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Promoting Earth Buildings for Residential Construction in New Zealand

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Abstract: The construction of earth buildings, both throughout history and in the current day, is well-established worldwide. Despite New Zealand's pre- and post-colonial history of earth construction, earth buildings as residential homes have not been well-received or popularised throughout present-day New Zealand. This research aims to identify the reasons for this lack of awareness and to determine methods that promote earth buildings in New Zealand. This research is based on data collected from semi-structured interviews conducted with subject matter experts and via an online questionnaire completed by members of the Earth Building Association New Zealand (EBANZ). The data collected revealed the experiences and perceptions of all participants regarding the advantages, challenges and promotion of earth buildings specific to New Zealand. Following analysis of these responses, key reoccurring themes were identified and compared. Regarding New Zealand's lack of awareness of earth buildings, interview and questionnaire participants responded that this shortcoming was due to earth construction being a very niche market and lacking commercial marketing. Education was the most frequently reoccurring theme raised by all participants as the top promotional tool for raising awareness of earth buildings. The results of this research can be applied to future work regarding obstacles that limit the growth of New Zealand's earth building industry, as well as research on the role of New Zealand's education system in exposing the next generation of builders, designers, and consumers to earth construction.

Keywords: earth buildings; residential construction; awareness; education; New Zealand

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1. Introduction

The process of building with earth is older than the written word. Researchers have focused on the history of earth building construction and how each part of the world developed its unique techniques, which were particularly influenced by local geography [1,2]. Earth building has a rich past, with archaeological evidence of mud brick housing dating from 10,000 years ago and rammed earth techniques dating back to 2600 BC. Whether modern society realises it or not, earth buildings include historically significant sites such as the Great Wall of China, the Alhambra in Spain and the Pyramid of the Sun in Mexico, among others [3]. These are structures of great cultural and historical importance attracting millions of visitors annually.

The history of earth buildings in New Zealand has also been explored. The concept of earth buildings is very native to New Zealand. The Māori used earth building materials for flooring and walls, a construction technique that continued following the arrival of European settlers [4]. Cob, the moulding mud to create walls using straw as reinforcement, was used by English immigrants to New Zealand, and more than 8000 cob homes were built [3]. One study focused on earth and straw bale homes in the South Island, specifically around Nelson. In this region, 144 earth-building houses have been built since 1945 and were occupied at the time of research in 2010. This proves the durability of earth homes, with 65-year-old homes still standing and functioning [5]. With the collaboration and

expertise of innovative earth building architects, in 1998, New Zealand established its very own building standards specific to design, materials, and workmanship [4].

Despite New Zealand's architectural history, knowledgeable architects, and comprehensive building standards dedicated to earth architecture, most homes in New Zealand are made of timber, cement and steel. In present-day New Zealand, less than 1% of all houses are earth buildings, and these are located primarily in rural areas of the country [6]. This varies substantially from the rest of the globe, where one third of the world's population live in earth building [7]. New Zealand's Researchers have found fewer earth buildings were built after the year 2000 in New Zealand because of increased insulation requirements for mainstream buildings in response to the "leaky buildings" syndrome and the absence of an official national standard for straw bales [3]. Through the participation of earth building subject matter experts, this research aimed to identify reasons why earth buildings are not promoted in New Zealand and to identify tools that could be used to raise awareness of residential earth buildings.

2. Literature Review

2.1. Promoting Earth Buildings

A literature review was conducted by compiling, organising and reading research articles focused on methods implemented to raise awareness and promote earth buildings, earth construction and earth manufacturing. This included research completed in Germany, Romania, Egypt, South Africa and New Zealand. Findings support the reliability of this research, with typical, repeated themes emerging regardless of location. A summary of the earth building promoting methods and examples are given in Table 1.

Table 1. Methods and examples of promoting earth buildings.

Promotion Methods		Examples	Reference/s
Education	Secondary/ Tertiary Schools	Earth building is taught within Germany's formal building trade education. There is also a "Specialist in Earth Building" qualification.	[8]
		Romanian secondary and tertiary schools have adopted earth construction and design learning materials developed by the REcult Association (a group of Romanian architects).	[9]
	Workshops	The University of Free Education's Unit of Earth Construction has trained ~170 community builders (men and women) who built homes, daycare centres, a school hall, an economic development centre and a tourism centre with adobe or compressed earth blocks.	[10]
		Earth building courses and community workshops in the New Zealand regions of Northland and Nelson have promoted and inspired new earth builders.	[11]
Government support	Codes and Standards	Global survey participants stated national codes are integral to promoting earth buildings; codes allow architects and engineers to design and build earth buildings, increasing earth build projects.	[12]
		Investing in government buildings made of the earth would increase public awareness and change public perception of what earth buildings look like.	[13]
	Funding	Standards NEW ZEALAND was once a government agency. Earth building standards are now left up to individuals and organisations like EBANZ to update and finance. Receiving government financial support would raise the value, credibility and profile of earth buildings for residential homes among the industry and the public.	[14]
		Timber is currently the only low carbon material receiving government funding for research; if earth materials research was given the same government financial support, it would increase awareness within the industry and with educators.	[14]

