earthquake maintenance cost decreases because the system is damage avoidance	4.1	31.9	0.9	0
Cost of new technology is higher compared to the conventional technologies	3.8	38.5	0.7	0
The cost of the project can be misestimated owing to lack of information about RSFJ	3.5	26.7	0.9	0
The project is targeted to reduce costs as much as possible	3.7	23.7	1.1	0
Type and quality of cost planning date	3.2	18.9	1.2	0
<b>(II) Market-related factors</b>				
Procurement system: Local representative	3.6	24.2	1.1	0
Procurement system: overseas representative	3.3	21.3	1.1	0
Product availability: Of the shelf products	3.6	27.7	0.9	0
Product availability: customized products	3.8	27.4	1	0
Inflation	3.3	22.7	1	0
Availability of construction material	3.6	22.3	1.2	0
Availability of labour	3.7	29.6	0.9	0
Fluctuating in labour prices	3.2	21.3	1.1	0
Fluctuating in material prices	3.3	22.3	1	0
Being a made-in New Zealand technology	3.7	21.3	1.2	0
<b>(III) bidding-related factors</b>				
Type of bidding	3.3	20.8	1.1	0
Tender period	3.3	22.1	1	0
Contract conditions	3.2	23.7	1	0
Government policy	3.3	21.1	1.1	0

Therefore, the set of responses were judged to be homogeneous and analysed as one statistical group. The top seven factors that provided the mean importance of above 3.6 are presented in Table 3.

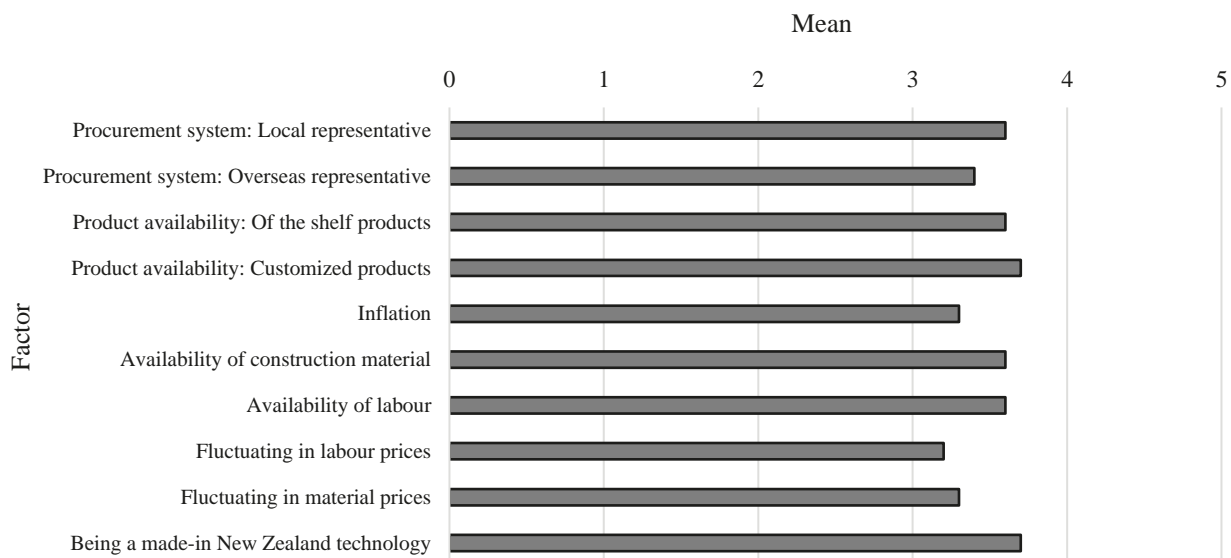
*Table 3: Ranking hierarchy of significant factors affecting trust to the new seismic-proofing technology*

Rank	Factors affecting the choice of technology	Mean
1	Post-earthquake maintenance cost decreases because the system is damage avoidance	4.1
2	Cost of new technology is higher compared to the conventional technologies	3.8
3	Product availability: Customized products	3.8
4	Being a made-in-New Zealand technology	3.7
5	Availability of labour	3.7
6	Availability of construction material	3.6
7	Procurement system: Local representative	3.6

Figures 3 and 4 present the factors divided into cost-related and market-related categories.



