

Concrete crack repair with polymer modified mortars: The status quo in the South African construction industry and the way forward.

Jannes Bester^{1,a*} and Deon Kruger^{2,b}

¹Faculty of Engineering and the Built Environment, Department of Civil Engineering Science, University of Johannesburg, South Africa

²Faculty of Engineering and the Built Environment, Department of Civil Engineering Science, University of Johannesburg, South Africa

^ajannesb@uj.ac.za, ^bdkruger@uj.ac.za

Keywords: concrete patch repair; training; repair material

Abstract. In recent years, concrete repair has become an integral part of the construction industry. With the vast quantity of concrete used in the South African construction industry over the past 100 years, one can expect an increase in repair and rehabilitation requirements during the extended lifecycle of exposed concrete structures. Crack repair, re-profiling of spalled areas and surface sealing with polymer related materials forms the bulk of such repair and rehabilitation operations. Due to the complexity of these projects and the variety of professionals and other stakeholders involved from the diagnostics to the implementation phase (specialists consultants, contractors, suppliers and owners of the structures), considerable problems seem to have surfaced to ensure cost-effective but sustainable and durable outcomes. It has been found that in many concrete repair projects, the responsibility for the repair work, adequate quality control and the assessment of successful patch repairs are not fully embraced by the various stakeholders.

This concern has led to the research as reported in this paper. The research entailed a series of questionnaires drawn up specifically for the four different stakeholder sectors of the concrete repair industry. The results indicate that, although there is agreement that concrete repair is a highly specialized field, there is not enough training in the correct use of the repair materials, nor enough knowledge regarding the diagnostics or material specification and selection processes. Knowledge on polymer modified mortar is also minimal. These problems are compounded by inadequate quality control and lack of ongoing monitoring of patch repair failure. The paper concludes with suggestions on the way forward.

Introduction

One of the requirements for a successful concrete patch repair is the selection of the correct repair material. This is based on many factors, some of which are construction, load-carrying capability and durability related. What makes the correct material selection even more difficult, is that the material suppliers use different tests and test criteria to determine their respective repair materials' properties [1]. In addition to proper materials selection, it is imperative that the root cause of the failure is known, fully understood, and addressed, before a repair strategy is decided upon [2,3]. In 2006, the U.S. Corps of Engineers found that 50% of the repairs that they performed to their structures can be classified as successful, 25% as fair or poor, and 25% as failed [4]. The complexity of the problem means that the repair of concrete structures are more difficult and

complex that what the design and construction of new structures are [5]. Although non-destructive testing (NDT) work well under laboratory conditions, the success of NDT on real structures depends on the experience of the assessor [6]. Figure 1 illustrates two scenarios of a structure. Line A indicates a structure that has been constructed well which does not need rehabilitation during its service life. Line B indicates a structure where there were poor construction practices which led to earlier and unplanned requirements for repair. As stated above, the U.S. Army Corps of Engineers found that only 50% of repairs of its structures can be rated as being good. The other 50% is fair or poor. This leads to a high probability that Line B in Figure 1 will have more than one unplanned rehabilitations, with serious financial consequences.

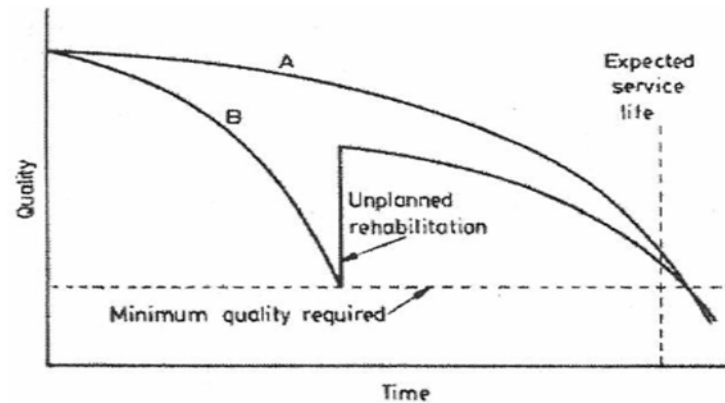


Figure 1: Two scenarios of the deterioration and rehabilitation of a structure. [7]

Research methodology

This research project made use of four different questionnaires, each one designed specifically for a different stakeholder within the concrete repair industry. The four different stakeholders are clients, consultants, applicators and suppliers of the repair materials.

