

Support and Development of Workflow Protocols for High Throughput Single-Lap-Joint Testing – Data Management

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*A reprint from the Proceedings of the 36th Annual Meeting of the Adhesion Society, Inc.,
Daytona Beach, FL, 3 March 2013.*

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To study the effects of aluminum coupon thickness, bond line thickness, surface preparation, and presence of an overflow fillet for a high strength epoxy and ductile methacrylate adhesive a parametric was used with a high quantity of sample sets. GEMS (Gains in the Education of Mathematics and Science) high school and middle school students prepared 960 single-lap-joint samples with ARL technicians fabricating and additional 240 controls. The time constraints imposed by working within the GEMS framework required a highly efficient experimental work-flow protocol to maintain high throughput and quality during fabrication. Of equal importance was maintaining data integrity during this study. This work focuses on coordinating laboratory experimental support with the U.S. Army Research Laboratory's Materials Selection and Analysis Tool (MSAT) database platform to insure [sic] both high throughput and data integrity by capturing the entire experimental response curve, supportive pedigree information, as well as experimental descriptors, which will augment further data analysis. The MSAT protocols also proved to be very pragmatic for physically tracking sample identification numbers and matching with subsequent failure surface images after mechanical testing was completed. The data is intended for eventual public release to augment the numerous academic models used to predict single-lap-joint response. The details of the data management workflow schema will be reported.					
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Introduction

To study the effects of aluminum coupon thickness, bond line thickness, surface preparation, and presence of an overflow fillet for a high strength epoxy and ductile methacrylate adhesive a parametric was used with a high quantity of sample sets. GEMS (Gains in the Education of Mathematics and Science) high school and middle school students prepared 960 single-lap-joint samples with ARL technicians fabricating and additional 240 controls. The time constraints imposed by working within the GEMS framework required a highly efficient experimental workflow protocol to maintain high throughput and quality during fabrication. Of equal importance was maintaining data integrity during this study. This work focuses on coordinating laboratory experimental support with the U.S. Army Research Laboratory's Materials Selection and Analysis Tool (MSAT) database platform to insure both high throughput and data integrity by capturing the entire experimental response curve, supportive pedigree information, as well as experimental descriptors, which will augment further data analysis. The MSAT protocols also proved to be very pragmatic for physically tracking sample identification numbers and matching with subsequent failure surface images after mechanical testing was completed. The data is intended for eventual public release to augment the numerous academic models used to predict single-lap-joint response. The details of the data management workflow schema will be reported.

Experimental

Single-lap-joints were prepared as described by Flanagan et al.¹ ASTM D 1002² was the basis standard used for the single-lap-joint testing. Single-lap-joint tests were performed using a 5500 series Instron testing machine in tension mode equipped with a 22 kN load cell and mechanical wedge grips. The length in the jaws of the grippers was set at 25.4 mm. The lap shear tests were run at a rate of 1.27 mm/min per the ASTM standard.

Prior to testing, each lab-shear sample was given a MSAT generated unique specimen identification (ID). The work flow scheme used transfers and converts relevant load versus displacement raw data directly to MSAT as a verifiable digital asset. Adhesive materials ID and test metadata (date of preparation, specimen lot identification (ID) information, basis testing standard, surface treatment, sample preparation procedure, calibration, operator, contact information of test lab, and perceived data of test engineer's observations) are captured in the test frame software prior to testing the lap shear sample. This metadata is exported directly as a text file, whose standardized format allows for automated upload into the adhesive database. Both the metadata file and the experimental test data file are tagged with the unique specimen ID to ensure proper data affiliation in the database.

Results and Discussion

Adhesive needs for Army ground vehicles are driven by high strength and high damage tolerance. These basic materials properties requirements do not coincide with traditional aerospace adhesive demands of high strength and high stiffness, which are derived from linear-elastic stress-strain behavior and very little energy absorption. High damage tolerance requires significant energy absorption and the accompanying nonlinear stress-strain response. Therefore, the simplified approach of defining adhesive bond strength as peak load per unit surface area to screen potential adhesives for ground vehicle use is inadequate. Any potential Army interest in defining adhesive property requirements must consider the increased complexity of the nonlinear adhesive response, which requires a level of raw data fidelity afforded by modern 21st century database platforms, such as MSAT. Additionally, the experimental response curve, supportive pedigree information, as well as experimental descriptors are fully captured (as shown in Figures 1, 2, and 3) for direct export of academic data for external academic modeling efforts.³ The advantage with this approach is that the modeler is not

relying on filtered data or the analysis interpretation of the data originators. External modelers will also be able to examine digitally archived failure surfaces to assist interpreting the loading response.