Table 1. *Cont.*

Promotion Methods		Examples	Reference/s
Marketing	Events	Earth building techniques were promoted with daily workshops during a four-day music festival. The event was attended by all ages and backgrounds within the community.	[9]
		A campaign called "About earth: people and their homes from Banat" raised awareness of earth homes at local festivals. This campaign included short films of earth homeowners and the benefits of living in an earth home.	[9]
		Attendees of the Auckland Build Expo were introduced to the benefits of earth building via a virtual reality presentation. This tool presented an easy and accessible way to raise public awareness.	[6]

The key elements in promoting earth buildings were education, government and marketing. Researchers found that earth-building techniques have been introduced into secondary and tertiary curricula and community workshops. Regarding the government, researchers found government support and funding to be an influential source for promoting the legitimacy of earth construction through codes and standards [15,16]. Researchers also found earth buildings were being promoted at public events, festivals, and expos. These events offered the public a rare opportunity to gain hands-on (and even virtual) experiences with earth materials and buildings.

2.2. Technological Developments in Earth Building Material Manufacturing

The future of earth building depends on the technological development and manufacture of earth building materials, globally and nationally. As sustainable and greener construction methods are popularised, the technological challenges of producing these materials will run into a roadblock: The production of sustainable earth building materials may not be able to meet the demand for high-density housing [17].

Further afield, the manufacture of compressed earth block (CEB) is being developed and promoted in Africa, Asia and Latin America. CEB machines can produce large bricks while ensuring uniform sizes and pressure resistance. One CEB machine used in Uganda could produce 360 blocks per hour and required eight to ten labourers [17].

In New Zealand, the rise of earth-building homes in Nelson during the 1990s can be attributed to locals developing and implementing a soil cement block production business. These blocks are larger and heavier than adobe bricks, and require more skill to manufacture. In present-day Nelson, there is an earth building material manufacturer called Solid Earth: Adobe Buildings Ltd. Solid Earth specialises in adobe bricks and floor tiles, earth plastering and earth wall building services [3].

However, earth block manufacturing is at a disadvantage compared to mainstream building materials in New Zealand. National cement and concrete associations can do more research and promotion of their materials because of the larger market [11]. Another challenge facing building materials labelled as "sustainable" and environmentally friendly" is the belief amongst international construction companies that the initial cost of green construction is still higher than conventional construction methods [18]. This means there is no commercial interest in earth buildings, making it challenging to monetise [3]. This supports findings that because earth materials are not advertised or promoted, there is a perception that there is "nothing to sell" to the public [11]. The truth is that natural earth building materials cost little and require minimal processing.

2.3. Automation in Earth Construction

Despite the significant development of automated processes in construction in recent years, earth construction has not been adequately studied for its potential automation. With modern automated construction technologies such as 3D printing and prefabrication,

earth construction has the potential to be accepted as mainstream construction due to its sustainability features, customizability and flexibility. Germany is an example of a country taking a proactive stance on the future of earth buildings. German construction practitioners are introduced to earth building techniques via education and the development of relevant building skills during their formal building trade instruction, where they can earn a "Specialist in Earth Building" qualification [8]. The German National Institute of Building Techniques gave earth building materials legal recognition in the construction market. By embracing earth building materials, Germany now manufactures innovative materials such as prefabricated rammed earth blocks with integrated heating/cooling pipes [8]. Mario Cucinella Architects and WASP 3D printing company in Italy have built the first 3D-printed building from raw earth. The process called TECLA (standing for technology and clay) is environmentally friendly with zero waste needing no materials to be transported to the site as it uses local soil [19]. Therefore, applying various modern automotive technologies in earth construction would help promote earth construction modern and sustainable construction methods.

