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TECHNICAL REPORT

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MODULAR HONEYCOMB CONCEPT FOR PREPARATION OF LOADS FOR DELIVERY BY AIRDROP

by

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Project Reference:
1F162203D195

March 1969

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FOREWORD

A study is currently being conducted as Task 08, "System for Rapid Preparation of Airdrop Loads" under DA Project No. 1F162203D195. The purpose of this study is to evaluate the basic functions and equipment for preparation of airdrop loads from an overall point of view with particular emphasis on simplification, and time and cost reduction. The initial general analysis identified a number of problem areas requiring detailed studies. One of these studies resulted in the modular honeycomb concept for energy dissipating which is described in this report.

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ABSTRACT

Current studies aimed at simplification of the preparation of loads for delivery by airdrop have resulted in a concept for a simplified method of preparing the honeycomb cushioning system. This concept employs a small number of standard size honeycomb modules which can be used as "building blocks" to construct the many different sized stacks employed in current rigging procedures. Analysis and limited testing indicate that it would be feasible to use five standard size modules of honeycomb to rig practically all airdrop loads.

MODULAR HONEYCOMB CONCEPT FOR PREPARATION OF LOADS FOR DELIVERY BY AIRDROP

INTRODUCTION

All aspects of the present system for preparation and retrieval of supplies and equipment delivered by airdrop is being studied currently in an effort to simplify and optimize this phase of an airborne operation. Several specific problem areas have been identified on which derivative studies have been conducted. The study reported here is directed toward simplifying the preparation of honeycomb cushioning for platform loads.

The present system for airdropping heavy equipment (vehicles and weapons) uses paper honeycomb to dissipate energy at ground impact. The honeycomb is placed between the airdrop platform and the item being delivered. This cushioning system is composed of a number of stacks of various sizes positioned at various locations beneath the item being dropped. The stacks are constructed by gluing layers of 3-inch-thick honeycomb cut to the required size. The stack dimensions are tailored to the individual item being dropped, and are built from pieces of honeycomb cut from large sheets (3' x 8').

A modular concept was developed which employs a small number of precut blocks of standard sizes, which are assembled in a fashion similar to laying bricks, to construct stacks having overall dimensions equal to or very close to the current stack dimensions (Fig 1). This eliminates cutting of honeycomb, simplifies the procedures for constructing the cushioning system, and offers additional potential logistic advantages.

SELECTION OF MODULAR SIZES

An initial analysis was conducted on the most common airdrop platform loads. Seven items were selected which constitute 80% or more of all vehicle drops. It was found that 25 different sizes of honeycomb were used to rig these seven items. Studies were then conducted to determine the optimum number and size of modules from which the 25 sizes could be constructed. Various combinations of size and number of modules were evaluated considering individual stack dimensions and area, total area of rigged load, total volume of honeycomb, and perimeter to area relationship. Sizes for the honeycomb modules were also selected to insure staggering of seams in successive layers, and for ease of handling. Results of this study indicated that it would be feasible to employ 5 modules (6" x 12", 12" x 12", 12" x 15", 12" x 24", 12" x 36"). The difference in area between the modular stacks and the standard stacks was 5% or less for 80% of the stacks. Since the manufacturing tolerances on paper honeycomb permit a variation of crushing stress of approximately ± 14%, the difference in area between modular stacks and standard stacks should be acceptable.

