Estimating Concrete Construction

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Introduction

In this session we will concentrate on what might be termed the standard elements of concrete for a concrete frame building. By that I mean those elements which comprise the majority of the cost for concreter frames. Due to time limitations, we will deal in a more abbreviated fashion with quantity survey issues so that more time can be spent on pricing issues. The elements we will discuss include footings, walls, columns, beams, and slabs. We will be discussing labor, material, and equipment pricing as well as concrete and formwork hoisting. We will include formwork, concrete material place and finish, protect and cure, and special finishes.

It should be noted from the outset that there are constraints the estimator has when estimating this work. The first may be labor productivity estimating. We will, of course, quantify labor units using productivity analysis, in this case denominated in manhours/unit. Manhours/unit has as its reciprocal units/mahour (I will continue to use the sexist term “manhour” because such terms as workerhour are even worse.) While most estimating reference books (e.g. Means) have productivities, and while I will give example “standard” productivities below, in the final analysis the degree to which the estimator may use productivities with confidence is the degree to which the estimator’s company maintains historical cost records in productivity terms. Ideally, the company will have such records for projects completed and the estimator will have some personal knowledge of those completed projects so that the estimator will recognize similarities between the current project and past projects and can use historical records as guides to productivities for the current project.

This is the reason why cost records should be kept in productivities, since these are unaffected by wage rate inflation, passage of time, etc.

The quantity of work to be done is yet another fundamental consideration in evaluating labor productivity. Smaller quantities of work necessitate lower productivities as a rule, since there is no learning curve and increased efficiencies gained from repetition. In the discussion which follows, adequate quantities of work are assumed to allow for the efficiencies of repetition. If such conditions are not present, the productivities given below may require from 25 to 100% more manhours per unit of work.

Another fundamental consideration in productivity estimating is the experience of the workforce with the type of work contemplated in the project under consideration. It may go without saying that an experienced crew will achieve better productivities than an inexperienced one and the estimator must be fundamentally aware of the experience of the work force. The form system contemplated may be a factor as well, the best of all situations being that the system used is one with which the work force is familiar.

A company's estimating system should be established with the "default" productivities for that company built in. This will save estimating time in that the estimator when pricing a particular job will have only to replace the default productivity, if necessary, with the appropriate job specific productivity and the system will automatically update the estimate for the change. This assumes that the company has a computer based estimating system, which has become almost an absolute necessity.

Another constraint the estimator may face is the decision of forming system to be used and the type of equipment to be used. For example, previous projects may have been stick built as opposed to flying forms, which has an effect both on productivity and hoisting equipment. Ideally, the estimator will consult with operations staff and jointly arrive at both the best forming system to be used and the equipment needed for that system so that the estimator may accurately price same. This will often involve discussions with formwork suppliers about systems and pricing, rent or buy decisions, etc.

A third consideration is schedule. Here again consultation with operations staff is essential. Many material prices are time sensitive and equipment may be estimated by monthly increments needed. So part of the estimating task is to develop a schedule for performing the work. Will the work be done on a standard day/week schedule or an accelerated schedule (multiple shifts or overtime?)

In this regard, another type of schedule the estimator should be aware of is the schedule of the estimate. It has been the author's observation that fully 60% of the manhours required to perform an estimate are in the quantity survey portion. Given the resources the estimator has, adequate time should be allowed after quantity survey for analysis and pricing. It is during this stage that the art of estimating comes into play.

One additional comment about quantity survey. There are ongoing debates about the degree to which a quantity survey should be accurate. No rules in this regard are set in stone and each company and to some degree each estimator may have somewhat different standards. A few general comments can be made however. The first was related to me by one of my bosses many years ago. It is "Don't spend more time surveying an item than the item is worth." The second is to decide to what degree accuracy makes sense in the case of the various types of items surveyed. For example column forms and concrete may be easily surveyed to a greater degree accuracy than slab on grade forms and concrete. Does it make sense to deduct openings in slabs from concrete and form quantities. Should small items such as keyway and waterstop be surveyed and to what extent? More about quantity survey when individual items are discussed below. It should also be noted that some estimators when dealing with formwork quantities divide work activities into two categories, place forms and strip, clean and oil forms. We will be using an all inclusive category in which the productivity represents placing, stripping, and cleaning and oiling the form. In the project where gang form systems are used, some estimators include an item for fabrication of gang forms. Again, the productivities given herein include form fabrication.

