LIGHTWEIGHT CMU

...a weight off our shoulders

Although unit price may be slightly higher, increased productivity more than offsets the expense when looking at costs in laying up a wall.

BY KYLE LOCHONIC

LIGHTWEIGHT CONCRETE MASONRY UNITS (CMU) have much to offer. They are cost efficient and increase productivity, shortening schedule durations. Their reduced weight benefits trucking and lessens wear and tear on equipment. Most importantly, they cause less wear and tear on employees and could potentially decrease their exposure to silicosis. I have also noticed a higher level of workmanship and fewer punch list items relating to chipped block when lightweight material is used. This certainly will not hurt in efforts to recruit new masons into the work force.

CMU are categorized into three weight classes per ASTM C90: normal (heavy) weight, medium weight and lightweight. Classes are defined by the weight per cubic foot (pcf) of material. Heavyweight units are 125 lb pcf or more. Medium weight units are between 105 and 125 lb pcf. Lightweight units are less than 105 lb pcf. This translates to 8″ heavyweight units at 34 lb or more, medium weight units between 28 and 34 lb, and lightweight units that are less than 28 lb based on a 50% solid unit.

A mason working 2000 hours in a year, laying 150 8″ heavyweight units per day, will handle more than 1.8 million pounds of block and mortar. A laborer tending these masons will handle three to five times this weight.

Aggregate availability

IN THE '60S, LIGHTWEIGHT UNITS WERE THE standard in southeast Michigan. Cinders, a byproduct of coal burning, provided an inexpensive aggregate source that also happened to be very lightweight for manufacturers, hence the term *cinderblock*. These aggregates fell from favor in the early '70s and are no longer used. Current lightweight units use expanded clay, shale or slag aggregate. During the same time period, a recession affected the construction industry in Michigan. Increased pressure to reduce prices, coupled with stiff competition, forced manufacturers to reduce costs wherever possible. The least-expensive, most readily available aggregates in the area are sand and gravel, byproducts of ice-age glaciers. Unfortunately these aggregates are heavy. Lightweight units ceased to exist and medium weight units weighing close to 125 pcf became the norm. Continued price pressure created by excess production in the area and contractors' desire to generate profits by purchasing the lowest priced units have maintained this situation.

This has adversely affected our industry. For the last 10 to 15 years, production has slowly and steadily decreased. There is little doubt that the weight of units is one of the factors that can be directly correlated to this decrease. Not only does weight affect daily production but, over an extended period of time, accumulated weight wears workers down. This can increase potential for workplace injury as body parts literally wear out. Effect of weight and price of CMU, in relation to profit, needs close analysis. The least expensive unit may not always be the best value.

Increased productivity for lower wall cost

NUMEROUS STUDIES SHOW THAT LIGHTWEIGHT units result in increased productivity when compared to heavyweight units. A study sponsored by the National Concrete Masonry Association (NCMA) and the Expanded Shale, Clay & Slate Institute to determine the effect of unit size and weight on mason productivity compared 16″ and

Nominal Size (in)	Weight (lb)	Lightweight Net Vol.* (cu ft)	Unit Weight (pcf)	Weight (lb)	Heavyweight Net Vol.* (cu ft)	Unit Weight (pcf)
4 x 8 x 16	17.0	0.19	88.9	24.3	0.19	130.1
6 x 8 x 16	19.1	0.23	84.1	32.6	0.25	129.7
8 x 8 x 16	25.3	0.28	90.5	34.3	0.27	128.1
12 x 8 x 16	35.6	0.40	89.0	48.4	0.38	126.6

* Calculated Values

Table 1. Unit properties from NCMA study. From Masonry magazine May/June 1989.

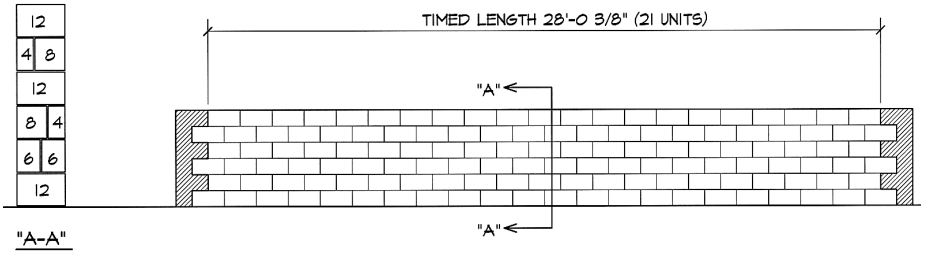

Figure 1. Layout of wall constructed of 16″ long CMU.