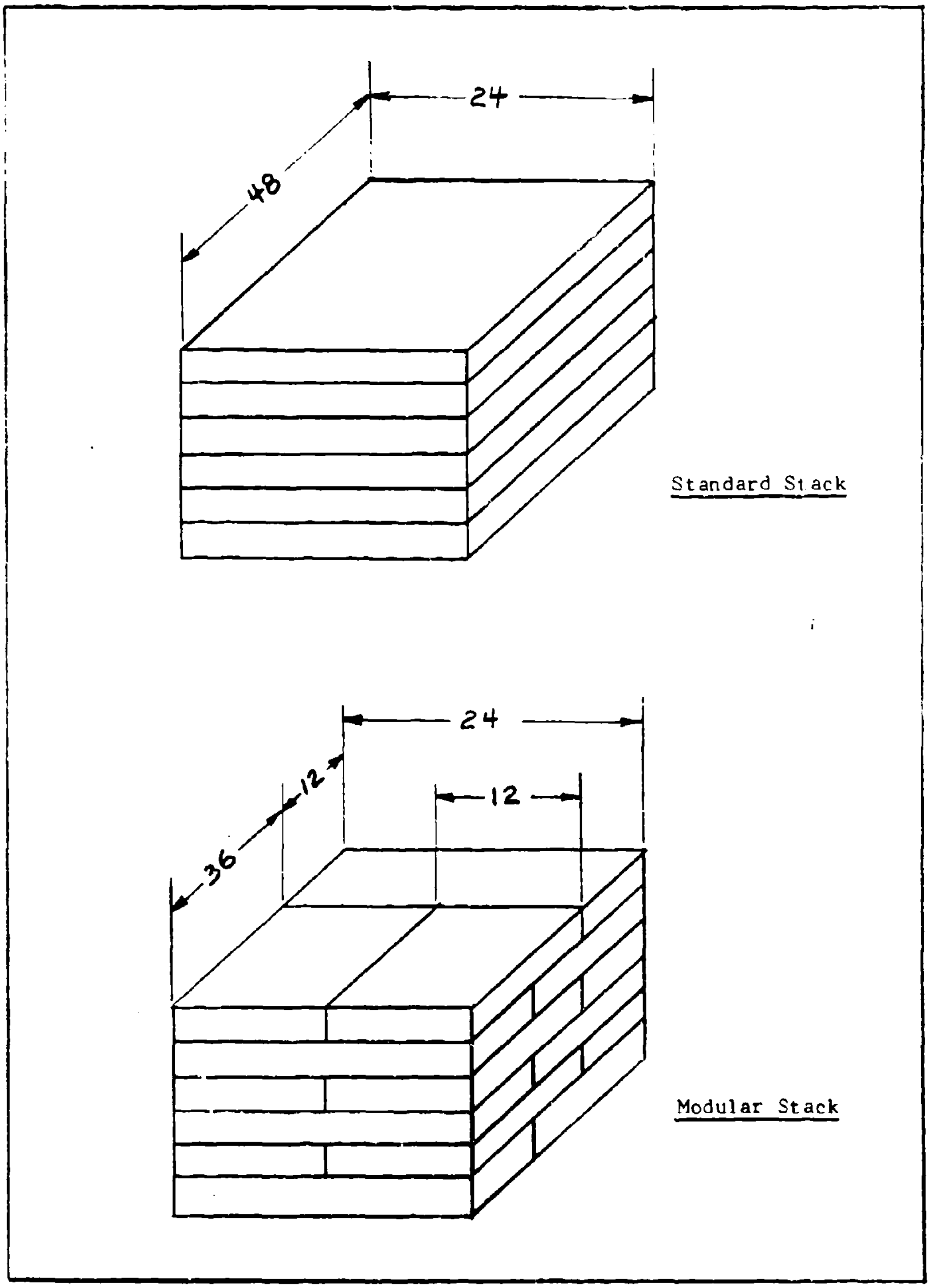

Figure 1. Modular Honeycomb Concept

Table I shows the items considered with a breakdown of the number of different sizes of honeycomb used to rig each vehicle and the total number of pieces of honeycomb. The last two columns show the number of different modular sizes and total number of pieces when using the proposed new system.

As shown on Table I, the total number of different sizes of honeycomb can be reduced from 25 to 5 while the total number of pieces employed would be approximately double. Assembly of modular stacks from precut sizes will be simpler and faster than cutting every piece for each stack and then assembling them even though the total number of modules is approximately twice the total number of standard pieces. Alternatively, precutting 25 sizes compared to five sizes would not be as efficient and would not be flexible since the sizes required for any particular vehicle/load are not necessarily the same as those for another item. The five modular sizes are used to construct stacks for all loads.

TABLE I

Comparison of Honeycomb Requirements of Present Standard and Proposed Modular Stacks

Item	Standard		Proposed Modular	
	No. of Diff. Sizes	Total Number of Pieces	No. of Diff. Sizes	Total Number of Pieces
1/4 Ton Truck	4	39	4	57
1/4 Ton Trailer	1	18	2	36
3/4 Ton Truck	10	50	5	105
3/4 Ton Trailer	6	43	4	84
M274 (Mech Mule)	10	30	3	52
105mm Howitzer	2	14	2	62
2 1/2 Ton Truck	13	77	5	150
Totals	25	271	5	546

DETAIL STACK CONSTRUCTION

The 25 required stack sizes as specified in current Army Technical Manuals for seven common airdrop items are shown in Table II. The resultant stack size constructed from the five proposed basic modules is also shown with a detailed breakdown of the modules used. The difference in area (percent) between the two is also shown. Some of the current cushioning systems employ pieces of honeycomb to connect two stacks. These pieces are common to the two stacks and span the gap (distance) between the individual stacks in a bridge-like manner.

The construction of these bridges requires a modification to the basic construction shown in Table II. This is necessary because of the unsupported length of the bridges. However, all of the bridges required for the common airdrop items can be constructed from the same five modules. Figure 2 illustrates the construction of these bridges. The unsupported area is depicted to show that the modules can accommodate the various spans and maintain structural integrity.

TABLE II.

Construction of Modular Honeycomb Stacks for Rigging the Seven Most Common Vehicular Type Loads

Required Size (per TM)	Modular Size (overall dimensions)	Modules 8 x 12	12 x 12	15 x 15	24 x 12	36 x 12	Percent Difference in Area (Mod. Size - Req. Size) / Req. Size
12 x 12	12 x 12		1				0.0
12 x 42	12 x 42	1				1	0.0
6 x 8	8 x 12	1					50.0
12 x 36	12 x 36					1	0.0
12 x 24	12 x 24				1		0.0
12 x 32	12 x 33	1	1	1			3.1
12 x 67	12 x 61	1		1	1	1	[illegible]
14 x 56	12 x 55	1	1			1	0.0
18 x 36	18 x 36	1				1	0.0
12 x 40	12 x 39			1	1		2.5
12 x 18	12 x 18	1	1				0.0
2 x 10	12 x 69				1	1	0.0
18 x 25	18 x 24	2			1		-4.0
12 x 25	12 x 24				1		-4.0
24 x 63	24 x 60				1	2	0.0
10 x 20	18 x 24	2			1		20.0
12 x 30	12 x 30	1			1		0.0
9 x 14	8 x 12	1					-42.4
6 x 21	6 x 16	2					-24.0
12 x 50	12 x 51		1	1	1		2.0
12 x 48	12 x 48		1		1		0.0
12 x 14	12 x 15			1			7.1
14 x 35	15 x 24			2			2.8
36 x 84	36 x 84				6	3	0.0
12 x 53	12 x 54	1	1			1	1.9