2.4. The Environmental and Performance Benefits of Earth Building Materials

Researchers have examined the different types of earth building materials and their environmental and performance benefits. As today's climate crisis calls for immediate action, researchers have looked at how energy conservation in residential housing has increased the popularity of earth sheltering. An earth shelter is built below the ground and is defined as "a structure built with the use of earth mass against building walls as external thermal mass, which reduce heat loss" [20]. They offer year-long steady indoor air temperatures. The earth building material of straw bale (with timber structural elements) in New Zealand is a proven high-performing construction method. These homes survived heavy rainstorms in 2011 and earthquakes in 2010 and 2011 [5]. Homeowners of straw bale homes also reported excellent thermal properties, ranking their straw bale homes a high IEQ (internal environment quality).

A country or region's specific climate conditions and natural disaster risks determine what type of sustainable building materials and techniques are best suited [17]. Earth construction types in New Zealand are connected to the climate and resources in different regions: adobe brick in Nelson (sunshine helps with drying), in situ adobe and rammed earth in Auckland (higher rainfall needs stabilised construction methods) and straw bale in Canterbury/Otago (drier grain growing areas) [5].

Regarding the risk of earthquakes in New Zealand, research has been conducted on the performance and durability of rammed earth construction, and its ability to handle seismic load. Unreinforced rammed earth walls were proven to resist moderate seismic loads when built on concrete/reinforced concrete floors and timber/reinforced concrete bond beams per NZS 4297 engineering design of earth buildings. Four out of five rammed earth houses surveyed in Christchurch after the September 2010 earthquake had minor damage to non-structural elements or non-threatening damage to structural elements. All rammed earth houses had wall thickness of 200 to 500 mm, with one house of 500 mm wall thickness experiencing a total wall collapse [21].

Additional research has focused on the durability of reinforced earth building materials; for example, the durability of rammed earth construction when combined with cement [22]. Cement-stabilized rammed earth (CSRE) is a popular building material in Australia due to its good thermal properties and appearance [23]. This material is also found in New Zealand. Nine CSRE houses surveyed in Christchurch after the November 2011 earthquake, with wall thickness of 150–250 mm, had minor cracking [21]. Research shows that exposed CSRE becomes less durable over a long period, with an erosion loss of 0.1 to 0.2 mm a year. These findings show that CSRE designers must understand the expected strength loss and volume loss that comes with CSRE when conducting weathering tests (wetting and drying) [24].

Research shows that earth building techniques are just as adaptable as mainstream building techniques. Earthen building walls made of compressed earth bricks and concrete can be constructed with cavities and drainage ports to help damp proofing as weatherproofing solutions [20]. This proves building with earth buildings in wet climates is a reality. In a New Zealand study, homeowners of earth buildings addressing the thermal properties shortcomings of their homes stated this only led to adapting and innovating these earth building materials. Earth builders found using lightweight earth material offered better insulation properties. They also began designing these walls in the home's interior to take advantage of their thermal attributes instead of using earth walls as exterior walls [5].

2.5. The Lack of Awareness of Earth Buildings

With respect to the public's unwillingness to live in earth buildings, the main reason given by most respondents is that they do not know enough about earth buildings. These comments prove that the lack of market guidance and an inability to acquire knowledge about earth buildings have effectively led to poor demand for this construction technology.

Architectural designer, Mark Fielding, says, "Most of my clients haven't heard of it when I talk about passive solar design and thermal mass because they never know anything about it, including television, magazines and any advertising". Since these things are natural, there is nothing to sell. Therefore, there will be no such information about earth buildings [11]. This study explains that earth buildings have numerous benefits, including quality indoor environments, aesthetics, thermal efficiency, solar gains and cheaper building materials. As explained by Samarasinghe, Baghaei & Stemmet [6], the population in New Zealand is mainly unaware of the benefits of earth buildings.

Moreover, many people in New Zealand wrongfully assume that modern buildings are more advantageous than earth buildings. Therefore, promoting the benefits of earth buildings, not only for individuals but for the environment, is crucial to gaining support for these buildings. According to Nikolić and Whyte [25] and Samarasinghe and Piri [26], using modern technology such as virtual reality is a more effective way to promote earth buildings as it shifts the attitudes and mindsets of individuals.

Furthermore, marketing the economic benefits of earth buildings is critical in promoting their adoption in New Zealand [27]. Earth buildings have numerous economic benefits resulting from cheaper and more sustainable building materials. In addition, there is greater availability of soil for constructing earth buildings than modern building materials like bricks or mortar [27], thus modern buildings tend to be more costly than earth buildings. With the current focus on efficiency and cost-effectiveness in construction, earth buildings could become immensely popular if more people were aware of their economic benefits. This lack of knowledge is a substantial barrier to their widespread adoption in New Zealand.

