Chapter 12
Concrete Masonry

Economics, Ergonomics and Efficiency of Lightweight Concrete Masonry Units

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Chapter 12

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12.0 Introduction

Lightweight Concrete Masonry Units (LWCMU) are up to 40% lighter than traditional concrete masonry units. CMU's that weigh less will significantly increase mason productivity up to 21% on 8 x 8 x 16" units. Increased productivity means increased profits, lower overhead costs, and competitive bidding advantages. Increased productivity often means earlier completion and the opportunity to build more projects with the same workforce.

Less weight also minimizes the physical demands on masons and equipment, resulting in fewer injuries, workers compensation claims, and the sustainability of the workforce (See appendix 12E). Repeatedly lifting less weight also extends a mason's career, and allows women and men to work efficiently. Equipment and scaffolding last longer and are safer to use because less overall weight is being handled.

During the time of manufacture, cubing, inventorying, loading, hauling and unloading at the jobsite, CM units are handled by mechanized equipment. It is when the mason lifts and places the unit to construct a wall that the weights of these units become most important. It is essential to the future of the masonry that all segments of the industry have a clear understanding and recognition of this fact. The use of LWCMU will extend the mason's career because even though a mason will lay approximately 20% more wall in a year, the mason still lifts 15% less weight…about 94 tons less per year. Additionally, LWCMU will allow one mason to lay a 12" unit because it weight only 35 pounds-not 52.

All these benefits are possible even when making the walls less expensive, thus making concrete masonry more competitive against other wall systems. The time has come for all to recognize (masonry groups. ASTM standards, labor organizations, contractors, owners, etc.) that the structural efficiency (strength/weight) and the user-friendly aspects of LWCMU can no longer be realistically ignored, it is time to stop fighting gravity!

12.1 Factors Determining the Density of Concrete Masonry

The density of block concrete is determined by three factors, aggregate, cementitious matrix and the degree of compaction. By looking at the relationship of these factors the concrete density can be estimated by an absolute volume analysis.

Aggregate: The approximate oven dry density of ordinary normalweight aggregate (coarse and fines) ranges from 2.3 to 2.9, with 2.62 being most common. The loose bulk density will vary based on particle shape and grading, with mid-range values are 95 pcf ($\pm$ 5). On a solid volume basis this would be 162 pcf (RD = 2.62)..

The approximate oven dry density for lightweight aggregate particles range from 1.2 to 1.6 with 1.5 being common. The loose bulk density will vary based on particle shape and grading with mid-range values at 48 pcf ($\pm$ 6). On a solid volume this would be 94 pcf (RD = 1.50).

Hydrated Cement Matrix: The oven dry density of the entrained hydrated cement paste (HCP), (hydrated cement, entrained air and air voids) for typical commercial CMU's is approximately 50-60 pcf. For example when we look closer at the HCP with a water to cementitious ratio of about 0.6:

	Wet Weight	Volume	Dry Weight
Water	0.6	0.6	-----
Cement	1.0	0.32	1.0 x 0.2*
Totals	1.6	0.92	1.2

Cement typically chemically combines with water of about 20% by weight.

Considering the effect of entrained and entrapped air pores of approximately 4% then the oven dry relative density of HCP

$$(\text{HCP}) = \frac{1.2}{1 + .04} = 1.15 \, (72 \, \text{pcf})$$

If a typical commercial CMU has an unfilled void space of 8% of the total volume and a cementitious material volume of approximately 30%, then the void content of the HCP would be:

$$\text{HPC Voids} \frac{.08}{.30} = .27$$

then the Oven Dry Relative Density of HCP matrix would be:

$$\text{ODRD} = \frac{1.15}{1 + .27} = 0.91 \, (57 \, \text{pcf})$$

Thus, unexpectedly, the lightest constituent in block concrete is the cement "matrix" (HCP + entrapped air + unfilled interstitial voids). As a side note this is an extremely important factor when analyzing the heat flow through block concrete; as the "matrix" provides for an aggregate encapsulating insulated path resisting heat flow through the unit.

Mixture and compaction: With approximate relative densities of 0.91 paste, 1.50 LWA and 2.62 NWA and assuming absolute volumes of 42% for the "matrix" and 58% for aggregate (LWA + NWA), we can analyze the dramatic increasing weight effect of blending heavy normalweight aggregates on the density of a CMU.

For example:

Replace 42% of the LWA by absolute volume (not bulk loose volume) with heavy aggregates, sand or stone, using mid-range, relative densities aggregates, then the approximate dry density of the CMU would be:

$$
\begin{aligned}
& \quad\ \text{HCP} \qquad\qquad\quad \text{HWA} \qquad\qquad \text{LWA} \\
\Delta &= (.3 \times .91) + (.7 \times .42 \times 2.62) + (.7 \times .58 \times 1.50) \\
\Delta &= \quad .27 \quad + \quad .77 \quad + \quad .61 = 1.65 \text{ RD} \\
\Delta &= \quad 1.65 \times 62.4 = 103 \text{ pcf}
\end{aligned}
$$

without HWA the density Δ will be: $\Delta = (.3 \times .91) + (.7 \times 1.5) = 1.32$ (82 pcf)

To achieve a density less than 95 pcf, allowable blending of approximately 25% would result in:

$$
\begin{aligned}
\Delta &= (.3 \times .91) + (.7 \times .25 \times 2.62) + (.7 \times .75 \times 1.50) \\
\Delta &= .27 + .46 + .79 = 1.52 \\
\Delta &= 1.52\ (62.4) = 95 \text{ pcf}
\end{aligned}
$$

Despite the admitted generality of this approach (Because of the influence of grading, particle shape, and the influence of free moisture on compaction) insight is provided in observing the contributions of the various constituents.

One concrete block producer in the Northeast was advised that the cheap stone screenings used in the production of commercial LWCMU was not inexpensive, as the relative density of the blended traprock fines was 3.0 thus making it difficult to make a LWCMU..

12.2 Density of Block Concrete

The weight of a CMU is a function of the density of the block concrete and the geometric dimensions of the unit. As with cast-in-place concrete the density of block concrete is a direct function of the constituents of the mixture primarily influenced by the weights of the aggregates, but also affected by manufacturing considerations, the wetness of the mixture and the duration of the compaction part of the production cycle.

As covered in section 12.1 the dry particle density of ESCS lightweight fine aggregate varies from about 1.2 to 1.6. The dry particle density of most normalweight aggregates is typically 2.62 or higher. Porous lime rock and air cooled slag may have values of approximately 2.3 ±. Several by-product LWA's, expanded slag for example show a deceptively low bulk density that is the result of a gap graded material with large void structure. However, measured density of this type of product reveals a high relative density of the individual particles that is evidenced by a low yield of CMU's where the excessive voids are filled with HCP.

ASTM C 90 "*Standard Specification for Load Bearing Concrete Masonry Units"* arbitrarily defines the density of lightweight CMU as less than 105 pcf (1680 kg/m³), medium weight as 105 – 125 pcf (1680-2000 kg/m³) and normalweight as greater than 125 pcf (2000 kg/m³). However, these density categories can be misleading. Stating that densities greater than 125 pcf is "normal" is out of contact with reality. In many areas of the U.S. the standard CMU density as manufactured, inventoried and sold has densities in the lightweight or medium weight category and units with densities greater than 125 pcf are considered "heavyweight".

12.3 Weights of Typical Concrete Masonry Units

For simplicity the weight of typical CMU's are calculated on the basis of oven dry densities of the block concrete. Procedures for measuring the oven dry density are included in ASTM C 140 "*Standard Test Method for Sampling and Testing Concrete Masonry Units and Related Units".* Typical properties that are a function of CMU are included within ASTM C 90 "*Standard Specification for Loadbearing Concrete Masonry Units".* The oven dry weights of typical CMU's are shown in Table 1.

In practice there will be the additional weight of the moisture content present that is dependent on ambient conditions. If the units are not rained on while cubed in the plant, in delivery or on the jobsite, then the moisture content may be estimated by ACI 122 "*Guide to Thermal Properties of Concrete and Masonry Systems".*

Additionally, wall weights are used to calculate other properties including:

- Gravity dead loads supported by the structural framing system.
- Indirectly in determining the fire resistance (while all other fire resistance tables e.g. fire resistance of floor slabs, the existing Table 3.1 of ACI 216 erroneously suggests that the fire rating is established only on the basis of aggregate type).
- Sound transmission loss
- Seismic base shear force (Heavier walls increase seismic forces).
- Thermal Properties (Static resistance and Dynamic resistance)

Table 12.1. Oven Dry Weight of Typical Hollow Concrete Masonry Units, (pounds)

Nominal Thickness	Specific Thickness	% Solid	Gross Volume CF	Absolute Volume CF	Oven Dry Density of Block Concrete (pcf)					
					85	95	105	115	125	135
4	3.63	74	.250	.185	16	18	19	21	23	25
6	6.63	61	.388	.237	20	23	25	27	30	32
8	7.63	52	.526	.273	22	25	28	30	33	36
10	9.63	50	.664	.332	28	32	36	38	42	45
12	11.63	48	.802	.385	33	37	40	44	48	52

12.4 The Effect Weight Has On Transportation/Shipping

The use of lightweight concrete building components manufactured will allow more building products to be carried on the same truck when compared to heavy building products. This will decrease the truckloads required to deliver the same volume of product. Less trucks on the road reduce the pollutants emitted from transportation as well as reducing traffic congestion. Switching from heavy normalweight concrete masonry units to lightweight concrete masonry units saves truck miles as illustrated below.

ITEM	Normalweight 135 PCF	Lightweight 93 PCF	Difference LW vs NW
Quantity of 8 x 8 x 16 on Job	100,000	100,000	0
Weight of CMU (lbs)	38	26	12 pounds less
Truck capacity (lbs)	32,000	32,000	0
Units per load	842	1,230	388 more block per load
Wall area per load (sq ft)	748	1,093	345 more sq ft of wall per load
Number of truckloads required	119	82	37 less truckloads
Distance to job (miles)	100	100	0
Total miles traveled	5,950	4,100	1,850 less truck miles traveled
Cost @ $.02 per mile	$ 11,900	$ 8,200	$3,700 savings in trucking cost
Delivery cost per block	$0.12	$0.08	$0.04 savings per block

12.5 Weights of Concrete Masonry Walls

Considering the large variations in CMU mold dimensions, the density and amount of mortar and calculating with the usual precision in estimating structural loads to two significant numbers, the wall weights may be approximated by

$$\frac{\text{CMU Equivalent Thickness}}{12} \times \text{Density of CMU}$$

e.g. for a typical 8" hollow CMU's

$$\frac{3.97}{12} x\, 95 = 31 \text{psf}$$

$$\frac{3.97}{12} x\, 135 = 45 \text{psf}$$

This approximate approach reasonably reflects the influence of face shell or web covering and the range of mortar densities which are typically assumed at 125 pcf. The weight of typical CMU walls as shown in Table 12.2

Table 12.2. Weight of Typical Concrete Masonry Walls (pounds)

Nominal Thickness	Actual Thickness	Typical % Solid	Typical Equiv Thickness	Net Vol/SF Of Wall	Oven-Dry Density of Block Concrete (pcf)					
					85	95	105	115	125	135
4	3.63	74	2.69	.224	19	21	24	36	28	30
6	5.63	61	3.43	.286	24	27	30	33	36	39
8	7.63	52	3.97	.331	28	31	35	38	41	45
10	9.63	50	4.85	.402	34	38	42	46	50	54
12	11.63	48	5.58	.465	39	44	49	53	58	63

12.6 Weights of Grouted Concrete Masonry Walls

The water content, entrapped and entrained air content and the relative density of aggregates vary considerably for commercial grouts. Additionally, since the filling of all cores and voids may be incomplete, for calculations of grouted walls it would be reasonable to assume a grout density of 130 pcf.

Thus for a fully grouted 8" hollow CMU wall the additional wall weight will be:

$$\mathbf{\frac{7.63 - 3.97}{12} x\, 130 = 40 \text{psf}}$$

and thus the wall weight of an 8" hollow, fully grouted:

@ 95 CMU density = 31 + 40 = 71 psf
@ 135 CMU density = 45 + 40 = 85 psf

In a similar fashion if 8" walls were grouted at 24" oc, then only one core in three would be grouted and the additional wall weight would be 40 psf (Full grout) ÷ 3 = 13 psf.

Wall weight @ 95 CMU = 31 + 13 = 44 psf
@ 135 CMU = 45 + 13 = 58 psf

The weights of typical grouted CMU wall are shown in Table 12.3.

Table 12.3. Weight of Grouted Concrete Masonry Walls (psf)

Wall Thickness	**8"**			**12"**		
Density of CMU (pcf)	**95**	**105**	**135**	**95**	**105**	**135**
No Grout	**31**	**35**	**45**	**44**	**49**	**63**
Full Grout	**71**	**75**	**85**	**110**	**115**	**129**
Grout @24	**44**	**48**	**58**	**66**	**71**	**85**
Grout @48	**38**	**42**	**54**	**55**	**60**	**74**
Grout @72	**34**	**38**	**50**	**50**	**55**	**69**

12.7 Lower First Costs of CMU Walls

Mason productivity is directly effected by the weight of the concrete masonry unit. Increasing productivity is crucial because labor is approximately 60% of the total wall cost. To maintain a strong competetive edge conctractors need to establish their own productivity rates based on good records of past performance. The production curves (Fig. 12.1) provide an excellent tool and refernce for estimating production.

Increased productivity does <u>NOT</u> mean working harder...it does mean less fatigue permitting the mason to maintan his/her normal pace longer. The result is more production with less effort. It is not widely recognized that the use of 8" lightweight CMU allows for an increase in productivity while simultaneously significantly reducing the total weight lifted each day (780 pounds less, see Table 12.4). With 12" CMU's there is such a pronounced increase in productivity when using lightweight CMU's, that there maybe a small or no significant difference in the total weight lifted/day.

Table 12.4. Example of how to lower total weight lifted while simultaneously increasing productivity.