A fourth consideration is crew mix per work item. What is the crew for formwork? For concrete placing and finishing? For reinforcing? How many apprentices in the crew? These have a direct effect on the average cost per manhour which will be multiplied by the productivity to determine the unit price per item of work.

Fifth, the estimator must decide to what level of detail the estimate should be carried. Many estimators feel comfortable surveying and pricing formwork, concrete placing and finishing, the equipment for same, but do not feel comfortable estimating reinforcing. In many areas of the country reinforcing labor and material is subcontracted so it is felt that detail estimates are not warranted. This paper will assume that reinforcing for the project being estimated will be quoted on a lump sum bases for labor and material by reinforcing subcontractors.

Foundations – Footings, Pile Caps, Grade Beams

Quantity Survey

The types that commonly come to mind – continuous footings (strip footings under walls etc) spread footings (column footings), pile caps, and grade beams (analogous to spread footing but usually thought of as having more height and less width than a continuous footing.

One issue to be decided is whether structural excavation is to be quantified as the estimator quantifies concrete. Also the estimator must decide whether the foundations may be neat dug or must be formed. If neat dug, forms are not required. If formed, foundations must be excavated to the extent that workers have adequate room to install the forms and remove them. If excavation is calculated, backfill should be also, bearing in mind that the quantity of backfill is affected both by compaction factors and that the concrete foundation member is in place.

Assuming the foundations are formed the items to be surveyed include forms, concrete, finish, excavation, fine grade, and backfill. In some cases miscellaneous items including keyway and waterstop will be included where appropriate.

Formwork will usually be quantified in square feet. Some estimators include form quantities of members less than 12 inches in height in linear feet. This will depend on company cost reporting practices. Concrete is calculated in cubic yards by strength, with the company appropriate waste factor added usually to compensate for uneven ground surfaces. If the foundations are neat dug, additional waste, perhaps in the 10% range should be included to allow for the extra width resulting both from bucket width used and the difficulty of machine digging a foundation to the exact dimensions required by the design documents.

(A general note about concrete waste factors might be noted here. Where concrete will be placed in contact with the earth, a waste factor is appropriate as noted above due to earth

unevenness. Some companies also add additional waste factors for the fact that the experienced field personnel will order excess concrete per pour due to the relative cost of the concrete material being small compared to labor crews waiting if an insufficient quantity is ordered. A percentage of 2-5% may be in order for this purpose.)

Finish is measured in square feet of top surface area of the foundation, point and patch is measured in square feet and may be the same quantity as formwork. Protect and cure will usually be measured in square feet and the quantity will be the same as finish quantity. Miscellaneous items such as keyway and waterstop will usually be measured in linear feet.

Pricing

Labor

Foundation unit labor pricing will be determined using labor productivities per each item, keeping in mind the company cost history for similar work. Reasonable "default" productivities based on the author's experience are given below.

1. Formwork – 0.10-0.12 manhours/sqft or lnft is a reasonable default value for foundation formwork.
2. Concrete placing -- Productivity will be affected by the method used for placing – for example direct from the concrete truck, carts, craned, or pumped. 0.4-0.5 mh/cuyd is a reasonable default value.
3. Concrete finish will be affected by the type of finish – screed, float, or trowel. 0.008-0.01 mnhr/sqft is a reasonable default value for a float fininsh, while 0.01-0.012 may be a reasonable value for trowel finish.
4. Point and patch (to repair air voids, form tie holes, etc) may be reasonably included at 0.006-0.008 mh/sqft as well.
5. Protect and cure may be reasonable priced using 0.001 mh/sqft as a default value.
6. Miscellaneous items may be reasonably priced at 0.1 mh/lf in the case of waterstop and 0.02 mh/lf for keyway.