2.6. The Educational Significance of Earth Buildings

Any building has educational significance, and earth buildings are no exception. Almost all earth building projects currently carried out in New Zealand involve some educational aspect, whether through workshops or training programmes, and 75% of the experts interviewed had participated in formal or informal earth building related educational programmes. Commercial builders could hold open days and workshops for earth construction projects to attract more understanding [28].

According to Schroeder [29], how education about earth buildings is offered varies widely based on the needs of target populations. While some participate in formal education regarding earth buildings and their various facets, other learn about these elements informally. Moreover, these educational categories for learning about earth buildings depend on whether learners are professional practitioners or academic students [29]. There are also various categories of educational training for learning about earth buildings, including vocational training, undergraduate training and advanced education and training [30]. However, the primary purpose and education concepts are similar in these categories.

They all target similar learner outcomes-promoting earth building construction's benefits, principles and models. Therefore, education regarding earth building construction is essential.

Furthermore, Jörchel [8] noted that adding earth building construction and benefits to the formal educational framework can significantly enhance the understanding of the population regarding these types of buildings. As noted above, the increased understanding of individuals regarding the concept and benefits of earth buildings, and the addition of earth buildings in the formal education framework, will promote earth buildings among the population and enhance their adoption in the country. This intervention framework has succeeded in Germany and is also viable in New Zealand [8]. Therefore, it is necessary to tap into the educational significance of earth buildings to enhance public awareness regarding both the concept and its benefits [16].

2.7. New Technologies for Promoting Earth Buildings

Virtual reality (VR) is a simulation experience that can be similar to or completely different from the real world. VR technology is a highly innovative field that can interpret persuasive technology well and change people's attitudes and ideas [31]. With the development of VR devices, popular and affordable headset VR devices offer great potential for influencing users' perceptions and attitudes [6]. The application of VR technology may become one of the main ways to promote earth buildings in the future; people can experience and better understand earth buildings through these simple devices. Compared with more traditional methods of education, VR can lead to an increase in participation and bring a fresh approach to learning.

Several other forms of modern technology could promote earth materials in modern construction. Nikolić and Whyte [25] explain that these technologies should focus on developing green buildings, which have numerous benefits for residents and the environment. Moreover, these technologies should be sustainable and promote sustainable earth-building materials. In addition, combining new and old-but-sustainable building technologies for constructing earth buildings could create contemporary and efficient construction designs. Udawattha, Arooz and Halwatura [32] concur that using modern technology in the construction of earth buildings leads to more sustainable buildings. Promising new research on earth materials and digital fabrication could offer architects greater creativity in design while creating less material waste. These innovative digital techniques include automated robotic machinery producing rammed earth walls, and robotic sprayed earth via 3D printing [19,33]. The essence of sustainability in modern construction is gaining momentum, and it is a critical foundation for most constructions in the contemporary period [29].

In addition, cost efficiency is a primary benefit of integrating modern innovations with existing building materials such as earth [32]. For instance, combining baked mud and concrete to create a daub mixture block resulted in a construction material that is cheaper and more sustainable and effective [34]. This type of material, and its benefits, indicate that the combination of new and existing technologies is highly beneficial for earth building constructions. Moreover, Samarasinghe and Wood [35] explain that the use of modern technologies in the construction and promotion of earth buildings can change the behaviours and attitudes of people in New Zealand regarding earth buildings.

3. Data Collection and Analysis

3.1. Methodology

Prior to determining the methods for this research, a literature review was conducted to better understand past research conducted on promotion and awareness of Earth buildings in New Zealand. During this research, a pattern of reoccurring themes appeared, and these themes became the basis for Section 2 and valuable resource in developing the research questions (see Table 2). The following sections discuss the development of the interview questions and the questionnaire survey produced by this research.

Table 2. Question development.

Interview Question	Online Survey Question
Why do you think earth buildings are appropriate for New Zealand? Why would you promote earth buildings in New Zealand? What made you decide to live in an earth home?	Q1. Please explain why you would promote earth buildings for a living.
Are there any advantages of earth buildings over conventional timber, concrete or steel structures? How do you compare living in an earth home to a conventional home?	Q2. What are your opinions on the performances of residential earth buildings?
How was your experience with councils getting approvals and inspections?	Q3. What do you think about the ease of obtaining building consent for residential earth buildings?
Why do you think there are few earth buildings in New Zealand?	Q4. Why do you think there are fewer earth buildings compared to conventional houses?
What are the challenges of living in an earth home?	Q5. What are the main challenges of living in earth buildings?
Are there any maintenance requirements?	Q6. What are your suggestions to overcome the challenges [of living in an earth building] you mentioned above?
What should be done to raise awareness/promote earth buildings in New Zealand?	Q7. What are the main reasons for the lack of awareness of earth buildings in New Zealand? Q8. What are your opinions on promoting earth buildings for a living?
Is there anything the New Zealand Government can do to promote earth buildings?	Q9. Who do you think can contribute to promoting earth buildings for a living? Please explain your answer.

