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FUNDAMENTALS OF ESTIMATING

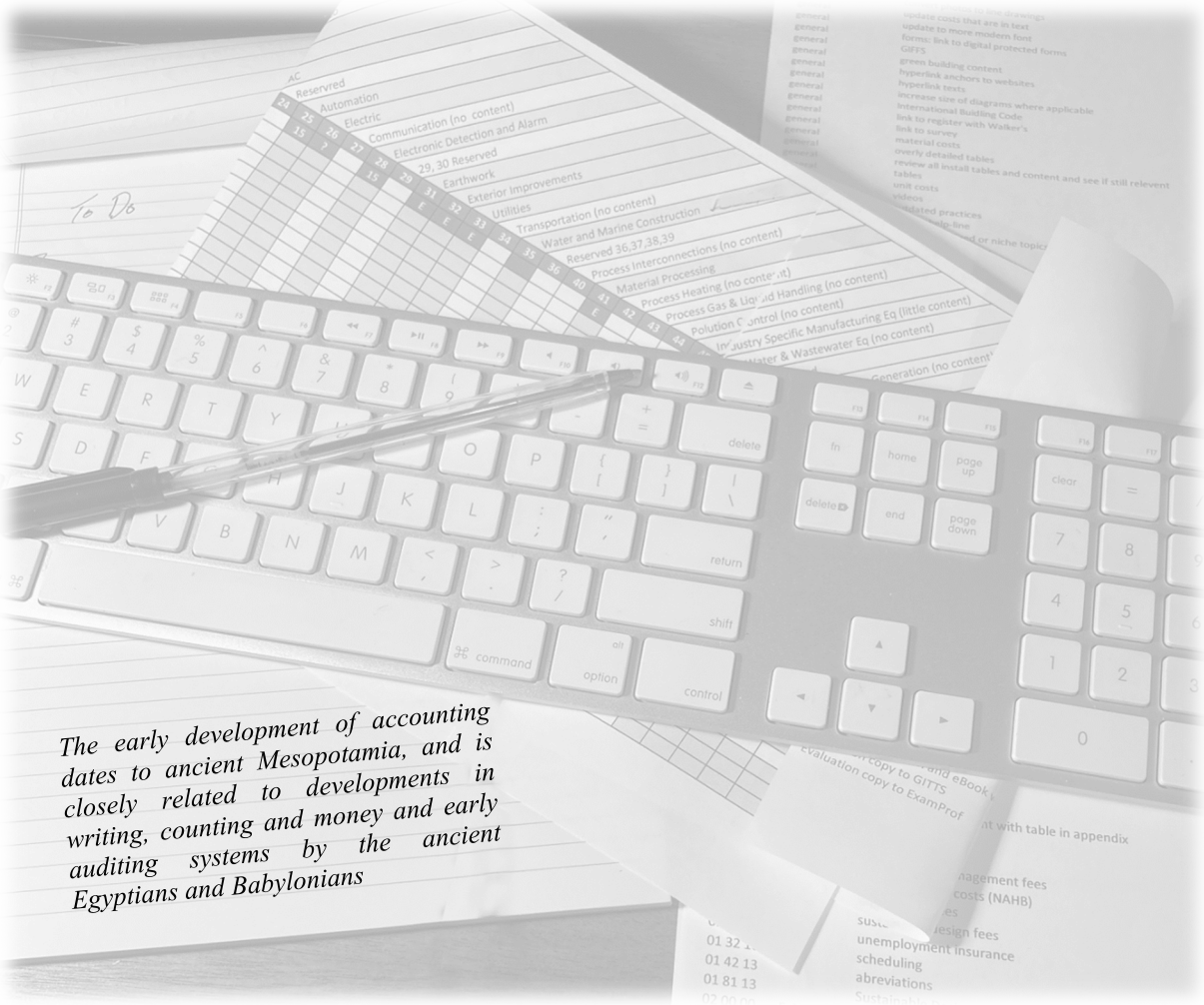


Photo by J L Mac

FUNDAMENTALS OF ESTIMATING

A building project is the effort of many parties. Traditionally, the primary parties are the owner, the architect/engineer, and the contractor. But the owner will also have as consultants lawyers for legal matters; realtors for land purchase and building management; and accountants and financiers, who provide short-term cash for building construction and a long-term mortgage when the project is complete

The Role of the Architect

The obvious role of an architect is to create and design the working drawings for a client. Even though this is a very simple view. The architect's role begins with visualizing the needs of the client from conception to completion. Success in the architect's role depends on this ability to work with the client, the various contractors, a multitude of engineering firms, and manufacturing companies. The technical know-how to incorporate the vast number of materials and methods of construction and their impact on the environment places a tremendous responsibility on the architect. The architect brings to the project several more in-house and outside consultants including structural and mechanical engineers, site planners, fire protection engineers, interior space planners, environmental engineers, and landscape architects
to name but a few. The architect also relies on the cooperation of many suppliers and manufacturers whose products are designed into a structure. The architect also coordinates with government agencies that control and monitor local zoning, building codes, and city planning. Even though normally it is the contractor—not the architect—who takes out a building permit, the latter must assure that permits can be issued based on the plans and specifications for the project. Many localities have adopted the International Building Code specifications and have modified them to suit their locality.

The Role of the Estimator

Estimators are considered by many to be the most important people in a contractor's organization because it is up to them to prepare estimates that will make the contractor money. The most efficient project organization or the best purchasing department in existence cannot make money on contracts taken below cost. The estimator should be practical and must possess a thorough understanding of job conditions, how the work will be carried on in the field, and the operations necessary to assemble the materials and put them in place in the structure. The estimator must be able to visualize and must be able to take a set of drawings and develop a mental picture of the building. The estimator must know every branch of the work to be handled, the materials required, and the labor operations necessary to convert piles of gravel, sand, brick, cement, lumber, steel, and glass into a completed building. The job superintendent or foreman may be able to take a set of drawings and lay the entire job out in their mind and picture the building progressing from the foundation to the finished structure, but unless they possess the knowledge necessary to compute the quantity and costs of material, labor and equipment costs of putting them in place, they will never be able to prepare an accurate estimate. The following requisites are essential for the making of a good estimator:

- Ability to read and measure plans.
- Possess basic knowledge of math.
- Able to visualize the project from the drawings.
- Have a working knowledge of materials and methods of construction.
- Possess the know-how to determine costs for materials, labor, and equipment.
- Possess an intimate knowledge of labor performances and operations and be able to convert them into costs.
- Have an amount of common sense to determine the project requirements and their costs.
- Have a working knowledge of digital spreadsheets, and the ability to learn new software applications.

Some of the math that an estimator will encounter will include basic geometry, converting words to algebraic expressions, working with exponents, ratios, averages and percentages. Refer to the mensuration section of this book for helpful formulas and tables. The inverse function comes in handy in estimating *(1/X),* for instance if we know it takes a mason 30 **hours to place** 200 square feet of brick, and we want to find the inverse, how many square feet of particular type of brick can a mason **place per hour**, the calculation would be as follows:
Hours per square feet = 30/200 or (.15 hrs./SF)
Square feet per hour = 200/30 = 3.33 SF/hr)

An example of some of the math required for construction cost estimating is in the following example:

Questions:
A contractor will place a concrete slab with the dimensions of six feet wide by six feet long and two feet high.
How many cubic yards of concrete will it take to complete this job?
What is the square footage of the formwork surfaces on all four sides?
If it takes two workers two hours to build the formwork at a labor cost of $26/labor hour, what is the labor cost?
If formwork materials are $8/square foot, what is the material cost of the formwork?
What is the total cost to build the formwork?
Answers:
Area = (6' x 6' x 2') = 72 cubic feet, one cubic yard = 3 feet^3 or (3 x 3 x 3) or 27cubic feet.
(72 cubic feet / 27) = 2.67 cubic yards of concrete
Square footage of formwork = (6' high x 2' wide) x (4 sides) = 48 square feet
2 workers x 2 hours = 4 hours x $26 = $104 labor cost
48 x 8 = $384 material cost
$384 + $104 = $488 total cost to build the formwork

See the Mensuration section of this book for handy charts and tables related to estimating math.

The Role of the Contractor

On the contractor's team, there are various subcontractors and the producers and suppliers of the equipment, materials, services, appliances, tools, and machinery called for by the architect and required to complete the job. The contractor must also cooperate with governing officials and must take out all building permits and conduct their operation without violating local laws that govern everything from blocking traffic to waking up the neighbors. And then there are the trade unions, the local utilities, and the ever-necessary bankers. When land becomes scarce, money rates increase, and ecological concerns grow, the exclusive club of owner-architect/engineer-contractor is forced to let in others, and the triangle becomes more of a circle. On large projects today, the owner may be the large landowner who wishes to develop their holdings, a government that is working to rebuild the inner city, or a large investment company that needs to keep its investments active. The architect's concern may no longer be the individual building but an entire complex, a neighborhood, or a whole new town. And the general contractor may find themselves in demand less for craftsmanship abilities than for managerial capabilities. But no matter how small or how complex the project, the owner has a need, the architect/engineer develops that need into satisfactory plans, and the contractor interprets the plans into an actual building.
Erecting a building is a complex undertaking, and seldom is one firm capable of doing all phases of the work. Yet the owner or developer usually prefers to let one contract and make one firm responsible for the completion of the project. That firm is then known as the General Contractor (General or GC), Prime Contractor (Prime or PC), or Construction Manager (CM), who usually assumes this role when the owner asks for firm price bids. It is they who will compile all material, labor and service, and other costs called for on the architect's drawings and specifications. Where the contractor's own firm is not able to do the work called for, they will turn to other contractors who have expertise in those fields. These are the Subcontractors (or subs), and if the project is awarded to the general, the subs will enter into contracts with the general and be responsible to the general rather than directly to the owner. The general contractor will ask for bids from several subcontractors in each trade. This enables the general contractor to put together the best price and what they believe to be the best team to perform the work.
The amount of work performed by specialty subcontractors varies to suit each project's needs. This is determined by the general contractor's in-house capabilities and the project scope. This major decision is not predicated solely upon economic factors. Each time some portion of the work is assigned to a subcontractor, another member is introduced into the construction team, whose strengths and weaknesses translate directly into the total performance plan. The general who attempts to "broker" a project by maximum use of subcontractors to limit financial responsibility will find that other hazards have been created. There will be a considerable loss in coordination and production because the general has relinquished the right and ability of direct control in the assignment of personnel, materials, and equipment. They might be subjected to a subcontractor who does not have the same dedication to the project. Initially, it may appear that the large dollar value assigned for subcontractor performance insulates the general from financial loss on that portion of the project, but this is usually found to be a false economy. Upon signing the subcontract document, the general contractor has inherited any faults

and deficiencies that exist in the subcontractor's company. The extent of these faults becomes apparent during the life of the contract, and they adversely affect the project schedule, subjecting the general contractor to delay claims from other subcontractors as well as from the owner. In addition, the general contractors' own direct costs will increase in direct proportion to delayed completion. In the most severe instances, the general may be forced to terminate the subcontract. There may well be excess costs incurred due to additional procurement costs and associated delays. It is an accepted practice to employ certain subcontractors who possess expertise in a particular discipline. However, they must be carefully selected on the basis of financial capacity, technical ability, and proven ability to perform consistently with the requirements of the contract documents. This policy can ensure a successful project, a credit to the owner, the A/E, and the contracting team.

The general contractor must retain the financial ability to perform the work volume they have under contract, including allowances for unanticipated delays in receiving payments for work performed. Such delays seem to be increasing at an alarming rate, placing an additional burden on the financial resources of the general. There must be in-house personnel who are experienced in the particular type of projects in which the firm is engaged. Of equal importance, there must be adequate managerial skills to coordinate the field construction activities and the administrative functions into a total effort. In private work or negotiated bidding the general contractor is normally expected to provide many services to the owner and the architect before the contract award as well as during construction. The general contractor's knowledge and contribution may be the deciding factor in receiving a contract award or in their expanding a project under construction.

How much of the contract will be sublet will vary with each general contractor. The American Subcontractor's Association claims that 90% of the workforce in the building construction industry is employed by subcontractors. It is certainly quite possible for a subcontractor to erect a greater portion of the project than the general. Some manufacturers insist that their products be installed by contractors employed and answerable to them. For example, in curtain wall construction the specifications will call for the supplier to install the product in order to put the responsibility for any corrective work on one source. Obviously, if anything near 90% of the contract is to be sublet to others, the general contractor becomes more of a construction manager and must have the managerial skills to administer the work, schedule, and coordinate all the firms involved so that the project proceeds without delay.

In addition to building and managerial skills, the contractor must be financially responsible. Not only must they meet their own payroll and overhead costs, but they also must pay their subcontractors and suppliers in advance of being reimbursed, hopefully with some profit, by the owner. Usually, the general contractor will put in a request for payment each month for that work completed the month before. These requests may have to be accompanied by waivers of lien for the amount requested from each sub and supplier. In submitting such a waiver, the sub gives up their right to file a claim against the property (this is a general statement the contractor needs to check with each state law). To obtain a waiver, the general contractor must pay the subcontractor or supplier at least the major portion of the payment request amount. Usually, there is a retainage of at least 5% to 10% by the general contractor to the subs and in turn by the owner to the general contractor. Retainage is not completely released until the project is substantially complete. It has become common practice to reduce the retainage by 50% when the project is 50% satisfactorily completed. A contractor whose financial affairs are in good order and who has a contract with a responsible client, who in turn has secured adequate construction and mortgage loans, should have little trouble in securing a loan from their bank to finance the month-to-month payments. The contract will serve as the loan security. But before quoting a final price for a project, the contractor should determine the length of the period they must finance, estimate the amount involved, and add the cost of the money to the job cost. It should not come out of the contractor's profit.

A successful general contractor is one who has a broad knowledge of building construction. Their initial contact with a prospective client may be about site selection, sources of construction finance, or the advantages of one type of construction over another. The general must develop contacts with architects, engineers, bankers, realtors, mortgage brokers, soil engineers, and the local enforcers of building and zoning codes. Their knowledge in these allied fields may be the deciding factor in their being considered for the job.

Most municipalities and many states require subcontractors and general contractors to be licensed. There is no general rule governing licensing in all jurisdictions. A state license may not fully qualify a contractor to practice in a municipality within that state. Many suburban areas will require additional fees from out-of-town contractors. Some states, for public work projects, may give in-state contractors a preference over out-of-state contractors. One must always inquire about the laws governing the site of construction. Often a license or permit bond is required guaranteeing a public body that the contractor will comply with all applicable statutes and ordinances. If land development is part of the contract, subdivision bonds may be required guaranteeing proper installation of roads, sewers, and other utilities, today even extending to the provision of schools and park systems.

Another decision is to operate as a union shop or merit/open shop firm. If selecting to operate as a union shop contractor, one must enter into proper relationships with the unions. The unions will have established wages and fringe benefits that must be met. To operate as a merit/open shop, a source for obtaining skilled labor must be determined. Certain projects may require that union labor must be used. Finally, one must also consider the type of business structure that defines the firm, whether to practice as an individual, a partnership, or a corporation. Consult your lawyer and banker.