Material

1. Foundation formwork material may be priced by square feet or lineal feet. The key to form material pricing is the value of the form assembly per formwork unit divided by the number of uses the estimator expects to get from the material. For example, assume the price of plywood to be $0.75/sqft and a 2x4 backup frame is calculated to cost $0.50/sqft of the assembly. The estimator includes $0.25/sqft for bracing, for a total unit cost of $1.50/sqft. If the estimator expects to get six uses out of this material, his unit material cost will be $0.25/sqft.
2. Concrete material will be priced by cubic yard by strength. Concrete material prices will usually be determined by receipt of a material quote from a concrete materials supplier. The estimator will be required to verify that the supplier quote

both matches the specification requirements and his own for the anticipated equipment used. For example, if the estimator plans to pump the concrete material, many concrete suppliers will require an added price/cuyd for a pumpable mix. Concrete material prices vary substantially in differing regions of the country and should always be solicited from suppliers in the market where the project is located.

3. Protect and cure material will be priced by determining the anticipated coverage rate/gallon of the specified curing compound divided into the price per gallon of the material which will be usually determined by a quote from a materials vendor which carries the material.
4. Keyway and waterstop material will be priced/lnft based on quotes received from a materials vendor.

Equipment

It is not unusual for an estimator to price concrete hoisting equipment for a project on a separate equipment analysis for the entire scope of the concrete work. This can be done by analyzing what equipment, operator costs, etc will be for the duration of the project. For example, assume a tower crane will be utilized to move forms, pour concrete, etc. The estimator in a separate portion of the estimate may choose to determine the number of cranes needed and the duration for same. He will determine the numbers of operator hours required and the monthly operator cost for same. He will determine the monthly rental cost for the crane he wishes to use and multiply the monthly costs by the number of months required for a total hoisting budget. The estimator will also be aware of the items of work required to put the tower crane in operation and remove it at the end of the concrete work. These include the value of the crane foundation pad, a tower insert to attach the tower to, the cost of erection and dismantling the crane and the cost of freight for both hauling the crane to the project and removing it, and potential power service for same.

The case for pumping equipment is usually somewhat more complex. Most contruction companies do not own, and thus have to rent a pump. Rental requirements may vary but typically include a charge to travel to and from the site and a cost/cuyd for the yards placed during that day's pumping session. The estimator will then have to determine how many yards will be placed during a typical day's pour and divide that value into the total cost for the pump for that day to determine a pumping cost per cubic yard. For example, the pump company requires a $250 trip charge each way and $3.50/cuyd pumped. If the estimator determines that the average pour will be 300 cuyd, the total pump cost/day will be $500 plus 300 times $3.50= $1050. Total pump cost/day will be $1550 and the pump cost per cubic yard will be $1550/300= $5.17/cuyd.

Equipment costs for finishing foundations and protect and cure foundations are usually minimal, consisting of hand trowels and hand held sprayers. They may be less that one or two cents/sqft of area covered. Many estimators ignore these.

Walls

Quantity Survey

Typical areas of discussion regarding concrete walls include the types of walls. These may include foundations walls or basement walls (by which is usually meant walls from footings to either slab on grade or in the case of structures with basements walls from foundations to the floor at exterior grade, which may be called the ground floor), retaining walls, shear walls, core walls, and walls above grade. The names given to wall types are not standard in the industry, but should be within a company. Whatever the name, wall types should be separated for reasons discussed below. They should also be segregated by concrete strength and the intended method of concrete placement.

The standard quantities are formwork, concrete, and finishes and are derived from the length times height times width formula.