All four questionnaires were designed under the supervision of STATCON, a statistical consulting service department within the University of Johannesburg. Having these professionals assist in the design of the four different questionnaires was to ensure that the wording of the questions, as well as the possible answers that were provided to the respondents would not lead the respondent in any way in order to ensure unbiased answers from the respondents.

Although much more information was gathered from these questionnaires than what is presented in this paper, the goal of the section of the four questionnaires presented in this paper was to gather more information regarding the overall quality management of polymer-modified concrete patch repairs in the South African context. The seven questions which were asked to achieve this goal were:

QUESTION 1: Do you believe that concrete repair is a specialist area?

QUESTION 2: How often is the concrete integrity checked? Once every.....year?

QUESTION 3: What tests do you perform (or have performed) to determine the condition of the concrete structure?

QUESTION 4: Please indicate your highest tertiary qualification.

QUESTION 5: To which professional association do you belong?

QUESTION 6: How often is the integrity of the concrete crack repairs checked?

QUESTION 7: What tests do you perform (or are performed) to determine the condition of the concrete crack repairs?

Results and Analysis of Results

Table 1 indicates the response rate to the questionnaire for each of the four different sectors. Clients had a very low response rate, but the other three sectors had acceptable response rates. As mentioned above, the questionnaires were set up in such a way that they do not lead individuals in any way, however, it must be noted that the authors are still totally dependent on the honesty of the individuals answering the questionnaires, which is a disadvantage when using questionnaires in gathering information.

Table 1: The response rates to the questionnaires of the four different sectors in concrete patch repair.

	Consultants	Contractors	Clients	Suppliers of repairs materials
Contacted	102	119	130	152
Replied	37	30	16	34
Response rate (%)	36	25	12	22

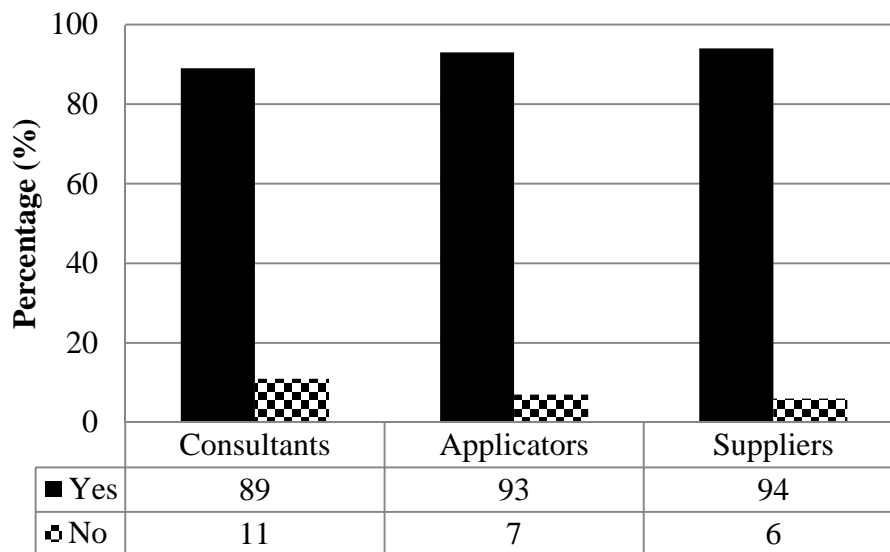


Figure 2: Sectors believing concrete repair is a specialist area. (Question 1)

Figure 2 is based on the results obtained from Question 1 and indicates that most of the respondents of the stakeholders representing the consultants, applicators as well as the suppliers, believe that concrete repair is a specialised area. Based on the agreement of all stakeholders that this is a specialist are, it can be deduced that the technical staff of consultants’ staff involved in the diagnostics, design of concrete patch repairs and also in the specifying of repair materials should be well-trained as specialists. In addition, the applicators’ staff that perform the work and install such repair materials should be well trained and experienced to apply the polymer mortar-repair systems correctly. It is also clear that the suppliers of polymer-modified patch repair material should be highly skilled in order to assist both the consultant and applicator with specialist advice.