CONSTRUCTION FINANCE

Before getting into the details of estimating the materials and labor that go into a project, let us take a quick look at the "material" that makes it all possible—money

The Cost of Money

Let us say a house that cost $75,000 ten years ago now costs $250,000. With finance charges, based on a 20% down payment and a mortgage for twenty-five years, with interest charges of 7% ten years ago and 7% today, the house really cost $143,700 ten years ago and costs $479,000 today. The increase in the initial cost of the house in ten years was 333%, but the increase in the cost of financing was 333%. Obviously, the point is that money must be used as efficiently as any other commodity. And by efficiently we mean not only spent wisely but carefully planned for, shopped for, drawn upon only at the exact time it is needed, and paid for on time.

Our concern here is not with the money that the contractor needs to run their own business affairs, but the money to pay for the project itself. This breaks down into two types of financing—immediate cash to pay for the labor and materials as they are placed on the job, and once the project is completed, a loan against the project with repayment scheduled over many years. These are known as short-term or construction loans and long-term or mortgage loans. Project financing is not usually the direct concern of the contractor. The owner's or project developer's responsibility is to secure both short- and long-term loans. But it is essential that a contractor understand all phases of the project financing and their relationship to it.

First, few projects today are paid for from funds the owner already has accrued. They must find someone willing to loan the money to make the project possible, and that someone must have enough faith in the project to be willing to wait for repayment of the loan from money generated by the success of the project. In order to "sell" the project to a loan source, the owner must prepare a complete analysis of all aspects, including reliable cost projections, and will often turn to a contractor for this information. It is important that the contractor understands the commitment associated with such an estimate, what the lender "sees" is what the contractor later "gets" if the project loan is approved.

Second, the construction loan is the source from which the contractor will be paid, and they will have to work closely with the lender and the job inspectors to get their money on time. If the contractor is inefficient in compiling the requests for payment, the workers and suppliers will go unpaid unless the contractor borrows the money until the next period the lender makes the payouts. The interest the contractor will have to pay will cut into the profit as surely as if they had underestimated the materials for the job.

Third, the owner may be very naive in construction finance. They may build only one project in their entire life. The local bank may be the only financial contact. The local banks are an excellent starting place to seek construction funds; they know the owner and the community and the owner's best interests are presumably the bank's best interests. But the bank may have other business loans with the owner, and they may not be willing or even legally able to make an additional loan of the size, at the rate, and for the length of time the owner requires. Thus, the project may die in the bank's board room. The owner may lack the time and the sophistication to search further, and so the contractor loses the job as surely as if they had been underbid by a competitor. But there are other money sources besides banks, and an aggressive contractor will develop these other contacts and steer the owner to them to salvage a good job that otherwise might never get off the drawing board.

Fourth, as we mentioned at the very beginning of this chapter, the triangle of owner-architect-contractor is nowadays often more of a circle, with each overlapping the other's territory. The contractor might also be the owner, either as the project developer or as the official landlord who then leases the project with perhaps an option to buy. Such arrangements can be very profitable and can be used in slack times to keep a contractor's force busy. But a good contractor does not always make a good landlord or even a good client for their company.

Sources of Money

The main sources of money are:

- Commercial Banks - short and intermediate-term financing
- Savings and Loans - small residential loans
- Insurance Companies - restricted long-term loans
- Pension and Trust Funds – long-term loans. These funds are often administered by commercial banks.
- Real Estate Investment Trusts (REITS) - long- and short-term loans, land loans, second mortgages, sell and leaseback deals.
- Governmental Agencies - FHA and VA loans for residential work (guarantee loans)
- Government Sponsored Bonds - industrial revenue bonds for projects that increase employment. Local governments issue tax-exempt bonds secured by the project income.
- Mortgage Banking Firms - long- and short-term loans, land loans, second mortgages, sell and leaseback deals.

Each source has an area it is most interested in, but they compete to a degree. Many projects will draw on two or more sources. Short-term loans are for three years or less. Long-term loans are seldom for less than ten years and may run up to thirty years. One thing all loan sources have in common is that they are "selling" their money, not "buying" your project. When the project is presented to them, they not only want to know the physical details but how the project will generate the money to pay back the loan. The essence of a good presentation is the proof that the loan can be repaid.

Mortgage Loans

While it is the construction, or short term, loan that is drawn on first, and land and "front money" loans may precede it, the mortgage, or long-term, loan is shopped for first. Once the owner has the mortgage loan lined up, the construction loan is more easily secured, because it will eventually be paid by the mortgage loan when the project is completed. Further, the interest charged for the mortgage loan may decide whether the project can generate the income to make the necessary payments. If one fails to get a commitment for the mortgage interest and interest rates soar, the debt service may take all the projected profits.

Small projects can usually be financed both long and short-term at local banks and savings and loan associations. These institutions make no direct charge for reviewing proposals and can usually give a yes or no answer in a few days, so one can shop several sources at the same time with no obligation. Once a loan is approved and accepted, there are certain charges called closing costs, and a part of these costs, known as points, origination fees, or the discount, cover the cost of setting up the loan. These points are a one-time charge made as a percentage of the loan and are deducted from the amount of the loan. If the points are 2%, then the amount of two dollars is deducted from every hundred dollars of the loan. The usual range of points is from 1% to 3%, but in states where there are legal limits set on the interest that may be charged, points have been quoted as high as 7% as a way to get around the usury laws. Such points are common to all loan sources and are one of the important items to shop for.

Mortgage Banker

For larger projects and projects that generate income, one should check out all the money sources. It isn't likely that even the most gregarious contractor knows all the institutional sources, or even if they did, could keep abreast of their current interests and capabilities. One must consult a specialist, and that specialist is the mortgage banker, as we shall call them here to distinguish them from a commercial banker.

The mortgage broker is an intermediary between borrowers and lenders, although their firm may have some funds of its own to invest. They are a "matchmaker" who brings parties together. To do this they must carefully evaluate both sides, shopping for the best terms for the owner and for projects most compatible with the portfolio of the lender. For consummating the transaction, they charge a flat fee of around 1% to 2% of all the loans placed. This fee is in addition to the usual closing costs that are charged by the lender. Both expenses are paid by the borrower. Many lenders require a 1% fee at the time the loan application is filled. This fee is refundable if the lender rejects the loan but becomes earned once the lender approves the application and is credited to the fee due to the lender at the time of settlement. There are other benefits to working with a

mortgage broker. They can advise on the techniques of financing as well as the sources. There are numerous options available, and the owner will want to review them all with their accountant and lawyer and select what may suit their particular situation best. Decisions to be made would include the desired length of the mortgage; whether to select a loan at lower rates but "locked in" for many years or one at higher rates but with prepayment provisions; what personality—that is, items not part of the building itself such as equipment, carpet, drapes and the like—should be included in the mortgage; what owner assets should be pledged; what existing property should be made part of the new mortgage (wrap-around mortgage); what "kickers" might be offered, such as sharing income or equity with the lender if certain income or worth is exceeded; what advantages second and third mortgages might have; what method of repayment of the mortgage loan should be adopted (usually a constant covering interest and principal); payments of interest only, with the principal paid when the note is due; a constant payment of principal with interest figured on the declining balance; no payments on either interest or principal until the note is due but with the interest compounding; or a combination of the preceding with refinancing at certain periods to fit the owner's needs. There are no fixed answers that cover all situations. These decisions can contribute as much to the success of the project as decisions about room arrangements or types of building materials.

Having determined the best package for the owner, the mortgage banker will then shop various money sources for the best deal. Each source will be looking for certain features, and the final deal probably will be a compromise. The mortgage banker's opinions are useful in other ways. Having reviewed numerous similar projects at the preliminary stage, they can often suggest refinements in the physical arrangements, as it relates to potential income, that they have seen work out well in other situations. And finally, in accepting or refusing a project, they give their opinion as to its probable success. If two or three mortgage bankers turn a project down when they are placing others, the owner should review the figures. The risk elements must be greater than those in the normal market. The mortgage broker need not be just a necessary evil. They can be a creative part of the building team.

Selling the Lender

Whether one works directly with a loan organization or through a broker, one must be prepared to make an effective presentation of the project. While each type of project will emphasize different elements, all should include the following:

- Physical analysis of the project including a surveyor's plot plan, an architect's sketch plans and specifications, an artist's rendering of the developed site, and a contractor's estimate of the cost.
- Market feasibility study.
- Financial analysis of the ownership including personal statements.
- Financial analysis of the project.
- Draft Environmental Impact Study (DEIS).

A great deal of thought must go into the presentation of the project. Once the project is approved, it is difficult to make major changes. With the use of computer presentations, it's easy to "overkill" the presentation. A too-glamorous presentation may backfire. It is utility not beauty that sells the lender. An impressive entrance framed by a tree-lined drive circling a large fountain may be just an artist's window dressing and will be the first thing abandoned when the final budgets are reviewed. But that may be the feature a lender remembers and insists be built. Another lender, with their eye on the cash flow, will see such embellishments as so much maintenance expense and as a detriment rather than an asset.

In addition to the contractor's estimate, the lender will make one also and may ask the borrower to have an independently certified estimator make up a third. This is usually done by a member of the American Institute of Real Estate Appraisers, whose members carry the title MAI (Member Appraisal Institute), or a senior member of an appraisal society such as the American Society of Appraisers. The certified estimate is made by a certified professional estimator.

The owner's financial statement may be prepared by their certified public accountant, but often the lender will have their own standard form to fill out. The proposed contractor may also have to file a financial statement. Some loans will only be made if performance bonds are posted. Before presenting a proposal, an owner will want to check with their lawyer and accountant as to the best form of ownership for the project-individual, corporate, partnership, or LLC. Some buildings are owned "at arm's length". A third party actually owns the building, and the promoter of the project becomes the tenant.

The market feasibility study shows the compatibility of the project with the surroundings, means of public access, the effect on the environment, and compliance with zoning regulations. Similar successful projects in the area should be noted, and the continuing need for additional facilities proven. And finally, the adaptability to another occupancy and resale value should be evaluated.

The most carefully scrutinized section of the presentation will probably be the projected value of the project based on income, or whether the project will generate enough income to repay the loan on time with interest. What is included here will vary with the type of project. Where rents are involved, rent rolls should be projected. The lender in such cases may stipulate that a certain rent level be reached, usually around 80% of the projection, before the mortgage becomes final. If not, the mortgage will be for a lower amount. This is called setting a floor for the mortgage. The spread may be as much as 20%, and if the owner does not reach the agreed-upon rent level, they must find another source to cover this amount. This will be discussed later.

The Commitment

Once a project is accepted by a lending organization, a commitment paper or contract is issued stating that the lender will lend a certain amount of money for a certain length of time at a certain rate of interest, providing the borrower fulfills certain stated conditions and closes the loan by a certain date. This commitment, if the owner accepts, will become the basis for the first mortgage on the project. There may be other mortgages either on the project as a whole, or on some phase of it, such as furnishings, equipment, or the land itself. But the holder of the first mortgage takes precedence over all other claims except taxes and has the authority to take possession of the project upon proven default and to sell it and deduct the amount due from the selling price, which is usually determined by a public auction. If any excess cash remains, it then goes to the holder of the second mortgage, then to the third, if any, and so on, with the original developer the last to receive any distribution. Holders of mortgages other than the first cannot instigate the sale of the project. They are subordinate to the first mortgage holder and therefore carry a higher risk and charge a higher rate of interest. The commitment will be quite specific and should not be thought of as a preliminary proposal, but rather, as the basis of a contract that one must live with for many years. This is why the presentation of the project must be carefully thought out and based on realistic goals.

Short Term Loans

Having received a commitment, the owner must then work fast to finalize the plans. The commitment will carry a deadline date for acceptance that may be only a couple of weeks away. It will also carry an expiration date by which time all closing documents shall be submitted to the loan company so that the final mortgage loan may go into effect. If this date is not met, the owner forfeits an agreed-upon deposit, which is usually around 1% of the mortgage amount, and is deposited with the lender's agent upon accepting the commitment. One must then proceed immediately to secure a construction loan, gap financing (if it is needed), and "front money". The construction loan is a short-term loan to cover the building costs during the erection of the project. With the mortgage loan commitment in hand, the construction loan repayment is guaranteed providing that the project is completed in a satisfactory manner, so it is not necessary to sell the feasibility of the project all over again. But the construction loan lender does take the risk that the owner or the contractor will not get in financial difficulties during the construction period, or that the projected budget will not prove inadequate. The lender may then have to complete the project themselves. Because the mortgage amount may be less than the stated amount if certain income levels are not reached, the construction loan will be based on the mortgage "floor" rather than the "ceiling" figure, which may deduct as much as 20% from the amount needed to complete the construction. Further, the construction loan is seldom for more than 80% of the floor figure, and like all loans, is subject to points and other closing costs, so perhaps another 2% will be deducted from the loan.

While shopping around might improve one's position, the construction loan will still fall short of the amount needed to complete the project. The missing funds must be supplied by the owner and represent their *equity* in the project. If the borrower can pledge sufficient liquid assets, that are cash, stocks, bonds, or other unencumbered property, they might be able to raise the additional funds from the same source as the construction loan. If not, they will have to take in a partner or borrow from those who take high risks. One such source is those who loan the difference between the floor and the ceiling of the mortgage. This is known as *gap financing*. They will issue a commitment to pay this difference if the income generated by the project is less than that specified to qualify for the full or ceiling amount. To obtain such a commitment one must pay in advance a flat fee, usually around 5% of the amount to be loaned. If the project reaches the income level to qualify for the full mortgage, and the gap loan is not needed, the fee is not refundable. If it is needed, the loan becomes a second mortgage against the project and is repaid with interest.

In setting up the project budget, there are other costs to be met besides construction costs. First, the land must be obtained. While this is sometimes leased or paid for under a mortgage arrangement, the first mortgage commitment may ask that the land title be unencumbered. In addition to land costs, there may be land development expenses such as surveys, soil

investigation borings, utility extensions and connections, and access roads or sidings. There also may be purchasing expenses, including attorney and real estate agent fees, taxes and permits, and zoning fees. If the zoning for the land is to be changed, it can be both time-consuming and expensive. The architect must also be paid. The fee will run from around 4% for a large industrial plant up to 15% for a fine residence or interior remodeling job. Some of this fee will not become due until the job is completed.

When the loan commitments are accepted, they may require a good faith deposit of around 1% of the loan. Consulting fees must be paid to accountants and lawyers. At loan closings legal and recording fees and transaction taxes may be charged, and if asked for, a performance bond obtained. When the work is started, there is always a lapse of time between paying for permits, materials, and salaries and being reimbursed for these items from the construction loan. Usually, each request for payment from the construction loan must be accompanied by waivers of lien. In actual practice the contractor may finance this period rather than the owner, but the lender may still demand that the owner show they have the money to cover these start-up costs.

How much front money, or equity, an owner will need to launch the project will vary with the type of project, the money market, and the owner's reputation. It is often said that an owner with a proven need, a piece of property free of debt, and an architect's set of plans can obtain all the financing they will need. We have used the term "owner" in our preceding discussions as if the one who builds the project were the one who will occupy it. Today even large corporations may choose to be tenants rather than owners and will rely on developers to put the project together. The contractor may be asked to be the developer or at least to become a partner in it. Often the owner of the real estate and the architect will be included as limited partners, their limits of both liability and equity being proportional to the cost of the services or land contributed by them. When the construction loan is paid off by the mortgage loan, they are also often bought out and the ownership reverts to the general partner. However, some mortgage commitments guard against such arrangements by adding a penalty fee if there is any change of ownership within a stipulated time.