Formwork is calculated by length times height times two, assuming both sides of the wall are formed. If there are instances in which walls are formed only on one side, such as basements in which the wall is poured against shoring, these should be segregated as well, because the pricing of one sided walls may vary significantly from that of two sided walls. If all or part of the wall has a special finish requiring a form liner, the quantity of the appropriate area should be measured.

Some estimators when calculating wall forms differentiate between erecting forms and wrecking forms, with the quantities for each being equal. This is a matter of company cost history and policy. There is no universal standard for the distinction.

As mentioned above, wall types should be separated for a number of reasons. The first is whether the wall will be loose formed or gang formed. The second is whether gang formed walls will be formed with a large panel as in basement walls or in a complete system as core walls are likely to be. The quantity of a particular wall type may influence the choice of a forming system, each type of which will influence form material and labor productivity considerations.

Concrete quantities are derived in cubic yards by strength from length times height times width where all dimensions are in feet and the resulting cubic feet quantity divided by 27 to yield cubic yards. Waste factors enter this survey as well. The factor should take into account the items discussed above with foundations but the overall percentage will be less since the formwork constrains the amount of material needed.

Wall finishes are typically the same quantity as the formwork. All walls should be “pointed and patched” (which consists of patching tie holes, knocking off fins, and patching any honeycomb or air bubble spaces). In addition, there may be numerous special finishes included for all or part of the wall. These may include rubbing,

bushhammering, sandblasting, special formed finish, sacking, etc. These should be quantified in addition to point and patching, the extent being clearly delineated.

There are many miscellaneous items which may be included in the wall estimate. These include keyway, waterstop, bulkheads (pour stops), pilasters, brick ledges, haunches, blockouts and the like.

Keyway is measured by size (2x4, 2x6, etc) in linear feet. Bulkheads are measured in square feet which is calculated by height by width by the number of occurrences of the bulkhead.

Waterstop is quantified by type in linear feet.

Pilasters may be calculated in different ways. Some estimators calculate formwork by the height of the pilaster times its projection out of the wall, times two sides, times the number of occurrences of a pilaster. Some add the face of the pilaster in length times height times number of occurrences. This results in doubling the quantity of formwork at the face of the pilaster and is not recommended. Pilaster concrete is length times height times projection width times the number of occurrences converted into cubic yards, again measured by concrete strength.

Brick ledges are formed “shelves” into the wall to receive brick. Formwork may be measured by the width of the shelf times its length or its length and height. This latter method is preferable provided the vertical quantity at and above the ledge is not surveyed twice. This latter practice is preferable since forming the vertical surface of a wall above a brick ledge is more costly than forming the wall proper. Concrete wall quantities calculated by LxHxW of the ledge area are converted to cubic yards and the quantity deducted from the overall wall concrete quantity.

Finishes for pilasters and brick ledges will be determined from brick ledge forms quantities. They will always include point and patch, but perhaps may have a special finish of one of the types noted above.

Haunches will be quantified as though they were horizontal pilasters and derive the same quantities in the same way that quantities were derived from pilasters discussed above.

Blockouts usually refer to openings in the wall, such as door and perhaps window openings. Blockout formwork should be calculated in square feet (the circumference of the opening times its width times the number of occurrences.) Concrete material should be calculated and deducted from overall wall material quantities, as should point and patch and any special finishes. Primary wall form quantities should not be deducted except in those rare instances where the forms will in fact not be erected. In the vast majority of cases wall forms will continue through openings.

Pricing

Labor

Wall formwork quantities should again be priced using productivities based on company history or analysis. Small quantities may be loose formed with the material being used one or two times. Large quantities may be gang formed or a combination of gang and loose formed. In some cases, large quantities may have to be completely loose formed if the walls are cut up to the degree that gang forms are not cost effective. Core wall forms if of sufficient quantity will likely be gang formed using one of the many form systems available. The reason for this is that while the material costs for a system will probably be higher than loose formed walls, the labor efficiencies of such systems more than offset the material cost added. These systems also may be designed to be used twenty or thirty or more times, which substantially reduces the material cost per use per square foot. In addition, gang forms lessen the amount of time required for installation, thus shortening the schedule of construction.