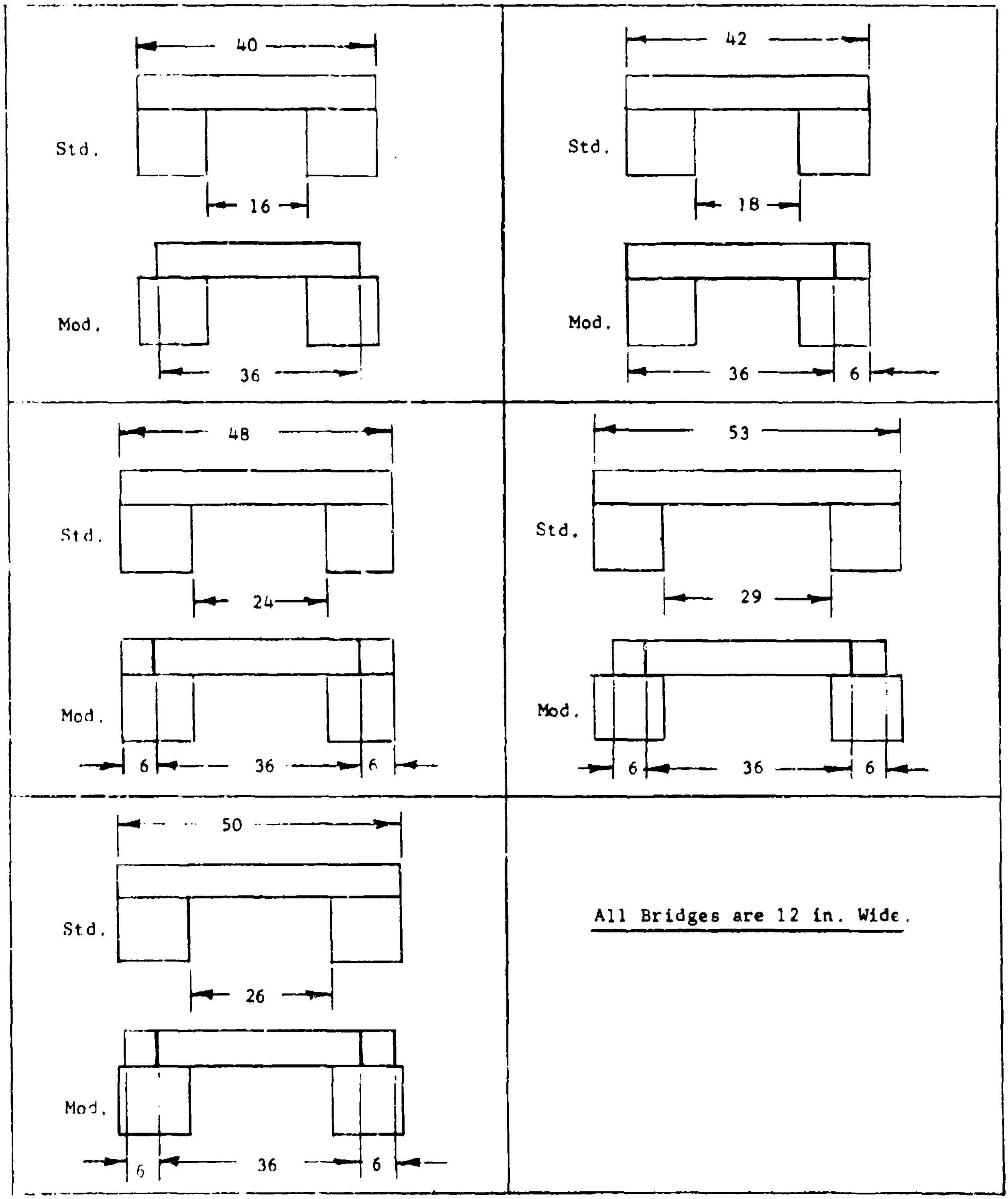

Figure 2

MODULAR HONEYCOMB BRIDGE CONSTRUCTION

Some of the larger size stacks can be constructed in more than one manner from the 5 proposed modules. This is illustrated in Figure 3. The construction of stacks in all of the tables in the report are based on using the largest sizes. This is considered as the preferred method since it results in a minimum number of total pieces. The location of the individual modules is varied in successive layers to stagger the seams as in laying bricks. This provides a more stable construction than laying like modules on top of another.