Unit Type/Density	Weight Of CMU	Productivity Units/day	Productivity Increase Compared To HWCMU	Weight Lifted per Day	Decrease Weight Lifted per Day	% Decrease in weight Lifted
8" HWCMU @ 135	37	137	-----	5070	----	----
8" LWCMU @ 105	29	160	+17%	4640	350	+8%
8" LWCMU @ 95	26	165	+20%	4290	780	+15%

*Productivity numbers are as reported in, *"Masonry Estimating"*, Koloski R.V., Craftsman Book Co., The Aberdeen Group, Addison, IL (See fig. 1)

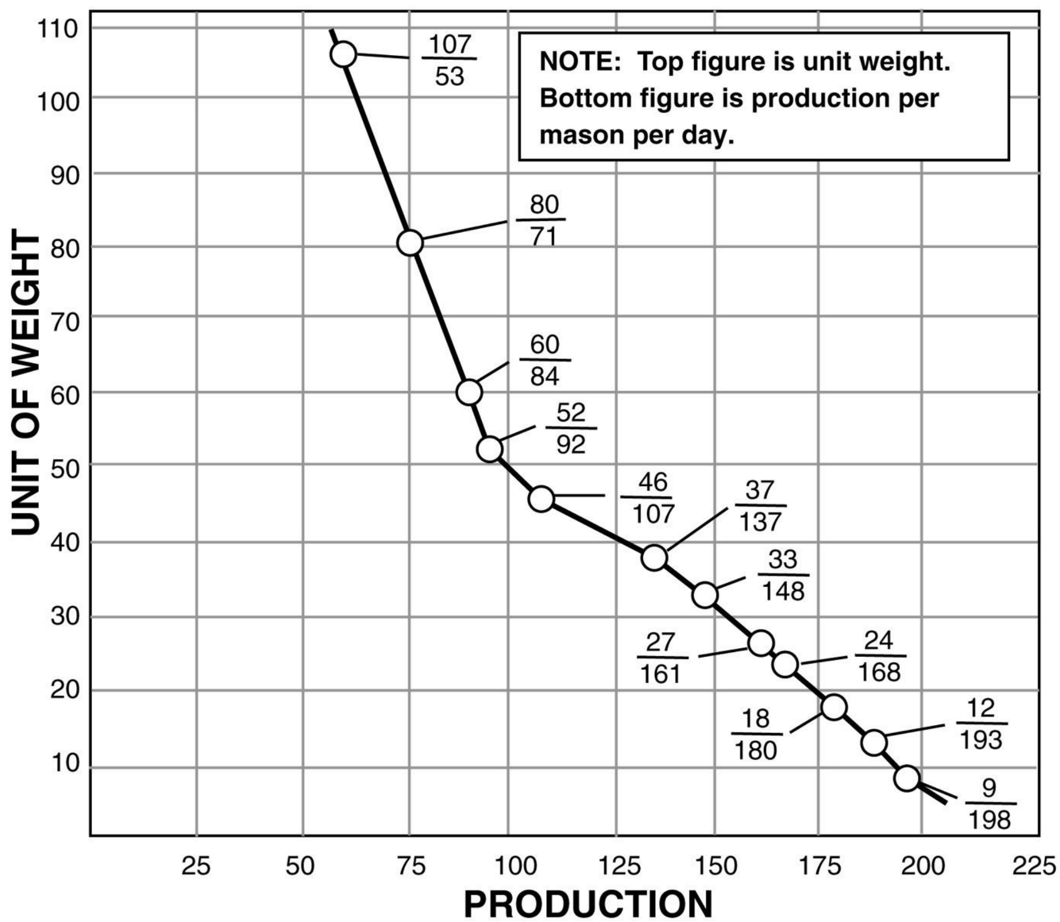


Figure 12.1. ***Productivity of Masons as a Function of the Weight of a Concrete Mansonry Unit (Adapted from Kolkoski R.)***

Note: In some areas the union requires two people on units heavier than 37 lbs.

Increased efficiency from using lightweight concrete masonry units will be:

- Lower labor costs (The largest cost component)
- Provide faster completion >> Quicker occupancy
- Shorten constuction time thus reducing overhead costs.
- Lower contractor overhead cost
- Extend equipment life.
- Lower overall wall costs thereby allowing the masonry industry to be more competitive with other wall systems (Tilt-Up, precast, etc.)
- Allow one masonr to lay a 12" unit.
- Better Ergonimics with lighter units
- Less fatigue and fewer injuries
- Lower workman's compensation

The following effect of reduced weight have been extracted from ESCSI information sheet #3650.3.

Block Weight	**Increased Productivity**	
Heavyweight block to lightweight block	8x8x16	12x8x16
	17%	24%

(3)These productivity increases are adjusted down 20% to account for fixed labot costs (scaffolding, etc.)

Lightweight Masonry vs. Heavyweight Masonry Examples:	**Total Wall Costs**
8x8x16 Change from heavyweight to lightweight	
Labor cost 17% savings x 55% =	9.4% less
Block cost 30% increase x 20% =	6.0% more
Block delivery 20% savings x 3% =	0.6% less
Fixed overhead 17% savings x 8%	1.4% less
Cost reduction =	5.4% savings
12x8x16 Change from heavyweight to lightweight	
Labor cost 24% savings x 55% =	13.2% less
Block cost 21% increase x 20% =	4.2% more
Block delivery 20% savings x 3% =	0.6% less
Fixed overhead 24% savings x 8% =	1.9% less
Cost reduction =	11.5% savings

These savings correlate reasonably well with information contained in the 2005 Wall Cost Data, page A4-05 in the *"Masonry Cost Guide"* produced by the Masonry Advisory Council Brochure for the Chicago area, July 2005, Charles Ostrander, Executive Director, Oak Ridge, Illinois, where the installed wall costs were reported for 8" NW at $8.89 psf, 8" LW $8.69 psf, and 12" NW $12.78 psf, 12" LW $9.59 psf.

Wall Costs: Typical Masonry Wall Costs (8x8x16)		HW[1]	LW[2]
Labor		55%	45.6%
Block		20%	26.0%
Block delivery		3%	2.4%
Misc. Materials (reinforcing, mortar, etc.)		5%	5.0%
Equipment		5%	5.0%
Overhead	Fixed	8%	6.6%
	Variable	4%	4.0%
Savings		0	5.4%
Total		100%	100%

(1) these percentages are averages based on converstions with mason contractors across the country.
(2) The lightweight percentages incorporate the savings illustrated in Fig. 12.2.

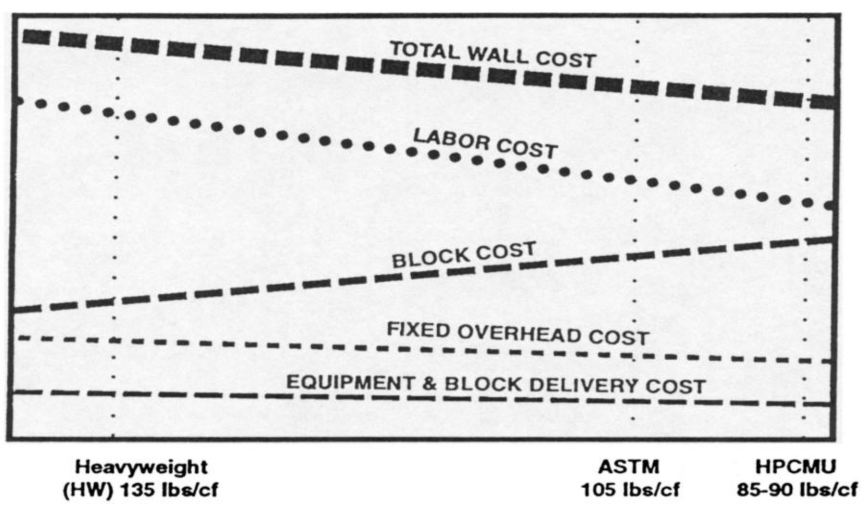


Figure 12.2. ***Total Wall Cost Trend (ESCSI #3650.3)***

As noted in Fig. 12.2 overall wall costs decrease when using lighter concrete masonry units. This is a direct result of the reduction in thelargest cost component: Labor. In the example shown, obtained in conversations with mason contractors across the country, one may notice an almost 10% reduction in labor costs (as a percentage of overall cost) more than offsetting the 6% increase in CMU cost, resulting in a 5.4% reduction in the cost of the wall.

INCREASED PRODUCTIVITY

- Does NOT mean working FASTER
- Does mean less fatigue permitting the mason to maintain his/her NORMAL pace longer.
- Results: More production with less effort
- Approximately 2 TONS less of CMU's lifted per week.

Productivity increases are typically shown for 8" and 12" standard strechers, but the increases in efficiency apply to all units. Note in Table 12.5 that for all sizes 4, 6, 8, 10, 12 and all architectural applications, from standard running bond to stacked bond...the lightweight CMU significantly increased efficiency.

Table 12.5. Special work production as influenced by weight of units.

Work Condition	Production Factor	4" 25#	6" 33#	8" 37#	10" 46#	12" 52#
Basic running bond, exp.	1.00	166	148	137	107	92
Half high, running bond, exp.	1.00	192	183	179	170	163
Foundation, running bond, exp.	1.12	186	166	153	120	103
Backup, running bond, exp.	1.06	176	157	145	113	98
Cav. B/U, running bond, exp.	1.00	166	148	137	107	92
Parts., running bond, exp. (S2S)	.88	146	130	121	94	81
Stack bond	.92	153	136	126	98	85
Not exposed	1.05	174	155	144	112	97
			Lightweight CMU			
Work Conditon	**Production Factor**	**4" 18#**	**6" 24#**	**8" 27#**	**10" 33#**	**12" 37#**
Basic running bond, exp.	1.00	180	168	161	148	137
Half high, running bond, exp.	1.00	199	193	190	183	179
Foundation, running bond, exp.	1.12	202	188	180	166	153
Backup, running bond, exp.	1.08	191	178	171	157	145
Cav. B/U, running bond, exp.	1.00	180	168	161	148	137
Parts., running bond, exp. (S2S)	.88	158	148	142	130	121
Stack bond	.92	166	155	148	138	126
Not exposed	1.05	189	176	169	155	144

***From R.V. Kolkoski, "*Masonry Estimating*" Craftsman Book Co., The Aberdeen Group, Addison, IL.**

12.8 Life Cycle Energy Cost Analysis of Buildings

The built-in thermal resistance and low thermal bridging provided by lightweight concrete masonry units will save energy requirements in both hot and cold climates. With energy costs continuously increasing owners must demand and designers specifiy the lowest practical block concrete density available. Reduced energy consumption is no longer desirable, it is essential for:

- Low operating costs of buildings.
- National economic health.
- National security – diminshed energy dependence on undependable foreign sources.

The following is the report of a life cycle energy cost saving analysis developd by Buildex, Inc. Ottawa, Kansas and published in the ESCSI Information Sheet 3530 (March 2000). The analysis compares the steady state energy requirements of single wythe walls constructed with CMU's having densitites of 135, 105 and 90 pcf.

The life cycle energy cost analysis shown in Table 12.6 is reproduced from ESCSI Information Sheet 3530 (March 2000).

Table 12.6. Life Cycle Energy Cost Analysis

Life Cycle Energy Cost Analysis

Present Value of Annual Wall Heating and Cooling Energy Cost
Using Various Density CMU Over a Thirty Year Period
Calculated Using Steady State Method

Wall Construction:	Location:
Single wythe 12" CMU reinforced 48" vertically with foamed in place core insulation	Chicago, Illinois Winter 2005-06

R Value Data	CMU Density				
	135 lb / ft^3	125 lb / ft^3	115 lb / ft^3	105 lb / ft^3	90 lb / ft^3
R value(1)	3.65	4.17	4.74	5.41	6.62
Calculate: U value	0.274	0.240	0.211	0.185	0.151

R value in (hr · ft^2 · °F) / BTU. U value in BTU / (hr · ft^2 · °F)

The following analysis caclulates annual heating and cooling costs for the concrete masonry wall. All units are conventional 8" x 8" x 16" size.

	CMU Density				
	135 lb / ft^3	125 lb / ft^3	115 lb / ft^3	105 lb / ft^3	90 lb / ft^3
Heating Cost Calculations					
Natural Gas Cost(2) per mcf	$10.00	$10.00	$10.00	$10.00	$10.00
Furnace efficiency	0.80	0.80	0.80	0.80	0.80
Calculate: $ Cost per Btu output	1.25E-05	1.25E-05	1.25E-05	1.25E-05	1.25E-05
Heating Degree Days for This Location(3)	6459	6459	6459	6459	6459
Calculate: Energy Cost: $ / sq ft / yr	$0.5309	$0.4647	$0.4088	$0.3582	$0.2927
Calculate: Energy Cost: $ / block / yr	$0.4719	$0.4131	$0.3634	$0.3184	$0.2602
Present Worth of Heating Savings					
n (years)	30	30	30	30	30
i (nominal rate - energy and money)(4)	2.00%	2.00%	2.00%	2.00%	2.00%
Calculate: Present Worth of Wall Heating Costs, $ / block	*$10.57*	*$9.25*	*$8.14*	*$7.13*	*$5.83*
Cooling Cost Calculations					
Electricity Cost(2) per kwh	$0.1050	$0.1050	$0.1050	$0.1050	$0.1050
SEER	10	10	10	10	10
Cooling Degree Hours for This Location(3)	6606	6606	6606	6606	6606
Calculate: Energy Cost: $ / sq ft / yr	$0.0190	$0.0166	$0.0146	$0.0128	$0.0105
Calculate: Energy Cost: $ / block / yr	$0.0169	$0.0148	$0.0130	$0.0114	$0.0093
Present Worth of Cooling Savings					
n (years)	30	30	30	30	30
i (nominal rate - energy and money)(4)	2.00%	2.00%	2.00%	2.00%	2.00%
Calculate: Present Worth of Wall Cooling Costs, $ / block	*$0.38*	*$0.33*	*$0.29*	*$0.26*	*$0.21*
Calculate: Present Worth of Total Wall Heating and Cooling Cost, $ / block	*$10.95*	*$9.58*	*$8.43*	*$7.39*	*$6.04*

(1) R-values for Single Wythe Concrete Masonry Walls, TEK 6-2A, National Concrete Masonry Associtaoin, 1996. The R value is interpolated for 90 pcf.

(2) Natural Gas and Electricity Costs: Illinois Masonry Institute. Current for Winter 2005-06.

(3) Appendix A, Climatic Data for the US and Canada, ASHRAE 90.2, 1993.

(4) The 2% nominal discount rate was chosen as appropriate for this analysis because it represents the typical long term two percent difference between short term US T-bill rates and the CPI inflation rate. See Office of Management and Budget Circular A-94 Guildeines and Discount Rates fir Benefit-Cost Analysis of Federal Programs.

Calculations are based on Expanded Shale, Clay & Slate Institute (ESCSI) Information Sheet No. 3530.

As mentioned earlier results shown in Table 12.6 for annual energy cost savings are based upon steady state analysis. This is conservative as benefits of reduction in overall energy requirements due to thermal inertia also are increased with the use of CMU with a lower diffusivity.

A similar life cycle cost analysis shown in Table 12.7 developed by the Big River Company shows a remarkable return on investiment in a relatively short period of years. See Table 12.7 and Fig. 12.3.

Table 12.7. Annual Energy Cost Savings-Calculated Using 1999 Energy Costs

City	$/Block/Year
Asheville, NC	$0.12
Raleigh, NC	$0.11
Columbia, SC	$0.09
Charleston, SC	$0.08

Comparing 90 lb/ft³ SmartWall Systems to 135 lb/ft³ Heavy Weight Wall

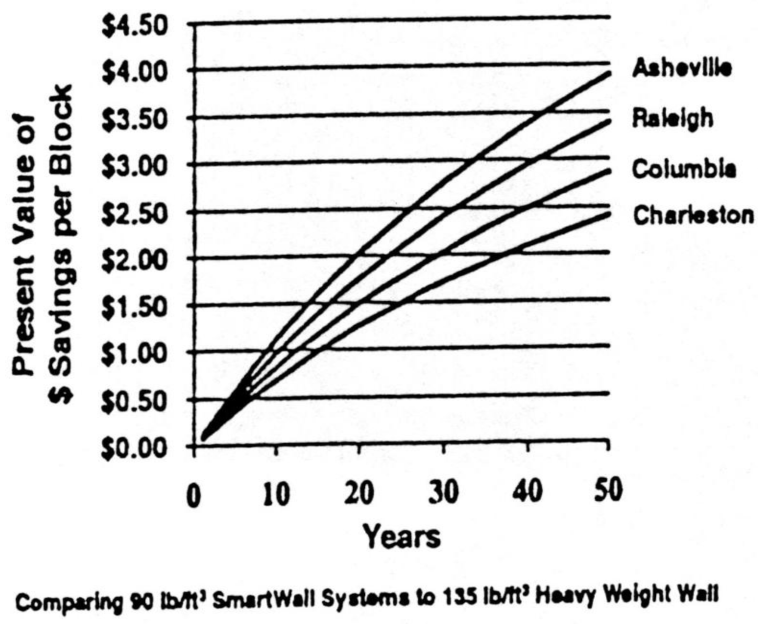


Figure 12.3. ***Life Cycle Energy Cost Savings***

12.8 Ergonomics

Ergonomics is the applied science concerned with making work stations and tasks more compatiable with human anatomy. After many years of application to manufacturing plants, ergonimic principles are now being applied to the constuction industry.