Formwork standard productivities may be rationally given as follows:

1. Loose forms .10-.12 mnhrs/sqft
2. Gang forms .08-.12 mnhrs/sqft
3. Core forms .08-.10 mnhrs/sqft
4. Bulkheads .13-.17 mnhrs/sqft
5. Pilasters .13-.17 mnhrs/sqft
6. Brick ledges .10-.15 mnhrs/sqft
7. Haunches .15-.20 mnhrs/sqft
8. Blockouts .12-.20 mnhrs/sqft
9. Form liners .10-.12 mnhrs/sqft (for the total amount of liner used in fabricating the form system)

Concrete placing productivities depend to some extent on the method used to place the material. Most vertical concrete is placed by crane unless the walls are low enough to be placed direct. In rare instances the volume of concrete is large enough to utilize a concrete pump, although these are rare.

Placing productivities may rationally vary from 0.4-0.6 mnhrs/cuyd.

Wall finishes productivities may be rationally given as follows:

1. Point and patch .003-.005 mnhrs/sqft
2. Rubbing .03-.05 mnhrs/sqft
3. Bushammering .02-.05 mnhrs/sqft (this varies greatly depending on specifications)
4. Sacking .005-.01 mnhrs/sqft
5. Sandblasting .02-.05 mnhrs/sqft, depending upon the depth of blast

Miscellaneous items productivities may be:

1. Keyway .01-.03 mnhrs/lnft
2. Waterstop .05-.10 mnhrs/lnft

Material

Formwork Material

For loose form material, see the discussion in foundations above. For gang form applications, the estimator should contact a supplier which specializes in such systems for a discussion of the estimator's view of the system and schedule, followed by a quote from the supplier, which can then be translated into material unit cost or included as a miscellaneous estimate item entry, either on a monthly rental value or a total value for a set duration or a total value for purchasing the system. There are a number of variations on this theme given by material supplier quotes. The estimator should not forget to factor into formwork material pricing costs for such items as wall ties. If the estimator wishes to reduce form material costs to a unit price per square foot cost, he should provide as estimate backup a detail analysis of the costs included and the number of uses anticipated.

Concrete Material

As with foundations, the estimator should price the material by cubic yard by strength.

Miscellaneous Material Items

Waterstop – see the discussion under foundations above.
Keyway -- see the discussion under foundations above.
Point and patch – costs are usually minimal, in the range of $0.02 to $0.05/sqft.
Rubbing -- $0.05-$0.10/sqft
Sacking -- $0.05-$0.10/sqft
Sandblasting -- $0.25-$0.50/sqft depending upon depth of blast

Equipment

For formwork and concrete placing discussion, see hoisting discussions in foundations above. Installing waterstop, keyway, pointing and patching, rubbing, and sacking require hand tools only in most cases. These costs are minimal, $0.01-$0.02/sqft at best. Sandblasting equipment may be rented by the month and included by the estimator as the total estimated cost/quantity = $0.10-$0.20/ sqft.

Columns

Quantity Survey

Concrete columns may be square, rectangular, round, oval, or about any shape the mind can conjure. We will restrict this discussion to rectangular and round shapes.

As an adjunct to the discussion above about quantity survey accuracy, it should be noted that some estimators take off column quantities from “floor to floor”. Others survey the height of columns from the top of the floor below to the bottom of the floor above, effectively removing the slab depth from the quantity survey. Estimators who use the former method note that it is quicker, while estimators who use the latter note that it is more accurate. In the case of columns the percentage delta between the two methods may be significant. For example on a structure with a floor to floor height of 10 feet and a slab depth of eight inches, the quantities resulting from each of the methods will vary about 6.5%. While there is no rule for surveying columns, the author prefers the latter method.

