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US Army Research Laboratory

Modification of General Research Corporation (GRC) Dynatup 8200 Drop Tower Rebounding Brake System

by David Gray, Robert Kaste, and Bradley Lawrence

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14. ABSTRACT The Double Column GRC Dynatup 8200 Drop-Weight pneumatic rebound brake system was intended to prevent secondary tup impacts on test specimen after the initial strike. Our investigation lead to the discovery of multiple impacts from a single test. To achieve a single mass impact of energy on laminate material test panel, we successfully modified the braking system. The details of which are explained in this report.						
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1. Introduction

The Double Column GRC Dynatup 8200 Drop-Weight pneumatic rebound brake system was intended to prevent secondary tup impacts on test specimens after the initial strike. Our investigation discovered multiple impacts from a single test. To achieve a single-mass impact of energy on a laminate material test specimen, we successfully modified the braking system, the details of which are explained in this report.

2. Background of Impact Test

The Dynatup 8200 drop weight test system was designed and manufactured in 1982 by GRC (Fig. 1). This model has a mass weight range of 7 to 34 lb (3.18 to 15.42 kg), a maximum drop height of 36 inches (0.91 m), and can produce energy impacts (potential energy) up to 96 ft-lb. (120 J). The US Army Research Laboratory has performed low-energy (<100 J) impact experiments per ASTM D7136/D7136M-15[1] with this system since 2001. The 8200 system was originally supplemented with two 1-inch bore/1.5-inch stroke 120-psi pneumatic actuators with 0.18-inch ID air supply lines that are used as a rebound brake system (Fig. 2). These actuators deploy via a pneumatic valve when a velocity optical sensor is tripped from a blade flag attached to the cross head milliseconds before the initial tup impact. There is an inherent lag time between initial impact and the actuators deploying due to the system's pneumatic solenoid valve response time. This pneumatic system was intended to prevent secondary tup impacts on test specimens after the initial strike.

Fig. 1 GRC Dynatup 8200 drop tower

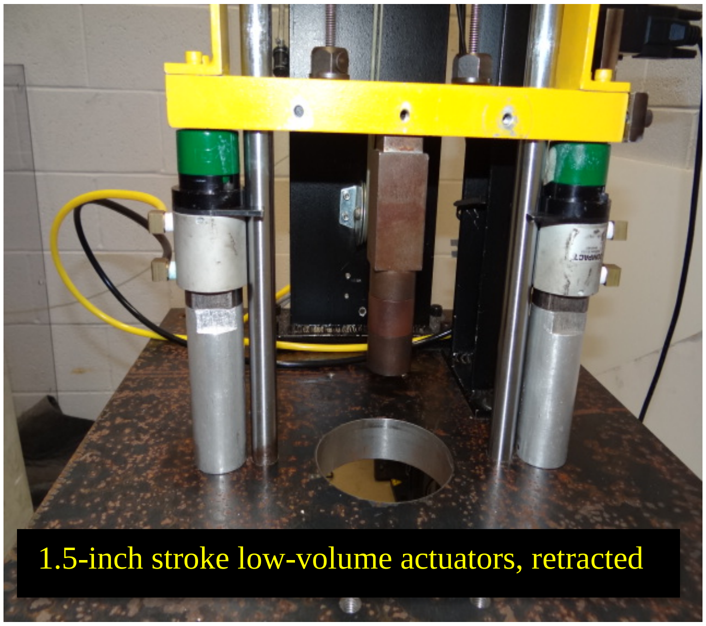

Fig. 2 Original equipment manufactured pneumatic brake actuators

Recently, it was suspected that releasing masses greater than 11 lb (5 kg) from heights greater than 30 inches (0.76 m) produced an undesirable secondary tup impact during the crosshead rebounding period. In test cases where coupons require ASTM D7137/D7137M-12[2] Compression After Impact test, the coupons are required to be subjected to a single impact from the ASTM D7136 test. Having multiple impacts from the drop tower testing can have direct influence on the coupon's residual strength. We set up a single Integrated Design Tools (IDT) Os5 4K high-speed digital camera with a frame rate of 1000 fps to capture the tup impact and rebound period on a generic scrap 0.20-inch-thick laminate (Fig. 3). We discovered the current system proved to be insufficient to halt repeated impacts from heavier mass assemblies for a single test. The Instron Impulse data collection software used by the test frame has a maximum recording time period of 100 ms. This misses the recording time period of the second and third impacts that start to occur around 500 ms. The nature of the rebound in amplitude and period after the initial impact can vary as the reaction is based on the material stiffness. Figure 4 shows tup impact period sequence stills.

