Compression Trailer Summary Report

August 2024

Executive Summary:

The Mattress Recycling Council contracted with G&G Transport to develop a prototype container that could compress discarded mattresses for the purpose of increasing the density of the cargo and then assess the potential cost savings through reduced transportation expenses. The project demonstrated that each load of mattresses can be densified by 50% and costs reduced by 26% despite the additional labor time and expense to load/unload as well as training for collectors, transporters and receiving facilities. The project was ultimately successful. Additional modifications to the prototype would increase the likelihood of widespread industrial adoption.

Objective:

A collaborative project with G&G Transport (G&G), an affiliate of Xtraction and Tough Stuff mattress recycling, was established to explore the feasibility of compressing discarded mattresses and foundations (together referred to as "units") to increase the density of trailers and reduce transportation costs. Following similar developments in Europe, it was hypothesized that units could be compressed as much as 50% from their initial height without impacting their recyclability. If successful, this technology could significantly increase the number of units carried per load from collection sites to recycling facilities and thereby reduce logistics costs and the carbon footprint of mattress recycling efforts.

Background Information

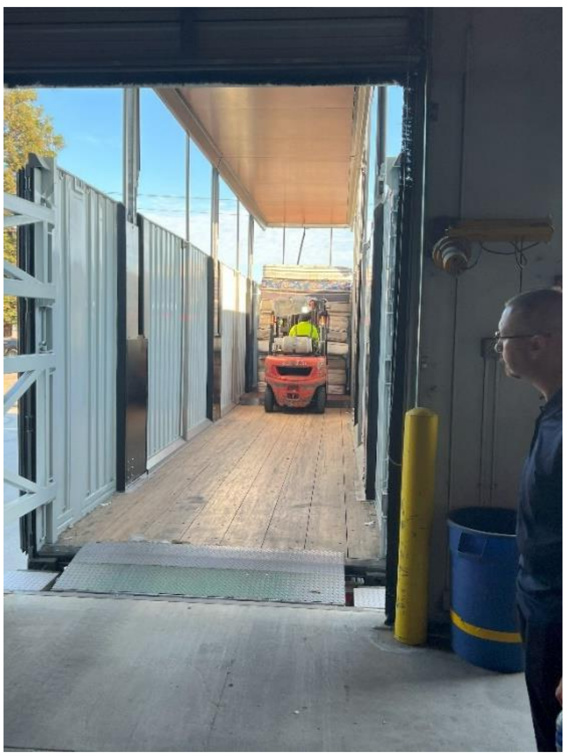
According to the Mattress Recycling Council's (MRC's) 2023 California annual report, transportation represents 26% of total program costs. This translates to $6.92/unit. Depending on the mix of sizes, a typical 53-foot trailer holds about 115 units or 6,325 pounds of cargo. Ideally, 53-foot trailers should contain 40,000 pounds of cargo to maximize the efficiency of each load.

In 2023, MRC transported over 12,000 mattress shipments in California and has worked to optimize its logistics operations so that only full, well-packed loads are deployed. However, due to the light, bulky nature of mattresses there are limitations to the benefits of these efforts. To achieve additional efficiencies and cost savings, densifying the units is required.

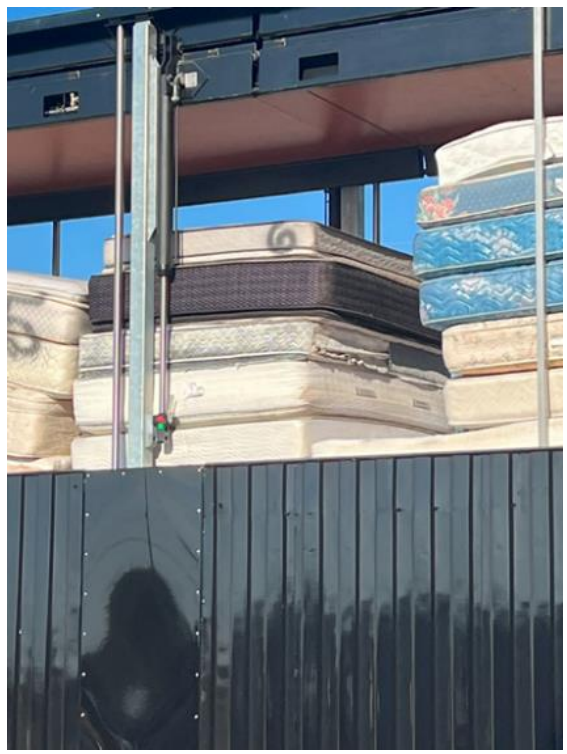
Prototype Compression Trailer

Using its relationship with an experienced European manufacturer, G&G oversaw the design and construction of a prototype compression trailer compliant with U.S. transportation requirements. The prototype was constructed using a modified 45-foot shipping container containing a foundation floor, middle floor and ceiling

When the first floor and ceiling are in their extended position, the height between the foundation and the first floor is sufficient for loading and unloading with a standard forklift (pic 1). The middle floor and ceiling are connected to hydraulic controls (pic 2) which are raised (pic 1 and 3) and lowered (pic 4) in the compression process. The attached photos show loading and compressing the mattresses in the prototype.



