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Development of testing methods for comparative assessment of Thin Spray-on Liner (TSL) shear and tensile properties.

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ABSTRACT

Spray-on linings in the form of shotcrete have been in use in the mining industry for the past 60 years. The introduction of Thin Spray-on Liners (TSLs) in mining has been more recent (approximately 20 years). There is no doubt that TSL technology, although it has great potential for success, will go through an extremely difficult implementation period as was experienced by shotcrete. Publications describing successful TSL application experiences have started to emerge. However, confusion and carelessness regarding standards, specifications, and design guidelines around the world will have to be addressed to overcome the teething problems experienced by the new TSL technology. There are still many aspects of TSLs that need to be investigated to provide information necessary to formulate a proper TSL design. This thesis is intended to bridge some of the knowledge gaps existing in the area of the mechanical property testing of TSLs.

A literature review provides the background to the concept of TSL technology and gives a summary of the previous testing methods performed to date. The shortcomings of these testing methods are emphasised and their applicability as standard testing methodologies is discussed. In the absence of sound test methods, the assessment of TSL suitability and performance is mainly based on opinion or short term visual observations at mine sites. The description and reporting of previous testing on TSLs, in general, have not been done appropriately and have often been found to lack critical information. Therefore, the absence of generally agreed testing methods results in a lack of parameters which are important in evaluating the quality and performance capabilities of available TSL products. For this reason, the development of appropriate and acceptable testing methods for TSLs is urgently needed so that design standards and requirements can be formulated.

This thesis focuses on four laboratory testing methods. The development of two new laboratory testing methods for the quantification of mechanical properties of TSLs is described, namely, shear-bond strength testing and material shear strength testing. In addition, two other existing testing methodologies were adopted with minor

modifications and included in the TSL testing programme. These are material tensile strength testing and tensile-bond strength testing. Large numbers of tests were carried out for each method as part of the research described. The results of all four testing methodologies have been collated and analysed in an attempt to make the comparison of the mechanical properties of various TSLs and shotcrete possible.

Each of the four testing methodologies is allocated a single chapter of the thesis, with particular focus on the details of the test considerations, and descriptions of apparatus, specimen preparation and test procedures. The results of testing are provided and analysed for the comparison of TSL performance in each of these chapters. A collective and comparative analysis and discussion on the test results is included.

Approximately 4000 tests were performed on 32 TSL products from 12 companies as well as one brand of plain shotcrete. Various factors such as temperature, humidity, substrate type and condition, rate of loading, specimen size, and storage duration significantly influence the performance of TSLs. All of these factors were considered, but their values or conditions remained fixed in the testing programme to limit the number of tests. However, an exception was the curing time, which was selected as the main test variable. Curing times from 1 day to 28 days were used in all the tests.

Subsequent analysis of the test results for the new testing methods provides a comparison of TSLs based on the measured strength properties. Comparison of TSL with shotcrete strength has also been possible through the same test methods, which have not been performed on shotcrete before. The test results also show an obvious strength increase with increasing curing time as expected. The simplicity and ease of performing these tests and the easy understanding of results compared with previous TSL testing has assisted in their general acceptance. The response from the mining industry and the product manufacturers towards the testing methodologies developed under the scope of the research in this thesis has been positive. The test results have been well received and have been used with confidence in the selection, quality control and comparative assessment of TSLs.

The extensive laboratory testing programme and the development of two new laboratory testing methods for TSLs, described in this thesis are considered to be a significant contribution to the state of the art of TSL technology. The database of test results and findings from this research can be used by liner manufacturers as a reference for the comparison of their products. Further improvements and development of new TSL products with better qualities will then assist in the further implementation of TSLs in the mining and civil engineering industries.