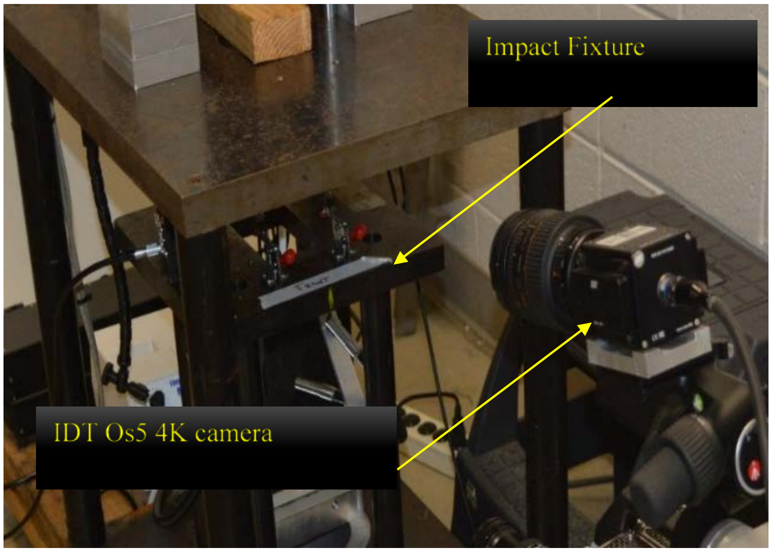

Fig. 3 IDT Os5 4K high-speed digital camera to capture tup impact period

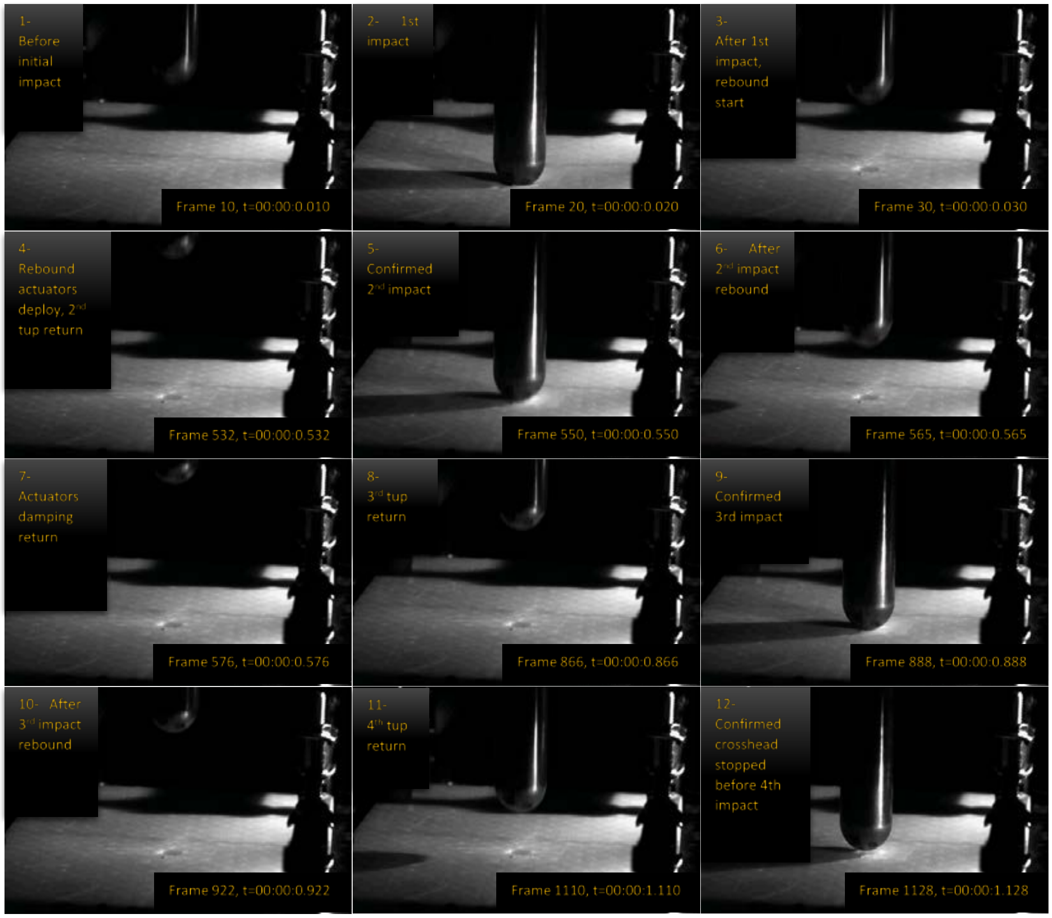

Fig. 4 Tup impact period sequence stills of generic laminate using old pneumatic rebound system

To correct this deficiency, larger 2-inch bore, 3-inch stroke 120-psi pneumatic cylinders with 3/8 inch OD/0.245-inch ID airlines were used to upgrade the rebound system (Fig. 5). To verify the effectiveness of the new system, the IDT Os5 4K camera was used again to capture the tup impact and rebound period at 1000 fps.

