Durability *of* Building *and* Construction Sealants *and* Adhesives

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Foreword

This publication, *Durability of Building and Construction Sealants and Adhesives*, contains papers presented at the symposium of the same name held in Ft. Lauderdale, Florida, on 29–30 January 2003, sponsored by the ASTM International Committee C24 on Building Seals and Sealants. The symposium chairman was Andreas T. Wolf, Dow Corning, Belgium.

This publication also contains papers from the Charles J. Parise ninth symposium on Science and Technology of Building Seals, Sealants, Glazing and Waterproofing, held in Ft. Lauderdale, Florida, on 6 February 2002, also sponsored by the ASTM International Committee C24 on Building Seals and Sealants. The chairman for this symposium was James F. Walker, Tremco, Incorporated, Cleveland, Ohio.

Contents

DURABILITY STUDIES OF SEALANTS AND ADHESIVES

DEVELOPMENT OF NEW TEST METHODS AND PERFORMANCE-BASED SPECIFICATIONS

Overview

This book contains the proceedings of the ASTM Symposium on Durability of Building and Construction Sealants and Adhesives (2003-DBCSA), which was held on 29-30 January 2003 at Fort Lauderdale, Florida. Seven of the papers included in this book were presented at the Ninth ASTM Symposium on Science and Technology of Building Seals, Sealants, Glazing and Waterproofing. This symposium, chaired by James F. Walker, was held on 6 February 2002 at the same venue. Since no proceedings were published of the 2002 symposium, the seven papers given in 2002 were resubmitted for the 2003 symposium and are therefore published as part of the 2003-DBCSA proceedings.

The importance of sealants and adhesives in modern construction engineering cannot be ignored. Continuing developments in construction techniques, such as the trend towards modular construction, the use of curtain wall facades and new glazing techniques in high-rise building construction, as well as a multitude of other building and construction techniques constantly involve sealants and adhesives in new applications and thereby contribute to the increasing expansion of their use.

All building and construction sealants and adhesives, once installed, are exposed to environmental and service degradation factors which affect their performance over time and ultimately cause them to fail. Replacing failed sealants and adhesives is time consuming and can be expensive, representing a substantial proportion of overall maintenance costs. Specifiers and property owners therefore need to know the predicted service life of a sealant or adhesive in order to estimate the overall cost associated with the maintenance of building and construction structures.

Since the commercial introduction of the first elastomeric sealants and adhesives about 50 years ago, major advancements have been made in our understanding of their durability and the factors governing it. The progress of sealant and adhesive technology in building and construction structures has brought with it many new materials, products, systems, designs and concepts. It has also brought an awareness of new or formerly unrealized problems relating to the durability of building and construction sealants, which ASTM C24 Committee on Buildings Seals and Sealants is addressing.

Against a background of national and international efforts to harmonize testing and approval of building materials and structures, ASTM C24 Committee has been looking for ways of bringing together the experience of international experts gathered in the application and testing of building and construction sealants.

As with most scientific disciplines, substantial advances often occur through a series of small steps, rather than in giant leaps. This is also the case for the papers presented at the two ASTM symposia covered by these proceedings. Many of the papers reflect progress reports on on-going research.

This volume contains twenty-eight contributions reflecting the wide spectrum of current state-of-the-art research into sealant and adhesive durability. The symposium papers cover the following topics:

- Field Experience with Sealed Joints and Adhesive Fixations
- Factors Influencing the Durability of Sealed Joints and Adhesive Fixations

- Durability Studies of Sealants and Adhesives
- Development of New Test Methods and Performance Based Specifications

Below is a short overview of the papers which were submitted in the above four categories.

Field Experience with Sealed Joints and Adhesive Fixations

The intent of this section was to reflect on the experience gained in the field with regard to the durability of sealants and adhesives, both in existing and new applications.

The first paper by L. D. Carbary and M. W. Ryan discusses a novel secondary drainage system for architectural panel walls that consists of tubes and joint protection collection reservoirs with one-way valves. These tubes and reservoirs are made from silicone extrusions and molds that are attached to the back of concrete or stone panels using silicone adhesives. The paper presents data on the durability of silicone adhesives used to bond the silicone extrusions to the substrate.

The paper by M. K. Schmidt reports on the retrofitting of a lock strip gasket system on the façade of a twenty-year old building. Custom designed repairs consisting of overlapping preformed silicone extrusions and molds were utilized to create a watertight barrier. Lessons learned from the application of this barrier system are presented.

The following four papers dealt with experiences gained with structural silicone glazing (SSG) systems.

The paper by A. Hagl describes the use of SSG to achieve the unconventional design of the Herz Jesu church in Munich, Germany. This box-shaped building features horizontal and vertical glass beams supporting the façade. Silicone adhesive is used to bond steel stringers along the main edges of the horizontal and vertical glass beams in order to establish load paths between beams and façade. The hereby-realized bonding design offers special features being favorable for the durability of the building. The paper discusses in details the finite-element analysis (FEA) considerations and the experimental testing that have guided the careful selection of an adequate adhesive cross-section.