Formwork quantities for columns are determined by column perimeter times height. For rectangular columns this becomes (2L+2W) times H. For round columns, it is piD times H. Both are multiplied by the number of occurrences of that size and height column. If the columns have capitals, the formula for the capital portion of a round column is that of a truncated cone. In some cases rectangular columns have their corners mitered with a chamfer strip which in the case of loose formed columns should be quantified by the linear foot. In this case chamfer strip is typically used only one time. In gang form applications, chamfer strip is typically fabricated into the form system and moves as a unit with the form.

Concrete quantities are determined in the case of rectangular columns by LWH/27 and for round columns as piR2H/27, both being multiplied by the number of occurrences of that specification. Capitals are determined by the volume formula for a truncated cone. Concrete quantities are aggregrated by strength as always.

Finish quantities for columns are usually taken to be the same as form quantities for point and patch. If special finishes such as rubbing, sandblasting, bushammering, etc are called for, just the area seen must be quantitified.

Pricing

Labor

Column formwork productivities vary according to whether the columns are loose formed or gang formed, and according to the height of the column and the number of uses for the form. In multiple story construction where there is substantial repetition and when one of the many gang form applications are appropriate, productivities may range from 0.10 – 0.12 mh=mnhr/sqft. Where there is little repetition or column heights ezceed about twelve feet, productivities may be less, approaching 0.15 mnhr/sqft. Loose formed columns may also be in these productivity ranges, depending upon height and number. In most cases where there is sufficient repetition gang form systems may be used. If loose chamfer is required, it may reasonably be priced at 0.01 – 0.02 mnhr/lnft.

Material placing productivities may range from 1.0 – 2.0 mnhr/cuyd depending upon the quantity placed at one time.

Column finishes may typically be priced similarly to wall finishes of the same type on the theory that the wall and column finishes will be accomplished at the same time.

Material

Formwork material costs may be estimated in several ways. One is to determine the quantity column form material needed and calculate the total cost of that material. The material unit price column in the estimate would then be blank. Another is to calculate the material unit cost based on the cost of one square foot of the form and divide that cost by the number of anticipated uses. For example, the estimator may determine that a form can be fabricated for a material cost of $20/sqft and that it will be used 20 times resulting in a material cost of $1/sqft. Often form vendors will provide quotes for column forms of a certain size and height. The estimator may use either of the methods outlined above to calculate the material cost of forms. Chamfer strip if required may be quoted by local form supplier vendors, usually by the linear foot or in quantities which the estimator may reduce to cost/lnft.

Concrete material is determined as noted above for other systems.

Special column finishes material may be priced as are wall finishes discussed above.

Equipment

Columns are usually placed using crane equipment. While an allowance for the equipment per cubic yard may be calculated, the more common approach is to determine what the hoisting equipment needs for the entire concrete project are and pricing the equipment for the duration of the work.

Beams

Quantity Survey

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If beams support slabs beam quantities are those measured below the bottom surface of the slab. Beam schedules give sizes including the slab so the height dimension of a beam must be reduced by the slab thickness for accurate survey. If the beam has no slab it should be quantified as an isolated beam, since productivities for isolated beams are typically somewhat lower than those for beams with slabs.

Beam forms are quantified typically as beam side forms and beam bottom forms, principally because the majority of beam form costs consists in the beam bottom since it must be shored. Both are measured in square feet of contact area measured by L x W. Some estimators quantify spanderal beams separately reasoning that the outside of a spanderal beam side will be the full height of the beam as scheduled and the productivity for such a beam may be somewhat less than that of an interior beam side. Total beam side

forms and beam bottom forms are summed for pricing. The estimator may wish to segregate beam forms by the height required for shoring within some rational increment, for example 8-12 feet, 12-16 feet, etc. The greater the shoring height, the less productive the beam bottom form cost.

Beam concrete is quantified by volume LWH and segregated by concrete strength as usual.

Beam finishes are surveyed similar to wall and column finishes.

