GREENING OUR ROAD CONSTRUCTION: VIEWS FROM THE TRANSPORTATION INDUSTRY IN SOUTH AFRICA

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ABSTRACT

Climate change is quite possibly the biggest challenge that the global population has had to face. Each year the amount of CO_2 in the atmosphere is increasing, and we are all under increasing pressure to end this trend. Concrete production is one of the largest contributors to CO_2 emissions, and any opportunity to reduce the carbon footprint of constructions should be embraced. Within the transport environment, the building of new roads, and the erection of crash barriers alongside them, is an area of high concrete consumption, and efforts need to be taken urgently to reduce the carbon footprint of road construction in the future.

The preponderance of cement in standard crash barriers poses an opportunity for the replacement of standard cement mix with greener alternatives. Stellenbosch University recently carried out research into the technical feasibility of such mixes, with positive results. But the readiness of the transport industry in South Africa is unclear. How concerned is the industry about climate change? Is there a sense of responsibility about addressing it? Is there appetite and willingness within this industry to allow change to happen? This paper presents the results of a survey with professional engineers working in the transport field in South Africa (SA), as well as respondents from the South African National Road Agency Limited (SANRAL) and the manufacturing sectors, to help identify what the prevailing opinions are about the likelihood of green alternatives in the manufacturing of crash barriers for SA roads. The paper reflects some practical concerns raised, as well as a sense that the problem of climate change in not necessarily viewed as a priority for the industry quite yet.

1. INTRODUCTION

The transportation sector is a major contributor to greenhouse gas emissions, and as such, addressing the issue of climate change is a critical challenge. In response, the South African Department of Transport developed a Green Transport Strategy in 2018, with the aim of promoting sustainable development in the country's transport sector. The strategy seeks to develop policies and strategies to facilitate sustainable development in the transport sector towards 2050. As part of this effort, several objectives were established, including the promotion and implementation of low-carbon technology and infrastructure across all modes of transportation (Department of Transport, 2018).

The purpose of this study is to investigate the potential of using green alternatives in the manufacturing of crash barriers for South African roads, and to identify the prevailing opinions of professional engineers in the transport sector, as well as stakeholders from the South African National Road Agency Limited and the manufacturing industry. To achieve

this objective, the methodology used in this study includes a survey of professional engineers in the transport sector and stakeholders from the South African National Road Agency Limited and the manufacturing industry.

In summary, this paper aims to contribute to the promotion of sustainable development in the South African transport sector by exploring the potential for using greener alternatives in the production of crash barriers for South African roads. The study identifies the prevailing opinions of stakeholders and professional engineers and suggests that more needs to be done to promote the use of sustainable alternatives in the transport sector.

2. BACKGROUND

The transportation sector is a major contributor to global carbon emissions, making it necessary to shift towards low-carbon alternatives. The Green Transport Strategy 2018 recognizes this and emphasizes the importance of policies and strategies to encourage low-carbon technology use in all transport modes and infrastructure. However, the production of concrete, a key component of transportation infrastructure, contributes significantly to carbon emissions. Therefore, reducing the carbon footprint of road construction, particularly in the building of new roads and crash barriers, is crucial to achieving sustainable development.

Alternative materials are being explored to reduce carbon emissions in the production of cement. One area where such efforts could be effective is in the production of crash barriers for roads. Stellenbosch University recently conducted a study on the technical feasibility of using greener alternatives to standard cement mix in the production of crash barriers, with promising results. However, it is uncertain whether the South African transport industry is prepared to embrace such changes.

Despite existing policies and strategies to promote green alternatives in the transport sector, there is a lack of specific research or opinions on the use of Green concrete infrastructure for crash barriers. This paper aims to address this knowledge gap by investigating the demand for green alternatives in the manufacturing of crash barriers for roads in South Africa. The survey of civil engineers with expertise in South Africa's transport industry aims to identify the potential for investment in the proposed new barrier and whether there is an appetite for this product.

By investigating the demand for green alternatives in the manufacturing of crash barriers for roads, this study aims to provide insights into the feasibility of greener alternatives in the transportation sector, which can have significant implications for achieving carbon reduction targets.

3. LITERATURE REVIEW

The transportation sector contributes significantly to CO_2 emissions and hence to global warming – in fact, the International Energy Agency reports that Transport has the highest reliance on fossil fuels of any sector and accounted for 37% of CO_2 emissions from end-use sectors in 2021 (International Energy Agency, 2019). While the majority of these emissions clearly originate from the vehicles within the system, the road infrastructure itself generates CO_2 both during the process of manufacturing of the cement (which is a key component in the construction of road pavements and barriers) and also during construction of pavements and roads infrastructure such as crash barriers. Loijos, Santero, and Ochsendorf investigated GHG emissions from roads in the United States and

discovered that cement production was the major sources of emissions. They note: “The majority of emissions occur during materials production, transportation, and end of life, constituting between 64% and 80% on all roads. Cement production has the largest single life-cycle GHG contribution on all roads: rom 43% on urban interstates to 56% on rural local roads” (Loijos, Santero & Ochsendorf, 2013,82)

Internationally, research has shown that the use of alternative materials in the production of cement, such as fly ash, slag, or silica fume, can reduce the carbon footprint of cement production. Furthermore, innovative approaches including the use of recycled materials and energy-efficient building practices, can help to reduce the overall impact of Portland cement on the environment.