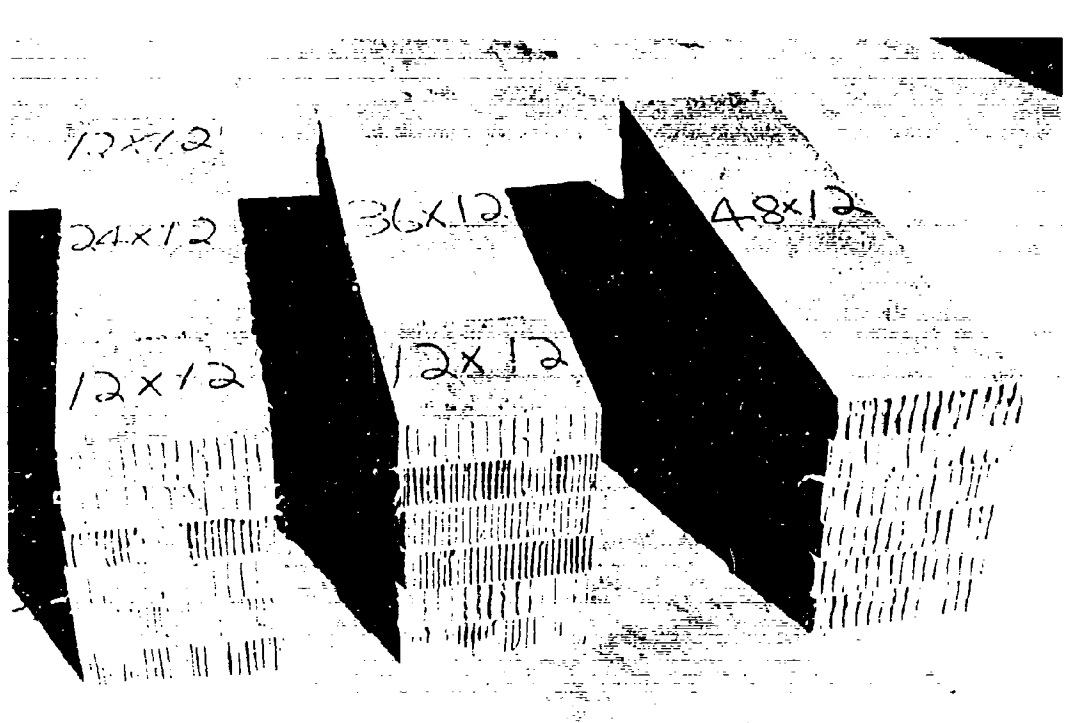

Figure 3. Modular and Standard Honeycomb Stacks

AREA AND VOLUME CONSIDERATIONS

The total surface area of the honeycomb used is of equal, or greater importance, than the area of the individual stacks of honeycomb. The individual stack dimensions distribute the total load in varying magnitudes to different points of the structure of the item being dropped. The total area determines the overall deceleration of the item and the total load and energy to be dissipated by the honeycomb stacks. Table III shows the total surface area for the seven considered items using standard stacks and modular stacks. The difference in all cases except one (1/4 ton truck) is less than 5%. The 1/4 ton truck presently uses a number of pieces of small honeycomb (6" x 8") in the uppermost 3 layers of one stack. This piece accounts for the large difference in the total area. However, since the dissipation of energy is not controlled entirely by the uppermost layers, the difference in energy dissipation of the modular stacks will not necessarily be equal to the difference in area. If re-design of the entire cushioning system (based upon the modular sizes) cannot be accomplished, the 6" x 8" size could be cut from a modular piece for this one load.

Table III also shows the total volume of honeycomb used in both the conventional stacks and the modular stacks. The total volume is also an indicator of the energy dissipating characteristics of the cushioning system, as well as a basic factor concerning cost of raw material.

TABLE III

Total Area and Volume of Modular Honeycomb Stacks Compared to Standard Stacks

Item	Total Surface Area (in^2)			Total Volume of Honeycomb (in^3)		
	Standard	Proposed	Percent Difference	Standard	Proposed	Percent Difference
1/4 Ton Truck	888	1152	30.8*	22,896	22,560	1.47
1/4 Ton Trailer	1008	1008	0.0	27,216	27,216	0.0
3/4 Ton Truck	2264	2252	0.5	76,476	76,224	0.33
3/4 Ton Trailer	1488	1512	1.6	44,100	44,742	1.46
M274 (Mech Mule)	1100	1152	4.7	28,512	27,216	4.55
105mm Howitzer	1296	1296	0.0	36,576	36,576	0.0
2 1/2 Ton Truck	5352	5328	0.5	114,480	113,904	0.50

*By cutting one size (6" x 8") instead of using standard modular size of 6" x 12", this difference would be only 8.1%.

Construction of large area stacks from smaller unit sizes will result in a large perimeter. The edge effects of built-up staggered stacks have not been evaluated. However, an analysis was conducted to determine the ratio of the perimeter to area for the seven items. The maximum difference per stack between standard and modular stacks was found to be 0.167 (Table A-6, Appendix). Although adequate data are not available to determine whether a critical difference exists between the perimeter/area ratios, the limited testing conducted to date indicates that the magnitude of the differences between conventional and proposed stacks will not be detrimental.

POTENTIAL OF CONCEPT FOR UNIVERSAL APPLICATION

The most common vehicular type airdrop loads were selected for the initial analysis to determine if the modular concept was feasible. Also, it was felt that if this concept were applied only to these common items, it would still provide a significant improvement in preparation of airdrop loads since the selected items represent more than 80 percent of all vehicle-type airdrops. The favorable results of this analysis prompted a second analysis to determine if the modular concept had potential for more universal application.

This second analysis considered 31 different items selected at random. These items are listed in Table A-4 in the Appendix. This study was limited to the individual stack construction only, and did not include total area, total volume or perimeter/area ratio determinations.

The 31 items selected require 86 different sizes of honeycomb for construction of the stacks. These 86 sizes can be closely approximated by only five modular sizes with 80 percent of the modular stacks within 10 percent of the current stack areas. The detailed construction of the 86 various size stacks considered in the second analysis is shown in Table A-5, Appendix.

This second study resulted in four of the modules identical to those in the initial analysis. The fifth module was changed from 12" x 15" to 6" x 15" to accommodate a greater variety of stack sizes. A more detailed study of the exact requirements for each cushioning system with special attention to possible minor changes in individual stack dimensions together with additional testing will be required for final determination of optimum number and size of modules. Additionally, it is felt that it would be more desirable to first select four or five basic sizes based on this study, and then design cushioning systems utilizing the basic predetermined modular sizes.

RESULTS OF LABORATORY TEST

Preliminary testing was conducted using a dynamic impact test facility. Only two sizes of stacks were used, 12" x 12" and 16" x 18". The capacity of the test equipment limited the maximum size of the test stack. A total of 10 tests were performed with the conventional construction and 15 tests utilizing modular construction. The maximum difference in crushing stress was five percent. Table IV shows the results of the tests and the perimeter/area ratio for the test stacks. The maximum difference in this ratio (between modular and conventional type stacks) for the test specimens was greater than the maximum difference in any of the proposed modular stacks for the seven common airdrop items investigated.