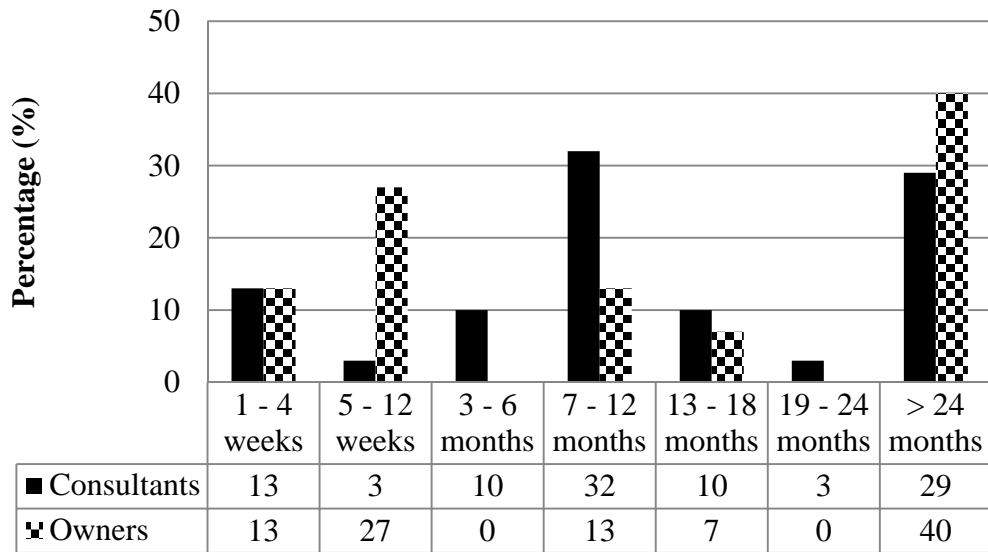


Figure 3: How often is the concrete integrity checked? (Question 2)

Figure 3 summarizes the results obtained from Question 2 which determined whether consultants and structure owners performs regular inspections on their structures. The results indicate that owners of concrete structures have a varied inspection and hence maintenance program. About 40% of structure owners inspect and evaluate their concrete structures only every two years or even at longer intervals. Figure 3 also shows that very few consultants monitor concrete structures past two years. This could lead to the concrete in structures degrading and in need of repair without the owner or his consultant being aware of such degradation until it is too late for minor repairs.

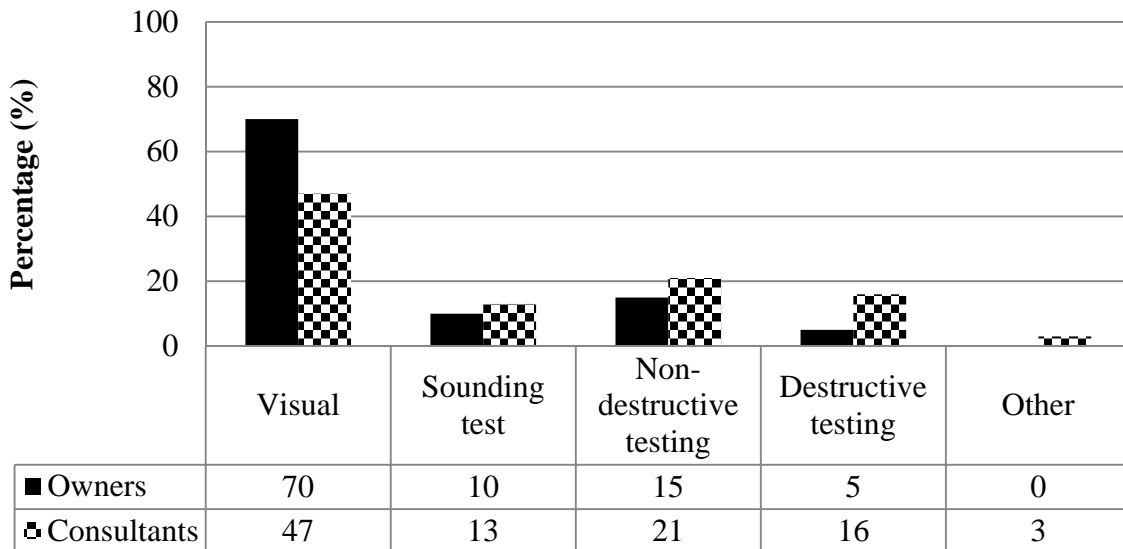


Figure 4: What tests do you perform (or have performed) to determine the condition of the concrete structure? (Question 3)

Based on the results from Question 4, Figure 4 indicates the various non-destructive tests that owners of structures use to determine the condition of a concrete structure. The majority of owners use only visual assessment methods to determine the condition of the concrete. This method relies on the physical exposure of degradation effects and may lead to concrete being degraded to

such an extent that concrete patch repair is inevitable. If the results shown in Figure 3 are combined with the results shown in Figure 4, it can be deduced that owners of structures have inadequate and poor inspection/maintenance programs in place. Because of this, timeous identification of degrading concrete is difficult and preventative maintenance is inefficient.