Lightweight CMU's are up to 40% lighter than the heavy concrete masonry units that use sand, gravel and stone. Less weight minimizes the physical demand on masons and equipment, resulting in fewer injuries and workers' compensation claims. Repeatedly lifting less weight will extend a mason's career, and allows women and men to work efficiently. Equipment and scaffolding last longer and are safer to use because of the reduction in overall weight is being handled. The sustainability of the mason workforce is directly influenced by the weight of unit lifted!

As mentioned earlier, during the time of manufacture cubing, inventorying, loading and unloading at the jobsite, CM unites are handled by mechanized equipment, it is <u>ONLY</u> when the units are lifted and placed by a human being, the mason craftsman, that the masonry wall is constructed.

Mason craftsman will be able to construct 20% more beautiful, energy conserving, durable, fire resistant walls while still lifting 15% less weight (about 94 tons less/year). Using lightweight CMU will enhance the careers of SKILLED MASON CRAFTSMEN.

12.10 Improved Quality, Value Added

Mason contractors have noticed the higher level of workmanship available when using lighter weight units that are easier to place. Improved quality is directly obvious; "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 workforce", (Lachonic).

Some of the advantages that are attributed to lightweight CMU's include:

- Fewer chips from handling
- Easier to lay, laid with better workmanship
- Fewer punch list items from chips
- Happier employees
- Less wear and tear on equipment from weight
- Lighter loads for trucking
- 15 more unit per cube with less weight
- Less fork lift time
- Easier to saw
- Improved schedule durations

The report continued, “For the last 10 to 15 years, production has slowly and steadily decreased. There is little doubt that the weight of units in 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”.

12.11 Summary

In summary lower wall cost along with better wall performance result from the following:

- Lighter weight walls using lightweight concrete masonry units made with Expanded Shale, Clay and Slate Aggregate.
- Increase mason productivity resulting from lighter units.
- Better workmanship as result of less mason fatigue when handling lighter units.
- Long-term energy cost savings resulting from better insulation with lighter units.
- Environmentally friendly – shipping with less truck loads, heating and cooling saving through out the life of the building
- Better fire rating.

For a listing of the benefits obtained when CMU weights go down, include increased productivity and improved fire resistance properties of the wall, see the advantages shown in Table 12.8.

Table 12.8. Fire Ratings and Productivity for Typical Concrete Masonry Units.

BASIC DMENSIONAL CRITERIA MEETING RQMTS OF ASTM C 90			HEAVYWEIGHT CMU'S			LIGHTWEIGHT CMU'S			
Nominal Width (inches)	Typical Percent Solid (1)	Minimum Face Shell Thickness (1)	Typical Dry Weight of Unit @ 135 pcf (2)	Fire Rating Hours (3)	Production Running Bond Exposed (4)	Typical Dry Weight of Unit @ 93.6 pcf (5)	Fire Rating Hours (6)	Production Running Bond Exposed (4)	Productivity Increases (%)
4	74	1.00	25	See Note 3	166	18	1	180	8
6	61	1.13	32	„	146	23	1.5	170	16
8	52	1.25	37	„	137	26	2	163	19
10	50	1.50	45	„	110	33	3	148	35
12	48	1.50	52	„	92	35	4	140	52
6	69	1.30	36	„	140	26	2	163	16
8	58	1.75	41	„	124	29	3	157	35
8	75.0 min	2.25	53	See Note 3	91	38	4	134	47

(1) From typical molds used in the manufacture of concrete masonry units.
(2) Calculations based upon dry density of 135 pcf. Adjust for differing density due to aggregate types, mix composition and compaction.
(3) Fire ratings for heavyweight units are a function of the mineralology of the aggregates used (e.g., siliceous, calcareou...).
(4) Productivity based upon running bond, exposed CMU's according to Figure 8.3 of MASONRY ESTIMATING, Kolkoski, R.V., 1968, The Aberdeen Group, 426 S. Westgate Street, Addison, IL 60101.
(5) Units weighed at the project site may contain additional concrete beyoned that shown in mold table minimums because of core geometry, curvature for mortar beds, moisture and widened hand holds. Weight of units are computed on the basis of a density of 93.6 pcf (1500 Kg/m^3).
(6) Fire ratings shown are based upon full scale tests conducted on conrete masonry units composed of ESCSI lightweight aggregate run strictly in accordance with ASTM E 119. References include:
    A. Solite sponsored Omega Point Test No. 1009-90969 dated 29 April 1992.
    B. ESCSI sponsored tests at Underwriters Laboratories, Chicago, IL (UL File R3746-7-8).
    C. ESCSI sponsored tests at National Research Council, Ottawa, Canada, 1963, Tests #10, #11, #12.
    D. National Bureau of Standards, Washington, DC, NBS #117, NBS #120.

12A

ESCSI Information Sheet 3650.3

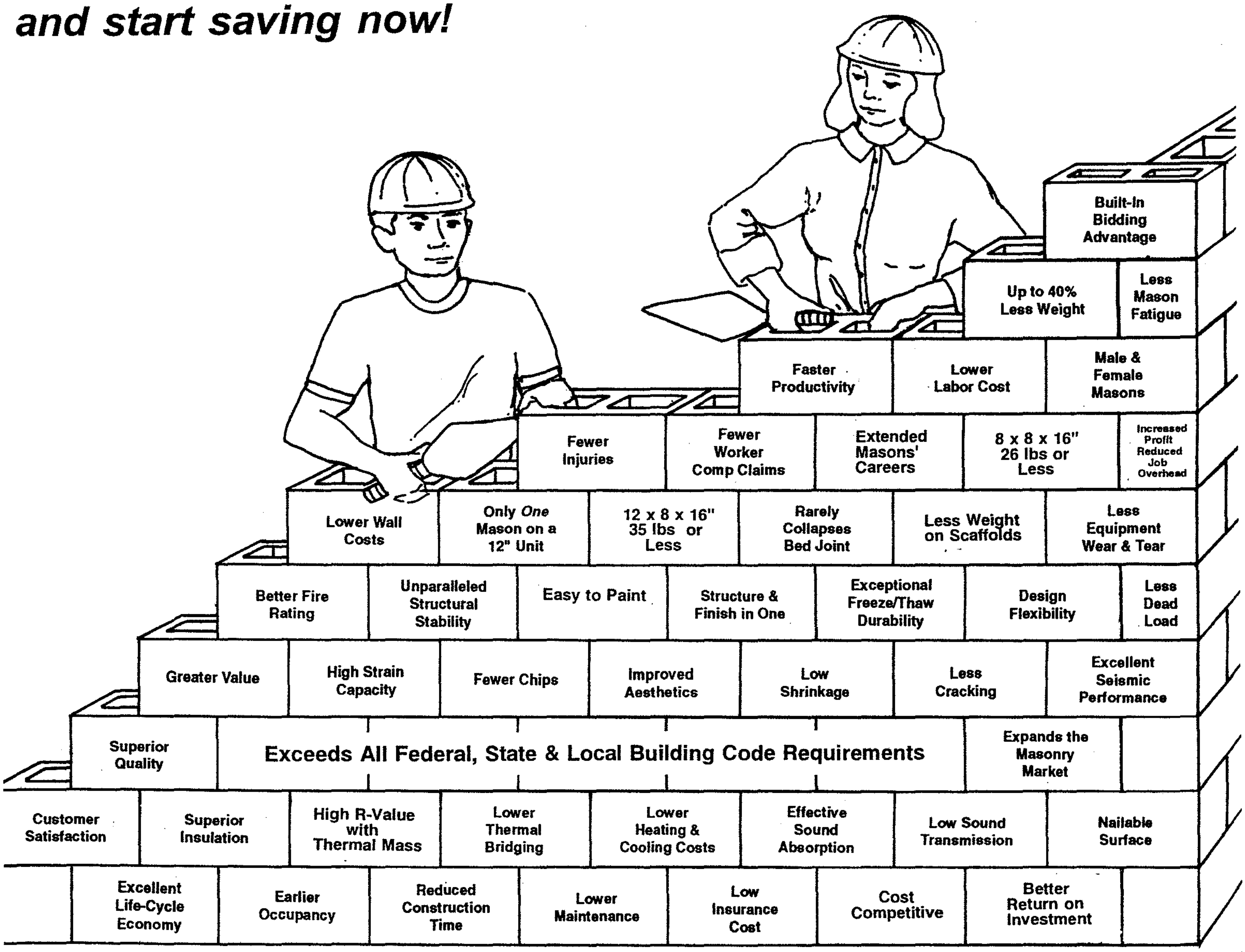
“High-Performance Concrete Masonry”

ESCSI *Expanded Shale Clay and Slate Institute*

Information Sheet 3650.3
for **Mason Contractors**

High-Performance Concrete Masonry

Join the high-performance team and start saving now!



The Building Blocks of Profitability and Customer Satisfaction

Built on the foundation that there is something *special* inside. High-performance concrete masonry is made with expanded shale, clay, and slate (ESCS) ceramic-lightweight aggregates. ESCS is prepared by expanding select minerals in a rotary kiln at temperatures over 1000°C. The ESCS manufacturing and raw-material selection are strictly controlled to insure a uniform, high-quality structural aggregate that is strong, stable, durable, and inert, yet also lightweight and insulative.

High-Performance Concrete Masonry Units (HPCMUs)

HPCMUs can reduce costs while adding value to all building phases: design, construction, and occupancy. HPCMUs are designed to increase job site productivity while providing superior structural performance, design flexibility, and ongoing energy savings.

The high-performance movement links specifiers, block producers, contractors, and occupants in a "value chain" of quality by delivering superior building products, competitive up-front construction costs, and user-cost benefits that will last the lifetime of the building.

Let HPCMUs expand the concrete masonry market by making masonry a more competitive alternative to wood, glass, metal, concrete, or tilt-up wall systems.

Mason Contractor Benefits

HPCMUs are up to 40% lighter than traditional concrete masonry units. CMUs that weigh less will increase mason productivity up to 21% on 8x8x16" units, and 55% on 12x8x16" units. [1, 4] Increased productivity means increased profits, earlier completion, lower overhead costs, and significant bidding advantages.

Less weight also minimizes the physical demands on masons and equipment, resulting in fewer injuries and workers' compensation claims. Repeatedly lifting less weight also extends a mason's career, and allows women and men to work efficiently. Equipment and scaffolding last longer and are safer to use because less overall weight is being handled.

High-Performance Concrete Masonry Will

- ❑ Help keep mason contractors profitable.
- ❑ Give the contractor a built-in bidding advantage.
- ❑ Lower labor costs through increased productivity.
- ❑ Allow male and female masons to perform efficiently.
- ❑ Extend the mason's career because, even though a mason will lay approximately 20% more wall area in a year, the mason still lifts 15% less weight (about 94 tons less/year).
- ❑ Allow one mason to lay a 12" unit because it weighs only 35 lbs—not 52 lbs.
- ❑ Shorten construction time and reduce job overhead costs.
- ❑ Extend equipment life because lighter loads mean less wear and tear.
- ❑ Help insure safer scaffolding and worker platforms. Less weight means it is easier to meet OSHA weight requirements.
- ❑ Make it easier to lay a true and uniform wall. HPCMUs rarely collapse the bed joint.
- ❑ Improve aesthetics and customer satisfaction by reducing chipping and shrinkage cracks.
- ❑ Provide the architect and engineer with more reasons to specify concrete masonry over other wall systems like wood, steel, tilt-up, etc.
- ❑ Expand the masonry industry.

Productivity

The productivity of a mason is primarily determined by the weight of the concrete masonry unit (CMU). Productivity is crucial because labor is usually 60% of the total wall cost. [1,3,4] The contractors need to establish their own productivity rates based on good records of past performance. The production curves (Figures 1 & 2) provide an excellent tool and reference for estimating production.

CMU Weights in pounds (lbs)

Size (in.)	HPCMU 85-90 lbs/cf	ASTM 105 lbs/cf	Heavyweight (HW) 135 lbs/cf
8x8x16"	23 - 26	29	37
12x8x16"	32 - 35	41	52
8x8x24"	32 - 35	40	52

"Generally speaking, productivity increased as the weight of the units decreased and the length of the units increased." [11]

CMU Productivity Curves [1]

Figure 1

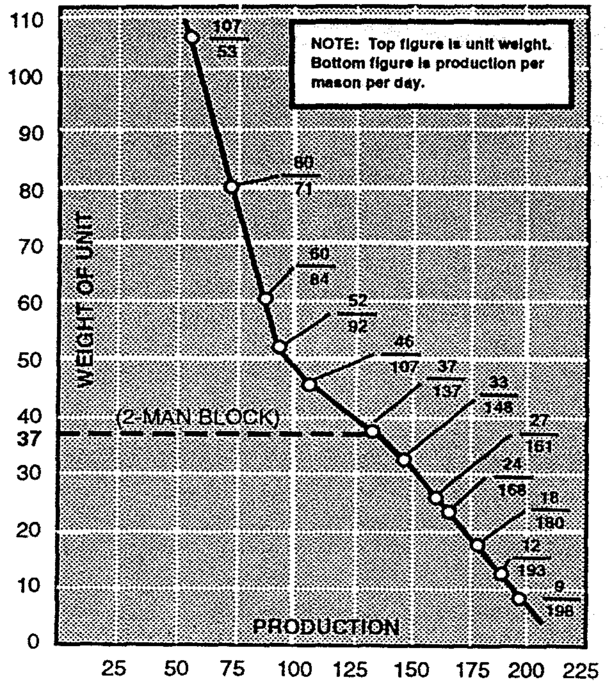
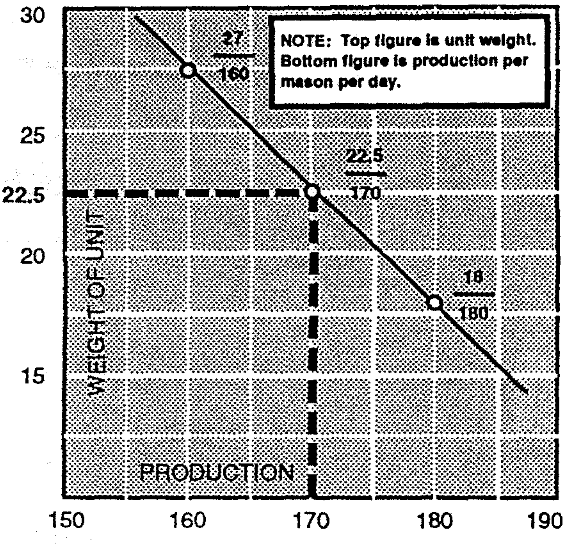


Figure 2.