Rates of interest on construction loans vary from week to week and community to community but are usually tied to the prime rate, which is the interest charged by commercial banks to their preferred customers for short-term loans. Currently construction loans are quoted at 2-1/2% to 4% over the prime. High-risk loans will have considerably higher rates. It is not our intention to encourage the contractor to become the project entrepreneur. But with the cost of money tied so closely to the success of the project, from an income-producing standpoint, a contractor must know all the procedures in order to follow the time and budget schedules, process monthly draws on time, and turn the completed project over to the owner in such condition as to be completely acceptable to the mortgage lender.

Interim Financing

This type of financing has nothing to do with paying for the construction costs of a project. Nor does it have to do with long-term mortgage financing, which is repaid over an extended period from the proceeds of the revenue generated from the project. The definition of the word interim is provisional, intervening, interlude, or relating to a time period. This is the type of financial assistance required by virtually all contractors, regardless of size, for short-term working capital to compensate for unanticipated delays in receiving payments from owners for work performed and properly invoiced.

The source is usually a commercial bank that is responsive to the needs of the contractor. Not all banks are receptive to this type of business, and the contractor must establish banking relations with a bank that has personnel who possess intimate knowledge of the financial structure found in the construction industry. Once an acceptable financial institution has been selected, then the contractor should identify a particular person within the bank with whom a personal relationship can be established. Next, it is the obligation of the contractor to prove, to the complete satisfaction of the bank, the credibility of the technical and financial assets of the company. This can be accomplished by furnishing certified (CPA) financial statements of the company along with a written detailed resume of the qualifications of each person directing the destiny of the company. Progress, at this point, should place the contractor in a position to obtain from the bank a general commitment as to the limit and terms under which they would participate in granting short-term loans (usually 30 to 90 days). The ideal situation is to obtain from the bank a letter of credit outlining its position so that at any time during the next 12 months, a loan could be arranged without further review from a committee. This avoids days, or even weeks, of delay from the time the loan application is presented until the proceeds are available.

At the time a loan request is made, the position of the contractor can be significantly enhanced by the presentation of a cash flow analysis of all current projects, projecting anticipated expenditures and income on a monthly basis so that the amount of money required and the availability of sufficient income to repay the loan can be clearly defined. Expect the interest on this type of loan to be from 1% to 6% above the current prime rate. Banks consider this a high-risk business. If the current

prime rate is 8% and the loan is assigned 3% over prime, this means the contractor is paying 11% for the use of the money. Obviously, a contractor is forced to impose restrictions on the use of such costly money. It cannot be used as continuous working capital, which at best has an earning capacity of about 10%. It has to be justified by large discounts. For example, prompt payment of equipment invoices would affect an early delivery date that would equate with a time and cost saving justifying the interest rate. The availability of interim financing provides a measure of security for the contractor, who is assured that external financial assistance is available to augment working capital during periods of depressed cash flow.

THE ESTIMATE

Estimating is one of the most important aspects of a building contractor's business. In nearly every instance it is necessary for a contractor either to estimate the cost of the work or to bid in competition with others before a contract for the work is awarded. If a contractor's bid is too low and a contract is awarded on the basis of it, the contractor often must complete the work without profit and sometimes at a loss in time and money. A contractor must know the size, complexity, and quality of work that their firm can efficiently handle. Exceeding these limits often leads to a poor contract, which can be costly not only monetarily but also in terms of dissatisfied customers and loss of future opportunities for bidding.

Most contractors fall into categories as to the type of work which their organizations can handle efficiently, expeditiously, and profitably. A heavy construction contractor specializing in structures such as airport runways, highways, bridge abutments, etc., usually should forego bidding on such work as churches, banks, hospitals, or modern office buildings. A contractor whose organization and personnel are geared to a particular category of construction can find it difficult if they stray from their specialty. Many of the smaller contractors in business today are former employees of contracting firms who have gone into business for themselves. Many of these people doubtless were exceptional mechanics, foremen, or superintendents, and had a thorough understanding of how the work should be carried out in the field. Sometimes they lack business ability and training to estimate costs accurately. Some of these contractors will make a reasonable profit on their work and remain in a similar sized business. Others will learn the importance of estimating and maintaining accurate cost records to grow their business. Unfortunately, many more of them will fail and eventually go back to work for someone else. There are various reasons for these failures, but probably the most common one is the inability of the person estimating costs to come up with realistic and profitable estimates. The procedures involved in preparing an accurate, detailed cost estimate necessary for a realistic bid are relatively simple. Yet almost all instances of failure of contracting firms are the result of poor estimating practices, resulting in the submission of unsound and unprofitable bids. There is no substitute for complete and detailed material take-off and pricing and for cross-checking estimated costs with actual costs so that adjustments in pricing can be made for future bidding. Another common reason for failure in the contracting business is overexpansion. Again, the contractor must know the capabilities of their office and supervisory staff and how much they can adequately handle at any one time. The successful contractor does not take on more work than their staff can perform.

Bonding and insurance companies have certain minimum requirements that contractors applying for surety bonds or contractual liability insurance must meet. Some of the most important considerations that such companies make before bonding an applicant are:

- The technical ability of the contractor applying for a bond, whether or not they understand the business thoroughly, and their capabilities in the preparation of detailed cost estimates.
- The reputation of the contractor for honesty and their standing among those with whom they do business.
- The financial ability of the contractor, and whether or not they have sufficient capital at their disposal to carry on the business, purchase materials and supplies, meet their payrolls and current expenses, etc.

Bonding companies seldom get the opportunity of bonding the best contracting firms. On public work projects the bidding is usually open to all bidders and in some instances as many as twenty or more bids may be received on one job. In most cases, the lowest responsible bidder is awarded the contract. The low bidder often may be the poorest risk because of substandard estimating procedures, lack of technical ability to perform the work as specified, and/or a lack of financial responsibility. On privately owned projects, the risk to the bonding company may not be as great, because the bidding list can be controlled. Only contractors with the proper credentials are usually asked to submit proposals.

Architectural and engineering firms that handle work for private owners are often asked to select contractors to bid on a project. They will attempt to choose bidders whom they know can perform the work equally well and will carry out the intent of the drawings and specifications in the best interest of the owner. Others besides the contractor attach importance to a

correct and detailed estimate. The success of a contractor depends as much on a well-prepared estimate as it does on the manner in which they purchase materials, let the subcontracts, or carry out the work on the job.

The skill level of the estimator determines the reliability of the estimate. If similarly skilled estimators are preparing estimates on the same project, they will attain similar results. If one of the bids is substantially low or exceptionally high, there may be many reasons for this. One of them may well be the skill level of the estimator. Other reasons could include the approach taken in determining how to perform the work, preferential pricing from major subcontractors and suppliers, or the economic conditions of the company. While no two estimators will have the same cost, they will have similar estimated costs based on their comparable experiences. Preconstruction estimates are prepared by contractors, construction management firms, architects, engineers, and independent cost estimators. The skill level and professional quality of the estimates prepared by these firms and individuals can vary widely. Estimates prepared by estimating professionals are generally the best quality. Construction estimates prepared by inexperienced estimators or non-estimating personnel will have less reliable results.

The estimating detail of a project should include the amount of detail represented in the plans and specifications. For projects with for which the plans and specifications are not fully developed, it is appropriate for a line item to consist of the description, unit of measure, quantity, a unit cost that includes material, labor and equipment, and the total cost. For projects where the plans and specifications are fully developed the line item may consist of the description, unit of measure, quantity, unit material cost, unit labor/hour, total labor/hour, wage rate, total labor hours, unit equipment cost, total equipment cost, and total cost. If an item of work is to be a subcontractor-performed work item, there will be a price obtained by the subcontractor with a contractor's administration fee added. Using line-item details such as these will provide the most reliable estimate results.

Each contractor needs to develop their own unit labor hours and costs from historical cost records that reflect their own company's particular experience and expertise. This expertise can vary widely from company to company, and it is up to the estimator to develop the estimates reflecting this cost history. In the final analysis of estimates and bids, they should be accepted as representing the projected final costs for performing certain prescribed work within a stipulated time schedule, taking into consideration all the variables that a prudent contractor can anticipate during a construction contract based on information available at the time of bidding.

To prove the validity of the bid, one must consider the extreme risks that the contractor is willing to assume by furnishing payment and performance bonds and by entering into a legal contract dedicating the technical and financial resources of the firm to the successful completion of the contract in hopes of realizing a modest profit. Estimating can be a time-consuming and costly operation. Under no circumstances should an estimator or contractor produce a less than totally professional estimate that will stand the test of proving each element contained in the estimate. In line with this, if there is not enough time to correctly prepare the estimate, the contractor should give serious consideration to not bidding on the project. Mistakes in the estimate/bid preparation period will have long lasting consequences. These consequences include missing out on a contract because the estimated prices developed were too high. It also includes losing money because the estimated costs were too low.

DRAWINGS AND SPECIFICATIONS

The owner's dreams and the architect/engineer's visions must eventually be put down in a form the contractor can use as a basis for bidding on the project and for constructing with enduring materials. This form has developed into the dual one of working drawings and specifications. Basically, the drawings present the design, the location, and the dimensions of a project. The specifications give the quality required Each section of each division of the specifications is divided into the Scope or Work Included, Materials listing the quality of all materials to be furnished, and finally, Fabrication and Erection, defining the quality of workmanship desired. Scope includes items to be furnished and installed, items to be furnished but installed by others, items furnished by others and installed under the section, and finally, related work in other divisions of the specifications. Scope will also list some general requirements such as those for shop drawings, samples, tests, methods of delivery, and storage that may be required. No matter how detailed the scope section, it will not include each and every item. The drawings must always be checked against scope, which often carries the phrase "including, but not limited to, the following". In the past drawings were done in pencil or ink on tracing paper or cloth, which is easily reproducible, and prints were delivered to the contractor. Now drawings are developed on the computer using CADD (Computer Aided Design and Drafting) technology to create 2D or 3D drawings. The architect retains the original drawings and CADD files in their office. The specifications, except on very small jobs for which they may be incorporated on the drawings, are produced separately. Both are made available to each contractor bidding the job in either electronic or hard copy formats. The digital format is

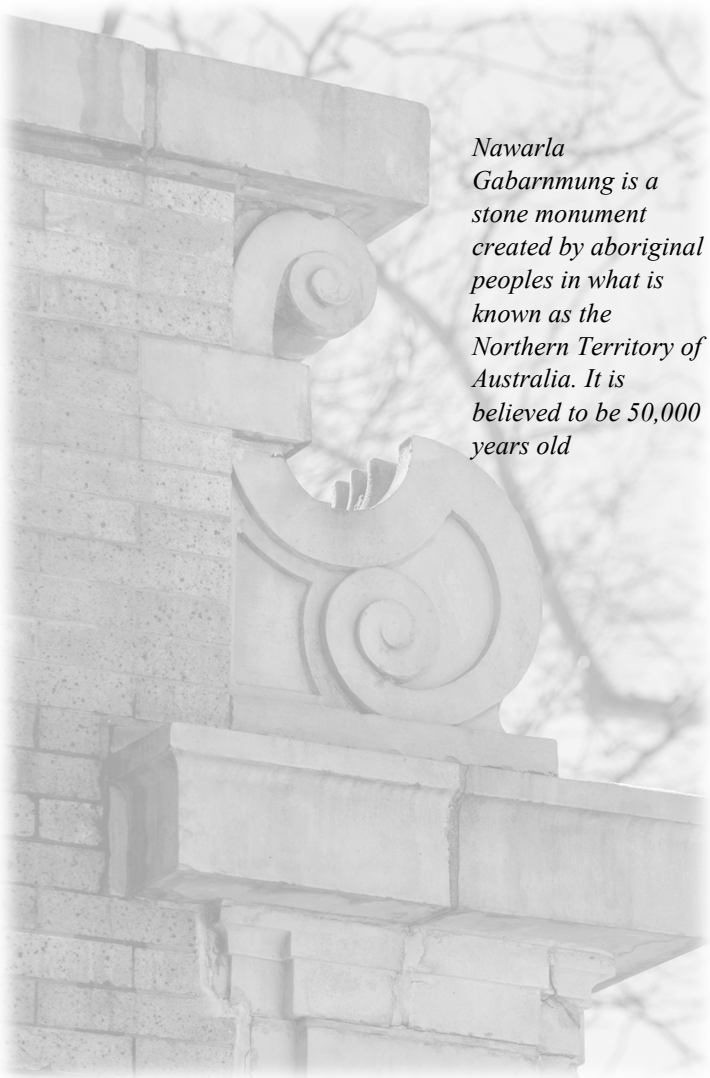
becoming more prevalent in the industry and has enabled estimators to utilize onscreen estimating software to determine the quantity of materials and therefore labor and equipment required to complete the project. The bidding process usually occurs in a relatively short time frame which forces the contractor to quickly interpret the bidding documents and form a realistic and complete bid. This chapter presents an outline of what information a contractor should expect to find in a bid set and where it can be found.

The Working Drawings

Typical complete project bid documents will consist of drawing sheets, usually all of uniform size, bound into one set. The first sheets typically include the site location, the complete job title, index of the drawings, symbols, definitions, and architect/engineers of record. Following the general information sheets are the civil drawings. The typical order for civil drawings is site survey, paving, grading, utilities and then details. This will be followed by the sheets showing architectural details, usually in the following order: basement plan, first floor plan, upper floor plans, exterior elevations, sections, interior elevations, and details. The architectural sheets are followed by the structural set including footing and foundation plans, basement framing plans, floor framing plans, roof framing plans, and then the structural details. These are followed by the heating and ventilating plans; then the plumbing plans, and finally, the electrical plans, each starting with the lowest floor and working upward. Each sheet should have a title block in the lower right-hand corner with the sheet number (usually "G-" for general information, "C-" for civil, "A-" for architectural, "S-" for structural, "M-" for heating and ventilating, "P-" for plumbing, "FP-" for fire protection, "E-" for electrical, "I-" for instrumentation and "T-" for technology); the number of sheets in each set (i.e., A-1 of 7); the date made plus each date it has been revised, and the initials of the person or persons who drew and approved the sheet. Revisions are sometimes listed outside the title block. Some architects, rather than revising a drawing once it is printed, will issue supplementary drawings which must be attached to the appropriate set as they are issued.

Most working drawings for building construction are based on orthographic projection, which is a parallel projection to a plane by lines perpendicular to the plane. In this way, all dimensions will be true. If the plane is horizontal, the projection is a plan; if vertical, it is an elevation for the outside of the building, or a sectional elevation if through the building. The only descriptive drawing that presents a building as the eye sees it is a perspective drawing. But perspective drawings are used mainly to study the building and present it to the client in an easily understood form. A perspective drawing is seldom useful for presenting information on working drawings. However, other pictorial presentations are helpful to the builder. Two of these are the isometric and the cabinet projection. Isometrics are drawings in which all horizontal and vertical lines have a true length, and those lines parallel to the object are also parallel on the drawing. Vertical lines are vertical, but horizontal lines are set at 30 or 60 degrees. Isometrics are often used for piping diagrams and to show complicated intersections, such as on sloped roofs. Cabinet drawings are those with the front face shown in true shape and size as if it was an orthographic projection, but they simulate a perspective. The sides are shown receding at 45 degrees and at 1/2 scale (1:20). Variations of this are oblique drawings, where the angle and side scale may be anything that best shows the object, and cavalier drawings, where the side scale is at the same scale as the front. Cabinet drawings get their name from the fact that they are often used for cabinet work.