3.2. Primary Data Collection

Subject matter experts were interviewed to understand research gaps related to promoting earth buildings. Five were identified as earth builders, three had a role in education, and four were earth homeowners (See Table 3 for a detailed profile of each participant). The subject matter experts were selected to represent the earth building professionals such as builders, architects, homeowners and researchers. Data saturation was reached with seven in-depth interviews conducted to answer the research questions established. For the online questionnaire, members of EBANZ were asked to participate with 79 members voluntarily returning completed questionnaires.

The questions asked were developed considering findings from the systematic literature review. These interviews were conducted via telephone and recorded with permission from the participants. After the interviews were conducted, they were transcribed and analysed to determine common, reoccurring themes raised by participants.

To collect a more comprehensive set of subject matter expert opinions, an online questionnaire survey was chosen as an effective research data strategy. The online questions were based on the initial interview questions and designed to collect meaningful qualitative and quantitative data regarding awareness and promotion of earth buildings. The interview questions and related online survey questions are given in the following table.

Table 3. Composition of interview participants.

Participant	Role	Background/Experience
Participant 1	Earth builder and director of earth construction company (BioBuild)	Seasoned in earth building, qualified and licensed builder
Participant 2	Earth builder and homeowner	Architecture, speciality in rammed earth
Participant 3	Earth builder, homeowner, and member of Earthsong Eco Neighbourhood	Architecture, earth home project management
Participant 4	Earth builder, earth homeowner, and earth material manufacturer (Solid Earth Adobe Buildings), and EBANZ member.	~30 years in earth construction and earth material manufacturing
Participant 5	Lecturer at Unitec Institute of Technology New Zealand School of Architecture, with a focus on low-energy architecture	~30 years registered architect, New Zealand Institute of Architecture (NZIA) award-winner, Standards New Zealand committee member
Participant 6	Researcher and senior lecturer at The University of Auckland on earth architecture and timber structures	Civil Engineering with ~30 years in education, New Zealand Timber Design Society and NZ Society for Earthquake Engineering
Participant 7	Educator, earth homeowner, and member of Earthsong Eco Neighbourhood	~20 years in earth homeownership

The questionnaire survey was conducted in English and developed to be completed online in Google Forms. Questions 1 through 8 were open-ended and designed for participants to explain their responses. Question 9 asked participants to base their answers on a figure in the survey listing different parties involved in the earth building supply chain. The last question captured the professional roles of the participants.

3.3. Content Analysis

Content analysis allows researchers to make specific inferences from the text by identifying reoccurring words and themes [36]. This form of analysis was used to make sense of responses, which ranged from one-word to paragraph-long. For both the interviews and online survey questionnaires, there was a process of analysing responses and notating the key, reoccurring words. Regarding the results of the online survey questionnaire, a frequency distribution table was created due to the large number of participants.

4. Results

4.1. Summary of Results

Tables 4 and 5 summarie the results of the subject matter expert interviews and the online questionnaire survey.

Table 4. Results of the complete interview questions—Content analysis.

Interview Questions	Key Themes Generated
Why do you think earth buildings are appropriate for New Zealand?	Environment Health
Why would you promote earth buildings in New Zealand?	Environment Health

Table 4. *Cont.*

Interview Questions	Key Themes Generated
What made you decide to live in an earth home?	Environment Health
Are there any advantages of earth buildings over conventional timber, concrete or steel structures?	Environment Health
How do you compare living in an earth home to a conventional home?	Health
How was your experience with councils getting approvals and inspections?	No issues
Why do you think there are few earth buildings in New Zealand?	Niche market Lack of education/skills Hesitancy
What are the main challenges of living in earth buildings?	Minor
Are there any maintenance requirements?	Minor Dependent on design
What are the challenges of earth construction in New Zealand?	Niche market Hesitancy Poor perception
What should be done to raise awareness/promote earth buildings in New Zealand?	Education
Is there anything the New Zealand Government can do to promote earth buildings?	Education Environment benefits

Table 5. Results of the online questionnaire survey—Content analysis.