24″ long heavyweight and lightweight units. The study shows direct correlations between size and weight of units and production. The study was published in Masonry magazine, May/June 1989. For the purpose of this article, focus will be placed on the comparisons of 16″ long units, which are typically used in Michigan.

Identical walls, constructed using heavyweight and lightweight units, were built by the same mason under strictly controlled conditions, established so that comparisons would be valid. Walls were constructed using pre-built line guides. End units at each course were laid first to position the line (trigs were used). These units were not considered part of the timed portion. Hardware cloth was laid in the bed joint of each course to provide a base for the mortar of various size face shells. Unit properties are found in Table 1. See Figure 1 for wall design.

Lightweight units show production increases from 3.6% to 32.1%. The average increase in production using lightweight units is 14.7%. With the exception of 4″ units, the rate of productivity increase grew with unit size. It is possible that the 4″ lightweight unit was laid one-handed as opposed to two-handed for the heavyweight units. The comparison of results between 16″ long heavyweight and lightweight units is shown in Table 2.

Information is supported in NCMA TEK Note 4-1A: Productivity and Modular Coordination in Concrete Masonry Construction (2002), which states "concrete masonry unit weight greatly impacts masonry productivity, with lighter weight units resulting in higher productivity rates (other factors being equal). Based on typical hollow concrete masonry units, the use of lightweight concrete masonry units (less than 105 pcf [1,680 kg/m^3] concrete) can increase productivity 10% to 18% over heavyweight units (125 pcf [2,000 kg/m^3] or denser concrete) 8″ (203-mm) units and 20% to 54% for 12″ (305-mm) units" (see Figure 2).

Based on this information, we can assume the following:

1. Lightweight units increase production over heavyweight units.
2. Production decreases as the weight of the unit increases.

Looking closely at Figure 2, the plotted production between 10 and 50 lb represents a fairly straight line. If the production for 10 lb units is 200 units per day and the production for 50 lb units is 100, the linear equation for the line would be $y = 225 - 2.5x$ where y is production and x is the weight of the unit. Plotting a representative sample of the various weights of an 8″ x 8″ x 16″ unit yields production information in Table 3.

Unit Size (in)	Type	Course	Line Placement	Time/course (Min:Sec)	Time/unit (Sec)	No. Block (hr.)	Rate (sf/hr.)	Rate (% change)
4 x 8 x 16	HW	3	Inside	15:28	44.2	81.4	72.9	
	LW			13:21	38.1	86.7	86.7	+18.9
4 x 8 x 16	HW	5	Outside	19:16	55.1	65.3	58.5	
	LW			15:36	44.6	80.7	72.2	+23.4
6 x 8 x 16	HW	2	Outside	15:04	43.1	83.5	74.8	
	LW			14:32	41.5	86.7	77.5	+3.6
6 x 8 x 16	HW	2	Inside	15:15	43.6	82.6	73.9	
	LW			14:01	40.1	89.8	80.4	+8.8
8 x 8 x 16	HW	3	Outside	16:26	47.0	76.6	68.6	
	LW			15:12	43.3	82.9	74.1	+8.0
8 x 8 x 16	HW	5	Inside	16:08	46.1	78.1	69.8	
	LW			14:40	41.9	85.9	76.8	+10.0
12 x 8 x 16	HW	1	Inside	16:08	46.1	78.1	69.8	
	LW			13:21	38.1	94.5	84.4	+20.9
12 x 8 x 16	HW	4	Outside	16:09	46.1	78.1	69.8	
	LW			14:51	42.3	85.1	75.9	+8.7
12 x 8 x 16	HW	6	Inside	20:36	58.9	61.1	54.7	
	LW			15:35	44.5	80.9	72.3	+32.1

Table 2. Comparison of results 16" long heavyweight vs. lightweight units. From Masonry magazine May/June 1989.