MASONRY



Nawarla Gabarnmung is a stone monument created by aboriginal peoples in what is known as the Northern Territory of Australia. It is believed to be 50,000 years old

Photo by Laura Tancred

MASONRY

Division 04, Masonry, covers many aspects of masonry construction, including unit masonry, such as bricks or blocks, that are laid and bound together by mortar, stone assemblies both natural or manufactured stone materials. The trades involved in masonry work include: Masons, Mason Tenders, Plasterers, and Laborers.

An accurate estimate of the cost of masonry requires a knowledge of various factors, including type of building, thickness of walls, kind of mortar, style of mortar joint, class of workmanship, ability of workers, and the ability of the foreman. Estimating masonry is more than a matter of referring to a table or chart to obtain the prevailing wage scale and then determining the labor cost of laying a thousand brick. Accuracy is important in the preparation of your estimates, and all the above items should be considered when determining the unit costs. The type of building plays an important part in the costs. A mason can lay far more brick on a factory or warehouse building having long straight walls than on a school or office building that is cut up with numerous windows, which require straight walls, plumb jambs, pilasters, etc. A mason can lay far more brick on a 16" wall than on an 8" wall and can lay more brick in smooth working lime mortar than in coarse portland cement mortar. He can also lay more brick by merely cutting the mortar joints than by striking them with the point of his trowel. The class of workmanship plays an important part. Many cheaply constructed, speculative buildings have crooked walls and open mortar joints, presenting a slovenly appearance, while the best grade of workmanship requires full mortar joints, straight walls, plumb jambs, and corners-in other words, good workmanship. Weather conditions also affect labor costs. A mason can lay more brick on a clear, dry day than when it is cold and wet, or when it is necessary to heat materials during freezing weather. The ability of the foreman in charge to plan, schedule, and lay out the work affects final costs.

04 01 20.91 Unit Masonry Restoration

Cleaning Paving Brick Using Pneumatic Chipping Hammers. A satisfactory method of cleaning brick with pneumatic chipping hammers is to use a 4"x12" plank about 10'-0" long, placed on 2 carpenter horses and raised at one end 15 to 18 degrees. This is used to hold the brick, which may be placed lengthwise across the plank, so that one side and one end can be cleaned without moving. A plank will hold about 56 brick. Using a pneumatic chipper with a hexagon nozzle and a 2" chisel bit, a worker should clean 150 to 180 brick per hr. or 1,200 to 1,440 per 8-hr. day.

Sandblast Cleaning of Buildings

The portable compressor and the sandblast are widely used for cleaning buildings, bridges, and other structures, either preparatory to repainting or for the purpose of brightening up the surface. The cost of this work, however, is contingent entirely upon the condition of the old building, as some of them have nothing more than many years' accumulation of dirt while others have been painted numerous times, making it necessary to remove several coats of paint before the surface of the brick or stone can be touched. Also, it is often necessary to repoint all the old mortar joints. The estimator should consider all these items when preparing the estimate. The process of sandblasting is to force sand against the surface to be cleaned through a small hose connected with the air compressor, and the force of the sand striking the object to be cleaned removes the old surface. Where it requires a maximum pressure of sand and air to remove the old dirt, a 3/4" hose is used but where volume is desired more than high pressure a 1" hose is used. It usually requires four workers to operate a sandblasting machine: one worker attending the machine, one at the nozzle, and two on the ground assisting with hose, scaffold, and sand. When estimating quantities, take the entire area of the surface to be cleaned and make no deductions for door or window openings. On court houses, state capitols, post offices, public libraries, and other ornamental structures, the quantities are computed as above, and in addition, balustrades, balusters, etc., are measured on both sides, as it is necessary to go around each baluster separately to clean it. With a portable compressor supplying air, the average operator can cover a strip 25'-0" wide and 60'-0" to 75'-0" high per 8-hr day. The exact area varies with the quality of the stone encountered but the following table shows the speed at which various stones can be cleaned.

Clean Stone	
Material	**Sq.Ft. per min.**
Limestone	7 - 9
Terra Cotta	8 - 10
Marble	3 - 5
Brick or Brownstone	8 - 10
Granite	6 - 8
Sand stone	10 - 12

The quantity of sand required for sandblasting will vary with the method used, but where a canvas screen or covering surrounding the scaffold catches most of the sand, it is then carried back to the tank on the ground. If this is done, about 75% of the sand is saved for use again. This, however, is governed somewhat by the conditions of the work. The following costs are for removing and cleaning only the natural accumulation of dirt and do not include removing paint, oil stains, etc., unless otherwise mentioned. Maximum quantities are not figured in the tables as average job conditions usually include delays, moving from one job to another, placing and removing scaffold, etc.

Sandblasting 100 Sq.Ft. of Old Brick or Limestone Buildings			
	Hours	Rate	Total
Compressor Operator	0.33	$ 96.70	$ 31.91
Nozzelman	0.33	$ 78.73	$ 25.98
Labor	0.67	$ 70.91	$ 47.51
Cost per 100 Sq.Ft.			$ 105.40
Cost per Sq. Ft.			$ 1.05

Note: Add for equipment rental, Sand, and Scaffold Cost together with enclosure

Sandblasting Old Brick Work That Has Been Painted. If the old brick work has been painted and the paint can be blasted off without the necessity of repointing the mortar joints, the costs will be about the same as given above for plain work.

Sandblasting Ornamental Buildings, Such as Post Offices, Courthouses, State Capitols, Public Libraries, Etc., Constructed of Granite or Limestone. The cost of sandblasting buildings as enumerated above, having exterior elaborations, such as balustrades, gables, pediments, plain or fluted columns, etc., will be higher than plain buildings on account of the extra labor required for scaffolding, sandblasting balusters, columns, caps, etc., that are not found on the average building.

Repointing Mortar Joints After Sandblasting. On many old buildings that are unusually dirty or that have been painted, it often happens that the mortar is blasted from the joints when removing the paint from the brick. After the job has been cleaned, the tuckpointers must go over the entire surface and repoint all of the brick joints.

04 05 13 Masonry Mortaring

Cements. Different types of Portland cement are manufactured to meet different physical and chemical requirements for specific purposes. The American Society for Testing and Materials (ASTM) Designation C 150 provides for eight types of Portland cement:

Type I portland cement is the basic cement used in most mortars. Type II is used where moderate sulphate action is a problem. Type II cement will usually generate less heat at a slower rate than Type I. Type III is a high early portland strength cement that provides high strengths at an early period, usually a week or less. Although richer mixtures of Type I cement can be used to gain high early strength, Type III, high-early-strength portland cement, may provide it more satisfactorily and more economically.

TYPE IA, IIA, IIIA. Specifications for three types of air-entraining Portland cement (Types IA, IIA, and IIIA) are given in ASTM C 150. They correspond in composition to ASTM Types I, II, and III, respectively, except that small quantities of air-entraining materials are interground with the clinker during manufacture to produce minute, well-distributed, and completely separated air bubbles. These cements produce concrete with improved resistance to freeze-thaw action.

TYPE IV. Type IV is a low heat of hydration Portland cement for use where the rate and amount of heat generated must be minimized. It develops strength at a slower rate than Type I cement.
TYPE V. Type V is sulfate-resisting Portland cement used only in concrete exposed to severe sulfate action—principally where soils or groundwater has a high sulfate content.
All are included under ASTM C150-04ae1 Standard Specification for Portland Cement. Air entraining cements should usually not be substituted, because this affects bond strength. Full information on tests and specifications are available in ASTM publications and in information published by the Portland Cement Association. Masonry cements are included in ASTM specifications, but their chemical makeup is not regulated and varies widely among the manufacturers. It may therefore take some experimenting to find the product most suited to the job. Masonry cements do, however, contain additives that increase workability and water retentivity, and the single product saves handling both portland cement and lime on the job, and mortar can be used as soon as mixed. However, where a Type S mortar is selected for bonding strength, care should be taken not to select a masonry cement with air entrainment properties.
Lime. Lime for construction purposes is available in both the quick (unslaked) and hydrated (slaked) forms, though in recent years hydrated lime has been preferred to quicklime, because it is faster, easier, and safer to use. Building lime is supplied in bulk or packaged in 50-lb. multiple-wall, moisture resistant bags. Barrels, once used to package lime, are no longer in use as containers for domestic lime shipments. Lime products sold in bulk or bags are generally quoted on a ton—2000 lbs. net—basis.
Quicklime may be purchased in the following forms, the principal difference being in the size of the particles: pebble lime, crushed lime, ground lime, and pulverized lime. All quicklime must be slaked prior to use and manufacturer's directions for slaking should be followed to secure best results. Due to the greater ease with which complete slaking is secured, the finer divided types of quicklime are preferred. Since quicklime is very reactive with water, care should be exercised at all times during the slaking operation to prevent splattering of the lime and potentially serious burns of the eyes and skin. Slaked quicklime putty should be screened and permitted to age until all the lime particles are completely slaked. The aging period may vary from a few hours to several days, depending on the chemical and physical properties of the quicklime used and on the skill of the operator in slaking the lime.
Hydrated lime for structural use is furnished in the dry powdered form usually packaged in 50 lbs. net paper bags and sold by the ton (2000 lbs.). It may also be purchased in bulk if proper facilities are available for handling and storage. There are several types of hydrated lime 1- Type N, Normal Hydrated Lime. 2- Type NA, Normal Air-entraining hydrated Lime 3- Type S, Special Hydrated Lime and 4- Type SA, Special Air-Entraining Hydrated Lime. Types S and SA are differentiated from types N and NA principally by their ability to develop high early plasticity, higher water retentivity, and by their limitations on unhydrated oxide content. The maximum air content of cement-lime mortar made with types NA and SA is 14%; with types N and S lime 7%
Type "S" or pressure hydrated lime is a highly hydrated product contains a maximum of 8% combined unhydrated calcium and magnesium oxides. In addition, putties made from this lime develop high plasticities instantly upon mixing. Type "S" special hydrated limes meeting all ASTM C 207 requirements are commercially available in both the dolomitic and high calcium varieties. Type "N" normal hydrated limes should be soaked in a paste or putty form for several hours or overnight prior to use in order to enhance their plasticity and workability. The preferred method for soaking is to sift the hydrated lime evenly into a watertight box or vat that has been previously half filled with clean water. Do not stir, mix, or agitate the mass, but allow the lime to settle naturally; continue to add the hydrate slowly and evenly over the entire surface of the water until the thick paste is formed, after which the mass is permitted to soak until required for use. All building limes should comply with the requirements of the Standard Specifications for Hydrated Lime for Masonry Purposes (ASTM C-207-04) or Quicklime for Structural Purposes (ASTM C-5-03).
Storage of Lime and Lime Putty. Prior to slaking or use, all quicklime and hydrated lime previously delivered to the job site should be stored in a clean, dry place. Quicklime is shipped in bulk and in waterproofed, multi-wall paper bags. When furnished in bulk, it should be slaked immediately to assure maximum putty yield and to avoid loss. Quicklime furnished in bags may be stored for considerable time, depending on humidity and storage conditions. Hydrated lime in bulk or packed in bags may be stored for relatively long periods of time provided it is placed in a clean, dry, properly ventilated warehouse. Lime putty should be aged and stored in clean, tight vats and should be well protected from direct contact with the atmosphere by maintaining a thin film of water over the surface. Commercial plants for the production of scientifically prepared, well-aged putty, are in operation in many markets. The use of commercially prepared lime putty eliminates the need for slaking and aging or soaking of lime on the job. It also has the advantage of providing the estimator with reliable figures for estimating purposes, because purchase order is based on net quantity of lime putty required for the operation. Other advantages of commercially produced lime putty include flexibility during construction, elimination of lost time awaiting preparation of lime putty and admitting of expansion in operations on short notice, reduction in storage space

required for materials at the site of the work, and improved quality of putty due to careful supervision during slaking and aging of lime putty.

Lime Putty and Its Preparation. Job specifications generally require mortar to be mixed in definite predetermined proportions by volume. The lime proportion is usually determined in volumes of lime putty, so some knowledge of putty yield of lime is necessary in preparing estimates of quantity of lime required. The putty yield of different limes varies widely, according to chemical and physical properties of the lime, methods of processing, etc. However, the quantities given in the following table may be used as a sound, conservative average for estimating purposes.

Quantity of Lime Putty Obtainable From Various Types of Lime		
Type of Lime	Average C.F. Putty per Ton of Lime	Average Lbs of Lime per C.F. Putty
Hydrated Lime	46	44
Pebble or Pulverized Quicklime	80	25

It takes 109 lbs. portland cement to produce 1 cu.ft. of cement paste of normal working consistency.
It takes 9 cu.ft. of putty or paste with 27 cu.ft. of ordinary building sand to produce 1 cu. yd. of 1:3 mortar.
Where hydrated lime is used in dry powdered form, it is usually assumed that a given volume of dry hydrated lime will produce an equivalent volume of lime putty. A bag of dry hydrated lime - 50 lbs. net - equals about 1.15 cu.ft. of lime putty.

Quantity of Materials Required for Masonry Using Pebble or Pulverized Quicklime at 80 Cu. Feet Lime Putty per Ton								
Proportion by Volume			Quantity of Materials					
			For One Cu.Yd. Mortar			To Lay 1,000 Brick		
Lime Putty	Portland Cement	Sand	Lime Lbs*	Cement Sacks	Sand CY	Lime Lbs*	Cement Sacks	Sand CY
1	0	3.0	225	0.00	1	150	0.0	0.67
3	1	12.0	169	2.25	1	113	1.5	0.67
2	1	9.0	150	3.00	1	100	2.0	0.67
1 1/2	1	7.5	135	3.60	1	90	2.4	0.67
1	1	6.0	113	4.50	1	75	3.0	0.67
1/2	1	4.5	75	6.00	1	50	4.0	0.67
0	1	3.0	0	9.00	1	0	6.0	0.67
10% **	1	3.0	22.5	9.00	1	15	6.0	0.67
15%	1	3.0	34	9.00	1	23	6.0	0.67

** Dry unslaked Lime*

*** Based on volume of cement required. Add 5% to 15% for waste.*

Labor Slaking Lime and Making Mortar. When mixing mortar by hand, a good mortar maker should slake and sand about a ton of quicklime per 8-hr. day and should make about 4 cu.yd. of mortar per 8-hr. day.

Quantity of Materials Required for Masonry Mortar Using Hydrated Lime at 46 Cu. Feet Lime per Ton								
Proportion by Volume			Quantity of Materials					
			For One Cu.Yd. Mortar			To Lay 1,000 Brick		
Lime Putty	Portland Cement	Sand	Lime Lbs*	Cement Sacks	Sand CY	Lime Lbs*	Cement Sacks	Sand CY
1	0	3.0	391	0.00	1	96	0.0	0.88
3	1	12.0	294	2.25	1	116	2.0	0.88
2	1	9.0	261	3.00	1	103	2.6	0.88
1 1/2	1	7.5	235	3.60	1	93	3.1	0.88
1	1	6.0	196	4.50	1	77	3.9	0.88
1/2	1	4.5	131	6.00	1	52	5.2	0.88
0	1	3.0	0	9.00	1	0	7.8	0.88
10% **	1	3.0	39	9.00	1	15	7.8	0.88
15%	1	3.0	59	9.00	1	23	7.8	0.88

** Dry unslaked Lime*

*** Based on volume of cement required. Add 5% to 15% for waste.*

The actual labor cost of making 18 cu.ft. of mortar, sufficient for 1,000 common brick, should average as follows:

Labor Making 18 Cu.Feet Mortar for 1,000 brick			
Item	Hours	Rate	Total
Mortar Maker	1.33	$ 96.70	$ 128.61
Cost per Cu. Foot			$ 7.15

On jobs of any size, the mortar is mixed in a mixer, which produces a more uniform and more easily spread mortar. It not only enables a mason to lay more brick but also results in a saving of 10% to 20% in labor required to mix.