TABLE IV

Dynamic Crushing Test of Sample Modular Honeycomb Stacks

Stack Size	Module Size(s)	Percent Change in Stress *	Perimeter to Area Ratio	Difference
12 x 12	12 x 12		0.333	
12 x 12	6 x 12	0.7	0.500	0.167
16 x 16	16 x 16		0.236	
16 x 16	9 x 16/8 x 16 ▲	5.0	0.347/0.311	0.111/0.075
16 x 16	6 x 16/8 x 16 ▲	0.3	0.458/0.361	0.222/0.125

* Average of 5 tests

▲ Alternate layers in stack

All stacks 12" thick

CONCLUSIONS

Results of studies to date indicate that it is entirely feasible to rig airdrop loads using a small number of precut modular sizes of honeycomb to construct the stacks required for energy dissipation at ground impact. Five modular sizes appear to offer the best potential for minimum number of total pieces, acceptable handling, and structural integrity of stacks.

Re-design of honeycomb cushioning systems based upon the modular concept would optimize this type construction and possibly reduce the number of modular sizes required.

In addition, the smaller size modules offer better potential for development of practical field expansion of honeycomb than the present large sheets.

RECOMMENDATIONS

a. Conduct further testing of concept using actual rigged loads. Tests should first be static drop tests and then actual airdrops.

b. Evaluate human factors aspects employing Army riggers and standard airdrop loads with modular honeycomb.

c. Conduct cost analysis considering impact on production, storage and preparation of loads for airdrop.

d. Investigate feasibility of re-design of present honeycomb configuration to optimize the use of modular construction.

e. Investigate the feasibility of using 6 inch thick modules in lieu of the present 3 inch thickness honeycomb to further reduce the total number of pieces required for rigging.

APPENDIX

TABLE A-1 DETAIL STACK CONSTRUCTION FOR COMMON ITEMS

Item	Honeycomb Dimensions (Standard Stack)	Number of Pieces	Number of Modules					Total Number of Modules
			6 x 12	12 x 12	15 x 12	24 x 12	36 x 12	
1/4 Ton Truck	18 x 20	6	12	0	0	6	0	18
	6 x 8	24 (or cut special 6 x 8)	24	0	0	0	0	24
	24 x 48	3	0	0	0	3	6	9
	12 x 12	6	0	6	0	0	0	6
Totals		39	36	6	0	9	6	57
1/4 Ton Trailer	12 x 42	18	18	0	0	0	18	36
Totals		18	18	0	0	0	18	36
3/4 Ton Truck	24 x 48	6	0	0	0	6	12	18
	12 x 24	3	0	0	0	3	0	3
	12 x 54	14	14	14	0	0	14	42
	12 x 40	2	0	0	0	0	2	2
	12 x 30	2	2	0	0	2	0	4

TABLE A-1 (Cont'd)

Item	Honeycomb Dimensions (Standard Stack)	Number of Pieces	Number of Modules					Total Number of Modules
			6 x 12	12 x 12	15 x 12	24 x 12	36 x 12	
3/4 Ton Truck (Cont'd)	12 x 12	10	0	10	0	0	0	10
	12 x 48	1	2	0	0	0	1	3
	12 x 40	9	0	0	9	9	0	18
	12 x 14	2	0	0	2	0	0	2
	12 x 48	1	2	0	0	0	1	3
Totals		50	20	24	11	20	30	105
3/4 Ton Trailer	12 x 36	10	0	0	0	0	10	10
	12 x 12	12	0	12	0	0	0	12
	12 x 50	1	2	0	0	0	1	3
	12 x 32	18	18	18	18	0	0	54
	12 x 42	1	1	0	0	0	1	2
	12 x 53	1	2	0	0	0	1	3
Totals		43	23	30	18	[illegible]	13	84

TABLE A-1 (Cont'd)

Item	Honeycomb Dimensions (Standard Stack)	Number of Pieces	Number of Modules					Total Number of Modules
			6 x 12	12 x 12	15 x 12	24 x 12	36 x 12	
M274 Mech Mule	18 x 25	5	10	0	0	5	0	15
	9 x 14	2	0	0	2	0	0	2
	14 x 25	1	0	0	0	2	0	2
	18 x 25	5	10	0	0	5	0	15
	9 x 14	2	0	0	2	0	0	2
	14 x 25	1	0	0	0	2	0	2
	12 x 25	5	0	0	0	5	0	5
	8 x 25	2	0	0	0	2	0	2
	12 x 25	5	0	0	0	5	0	5
	8 x 25	2	0	0	0	2	0	2
Totals		30	20	0	4	28	0	52
105mm Howitzer	36 x 84	2	0	0	0	0	14	14
	18 x 36	12	36	0	0	0	12	48
Totals		14	36	0	0	0	26	62

TABLE A-1 (Cont'd)

Item	Honeycomb Dimensions (Standard Stack)	Number of Pieces	Number of Modules					Total Number of Modules
			6 x 12	12 x 12	15 x 12	24 x 12	36 x 12	
2 1/2 Ton Truck	12 x 24	13	0	0	0	13	0	13
	12 x 12	7	0	7	0	0	0	7
	12 x 18	7	7	7	0	0	0	14
	12 x 50	1	2	0	0	0	1	3
	12 x 82	8	8	0	8	8	8	32
	12 x 82	8	8	0	8	8	8	32
	12 x 30	1	1	0	0	1	0	2
	12 x 60	5	0	0	0	5	5	10
	12 x 30	1	1	0	0	1	0	2
	12 x 60	5	0	0	0	5	5	10
	12 x 36	13	0	0	0	0	13	13
	12 x 18	4	4	4	0	0	0	8
	12 x 24	4	0	0	0	4	0	4
Totals		77	31	18	16	45	40	150