Graph Reference: **Rynold V. Kolkoski, *Masonry Estimating*, The Aberdeen Group, Addison IL 60601**

Long-Term Problems Stem from Heavyweight CMUs. Center for Infrastructure Research, University of Nebraska at Lincoln. [4]

"Concrete masonry is a dominant material in wall construction. Over $10 billion worth of masonry walls are constructed in the United States every year. However, the industry is facing a shortage of qualified masons, and the average age of active masons has been gradually increasing due, in part, to the hard work they have to do in lifting heavy CMUs. . . The load of lifting these blocks, day after day, can make drudgery out of a day's work for a mason, especially after many years. **Some older masons must retire early due to the heavy lifting, and many masons experience crippling back and shoulder injuries before retirement."**

Concrete Masonry Wall Costs

	Increased Productivity [1, 3, 11]	Total Wall Costs [1, 2, 4, 5]
8x8x16" HW (37 lbs) to HPCMUs (24 lbs)	21%	2 to 7% less
12x8x16" HW (52 lbs) to HPCMUs (34 lbs)	55%	12 to 22% less
8x8x16" HW (37 lbs) to 8x8x24" HPCMUs (34 lbs)	53%	10 to 18% less*

* Additional savings: The 8x8x24" unit also requires less mortar because of fewer head joints.

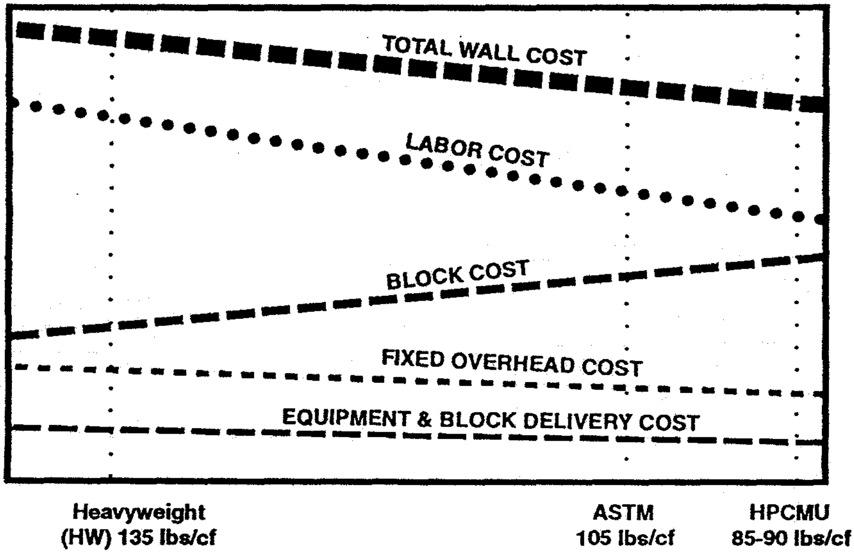


Figure 3. **Wall Cost Trends**

The mason contractor must:

- Keep good job records of mason productivity so that estimates are competitive, yet profitability is maintained.
- Provide quality workmanship. This will insure customer satisfaction and industry growth.
- Use HPCMUs. The future of the concrete masonry industry depends on a healthy labor force, customer satisfaction, and a competitive wall system—HPCMUs help to insure all three.
- Develop personal relationships with architects and engineers. They need your help in designing high-performance concrete masonry buildings that provide safety features, quiet comfort, and lower operating costs.

Customer Satisfaction

Improved customer satisfaction will ultimately expand any market. When you specify HPCMUs, you are selecting a wall system that will greatly exceed traditional building performance standards, thus improving customer satisfaction. HPCMUs will help expand the masonry industry because it has many advantages.

Better Fire Ratings [8]

When specifying rated fire walls, HPCMUs will give you an extra margin of safety that can save lives and dollars—two vital benefits we all value. HPCMUs exceed all UL and National Building Code requirements for equivalent thickness.

Unparalleled Structural Stability

ESCS has a coefficient of thermal expansion significantly lower than that of heavyweight aggregates. HPCMU walls can withstand extreme heat up to 1000°C, and the thermal shock of high-pressure fire-hose spray without cracking, caving in, or deforming. Time and time again, HPCMU walls will remain intact, ready for reuse after a fire.

Effective Noise Control [8]

The sound absorption and low sound transmission of HPCMU walls create a quiet, more peaceful living and working environment. A Noise Reduction Coefficient (NRC) of 0.50 is common—a real benefit in noise-filled rooms or for sound-barrier walls.

Unsurpassed Strength

HPCMUs are made with an optimum density mixture of ESCS aggregate and cement paste to give an improved particle interlock and consolidation. The result is a high strength-to-weight-ratio CMU that far exceeds current ASTM minimum strength standards by 65% to 250%. With net compressive strength commonly in the 3000 psi ranges, HPCMUs can meet the most stringent specification requirements.

Exceptional Freeze-Thaw Durability

Freeze-thaw testing programs at both the University of New Brunswick[6] and the University of Nebraska at Lincoln[4] show that properly designed mixes used in HPCMUs and ASTM lightweight CMUs perform as well as or better than heavyweight CMUs.

Improved Aesthetics

HPCMUs have a greater capability to flex prior to fracture. This improved strain capacity means the HPCMUs will be less subject to chipping and cracking. If you're committed to total quality and customer satisfaction, specify HPCMUs.

continued...

Choose a construction system that won't compromise quality or safety.

Tom Wallace, PE, Wallace Engineering Structural Consultants Inc., Tulsa, OK

"As structural engineers for Wal-Mart Corporation, it is our responsibility to help choose construction systems that are no compromise to quality or safety, and which lend themselves to rapid and economical construction. Concrete masonry units are attractive, economical, and provide fire safety, longevity, and lower insurance rates. They also have the structural capacity to carry gravity, wind, and earthquake loads without backup support.

"We specify lightweight concrete masonry units for all Wal-Mart stores because masons may handle many more units per day without fatigue. Lightweight units weigh about ⅓ less than heavyweight units, so productivity is naturally increased. Maximum productivity is an advantage that we desire in each store built."

Lower Energy Costs

Everyone benefits from HPCMUs, not just the mason contractor. The owners and occupants benefit for years from accrued energy savings. HPCMUs can lower heating and cooling costs by as much as 60%. [7] HPCMUs provide superior insulation by combining high R-values with thermal mass and low thermal bridging.

When comparing tilt-up walls to HPCMU walls of a Houston retail facility (50,000 - 12" CMUs), the HPCMU wall showed a 15% saving in total construction and operating costs over a five-year period. The energy savings alone netted the retailer $21,800 annually. [7]

Reduce Thermal Bridging

Metal frame and heavyweight CMU wall systems are notoriously bad thermal conductors that allow *thermal bridging*. Simply put, thermal bridges allow the funneling of outside temperatures (hot or cold) through the wall via the bridge. This effectively overpowers the R-values of the insulation.

The results are higher energy costs, and uncomfortable hot and cold spots. Metal and wood studs, metal fasteners, and the web in heavyweight CMUs are common high-conductive thermal bridges. The negative effect of the high thermal bridging for heavyweight CMUs and metal studs is clearly shown in the following tables. The superior insulating ability of HPCMUs is a direct result of the low thermal bridging through the web.

R-Values* for Concrete Masonry Walls (h-ft^2 °F/BTU) [9]

Exposed block, both sides	Concrete Density pcf	Cores empty	Cores filled with loose-fill Perlite
8x8x16"	85 135	2.5 1.9	7.1 3.3
12x8x16"	85 135	2.8 2.0	10.3 4.4

* R-values are mid-range.

Parallel Path Correction Factors - Metal Framed Walls with Studs 16 Ga. or Lighter [10]

Size of Member	Spacing of Framing in.	Cavity Insulation R-value	Correction Factor F_c	Equivalent Resistance R_e
2 x 4	16 O.C.	R - 11 R - 13 R - 15	0.50 0.46 0.43	R - 5.0 R - 6.0 R - 6.4
2 x 4	24 O.C.	R - 11 R - 13 R - 15	0.60 0.55 0.52	R - 6.6 R - 7.2 R - 7.8
2 x 6	16 O.C.	R - 19 R - 21	0.37 0.35	R - 7.1 R - 7.4
2 x 6	24 O.C.	R - 19 R - 21	0.45 0. 43	R - 8.6 R - 9.0
2 x 8	16 O.C.	R - 25	0.31	R - 7.8
2 x 8	24 O.C.	R - 25	0.38	R - 9.6

Mason Contractors' Comments

"Using High-Performance Concrete Masonry helped us increase our productivity almost 20%." William (Bill) Wagner, Founder, Tri-Masonry Co.

"I founded Tri-Masonry in 1965. At Tri-Masonry we do all types of masonry including brick, stone, and CMU exclusively on commercial projects. Our customers include Wal-Mart, Target, Hi/Lo Auto Supply, Albertson's, and the Arlington (Texas) and Coppell (Texas) Independent School Districts.

"Recently, we used HPCMUs on a Wal-Mart in Southlake, TX. Using HPCMUs helped us increase our productivity almost 20% versus the Wal-Mart stores we've constructed using heavyweight CMUs. One reason is the 12 in. HPCMU only requires one man while the heavyweight CMU needs two men. The men don't get as tired as fast, either. One man can go seven or eight hours with the HPCMU before he gets as tired. The HPCMU is just what the doctor ordered for us!" ♦

"We support the use of High-Performance Concrete Masonry Units on the jobs we do." David Knight, Owner and Mel Oller, Chief Estimator, D and H Masonry.

"D and H Masonry was established in 1985 in Houston, TX, and is committed to supplying the construction industry with the highest quality masonry jobs possible. We have successfully completed numerous schools for Fort Bend and Houston Independent School Districts, as well as the recently completed Museum of Fine Arts Junior School and Administration Building.

"We support the use of HPCMUs on the jobs we do. We expect better productivity and less chipping due to the lighter weight and higher compressive strength of each unit. As part of the total masonry system that includes quality masonry performed by D and H Masonry, the addition of yet another quality component only results in a winning combination!" ♦

Better attitudes, higher morale, and less breakage. Danny A. Batten, President, Consolidated Masonry Systems, Inc., Garner, NC.

"Using lightweight block, rather than heavyweight, has increased our production and quality of work, as well as created a better attitude and higher morale among our masonry crews. We also have less breakage with lightweight." ♦

Saves both time and money. Bill Merillat, Jayhawk Masonry, Topeka, KS.

"With 8x8x16" lightweight masonry units, we can see at least a 15% increase in mason productivity. With 12x8x16" lightweight units, the increase is more like 35-40%. Time is money, and lightweight saves both." ♦

"We are encouraging the specification of High-Performance Concrete Masonry Units." Robert V. (Buddy) Barnes Jr., President & CEO, Masonry Technology Inc.

"The Dee Brown Companies were formed during the past 40 years with a goal to provide our client with the highest quality masonry product, on time, and within the client's budget. We have provided this work on projects such as the Lew Sterrett Justice Center, Dallas; The Meyerson Symphony Center, Dallas; Burlington Northern Railroad, Ft. Worth; Brooke Army Medical Center, San Antonio; World Savings Corporate Offices, San Antonio.

"As a member of the ASTM-C15 Committee, I understand the HPCMU exceeds all existing ASTM standards, yet will weigh less than the existing CMUs. The lighter weight, along with a more uniform edge and texture, will increase the mason's productivity, thus allowing for a better quality product. We are encouraging the specification of HPCMUs, and we are excited about using this high-quality product to enhance the value and quality of the masonry wall systems we install." ♦

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Salt Lake City, Utah 84117

References

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12B

ESCSI Information Sheet 365.2
"The Modern Approach to Masonry"

The Modern Approach to Masonry
for Mason Contractors

Surviving and Growing in the '90s. It is essential to stay profitable, identify the facts, and expand the masonry market.

1. **Staying Profitable:** Management is responsible for the outcome of the project -- good or bad. If management does not provide the field crew with the proper tools, equipment, or material, the crew is at a serious disadvantage, no matter how good they are.

Management MUST:
- Think long term.
- Purchase carefully.
- Estimate accurately.
- Manage people efficiently.
- Insist on quality workmanship.
- Develop a professional/educational relationship with architects.
- **Be creative and smart -- give the crew a Built-in-Advantage.**

The Built-in-Advantage Is Quality Lightweight Masonry. Lightweight masonry will:
- Lower labor costs through increased productivity with lightweight block.
- Control workers' compensation costs by reducing fatigue and injuries.
- Allow male and female masons to perform efficiently.
- Extend the mason's career because, even though a mason will lay 20% more wall area in a year, the mason still lifts 15% less weight (about 94 tons less per year).
- Let one mason lay a 12" unit because it weighs 35#s, not 52#s!
- Shorten construction time and reduce overhead costs per job.
- Extend equipment life because lighter loads mean less wear and tear.
- Help insure safer scaffolding. Less weight also means it is easier to meet OSHA requirements.
- Make it easier to lay a true and uniform wall. Lightweight masonry tolerates softer mortar and rarely collapses the bed joint.

Lower Wall Costs: Typical Masonry Wall Costs (8"x8"x16")

		HW (1)	LW (2)
Labor		55%	45.6%
Block		20%	26.0%
Block delivery		3%	2.4%
Misc. materials (reinforcing, mortar, etc.)		5%	5.0%
Equipment		5%	5.0%
Overhead	Fixed	8%	6.6%
	Variable	4%	4.0%
Savings		0	5.4%
Total		100%	100%

(1) These percentages are averages based on conversations with mason contractors across the country.
(2) The lightweight percentages incorporate the savings illustrated on page 2.

Productivity: The productivity of a mason is primarily determined by the size and weight of the Concrete Masonry Unit (CMU). Productivity is crucial because labor and block costs equal about 78% of the total wall costs.

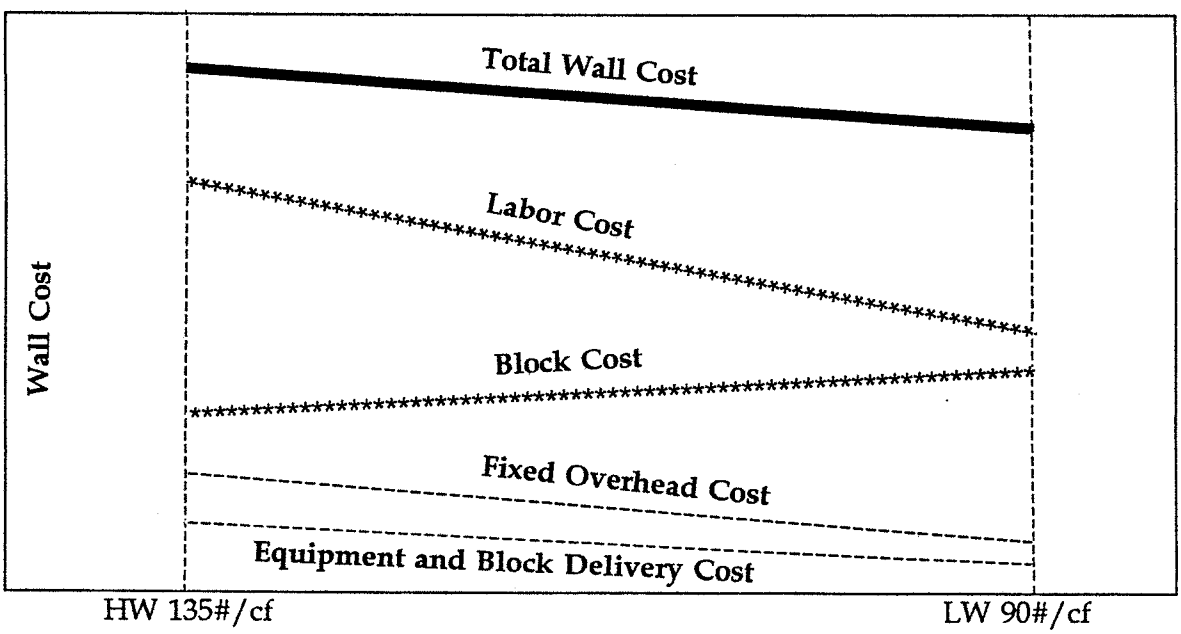
Productivity Table

Block Weight	**Increased Productivity**[3] 8x8x16	12x8x16
Heavyweight block to lightweight block	17%	24%
Heavyweight 8"x8"x16" to lightweight 8"x8"x24"	48% increase	

(3) These productivity increases are adjusted down 20% to account for fixed labor costs (scaffolding, etc.).