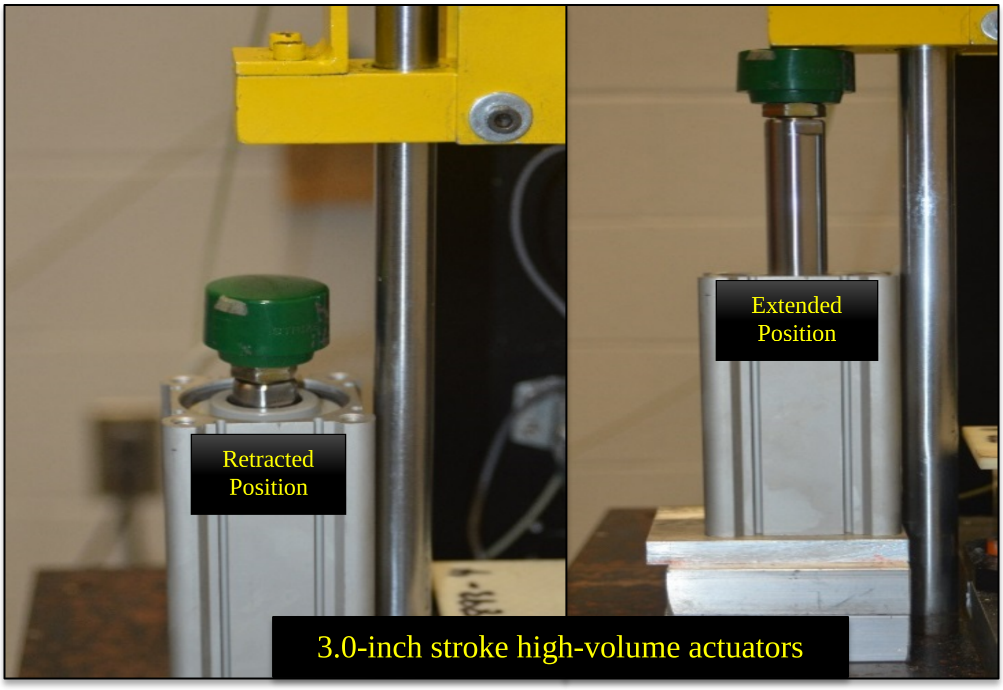

Fig. 5 New upgraded 3-inch pneumatic cylinders

Figure 6 shows sequenced stills from a 0.24-inch-thick carbon fiber composite material impact test using the updated 3-inch rebound cylinders. With a 26.5-lb mass (12.02 kg) at 33-inch (0.838-m) drop height, the test yields an impact energy of about 74 ft-lb. (100 J). The sequence shows the tup prior to impact, impacting, rebounding from the plate, and being stopped by the pneumatic system prior to secondary contact.