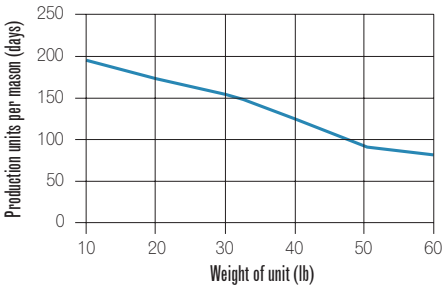

Figure 2. Estimated production rates based on CMU weight. Reprinted with NCMA permission from Kolkoski, R.V., Masonry Estimating. Craftsman Book Company, 1988.

With these production numbers, installed square foot cost comparisons can be made among different weight units using 8″ units laid in the Detroit Metro area. The list price from one metro area supplier for 8″ CMU is:

8″ x 8″ x 16″ heavyweight $1.21
8″ x 8″ x 16″ medium weight $1.52
8″ x 8″ x 16″ lightweight $1.87

Most contractors receive some discount from list price and we will also see how that affects the installed cost. To determine the installed square foot cost, we need to establish a labor rate to use. The process of laying masonry requires each mason to be tended by laborers who, in turn, are supported by a mixer man and a forktruck driver. A non-working foreman usually supervises the crew. The best way to incorporate these support personnel is to use a *manday* cost. A manday cost is defined as the cost per eight hours for a tended, supervised mason. To determine a manday cost, we calculate the cost of a typical crew and divide by the number of working masons. The manday cost would be calculated as shown in Table 4.

Unit Type	Weight (pcf)	Weight (lb)	Production
Heavyweight	145	38.9	127.9
	140	37.5	131.2
	135	36.2	134.6
	130	34.8	137.9
	125	33.5	141.3
Medium weight	120	32.2	144.6
	115	30.8	148.0
	110	29.5	151.3
	105	28.1	154.7
Lightweight	100	26.8	158.0
	95	25.5	161.4
	90	24.1	164.7
	85	22.8	168.1
	80	21.4	171.4
	75	20.1	174.8

Table 3. Weight vs. production

Crew Cost	Quantity	Hours	Rate	Total
Mason Foreman	1	8	$51.63	$413.04
Mason	6	48	$48.04	$2,305.92
Laborer Foreman	1	8	$38.99	$311.92
Laborer	3	24	$37.01	$888.24
				$3,919.12
Crew Size	1	Working Masons		6.00
		Manday Cost		$653.19

Table 4. Manday cost

Applying the material cost and the labor cost to the Production Table yields the figures in Table 5.

Unit Type	Price	Weight (pcf)	Weight (lb)	Production	sf/Day	Material	Labor	sf Cost
Heavyweight	$1.21	145	38.9	127.9	113.6	$154.70	$653.19	$7.11
	$1.21	140	37.5	131.2	116.6	$158.75	$653.19	$6.96
	$1.21	135	36.2	134.6	119.6	$162.81	$653.19	$6.82
	$1.21	130	34.8	137.9	122.6	$166.86	$653.19	$6.69
	$1.21	125	33.5	141.3	125.6	$170.91	$653.19	$6.56
Medium weight	$1.52	120	32.2	144.6	128.5	$219.79	$653.19	$6.79
	$1.52	115	30.8	148.0	131.5	$224.88	$653.19	$6.68
	$1.52	110	29.5	151.3	134.5	$229.98	$653.19	$6.57
	$1.52	105	28.1	154.7	137.5	$235.07	$653.19	$6.46
Lightweight	$1.83	100	26.8	158.0	140.4	$289.14	$653.19	$6.71
	$1.83	95	25.5	161.4	143.4	$295.27	$653.19	$6.61
	$1.83	90	24.1	164.7	146.4	$301.40	$653.19	$6.52
	$1.83	85	22.8	168.1	149.4	$307.53	$653.19	$6.43
	$1.83	80	21.4	171.4	152.4	$313.66	$653.19	$6.35
	$1.83	75	20.1	174.8	155.3	$319.79	$653.19	$6.26