Picture 1. Loading Trailer



Picture 2: Stacked mattresses prior to compression

Picture 3. Partially loaded trailer

Picture 4. Compressed mattresses

Static Loading Evaluation:

After commissioning and operator training, a 3-load trial was conducted at Xtraction mattress recycling in Fresno, CA to determine to what extent units could be compressed and the additional labor time and associated expenses required to compress units. During the trial, several challenges were encountered including:

- The manual loading of units on the second floor was problematic due to the instability of the stacks falling over. G&G rented a portable scissor jack for staff to have external access to the stacks which alleviated most stacking issues, but some units still spilled out during the compression cycle. The prototype was later modified with collapsible side curtains to keep stacks contained and aligned.
- Foundations (also known as box springs), also posed challenges during the compression stroke with some of them crushed to the point where recycling those units would be difficult. Better stacking and lower compression techniques were used to prevent recurrence.
- Loading the compression trailer took about 2 hours of labor. The prototype has since been modified to automate the lift and compression controls to speed operation.

- Modifications to the back four feet of the floor are necessary to improve dock level loading of the top floor of the prototype.

Test Shipments and Data Collection:

Following the initial trial, the prototype was modified to address easy-to-rectify design issues including floor and side reinforcements and safety control features. Load, compression and unload procedures were also updated. Some additional modifications that were identified, but not implemented before collecting data on 10 trial shipments including floor modifications to improve dock height level loading. Upon completion of the modifications and procedure revisions, a 10-shipment trial was conducted using the 45' compression prototype. That data was then extrapolated to compare costs against shipments of uncompressed units in a 53' trailer, 48' trailer and unmodified 45' sea-container (Table 1).

Data points collected include:

- Net weight of units
- Load time
- Load labor cost
- Unload time
- Unload labor cost
- Transport distance per load (same for all types)
- Fuel cost per load
- Cost per unit per mile
- Cost per lb. per mile

Compression prototype data was then compared to standard 53' trailer loads. The results are provided in Table 1 below.

Table 1. Trial Shipment Test Data

Baseline - Not Compressed	# Units	Total Net Weight, lbs.	Load Cycle Time, min.	Load Labor	Unload Cycle Time, min.	Unload Labor	Transport Distance, mi.	Transport Cost	Fuel Cost	Logistics Cost per unit per mile	Logistics Cost per lb. per mile
53' Trailer	150	8,250	45	$ 22.50	47	$ 23.50	60	$ 400.00	$ 46.15	$ 0.055	$ 0.00099
48' Trailer	138	7,590	40	$ 20.00	40	$ 20.00	60	$ 400.00	$ 46.15	$ 0.059	$ 0.00107
45' Container	130	7,150	38	$ 19.00	40	$ 20.00	60	$ 400.00	$ 46.15	$ 0.062	$ 0.00113

Prototype Shipments	# Units	Total Net Weight, lbs.	Load Cycle Time, min.	Load Labor	Unload Cycle Time, min.	Unload Labor	Transport Distance, mi.	Transport Cost	Fuel Cost	Logistics Cost per unit per mile, $	Logistics Cost per lb. per mile, $
1	192	10,560	124	$ 62.00	65	$ 32.50	60	$ 400.00	$ 50.77	$ 0.047	$ 0.00086
2	217	11,935	120	$ 60.00	65	$ 32.50	60	$ 400.00	$ 50.77	$ 0.042	$ 0.00076
3	226	12,430	121	$ 60.50	65	$ 32.50	60	$ 400.00	$ 50.77	$ 0.040	$ 0.00073
4	239	13,145	124	$ 62.00	65	$ 32.50	60	$ 400.00	$ 50.77	$ 0.038	$ 0.00069
5	238	13,090	117	$ 58.50	65	$ 32.50	60	$ 400.00	$ 50.77	$ 0.038	$ 0.00069
6	224	12,320	121	$ 60.50	65	$ 32.50	60	$ 400.00	$ 50.77	$ 0.040	$ 0.00074
7	220	12,100	119	$ 59.50	65	$ 32.50	60	$ 400.00	$ 50.77	$ 0.041	$ 0.00075
8	217	11,935	118	$ 59.00	65	$ 32.50	60	$ 400.00	$ 50.77	$ 0.042	$ 0.00076
9	238	13,090	122	$ 61.00	65	$ 32.50	60	$ 400.00	$ 50.77	$ 0.038	$ 0.00069
10	235	12,925	118	$ 59.00	65	$ 32.50	60	$ 400.00	$ 50.77	$ 0.038	$ 0.00070
Total	2,246	123,530	1,204	602	650	325				0.405	0.0074
Avg.	225	12,353	120	60.2	65.0	32.5				0.040	0.0007