Lightweight Masonry vs. Heavyweight Masonry Examples:	**Total Wall Costs**
8"x8"x16" Change from heavyweight to lightweight.	
Labor cost 17% savings x 55% =	9.4% less
Block cost 30% increase x 20% =	6.0% more
Block delivery 20% savings x 3% =	0.6% less
Fixed overhead 17% savings x 8% =	1.4% less
Cost reduction =	5.4% **savings**
12"x8"x16" Change from heavyweight to lightweight.	
Labor cost 24% savings x 55% =	13.2% less
Block cost 21% increase x 20% =	4.2% more
Block delivery 20% savings x 3% =	0.6% less
Fixed overhead 24% savings x 8% =	1.9% less
Cost reduction =	11.5% **savings**
8"x8"x24" Change from 8"x8"x16" heavyweight to 8"x8"x24" lightweight.[4]	
Labor cost 48% savings x 55% =	26.4% less
Block cost 80% increase x 20% =	16.0% more
Block delivery 20% savings x 3% =	0.6% less
Fixed overhead 48% savings x 8% =	3.8% less
Cost reduction =	14.8% **savings**

(4) Additional savings: The 8"x8"x24" unit also requires less mortar because of fewer head joints. If two masons are required on a block, why not make it a 24" long unit?



Total Wall Cost Trend

2. Identifying the Facts: There are some old industry misconceptions.

The Facts on Quality Lightweight Masonry Are:

- Energy (hot or cold): Lightweight masonry provides better thermal resistance with no core insulation than heavyweight masonry with insulating core inserts.
- Total Wall Costs: Lightweight masonry can save you money by increased productivity.
- Strength: Lightweight masonry made from quality lightweight aggregate (LWA) meets the strength requirements of all modern structural applications.
- Durability: Lightweight masonry made with quality LWA provides equal durability.
- Fire: Quality lightweight masonry provides better fire resistance while maintaining dimensional stability.

A Better Wall System: Quality lightweight masonry combines all the traditional strength of concrete masonry plus much, much more.

- High energy efficiency
- Better fire rating
- Excellent seismic performance
- Nailable surface
- Higher sound absorption
- Low sound transmission
- Structural stability
- Structure and finish in one step -- single wythe walls lay up faster and create superior insulated load-bearing walls that are finished on both sides.

What Is Lightweight Masonry?

Block Size	LW 90#/cf ESCSI	LW 105#/cf ASTM	135#/cf Heavyweight
8"x8"x16"	25#	29#	37#
12"x8"x16"	35#	41#	52#
8"x8"x24"	35#	40#	52#

What Makes Masonry Light? Concrete block consists of:

- Cementuous materials (cement, fly ash, water, admixtures)
- Aggregate (heavyweight or lightweight)

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What Is Lightweight Aggregate?

- Manufactured structural grade lightweight aggregate:
  * Expanded shale, clay and slate (ESCS)

- Natural lightweight aggregate:
  * Pumice * Volcanic cinders
  * Scoria * Rhyolite

- By-products:
  * Coal cinders
  * Bottom ash
  * Expanded slags

Note: Not all lightweight aggregates are equal. Not all lightweight CMUs are equal. Some perform better than others. There is usually a price-to-quality tradeoff; make sure you know what aggregate the CMU is made with, and how well the CMU will perform.

3. **Expanding the Masonry Market:** Architects and engineers analyze the total building system (aesthetics, performance, cost, etc.). They base their decisions on the best value for their client's money. If their clients are satisfied, architects will design more masonry buildings.

Quality Lightweight Masonry Provides the Best Return on Everyone's Investment.

- Competitive initial cost.
- Reduced construction time.
- Earlier occupancy.
- Excellent life-cycle economy.
- Lower energy bills.
- Low maintenance.
- Low insurance costs.

Your Future: Profitability in the '90s means a mason contractor must:

- Put crews in the field with the Built-in-Lightweight-Advantage.

- Market quality lightweight masonry because it clearly gives everyone a better return on their investment.

Quality Lightweight Masonry Is the Smart Way to Profit in the '90s.

12C

ESCSI Information Sheet 3700.3

"NCMA Investigation of Mason Productivity"

Research Investigation of
MASON PRODUCTIVITY

ESCSI # 3700.3

NCMA Research & Development Laboratory

Sponsored by
National Concrete Masonry Association
Expanded Shale, Clay & Slate Institute

Designed by
Masonry Consultants, DeBary, Florida

Preface

This research program was carried out under the supervision of Mr. Reg Miller, Masonry Consultants, and Mr. Ed Hedstrom, Director of Research and Development, National Concrete Masonry Association.

Construction of the test walls was conducted in a controlled environment to prevent the introduction of outside variables which might directly or indirectly influence the results of the study.

The National Concrete Masonry Association, the Expanded Shale, Clay And Slate Institute, and Masonry Consultants make no claims, expressed or implied, as to the relevance of production rates determined as a result of this limited investigation to actual production rates which may be expected under actual job site conditions.

Results of this study shall not be used for estimating purposes and may not be reproduced without written approval of the sponsoring organizations.

Abstract

This report presents the results of research conducted on concrete masonry to determine the effect of such properties as unit size and weight on mason productivity.

The investigation was carried out in a controlled environment to avoid the introduction of additional variables which might influence the results and/or render it impossible to duplicate the test conditions at some later date and location.

Four concrete masonry walls were constructed under close supervision using 16" and 24" long lightweight and heavyweight units. The original intent was for all four walls to be constructed of the same width. However, due to the inability to locate a source of 6"x8"x24" heavyweight units, it was decided to construct the two walls consisting of 24" long units of a different width and bonding pattern of that selected for the 16" units.

It therefore was possible to make a direct comparison of the productivity rates of only two courses of the walls constructed of 16" and 24" long units.

However, direct comparison between the courses of walls constructed of 16" long lightweight and heavyweight units and the courses of walls constructed of 24" long lightweight and heavyweight units was possible.

By summing the measured times of all the courses of each wall it can be shown that the production rate of the wall constructed of 16" long lightweight units exceeds that of the wall constructed of 16" heavyweight units by approximately 14.7%. In like manner it can be shown that the production rate of the wall constructed of 24" long lightweight units exceeds that of the wall constructed of 24" heavyweight units by approximately 18.7%.

Generally speaking, productivity increased as the weight of the units decreased and the length of the units increased.

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1.0 Research Objective

The objective of this investigation was to document the effect of concrete masonry physical properties, weight and size, on the comparative times required for a mason to place the units in a wall of predetermined length and height.

The objective also included documenting the relationship between the time required to lay units of varying size and weight at different courses (heights) within the wall, and the relationship between the time required to lay units facing the line (line along the inside face of the wall) and the time required to lay the units overhand (line along the outside face of the wall).

The investigation was designed in such a manner to insure its reproducibility at other locations across the country to establish the validity of the results obtained.

The tests results are intended to be used as a guide to develop recommendations for the implementation of materials and/or methods designed to decrease time and costs required for the construction of concrete masonry walls.

2.0 Scope

This test program involved the construction of four concrete masonry walls using concrete masonry units of different size and weight, but consisting of the same number of courses and being equal in size in total area of exposed wall surface.

Variables included size of units (width and length), weight of units, and method of placement (laid facing the line or overhand). Measurements were taken of the time required to complete the individual courses and recorded.

Although fatigue is an important consideration in any task involving manual lifting and repetitive movements, no provisions for the introduction of a fatigue factor was provided.

Economic considerations, such as those related to material costs, additional labor to place units above 4'-0", etc., are beyond the scope of this investigation.

3.0 Material Properties

3.1 Concrete Masonry Units

Concrete masonry units for use in this investigation were selected on the basis of two variables: unit weight (density) and length.

Unit Weight:

Lightweight units were to be manufactured from concrete having a unit weight of 85 lbs. per cu. ft.

Heavyweight units were to be manufactured from concrete having a unit weight of 135 lbs. per cu. ft.

However, unit weights of the concrete from which the units actually used during the course of this investigation were found to vary from 84.1 to 101.6 pcf for lightweight units and 126.6 to 133.8 for heavyweight units.

Length:

Two sizes of concrete units were employed: those having a nominal length of 16 inches (15⅝ actual) and those having a nominal length of 24 inches (23⅝ actual).

A complete description of the concrete masonry units used is as follows:

▶

	Lightweight			Heavyweight		
Nominal Size: (in.)	Weight: (lbs.)	Net Vol.* (cu. ft.)	Unit Wt.: (pcf)	Weight: (lbs.)	Net Vol.* (cu. ft.)	Unit Wt. (pcf)
4×8×16	17.0	0.19	88.9	24.3	0.19	130.1
6×8×16	19.1	0.23	84.1	32.6	0.25	129.7
8×8×16	25.3	0.28	90.5	34.3	0.27	128.1
12×8×16	35.6	0.40	89.0	48.4	0.38	126.6
4×8×24	26.1	0.28	93.9	36.6	0.27	133.8
8×8×24	46.4	0.46	101.6	52.9	0.40	131.8

* *Calculated Values*

3.2 Mortar

The mortar used was an extended life plastic (ready mixed) mortar, selected on the basis of easily controllable consistency and delivered to the site pre-mixed, thus eliminating any variables which might be introduced during batching and mixing at the job site.

It was delivered and maintained at a cone penetrometer reading of 51 mm ± 5 mm. Variations in consistency were dictated by the mason: higher cone readings for lighter units and lower cone readings for heavier units.

4.0 Mason Profile

The mason selected for this program is employed in the metropolitan Washington, D.C. area where he doubles as a foreman and line mason.

He is of medium height (5′10″) and weight (165 lbs.) and slightly below the estimated average age for masons in the United States (43 years as compared to 53 years on the national average).

The mason professed to being of average speed, which is desirable for the purposes of this investigation.

5.0 Layout of Test Walls

Timed portions of the test walls were designed to measure 28′-0⅜″ in length and provide 18.78 sq. ft. of wall area per course. Courses consisted of single units and multiple units of various widths. (See Figures 5.0-1 and 5.0-2).

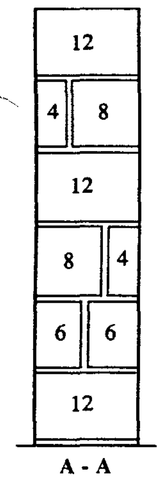
Walls constructed using 16″ long units consisted of 21 units per course, while walls constructed using 24″ long units consisted of 14 units per course (timed length).

Masonry leads were not built; instead, pre-built guides were provided from which to pull the lines. The guides were located outside the length limits of the test walls and units of proper size and length were placed at each end to provide a closure for each course and insure that the proper wall length (28′-0⅜″) was maintained.

6.0 Wall Construction Procedures

The order in which the test walls were to be built was determined by a blind draw. The construction was as follows:

1st Day (10/27/87): Walls consisting of 16″ long heavyweight units



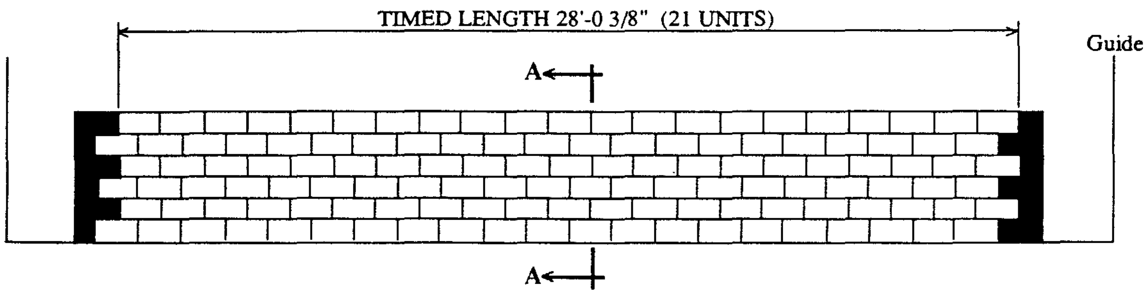
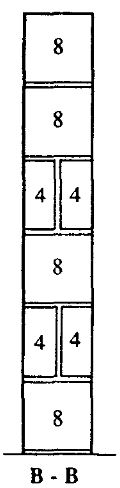


FIGURE 5.0-1 LAYOUT OF WALLS CONSTRUCTED OF 16" LONG CONCRETE MASONRY UNITS



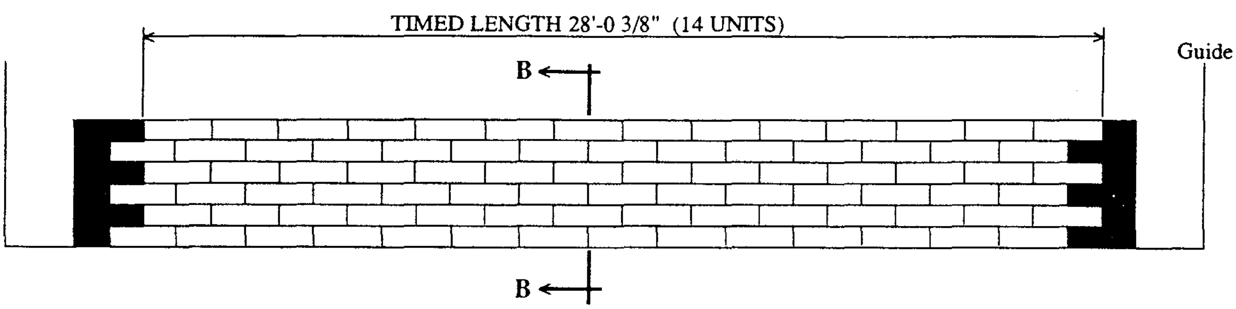


FIGURE 5.0-2 LAYOUT OF WALLS CONSTRUCTED OF 24" LONG CONCRETE MASONRY UNITS

2nd Day (10/28/87):	Walls consisting of 24″ long heavy-weight units
3rd Day (10/29/87):	Walls consisting of 24″ lightweight units
4th Day (10/30/87):	Walls consisting of 16″ lightweight units

The walls constructed of 16″ long units were laid up according to the schedule listed in Table 6.0-1.