TABLE A-2 VOLUME OF STACKS FOR COMMON ITEMS

Item	Stack No.	Standard Stack Dimensions	Volume	Modular Stack Dimensions	Volume
1¼ Ton Truck	1	1[illegible] x 20 x 6 x 3	6480	6 x 3 x 24 x 18	6144
	2	24 x 48 x 3 x 3	10,368	3 x 3 x 24 x 48	10,368
		3 x 6 x 8 x 3 x 3	3,456	24 x 3 x 6 x 8	3,456
	3	12 x 12 x 6 x 3	2,592	6 x 3 x 12 x 12	2,592
Total			22,896		22,560
1/4 Ton Trailer	1	18 x 3 x 12 x 42	27,216	18 x 3 x 12 x 42	27,216
Total			27,216		27,216
3/4 Ton Truck	1	(6 x 3 x 24 x 48) -(9 x 12 x 3)	20,736 -324	(6 x 3 x 24 x 48) -(3 x 9 x 12)	20,736 -324
		3 x 3 x 12 x 24	2,592	3 x 3 x 12 x 24	2,592
	2	(14 x 3 x 12 x 54) -(6 x 4 x 22)	27,216 -528	(14 x 3 x 12 x 54) -(3 x 4 x 22)	27,216 -528
		2 x 3 x 12 x 40	2,880	2 x 3 x 12 x 40	2,880
		2 x 3 x 12 x 30	2,160	2 x 3 x 12 x 30	2,160
	3	10 x 3 x 12 x 12	4,320	10 x 3 x 12 x 12	4,320

TABLE A-2 (Cont'd)

Item	Stack No.	Standard Stack Dimensions	Volume	Modular Stack Dimensions	Volume
3/4 Ton Truck (Cont'd)		1 x 3 x 12 x 48	1,728	1 x 3 x 12 x 48	1,728
	4	9 x 3 x 12 x 40	12,960	9 x 3 x 12 x 39	12,636
		2 x 3 x 12 x 14	1,008	2 x 3 x 12 x 15	1,080
		1 x 3 x 12 x 48	1,728	1 x 3 x 12 x 48	1,728
Total			76,476		76,224
3/4 Ton Trailer	1	10 x 3 x 12 x 36	12,960	10 x 3 x 12 x 36	12,960
	2	12 x 3 x 12 x 12	5,184	12 x 3 x 12 x 12	5,184
		1 x 3 x 12 x 50	1,800	1 x 3 x 12 x 50	1,800
	3	18 x 3 x 12 x 32	20,736	18 x 3 x 12 x 33	21,378
		1 x 3 x 12 x 42	1,512	1 x 3 x 12 x 42	1,512
		1 x 3 x 12 x 53	1,908	1 x 3 x 12 x 53	1,908
Total			44,100		44,742
M274 Mech Mule	1	5 x 3 x 15 x 25	6,750	5 x 3 x 18 x 24	6,480
		2 x 3 x 9 x 14	756	2 x 3 x 12 x 15	1,080

TABLE A-2 (Cont'd)

Item	Stack No.	Standard Stack Dimensions	Volume	Modular Stack Dimensions	Volume
M274 Mech Mule (Cont'd)		1 x 3 x 4 x 25	1,050	1 x 3 x 12 x 24	864
	2	Same as stack 1		Same as stack 1	
	3	5 x 2 x 12 x 25	4,500	5 x 3 x 12 x 24	4,320
		2 x 3 x 8 x 25	1,200	2 x 3 x 6 x 24	864
	4	Same as stack 3		Same as stack 3	
Total			28,512		27,216
105mm Howitzer	1	2 x 3 x 36 x 84	18,144	2 x 3 x 36 x 84	18,144
		6 x 3 x 18 x 36	9,216	6 x 3 x 18 x 36	9,216
	2	6 x 3 x 18 x 36	9,216	6 x 3 x 18 x 36	9,216
Total			36,576		36,576
2 1/2 Ton Truck	1	13 x 3 x 12 x 24	11,232	13 x 3 x 12 x 24	11,232
	2	7 x 3 x 12 x 12	3,024	7 x 3 x 12 x 12	3,024
		7 x 3 x 12 x 18	4,536	7 x 3 x 12 x 18	4,536
		1 x 3 x 12 x 50	1,800	1 x 3 x 12 x 50	1,800

TABLE A-2 (Cont'd)

Item	Stack No.	Standard Stack Dimensions	Volume	Modular Stack Dimensions	Volume
2 1/2 Ton Truck (Cont'd)	3	8 x 3 x 12 x 82	23,616	8 x 3 x 12 x 81	23,328
	4	Same as Stack 3		Same as Stack 3	
	5	1 x 3 x 12 x 30	1,080	1 x 3 x 12 x 30	1,080
		5 x 3 x 12 x 60	10,800	5 x 3 x 12 x 60	10,800
	6	Same as Stack 5		Same as Stack 5	
	7	13 x 3 x 12 x 36	16,848	13 x 3 x 12 x 36	16,848
	8	2 x 3 x 12 x 18	1,296	2 x 3 x 12 x 18	1,296
	9	Same as Stack 8		Same as Stack 8	
	10, 11, 12, 13	4 x 3 x 12 x 24	3,456	4 x 3 x 12 x 24	3,456
Total			113,450		113,904

TABLE A-3 SURFACE AREA OF STACKS FOR COMMON ITEMS

Item	Stack No.	Standard Stack Dimensions	Surface Area (in^2)	Modular Stack Dimensions	Surface Area (in^2)
1/4 Ton Truck	1	18 x 20	360	18 x 24	432
	2	8 x 6 (8)	384	12 x 6 (8)	576
	3	12 x 12	144	12 x 12	144
Totals			888		1152
1/4 Ton Trailer	1	12 x 42	504	12 x 42	504
	2	12 x 42	504	12 x 42	504
Totals			1008		1008
3/4 Ton Truck	1	12 x 24	288	12 x 24	288
	2	12 x 54	648	12 x 54	648
		8 x 22	176	8 x 22	176
		12 x 32	384	12 x 32	384
	3	12 x 12	144	12 x 12	144
		12 x 12	144	12 x 12	144
	4	12 x 40	480	12 x 39	468
Totals			2264		2252

