

# How to Estimate the Cost of Shear Walls

By Robert G. Queen, CPE

## BIOGRAPHY

The author is Robert G. Queen, CPE, Chief Estimator for Recreational Design and Construction, Inc. a Fort Lauderdale based General Contracting firm specializing in Design-Build Sports and Recreational Facilities throughout Florida and the Caribbean, including Athletic Fields and Municipal and Competition Tennis and Aquatic Complexes.

Prior to joining RDC and in his 30-year tenure in the industry his primary estimating expertise has involved major concrete work for Waste Water Treatment Plants, High Rise Buildings, and NASA structures at Cape Canaveral.

He is a Charter Member of the American Society of Professional Estimators, Gold Coast Chapter 49, serves on its Board of Directors and is an instructor for ASPE supported Open University and Continuing Education Programs at Florida Atlantic University.

## INTRODUCTION

This paper addresses the development of a cost estimate for a major structural component of a building known as a shear wall.

- Main CSI division: division three (3) "Concrete"
- Subdivisions: section 03100 "Concrete Formwork"
- Section 03200: "Concrete Reinforcing"
- Section 03300: "Concrete Placement"

Division three and related subdivisions include but are not limited to the following: Formwork materials, form ties and accessories, exposed surface finishes, embed items, joints, bulkheads, keyways, waterstop, etc. Reinforcing steel and accessories, concrete placing requirements, concrete admixtures and quality standards design criteria (ACI, ASTM, etc.)

## BRIEF DESCRIPTION

Means Illustrated Construction Dictionary defines a shear wall as "a wall portion of a structural frame intended to resist lateral forces, such as earth-

quake, wind and blast, acting in the plane or parallel to the plane of the wall". In other words, the forces applied to the exterior of the structure are transferred through the shear walls to the building foundation. (see sketch #2).

Shear walls can be constructed of reinforced concrete masonry units, wood framing, or cast-in-place reinforced concrete. The most commonly recognized material of choice for shear walls is cast-in-place reinforced concrete. For this reason, the concrete method was selected to be the subject of this paper.

More likely than not, reinforced concrete shear walls will be incorporated into the design of such areas as elevator shafts and/or stairwells. They can provide numerous architectural options with patterns and/or finishes built directly into the face of the forming panel. Factors such as the finish required, the amount of re-use and/or the complexity of the structure will dictate the method of forming the wall.

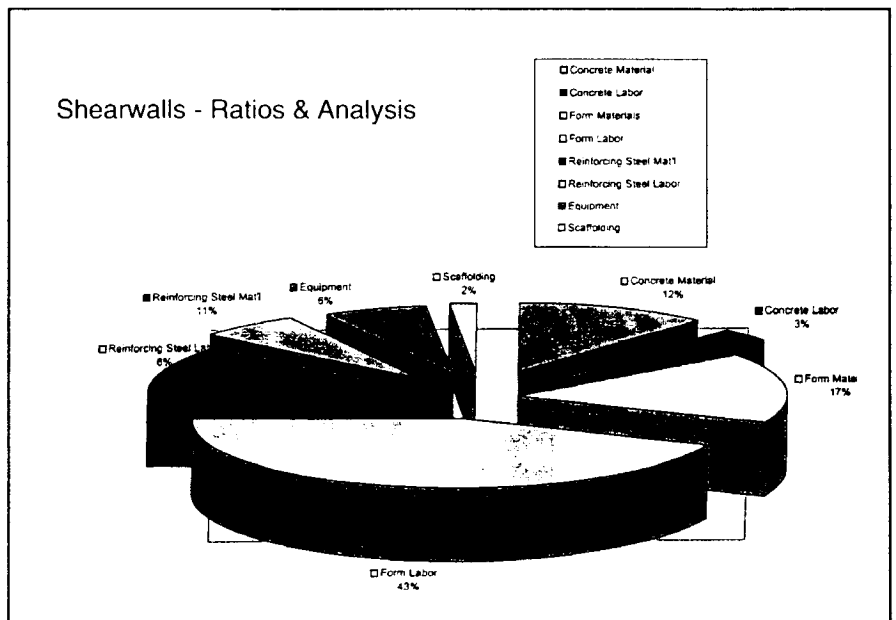
## METHOD OF MEASUREMENT

For the purposes described herein the units of measurement will be as follows: square foot of contact area (sfca) in the development of the costs of the formwork system used, cubic yards (cy) in the quantity of concrete

required, and tons in the determination of reinforcement required.