For many countries, green building technologies are seen as not only necessary, but desirable. Within building design, a new focus has emerged to address the increasing energy consumption and carbon emissions in response to climate change (Bianchini & Hewage, 2012; Pacheco, Ordóñez & Martínez, 2012; Zuo & Zhao, 2014; He *et al.*, 2018). The road construction industry has been caught up, too, in the drive for greener roads, and countries in both the developed and developing world are experimenting with the incorporation of non-traditional and recycled materials in pavement construction and barrier designs (Rushendrareddy, Surendra & Rahul, 2017; Limantara *et al.*, 2019; Djalante, Oneyama & Arsyad, 2020).

In theory, South Africa stands alongside most other nations in its commitment to reducing carbon emissions. In 2009, SA pledged to reduce its carbon emissions by 34% before 2020. Six years later, in 2015, SA signed the Paris Agreement - an international treaty which focuses on combatting climate change by reducing emissions and thus limiting the rate at which the global temperatures increase. SA has also formally agreed to the principles stated in the United Nations Framework Convention on Climate Change (UNFCCC).

There are numerous policies that the Transport sector of South Africa has created or committed to adhering to in the future. Two of the main policies are the White Paper on Climate Change Response Policy (South Africa Department of Environmental Affairs, 2001) and the National Development Plan (National planning commission (NPC), 2012). These policies and plans are overarching and encompass all of South Africa's emissions, including the Transport sector. The main focus of the Transport sector would be to use Greener fuel alternatives, develop the public transport networks and create safe spaces to ensure the safety of pedestrians and cyclists.

4. PROJECT SCOPE

4.1 Objective

The objective of the study was to determine if there is a demand for a Green concrete barrier from the perspective of South Africa’s transport sector. Although the transport sectors policies and strategies align with the promotion of green alternatives, no specific research or opinions were found on Green concrete infrastructure. Therefore, civil engineers with expertise in South Africa’s transport industry were consulted to determine the demand for this product.

The knowledge obtained from surveys was important to help establish whether there is potentially an appetite for the proposed new barrier in the road transport industry, how the

proposed barrier could be improved and if this is a product the transport industry would invest in. The survey captured the engineers' personal opinions only and did not refer to the policies and practices of specific transportation authorities.

4.2 Sample Specifications

Although engineers from across South Africa were asked to participate in the study, the participants who responded to the invitation were predominantly based in the Western Cape, with some individuals from KwaZulu-Natal and Gauteng. Ultimately, 28 civil engineers participated in the study. The participants' ages ranged from 24 to 69 years, and all the participants have at least obtained a Bachelor's or BTech degree in Civil Engineering.

The sample of 28 civil engineers who participated in the study may be deemed statistically sufficient to gather preliminary data and insights, which can be used to guide further research. the 28 engineers surveyed were chosen randomly and are representative of the broader population of transport engineers in South Africa, therefore the results may be generalizable to the larger population. Additionally, opinions were also gauged from representatives of SANRAL and the barrier manufacturing sector. Therefore, despite the relatively small sample size, the study may be considered adequate for the exploratory purpose of the study.

4.3 Data Collection Tool

An online survey was created for the collection of data. This contained questions relating to the opinions that respondents had about the value and viability of increasing Green concrete as an alternative material in South Africa. The survey included two demographic based questions, so that the age/region/experience of the respondent could be accounted for, but was otherwise confidential (no personal information was collected). There were nine subsequent questions, two multiple choice and seven open-ended. Ethics permission as given by Stellenbosch University, and all respondents were informed that their participation as voluntary, and they were able to leave out questions should they choose to.

5. DATA AND ANALYSIS

5.1 Participants' Opinions on Green concrete Products

The participants predominantly have positive opinions regarding Green concrete and sustainable alternatives, as seen in Figure 1.

89% (n=25) of participants support the implementation of Green concrete products and switching to only using Green concrete alternatives. The products were deemed to be more environmentally conscious and promote sustainable development. This group of participants believed the implementation of Green concrete is an important step in the direction of sustainability. However, 4% (n=1) of the participants, as well as the representative of the manufacturing sector questioned the cost and quality of the concrete, and support the switch to Green concrete products only if the quality can be assured to be the same as standard concrete, and if the cost would not be excessively more than the cost of producing standard concrete. Some participants also questioned the ease with which the Green concrete can be produced, or whether special expertise would be required. One participant mentioned that the current civil engineering environment is

primarily based on profit, with the focus being placed on the most reliable products with the lowest prices. This respondent believed that the only benefit of using Green concrete would be if it were to provide the barrier producers with a competitive advantage.

Lastly, 7% (n=2) of the participants were not familiar with Green concrete and had a neutral opinion.