Increased Capacity	Net Units per load	% increase
53' Trailer	75	49.7%
48' Trailer	87	62.8%
45' Container	95	72.8%

Cost Savings	Net $/unit/mile	% decrease
53' Trailer	$ 0.014	-26.0%
48' Trailer	$ 0.018	-31.0%
45' Container	$ 0.022	-34.9%

Potential Cost Savings per Year using 53'		
2023 Total Projected Logistics Costs		$ 8,965,901
Savings potential	100% utilization	$ (2,326,832)
	50% utilization	$ (1,163,416)

Conclusions

The compression trailer averaged 225 units per load and the average net cargo weight increased to 12,353 pounds. This represents a 49.7% increase over a standard 53-foot container. While some potential savings were diluted by increased labor costs to load and unload, shipping and fuel costs for hauling the container were 26% lower per mile.

Full implementation of the trailers at the demonstrated capacity increase by MRC could potentially reduce the number of shipments required to transport mattresses statewide by 3,120 (from 12,000 to 8,880) annually. This translates to a potential savings of $2.3 million per year.

While the results are encouraging, limits in the current design prevent full realization of the potential savings. The trailer is not designed to handle more than one compression cycle. Therefore, a collection site would need to have a capacity to store at least 225 units to fully load the trailer. This may not be a suitable approach for smaller, more remote collection sites. Other sites may also not have the clearance required in their loading docks to handle the extended trailer height. Similarly, some recycling facilities may also have clearance issues for decompressing and unloading mattresses. The current design seems well-suited for collection events and transfers from high-volume collection sites. Partial utilization seems like a practical next step.

Next Steps:

Although the project with MRC has concluded, the compression technology is currently being adapted into a final production 53' trailer with the new modifications. This next iteration will be dock-height to expedite the loading and unloading of both mattress layers along with automated stack loading for the top layer.

One hurdle to consider would be the capital expense required to adopt the solution. For the current iteration, the investment and payback breaks down as follows:

- Conservatively, 8,880 shipments per year translates to 34 shipments per operating day (8,880/260).
- It is assumed there is some need for redundancy and downtime.
- At an estimated cost of $150,000/unit, 38 containers would require an investment of ~$5.7 million. Partial implementation would require fewer units.
- Payback for full or partial implementation would be approximately 29 months.
- Other business models, such as leasing, or development agreements with service providers should also be considered.

Depending on usage and distance hauled, the return on investment (ROI) is estimated to be approximately 12 months for a 53' compression trailer which hauls one load per day over a distance of 60 miles. Detailed payback calculations are provided in Table 2.

Contact Information:

Questions or comments regarding this work can be directed to Mike Gurnee at mikeg@toughstuffrecycling.com.

Table 2. Payback Calculations

		Baseline Peformance	Demonstrated 48' Prototype	Projected 53' Performance
2023 Total Logistics Costs	**$**	**8,965,901**		
Cost per unit per mile	$	0.055	$ 0.040	$ 0.029
% Decrease			-26.0%	-46.3%
Savings potential				
100% utilization			$ (2,326,832)	$ (4,153,981)
50% utilization			$ (1,163,416)	$ (2,076,991)
Payback Calculation (100% Utilization)				
Estimated compressed shipments per year*		12,000	8,886	6,440
Compression Trailers required (+4 redundant)			38	29
Capital Investment			$ 5,700,000	$ 4,350,000
Months to recover capital investment			29.4	12.6
Payback Calculation (50% Utilization)				
Estimated compressed shipments per year*		12,000	4,443	3,220
Compression Trailers required (+2 redundant)			19	14
Capital Investment			$ 2,850,000	$ 2,100,000
Months to recover capital investment			29.4	12.1
* Baseline reflects current uncompressed shipments				