## FACTORS WHICH MAY AFFECT THE ESTIMATE AND SPECIAL RISK CONSIDERATIONS

The determination of the most efficient means and methods of producing an accurate estimate for this scope of work might possibly be affected by such things as project size and complexity, equipment accessibility, project completion schedule, concrete curing requirements, concrete placement requirements, surface finishes, material availability and re-use, footing elevation changes, deck elevation consistency, and weather. While weather will not have a direct affect on the type of formwork system used, it may very well affect the design of the formwork. Furthermore, consideration must be given to whether or not to construct one set of wall forms to be used for both stairwell walls, since they are mirror image, or two complete separate systems. This would be a determination dependent on the construction schedule and any sub-trade activity which would affect the work. Also, in the event of required minority participation (MBWE) or prevailing wage rates (Davis-Bacon), the costs necessary to



comply with either could impact the selection of sub-trades to perform portions of the work, i.e. reinforcing placement, concrete pumping, etc.

## TYPES OF FORMING SYSTEMS

There are various manufactured wall forming systems available which, when used in large projects, will provide the most re-use, speed of erection and dismantling and allow for whatever finish is required. These systems, commonly referred to as "gang forms", lose their efficiency when being considered for smaller projects or projects which have various changes in footing elevations and/or upper deck elevations. Job built or "hand set" forms enable the forming crew to customize the forms to fit the conditions.

## OVERVIEW OF LABOR, MATERIAL, EQUIPMENT, INDIRECT COSTS

As mentioned in "types of forming systems" there are several methods of forming available to achieve the end result. Of these systems the use of "handset forms" is the basis of this estimate. The quantity survey and pricing extensions will be manually entered in lieu of more sophisticated computer software systems and computer driven quantity survey equipment (digitizers) which may not be available to all estimators. By performing a manual take-off, I will complete the method by which the square foot of contact area (sfca) costs are derived with an itemized component list of materials. These materials are in the development of 64 (sfca) which is represented by 24'-0" x 8'-0" sheets of 1/2" thick "b-b" formply. The shearwall to be estimated is a component part of a first floor stairwell located in a three floor commercial office building. The specifications require that concrete formwork and subsequent concrete placement is not exceed 8'-0" per lift.

## THE ESTIMATE

Components of 1 (one)  
8'0" x 8'0" wall panel  
(see sketch)

### Reusable:

- 8 lf (5.33bf) 2" x 4" soleplate
- 64 lf (42.67 bf) whaler
- 56 lf (39.96 bf) 2" x 4" stud
- 8lf (5.33 bf) 2" x 4" top plate
- 36 lf (23.76 bf) 2" x 4" bracing
- 2 ea 4'0" x 8'0" x 1/2" bb formply
- 20 ea. Form tie shoe (one side)

### Non reusable:

20 ea. Form tie

Approximately 5 lbs. Nails

SAMPLE TAKE-OFF SHEET							1st & 2nd LIFT
PROJECT:	ASPE SHEARWALL	ESTIMATOR:		Form PANELS	8' x 8'	ESTIMATE NO.	
LOCATION:	STAIR WELL #1	EXTENSIONS:		SHEET NO.		SHEET NO.	
ARCH/ENGR:		CHECKED:		DATE:		DATE:	
CLASSIFICATION:							
Size	Item	Qty ea panel	No. of panels	Matt Extension	Unit Cost	No. of Lifts	Total
2" x 4"	PLATE	16'	8	128'	70.40	2	102.40
	WHALER	64'		512'			409.60
	STUD	56'		448'			358.40
	BRACING	36'		288'			230.40
3/4"	1" X 8" FORMPLY	2 EA		16 EA	31.20		998.90
2" x 4"	LIFT CLEAT			70'	0.40	1	28.00
SUB-TOTAL							2127.20
ADDITIONAL MATERIAL TO CUSTOMIZE PANELS							
1/2"	4' X 8' PLY		1		12.00		12.00
2" x 4"	STUD, WHALER, PLATE			20'	0.40		8.00
2" x 8"	BULKHEAD			20'	0.96		19.60
SUB-TOTAL							39.60
TOTAL REUSABLE MATERIALS							2166.80
ASSUME 3 USES = 722.27							
RENTAL AND ONE TIME MATERIALS:							
	NAILS - 45 LBS X 1.00 LB =						27.00
	SNAP TIES - 164 X 2.00 = 107 EA X .39 =						45.13
	PINS & SHOTS - 1022 SF X .015 =						15.33
(RENTAL)	SNAP TIE SHOES - 328 X 5.50 = 344 X .50 =						172.20
TOTAL							279.66
REUSE PANELS							722.27
ONE TIME ITEMS							279.66
TOTAL							1001.97