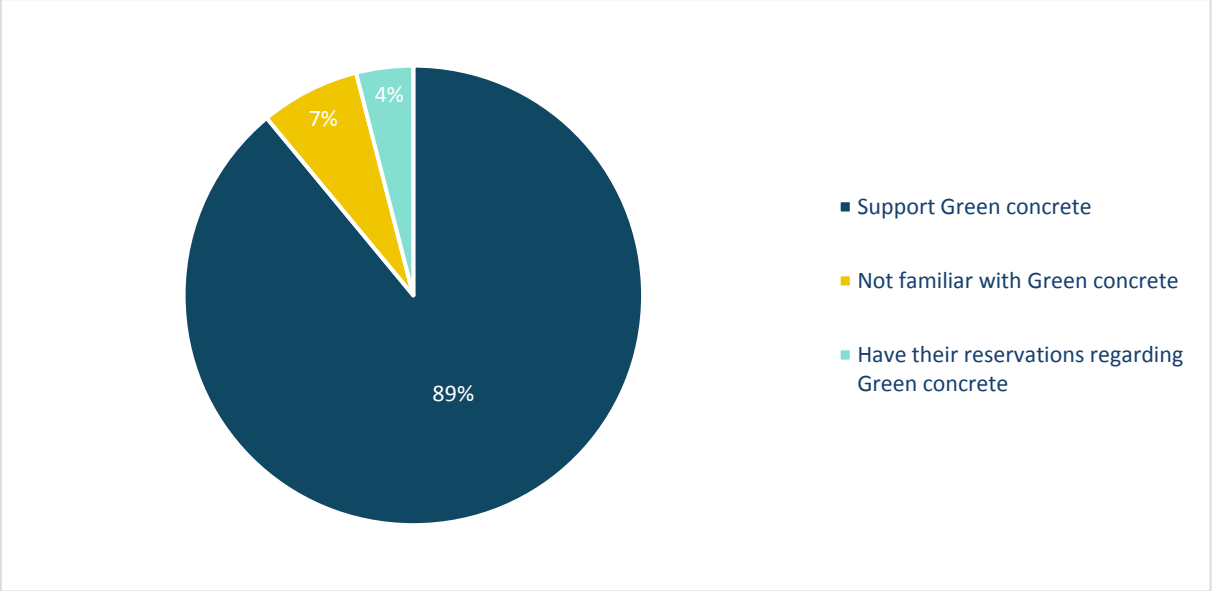

Figure 1: The participants' opinions on Green concrete

5.2 Road Restraint Barriers in South Africa

The participants were asked if precast concrete barriers are commonly used as median/roadside barriers on South Africa's roads. The results of the findings are shown in Figure 2.

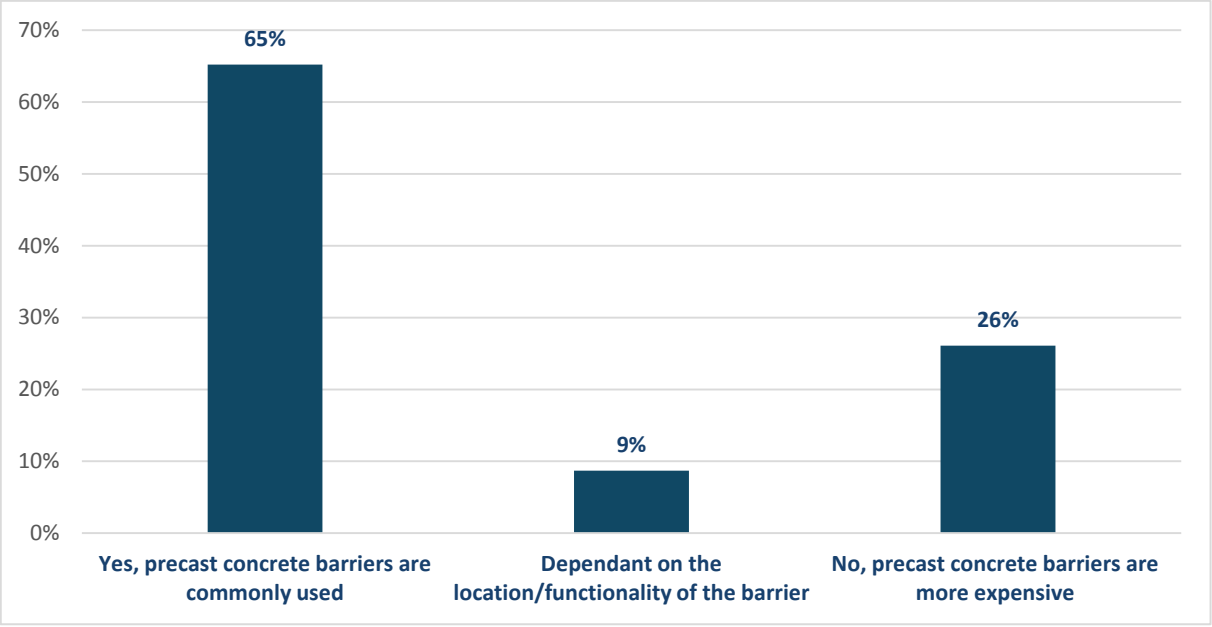

Figure 2: Precast concrete barriers on South Africa's roads

Precast concrete barriers were deemed a trusted and strong road restraint barrier alternative. These barriers are built on either side of the road, or used as median barriers. The participants saw concrete barriers as an effective tool to implement on high-speed roads, bridges, freeways and where larger vehicles travel.