TABLE 6.0-1
Construction Sequence:
Walls Constructed of 16″ Long
Concrete Masonry Units

Course No.	Unit Size	Line Placement Inside	Line Placement Outside
1	12×8×16	X	
2	6×8×16		X
	6×8×16	X	
	10 Minute Break		
3	8×8×16		X
	4×8×16	X	
4	12×8×16		X
	40 Minute Lunch Break		
5	4×8×16		X
	8×8×16	X	
6	12×8×16	X	

Unit Weight Of Concrete	*Varies (126.6–133.8 pcf)*
Length Of Timed Course	*28′–0⅜″*
Number Of Units Per Course	*21*
Area Of Exposed Wall Surface, Each Wythe	*18.78 Sq. Ft.*

TABLE 6.0-2
Construction Sequence:
Walls Constructed of 24″ Long
Concrete Masonry Units

Course No.	Unit Size	Line Placement Inside	Line Placement Outside
1	8×8×24	X	
2	4×8×24		X
	4×8×24	X	
	10 Minute Break		
3	8×8×24		X
4	4×8×24		X
	4×8×24	X	
5	8×8×24	X	
6	8×8×24		X
	40 Minute Lunch Break		
6A	8×8×24		X

Unit Weight Of Concrete	*Varies (126.6–133.8 pcf)*
Length Of Time Course	*28′–0⅜″*
Number Of Units Per Course	*21*
Area Of Exposed Wall Surface, Each Wythe	*18.78 Sq. Ft.*

A 10 minute break was provided at the completion of the 2nd course and a 40 minute lunch break upon completion of the 4th course.

The walls constructed of 24″ long units were laid up according to the schedule listed in Table 6.0-2.

A 10 minute break was provided at the completion of the 2nd course and a 40 minute lunch break upon completion of the 6th course.

The 6th course of the walls constructed of 24″ long units was removed during the lunch break and repeated using two masons. This course, designated 6A, was also timed.

Block were placed at the ends of each course to position the lines for laying (trigs were used) and provide a course for the

please turn page

timed portion of the test (see Figures 5.0-1 and 5.0-2). The placement of these units was not considered a part of the test and was not timed.

Previous to laying the courses consisting of multiple units, hardware cloth was placed on top of the preceding course. This served to provide a setting bed for the mortar forming the bedding for the face shells located along or near the enter of the wythe. This screen also prevented mortar from falling into the cores and allowed for some absorption of water into the crosswebs of the units below. This absorption is necessary to activate the setting mechanism of the extended life plastic mortar being used.

Throughout the test, mortar was applied to the head (vertical) joints of the unit previously placed as well as the unit to be laid. This method of forming head joints was arbitrarily determined prior to the start of the test and was not intended to be an integral part of the investigation.

The test walls were not struck or tooled, the determination for completion of each course being that all joints be full and ready to be finished.

The investigation took place inside the facility of the National Concrete Masonry Association's Research and Development Laboratory under controlled climate and temperature conditions. This was done to exclude such variables as may be encountered under outside weather conditions and to make the investigation more easily reproducible.

The mason performed the timed portions of the test without interruptions or distractions. Talking and smoking was discouraged, although not prohibited. During the placement of course 6A in the walls constructed of 24″ long units, talking was necessary in order to assure coordination between the two masons.

7.0 Test Results

A tabulation of test results is presented in Tables 7.0-1 through 7.0-4.

Tables 7.0-1 and 7.0-2 illustrate the relative increases in number of concrete masonry units placed per hour and subsequent increased square footage of wall per hour which can be expected when lightweight units are used in lieu of heavyweight units. This comparison is made for 4″, 6″, 8″ and 12″ units, 16 inches in length; and for 4″ and 8″ units, 24 inches in length.

Table 7.0-3 provides a direct comparison of measured production rates between 8″×8″×16″ and 8″×8″×24″ heavyweight units, as well as lightweight units.

Table 7.0-4 illustrates the effect of unit weight and line placement on productivity.

Although not indicated in the tables, productivity doubled when two men were used to place course 6A as compared to one man placing course 6.

TABLE 7.0-1
Comparison of Results:
16″ Long Heavyweight Vs. Lightweight Units

UNIT Size	Type	COURSE	LINE PLACEMENT	TIME/COURSE (Min:Sec)	TIME/UNIT (Sec)	NO. BLK. (Hr.)	RATE (Sq. Ft./Hr.)	RATE (% Change)
4×8×16	H.W.	3	Inside	15:28	44.2	81.4	72.9	
	L.W.			13:21	38.1	86.7	86.7	+18.9
4×8×16	H.W.	5	Outside	19:16	55.1	65.3	58.5	
	L.W.			15:36	44.6	80.7	72.2	+23.4
6×8×16	H.W.	2	Outside	15:04	43.1	83.5	74.8	
	L.W.			14:32	41.5	86.7	77.5	+ 3.6
6×8×16	H.W.	2	Inside	15:15	43.6	82.6	73.9	
	L.W.			14:01	40.1	89.8	80.4	+ 8.8
8×8×16	H.W.	3	Outside	16:26	47.0	76.6	68.6	
	L.W.			15:12	43.4	82.9	74.1	+ 8.0
8×8×16	H.W.	5	Inside	16:08	46.1	78.1	69.8	
	L.W.			14:40	41.9	85.9	76.8	+10.0
12×8×16	H.W.	1	Inside	16:08	46.1	78.1	69.8	
	L.W.			13:21	38.1	94.5	84.4	+20.9
12×8×16	H.W.	4	Outside	16:09	46.1	78.1	69.8	
	L.W.			14:51	42.3	85.1	75.9	+ 8.7
12×8×16	H.W.	6	Inside	20:36	58.9	61.1	54.7	
	L.W.			15:35	44.5	80.9	72.3	+32.1

TABLE 7.0-2
Comparison of Results:
24″ Long Heavyweight Vs. Lightweight Units

UNIT Size	Type	COURSE	LINE PLACEMENT	TIME/COURSE (Min:Sec)	TIME/UNIT (Sec)	NO. BLK. (Hr.)	RATE (Sq. Ft./Hr.)	RATE (% Change)
4×8×24	H.W.	2	Outside	13:07	56.2	64.1	85.9	
	L.W.			9:41	41.5	86.7	116.4	+35.5
4×8×24	H.W.	2	Inside	11:36	49.7	72.4	97.1	
	L.W.			9:03	38.8	92.8	124.5	+28.2
4×8×24	H.W.	4	Outside	11:36	49.7	72.4	97.1	
	L.W.			9:49	42.1	85.5	114.8	+18.2
4×8×24	H.W.	4	Inside	10:52	46.6	77.3	103.7	
	L.W.			9:34	41.0	87.8	117.8	13.6
8×8×24	H.W.	1	Inside	11:52	48.7	73.9	95.0	
	L.W.			9:52	40.1	89.8	114.2	+20.2
8×8×24	H.W.	3	Outside	10:49	46.4	77.6	104.2	
	L.W.			10:16	44.0	81.8	109.8	+ 5.4
8×8×24	H.W.	5	Inside	12:57	55.5	64.9	87.0	
	L.W.			11:28	49.1	73.3	98.3	+13.0
8×8×24	H.W.	6	Outside	13:57	59.8	60.2	80.8	
	L.W.			11:57	51.2	70.3	94.3	+16.7

TABLE 7.0-3
Comparison of Results:
16" Long Vs. 24" Long Masonry Units

UNIT Size	Type	COURSE	LINE PLACEMENT	TIME/COURSE (Min:Sec)	TIME/UNIT (Sec)	NO. BLK. (Hr.)	RATE (Sq. Ft./Hr.)	RATE (% Change)
8×8×16	H.W.	3	Outside	16:26	47.0	76.6	68.6	
8×8×24	H.W.			10:49	46.4	77.6	104.2	+51.9
8×8×16	L.W.	3	Outside	15:12	43.4	82.9	74.1	
8×8×24	L.W.			10:16	44.0	81.8	109.8	+48.2
8×8×16	H.W.	5	Inside	16:08	46.1	78.1	69.8	
8×8×24	H.W.			12:57	55.5	64.9	87.0	+24.6
8×8×16	L.W.	5	Inside	14:40	41.9	85.9	76.8	
8×8×24	L.W.			11:28	49.1	73.3	98.3	+28.0

TABLE 7.0-4
Comparison of Results:
Line Placement—Outside Vs. Inside

UNIT Size	Type	COURSE	LINE PLACEMENT	TIME/COURSE (Min:Sec)	TIME/UNIT (Sec)	NO. BLK. (Hr.)	RATE (Sq. Ft./Hr.)	RATE (% Change)
4×8×24	H.W.	2	Outside	13:07	56.2	64.1	85.9	
	H.W.		Inside	11:36	49.7	72.4	97.1	+13.0
4×8×24	L.W.	2	Outside	9:41	41.5	86.7	116.4	
	L.W.		Inside	9:03	38.8	92.8	124.5	+ 7.0
4×8×24	H.W.	2	Outside	13:07	56.2	64.1	85.9	
	L.W.		Inside	9:03	38.8	92.8	124.5	+44.9
4×8×24	H.W.	2	Inside	11:36	49.7	72.4	97.1	
	L.W.		Outside	9:41	41.5	86.7	116.4	(+19.9)
4×8×24	H.W.	4	Outside	11:36	49.7	72.4	97.1	
	H.W.		Inside	10:52	46.6	77.3	103.7	+ 6.8
4×8×24	L.W.	4	Outside	9:49	42.1	85.5	114.8	
	L.W.		Inside	9:34	41.0	87.8	117.8	+ 2.6
4×8×24	H.W.	4	Outside	11:36	49.7	72.4	97.1	
	L.W.		Inside	9:34	41.0	87.8	117.8	+21.3
4×8×24	H.W.	4	Inside	10:52	46.6	77.3	103.7	
	L.W.		Outside	9:49	42.1	85.5	114.8	(+10.7)
6×8×16	H.W.	2	Outside	15:04	43.1	83.5	74.8	(+ 1.2)
	H.W.		Inside	15:15	43.6	82.6	73.9	
6×8×16	L.W.	2	Outside	14:32	41.5	86.7	77.5	
	L.W.		Inside	14:01	40.1	89.8	80.4	+ 3.7
6×8×16	H.W.	2	Outside	15:04	43.1	83.5	74.8	
	H.W.		Inside	14:01	40.1	89.8	80.4	+ 7.5
6×8×16	H.W.	2	Inside	15:15	43.6	82.6	73.9	
	L.W.		Outside	14:32	41.5	86.7	77.5	(+ 4.9)

8.0 Conclusions

When evaluating the results from Tables 7.0-1 and 7.0-2, it becomes quite evident that significant increases in productivity can be realized when lightweight concrete masonry units are used in lieu of *heavyweight* units.

Further, a review of Table 7.0-3 indicates that the use of 24" long units can increase productivity by approximately 25–50% over 16" long units, depending upon the height of the lift.

Table 7.0-4 illustrates that there is a distinct advantage to laying facing the line as opposed to laying overhand; the exception being that it is more productive to lay lightweight units overhand than to lay heavyweight units facing the line.

As noted in Section 3.0, Material Properties, the unit weight of the concretes from which the units were manufactured varied from that specified. As a result, the differences in weight between the *heavyweight* and lightweight units was less than anticipated. The assumption can be made that had the proper density units been provided, the increases in productivity noted in the tables would be more substantial.

Although, as indicated in the results, productivity doubled when two men were used to place the top course of 24" long units (8"×8"×24"), it has not been established whether this was due to the weight of the unit or height of the lift. Undoubtedly, it was a combination of the two. Nevertheless, it is apparent that 24" long units placed at heights of 4'-0" or above should be handled by 2 masons.

9.0 Recommendations

If it is determined that this investigation be repeated. the following recommendations are herewith presented:

1. **The widths of all walls should be the same.**
2. **Layout of courses should be the same (i.e. single units in the same course, multiple units in the same course).**
3. **A fatigue factor should be included by constructing walls of predetermined length using 12"×8"×16" units on the same day and following construction of the walls consisting of 24" long units.**
4. **Additional tests be conducted at one or more different locations under the same conditions and supervision to determine the reproducibility of test results.**

Mason's Comments

"I felt that I accomplished more after laying the 24" long units. I like them. Masons like to feel that they're accomplishing something regardless what others might think. You know, with these long units, you have fewer joints to fool with and fewer joints to leak." ▶

MASON PRODUCTIVITY

continued from page 13

"The lightweight block had to be laid, the heavyweight block seem to lay themselves if you spread the right amount of mortar."

"I thought that it was taking just as long or longer to lay the lightweight block as it did the heavyweight units. I'm surprised at the results of the test."

"I furrowed the mortar sometimes and didn't furrow it at other times depending on the consistency of the mortar at the time and the unit to be laid. I was taught to not fool with the mortar, just pick it up and lay it down, that's why I like the mortar tubs over mortar boards, you don't have to roll the mortar to pick it up. If I don't have to furrow the mortar, I'm not going to. It just wastes time."

"I could pick up the 4"–24" long units with one hand, from a weight standpoint, but because of the length, I needed the other hand for balance."

"I'm not nearly as tired after laying these lightweight units as I was yesterday after the heavy ones. I was even able to keep my trowel in my hand some of the time. After you got used to these block, I think you could keep your trowel in your hand all the time and that's important. Every time you put your trowel down, you lose time. There is no way to keep your trowel in your hand while laying heavyweight block, either 16" or 24" long."

"I didn't knowingly slow down or speed up during the test. I tried to keep a steady pace. I might work faster on the job because I'm working against someone and don't want to be caught in the hole."

"I think the test was fair. You should cut these production figures at least in half due to job conditions, but all in all, it was a fair test."

Your Comments Invited. . . .

You are invited to submit your comments on this test, its results and its procedures. Additional tests are being planned and constructive comments relative to the methods followed are welcomed.

Gentlemen:

I would like to offer the following remarks concerning the Mason Productivity tests.______________

____

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____

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____

____

Signature ______________________

Send your comments to:

Mason Contractors Association of America
17W601—14th Street
Oakbrook Terrace, IL 60181

12D

ESCSI Information Sheet 3600.0

"Lightweight CMU-A Weight off our Shoulders"

ESCSI Expanded Shale Clay and Slate Institute

Publication #3600.0
February 2004

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.

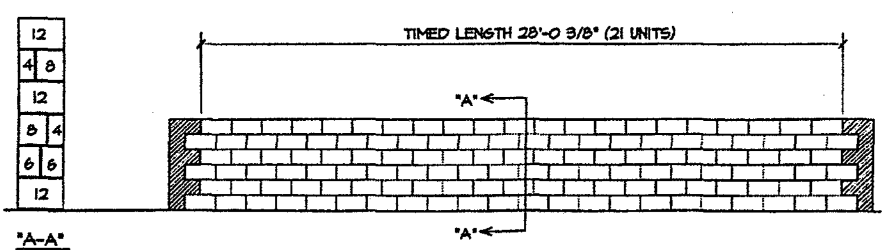

Figure 1. Layout of wall constructed of 16" long CMU.

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.

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.

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/m³] concrete) can increase productivity 10% to 18% over heavyweight units (125 pcf [2,000 kg/m³] 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.