The paper by M. E. Baker reports five case studies of actual SSG projects where silicone sealant failure had occurred as a result of improper use of the material. The author recommends that sealant applicators involved in four-sided SSG projects should be trained and certified in a similar way as welders, who carry certification cards. The paper also discusses the South Florida Building Code that makes specific requirements for SSG. These requirements could serve as a model for a more formal SSG certification program.

L. D. Carbary and J. Gustafson discuss quality control guidelines that should be used in factory applied SSG. Included in this paper is a unique test method utilizing a portable tensile testing device that allows to quantify accurately the structural strength of the silicone bonding and to verify that the installed sealant meets the minimum requirements as set forth by the ASTM Specification for Structural Silicone Sealants (C1184-00). This quick method of testing deglazed panels can provide accurate information on the strength of the installed silicone within 24–48 hours after the deglazing operation.

Finally, the last paper in this section by W. Yue-lin, W. Hong-min and W. Li-min reports on the historical development and future prospects of structural silicone sealants in China. Since the first four-sided SSG project was finished in 1987 in Beijing, curtain wall installation by SSG has become quite popular in China and the authors estimate that now about 5 million square meters of glass are installed in this fashion every year. The paper discusses details of the Chinese Specification for Structural Silicone Sealants (GB 16776-1997) and compares

its requirements to those of ASTM C1184. The authors predict further growth of SSG in China based on the country's continuing development of building infrastructure.

Factors Influencing the Durability of Sealed Joints and Adhesive Fixations

While our understanding of the factors influencing the durability of sealed joints and adhesive fixations has progressed much over the past decades, there is still much to learn. A number of papers therefore focused on this topic.

The first paper by F. De Buyl on the influence of polyester powder coating chemistry on the adhesion durability of silicone sealants represents an attempt at relating the surface energy, chemical composition and morphology of these coatings to the adherence of various silicone sealants. Surface analyses demonstrate the presence of waxes on the surface of polyester powder coatings. These waxes have a detrimental effect on the subsequent adhesive bonding capability of silicone sealants.

J. Strong and J. Keegan discuss factors that influence the water absorption in cold liquid-applied waterproofing and show that products with known incidents of failure include ones meeting ASTM Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course (C836). The authors evaluate the role that applications errors play in water absorption failure and suggest additional requirements to those mentioned in ASTM C836.

The paper by J. T. Ma, S. S. Chen, W. Zhou and S. Wang highlights cleaning and substrate preparation as key factors that influence the adhesion buildup of silicone sealants on float glass substrates. For certain silicone sealant chemistries and formulations, cleaning the substrate with a mixture of polar solvents with water can accelerate adhesion build-up.

M. E. Kenney and R. J. Kenney in their paper explore the relationship between elevated moisture conditions in substrates and the ability of sealants to develop and maintain adequate bond strength to these substrates. Laboratory and field tests reveal that, typically, a low adhesive bond develops when elevated moisture levels are present, even when the substrates feel dry to touch. The authors further show that the use of certain primers results in greatly improved adhesion, even when the substrate is very damp.

A. E. O'Connor's paper compares the properties of silyl-terminated polyurethanes (SPUR) with those of traditional polyurethanes as well as silyl-terminated polyether (MS Polymer) sealants. These SPUR sealants show improved adhesion to glass, UV stability, and weatherability. Effects of the glass-transition temperature and rheological properties of silyl-terminated sealants on their properties are discussed.

H. Miyauchi and K. Tanaka in their paper investigate the fatigue resistance of sealants to shear movement at intersections of sealed joints and suggest improvements to the method of joint design based on the observed effect of curvature radius at the corners of the intersections.

Durability Studies of Sealants and Adhesives

The study of the durability of sealants and adhesives in the laboratory always represents one of the cornerstones of this series of symposia.

In two papers, S. Iglauer, A. R. Hutchinson and T. C. P. Lee study the effect of different foam backer rods on the cure and mechanical performance of sealed joints. The research shows that closed cell polyethylene foam clearly inhibits the cure of one-part sealants at the

interior face of the joint, in some cases substantially, whilst open cell polyurethane foam does not influence their cure speed. Backing foams, therefore, can negatively affect the fatigue performance of sealed joints. In particular, tensile adhesion joints made with one-part sealants in combination with closed cell polyethylene foam, and subjected to movement during cure, have a dramatically reduced fatigue life. Joints made with multi-part sealants are also affected in a detrimental way, but less substantially than with one-part products.

H. Miyauchi, N. Enomoto, S. Sugiyama and K. Tanaka report on their results obtained on commercially available sealants in Japan using an artificial weathering and cyclic movement test based on the RILEM TC 139-DBS Durability Test Method for Curtain wall Sealants. An important difference in the behavior of sealants is observed for exposures with and without mechanical fatigue cycling, confirming the importance of fatigue cycling in the degradation of sealants.