In South Africa, the precast concrete restraint systems and metal guardrails are the two standard road restraint systems according to the participants. Although the metal guardrails are useful and absorb more impact energy, these barriers get damaged easily and therefore are more expensive to maintain over time. Consequently, 65% (n=15) of the participants believed concrete barriers are commonly used, especially for more permanent solutions on the National roads. One participant mentioned that the maintenance on South African roads is below the standards on many other countries. This respondent felt that providing a barrier that requires less maintenance and upkeep would thus be beneficial. The same participant believed the risk of delays and crashes is expected to increase when maintenance vehicles work on roads to replace or fix the damaged metal guardrails.

Interestingly, 26% (n=6) of the participants commented the capital cost to implement steel guardrails is less than that of concrete barriers. Of course, it could be argued that the costs level out over time due to the maintenance costs of the steel guardrails, but the opinions of the participants were that the concrete barriers are more expensive and therefore used more sparingly or only if a high containment level is needed. This also led the participants to believe that the cheaper alternatives available would be chosen over the concrete barriers since the initial cost is the main consideration.

5.3 The Green Transport Strategy 2050

The opinions of the participants were gauged on whether Green concrete barriers could be incorporated into, and promoted due to, the Green Transport Strategy 2050. The results of the findings are shown in Figure 3.

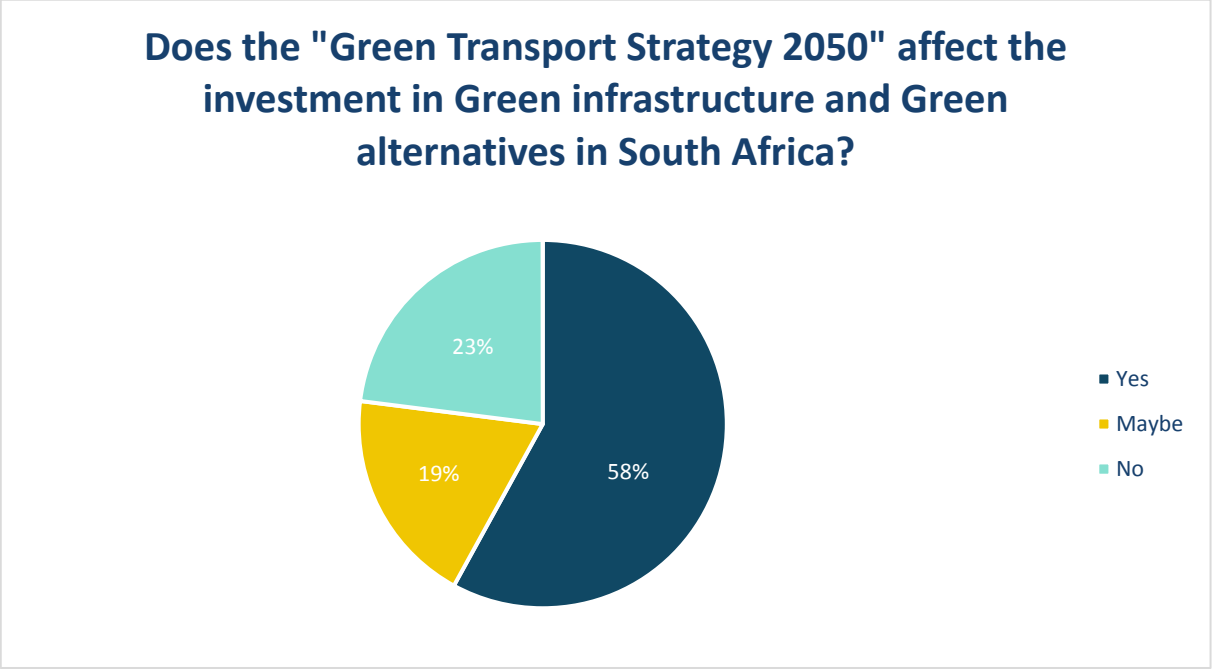

Figure 3: Effect of the "Green Transport Strategy 2050" on the investment in Green Infrastructure

More than half of the sample (58%, n=16) said the Green Transport Strategy would encourage stakeholders to promote and implement green infrastructure, such as the Green concrete barrier, in the Transport sector of South Africa. However, 23% (n=6) of the participants believed the promotion and implementation of the barrier would not be affected by the strategy. These participants were generally of the view that South Africa has a poor history of complying with and achieving the goals that were set. The strategy and components of the strategy are deemed excellent in theory, but the actual implementation is problematic. These six participants suggested that the effectiveness of government institutions in promoting and implementing the change needs to be driven by a change in their mindset. Furthermore, 19% (n=5) of the participants were unsure if the strategy would have an effect. One participant suggested that effectiveness would require a marketing strategy of the product in order to encourage the main government stakeholders to invest in the product.