SAMPLE TAKE-OFF SHEET							CONCRETE
PROJECT:	ASPE SHEARWALL	ESTIMATOR:	RD	3000PS	P.R. PUMP	ESTIMATE NO.	
LOCATION:	STAIRWELL #1	EXTENSIONS:				SHEET NO.	
ARCH/ENGR:		CHECKED:	AMB			DATE:	28-May-97
CLASSIFICATION:							
Size	Item	NO.	DIMENSIONS		sqft/sfca	cuft/amp	Total
	3" W. #1		32.75	.67	16.0	351.08	13
	FRAME OPENING		4.75	.67	7.0	<22.18>	<.825>
SUB-TOTAL							12.18
WASTE 3%							.37
TOTAL							12.55
CONCRETE REQ 3000:							
			12.55	4 X 50.00 =			627.50
			12.55	4 X 7.00 =			87.85
TOTAL MATLS							715.35
SUPPORT:							
CONC. PUMPING							
	2 TRIPS X	125.00 =	250.00				
	STAND BY 1 Y	125.00 =	125.00				
TOTAL							375.00
HOSE TENDERS:							
	2 EA. X 7.00/CY =	13 X 7.00 =	91.00				
GENERAL LABR:							
	GRIND & PATCH 1022 SF X .05 =		51.10				
(D)	CURING 1022 SF X .22 =		224.84				
(M)	" " X .22 =		224.84				
TOTAL							511.00

SAMPLE TAKE-OFF SHEET						FORM LABOR	
PROJECT:	ASPE SHEAR WALL		ESTIMATOR:	RQ		ESTIMATE NO.	
LOCATION:	STAIRWELL #1		EXTENSIONS:			SHEET NO.	
ARCHITECT:			CHECKED:	MA		DATE:	
CLASSIFICATION							
Size	Item	Qty sq. panel	No. of panels	Ext Extension	Unit Cost	No of LRA	Total
<b>CREW:</b>							
	2 CARPENTERS	15.00/HR			30.00		
	3 LABORERS	10.00/HR			30.00		
					60.00		
	BURDEANS	45%			27.00		
	CREW COST				87.00/HR		
<b>LAYOUT, FABRICATE, INSTALL 1<sup>ST</sup> LIFT (INCLUDES MOVING MATERIALS)</b>							
	4 PANELS @ 2 HR/EA				8 HRS		
	5 PANELS				8 HRS		
					16 HRS		
	STRIP 1 <sup>ST</sup> LIFT PANELS, CLEAN P.O.L.				4 HRS		
	INSTALL LIFT CLEATS, 2 <sup>ND</sup> LIFT PANELS				6 HRS		
	STRIP 2 <sup>ND</sup> LIFT PANELS, CLEAN P.O.L.				4 HRS		
					30 HRS @ 87.00/HR		2610.00
	TOOL REPAIR/REPLACE						50.00
							<u>2660.00</u>

SAMPLE SFCA AND CONC. CY COSTS					
PROJECT:	ASPE SHEAR WALL		ESTIMATOR:	RQ	
LOCATION:			EXTENSIONS:		
ARCHITECT:			CHECKED:		
CLASSIFICATION					
Item	Survey Cost	Cost SFCA	Cost CY		
CONC. MAT'L	715.35	.70	57.00		
CONC. LABOR	193.20	.181	15.39		
FORM MAT'L'S	1001.95	.98	79.84		
FORM LABOR	2450.00	2.59	211.16		
REINF. MAT'L	672.00	.66	53.55		
REINF. LABOR	360.00	.35	28.61		
PUMP EQUIP.	175.00	.31	24.88		
SCAFFOLD	100.00	.10	7.97		
		5.94	483.41		