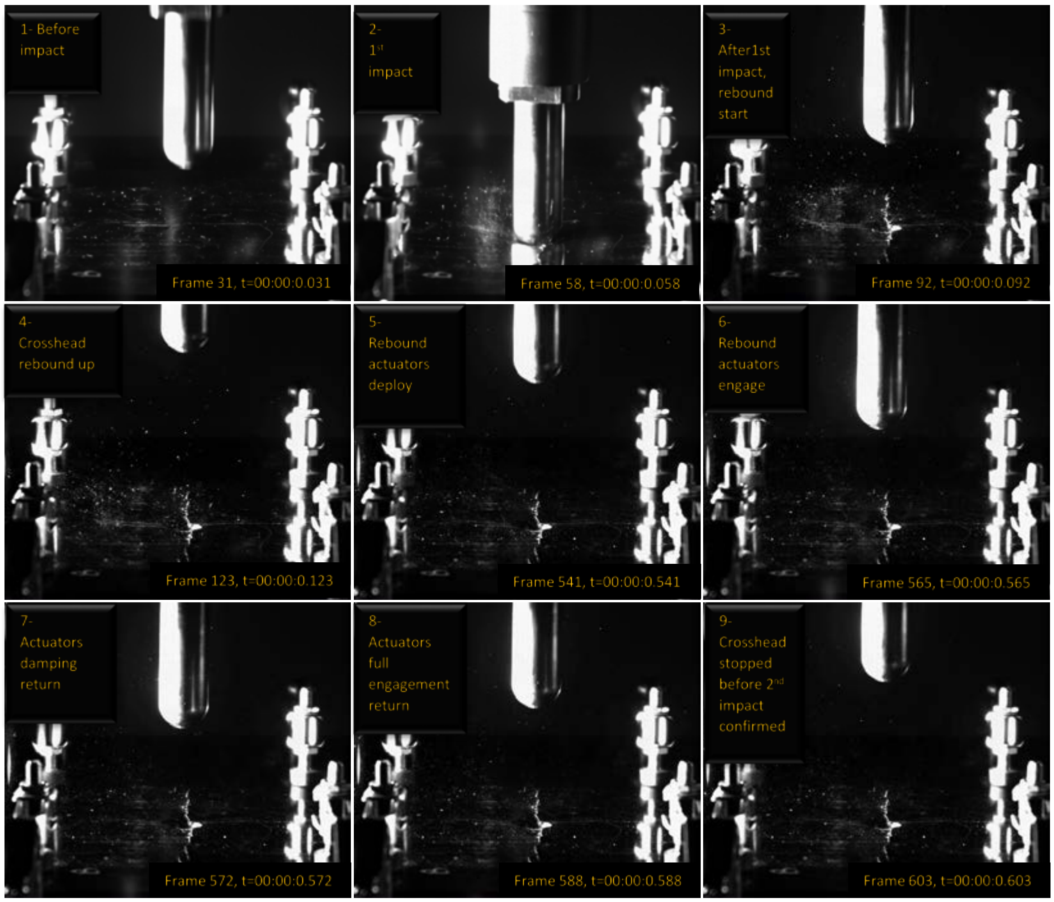

Fig. 6 Tup sequenced impact stills from carbon fiber composite laminate test material

3. Conclusion

We were able to successfully perform drop-weight standardized testing per ASTM D7136/D7136M using a heavier cross head mass assembly dropped from various heights with a single impact. Using high-speed photography, verification was made that a single impact was achieved on generic laminate material coupons. The GRC Dynatup 8200 Drop Weight system was outfitted with 2 large bore, longer stroke pneumatic actuators and 3/8-inch OD/0.245-inch ID airlines. This update eliminated the secondary rebound impacts that had occurred with the previous pneumatic system under the same drop conditions.

4. References

1. ASTM D7136/D7136M-15. Standard test method for measuring the damage resistance of a fiber-reinforced polymer matrix composite to a drop-weight impact event. West Conshohocken (PA): ASTM International; 2015.

2. ASTM D7137/D7137M-12. Standard test method for compressive residual strength properties of damaged polymer matrix composite plates. West Conshohocken (PA): ASTM International; 2012.

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