The participants were asked to provide their opinions on the type of green development they believed the Transport sector of South Africa should focus on. The distribution of the participants' responses is shown in Figure 4.

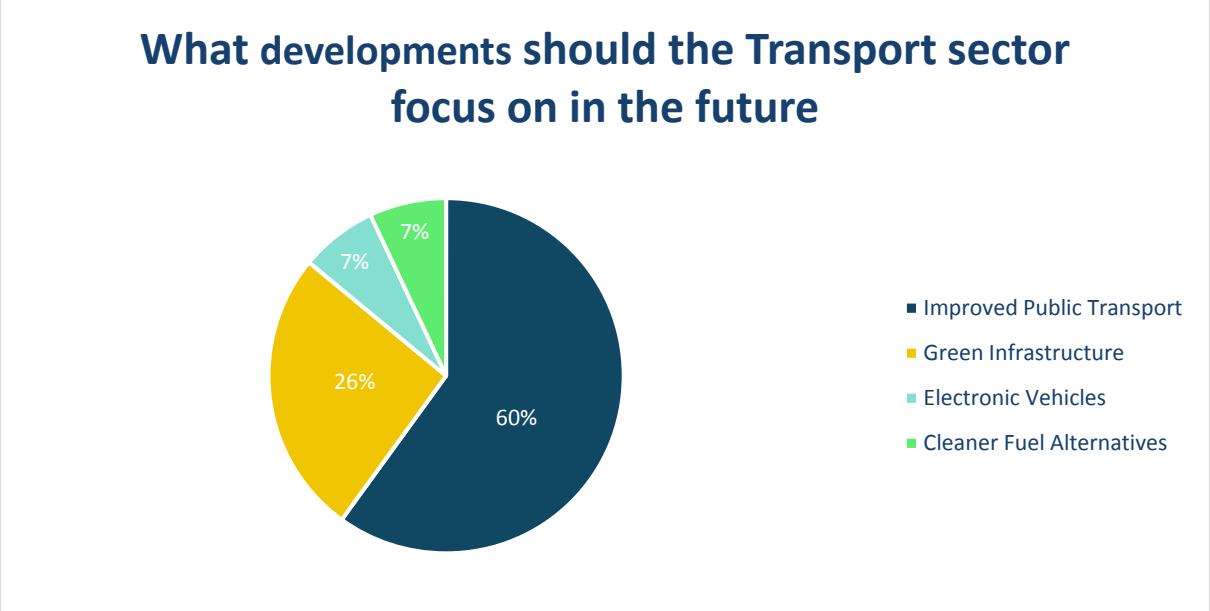

Figure 4: Developments the transport sector should focus on

60% (n=17) of the participants believed that the transport sector should first focus on the improvement of the public transport network in South Africa. The participants voiced the opinion that this would indirectly reduce the carbon emissions of the Transport sector, since the number of private vehicles on the road can be reduced if more individuals would be willing to shift toward public transport alternatives. However, the participants mentioned that this would only be possible if the public transport alternatives are safe and efficient.

26% (n=7) of the participants believed greener infrastructure, including the Green concrete barrier, should be developed and implemented to ensure a sustainable future. The participants said that the implementation of the Green concrete barrier is an efficient way to promote sustainable alternatives without requiring extensive capital investment.

Electronic vehicles and cleaner fuel alternatives had the lowest number of votes at 7% (n=2). The participants said since South Africa is still a third-world country, the improvement of the public transport network is the main goal that needs to be focused on

whilst South Africa should not focus on electric vehicles and the infrastructure that needs to be implemented with this technology. Furthermore, given the current state of the power supplier in South Africa, electric vehicles were deemed an unrealistic goal.

5.4 Implementation of the Green concrete Barrier

The participants were asked if the Green concrete barrier should be actively implemented and whether they believed that the Transport sector would implement Green concrete barriers in the future. The consensus of the participants was that the implementation of the Green concrete barrier is advantageous and that it should in theory be considered. They believe it would be a good alternative to the standard barrier and fully support the implementation, on the condition that the barrier has a similar price to produce as the standard barriers, with the quality of the barrier not being compromised. One of the participants suggested that the cost should be less than 110% of the current barrier cost to be feasible.

The participants were asked if they believed the transport sector would implement the barrier. The results of this question are shown in Figure 5.