Online Questionnaire Survey Questions	Key Themes Generated
Q1. Please explain why you would promote earth buildings for a living.	Environment Health Sustainability
Q2. What are your opinions on the performances of residential earth buildings?	Dependent on design Dependent on builder
Q3. What do you think about the ease of obtaining building consent for residential earth buildings?	No experience Challenging
Q4. Why do you think there are fewer earth buildings compared to conventional houses?	No education/training No public awareness
Q5. What are the main challenges of living in earth buildings?	No challenge Maintenance
Q6. What are your suggestions to overcome the challenges mentioned above?	Education/training Public promotion
Q7. What are the main reasons for the lack of awareness of earth buildings in New Zealand?	No education No marketing/advertising
Q8. What are your opinions on promoting earth buildings for a living in an earth dwelling?	Promote with media Promote environmental benefits
Q9. Based on the figure below, who do you think can contribute to promoting earth buildings for a living?	Government

4.2. Key Themes

4.2.1. Environment

The environment was the primary reason interview and survey participants promoted, built and lived in earth buildings. Participants specified that earth buildings are environmentally-friendly because less waste is produced, and fewer trees are cut down.

Natural materials are abundant, and these materials are locally sourced for construction. More than one interview participant brought up the concept of embodied energy regarding why mud brick was a preferred earth building material. Survey participants responded with words such as "low carbon", "low waste", and "sustainability". When asked to compare the advantages of earth buildings to buildings made with steel, timber and concrete, survey participants frequently answered, "the environment", with the advantages of building with a low carbon footprint, building with natural building materials and creating little to no waste. The environmental benefits discussed by the participants were well-aligned with Rauch [37]'s environmental sustainability concept which is based on constructing, maintaining and demolishing buildings in harmony with the nature using minimum energy consumptions.

4.2.2. Health

Health and concepts connected to health such as "non-toxic" and "natural" were also themes that frequently came up as a reason for promoting earth buildings. When asked to compare earth buildings to conventional builds, participants stated that using non-toxic materials was a benefit. The toxic chemicals used to treat timber were explicitly noted as a reason why using natural materials was the more favourable option. The indoor climate and humidity control offered by earth homes were also more specific health-related themes frequently brought up by participants. Several interview participants reported that their health and family members' health were significant considerations for building an earth home. In addition, they expressed the personal connection felt when living in a healthy home. This was echoed by survey participants who stated living in an earth home improved mental health and offered a sense of creativity and satisfaction for owner/builders. These participants believed there was a connection between earth buildings and a personal sense of satisfaction and happiness.

4.2.3. Niche Market

Another reoccurring theme raised by interview and survey participants was the concept of "niche" regarding New Zealand's small earth building market. When asked why there are so few earth buildings in New Zealand, "niche market" was a typical response due to the earth building industry being characterised as a highly-specialised market. Multiple interview participants brought up the lack of commercial earth construction materials available on the market. These responses reinforced the fact that the earth building market is a tiny segment of the entire construction industry in New Zealand. Survey participants referred to the earth building industry as "small and fragmented". Regarding the lack of awareness of earth buildings, survey participants believed the lack of awareness was due to very poor marketing or advertising carried out to promote them.

4.2.4. Education

Education was the overwhelming response from interview and survey participants regarding what should be carried out to promote and raise awareness of earth buildings. Participant suggestions for raising awareness through education are further discussed in Section 5.2.

4.2.5. Media

Using the media, specifically social media, television and print, to raise awareness was equal to education as the best way to promote earth buildings for living in. Only one interview participant suggested print media but specified the BRANZ publication as opposed to aspirational architecture and design publications suggested by survey participants. Survey participants also stated promoting on television shows such as Grand Designs and showing high-end earth buildings in expensive neighbourhoods would add to earth buildings desirability and value.

4.2.6. Poor Perceptions and Hesitancy

The themes of poor perception and hesitancy towards earth buildings frequently reappeared in interview and survey responses regarding the challenges of earth building construction in New Zealand and why there are so few earth buildings in New Zealand. Words such as "alternative", "hippy", "old", and "poor" were explicitly associated with this theme. Regarding hesitancy, a participant identifying as a builder replied that the challenges of earth buildings come from hesitancy and a fear of the unknown within the industry. A participant identifying as an educator replied that hesitancy to earth buildings comes from within the industry because they are perceived to be very expensive to construct and maintain, and anxiety that the building consenting process would be complicated. This was echoed by some survey participants who responded that although they had no experience with the consent process, they were under the impression it was challenging.