SAMPLE TAKE-OFF SHEET						REINFORC #5 @ 16" X 16" JG STL	
PROJECT:	ASPE SHEAR WALL		ESTIMATOR:	RQ		ESTIMATE NO.	
LOCATION:	STAIRWELL #1		EXTENSIONS:			SHEET NO.	
ARCHITECT:			CHECKED:			DATE:	28 May 97
CLASSIFICATION							
Size	Item	NO	DIMENSIONS		Ext Face	sq ft face	sq ft face
			L	W			
HORIZ.	SW @ 24.0'	17	23.5'		2	799.0	1.043
"	" @ 8.75'	17	8.25'		2	280.5	1.043
VERT.	SW @ 24.0'	24	17.25'		2	828.0	1.043
"	" @ 8.08'	8	17.25'		2	276.0	1.043
VERT.	CORNER	2	17.25'		2	69.0	1.043
	DEDUCT FR. OPENING	12	4.75'		-	57.0	1.043
		8	7.0'		-	56.0	1.043
	ADD PER ELEVATION					152.0	1.043
							158.5
							TOTAL WT. #
							2390.1
							2390.1# @ 1.2 TONS
							MATERIAL COST:
							1.2 T @ 560.00 = 672.00
							LABOR SUB-CONTRACT COST
							1.2 T @ 300.00 = 360.00

Note: the listed components could easily vary in the number of walers, spacing of studs, and the spacing of form ties due to rate of concrete placement, concrete slump, or any design condition which would increase the pressure per square foot on the form surface.

The "lb" formply is pre oiled by the manufacturer but will require field coatings between uses and at those areas of the panel which have been saw cut. Proper maintenance of the forms such as stacking face to face, if not ready for erection, will help to insure the 5 to 6 uses generally available.

The shear wall in question has been labeled "SW-1" on the wall schedule of the structural drawings. This schedule gives the following information: wall thickness, concrete mix design and strength requirements, along with reinforcing steel requirements. It is important to note that in buildings with multiple floors, changes in concrete strengths and reinforcing steel sizes are quite common and the estimator needs to set up the quantity survey sheets to reflect these changes.

SW-1 has been determined to be 32'-9" long and has an overall height to the second deck of 16 feet (finish floor height is 12 feet + 4 feet from top of footing to top of the slab on grade). The length of the wall times the height of the wall gives the surface area of one side of the wall. This surface area is 524 square feet. The opposite wall side is 31'-1" long by 16' high which equals to 497.28 square feet the total S.F.C.A. is 1021.88.

This particular wall has one angle, one framed opening and does not allow the use of standard 8' x 8' wall panel sections. In some areas as noted on the panel schedule. The labor involved to customize these panel sections can carry a degree of difficulty add on for the first lift of panels but not for the remaining lifts. However, the requirement of 8' maximum formed lifts will require more stripping and erection cost than if the entire wall were formed to finish elevations at one time. On all forming components it is important to bear in mind the anticipated reuses and prorate the costs accordingly.

### CONCRETE

The method of determining the cubic yards of concrete is to multiply the length (32'-9" or 32.75 feet) times the height (16') times the wall thickness (8" or .667 feet) to arrive at the volume in cubic feet (351.08). One cubic yard of concrete displaces 27 cubic feet so that when 351.08 is di-

vided by 27 the result is that 13 cubic yards are required. The framed opening of 4'9" by 7'0" by 8" thickness will deduct 22.28 cubic feet or .825 cubic yards therefore, the net amount is now 12.18 cubic yards. This yardage is "neat" in that there has not been a wastage factor added. A wastage factor of 3% is not uncommon for this scope of work. The concrete material specified for this project is 3000 psi and the type of concrete selected is a "pea rock pump mix". This type of concrete incorporates much smaller aggregate than regular mix concrete and will add approximately \$7.00 to each cubic yard beyond the normal cost.

### CONCRETE PLACEMENT

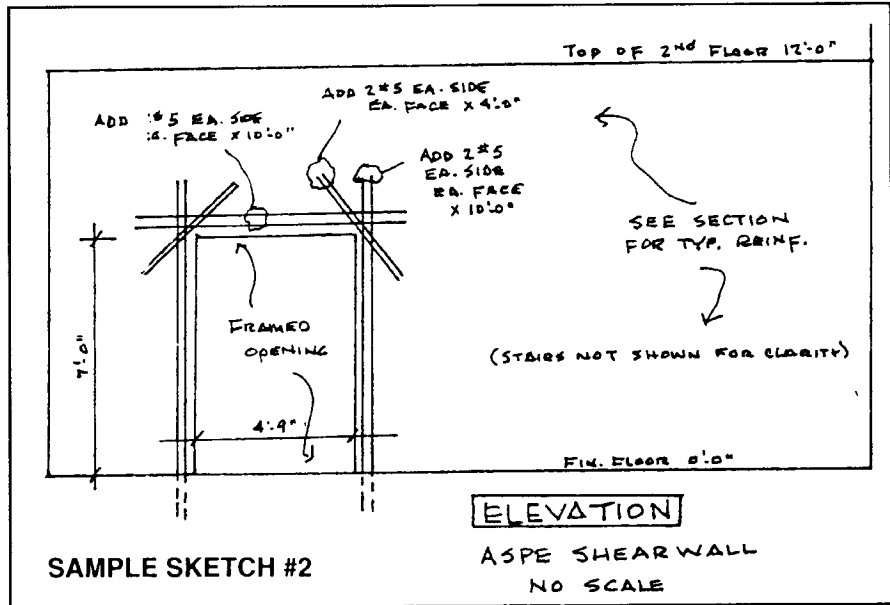
The concrete mix selected allows for the use of a concrete pump. This method of placing the concrete is the most efficient in that the materials being placed in the forms can be controlled as to the rate of fall into the form and the rate of flow of the concrete, thus minimizing "shock loading". Furthermore, the concrete ready mix truck or portable batch facility does not have to be in close proximity to the final placement area. Proper maintenance of the pump and related equipment is absolutely critical. To have equipment break down or have hoses break during the concrete placement could be result in a very bad day for everyone concerned. It is a prudent practice to allow for back-up equipment. The requirement of 8' maximum lifts of placement will increase the number of trips to be made by the pumping company and will result in additional re-mobilization costs.