Aggregate. Aggregate may be either natural sand that is clean and sharp, or sand manufactured by crushing stone, gravel, or air-cooled iron blast furnace slag. Sand should be properly graded, as set forth in ASTM Specification C 144-04, with all sand passing a No. 4 sieve and approximately 10% passing a No. 200 sieve for manufactured sand. Too coarse a sand decreases workability while too fine a sand decreases water retentivity.

Mortar Colors. Mortar coloring agents may be added, either natural, such as white sand, or pigments. While different color effects will require some experimenting, in general, 4 to 8 lbs. of color to one bag of cement, hydrated lime or c.f. of putty and 3 cu.ft. of sand can be figured, or about one 50-lb. bag per 1000 bricks with a 3/8" joint.

Waterproofing and Shrink proofing Mortar

Leaky masonry walls have aroused considerable concern, and this has led to extensive investigation and tests by the National Bureau of Standards which investigated not only the materials such as brick, tile, concrete blocks, mortar, etc., but also the effects of different grades of workmanship. After extensive tests, it was determined that workmanship affected the permeability of the walls more than any other factor. Walls with tooled joints were less permeable than similar walls with cut joints. But the quality of the workmanship inside the walls had a greater influence than the kind of surface finish on the joint. In other words, brick as laid on the average contract job, where mortar was spread and furrowed and the joints were not completely filled with mortar, leaked far more than bricks laid in a full bed of mortar and "shoved" into position with full bed and head joints and a complete filling of joints between all brick. It was also determined that nearly all the leakage was through the mortar joints regardless of the kind of brick used and that in practically every instance where the "commercial" grade of workmanship was used, leaky walls resulted. Where brick of high absorptive properties were used, the brick absorbed the water from the mortar, making it difficult to work and resulting in small hair cracks between the mortar joints and the brick. This also caused leakage through the walls. The use of lime with low plasticity produces mortar with low water

retention and greatly increases the permeability of the walls. This effect was more pronounced when the mortar was used with high absorptive brick. Water reduction in cement and lime mortars is highly desirable, because with less water there is less evaporation, and mortar shrinkage is reduced below the critical point. Since these investigations were made, numerous admixtures have been placed on the market. These are to be added to the mortar mixture and are said to give the mortar greater plasticity, to retain the water in the mortar, to prevent shrinkage and leakage in the mortar joints, and to make a smoother mortar that will work better under the trowel.

Types of Mortar

The following mortars are based on proportion set forth in ASTM specifications. Type M mortar is a high strength mortar used primarily in foundation masonry, retaining walls, walks, sewers, and manholes. Type S mortar also has a reasonably high compressive strength and develops maximum tensile bond strength between brick and cement-lime mortars. It is recommended for use in reinforced masonry and where flexural strengths are required, such as cavity walls exposed to strong winds, and for maximum bonding power, such as for ceramic veneers. Type N mortar is a medium strength mortar, generally used in exposed masonry above grade. Type O mortar is a low strength mixture for general interior use where compressive strengths do not exceed 100 psi. It may be used elsewhere where exposures are not severe, and no freezing will be encountered.

Cu.Ft. of Mortar Required to Lay 1,000 Face Brick

Based on standard size brick having 1/4” to 3/8” end joints and bed joints as follows:

Cubic Foot Mortar to lay 1,000 Face Brick							
Width of Mortar Joints, Inches							
1/8"	1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1"
4	7	9	12	14	16	18	20

For Dutch, English, and Flemish Bond, add about 10% to the above quantities on account of additional head joints. Labor cost to mix mortars is usually figured as part of labor cost setting brick.

Quantity of Mortar Required to Lay 1,000 Brick						
Cubic Feet of Mortar per 1,000 Brick						
Joint Thickness, Inches	Wall Thickness, Inches					
	4”	8”	12”	16”	20”	24”
1/8"	2.9	5.6	6.5	7.1	7.3	7.5
1/4"	5.7	8.7	9.7	10.2	10.5	10.7
3/8"	8.7	11.8	12.9	13.4	13.7	14
1/2"	11.7	15	16.2	16.8	17.1	17.3
5/8"	14.8	18.3	19.5	20.1	20.5	20.7
3/4"	17.9	21.7	23	23.6	24	24.2
7/8"	21.1	25.1	26.5	27.1	27.5	27.8
1"	24.4	28.6	30.1	30.8	31.2	31.5

For various thicknesses of walls and joints. No allowance for waste.

Selecting Mortars. Often the estimator has no choice in the makeup of mortar because the architect’s specifications set forth exactly what is required. Because replacing masonry that is found not acceptable by an architect or owner is extremely expensive, it is false economy, not to mention the loss of reputation involved, to alter specifications without approval from the architect. However, many jobs will leave considerable leeway in the selection of mortars, and an informed estimator may even perform a valuable service in suggesting changes to the mortar proportions that will either save money or make a better job. All too often a mortar may be selected on the basis of high compressive strength when the job may require only a 100

psi. This not only wastes cement, but such mortars do not have the adhesive and sealing powers of the weaker mortars, and these two characteristics are the primary functions required on most jobs. Of further importance to the estimator is the workability of the mortar, which will enable the bricklayer to lay more units.

Mortar for Concrete Masonry. For laying masonry walls subject to average conditions of exposure, use a mortar made in the proportions of 1 volume of masonry cement and between 2 and 3 volumes of damp, loose mortar sand; or 1 volume of portland cement and between 1 and 1-1/4 volumes of hydrated lime or lime putty and between 4 and 6 volumes of damp, loose mortar sand. Walls that will be subject to extremely heavy loads, severe winds, earthquakes, serious frost, or other conditions requiring extra wall strength should be laid with a mortar made of 1 volume masonry cement plus 1 volume portland cement and between 4 and 6 volumes of damp, loose mortar sand; or 1 volume of portland cement, to which may be added up to 1/4 volume of hydrated lime or lime putty, and between 2 and 3 volumes of damp, loose mortar sand.

Quantity of Mortar Required to Lay 1,000 Concrete Brick of Various Sizes				
Width of Bed Joint,	Thickness of Wall			
	1 Brick	2 Bricks	2 Bricks	3 Bricks
Inches	4” Wall	8” Wall	8” Backup	12” Wall
Modular Size Brick, 2-1/4” x 3-5/8” x 7-5/8”				
5/12”	9.64 c.f.	12.19 c.f.	14.73 c.f.	13.01 c.f.
Jumbo Brick, 3-5/8” x 3-5/8” x 7-5/8”				
3/8”	10.06 c.f.	13.88 c.f.	17.70 c.f.	15.15 c.f.
Double Brick, 4-7/8” x 3-5/8” x 7-5/8”				
11/24”	12.68 c.f.	17.77 c.f.	22.86 c.f.	19.47 c.f.
Roman Brick, 1-5/8” x 3-5/8” x 11-5/8”				
3/8”	11.79 c.f.	14.65 c.f.	—	—
Roman Brick, 1-5/8” x 3-5/8” x 15-5/8”				
3/8”	15.25 c.f.	19.07 c.f.	—	—

All end and back joints figured 3/8”. Quantities include 10% for waste.

Mortar for glass blocks shall be composed of 1 part waterproof portland cement, 1 part lime, and 4 parts well graded sand, all well mixed to a consistency as stiff and dry as possible.

Mortar Required for Setting Stone. The quantity of mortar required for stone setting will vary with the size of the stone, width of bed, etc., but generally, it will require 4 to 5 cu.ft. of mortar per 100 cu.ft. of stone.

If the stone is to be back-plastered, the quantity of mortar will vary with the thickness of the plaster coat, but as most ashlar is 4” to 8” thick, it will require the following cu.ft. of mortar per 100 cu.ft. of stone:

Cubic Foot of Mortar			
Plaster Thick., Inches	Thickness of Stone, Inches		
	4"	6"	8"
1/4"	6 1/2"	4 1/4"	3 1/4"
1/2"	13"	8 1/2"	6 1/2"
3/4"	19"	13"	9 1/2"

It is customary to use white non-staining portland cement for setting and backplastering limestone or other porous stone to prevent stains from appearing on the face of the stone. Never use ordinary portland cement for setting limestone.

04 05 13.91 Masonry Restoration Mortaring

Cutting out Mortar Joints in Old Brickwork with an Electric Grinder. On old buildings, where it is necessary to cut out the mortar joints in the old brickwork to a depth of 1/2" and repoint them, the most efficient method is to use an electric carborundum wheel, about 5" in diameter and 1/4" thick, depending upon the width of the mortar joints. The motor is hung above the scaffolding with a flexible shaft connected to the carborundum wheel. This method is nearly twice as fast as using an ordinary electric hand saw on account of the weight of the saw, approximately 17 lbs., which is difficult and awkward to handle for workers on a swinging scaffold. Either two or four workers work from each scaffold, depending on the size of the job, and it will require one helper on the ground to each scaffold. An experienced tuckpointer or operator should grind out lime or lime-cement mortar joints in 350 to 450 sq. ft. of brick wall per 8-hr. day, at the following labor cost per 100 sq. ft.:

Grind Out Lime or Limestone Joints			
	Hours	Rate	Total
Tuck pointer	2.0	$ 78.73	$ 157.46
Labor	1.0	$ 70.91	$ 70.91
Cost per 100 Sq.Ft.			$ 228.37
Cost per Sq. Ft.			$ 2.28

Using ordinary methods, with an electric saw or grinder, a mason will cut out about 25 sq. ft. of joints per hr. at the following labor cost per 100 sq. ft.:

Using Ordinary Methods, Grind Out Lime or Limestone Joints			
	Hours	Rate	Total
Mason	4.0	$ 78.73	$ 314.92
Cost per 100 Sq.Ft.			$ 3.15
Cost per Sq. Ft.			$ 0.03

Repointing Mortar Joints in Old Brickwork. After the mortar joints have been cut out, two tuckpointers working on the scaffold, with one helper on the ground, should point 400 to 500 sq.ft. of brick wall per 8-hr. day, at the following labor cost per 100 sq. ft.:

Repoint Mortar Joints in Old Brickwork			
	Hours	Rate	Total
Tuckpointer	3.5	$ 96.70	$ 338.45
Labor	1.5	$ 65.71	$ 98.57
Cost per 100 Sq.Ft.			$ 437.02
Cost per Sq. Ft.			$ 4.37

The ordinary hanging or swinging scaffold is 25' long. The tuckpointers working from each scaffold can cover approximately 6' in height, so that each lift of the scaffold covers 150 sq. ft..

MASONRY

04 06 00 Schedules for Masonry

Masonry Specifications

In preparing a proposal from plans and specifications, the estimator will usually find masonry units specified according to the American Society for Testing and Materials (ASTM). These specifications set limitations on requirements and properties of the various materials and are generally accepted by manufacturers. ASTM specifications are available for all the following materials:

ASTM Specifications for the following Materials	
C 32*	Sewer and Manhole Brick (made from clay or shale)
C 55*	Concrete Building Brick
C 62*	Building Brick (solid masonry units made from clay or shale)
C 73*	Calcium Silicate Face Brick (sand-lime) brick
C 91*	Masonry Cement
C 105*	Ground Fire Clay or Refractory Mortar for laying up fireclay brickwork
C 126*	Ceramic Glazed Structural Clay Facing Tile, Facing Brick and Solid Masonry Units
C 144*	Aggregate for masonry mortar
C 150*	Portland Cement
C 207*	Hydrated Lime for masonry purposes
C 270*	Mortar for unit masonry
C 216*	Facing Brick (solid masonry units made from clay or shale)
C 279*	Chemical-Resistant Masonry Units
C 287*	Chemical-Resistant Sulphur Mortar
C 331*	Lightweight Aggregates for Concrete Masonry Units
C 476*	Grout for Reinforced and Nonreinforced Masonry
C 652*	Hollow Brick (hollow masonry units made from clay or shale)
C 902*	Paving Brick

**Check for latest edition*

The estimator should have a general acquaintance with all the above specifications but will deal primarily with face brick, building (formerly called common) brick, and mortar for unit masonry. Building brick is subdivided into 3 grades: SW, MW, and NW, indicating severe, medium, and negligible weathering. Face brick is subdivided into only SE and MW grades, but each of these grades has 3 types—FBX, FBS, and FBA—which set forth requirements for appearance and size. Mortar specifications cover both portland cement-lime and masonry cement mortars and are subdivided into types M, S, N, and O, based on 28 day compressive strengths of 2,500, 1,800, 750, and 350 lbs./in^2. ASTM specifications are also published for all the manufactured ingredients for the mortar. Specifications based on these ASTM designations allow the estimator to figure within well-defined limits, and the ASTM terminology should be adopted in proposals.

04 21 13 Brick Masonry

Brick walls can be separated into 3 general categories: conventional, bonded walls; drainage type walls; and barrier type walls. The drainage type walls include brick veneer, the cavity type wall, and the masonry bonded hollow wall. Drainage type walls are recommended for walls subjected to the most severe exposures. The success of this type of wall, of course, depends on the care taken to provide continuous means for water to escape. The barrier type walls include metal tied walls and reinforced brick masonry. The success of these walls will depend on a solidly filled collar joint. The BIA presently recommends using an 8” metal tied wall in preference to an 8” bonded wall for areas subjected to moderate exposure. Metal tied walls adapt well to brick and block backup. When estimating the number of brick required for any job, obtain the length, height,

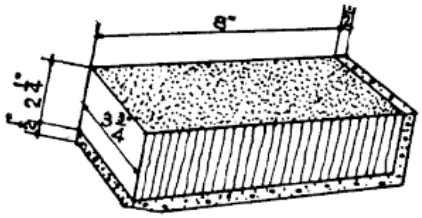
and thickness of each wall, stating the totals in cu. ft., or obtain the length and height, stating the totals in sq. ft. In present day estimating, all openings should be deducted in full, regardless of their size, because the estimate should show as accurately as possible the exact number of brick required for the job.

The old method of counting corners twice, doubling the number of brick required for pilaster, chimney breasts, etc., is not used by modern builders. Knowing actual quantities and costs is the only sure method of getting your share of work at a profit. Brick walls are usually designated on the plans as 4" or 4-1/2" 8" or 9" or 12"; 13"; 16" or 17" etc., increasing by 4" or 4-1/2" in width. This variation in thickness need not be considered by the estimator because a 4" or 4-1/2" wall is 1 brick thick; and 8" or 9" wall is 2 bricks thick; a 12" or 13" wall is 3 bricks thick; a 16" or 17" wall is 4 bricks thick, etc. The easiest method for the estimator is to mark all walls, 4", 8", 12", or 16" and then reduce the totals to cu. ft. After the number of cu. ft. has been obtained, multiply by the number of brick required per cu. ft of wall and the result will be the number of brick required for the job.