TABLE A-3 (Cont'd)

Item	Stack No.	Standard Stack Dimensions	Surface Area (in^2)	Modular Stack Dimensions	Surface Area (in^2)
3/4 Ton Trailer	1	12 x 36	432	12 x 36	432
	2	12 x 12	144	12 x 12	144
		12 x 12	144	12 x 12	144
	3	12 x 32	384	12 x 33	396
		12 x 32	384	12 x 33	396
Totals			1488		1512
M274 Mech Mule	1	14 x 25	350	12 x 24	288
	2	14 x 25	350	12 x 24	288
	3	8 x 25	200	12 x 24	288
	4	8 x 25	200	12 x 24	288
Totals			1100		1152
105mm Howitzer	1	18 x 36	648	18 x 36	648
	2	18 x 36	648	18 x 36	648
Totals			1296		1296

TABLE A-3 (Cont'd)

Item	Stack No.	Standard Stack Dimensions	Surface Area (in^2)	Modular Stack Dimensions	Surface Area (in^2)
2 1/2 Ton Truck	1	12 x 24	288	12 x 24	288
	2	12 x 12	144	12 x 12	144
		12 x 18	216	12 x 18	216
	3	12 x 82	984	12 x 81	972
	4	12 x 82	984	12 x 81	972
	5	12 x 30	360	12 x 30	360
	6	12 x 30	360	12 x 30	360
	7	12 x 36	432	12 x 36	432
	8, 9	12 x 18	2 x 216	12 x 18	2 x 216
	10, 11 12, 13	12 x 24	4 x 288	12 x 24	4 x 288
Totals			5352		5328

TABLE A-4 LIST OF LOADS

1. 1/4 Ton Utility Truck
2. M37 Cargo
3. M101 3/4 Ton Cargo Trailer
4. M410 1/4 Ton Cargo Trailer
5. 105mm Howitzer
6. M34-M35 2 1/2 Ton Truck
7. Full Tracked Tractors
8. M56 Self Propelled Full Track 90mm Gun
9. M22 Road Grader
10. AC4 Road Rollers
11. 7-35 Ton Road Rollers
12. Road Scraper
13. 1 1/2 Ton 2 Wheeled Trailers
14. M274 1/2 Ton 4 x 4
15. 3/4 Ton 4 x 4 Emergency Repair Shop Truck
16. Caterpillar 93 Bucket Loader
17. 7 Ton Airborne Crane
18. Water Purification - Trailer Mounted
19. 318mm Rocket System
20. 2 1/2 Ton Pole Type Utility Trailer
21. M220 Road Grader
22. Tracked Personnel/Cargo Carrier
23. Trailer Mounted Air Compressor
24. 7 1/2 Cubic Yard Scraper
25. Industrial Wheel Tractor
26. M28, M29
27. ENTAC MISSILE SYSTEM
28. M85, AM Scoop Type Loader
29. M114 Armored
30. Trailer Mounted Generator Set
31. A/S 32/H-12

TABLE A-5 Construction of Modular Stacks for 31 Drop Items

Required Size	Modular Size	Number of Modules					Percent Difference In Area
		6 x 12	6 x 15	12 x 12	12 x 24	12 x 36	
5 x 10	6 x 12	1					44.0
5 x 12	6 x 12	1					20.0
5 x 25	6 x 24	2					15.2
6 x 8	6 x 12	1					50.0
6 x 12	6 x 12	1					0
6 x 30	6 x 30		2				0
7 x 12	6 x 12	1					14.3
8 x 12	6 x 12	1					25.0
8 x 15	6 x 15		1				25.0
8 x 18	12 x 18	1		1			50.0
8 x 25	6 x 24	2					28.0
8 x 27	6 x 30		2				16.6
8 x 38	6 x 42	1	3				12.1
9 x 14	6 x 15		1				28.5

TABLE A-5 (Cont'd)

Required Size	Modular Size	Number of Modules					Percent Difference In Area
		6 x 12	6 x 15	12 x 12	12 x 24	12 x 36	
9 x 24	12 x 24				1		33.3
10 x 12	12 x 12			1			20.0
11 x 27	12 x 27		2	1			9.1
12 x 12	12 x 12			1			0
12 x 16	12 x 15		2				6.2
12 x 18	12 x 18	1		1			0
12 x 20	12 x 21	1	2				5.0
12 x 22	12 x 21	1	2				4.5
12 x 24	12 x 24				1		0
12 x 25	12 x 24				1		4.0
12 x 28	12 x 27		2	1			3.5
12 x 29	12 x 30		4				3.4
12 x 30	12 x 30		4				0
12 x 32	12 x 33	1	2	1			3.1

TABLE A-5 (Cont'd)

Required Size	Modular Size	Number of Modules					Percent Difference In Area
		6 x 12	6 x 15	12 x 12	12 x 24	12 x 36	
12 x 33	12 x 33	1	2	1			0
12 x 36	12 x 36					1	0
12 x 40	12 x 39		2		1		2.5
12 x 42	12 x 42	1				1	0
12 x 48	12 x 48			1		1	0
12 x 50	12 x 51	1	6				2.0
12 x 53	12 x 54	1		1		1	1.9
12 x 54	12 x 54	1		1		1	0
12 x 58	12 x 57	1	2			1	1.7
12 x 60	12 x 60				1	1	0
12 x 80	12 x 81	1	2		1	1	1.2
12 x 84	12 x 84			1		2	0
12 x 96	12 x 96				1	2	0
13 x 22	12 x 21	1	2				11.9
14 x 25	15 x 24		4				2.5