Pricing

Labor

Beam bottom forms should be analyzed for labor productivity according to shoring height and form system used, and total quantity of forms. With the exception of specialized forming systems for parking garages, beam forms are not typically ganged. A beam bottom form with shoring in the 8-12 foot height, rational productivities may range from 0.30-0.40 mnhr/sqft. Beam side productivities may rationally be in the 0.12-.017 mnhr/sqft range.

Material placing productivities for beams with slabs are typically the same as those used for slabs since the two are placed at the same time If the slabs and beams are pumped a productivity of 0.45-0.55 mnhr/cuyd is reasonable. If the concrete is placed using a crane, the productivity may decrease to 0.55-0.75 mnhr/cuyd.

Beam finish productivities are in the lower productivities of those given for wall finishes.

Material

Beam forming systems material costs may require substantial analysis. The type of shoring used, the material assembly used for the actual beam bottom, and the amount or reuse all impact the cost of beam bottom material. One useful method the estimator may employ is to determine the amount of shoring and beam bottom material required for one typical bay of beam bottom. This estimator will quantify the number of elements of the shoring system required, for example, scaffold jacks, cross braces, top and bottom feet for the jacks, etc. The total rental value of the shoring material is then determined and divided by the number of uses expected during the month, resulting in an expected cost per use.. In a similar fashion the quantity of the beam bottom form proper may be determined. For example, the shoring may be at 5 feet on center, have a double 2x10 member (called a purlin) on the top of each jack assembly which may support 2 sets of 2x10 ledgers perpendicular to the purlins. On top of these members may be the actual plywood beam bottom form supported by 4x4s at 12” on center. All of these components can be priced along with the fasteners needed to connect the members together, summed, divided by the expected number of uses. and added to the cost of the shoring. Dividing

the total material cost by the square footage of the beam bottom contact area gives a square foot material cost.

Beam side form material can be calculated by pricing the components of the assembly and dividing the total cost by the expected number of uses of the material.

Concrete material costs may be determined as described above.

Concrete finish costs may be determined using the methods described above for wall finishes.

Equipment

Concrete pumping costs will be discussed with slabs below. Crane costs have been discussed above.

Slabs

There are several types of slab systems which have been used in concrete construction systems. These include flat slabs, pan slabs and waffle or dome slabs.

The latter two systems are not common in today's environment and should the estimator encounter either of the systems, he or she may contact a vendor which rents or sells equipment for forming these systems. Such vendors typically provide graphs which allow the estimator to determine the quantity of concrete needed and the cost of the pan or waffle forms. National publications such as Means give suggested productivities for these systems. In this session we will address only flat slab systems.

Quantity Survey

Formwork for flat slabs is quantified in square feet of contact area for slab surfaces, edge forms if not a beam/slab system, and construction joints. Edge forms in this context include perimeter edges. Interior edge forms should be designated as blockouts or a similar designation and quantified separately since they typically require more labor per unit than do edge forms. Edge forms, blockouts, and construction joint forms may be quantified either in square feet or linear feet in accordance with company practice. It should be noted that no adjustment in slab formwork quantity should be made for minor blockout areas since the slab formwork is typically erected through the area of the blockout. Major openings such as elevator and stair shafts may be quantified as slab forms or not, depending upon the situation.

If the system being surveyed is a beam/slab system the estimator should be careful not to include the area of beam bottoms in his/her slab quantity survey since this results in double counting the area of beam bottoms.

Construction joints are usually left to the discretion of the contractor as a means and methods issue. The estimator will determine what the logical typical pour size will be and place a construction joint at the appropriate location. These may be measured as with edge forms in linear feet or square feet in accordance with company practice.

Concrete quantity is determined by LWH where H is slab thickness, adjustments being made for slab openings. As usual the quantity is separated by strength. Recall that no slab quantity adjustment is made for the area over beams in beam slab systems, since beam quantities have been determined from the bottom of the slab.

Slab finishes may be quantified net of minor blockouts or including minor blockouts, according to company practice. Major blockouts should be deducted.