It may be more cost effective, if time is a serious factor, to allow a "layered" pour to the full 16' height with only 1 mobilization. This could be accomplished with high early strength concrete or possibly redesigned forms.

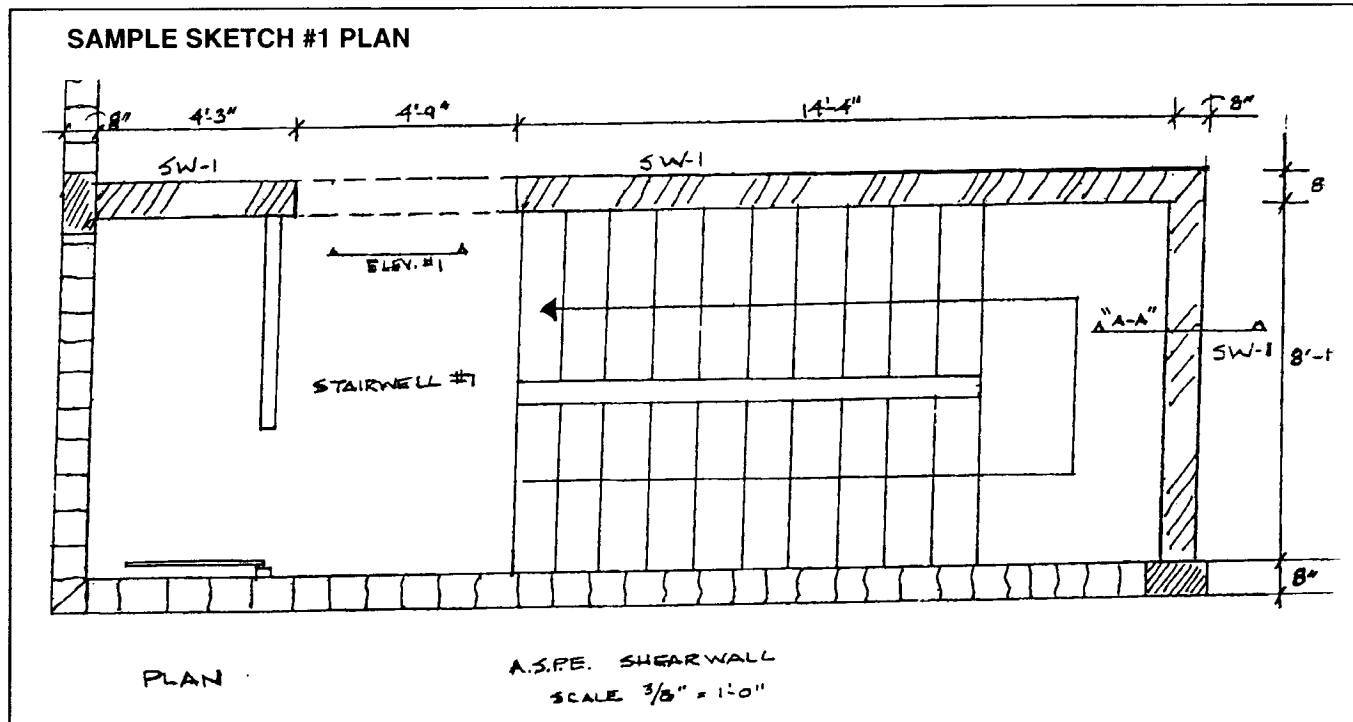
### REINFORCING STEEL

Reinforcing steel is estimated by pounds and tons while labor is rated according to the individual bar size of the reinforcing involved in conjunction with the overall weight of the total requirement of reinforcing. i.e., it is far more economical to place 1 ton of # 7 reinforcing which weighs 2.044 pounds per lineal foot than it would be to place the same tonnage of # 4 reinforcing which weighs .668