When brickwork is estimated on the above basis, it is advisable to add 1-1/2 to 2% to the total to take care of salmon brick, broken brick, bats, etc. The waste should not exceed this amount unless very poor brick or poor job handling methods are used. Years ago contractors figured their building brickwork on the basis of 7 or 7-1/2 brick per sq.ft. of 4" or 4-1/2" wall; 14 or 15 brick per sq.ft. of 8" or 9" wall; 21 or 22-1/2 brick per sq.ft. of 12" or 13" wall, etc. This method is no longer used because modern business demands that actual quantities be figured. Work is being estimated too closely today to permit a 10% to 20% overrun on the brickwork, especially when many contractors are figuring on a 5% to 10% margin of profit. After the number of cu.ft of brickwork has been obtained, it will be necessary to determine the number of brick required per cu.ft of wall. This will vary with the size of the brick and the width of the mortar joints. The standard non-modular size is 8"x2-1/4"x3-3/4". Modular brick is 8"x2-2/3"x4". Sizes will vary somewhat depending upon the burning, the brick in the center of the kiln usually being more thoroughly burned. When estimating the number of face brick required for any job, obtain the length and height of all walls to be faced with brick, and the total will be the number of sq.ft of wall. Always make deductions in full for all openings, regardless of size, because the estimate should show as accurately as possible the exact number of brick required to complete the job. When making deductions for door and window openings, always note the depth or width of the brick jambs or "reveals". If they are only 4" deep, deduct the full size of the opening as the 4" end of the brick forms the "reveal" or jamb. If the jamb is more than 4" wide, the full depth of the jamb or "reveal" should be deducted. Example: Deduct for a 5'-0"x7'-0" opening in a 12" brick wall where the face brick jamb or "reveal" returns the full thickness of the wall. It will be necessary to deduct for the 12" jamb or reveal on each side of the opening, i.e., 2 x 12" = 24" or 2'-0". Deduct this from the width of the opening, i.e., 5' - 2' = 3'. The opening deducted should be 3'-0"x7'-0" instead of 5'-0"x7'-0", as shown on the plan.

Standard Brick

A standard non-modular brick is 8" long, 2-1/4" high, and contains 18 sq. in. on the face. A standard modular brick is 8" long, 2-2/3" high, and contains 21.28 sq. in. on the face. If using a standard non-modular brick, laid dry without a mortar joint, it would require 8 brick per sq.ft. of wall: 144 ÷ 18 = 8. However, the thickness of the mortar joint must be added, and this will vary from 3/8" to 5/8", with 1/2" the average width and 3/8" the normal thickness. A brick is 8" long, plus 3/8" for the vertical or end mortar joint makes a total length of 8-3/8". A brick is 2-1/4" high, plus 3/8" for horizontal or bed mortar joint, making the total height of each brick course 2-5/8". 8-3/8" x 2-5/8" = 21.984 or 22 sq. in. on the face.



To obtain the number of brick required per s.f. of wall, divide 144 by 22 and the result is 6.54 or 6-1/2 brick per sq.ft. of 4" or 4-1/2" wall. If the wall is 8" or 9—2 brick—thick, 2 x 6-1/2 = 13 brick per sq.ft. of 8" or 9" wall. If 12" or 13"-3 brick-thick, 6-1/2 x 3 = 19.5 brick per sq.ft. of wall, etc. This same method should be used to obtain the number of brick of any size required for 1 sq.ft. of wall of any thickness.

Number of Standard Brick (8” x 2-1/4” x 3-3/4”) Required for One Square Foot of Brick Wall of any Thickness							
Vertical or End Mortar Joints Figured as 1/4” Wide							
Thickness of Wall	No. of Brick	Width of Horizontal or “Bed” Mortar Joints					
		1/8”	1/4”	3/8”	1/2”	5/8”	3/4”
4 or 4 1/2"	1	7.33	7.00	6.67	6.33	6.08	5.80
8 or 9"	2	14.67	14.00	13.33	12.67	12.17	11.60
12 or 13"*	3	22.00	21.00	20.00	19.00	18.25	17.40
16 or 17"	4	29.33	28.00	26.67	25.33	24.33	23.20
20 or 21"	5	36.67	35.00	33.33	31.67	30.42	29.00
24 or 25"	6	44.00	42.00	40.00	38.00	36.50	34.80

**Use this column for computing the number of brick required per cu.ft. of wall with any width mortar joint*

A typical calculation for determining the number of bricks is as follows:
The contractor is constructing a double wythe wall 150’ long and 12‘ tall using standard brick. The bed joint will be 3/8”. How many bricks will be required? Add 10% for waste.
150 x 12 = 1800 s.f.
1800 x 13.33 = 23,994 bricks (Because the wall is double wythe, the second column is used.)
23,994 x 1.1(10% waste) = 26,394 bricks

Variations in Face Brick Quantities. If the brick are laid in running bond without headers, the above quantities will prove sufficient, but if there is a full course of headers every 5th, 6th, or 7th course, it will be necessary to allow for the extra brick required. Also, if the brick are laid in English, Flemish, English Cross, or Dutch Bond, it will be necessary to make an allowance for extra brick where full header courses are required.

Number of Square Inches Occupied by One 8” x 2-1/4” Face Brick With Various Width Mortar Joints							
All Vertical Mortar Joints Figured 1/4” Wide Width of Horizontal or "Bed" Mortar Joint in Inches							
1/8”	1/4”	3/8”	1/2”	5/8”	3/4”	7/8”	1”
19.30	20.63	21.66	22.69	23.72	25.13	25.78	26.81

Number of 8”x 2-1/4”x 3-3/4” Face Brick Required per Sq.Ft. of Wall in Running Bond Without Headers							
All Vertical Mortar Joints Figured 1/4” Wide Width of Horizontal or "Bed" Mortar Joints in Inches							
1/8”	1/4”	3/8”	1/2”	5/8”	3/4”	7/8”	1”
7.46	7.00	6.65	6.35	6.08	5.82	5.60	5.38

The above tables do not include any allowance for waste, breakage, or header courses extending into the building brick backing to form a bond. It is based on using all stretchers or blind headers with metal wall ties. On face brick work, 3% to 5% should be added to the net quantity for waste. For face brick laid with a row of full “headers” every 5th, 6th, or 7th course, add the following percentages to the above quantities:

Percentage to be Added for Various Brick Bonds	
Common (full header course every 5th course)	20% or 1/8
Common (full header course every 6th course)	16.66% or 1/8
Common (full header course every 7th course)	14.33% or 1/7
English or English Cross* (full headers every other course)	50% or 1/2
English or English Cross* (full headers every 6th course)	16.66% or 1/6
Dutch or Dutch Cross* (full headers every other course)	50% or 1/2
Dutch or Dutch Cross* (full headers every 6th course)	16.66% or 1/6
Flemish (full headers every course)	33.33% or 1/3
Flemish (full headers every 6th course)	5.6% or 1/18
Double Header (two headers and a stretcher every 6th course)	8.33% or 1/12
Double Header (two headers and a stretcher every 5th course)	10% or 1/10
Double Flemish (full headers every other course)	10% or 1/10

**Add 10% to 15% extra brick for waste in cutting, unless a masonry saw is used.*

Percentages To Be Added for Various Brick Bonds	
Double Flemish (full headers every 3rd course)	6.33% or 1/15
3 Stretcher Flemish (full headers every other course)	7.14% or 1/14
3 Stretcher Flemish (full headers every 3rd course)	4.8% or 1/21
4 Stretcher Flemish (full headers every other course)	5.6% or 1/18
4 Stretcher Flemish (full headers every 3rd course)	3.7% or 1/27

For garden walls, porch walls, and other places where an 8” wall is used, with face brick on both sides of the wall, no additional brick are required for any type of bond. For walks and floors with the brick laid on edge, in any pattern except diagonal, calculate as you would for face brick in common bond without headers. For herringbone or other diagonal work, additional brick will be required because of the waste in chipping or cutting the brick for the borders. The additional number of brick will vary with the width of the walk or floor, as the wider the surface, the smaller the average waste per sq. ft.. Walks and floors having the brick laid flat require one-third less brick than where they are laid on edge.

Coursing Tables

The following tables contain vertical coursing dimensions for both non-modular and modular brick. For the non-modular brick, vertical coursing dimensions are shown for both 3/8” and 1/2” mortar joints. In both tables the bricks are assumed to be positioned in the wall as stretchers.

Vertical Coursing Table for Non-modular Brick*						
No. of Courses	2 1/4" high		2 5/8" high		2 3/4" high	
	Size of Joint					
	3/8" Joint	1/2" Joint	3/8" Joint	1/2" Joint	3/8" Joint	1/2" Joint
1	0' - 2 5/8"	0' - 2 3/4"	0' - 3"	0' - 3 1/8"	0' - 3 1/8"	0' - 3 1/4"
2	0' - 5 1/4"	0' - 5 1/2"	0' - 6"	0' - 6 1/4"	0' - 6 1/4"	0' - 6 1/2"
3	0' - 7 7/8"	0' - 8 1/4"	0' - 9"	0' - 9 3/8"	0' - 9 3/8"	0' - 9 3/4"
4	0' - 10 1/2"	0' - 11"	1' - 0"	1' - 1/2"	1' - 1/2"	1' - 1"
5	1' - 1 1/8"	1' - 1 3/4"	1' - 3"	1' - 3 5/8"	1' - 3 5/8"	1' - 4 1/4"
6	1' - 3 3/4"	1' - 4 1/2"	1' - 6"	1' - 6 3/4"	1' - 6 3/4"	1' - 7 1/2"
7	1' - 6 3/8"	1' - 7 1/4"	1' - 9"	1' - 9 7/8"	1' - 9 7/8"	1' - 10 3/4"
8	1' - 9"	1' - 10"	2' - 0"	2' - 1"	2' - 1"	2' - 2"
9	1' - 11 5/8"	2' - 3/4"	2' - 3"	2' - 4 1/8"	2' - 4 1/8"	2' - 5 1/4"
10	2' - 2 1/4"	2' - 3 1/2"	2' - 6"	2' - 7 1/4"	2' - 7 1/4"	2' - 8 1/2"
11	2' - 4 7/8"	2' - 6 1/4"	2' - 9"	2' - 10 3/8"	2' - 10 3/8"	2' - 11 3/4"
12	2' - 7 1/2"	2' - 9"	3' - 0"	3' - 1 1/2"	3' - 1 1/2"	3' - 3"
13	2' - 10 1/8"	2' - 11 3/4"	3' - 3"	3' - 4 5/8"	3' - 4 5/8"	3' - 6 1/4"
14	3' - 3/4"	3' - 2 1/2"	3' - 6"	3' - 7 3/4"	3' - 7 3/4"	3' - 9 1/2"
15	3' - 3 3/8"	3' - 5 1/4"	3' - 9"	3' - 10 7/8"	3' - 10 7/8"	4' - 3/4"
16	3' - 6"	3' - 8"	4' - 0"	4' - 2"	4' - 2"	4' - 4"
17	3' - 8 5/8"	3' - 10 3/4"	4' - 3"	4' - 5 1/8"	4' - 5 1/8"	4' - 7 1/4"
18	3' - 11 1/4"	4' - 1 1/2"	4' - 6"	4' - 8 1/4"	4' - 8 1/4"	4' - 10 1/2"
19	4' - 1 7/8"	4' - 4 1/4"	4' - 9"	4' - 11 3/8"	4' - 11 3/8"	5' - 1 3/4"
20	4' - 4 1/2"	4' - 7"	5' - 0"	5' - 2 1/2"	5' - 2 1/2"	5' - 5"
21	4' - 7 1/8"	4' - 9 3/4"	5' - 3"	5' - 5 5/8"	5' - 5 5/8"	5' - 8 1/4"
22	4' - 9 3/4"	5' - 1/2"	5' - 6"	5' - 8 3/4"	5' - 8 3/4"	5' - 11 1/2"
23	5' - 3/8"	5' - 3 1/4"	5' - 9"	5' - 11 7/8"	5' - 11 7/8"	6' - 2 3/4"
24	5' - 3"	5' - 6"	6' - 0"	6' - 3"	6' - 3"	6' - 6"
25	5' - 5 5/8"	5' - 8 3/4"	6' - 3"	6' - 6 1/8"	6' - 6 1/8"	6' - 9 1/4"
26	5' - 8 1/4"	5' - 11 1/2"	6' - 6"	6' - 9 1/4"	6' - 9 1/4"	7' - 1/2"
27	5' - 10 7/8"	6' - 2 1/4"	6' - 9"	7' - 3/8"	7' - 3/8"	7' - 3 3/4"
28	6' - 1 1/2"	6' - 5"	7' - 0"	7' - 3 1/2"	7' - 3 1/2"	7' - 7"
29	6' - 4 1/8"	6' - 7 3/4"	7' - 3"	7' - 6 5/8"	7' - 6 5/8"	7' - 11 1/4"
30	6' - 6 3/4"	6' - 10 1/2"	7' - 6"	7' - 9 3/4"	7' - 9 3/4"	8' - 1 1/2"
31	6' - 9 3/8"	7' - 1 1/4"	7' - 9"	8' - 7/8"	8' - 7/8"	8' - 4 3/4"
32	7' - 0"	7' - 4"	8' - 0"	8' - 4"	8' - 4"	8' - 8"
33	7' - 2 5/8"	7' - 6 3/4"	8' - 3"	8' - 7 1/8"	8' - 7 1/8"	8' - 11 1/4"
34	7' - 5 1/4"	7' - 9 1/2"	8' - 6"	8' - 10 1/4"	8' - 10 1/4"	9' - 2 1/2"
35	7' - 7 7/8"	8' - 1/4"	8' - 9"	9' - 1 3/8"	9' - 1 3/8"	9' - 5 3/4"
36	7' - 10 1/2"	8' - 3"	9' - 0"	9' - 4 1/2"	9' - 4 1/2"	9' - 9"
37	8' - 1 1/8"	8' - 5 3/4"	9' - 3"	9' - 7 5/8"	9' - 7 5/8"	10' - 1/4"
38	8' - 3 3/4"	8' - 8 1/2"	9' - 6"	9' - 10 3/4"	9' - 10 3/4"	10' - 3 1/2"
39	8' - 6 3/8"	8' - 11 1/4"	9' - 9"	10' - 1 7/8"	10' - 1 7/8"	10' - 6 3/4"
40	8' - 9"	9' - 2"	10' - 0"	10' - 5"	10' - 5"	10' - 10"
41	8' - 11 5/8"	9' - 4 3/4"	10' - 3"	10' - 8 1/8"	10' - 8 1/8"	11' - 1 1/4"
42	9' - 2 1/4"	9' - 7 1/2"	10' - 6"	10' - 11 1/4"	10' - 11 1/4"	11' - 4 1/2"
43	9' - 4 7/8"	9' - 10 1/4"	10' - 9"	11' - 2 3/8"	11' - 2 3/8"	11' - 7 3/4"
44	9' - 7 1/2"	10' - 1"	11' - 0"	11' - 5 1/2"	11' - 5 1/2"	11' - 11"
45	9' - 10 1/8"	10' - 3 3/4"	11' - 3"	11' - 8 5/8"	11' - 8 5/8"	12' - 2 1/4"
46	10' - 3/4"	10' - 6 1/2"	11' - 6"	11' - 11 3/4"	11' - 11 3/4"	12' - 5 1/2"
47	10' - 3 3/8"	10' - 9 1/4"	11' - 9"	12' - 2 7/8"	12' - 2 7/8"	12' - 8 3/4"
48	10' - 6"	11' - 0"	12' - 0"	12' - 6"	12' - 6"	13' - 0"
49	10' - 8 5/8"	11' - 2 3/4"	12' - 3"	12' - 9 1/8"	12' - 9 1/8"	13' - 3 1/4"
50	10' - 11 1/4	11' - 5 1/2"	12' - 6"	13' - 1/4"	13' - 1/4"	13' - 6 1/2"
100	21' - 10 1/2	22' - 11"	25' - 0"	26' - 1/2"	26' - 1/2"	27' - 1"