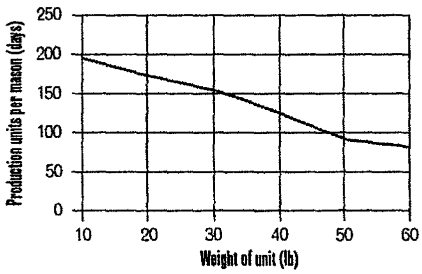

Figure 2. Estimated production rates based on CMU weight. Reprinted with NCMA permission from Kolkoski, R.V., Masonry Estimating. Craftsman Book Company, 1988.

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

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.

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.

Kyle Lochonic is project manager for Davenport Masonry, Inc. and a preservationist.

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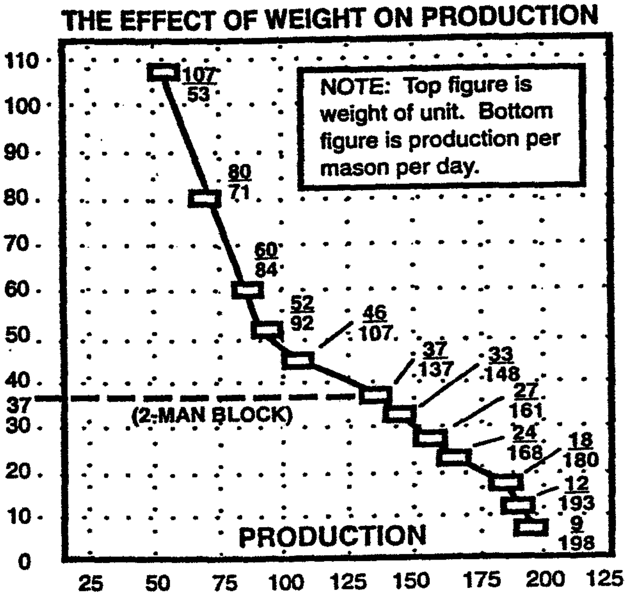
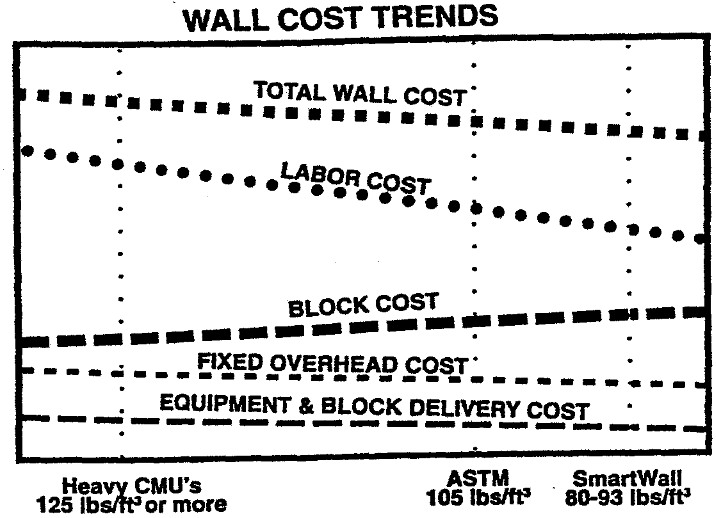
THE EFFECT OF WEIGHT ON PRODUCTION



Reference: Rynold V. Kolkosk, *Masonry Estimating*, The Aberdeen Group, Addison,IL

WALL COST TRENDS



SmartWall Systems® Guide Specifications

Guide Specification (Short Form): Sec 04810 - Unit Masonry Assemblies:

SmartWall Systems walls shall be constructed using high performance concrete masonry units manufactured by a SmartWall systems producer certified by the Expanded Shale Clay and Slate Institute, Salt Lake City, Utah. The concrete masonry units shall meet the requirements of ASTM C 90 *Standard Specification for Load Bearing Concrete Masonry Units* and the following additional requirements:

- The concrete masonry unit shall have a minimum net compressive strength of 2500 psi (17 Mpa) and a density not exceeding 93 lb/cu ft (1500 kg/m³), determined in accordance with ASTM C 140 *Sampling and Testing Concrete Masonry Units.*

- The lightweight aggregate used in the manufacture of the concrete masonry units shall be structural grade expanded shale, clay or slate manufactured by the rotary kiln process, and shall meet the requirements of ASTM C 331 *Standard Specification for Lightweight Aggregate for Concrete Masonry Units.*

SmartWall Units, Maximum Jobsite Weight (Mass) of SmartWall Units (1)

Size	Not To Exceed	Size	Not To Exceed
4" x 8" x 16"	18 lbs. (8.0 kg)	10" x 8" x 16"	33 lbs. (14.5 kg)
6" x 8" x 16"	23 lbs. (10.5 kg)	12" x 8" x 16"	36 lbs. (15.5 kg)
8" x 8" x 16"	26 lbs. (11.5 kg)	8" x 8" x 24"	38 lbs. (17.0 kg)

The maximum job weight of SmartWall units is based on typical net volumes and may vary depending on the block mold configuration.

12E
Ergonomic Progress Report

LIGHT WEIGHT BLOCK PROJECT – PROGRESS REPORT

Laura Welch
CPWR
September 18, 2003

Background:

Back disorders are common among construction workers, and masons have a particularly high risk of developing low back pain and low back disorders. Masonry is one of the top five industries for musculoskeletal disorders. Among working masons, 70-80% report on-going back pain. In addition to back disorders, masons also have high rates of hand/wrist and shoulder problems. These conclusions are based on studies from several countries, data from multiple sources – the problem is clear.

Masonry work involves several risk factors for lower back injury. Primary among them are the weight of bricks or blocks, the frequency of lifting, the height from which the block is picked up, the height at which the block is placed, the height of the mortar stand, the distance of the block from the worker's body, and degree and frequency of twisting involved. The Construction Safety Association of Ontario, WIHSA in Washington State, and TNO/Arbouw in the Netherlands have performed several ergonomic analyses of mason work, and so we have available a good understanding of the specific risk factors. Other studies document time spent in different masonry tasks, and improvements expected with assistive devices such as height adjustable mortar boards.

Goals/objectives of this project:

Our specific aim for the study was to determine if a change from standard cement block to a lightweight block leads to a reduction in musculoskeletal symptoms among masons. Our target was to enroll 100 masons in the study, and have each complete five questionnaires over the course of several months. We hoped to interview each mason after several weeks of work with light weight block and with standard weight block. We asked about pain in the back, shoulders, and hand/wrist area over different periods of time, and asked about the frequency and severity of a problem if present. The goal was to see if current symptoms were reduced in frequency or severity when a mason used light weight block, as compared to his usual work.

The University of Iowa has completed data collection on its parallel project, to observe changes in muscle activity in the back while masons used light weight and standard weight block. NIOSH has proposed, but not begun, a study of the effect of light weight block on productivity.

Results to date:

We have interviewed about 50 masons, and along the way learned a lot more about light weight block. As expected, the masons have a high rate of back pain, and also have a high rate of hand/wrist problems – see below. (We added the hand/wrist questions after the initial set of interviews, so the number of participants is fewer there).

Lightweight Block Study
Prevalence of Musculoskeletal Problems at Baseline

	Yes	Total Responding	Prevalence
Lower back trouble			
ever	40	48	83.33%
in past year	33	48	68.75%
in past 7 days	17	48	35.42%
1 or more days in past 7	14	46	30.43%
lasting a few hours or more	12	48	25.00%
Upper back, shoulder or neck trouble			
ever	23	47	48.94%
in past year	17	45	37.78%
in past 7 days	9	46	19.57%
1 or more days in past 7	8	45	17.78%
lasting a few hours or more	7	46	15.22%
Hand or wrist trouble			
ever	15	29	51.72%
in past year	12	29	41.38%
in past 7 days	9	28	32.14%
1 or more days in past 7	8	28	28.57%
lasting a few hours or more	9	28	32.14%

These data are consistent with prior surveys of masons. Cook [1] reported that, among 39 masons who were working at the time of the survey, 73% had low back pain, 30% had upper back pain, 54% had shoulder pain, 40% had neck pain, and 41% had hand or wrist pain in the prior 12 months.

Lessons learned:

BAC, IMI, the contractors and masons have been very supportive and cooperative. However, based on the work to date, we don't think our study can meet its goal. Key points are:

[1] Cook TM, Rosecrance JC, and Zimmerman CL. Work-Related Musculoskeletal Disorders in Bricklaying. Appl. Occup Environ Hyg 11:1335-1339 1996

Light weight block varies in weight depending on the specific aggregate used. There are some forms of light weight block weigh only four to five pounds less than some of the lighter forms of standard block. The contractors may not know the weight of the block being used at a specific job. In order to have as much separation as possible in the stress of block work, we would need to pre-screen light weight jobs to choose only those using blocks at the lighter end of the spectrum of weight.

Other physical factors are as important as the weight of the block, and it is not possible to hold those other factors constant from job to job. For example the height of the wall under construction, the size and type of block, and the height at which the mason works, affect the stress on the back and shoulders. Light weight block used to build a wall while the mason picks the block up from floor level and lays it above chest level might produce higher forces on the spine than standard block picked up from knee level and laid at waist level. Size and type of block are also important factors. Unless we could find jobs that hold those other factors reasonably constant we might miss the beneficial effect of lighter block, or attribute an effect to the block when an improvement in the back forces was due to factors other than the block.

The industry knows quite a bit about the impact of light weight block on productivity and cost. The NCMA has a study looking at change in productivity when a mason changes from regular to light weight block, and how that is affected by the size of the block, and there are several other studies published as well.

Existing data on masons is extensive, and even if successful this study might not add anything significant to what we already know.

Proposed plan

We think there is sufficient information on the ergonomics of masonry to encourage implementation of best practices. Before promoting specific changes as best practices however, we need to know:

- What is the universe of methods and tools available to reduce back, shoulder and wrist stress?
- Who is currently using the best available technology? Why are some contractors and masons not using available technology? Is this because some key questions have not been answered by research to date?
- How would any work change affect ergonomics, productivity and cost?

We would propose to explore these questions in three phases:

(1) Focus groups with owners, suppliers, contractors and masons/mason tenders.
(2) Targeted field testing of specific interventions determined to be the most viable based on the focus groups. The focus groups will pinpoint what data are needed

before determining which tools and materials represent best practices. As a priority, we would expect to field test:

a. Adjustable height work scaffolds/platforms
b. Adjustable height masonry stands
c. Light weight masonry block
d. Mechanical lifting devices for block

Use of each of these tools or materials has been shown in a laboratory setting to improve the ergonomics of masonry work. Field testing would be designed to fill in gaps in existing research, and answer questions identified in the focus groups as impediments to implementation. We expect for all field testing we would include a measure of productivity, to be chosen by talking with contractors. For some interventions, if prior ergonomic analyses are not sufficiently detailed, we may also use:

- Observations of muscle activity using a data logger
- Measure of a quantitative reduction in awkward posture, using the Lumbar Motion Monitor (LMM)
- Postural analysis
- Repeated measure of grip strength to look at fatigue over a work day
- Heart rate measurement to measure total work load, and fatigue
- Symptoms survey and fatigue survey

(3) Demonstrate that use of these best practices in a comprehensive program is both feasible and also decreases musculoskeletal load and WMSDs. We plan to have at least three masonry contractors and/or owners implement an ideal program, have another set of contractors and/or owners do work as usual, and compare a range of outcomes between the two groups. Participating contractors would agree to implement as many of the best practices as possible for each specific job; the mix of tools and materials would by necessity vary between contractors and between jobs. The overall goal would be to introduce as many of the tested tools and materials as possible, and with each contractor evaluate the benefits of, and constraints on, use of best practices. We would target small and medium sized contractors as well as large contractors.

Outcomes would include:

- Measures of program compliance, using audits of key program components.
- Measures of productivity
- Measures of acceptability, using questionnaires and focus groups:
    - Did the contractor continue to use best practices - follow up 6 months after the end of the intervention to see if the company or mason continues to use it
- Measures of change in symptoms and/or ergonomic risk factors, which could include:
    - Reductions in pain ratings
    - Reductions in fatigue
    - Reductions in musculoskeletal injuries- number and/or severity

12F
ESCSI Publication 3650.0
“SmartWall Systems®-The Answers”

SmartWall Systems®

The Answers!

SmartWall
HIGH PERFORMANCE MASONRY
Systems®

SmartWall Advantages

Owner/Occupant

- Earlier Occupancy
- Reduced Heating & Cooling Costs
- Exceptional Fire Resistance
- Passes UL E 119 Hose Stream Test
- Sound Absorbing
- Low Sound Transmission
- Nailable Surface
- Impact Resistant
- Low Maintenance
- Wind Resistant
- Termite Proof
- Long Term Durability
- Non-Toxic
- Easy To Paint
- Excellent Life Cycle Economy
- Excellent Return on Investment

Architect-Engineer-Designer

- Greater Design Flexibility
- Less Dead Load
- Less seismic load
- Higher Strength
- Higher Strain Capacity
- Less Chipping
- Multiple Colors, Shapes & Textures
- Readily Available
- Cost Competitive
- Structural Stability
- Structure and Finish In One
- Exceptional Freeze/Thaw Durability
- Aesthetically Pleasing
- Low Shrinkage
- Less Cracking
- Less Chipping
- Excellent Energy Performance: High R-values with Thermal Mass and Low Thermal Bridging

SmartWall Systems®

SmartWall Systems is a concrete masonry wall system that outperforms other masonry and non-masonry wall systems, especially in terms of weight, energy efficiency, maintenance, appearance, fire resistance, durability and strength.

SmartWall is a mason friendly, cost effective wall system that provides speedy construction and a very high degree of customer satisfaction.

What Will SmartWall Do For Me?

Owner/Occupant – SmartWall provides a low maintenance, aesthetically pleasing structure that saves you money on the front-end by speeding construction, and provides energy savings in lower heating and cooling costs year after year. SmartWall also gives you design flexibility, unparalleled safety features, and quiet comfort.

Architect, Engineer & Designer – Available in a wide variety of colors, shapes and textures (such as split-face, split-rib, ground-face, etc.), SmartWall maximizes all the benefits of traditional concrete masonry: flexibility for design expression, durability and economy. Stronger, lighter units make walls more structurally efficient. SmartWall gives you the confidence of knowing you are specifying the best product available. Your client will also benefit from earlier completion and life cycle cost savings. Your customer's satisfaction will be the hallmark of your portfolio for many decades to come.

Masonry Contractor – SmartWall's reduced weight and high strength shorten construction time, provide safer scaffolds, decrease the potential for chips, save wear and tear on your equipment, and make you more competitive with other wall systems. Reduced weight improves ergonomics and reduces work related injuries resulting in fewer worker compensation claims and lower insurance rates, increases mason productivity, and extends the careers of your masons. SmartWall gives you a built-in advantage and a safer working environment.

Block Manufacturer – SmartWall maximizes concrete masonry's competitiveness. By manufacturing high performance concrete masonry units, you help insure the future of the masonry industry by providing a product that is mason-friendly, owner-friendly, and which competes effectively with other wall systems.

What Makes SmartWall So Smart?