pounds per lineal foot. The wall schedule previously referenced indicates that this particular wall section shall have # 5 reinforcing at 12 inches on center each way and at each face of the wall (see sketch). Given the length of the wall at 32'-9" it is known that the horizontal reinforcing will be that same length less the amount of space required at each end for proper concrete coverage of 3 inches plus whatever bar lap is required. Bar lap is the length in inches that one reinforcing bar must have at minimum overlap with another reinforcing bar to insure strength continuity. If, for instance, a 24 bar diameter lap was required, the lap in inches could be determined by the following method for a # 5 reinforcing bar:

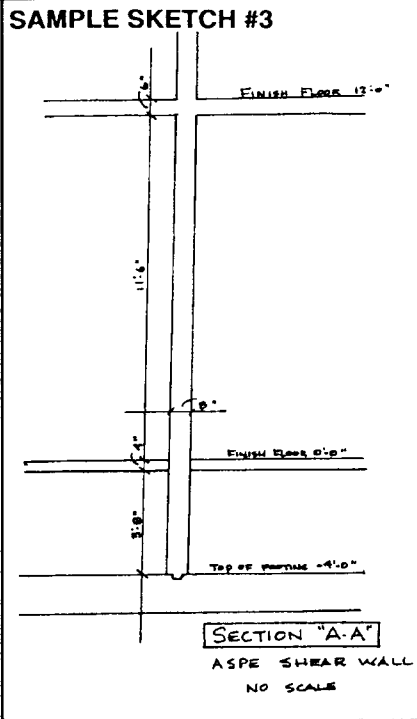


SAMPLE SKETCH #2



PLAN

ASPE SHEAR WALL  
SCALE 3/8" = 1'-0"



A # 5 reinforcing bar is 5/8 " in diameter. When multiplied by the 24 diameters required the lap is equal to 15", (24 " divided by 8 is equal to 3, 3 multiplied by 5 equals 15).

Reinforcing steel for a project of this size is generally shipped to the job site "bent, tagged and bundled". This means that the reinforcing which require bends in the bar to accommodate a certain design has been so bent under controlled conditions by the fabricator. The reinforcing has been labeled as to which area of the project it is destined to be used, and bundled together in like groups for easy identification. Shop drawing showing actual layout of each piece normally accompanies the steel to the site for accurate lay-out and placement.

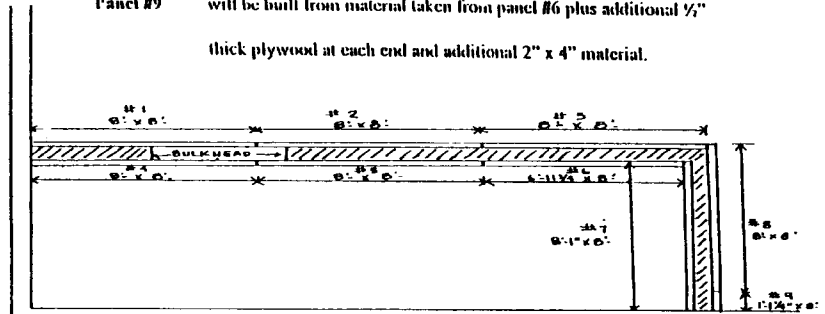
When the reinforcement placing crew "shakes out" the steel (sorts by location) they will most likely have cut sheets from the fabricator to aide in the identification of the materials.

The wall height has been determined to be 16 feet, the first row of horizontal steel will begin 3" above the top of the footing and the spacing will continue at 12" on center from that point. This will give 17 rows of horizontal reinforcing at each face of the wall times the length of the wall (32.75 feet) equals 1,113.5 lineal feet of horizontal reinforcement.