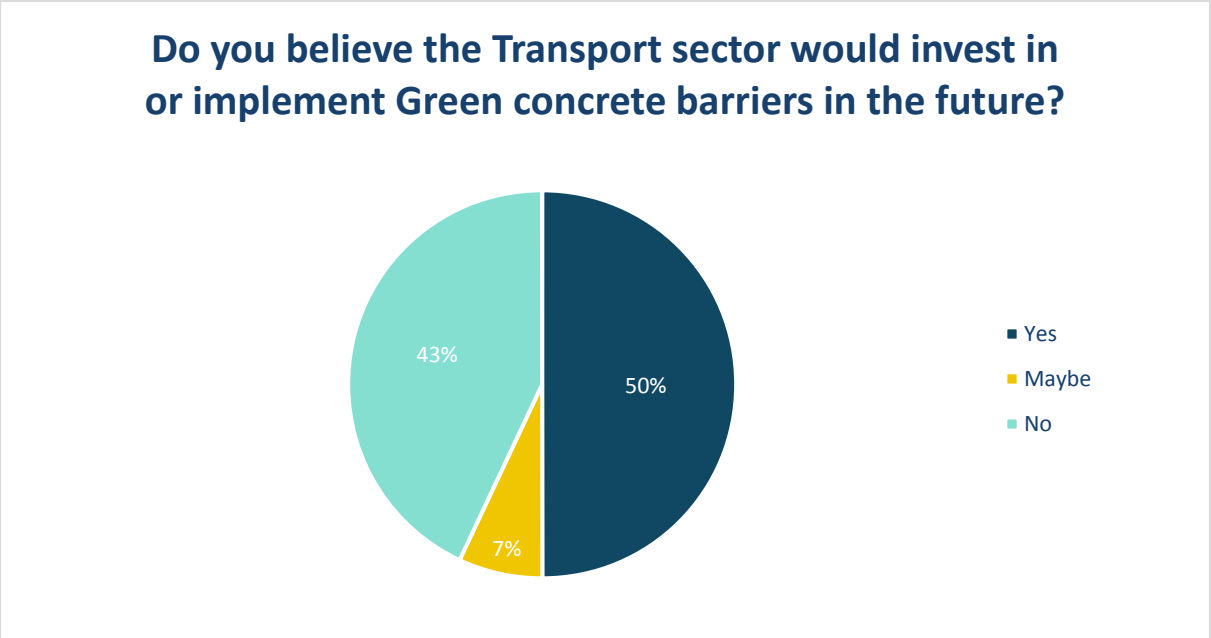

Figure 5: Investment in the Green concrete barrier

Half of the participants (50%, n=14) believed the transport sector would invest in the Green concrete barrier. These participants believed the authorities would implement the barrier due to the environmental benefits the barrier has with it having a smaller a carbon footprint. If the barrier is more cost-effective than the standard barrier, that would further incentivise the government to implement the barrier. The participants noted some challenges with the implementation of the barrier, stating that the implementation would take time due to the guidelines and further tests that need to be conducted before it could be implemented.

However, 43% (n=12) of the participants did not believe that the higher authorities would implement the barrier. They felt that strict guidelines need to be followed since the SOEs

often procure according to an approved list of suppliers that offer approved products. They believed that if there is no approved Green concrete product, it will simply not be considered.

The remaining 7% (n=2) of the participants were unsure about whether the transport sector would implement the barrier. They mentioned the concrete barriers need to comply with all the 'red tape' and also be priced similarly to (or less than) the standard barrier. Furthermore, they stated that transport authorities prioritize costs over the possible sustainable benefits the barrier could provide since the transport sector is in a financial crisis. They also believed the private sector would need to play a role in the accreditation and implementation of the barrier for it to be feasible.

The age group of the participants were then compared with the responses given in Figure 6 to see if the age of the respondent had any bearing on their answer. The sample size consists of 19 engineers aged younger than 30 years, and 9 engineers older than 30. This distribution is shown in Figure 6.