Pricing

Labor

Slab form pricing will vary significantly according to the type of forming system used, the type of concrete system (beam/slab or not), quantity, etc. In some beam/slab systems, the slab forms may simply span from beam side to beam side, while in some the slab must be shored in much the same way as is the beam bottom. In the former case, slab form productivities of 0.08-0.10 are not uncommon while in the latter productivities of 0.10-0.12 or higher may be warranted.

In the case of flat slabs alone, the advent of flying form systems has enabled increased productivities while possibly requiring more hoisting equipment. Truss supported systems may allow productivities in the 0.08-0.05 mnhr/sqft range while the column mounted systems may allow productivities in the lower end of that range.

In most beam/slab systems an edge form will not be required since there will be a spanderal beam at the slab perimenter and the spanderal beam side will function as the edge form. Where edge forms are necessary, they may be reasonably anticipated to be produced in the 0.10-0.12 mnhr/sqft range. The estimator should note, however, that some flat slab systems utilize post tensioning cables for reinforcing. In such cases the cables must penetrate the edge form in order to be stressed, decreasing the productivity of edge forms as much as 25-40%.

Blockouts, because of the typically small quantity of work in each, will likely be in the upper end of the edge form productivity range, 0.13-.017 mnhr/lnft. Construction joints because of reinforcing penetrations will likely be in this productivity range as well.

Concrete placing labor is addressed in the discussion of beams above.

Concrete finishing labor for slab pours of size (5,000 sqft or more) may be anticipated to be in the 0.008-0.01 mnhr/sqft range if finished using troweling machines. Hand troweled areas may be half that productivity. Any requirement for slabs flatter than 1/8 inch in ten

feet will also result in substantial loss of productivity. Special finishes such as sandblasting, water washing exposed aggregrate, etc. will require additional research.

In addition to finishing costs, flat slabs must have a curing compound sprayed on them. This may be accomplished in the 0.001-0.0015 mnhr/sqft range.

Material

The comments above related to beam forming also apply to slab form material analysis. The estimator must choose a forming system, whether loose formed or gang formed, investigate the cost of the components of the chosen system, determine the number of uses anticipated and divide the cost of the system by the number of uses to ascertain a slab form material cost/sqft. These comments apply to both edge forms as well as blockout and construction joint forms, with the added proviso that blockout and especially construction joint form uses will typically be substantially less than those of edge forms.

Concrete for slabs is similar to that for other concrete items as discussed above.

Finish material will typically include curing material and/ or any special finish material costs. Curing compound may be purchased in the $0.02-0.03/sqft range.

Equipment

Hoisting costs for slab forms has been discussed in the context of overall equipment costs above. Pumping equipment costs may be calculated by determining the average pour size for flat slabs or slabs/beams. For example, the estimator may determine that a logical pour size is 8000 square feet and contains 300 cubic yards of concrete. A pump vendor has quoted a two way travel charge of 2 hours at $150/hour, a pump charge of $150/hour and a $3.50 per cuyd charge. For the typical pour the estimator believes the 300 cuyd can be placed at 60 cuyd/hour. Total charges for a typical pour will be $300 travel, $750 pump time and $1050 per yard for a total cost of $2100. This total divided by the 300 cubic yards placed results in a pump charge of $7.00/cuyd.

Finishing equipment – power trowels for example may be reasonably expected to be in the 0.02-0.05/sqft.range.

Conclusion

There are innumerable topics related to concrete estimating that it is impossible to address them in this short time allotted. They include site concrete, industrial concrete such as treatment plants, heavy construction such as bridges and highways, etc. It is

hoped that the material presented herein both gives an introduction to the types of issues encountered in estimating concrete as well as rational guidelines for “default” pricing for these items. Each project is of course unique, as to the elements of construction, location, marketplace, labor force and myriad other issues. A truly comprehensive comprehension of the myriad issues involved encompasses years of experience and a true appellation of “Professional Estimator.”