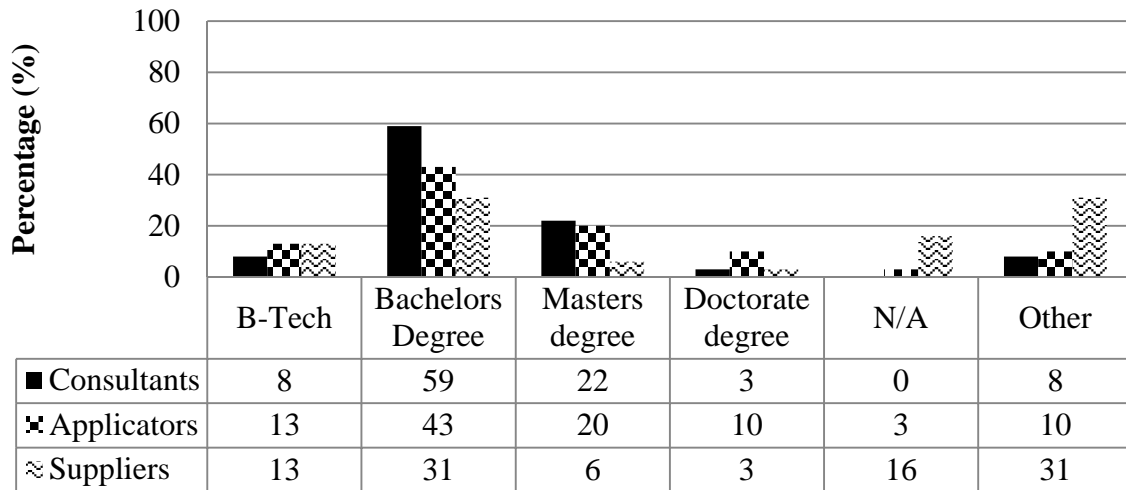


Figure 5: Highest tertiary qualification. (Question 4)

Considering the specialist nature of concrete repair, education and training of all stakeholders is crucial. Question 4 investigated the level of tertiary education amongst the decision making staff at the various stakeholders. The results as shown in Figure 5 indicate that 92% of the consultant respondents have tertiary education, 87% of applicator respondents and 53% of supplier respondents are trained at tertiary level. These results indicate a fair to good level of well-trained senior staff amongst the stakeholders, however, the training and education level amongst wage-earning staff especially at applicator level is a concern.

Another indicator of specialist or professional stakeholders is their association or membership with professional societies. Question 5 investigated this scenario and the results are shown in Figure 6.

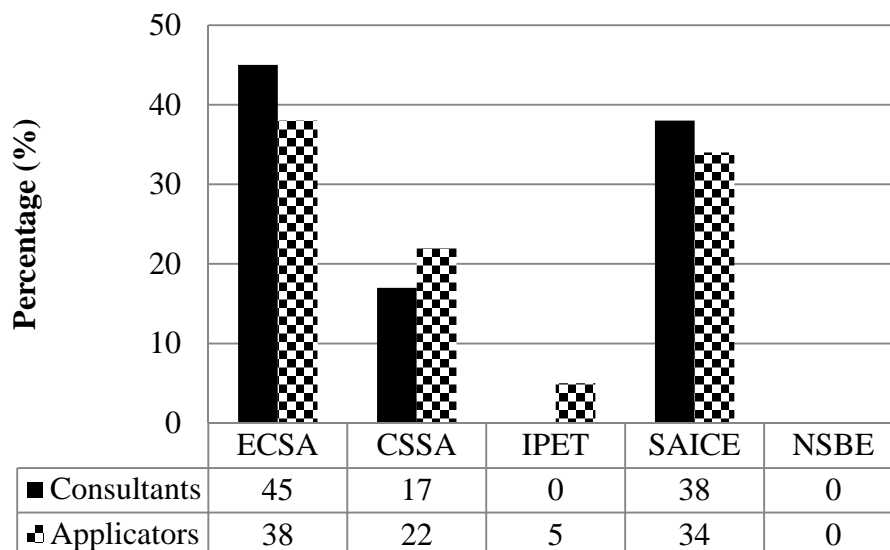


Figure 6: Professional association membership. (Question 5)