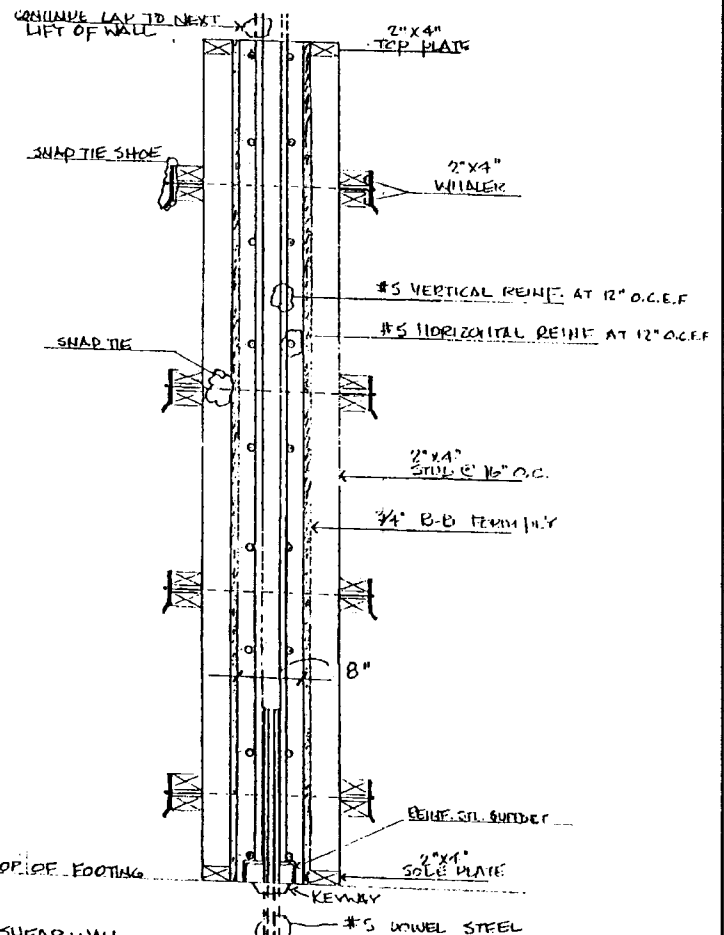
The vertical reinforcement will also begin the first row 3" off the face of each adjacent wall and continue through the wall at 12" on center from that point. This will give 33 vertical bars at each face of the wall times the height of the wall (16feet) plus 24 bar

THE DESIGN OF THIS PARTICULAR WALL REQUIRES THAT 3 CUSTOMIZED PANELS BE BUILT:

- Panel #6 will be reduced from an 8' panel to a 6'-11 1/2" panel.
- Panel #7 will be extended from 8' to 8'-1" by placing 1 strip of 1/2" thick plywood at each end.
- Panel #9 will be built from material taken from panel #6 plus additional 1/2" thick plywood at each end and additional 2" x 4" material.