4.2.7. The Role of Government

Interview and survey participants alike were all in agreement that the government plays a crucial role in the promotion of earth building in New Zealand. Echoing the views on education, multiple participants stated there is a lack of people within government organisations with knowledge of earth building construction technology. Participants also stated that the government could support earth building education, offer the same support the timber industry receives and consider earth building a natural solution to lowering the carbon footprint.

5. Discussion

5.1. Raising Awareness of Earth Buildings through Marketing

When it comes to the lack of awareness of earth buildings in New Zealand, most participants believed this was due to a lack of marketing and a lack of education. Regarding a lack of marketing, some participants elaborated that there was no exposure because earth building materials cannot be purchased at "Bunnings", there is "little money invested in the industry", and they do not acquire exposure in print and television media. These sentiments coincide with past research on New Zealand's cultural perceptions of earth building materials in that the public was unaware of earth buildings because there was "nothing to sell", and earth materials were not advertised because there was not a mainstream earth building industry [11].

These responses highlight that the most popular "media" response puts the proverbial cart before the horse. Before earth buildings can be marketed, there needs to be an established earth building industry, which can only be carried out with support within the industry and with tangible earth building materials that can be manufactured and sold. This leads to another concern raised by survey participants in Q4 and Q7 that the mainstream/conventional materials industry has a hold on supply. Within these responses were the words "dominate", "cartels", and "monopoly". Their perception was that mainstream industries lobby for their products to be tested and certified, which puts the tiny and under-funded earth building industry at a significant disadvantage. Again, these perceptions align with previous research that found earth building material manufacturing was at a significant disadvantage because New Zealand-based cement and concrete associations could fund research and marketing of their products [11]. Past research also found no mainstream commercial interest because processing earth building materials was not profitable [4].

5.2. Raising Awareness of Earth Buildings through Education

A lack of education as a reason why there is a lack of exposure to earth buildings; however, in some areas this is being addressed. Germany's formal trade education system offers a "Specialist in Earth Building" qualification [8]. Romanian architects have created learning materials on earth building designs and techniques that are taught in secondary and higher education schools [9]. The University of the Free State's Department of Architec-

ture in South Africa offers an entire Unit of Earth Construction (UEC), thus raising student awareness of and exposure to building with earth [10].

This was echoed in previous research that found when members of the public have seen an earth building, their perceptions and willingness to live in one are positive [11]. Researchers in Romania found that showcasing earth buildings to the public could be taken further by offering a hands-on educational approach. This was accomplished with daily workshops in earth building techniques at a music festival attended by the public [9]. Offering a collaborative earth building experience in an environment where the public is naturally at ease, and embracing creativity with entertainment, is an avenue worth exploring in a culture that celebrates the arts, such as in New Zealand.

5.3. Negative Perceptions of Earth Buildings and Their Inhabitants

Perceptions and stereotypes about earth buildings were another common thread linking past research with this study's findings. Previous research on New Zealand's cultural perceptions of earth building materials found that most of the earth building specialists believed the most significant barrier to popularity was the general public's poor perception of the earth as a building material. Earth construction was perceived as "cheaper" and "poorer" in that study. There was also the perception that living in an earth building is unsafe and not durable [11]. This also aligns with past research that found earth buildings were no longer celebrated in New Zealand due to the country's higher value on "modern" industry and infrastructure [6]. This echoes responses from participants who believed there was a perception by the public that earth buildings are "old" and "quaint". These participants also stated there was a perception that homes built with conventional materials are "stronger" and "better" and that earth buildings are "inferior", "substandard", and not "modern". Over ten years of research, it was interesting to see the same stereotypes manifesting themselves regarding who lives in earth buildings. Past research on cultural perceptions found Western attitudes on what is considered modern and progressive do not include earth buildings, and this creates a stereotype that earth buildings are for "poor people" and "hippies" [11]. Our study's participants pointed to stereotypes that earth building was also for "hippy" people who live an "alternative lifestyle". Participants stated these negative perceptions held by the public and the general construction industry.

5.4. Environmental and Health Benefits of Earth Buildings

When asked why earth buildings should be promoted for living, the top reoccurring themes were all related to benefitting the environment and health. The top reoccurring words were "environment", "non-toxic", "low-toxicity", "sustainability", "low carbon", "local", "natural", "humidity control", "climate control" and "healthy". As one participant succinctly put it, "Earth buildings are healthy to construct, to live in, and for the planet". These reasons are in accordance with previous research conducted in New Zealand that found participants would want to live in an earth building for environmental benefits, believing it is best for the environment [11]. This also backs up research findings that environmental and health reasons people build or buy earth homes [5].