Figure 6 shows the membership of the some of the applicable professional associations such as the Engineering Council of South Africa (ECSA), the South Africa Institute for Civil Engineering (SAICE), the Concrete Society of Southern Africa (CSSA) and more. Only 45% of the consultants and 38% of the applicators are members of ECSA. Only 38% of consultants and 34% of applicators are members of SAICE while a low number of both stakeholders are members of CSSA which is the most appropriate association to be part of as specialist concrete consultant or applicator. This indicates that although the respondents describe the concrete repair field as a specialist area, these respondents are reluctant to join professional associations which would normally benefit them by providing continuous professional development to enhance their specialist knowledge base.

The last two questions in the survey focussed on the monitoring of completed concrete repair projects. Just as it is very important to correctly diagnose, specify and apply polymer concrete patch repair methods, is it also crucial to monitor the performance of such repairs over an extended period of time. This is essential to build up a knowledge base and also to ensure a sustainable long-term repair.

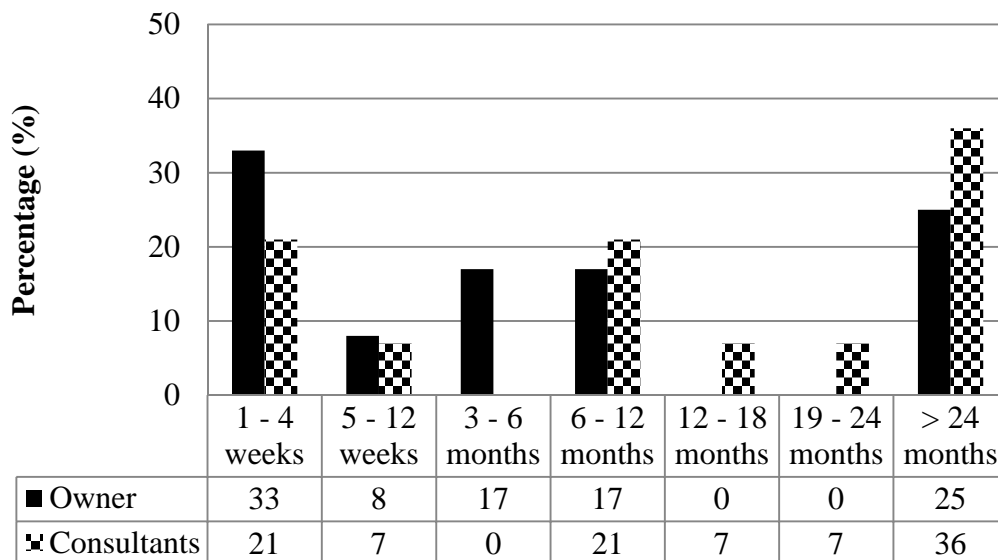


Figure 7: How often is the integrity of the concrete crack repairs checked? (Question 6)

From Question 6 and as can be seen in Figure 7, there is a wide timeline associated with the monitoring of concrete crack repairs. Only 25% of owners of structures monitor completed concrete patch repairs for at least two years after the repairs. Consultant respondents provided a slightly better picture in that about 36% of consultant's report monitoring periods of over two years. However, for both respondent groups, the indication is clear that minimal long-term monitoring is the norm. This will lead to defective patch repairs not being discovered nor will it be monitored to determine further degradation. This will obviously lead to premature failures. Based on this, it can be concluded that there is not adequate post-project quality control and assessment practices in place and hence it is concluded that post-project assessment is not fully embraced by the various stakeholders.

The final question investigated the monitoring methods used by the stakeholders to perform post-project monitoring.