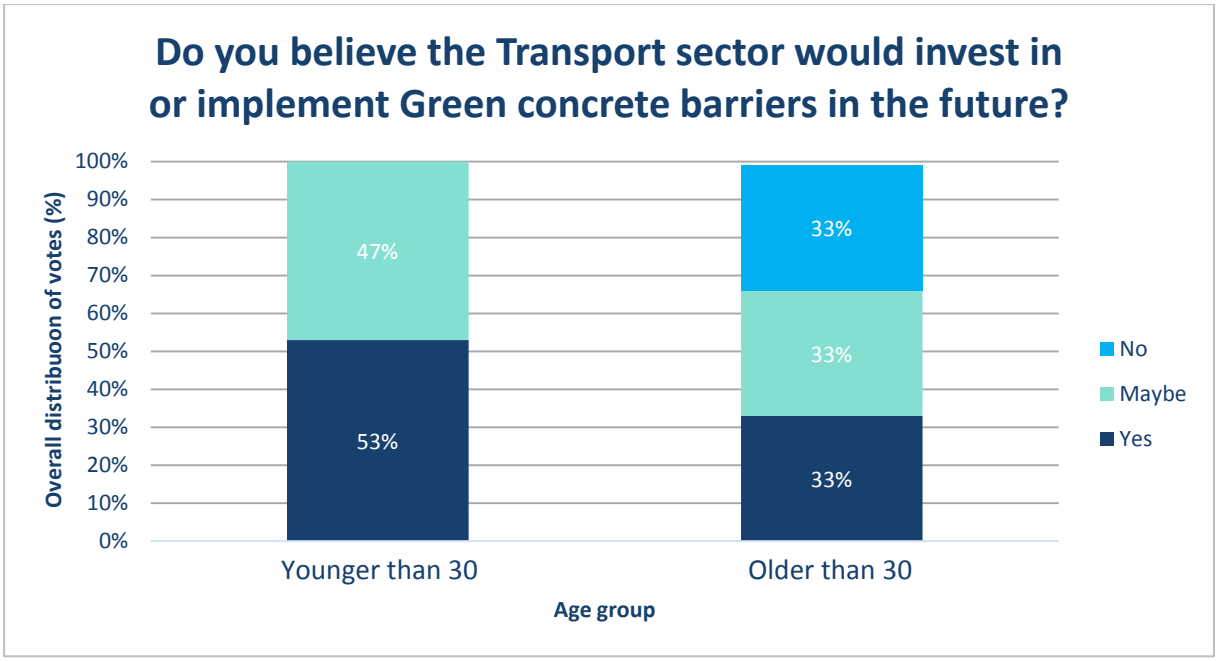

Figure 6: Overall distribution of votes for each age group

The distribution shows that the older age group are more skeptical of the implementation of the Green concrete barrier than those in the younger age group. Less than half (33%, n=3) of the older age group believe the transport sector would invest and implement the Green concrete barrier, with 33% (n=3) of the participants unsure and the remaining 33% (n=3) not believing it is something the transport sector would invest in. The distribution of the younger age group shows that they are more optimistic, with 53% (n=10) of the participants believing the barrier would be implemented, and the other 47% (n=9) being unsure. Figure 6 and the survey responses indicate that the engineers who have been in the industry longer are less optimistic about the transport authorities implementing green barriers than younger engineers. The reasons for this are unclear.

5.5 Challenges of Implementation in South Africa

The opinions of the participants on the challenges of implementing the barrier in South Africa are presented in Figure 7.

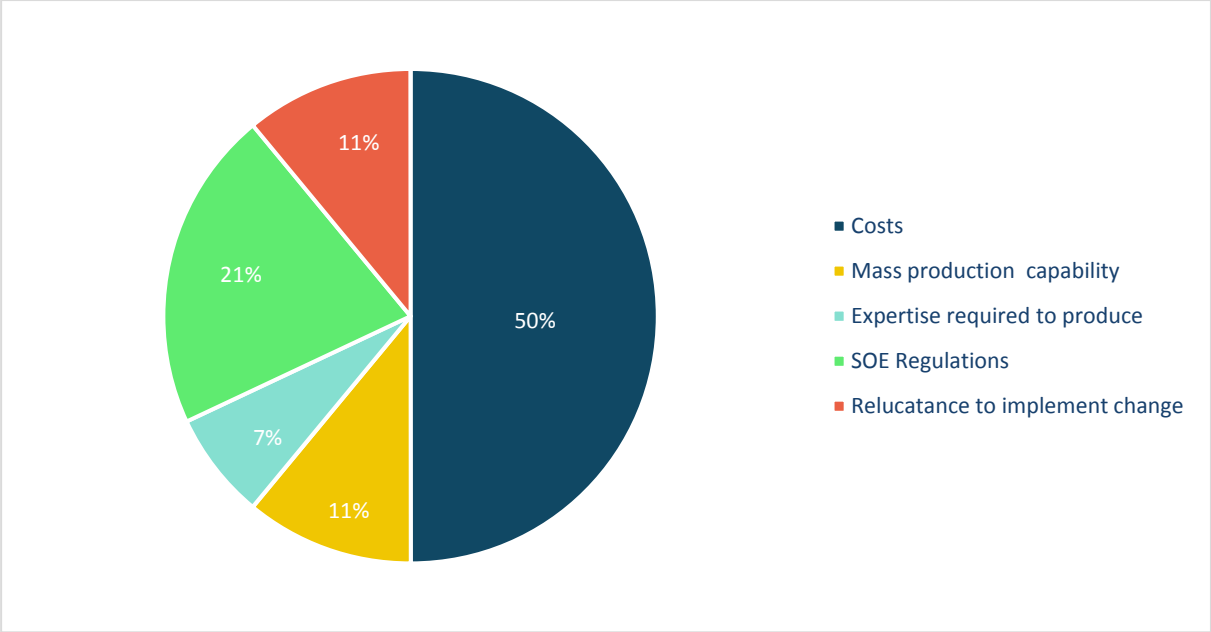

Figure 7: Implementation challenges for the Green concrete barrier

The main challenge for the implementation of the barrier was considered to be the cost of the barrier, as 50% (n=14) of the participants mentioned this obstacle. The participants immediately assumed that a greener alternative would come at a cost or be more expensive to produce. They argued that if the barrier was not cost-effective and significantly more expensive (more than 110%) than the cost of a standard barrier, it would be difficult to justify the implementation of the barrier. The SANRAL representative stated that although cement is one of the main costs and has the highest environmental impact, other factors have been major issues with the production and placement of the barriers. The extensive delay costs to store, move and place the barriers is also a massive issue that they are facing. These delay costs add up and become significant throughout a project.

