ModRooster

Automated Fatigue Testing Machine

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Problem Statement

The Tufts Mechanical Engineers are responsible for developing a fully automated fatigue testing device that can perform cyclic tests on the ReMaterials ModRoof panels to provide information about material strength properties.

Background Research

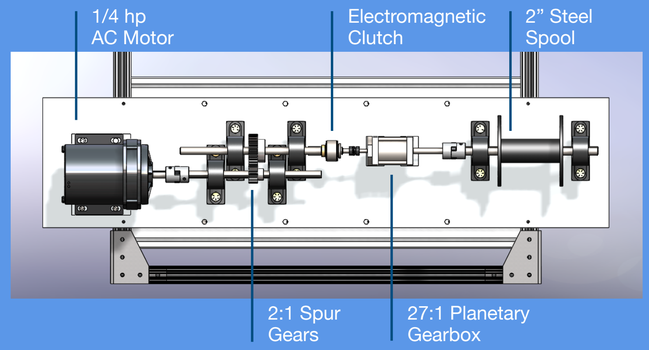
Many poor families in India have either corrugated metal and concrete slab roofing, neither of which are ideal for the environment. The ReMaterials ModRoof panels are manufactured from packaging and agricultural waste products and provided better insulation, waterproofing, and durability.[1] ReMaterials currently has a man jump from 75cm onto the panels 300-500 times to test for fatigue failure. ReMaterials needs a system that can automate fatigue testing.

Concept Generation

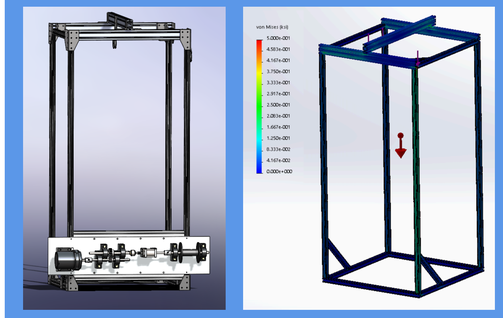
		Human Jump		Linear Electric Actuator		Pnuematic Actuator		Drop Tower Impact System	
Major Components		None		Linear Electric Actuator		Tie Rod Air Cylinder, Air compressor, Precision Compressed Air Regulator		AC Motor, Electromagnetic Clutch, Spur Gears, Gearbox	
	Weight	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Base Cost	10%	$0	0.10	$460	0.03	$680	0.00	$610	0.01
Automatation	30%	–	0	+	0.3	+	0.3	+	0.2
Impact Speed Acuracy	20%	+	0.2	–	0	0	0.1	+	0.2
Impact Force Acuracy	20%	+	0.2	–	0	+	0.2	+	0.2
Impact Precision	5%	0	0.025	+	0.05	+	0.05	0	0.025
Maintenance Difficulty	15%	0	0.075	0	0.075	0	0.075	+	0.15
			0.6		0.46		0.73		0.79

Diagram of Solution

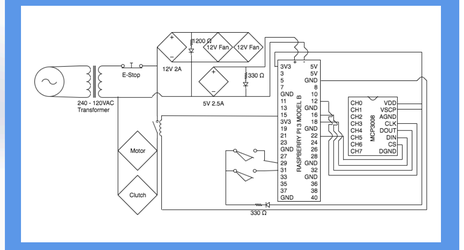
Actuator



Superstructure



Control System



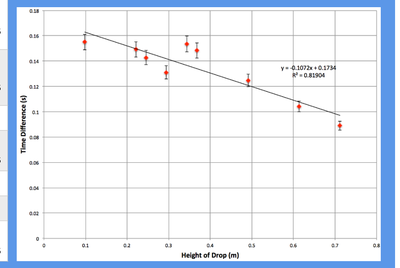
Technical Details

The ModRooster raises and drops a 176 lb sandbag onto the ModRoof panels. According to a report by the British Health and Safety Laboratory, dropping a sandbag is the most accurate proxy for dynamic human loading on a roof.[2] The 1/4 hp AC motor runs at 1725 RPM and 0.7625 ft-lb. 2:1 spur gears reduce the speed to the operating point of the electromagnetic clutch. A 27:1 3-stage planetary gearbox reduces the speed to allow the 2” steel spool to raise the weight in under 30 seconds. The superstructure was designed to distribute loads away from connection points and into 80/20 aluminum members. The Raspberry Pi-driven control system uses a limit switch to recognize when the load has reached maximum height to disengage the clutch and drop the sandbag.

Requirements & Validation

Requirement	Marginal	Ideal	Actual
Maximum Force Applied by Actuator	2,600 N	3,900 N	In Progress
Fall Time Deviation From Free Fall	30%	10%	In Progress
Fall Height	0.75 m	2 m	1.5 m
Maximum Cycle Time	40 s	30 s	In Progress
Size of Test Bed	2’ × 2’	3’ × 3’	3’ × 3’
Duty Cycle	70%	100%	100%
Has UI to Specify Force & Cycles	No	Yes	In Progress

Calculated Time Minus Fall Time Vs. Height



A clutch validation experiment proved the system adequately simulates free fall conditions. More testing will occur before travel to India.

Prototype Installation

The team will travel to Ahmedabad, India in January 2018 to install the ModRooster at the ReMaterials headquarters. The team will modify the design during the spring semester based on feedback from the Engineers at ReMaterials.

Visit our crowdfunding site for details on the trip
crowdfund.tufts.edu/project/8266

Acknowledgments

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References

[1] “Challenge.” ReMaterials, re-materials.com/challenge/.
[2] Maitra, A. *Human Impact Loads On Roofs*. British Health and Safety Laboratory, Sheffield, 2007.