Table 5. Weight vs. sf cost

Unit Type	Price	Weight (pcf)	Weight (lb)	Production	sf/Day	Material	Labor	sf Cost
Heavyweight	$0.70	145	38.9	127.9	113.6	$89.50	$653.19	$6.54
Medium weight	$0.90	124	34.7	138.2	122.8	$124.38	$653.19	$6.33
Lightweight	$1.15	78	21.8	170.4	151.5	$195.96	$653.19	$5.61

Table 6. Local cost

Unit Type	Production	sf/Day	Material	Labor	sf Cost
Medium weight	138.0	142.2	$124.38	$653.19	$6.33
Lightweight	148.0	151.1	$170.20	$653.19	$6.26

Table 7. Revised Production

The overall trend shows reduced cost from heavyweight to lightweight units. It should be noted that units within an individual weight class cost the same, although their weight range within the class varies, affecting production. For this reason, a unit at the heavy end of a weight class costs more to install than a unit at the light end of the next heavier class. By contrast, the difference in cost of a unit at the light end of a weight class is significantly less expensive to install than a unit at the heavy end of the next heavier class.

Now look at an example using discounted pricing and unit weights typical for our area (see Table 6).

Lightweight units, when installed, are almost 13% less than medium weight units and 16% less than heavyweight units. At this point, contractors reading this article are saying "sure that sounds great, but I think your production numbers may be incorrect" or some similar unprintable expletive. I acknowledge that the weight to production numbers from the NCMA table do seem a bit different from what I would expect. It would certainly be worth studying further to see if the reality of production to weight in this area is accurately reflected in the table. I'm willing to bet, however, that almost everyone will agree that laying lightweight 8″ units is good for at least a production increase of 10 to 15 units per day. Using the more conservative 10 units per day in our table gives the figures represented in Table 7.

Added value

BASED ON THESE FIGURES, LIGHTWEIGHT UNITS are at least equal to medium weight units in installed cost, but what about value? My experience with lightweight units has shown that they also bring additional benefits. An example of some of these benefits would be:

1. Fewer chips from handling
2. Easier to lay, laid with better workmanship
3. Fewer punch list items from chips
4. Happier employees
5. Fewer strain injuries
6. Less wear and tear on equipment from weight
7. Higher fire ratings
8. Lighter loads for trucking
9. 15 more units per cube with less weight, less forklift time
10. Easier to saw
11. Reduced silica in aggregate, less risk of silicosis
12. Improved schedule durations

These items all have value. The best way I know to apply value of subjective items is to break them down by groups and apply my best estimate based on known costs. See Table 8.

Item	Description	Rating	Value
Base Cost	Lightweight sf installed cost	88.0%	$6.26
Equipment	Wear and Tear	2.5%	$0.16
Morale	Happy, less tired employees	2.0%	$0.13
Injuries	Less strain injuries	2.5%	$0.16
Workmanship	Higher quality workmanship	2.0%	$0.13
Schedule	More volume in less time	3.0%	$0.19

Table 8. Value of subjective items

This would seem to indicate another $0.77 or 12% added value when using lightweight units.

Possible issues

EVEN CONSERVATIVELY, IT IS HARD TO FIND reasons not to use lightweight units. Some issues that arise in discussions about using lightweight units include:

• Lack of space at block plants for additional types of block and fittings. Lightweight mix designs can be made to match medium weight fittings in texture during the initial trials. This helps to eliminate the need for too much additional space. Ultimately, the goal would be to replace medium weight units with lightweight units.

• Unit strength has been stated as an issue. Strength is easily controlled by mix designs. The units I'm currently using have an average net area compressive strength of around 3,000 psi. Strength properties are the same for lightweight, medium weight and heavyweight block.

• Absorption can also be an issue. Lightweight units, by their nature, contain more air and have higher absorption rates. Proper usage such as not placing them in exposed unpainted exterior walls can eliminate this concern. There have been studies on mix designs and integral water repellent admixtures which can control absorption.

I encourage you to take another look at the benefits of using lightweight CMU as one way to improve the industry, keeping competitive in costs and efficiency, as well as protecting our workers.

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