21% (n=6) of the participants mentioned the regulations and attitudes of the SOEs toward innovative solutions which could hinder the implementation of the barrier. Some other concerns, both at 11% (n=3), was the additional production facilities required to produce the Green concrete barriers, which may influence the cost of production as well as the reluctance of authorities to implement and promote change to a tried and tested practice. The representative from the barrier manufacturing sector commented on the training, supervision and manufacturing time needed for the green barrier. If the barrier requires additional equipment or expertise to produce it would also discourage the implementation of the barrier as 7% (n=2) of the participants and the representative mentioned. If the process to produce Green concrete requires additional training and supervision this would be a challenge to overcome. Additionally, the time to produce the barrier needs to be similar to the production of standard barriers to be feasible.

Subsequently, the majority of the participants (77%, n=21) believed that the implementation of this barrier in other countries would be more successful than in South Africa. Figure 8 illustrates this sentiment.

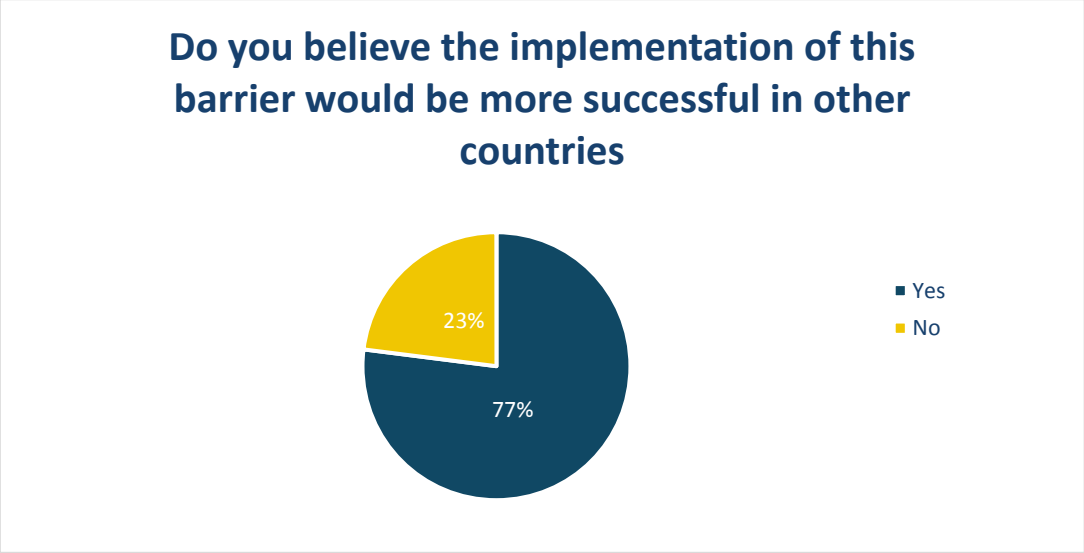

Figure 8: Implementation of Green concrete barriers in other countries

These participants believed that other countries have a greater budget to implement the barrier. Countries of the developed world are also believed to be more concerned with the promotion of environmentally friendly alternatives and focused on sustainable development. It was also suggested that the recycled waste aggregate concrete would also be more effective in countries with a shortage of fine aggregates, which is in abundance in South Africa. It was also mentioned that the roads themselves are made of concrete in countries like the United States of America, and with further testing, the Green concrete could be used to construct more sustainable roads.

6. CONCLUSION

The survey of transport engineers elicited the general opinions of the participants about the future of Green concrete in SA. Almost without exception, the participants supported the implementation of Green concrete products. The products were deemed to be more environmentally friendly and promoted sustainable development. However, when asked what the most immediate development goal in the Transport Industry of South Arica should be, 17 of the 28 respondents believed the improvement of the public transport network was a more pressing concern.

Of course, the two developments are not necessarily mutually exclusive but there is a sense that moving resources into Green concrete development may be at the expense of resources for Public Transport.

The main challenge of implementing the barrier was considered to be the cost of the production of the barrier. The participants argued that if the barrier was not cost-effective and was significantly more expensive (more than 110%) than the cost of a standard barrier, it would be difficult to justify the implementation of the barrier. The cost issue is of course logical to those involved in the Transport industry already, but the common worry about costs that was raised (14 of the 28 respondents) suggests that there may be some level of unfamiliarly with the processes of Green concrete manufacturing, meaning that it is conceived of as more expensive that it actually is.

Although the improvement of the public transport system is the primary sustainable goal of the transport sector, the implementation of greener infrastructure such as the Green

concrete barrier is arguably a cheap and effective method to encourage sustainable development. The Green concrete barrier could also be the initial step required to develop other green infrastructure in the transport industry. Pedestrian bridges, bridges, and railway infrastructure could be produced with Green concrete to save costs and provide an environmentally friendly alternative. Furthermore, in countries like the United States, the roads are constructed from concrete. If additional tests are completed to determine the durability of the Green concrete under road surface conditions, the Green concrete could replace the current road surfaces.

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