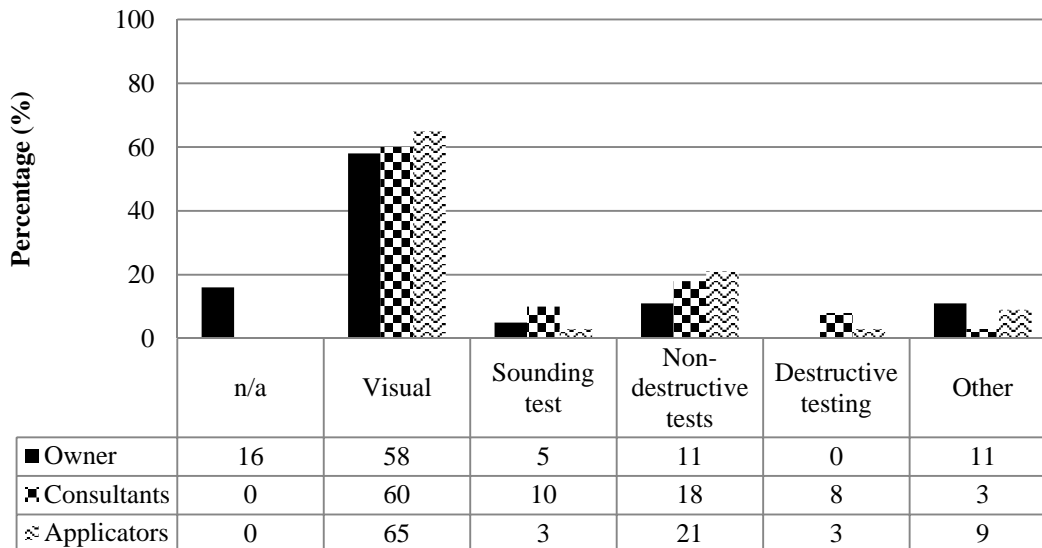


Figure 8: What tests do you perform (or are performed) to determine the condition of the concrete crack repairs? (Question 7)

Figure 8 presents the results of Question 7 and shows that the bulk structures owners, consultants and applicators only use visual assessment as a methodology to evaluate the condition of the completed concrete crack repair over a period of time. The use of sounding and other non-destructive test methods are rather low. This could lead to defective patch repairs not being discovered by the assessment or maintenance team as visual assessment may not reveal defects, such as delamination, which has a negative effect on the quality of the patch repairs. This lack of proper monitoring of concrete patch repairs could be very costly over time as it would lead to secondary repair of completed repaired concrete, as well as further concrete degradation of the repaired concrete. When the results of Figure 7 and 8 are combined, it can be concluded that there is an unacceptable level of assessment and monitoring of concrete patch repairs. In addition, the use of the more conclusive non-destructive tests is minimal.

Conclusions

The results described above indicate that, although there is agreement that concrete repair is a highly specialized field, there is not enough training in the correct use of the repair materials, nor enough knowledge regarding diagnostics or material specification and selection. Specialist knowledge on and the nature and properties of polymer modified mortar are also debatable. These problems are compounded by inadequate quality control and lack of ongoing and proper assessment and monitoring of completed patch repairs.

The way forward is that the need for further training and education of all stakeholders from management level to worker level must be addressed, proper monitoring programs need to be implemented by owners of structures and their consultants to ensure that concrete patch repairs are properly monitored for premature failures to ensure durability and sustainability.

References

[1] D.W. Fowler, Repair materials for concrete structures, in: N. Delatte (Ed.), Failure, distress and repair of concrete structures, Woodhead Publishing Limited, Cambridge, 2009, pp. 194 – 207.

- [2] M. G. Grantham, Understanding defects, testing and inspection, in: M.G. Grantham (Ed.), Concrete Repair A practical guide, Taylor & Francis, Oxon, 2011, pp. 1 – 55.
- [3] A.F. Baker, Structural investigations, in: G. Mays (Ed.), Durability of concrete structures Investigation, repair, protection, E & FN Spon, London, 1992, pp. 37 – 81.
- [4] G.P. Tilly, Durability of concrete structures, in: M.G. Grantham (Ed.), Concrete Repair A practical guide, Taylor & Francis, Oxon, 2011, pp. 231 - 247.
- [5] K. Tuutti, Repair philosophy for concrete structures, in R.K. Dhir, M.J. McCarthy (Eds.), Concrete durability and repair technology, Thomas Telford Publishing, London, 1999, pp. 159 – 169.
- [6] T. Vogel, Operation successful, patient died – the assessment of structures as an engineering (or a medical) problem, in R.K. Dhir, M. J McCarthy (Eds.), Concrete durability and repair technology, Thomas Telford Publishing, London, 1999, pp. 549 – 562.
- [7] J.J. Basson, Y. Ballim, Durability of concrete, in B.J. Addis (Ed.), Fulton's Concrete Technology, seventh ed., Portland Cement Institute, Midrand South Africa, 1994, pp. 153 – 179.