TABLE A-5 (Cont'd)

Required Size	Modular Size	Number of Modules					Percent Difference In Area
		6 x 12	6 x 15	12 x 12	12 x 24	12 x 36	
17 x 17	18 x 15		3				6.9
17 x 33	18 x 30		6				3.7
17 x 96	18 x 96	8			1	2	5.9
18 x 18	18 x 15		3				16.6
18 x 20	18 x 24	2			1		20.0
18 x 22	18 x 24	2			1		9.1
18 x 25	18 x 24	2			1		4.0
18 x 30	18 x 30		6				0
18 x 32	18 x 30		6				6.3
18 x 36	18 x 36	3				1	0
18 x 39	18 x 39	2	3		1		0
18 x 40	18 x 42	[illegible]	6	1			5.0
18 x 4[illegible]	18 x 48	4		1		1	0
18 x 52	18 x 54	2	6		1		3.8
18 x 56	18 x 57	1	9	[illegible]			1.9
18 x 58	18 x 60	5			1	1	3.4
18 x 60	18 x 60	5			1	1	0

TABLE A-3 (Cont'd)

Required Size	Modular Size	Number of Modules					Percent Difference In Area
		6 x 12	6 x 15	12 x 12	12 x 24	12 x 36	
18 x 62	18 x 60	5			1	1	3.2
18 x 63	18 x 60	5			1	1	4.8
18 x 72	18 x 72	6				2	0
18 x 84	18 x 84	7			2	1	0
18 x 91	18 x 90	5	6		1	1	1.1
18 x 96	18 x 96	5			1	2	0
18 x 114	18 x 120	10			5		5.0
18 x 144	18 x 144	12				4	0
20 x 30	18 x 30		6				10.0
36 x 20	26 x 21	3	6				5.0
22 x 33	21 x 36	3	6				4.1
22 x 46	21 x 48	4	6				0.4
22 x 49	21 x 48	4	6				4.5
22 x 50	21 x 54	7	12				[illegible].2
24 x 24	24 x 24				2		0
24 x 36	24 x 36					1	[illegible]

TABLE A-5 (Cont'd)

Required Size	Modular Size	Number of Modules					Percent Difference In Area
		6 x 12	6 x 15	12 x 12	12 x 24	12 x 36	
24 x 36	24 x 36					2	0
24 x 48	24 x 48			2		2	0
24 x 84	24 x 54			2		4	0
24 x 96	24 x 96				2	4	0
36 x 40	36 x 39		6		3		2.5
36 x 48	36 x 48			3		3	0
36 x 52	36 x 51		6			3	1.9
36 x 80	36 x 81	3	6		3	3	1.2
36 x 84	36 x 84				6	3	0
36 x 90	36 x 90		12		3	3	0
36 x 96	36 x 96				6	3	0

Table A-6. Perimeter to Area Ratio Comparison

Item	Stack Number	Ratio		
		Standard Stack	Modular Stack	Difference
1/4 Ton Truck	1	0.211	0.333	0.122
	2	0.583	0.583	0.000
	3	0.333	0.333	0.000
1/4 Ton Trailer	1	0.214	0.262	0.048
	2	0.214	0.262	0.048
3/4 Ton Truck		0.250 0.204	0.250 0.278	0.000 0.074
	2	0.264	0.307	0.043
	3	0.333	0.250	0.083
	4	0.217	0.269	0.052
3/4 Ton Trailer	1	0.222	0.222	0.000
	2	0.333	0.333	0.000
	3	0.229	0.348	0.119
	4	0.229	0.348	0.119
M274 Mech Mule	1	0.166	0.250	0.084
	2	0.166	0.250	0.084
	3	0.333	0.500	0.167
	4	0.333	0.500	0.167

Table A-6 Cont'd)

Item	Stack Number	Ratio		
		Standard Stack	Modular Stack	Difference
105mm Howitzer	1	0.167	0.315	0.148
	2	0.167	0.315	0.148
2 1/2 Ton Truck	1	0.250	0.250	0.000
	2	0.333	0.333	0.000
	3	0.189	0.265	0.076
	4	0.189	0.265	0.076
	5	0.233	0.300	0.067
	6	0.233	0.300	0.067
	7	0.222	0.222	0.000
	8	0.278	0.389	0.111
	9	0.278	0.389	0.111
	10 - 13	0.250	0.250	0.000

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Natick Laboratories Natick, Massachusetts 01760	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

Modular Honeycomb Concept for Preparation of Loads for Delivery by Airdrop

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

James F. Falcone

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1969	31	

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1F162203D195 c. Task 08 d.	9a. ORIGINATOR'S REPORT NUMBER(S) 69-63-AD 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	US Army Natick Laboratories Natick Massachusetts 01760

13. ABSTRACT

Current studies aimed at simplification of the preparation of loads for delivery by airdrop have resulted in a concept for a simplified method of preparing the honeycomb cushioning system. This concept employs a small number of standard size honeycomb modules which can be used as "building blocks" to construct the many different sized stacks employed in current rigging procedures. Analysis and limited testing indicate that it would be feasible to use five standard size modules of honeycomb to rig practically all airdrop loads.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Design	8		8			
Modular structures	9		2			
Paper Honeycomb	9		1			
Air drop operations	4		4			
Construction			8			
Stacking			8			
Honeycomb structures			1			
Size separation	9		8			