Heating, ventilation and air conditioning (HVAC) duct leakage has been identified as a major source of energy loss in residential buildings in the United States. The Lawrence Berkeley National Laboratory (LBNL) has been testing HVAC sealant longevity for several years. I. Walker and M. Sherman discuss experimental findings based on the accelerated test method developed by LBNL. Current research efforts are focusing on making less accelerated measurements of state-of-the-art tape products to corroborate the results found in the previous tests.

F. De Buyl and H. Gastaldi provide insights into the use of biocides in silicone sealants. Comparative testing carried out with various silicone sealant systems enables the identification of active ingredients adequate to provide durable protection of the cured silicone sealant, in particular after underwater leach-out conditioning.

A. T. Wolf, C. McMillan, W. Stiell and K. Lieb report on the effect of float glass surface composition on silicone sealant adhesion under hot water immersion conditions. The authors observe no correlation between the hydrolytic stability of float glass samples and sealant adhesion. However, the chemical surface composition of the float glass appears to affect sealant adhesion.

A. D. Zima, Jr. studies key attributes of different adhesive systems, which can be related to performance differences between typical butyl and modified asphalt adhesives used in window flashing products.

There is an epidemic of premature horizontal sealant joint failures throughout the United States. D. H. Nicastro and P. D. Gorman present case histories of horizontal sealant joint failure investigations, a summary of research on the resistance of horizontal joints to concentrated loads, a test method for penetration resistance, data collected from numerous projects throughout the United States as well as recommendations for sealant joint design and installation.

In their paper, L. D. Carbary and E. A. Zimmer study the durability and rate of adhesion build-up of one-part silicone sealants to silicone rubber extrusions for new and remedial glazing and weatherproofing applications. They conclude that suitable silicone adhesives can provide adequate cure and strength in less than twenty-four hours to withstand typical stresses incurred during the first day's movement.

The paper by G. Wypych, S. Kuberski and F. Lee discusses changes in the morphology of sealant surfaces as a result of their exposure to natural and various laboratory-based accelerated weathering conditions. Based on their findings, the authors suggest criteria for the selection of laboratory equipment for weathering studies of sealants that allow improvements in the correlation of accelerated weathering results with outdoor weathering results.

Development of New Test Methods and Performance Based Specifications

The final section of the symposium proceedings reviews attempts at developing new test methods for assessing the durability of sealants and adhesives, and, at reaching the ultimate goal, the development of performance-based specifications.

Quantification of the mechanical properties of cured sealants is complicated by the presence of the Mullins effect. C. C. White and D. L. Hunston examine issues related to the mechanical property characterization of sealants, and formulate simple rules to describe the Mullins effect.

D. Huff describes a novel device that allows the nondestructive field-testing of installed weatherproofing sealant joints in a uniform and controlled manner. The paper also provides a detailed description of the process by which the device is being calibrated to the properties of a variety of sealants.

Recent studies on crack sealants used in airport pavements that experience cold climates suggest that sealant failure is common. In their paper, M. A. Lacasse and J.-F. Masson discuss a systematic approach towards developing a performance-based guide for the selection of crack sealants used in airport pavements.

N. D. Searle reviews the efforts within ASTM Committee C24 directed at the harmonization and optimization of exposure conditions within weathering test methods for building and construction sealants and adhesives. Her paper reviews differences among weathering tests and provides data and justification in support of recommended exposure conditions that optimize the validity of the test results. The discussion focuses on spectral properties of light sources used for simulation of weathering versus solar radiation, irradiance levels, wet/dry cycles, and test durations.

A. T. Wolf and H. L. Cleland-Host report the effect of ambient laboratory climate ageing on material properties used in the FEA modeling of silicone sealants. The paper examines changes in the stress relaxed uniaxial tension and compression behavior of silicone sealants that occur upon prolonged cure at ambient laboratory conditions. The study is intended as a first step towards developing simple working models that account for the effects of sealant ageing in FEA modeling.

Despite extensive research on the durability of building materials and components performed over the past two decades, no reliable, quantitative method of service life prediction (SLP) has gained wide acceptance. Generic guidance is provided in documents published by ASTM, RILEM, EOTA and ISO. Although the methodology is logical and easy to understand, its application is not simple, since much judgment is required in the interpretation of the results. Recently, a more specific method of estimating the service life of sealed joints has been proposed. The paper by A. T. Wolf discusses the key requirements relevant to any service-life-prediction methodology, critiques the preliminary method proposed in the literature, and proposes a possible extension of this method.

Closing

As we publish this volume, I look forward to the next Symposium on Durability of Building and Construction Sealants and Adhesives and the associated flurry of papers in this dynamic industry. I encourage all readers to participate in the work of ASTM International C24 committee, to attend the future symposia and to contribute new papers. Your participation and feedback help to advance the industry and, as a result, we will all benefit from improvements to our built environment.

In closing, I would like to gratefully acknowledge the outstanding quality of the contributions made by the authors as well as the dedicated efforts of the 2002 symposium chairman, the session chairpersons, the peer reviewers, and the staff of ASTM, who all helped to make the 2002 and 2003 symposia and the publication of these proceedings possible.

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