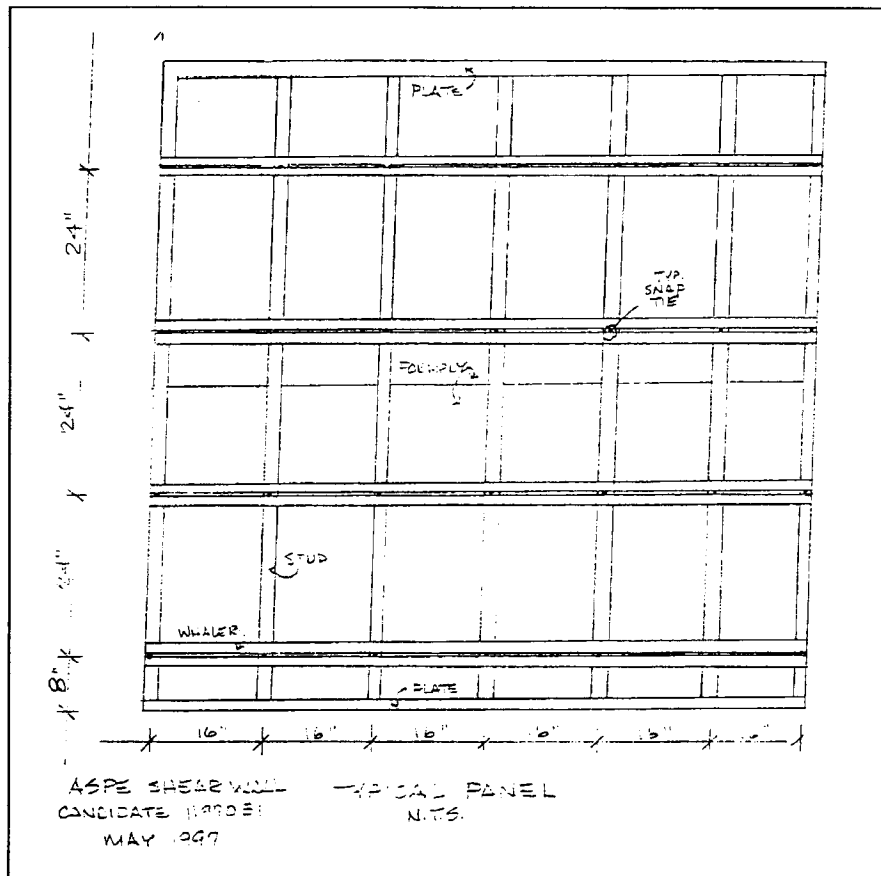
**SAMPLE SKETCH #4**



CANDIDATE 1197031  
MAY, 1997

**B' x B' FORMED SHEAR WALL SECTION**

**SAMPLE SKETCH #5**



termining these costs would be by in-house historical data. This information has varying degrees of accuracy dependent upon whether or not this scope of work is performed in-house or is traditionally work that would be sub-contracted. The estimator that has an accurate in-house labor data base to draw upon would be at a much greater advantage than the estimator who must rely on the comparison of sub-trade bids based upon different types of projects or the various publications available. While these publications are a valuable source of information. One must use caution for item costs in different parts of the country can vary widely and the estimator needs to compare to accurate historical data as often as possible. **E**

## GLOSSARY

**Aggregate:** Granular material such as sand, gravel, crushed gravel, crushed stone, slag and cinders.

**Aggregate-concrete:** The fine and coarse aggregate used in manufacturing concrete. Both are usually washed and graded.

**Cement:** Any chemical binder that makes bodies adhere to it or to each other such as glue, paste or Portland cement

**Concrete:** A composite material consisting of sand, coarse aggregate, cement and water when mixed and allowed to harden, it forms a stone-like material.

**Davis-Bacon:** A Federal Labor Law enacted in 1931 that requires laborers and mechanics (those who do physical work) on federally funded construction projects be paid no less than the local prevailing wages.

**3000 psi:** The minimum strength in pounds per square inch of a concrete mix when tested in 28 days.

**E.F.:** Each Face

**E.W.:** Each Way

**High Energy Strength Concrete:** Concrete containing high-early strength cement or admixtures causing it to attain a specific strength earlier than regular concrete.

**Lifts:** The height of each individual section being formed and placed at one time

**MBWE:** Minority, black and women enterprises

**Mix Design:** The selection of specific materials and their proportions for a concrete or mortar batch, with the goal of achieving the required properties with the most economic use of materials

**O.C.:** On Center

**Reinforcing Bar:** A Steel Bar, usually with manufactured deformations, used in concrete and masonry construction to provide additional strength.

**Shock Load:** The impact load of material such as aggregate or concrete as it is released or dumped during placement.

## REFERENCES:

Means Illustrated Construction Dictionary.

Walkers Building Estimators Reference Book.

Concrete Reinforcing Steel Institute- Placing Reinforcing Bars.

Formwork for Concrete Structures- R.L. Peurifoy

A.S.P.E.- Standard of Manual Practice

Ratios and Analysis			
		Total Cost	Percentage Cost
A	Concrete Material	\$ 715.35	11.8%
B	Concrete Labor	\$ 193.20	3.2%
C	Form Materials	\$ 1,001.93	16.5%
D	Form Labor	\$ 2,650.00	43.7%
E	Reinforcing Steel Mat'l	\$ 672.00	11.1%
F	Reinforcing Steel Labor	\$ 360.00	5.9%
G	Equipment	\$ 375.00	6.2%
H	Scaffolding	\$ 100.00	1.6%
		<b>\$ 6,067.48</b>	<b>100.0%</b>

diameter lap (1.25 feet) equals 1138.5 lineal feet of vertical reinforcement.

The sum total of the scheduled reinforcing is 2,252 lineal feet times the weight of the bar of 1.043 pounds per lineal foot (for # 5 reinforcing) and is equal to 2,262 pounds divided by 2,000 pounds (ton) equals 1.13 tons plus minimal corner steel. No deduction was allowed for the framed opening to offset the added reinforcement shown on the elevation. These calculations include the extension of the vertical steel into the next lift of

shearwall.

Dependent on the required method of curing the wall i.e. chemical, burlap, etc. The cost of this portion of the work will become a part of the overall cost of the wall.

Once the quantities of formwork, concrete and reinforcing steel materials have been determined; the labor and equipment costs are necessary to complete the estimate total cost.

With regards to the formwork labor, the most accurate method of de-