** Brick positioned in wall as stretchers. Vertical dimensions are from bottom of mortar joint to bottom of mortar joint. (Courtesy of Brick Institute of America)*

Brick Dimensions and Nomenclature

The sizes of brick units shown and discussed below are typical of those currently being produced. However, few manufacturers produce all sizes shown and different manufacturers will vary. It is recommended that the designer consult manufacturers or distributors before proceeding with a design incorporating a specific size of brick that may not be readily available in the particular locality. The nomenclature indicated, while typical, is not completely standard throughout the industry. Except for the Standard, Roman, and Norman sizes, individual manufacturers may have their own names for certain sizes listed. It is suggested that in order to avoid confusion, the purchaser or specifier first identify the brick by size. Except for the non-modular Standard, Oversize, and 3-in. units, most bricks are produced in modular sizes. The nominal dimensions of modular brick are equal to the manufactured dimensions plus the thickness of the mortar joint for which the unit is designed. In general, the joint thicknesses used with brick are either 3/8” or 1/2”. The actual manufactured dimensions of the units may vary from the specified dimensions by not more than the permissible tolerances for variation in dimensions as prescribed in the applicable ASTM specifications (Standard Specification for Facing Brick, ASTM Designation C 216; Standard Specifications for Building Brick, ASTM Designation C 62; Standard Specifications for Hollow Brick, ASTM Designation C 652). It should be noted that the designated manufacturers heights for the standard brick, the standard modular brick, and all other modular brick designed to be laid 3 courses to 8” are the same—2-1/4”. There is a very practical reason for this. In 1946-47, with the adoption of modular coordination by the structural clay products industry, brick manufacturers who converted their production completely to modular sizes were faced with a problem in connection with supplying matching brick for additions to existing non-modular buildings. From the standpoint of appearance, most designers required that the vertical coursing in the addition built with modular brick match those in the existing building constructed with non-modular brick. It was agreed that the manufactured face height of the standard modular brick would remain at 2-1/4”, even though the other dimensions, length and thickness, would become modular. Since that time, the custom has continued. The differences in mortar bed thickness required to maintain the modular coursing of 3 courses in 8” were considered minimal.

Size of Modular Brick in Inches *			
Unit Designation	**Nominal Dimensions, Inches**	**Joint Size, Inches**	**Manufacturer Dimensions, Inches**
	t x h x l		t x h x l
Modular	4 x 2 2/3 x 8	3/8	3 5/8 x 2 1/4 x 7 5/8
		1/2	3 1/2 x 2 1/4 x 7 1/2
Engineer, Modular	4 x 3 1/5 x 8	3/8	3 5/8 x 2 13/16 x 7 5/8
		1/2	3 1/2 x 2 11/16 x 7 1/2
Closure Modular	4 x 4 x 8	3/8	3 5/8 x 3 5/8 x 7 5/8
		1/2	3 1/2 x 3 1/2 x 7 1/2
Roman	4 x 2 x 12	3/8	3 5/8 x 1 5/8 x 11 5/8
		1/2	3 1/2 x 1 1/2 x 11 1/2
Norman	4 x 2 2/3 x 13	3/8	3 5/8 x 2 1/4 x 11 5/8
		1/2	3 1/2 x 2 1/4 x 11 1/2
Engineer Norman	4 x 3 1/5 x 12	3/8	3 5/8 x 2 3/4 x 11 5/8
		1/2	3 1/2 x 2 11/16 x 11 1/2
Utility	4 x 4 x 12	3/8	3 5/8 x 3 5/8 x 11 5/8
		1/2	3 1/2 x 3 1/2 x 11 1/2
Triple	4 x 6 x 8	3/8	3 5/8 x 5 5/8 x 7 5/8
		1/2	3 1/2 x 5 1/2 x 7 1/2
Jumbo Utility	4 x 8 x 8	3/8	3 5/8 x 7 5/8 x 7 5/8
		1/2	3 1/2 x 7 1/2 x 7 1/2
6-inch Norwegian	6 x 3 1/5 x 12	3/8	5 5/8 x 2 13/16 x 11 5/8
		1/2	5 1/2 x 2 11/16 x 11 1/2
6-Inch Jumbo	6 x 4 x 12	3/8	5 5/8 x 3 5/8 x 11 5/8
		1/2	5 1/2 x 3 1/2 x 11 1/2
8-Inch Jumbo	8 x 4 x 12	3/8	7 5/8 x 3 1/2 x 11 1/2
		1/2	7 1/2 x 3 1/2 x 11 1/2
8-Inch	8 x 4 x 8	3/8	7 5/8 x 3 5/8 x 7 5/8
15-Inch	4 x 4 x 16	3/8	3 5/8 x 3 5/8 x 15 5/8

** Available as solid units conforming to the latest ASTM requirements, or in a number of cases as hollow brick conforming to the ASTM Specifications for hollow brick.*

Size of Non-Modular Brick			
Unit Designation	Manufacture Size, Inches		
	Thickness (In)	Height (In)	Length (In)
Three-Inch (king Size)	3	2 3/4	9 5/8
Three-Inch (Queen Size)	3	2 3/4	8
Three-Inch	3	2 3/4	8 5/8
Standard *	3 5/8	2 1/4	8
Engineered Standard	3 5/8	2 13/16	8
Closure Standard	3 5/8	3 1/2	8

In recent years, the so called "three-inch" brick has gained popularity. The term three-inch designates its thickness or bed depth. The size shown in the table are the ones most commonly produced.

** The manufactured thickness of standard or oversized non-modular brick will vary from 3 1/2 to 3 3/4 inch. If other then a running bond is desired, the designer should check with the manufacture of the brick selected.*

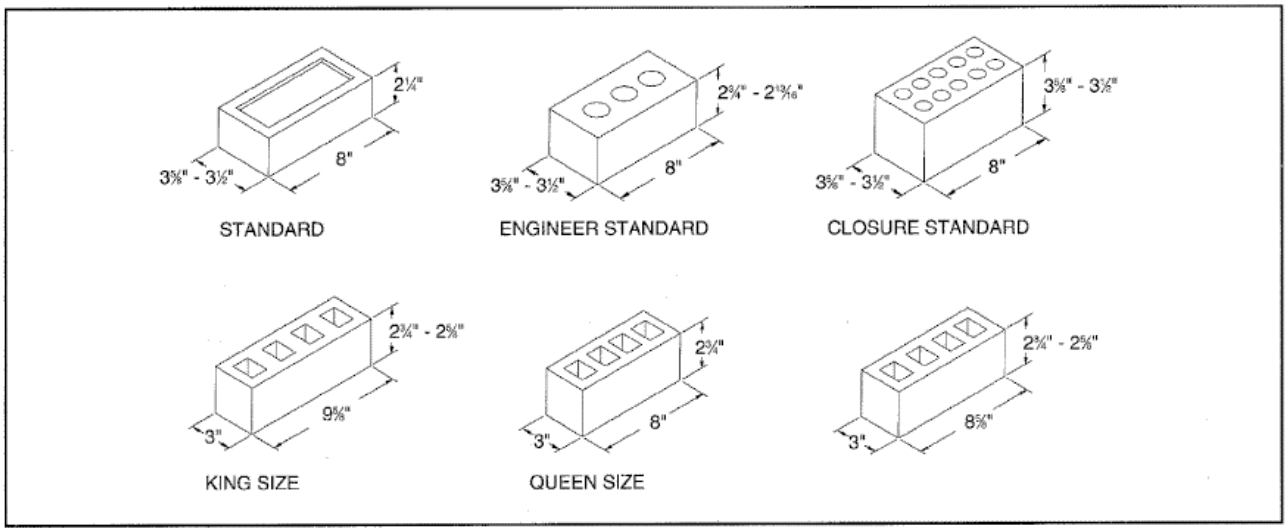
Nominal Modular Sizes of Brick*				
Designation	Thickness, Inches	Face Height, Inches	Dimensions Length, Inches	# Unit Courses in 16 Inches
Standard	4	2 2/3	8	6
Engineer	4	3 1/5	8	5
Economy 8 or Jumbo Closure	4	4	8	4
Double	4	5 1/3	8	3
Roman	4	2	12	8
Norman	4	2 2/3	12	6
Norwegian	4	3 1/5	12	5
Economy 12 or Jumbo Utility	4	4	12	4
Triple	4	5 1/3	12	3
6-in. Norwegian	6	3 1/5	12	5
6-in. Jumbo	6	4	12	4
8-in. Jumbo	8	4	12	4

**Available as solid units conforming to latest ASTM, or in some cases, as hollow brick conforming to ASTM Specifications.*

Position of Brick in the Wall. Most brick are laid as stretchers so that the longer of the face dimensions is horizontal. The drawings below also illustrate terms applied to other brick positions as placed in the wall. The shaded areas indicate the surfaces of the brick that are exposed.

Brick Bonds and Patterns

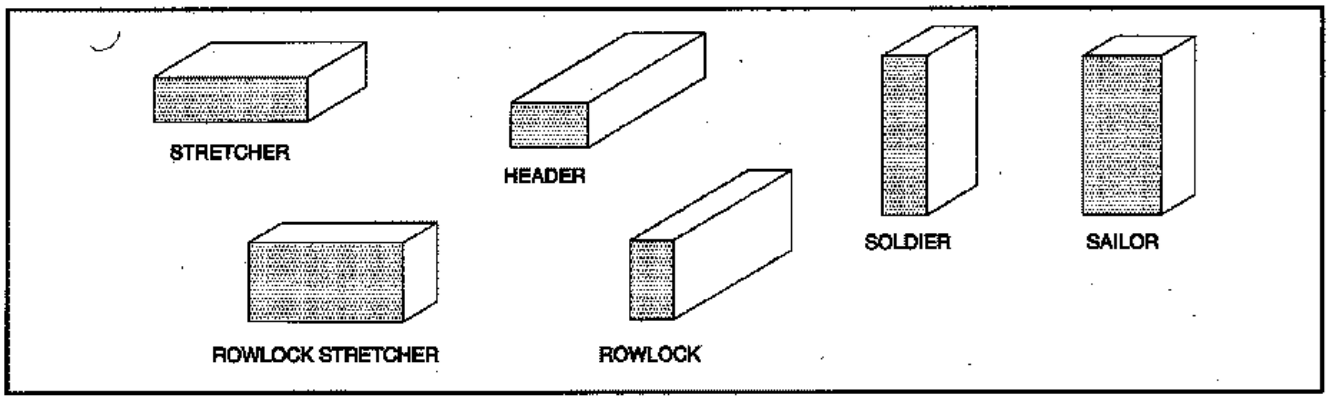
Bond in brickwork is the overlapping of one brick upon the other, either along the length of the wall or through its thickness, in order to bind them together into a secure structural mass. Units are shifted back and forth so that the vertical joints in two successive layers or “courses” do not come into line; in other words, the brick are laid so as to break the joint, the whole forming a natural bond or a structural unit giving strength to the wall.



Non-Modular Brick Sizes
(Specified Dimensions)

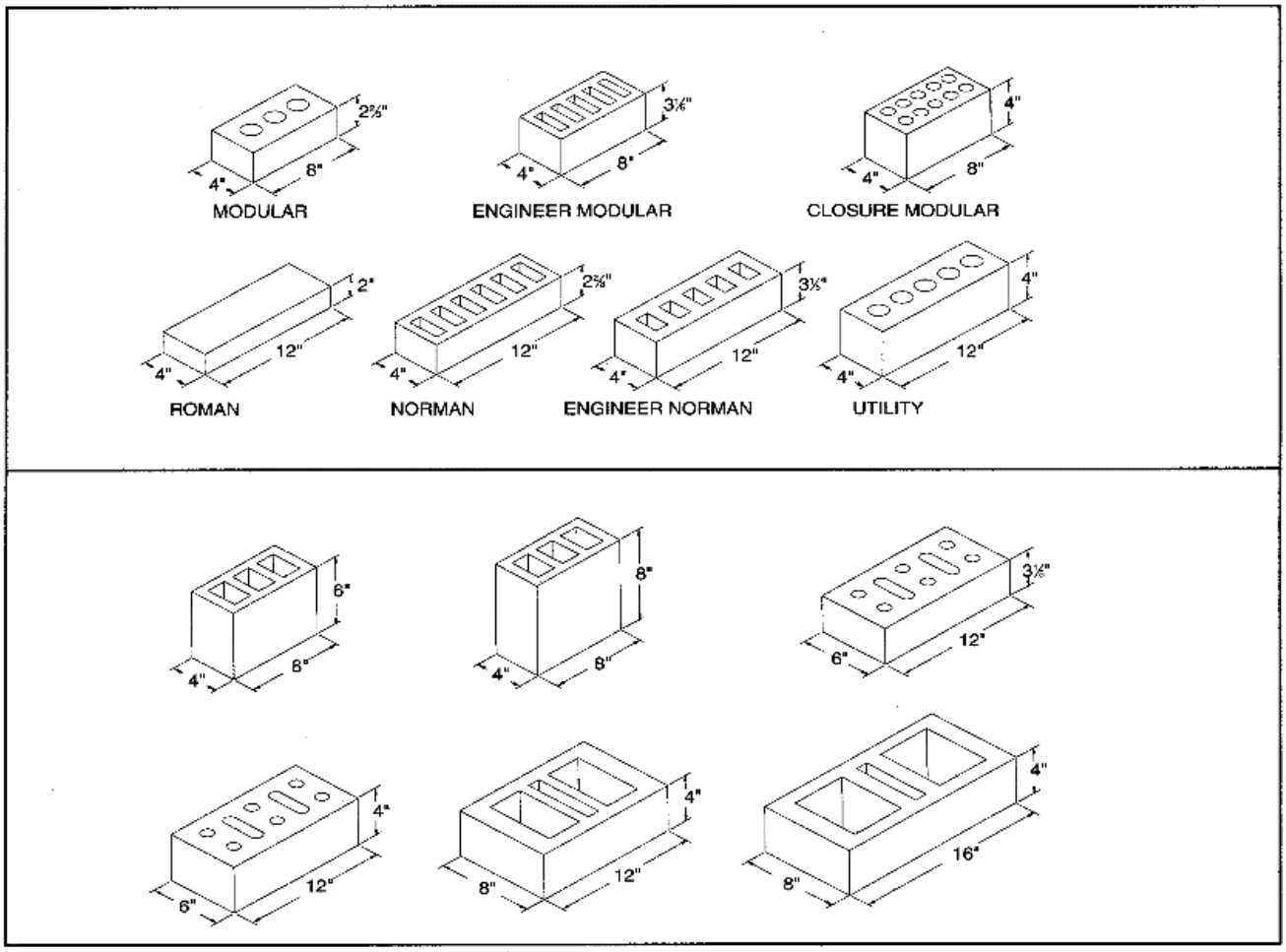
Bond. The word bond, when used in reference to masonry, has three meanings:

1. *Structural Bond:* The method by which individual masonry units are interlocked or tied together to cause the entire assembly to act as a single structural unit.
2. *Pattern Bond:* The pattern formed by the masonry units and the mortar joints on the face of a wall. The pattern may result from the type of structural bond used or may be purely a decorative one, unrelated to the structural bonding.
3. *Mortar Bond:* The adhesion of mortar to the masonry units or to reinforcing steel.