Conclusions

During the course of the GEMS single-lap-joint experiments high pedigree experimental data was collected for 1200 single-lap-joint samples. Work is ongoing at ARL to both analyze the results for internal research efforts and to properly archive and publically export the data for external peer review.

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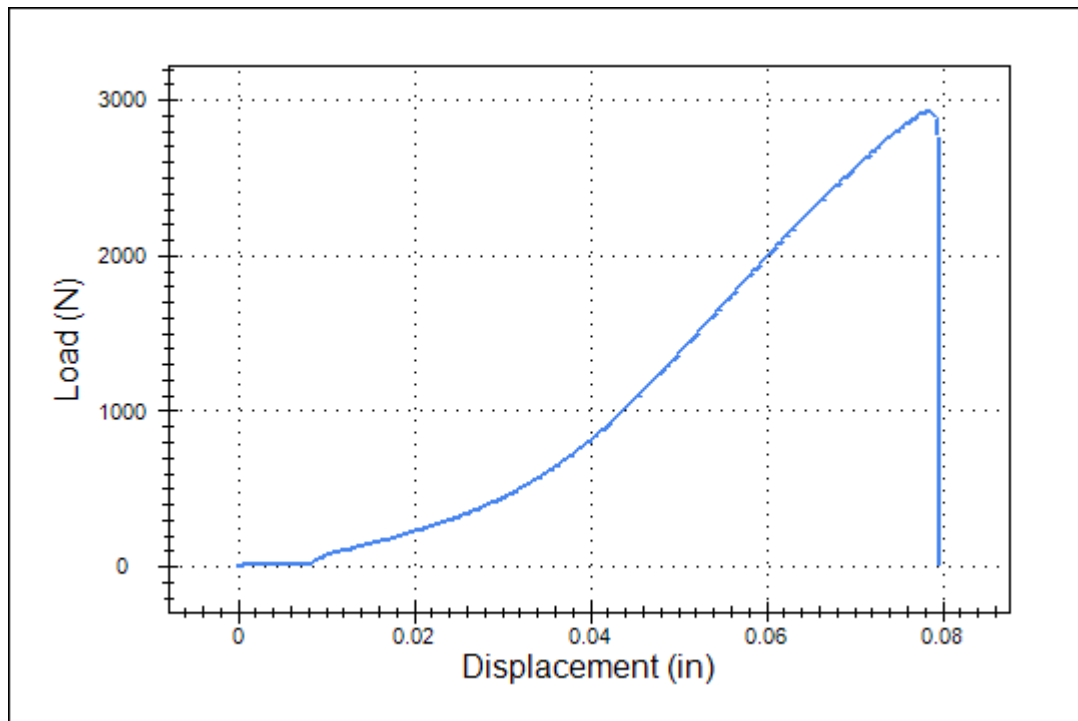


Figure 1. Raw data load-versus displacement curve captured for single-lap-joint MSAT sample 20120119. Sample plot is a representative example for the 1200 total single-lap-joints tested under the GEMS program and retrievable using ARL's MSAT database platform.

Testing organisation	U.S. Army Research Laboratory
Basis testing standard	ASTM D 1002
Valid test	Yes
Used in Summary	Yes
Sample ID	20120119
Material ID	SG300-ARL
Material classification	Acrylic/Acrylate
Lap Shear joint substrate aluminum grade	2024 T3
Lap Shear joint substrate aluminum thickness (in)	0.045
Average thickness of the adhesive layer (in)	0.005
Length of overlap used (in)	0.5
Joint width (in)	1
Method of cleaning and preparing bonding surface	The bonding surfaces were wiped down with acetone before adhesive application and air dried. Wipes: ITW TEXWIPE TX612 Technicloth 2-part cartridge, pneumatic mixing gun, static mixing head Pneumatic mixing gun: MIXPAC type DP 400-100 serial number 2008-07153 acetone solvent wipe only
Adhesive Preparation	
Type of surface treatment	
Date of sample preparation	25-Jun-12
Adhesive lot ID	NC11I-131
Adhesive expiration date	4-Oct-12
Model	Instron Model 1125
Load cell	1124.8 lbf Tension/Compression Load Cell
Load cell calibration date	16-Nov-10
Crosshead speed (in/s)	0.000833
Max strength (ksi)	1.31
Type of Failure	cohesive (visual inspection of actual sample)

Figure 2. Limited sample (all not shown) of supportive pedigree information and experimental descriptors for single-lap-joint MSAT sample 20120119. Sample is a representative example for the 1200 total single-lap-joints tested under the GEMS program and retrievable using ARL's MSAT database platform.



Figure 3. Failure surface for single-lap-joint MSAT sample 20120119. Failure surface is representative example for the 1200 total single-lap-joints tested under the GEMS program and retrievable using ARL's MSAT database platform.

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