It's the aggregate. You may have heard the slogan, "It's what's inside that counts." Inside all SmartWall units is high quality structural grade expanded shale, clay or slate (ESCS) aggregate, manufactured to optimum gradation for compaction, strength, shrinkage control and uniformity of texture. The ESCS aggregate blend is mixed with water, cementitious materials, and admixtures in a precise formulation that is compacted to optimum conditions. Mixture composition may vary according to the manufacturer; however, all SmartWall units must meet or exceed the quality and performance standards (*See Page 5*) established for SmartWall by the Expanded Shale, Clay and Slate Institute.

SmartWall Advantages

Mason Contractor

- Mason Friendly
- Up to 40% Less Weight Compared To Heavy Masonry Units
- Less Mason Fatigue
- Fewer Injuries
- Improved Ergonomics
- Fewer Worker Compensation Claims
- Opportunity For Both Male & Female Masons
- Extends Masons' Careers
- Speedy Construction
- Rarely Collapses Bed Joints
- Reduced Wear On Equipment
- Less Weight On Scaffolds
- One Mason On A 12" Unit
- Reduced Job Overhead
- Lower Labor Cost
- Lower Over-all Wall Cost
- Built-in Advantages

Block Manufacturer

- Maximizes Concrete Masonry Competitiveness
- Less Chipping
- Expands Masonry Market
- Customer Satisfaction

SmartWall Is The Answer!

What Is ESCS?

ESCS (Expanded Shale, Clay or Slate) is a unique, structural grade ceramic aggregate manufactured by expanding select minerals in a rotary kiln at more than 1000°C. The material selection and production are strictly controlled to insure a uniform, high quality product that is structurally strong, stable, durable and inert, yet also light weight and insulative. ESCS aggregate is used in structural lightweight concrete for high- rise buildings, bridges and other exposed structures.

Why Is Reduced Weight A Benefit?

The ESCS structural grade aggregate in SmartWall units provides numerous benefits: Labor, handling and transportation costs are reduced; energy, acoustical and structural performance are enhanced. Reduced weight means less dead and seismic load. This allows greater design flexibility, and often provides significant economies.

What About SmartWall's Structural Stability and Fire Resistance?

Because the ESCS aggregate in SmartWall units has been fired and expanded under extreme heat, the aggregate is insulative and thermally stable; thus, SmartWalls have exceptional fire ratings. ESCS has a coefficient of thermal expansion significantly lower than most ordinary aggregates. SmartWalls can withstand extreme heat and the thermal shock of high pressure fire-hose spray without cracking, caving in, or deforming. They remain intact, ready for reuse after a fire. Proven performance in real world fires has substantiated the excellent fire endurance documented in laboratory test programs. SmartWalls have successfully withstood hose stream exposure after a four-hour fire test. An eight-inch SmartWall easily provides a minimum two-hour rating. Higher ratings can be specified. SmartWall gives you that extra margin of safety that can save lives and dollars.

ESCS aggregate, when combined with high temperature resistant cements, provides the refractory used in kilns, boilers, fire boxes, chimney linings, etc., for residential and industrial applications worldwide.

Two, three and four-hour fire ratings are available. Contact your local SmartWall supplier.

How Strong Is SmartWall?

By optimizing ESCS aggregate gradation and other mix proportions, a very high strength-to-weight ratio is obtained. All SmartWall units exceed ASTM minimum strength by more than 32%. While all SmartWall units must have a **minimum net compressive strength of 2500 psi**, higher strengths are easily achievable when required for structural reasons, a real benefit to design and economy.

Does SmartWall Reduce Noise? YES!

SmartWall's high sound absorption and low sound transmission provide a quiet, peaceful living and working environment. With SmartWall a Noise Reduction Coefficient (NRC) of 0.50 is achievable. SmartWall provides the ideal balance of NRC and STC for excellent noise control.

What About Termites and Decay?

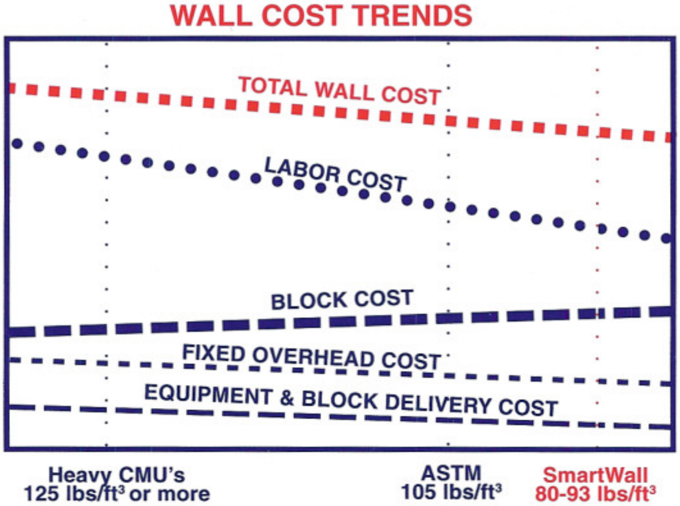
The materials in SmartWall are impervious to attack by termites and will not decay.

SmartWall Is The Answer!

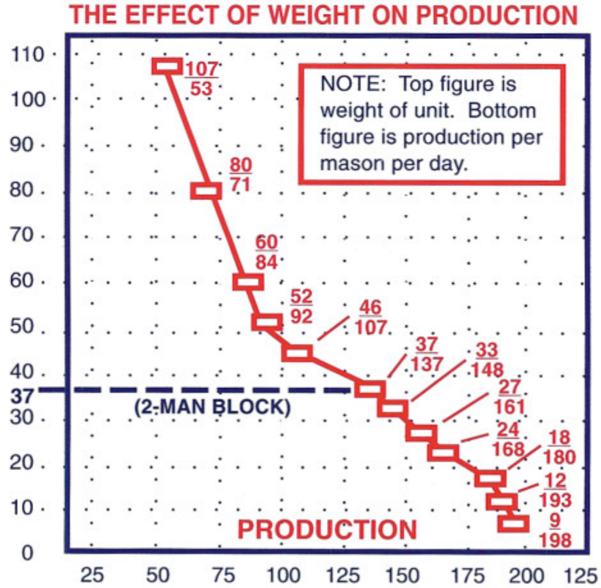
Is SmartWall Cost Effective? YES!

The SmartWall system provides speedy construction that lowers contractors' overhead costs, and affords earlier building occupation. Additionally, SmartWall's reduced weight lowers equipment and material delivery costs. It also reduces the cost of foundation and structural supports, and provides on-going energy savings. Mason friendly SmartWall units help insure a healthy and productive work force. This also helps reduce construction cost. SmartWall provides up-front savings as well as economic benefits that accrue over the useful life of the structure.

WALL COST TRENDS



THE EFFECT OF WEIGHT ON PRODUCTION



Reference: Rynold V. Kolkosk, *Masonry Estimating*, The Aberdeen Group, Addison,IL

What About Water Penetration?

SmartWall can reduce water penetration in two ways: the concrete mixture and ease of placement. By optimizing the aggregate gradation, admixture use, and cementitious content, SmartWall units are very tightly compacted in the block machine. This produces higher strengths, tighter textures, and fewer interstitial voids – all three contribute to reduced water absorption and permeability. These three qualities also enhance the effectiveness of water repellant coatings. Additionally, masons are able to lift and place SmartWall units more easily and consistently, which also contributes to producing a more water-tight wall.

What About Durability?

Freezing and thawing testing programs conducted at both the University of New Brunswick and the University of Nebraska at Lincoln show that properly designed mixtures using ESCS aggregate in high performance concrete masonry perform as well as, if not better than comparable mixtures containing ordinary aggregates. The high performance mixtures were tested in concrete masonry and segmental retaining wall units.

Why Does Mason Productivity Increase?

Mason productivity is primarily determined by the weight of the units being used. Since labor is usually 60% of the total finished wall cost, productivity is of critical importance.

SmartWall Advantages

Energy Efficiency

- High R-Values
- Optimized Thermal Mass
- Low Thermal Bridging
- Reduced Heating And Cooling Costs
- Better Insulation
- Slow Energy Release

SmartWall Is The Answer!

Is SmartWall Energy Efficient? YES!

SmartWall provides superior energy conservation by combining high R-values with thermal mass and low thermal bridging. Wall heating and cooling costs may be reduced by as much as 60%! The concrete in SmartWall has up to 2.5 times the thermal resistance of the concrete in a typical heavy block. This significantly reduces thermal bridging, maximizes the effectiveness of core insulation, and results in the high R-value of SmartWall. Even an un-insulated SmartWall performs as well as core-insulated heavy units! *(See Table Below)*

In addition to thermal resistance, SmartWall also benefits from thermal mass – the *flywheel* effect that minimizes peaks and valleys in heat load as a wall responds to daily changes in ambient temperature. Walls with optimized thermal mass reduce overall energy use, compared to non-masonry walls. SmartWall has the proper balance of thermal mass and thermal resistance for optimum performance.

Calculating the overall effect of thermal mass and thermal resistance in a wall's dynamic response to the environment is a complicated task, one that the ASHRAE 90.1 energy code uses a computer program, ENVSTD*, to perform. However, the results can be dramatic. For example, using ENVSTD to compare the energy performance of a 12" SmartWall with perlite core insulation to an R-19 batt insulated metal stud wall shows that SmartWall outperforms the metal stud system! ENVSTD factors many variables besides opaque wall properties, including glass area, shading overhangs, and building orientation. Using ENVSTD and SmartWall, energy efficient buildings can be designed that comply with energy codes without the need for *added-on* insulation. In many cases a single-wythe SmartWall does the job. **The energy performance of SmartWall is not just smart, it's a money saver!**

*Note: ENVSTD stands for ENVelope STanDard; refer to ESCSI Information Sheet #3201 for more information on ENVSTD and the energy comparison made in this example.

How Does It look? What About Color?

Not only does SmartWall resist chipping and cracking, its more uniform texture produces sharp corners and surfaces that provide structure and finish. If desired, SmartWall is readily paintable. SmartWall is available in the same wide range of sizes, colors and textures as other concrete masonry units.

R-Values For Concrete Masonry Walls (1) (Exposed Both Sides)

Unit Size	Concrete Unit Weight lbs/ft³	Cores Empty	With Core Inserts	Cores Filled With Perlite
8x8x16"	SmartWall(2)	2.5	4.0	6.6
	Heavy CMU's(3)	1.9	2.6	3.2
12x8x16"	SmartWall(2)	2.7	4.4	9.5
	Heavy CMU's(3)	2.0	2.7	4.4

(1) R-Values are mid-range per NCMA TEK 6.1A & 6.2A. R in (h • ft.^{2} • °F)/BTU

(2) SmartWall at 90 lbs/ft^3 (3) Heavy CMU's at 135 lbs/ft^3

SmartWall Systems® Guide Specifications

Guide Specification (Short Form): Sec 04810 - Unit Masonry Assemblies:

SmartWall Systems walls shall be constructed using high performance concrete masonry units manufactured by a SmartWall systems producer certified by the Expanded Shale Clay and Slate Institute, Salt Lake City, Utah. The concrete masonry units shall meet the requirements of ASTM C 90 *Standard Specification for Load Bearing Concrete Masonry Units* and the following additional requirements:

- The concrete masonry unit shall have a minimum net compressive strength of 2500 psi (17 Mpa) and a density not exceeding 93 lb/cu ft (1500 kg/m³), determined in accordance with ASTM C 140 *Sampling and Testing Concrete Masonry Units.*

- The lightweight aggregate used in the manufacture of the concrete masonry units shall be structural grade expanded shale, clay or slate manufactured by the rotary kiln process, and shall meet the requirements of ASTM C 331 *Standard Specification for Lightweight Aggregate for Concrete Masonry Units.*

SmartWall Units, Maximum Jobsite Weight (Mass) of SmartWall Units (1)

Size	Not To Exceed	Size	Not To Exceed
4" x 8" x 16"	18 lbs. (8.0 kg)	10" x 8" x 16"	33 lbs. (14.5 kg)
6" x 8" x 16"	23 lbs. (10.5 kg)	12" x 8" x 16"	36 lbs. (15.5 kg)
8" x 8" x 16"	26 lbs. (11.5 kg)	8" x 8" x 24"	38 lbs. (17.0 kg)

The maximum job weight of SmartWall units is based on typical net volumes and may vary depending on the block mold configuration.

What Are SmartWall Unit Details?

General Information on SmartWall high performance concrete masonry units:

The information below is for general use only. For exact shapes and physical properties, contact your supplier:

Unit Size (inches)	Maximum Jobsite Weight lbs. (1)	Minimum Weight Savings Percent (2)	Concrete Unit Weight Oven Dry lbs/ft³ (93 Max)	Wall R-Value (3)		Wall (4) HC Value
				No Insulation	UF Foam Insulation	
12x8x16	36	37	80-93	2.7	10.1	8.7
10x8x16	33	28	80-93	2.6	8.3	7.8
8x8x16	26	27	80-93	2.5	7.0	6.7
6x8x16	23	23	80-93	2.4	NA	5.6
4x8x16	18	31	80-93	2.1	NA	4.3
8x8x24	38	38	80-93	2.5	7.0	6.4

(1) Oven dry weights will be less than jobsite weights and will depend on unit shape and the concrete unit weight used. The maximum jobsite weights are given just for field control to help insure SmartWall units are being used. For maximum oven dry weights of SmartWall units, contact your supplier.

(2) When compared to heavy concrete masonry at 135 lbs/ft³

(3) R-Values are based on ASTM minimum required block dimensions and 90 lbs/ft³ concrete unit weight using series parallel method (air film included). R in (h • ft² •°F)/BTU.)

(4) Wall HC (Heat Capacity) is based on ASTM minimum required block dimensions, 90 lbs/ft³ concrete unit weight and mortar. HC in BTU/(ft² • °F)

SmartWall Is The Answer!

How Does SmartWall Compare With Other Systems?

	Wood Frame	Tilt-Up 145 lbs/ft³	Metal Stud	Heavy Concrete Masonry[2]	SmartWall[1]
Mason Friendly					X
Opportunity for Female Masons					X
Low Thermal Bridging	X				X
Thermal Mass		X		X	X
Fire Resistant		X		X	X
Lower Fire Insurance Rates		X		X	X
Passes UL E 119 Hose Stream Test		X		X	X
Quiet Comfort		X		X	X
High Sound Absorption					X
Low Sound Transmission		X		X	X
Nailable	X				X
Impact Resistance		X		X	X
Termite Proof		X	X	X	X

(1) SmartWall at 90 lbs/ft³ (2) Heavy CMU's at 125 lbs/ft³ or more

Why Is SmartWall Just Now Being Introduced?

In recent years the rules have changed. The challenges of competing wall systems, the growing cost of construction, the high cost of worker compensation insurance, the heightened focus on energy and real world fire performance, and the opportunity for female masons have created a demand for high performance masonry materials. SmartWall meets the needs of today's market, and gives specifiers all the best reasons to choose concrete masonry over competing wall systems.

Where Can I See SmartWall? Can I Talk To Someone Who Has First-Hand Experience?

There are many SmartWall projects already in service. They include strip malls, office buildings, high-rises, and many other industrial, commercial, and residential structures. For more information, just give us a call.

SmartWall Is The Answer!

Notes:

What is "HEAVY" Masonry?

Anyone who has lifted a concrete masonry unit made with ordinary aggregate knows it's heavy! ASTM defines masonry at 125 lbs/ft³ or more as "Normal Weight."

Let's be realistic. "Normal Weight" concrete masonry is **HEAVY !**

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