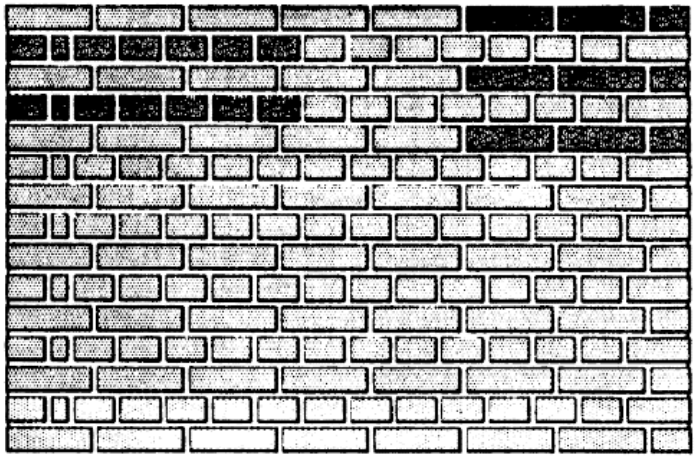


Brick Positions in Wall

Structural Bonds. Structural bonding of masonry walls may be accomplished in three ways: by the overlapping (interlocking) of masonry units, by use of metal ties embedded in connecting joints, and by the adhesion of grout to adjacent wythes of masonry. The overlapped bond is based on variations of two traditional methods of bonding. The first is known as English bond and consists of alternating courses of headers and stretchers (Figure 1). The second is Flemish bond and consists of alternating headers and stretchers in every course, so arranged that the headers and stretchers in every other course appear in vertical lines (Figure 1).



Modular Brick (Nominal Dimensions)


ENGLISH CORNER
DUTCH CORNER
ENGLISH BOND

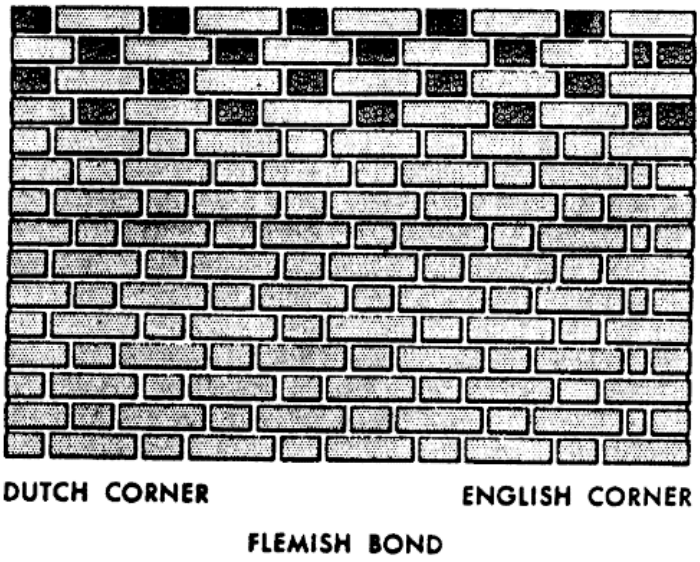

DUTCH CORNER
ENGLISH CORNER
FLEMISH BOND

Figure 1

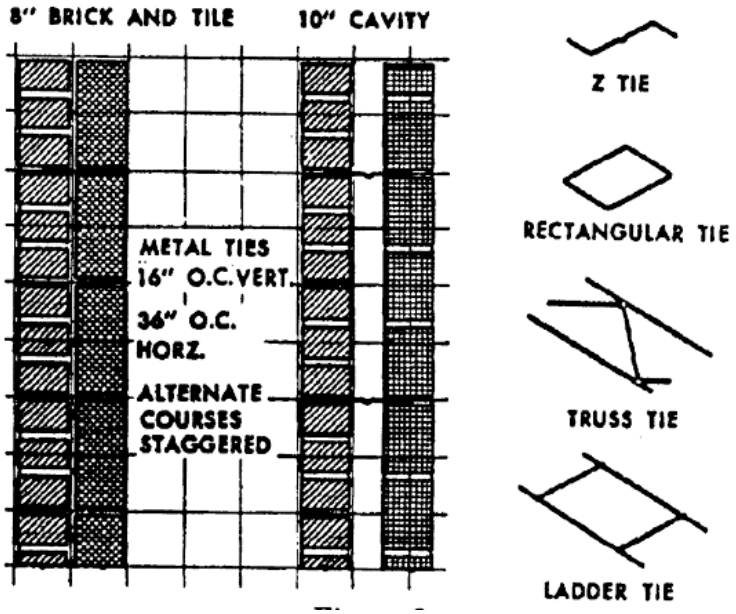


Figure 2

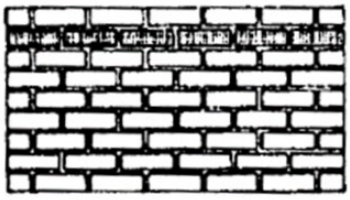


Figure 3

The stretchers, laid with the length of the wall, develop longitudinal bonding strength, while the headers, laid across the width of the wall, bond the wall transversely. Modern building codes require that masonry-bonded brick walls be bonded so that not less than 4% of the wall surface is composed of headers, with the distance between adjacent headers not exceeding 24", vertically or horizontally. Structural bonding of masonry walls with metal ties is used in both solid wall and cavity wall construction (Figure 2). Most building codes permit the use of rigid steel bonding ties in solid walls. At least one metal tie should be used for each 4-1/2 sq.ft. of wall surface. Ties in alternate courses should be staggered. The distance between adjacent ties should not exceed 24" vertically and 36" horizontally. Additional bonding ties, spaced not more than 3' apart around the perimeter and within 12" of the opening, should be provided at all openings. If ties less than 3/16" in diameter are used, tie spacing should be reduced so that the tie area per sq.ft. of wall is not less than specified above. Structural bonding of solid and reinforced brick masonry walls is sometimes accomplished by grout, which is poured into the cavity or collar joint between wythes of masonry.

The method of bonding will depend on the use requirements, wall type and other factors. However, the metal tie method is generally recommended for exterior walls. Some of the advantages of this method are greater resistance to rain penetration and ease of construction. Metal ties also allow slight differential movements of the facing and backing, which may relieve stresses and prevent cracking.

Pattern Bonds. Frequently, structural bonds, such as English or Flemish, or variations of these, may be used to create patterns in the face of a wall. However, in the strictest sense of the term, pattern refers to the change or varied arrangement of the brick texture or color used in the face. Therefore, it may be possible to secure many patterns using the same structural bond. Patterns also may be produced by the method of handling the mortar joint or by projecting or recessing certain brick from the plane of the wall, thus creating a distinctive wall texture that is not solely dependent on the texture of the individual brick. There are five basic structural bonds, which create typical patterns, commonly used today. These are running bond,

common or American bond, Flemish bond, English bond, and block or stack bond. Through the use of these bonds and variations of the color and texture of the brick, and of the joint types and color, an unlimited number of patterns can be developed.

Running Bond. The simplest of the basic pattern bonds, the running bond, consists of all stretchers. Because there are no headers in this bond, metal ties are ordinarily used. Running bond is used largely in cavity wall construction and veneered walls of brick, and often in facing tile walls where the bonding may be accomplished by extra width stretcher tile.

Common or American Bond. Common or American bond (Figure 4) is a variation of running bond with a course of full length headers at regular intervals. This bond is obtained by laying a course of headers every fifth, sixth, or seventh course. To maintain the effect of the running bond, a special double header bond is sometimes used. This method of using headers, as in Common or American Bond, in order to secure transverse strength of wall, can be treated in a way to produce more pleasing effects, as may be seen in Flemish or English Bonds.

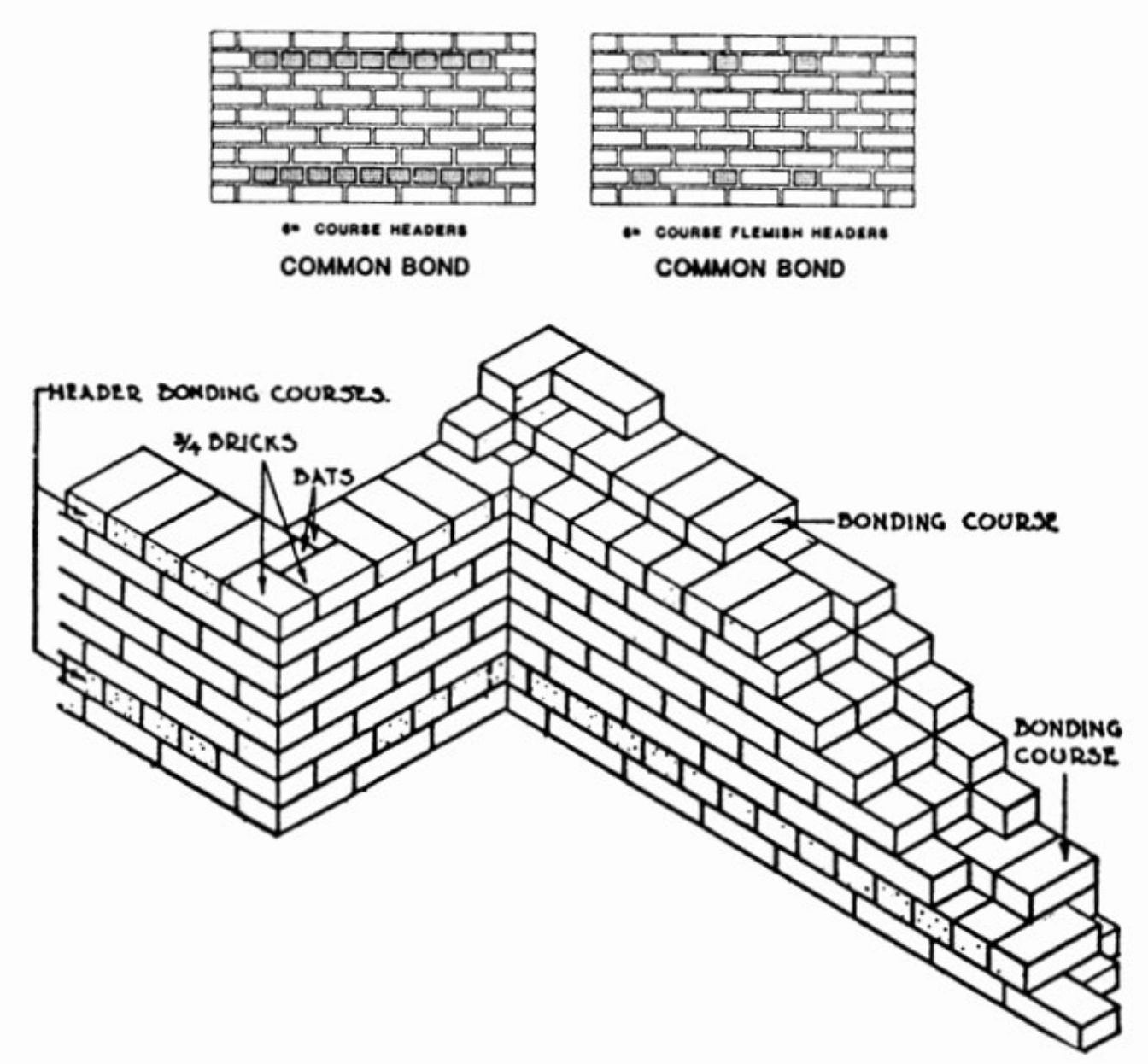
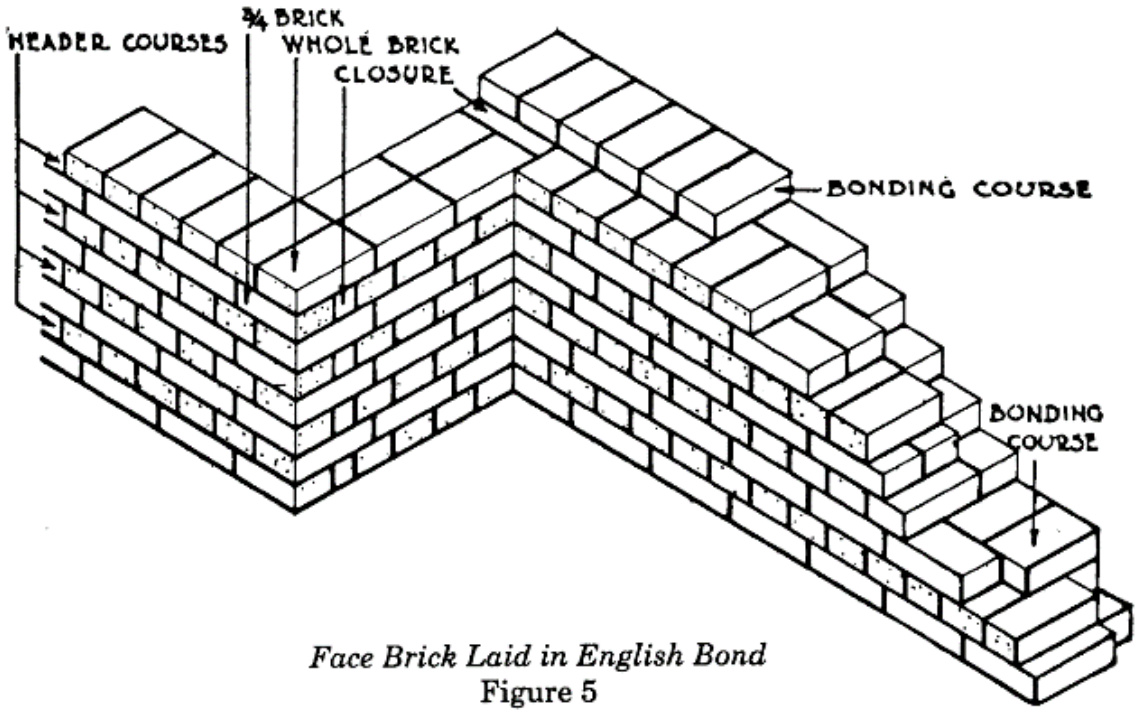


Figure 4 –Face Brick Laid in Common or American Bond

English Bond. English Bond (Figure 5) is made up of alternating courses of stretchers and headers. Ordinarily half brick are used for the header courses, except that every sixth course a full header course is used to tie the face and common brick walls together. The allowance for headers was given previously, under *Percentages to be Added for Various Brick Bonds*. Snap headers are used in courses that are not structural bonding courses.



Face Brick Laid in English Bond
Figure 5

Dutch Bond or English Cross Bond. Dutch or English Cross Bond (Figure 6) is similar to English Bond, except starting courses differ. Each course starts off with 1/4, 1/2, or 3/4 of a brick, alternating as shown in the illustration, and each successive course consists of stretchers and headers.