5.5. The Role of New Zealand's Government Agencies

Most interview and survey participants believed New Zealand's government agencies could contribute much more to promoting earth buildings. As one participant said, "Once the government is on board, the rest of the [construction] industry will follow." Participants stated that New Zealand's government could be better informed on earth buildings and should be educated on the merits of earth building techniques. This same train of thought could be applied to perceptions on obtaining building consent as there are substantial negative perceptions on the ease of gaining consent to construct earth buildings. These opinions coincide with past findings by earth building researchers that New Zealand's council officers needed more education and resources in order to promote sustainable homes [36]. These findings also correlate with past research confirming the government's

need to encourage environmentally-friendly construction practices. Currently, the funding and upkeep of these standards are entirely left to individuals and organisations such as EBANZ [4,38]. If the government reversed its position on Standards NZ, making it again a government agency, more resources could be allocated to updating and promoting earth building standards. Research previously carried out on evaluating earth building tools found participants from Australia, India, Iran, Malaysia, the UK and the USA all believed national building codes were "integral" in promoting earth buildings because government-led guidelines could help architects and engineers design and build earth buildings which would subsequently lead to an increase in earth building projects [12].

Current research maintains that the potential benefits of government-led awareness of earth buildings are global. Researchers in Egypt found high profile projects sponsored by the government could exponentially bring attention and change public perceptions of what modern earth buildings look such as [13]. International research has also shown legitimising and creating a market for earth buildings can become a reality given government support as proven by the German National Institute of Building Techniques, funded by the German government. The Institute has made the use of earth building materials legal in the construction market [8]. Further findings from the Egyptian researcher, Sameh, show that the government could promote earth buildings by ensuring students learn about the Nubian heritage and traditional architecture [13]. The participants of our study specified a suggestion of a similar nature. This idea could easily be implemented in New Zealand with an earth building education curriculum based on Māori heritage and architecture.

5.6. Solutions

A great benefit of this research are the solutions offered by the expert participants regarding earth building awareness.

These proposed solutions are:

- Using social media, television, and magazine to build an informed audience.
- Inter-industry promotion of earth architecture by construction professionals.
- Marketing earth buildings as commercial products.
- Providing certification and training in earth building through the education sector.
- Having compulsory subjects on earth architecture in university engineering/building courses.
- Showcasing residential earth homes through architecture/heritage tours.

Participants were also vocal about the government and its role in promoting earth buildings. These more specific, government-focused solutions are:

- Creating financial incentives for developers and builders.
- Using earth building materials in state housing.
- Encouraging the development of an industry for prefabricated earth building materials.
- Educating the public to make earth buildings a realistic housing option.

6. Conclusions

This research involved interviewing subject matter experts and members of EBANZ and then analysing their responses. Identifying and evaluating the reasons for the lack of awareness of earth buildings in New Zealand and what methods could be used to promote earth buildings effectively were the aims of this research. These findings are:

1. There is little awareness of earth buildings because their construction is a niche market with poor marketing or advertising to promote them.
2. There is a lack of education and training in earth building construction.
3. Media exposure and education should be used to promote earth buildings in New Zealand.
4. Earth buildings should be promoted because of their environmental and health benefits.
5. Government agencies could be the most effective way of promoting earth buildings.

The results of this study offer a snapshot of the current perceptions and opinions of earth building subject matter experts. Subsequent research could be conducted on

what needs to be carried out to legitimise earth buildings within local councils and what types of systems could be established to streamline a pro-earth home-building consent process. Another research opportunity would be investigating government incentives for construction companies and how earth buildings could be included. Researchers could ask why are there no tax incentives for building earth homes when there are tax incentives for purchasing electric vehicles?

Future research may apply these findings to the roles and actions of the New Zealand Government and its education system in promoting earth buildings, how local councils can ease the consenting process for earth architects and builders, and the risks and benefits of developing earth construction as a commercial industry.

Regarding this study's limitations, we acknowledge that the performances of earth materials are subjected to several parameters such as the location and extraction of the source material, geographical and weather conditions of the building location, the workmanship used in the construction process, and the operation and maintenance of the finished building. In terms of the scope of the study, future researchers may want to expand their target participants to include practitioners in other industries, not just those specific to EBANZ, so as to gain a broader perspective and range of opinions regarding earth buildings.

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