*Figure 3: Cost-related factors*



*Figure 4: Market-related factors*

## 5 DISCUSSIONS

The reasons for the importance of the top seven prominent factors and the possible ways to address them are discussed next.

### **Post-earthquake maintenance cost decreases because the system is damage-avoidance**

Given the impact and consequences of the recent seismic events on the economy and society of the country (Christchurch and Kaikoura events), it is no surprise that a maintenance-free seismic-proofing system with immediate functionality after the earthquake has been well received by the technology adopters. This maintenance-free characteristic of RSFJ can also be interpreted as zero or insignificant repair costs after the earthquake. Having this factor ranked as the most important determinant indicates the significance of individual experience in building trust when adopting new technology. It would thus be logical to assume that any testing that demonstrates the performance of a new technology will have positive effect on its adoption.

### **Cost of the new technology is higher compared to the conventional technologies**

Some of the new technologies (RSFJ included) may impose a higher initial cost, especially when compared to the current conventional systems. It can harm the trust level to adopt the technology.

Nevertheless, the high competitiveness of this type of new technologies is put into the spotlight when one takes the post-event repair/replacement costs into account. It is most likely the case for most of the new sophisticated technologies and methods that require high accurate manufacturing and implementation process. A reference to the overall lifecycle cost of the project may boost the attraction of the new technology for the decision makers.

### **Product availability: Customised products**

The technology used for the case study (RSFJ) can be tuned and customised based on the requirements of the building, its seismic characteristics, geometric properties, materials used, soil type and its location. This customisation characteristic was found to be an important market-related indicator in building trust. Therefore, to promote the adoption of the new technologies, the government may initiate new policies to support the manufacturers and providers whose offer the possibility of customised products.

### **Availability of labour**

The installation procedure of RSFJ technology is rather simple and can be handled by the mid-level skilled labours that properly fits into the skill sets available in the New Zealand market. Such an availability was found to be the fourth critical factor in forming trust in the new technologies.

### **Availability of construction material**

The study demonstrated that the use of materials which are locally available could significantly increase the likelihood of its adoption. The RSFJ technology is composed of common structural steel and disc springs which are readily available in the local market. It enables a shorter lead time for the projects that elevates the level of trust.

### **Being a made-in-New Zealand technology**

Technologies that are produced in New Zealand have the advantage of availability and minimum transportation cost. It facilitates a shorter lead time that enhances the trust level.

## Procurement system: local representative

With a local product representative, the technical and procurement support are easily available. It ensures the availability of the responsible person if there is a query or a special request (e.g. maintenance and support). Furthermore, if the adopter desires a change in specifications, the matter can be communicated with the local representative easier, and the queries can be addressed faster. This attribute has been suggested as the seventh important factor in building trust in the new technology.

## 6 CONCLUSIONS

Several new methods and technologies have been introduced to improve the performance of construction and meet the owners' demands. However, the low level of trust to these new methods and technologies presents a major barrier for the adopters. This research explored the factors contributing to trust by conducting a case study in New Zealand. It involved a survey with construction experts in different roles such as clients, contractors and consultants. The main contributory factors in building trust were divided into two main categories: (1) cost-related factors such as a decrease in post-earthquake maintenance cost, cost of new technology is higher compared to the conventional technologies, misestimation in the cost of the project, the project is targeted to reduce cost as much as possible and type and quality of cost planning data. (2) Market-related factors such as procurement system, product availability, inflation, availability of construction material, availability of labour, fluctuating in labour price and material price and finally being a made in New Zealand technology.

The findings highlighted the importance of seven factors. The personal experience with certain problems related to the technology, the potential of customising the product, the total cost of new technology, availability of labour, availability of its material, being a local built technology and the availability of local representative of procurement system were found as the most important factors in the uptake of new technologies and methods. This research forms a baseline to understand the adoption process of innovative technologies.

## 7 ACKNOWLEDGEMENT

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