

4.1.3. Planning the cost

Types of costs

Analytical estimating involves detailed measurements of project works, evaluation of resources required to perform those works and resource cost assessment. Instead of using pre-established rates as above, analytical estimating aims at computing actual costs for each construction work. This can only be done in the scope of a given production organisation which means that analytical estimating is specific of construction companies.

A key aspect of analytical estimating is thus costing. Construction costs are usually divided into two main classes: direct costs and indirect costs. Direct costs are those related to actual production works on the construction site. They include costs of labour and plant directly involved in performing those works, costs of materials needed for production and provisions for subcontracts. Costs of this nature are, at least in theory, easy to identify and to assess.

Indirect costs, on the contrary, cannot be allocated to individual units of work because they represent costs of a more general nature. However, they count towards all production units and must be allowed for within the overall costs of production. Furthermore, indirect costs are much less precise in terms of their assessment and they are often difficult to allocate to individual projects. Indirect cost items include preliminary costs or site on-costs, the contractor's general overheads (head office charges) and expenditure costs incurred away from the project. Many of these cost items can therefore only be allocated to the projects on some form of rough proportion basis or by means of a calculated percentage. Figure 1 below shows the usual cost structure of construction projects.

Direct costs	Construction costs	Net costs	Tender price
Site overheads			
General overheads			
Profit and risk			

Labour costs

The costs of labour should include all items associated with employment, such as national insurance, sick pay, bonus and productivity schemes, holiday pay, severance payments,

professional training, etc. All payments required by National Working Agreements should also be considered in the costs of labour. Accordingly, labour costs usually considered by contractors for estimation purposes are all-in labour rates.

Due to the large amount of legal labour charges, actual costs to construction companies of employing labour are presently more than twice the cost of the basic rates of pay. This will vary between the conditions applied by individual contractors, relevant legislation and the availability of labour.

Table 1 illustrates a typical all-in rate calculation for Portugal. Figures presented may be different among European countries but the calculation logic is the same. Contractors need to adapt calculations to the geographical area where they intend to work, to national rules governing wages, to employer's liability insurance taxes, etc. Some possible differences as are follows:

- The number of hours worked each week may vary;
- The allowance for bad weather depends on the geographical area of work and on the exposition of the work to be carried out;
- Wages obviously vary considerably among countries and among regions within each country;
- Attraction bonuses may be required to capture good craftsmen;
- Extra payments for special skills may be compulsory in some countries;
- The performance of economy may determine substantial changes on wages and on attraction bonuses.

Table 1: Calculation of all-in rates for construction labour.

Description	Entry Column	Calculation column	Hourly rate (€)
Working time			
Total working hours	52 x 40	2 080	
Public holidays	14 x 5,71	- 80	
Annual holidays	22 x 8,00	- 176	
Sickness	14 x 8,00	- 112	
Absence	2 x 8,00	- 16	
Bad weather	6 x 8,00	- 48	
Bank holiday	1 x 5,71	- 6	
Total productive hours		1 642	
Overheads			
National Insurance + Employer Liability & Third Party Insurance + Health & Safety + Training levy	41,35		
Annual holidays	22 x 8,00	x 14,18%	
	1,3235		
Holiday payment	30 x 5,71	x 13,82%	
	1,3235		
Christmas payment	30 x 5,71	x 13,82%	
	1,3235		
Public holidays	14 x 5,71	x 6,45%	
	1,3235		
Bank holiday	1 x 5,71	x 0,46%	
	1,3235		
Sickness	14 x 8,00	x 9,03%	
	1,3235		
Bad weather	6 x 8,00	x 3,87%	
	1,3235		
Compensations for unemployment		14,00%	
Meals		20,00%	
Tools		5,00%	
Total overheads		141,98%	
Workers			
Plant operator, skilled worker (€470,00 /month)	470,00 x 12 / 2080	€2,72	€6,56
Labourer (€368,00 /month)	368,00 x 12 / 2080	€2,12	€5,14

Labour costs are relevant both for direct and indirect cost assessment. Labour pertaining to direct costs includes all trades directly involved in the construction works on site, like craftsmen, gangers, labourers, tool operators and so on. However, there are some advantages of including the labour cost of some plant operators in the hourly rate of such equipments (for example, the tower crane operator). This may be useful for cost comparison with hired

equipment which often comes with operator. Site staff costs are seldom included in direct costs but are recovered as either head office overheads or as a lump sum within the site on-costs. All head office labour is included in indirect costs as mentioned above.

Material costs

The costs of materials include their net costs delivered to the site or to the contractor's workshops. Added to this are the costs of storage and a wastage factor covering the difference between the quantities of materials purchased and those eventually integrated in construction products paid for by the client. Moreover, measured quantities are usually net - exclusive of any bulking or shrinkage factors. Some allowances have also to be made for buying margins, where, for example, the price allowed for at the time of tender is different from the price actually paid for the materials when delivered to the site. Vandalism, materials deterioration and misuse of materials will also need consideration and possibly allowed for under this heading.

The allocation of the costs of materials by cost types depends on the expected use of such materials. For example, materials to be incorporated in ordinary construction works are included in direct costs; materials to be used in preliminary works (for example, site limitation works) are included under this heading; materials required for any work not directly related to site production are obviously allocated to some class of indirect costs.

Plant costs

Plant can be classified as non-mechanical, mechanical or small tools. The cost of small tools for exclusive use of craftsmen is sometimes added as a percentage of their salary rate. Other small tools are normally included as a site on-cost although they it can also be viewed as a general overhead expense.

Large items of plant, such as tower cranes, may be charged for as preliminary costs or, where they are directly related to a specific item of work, as in the case of earth moving, they can be included in full in corresponding direct costs.

The cost of mechanical plant may be evaluated as the sum of ownership costs, maintenance costs and operating costs, e.g.:

$$T_c = OW_c + MA_c + OP_c$$

Ownership costs include purchase cost, depreciation, interest charges and taxation, management costs, insurances and so on. Maintenance costs relate to keeping the machine in

good condition for operation. Operation costs include consumable costs (like fuel, oil, etc.) and operator wages. Construction companies compute hourly or daily machine rates by adding up all possible costs related to the machine and by making some assumptions on its use. For example, the yearly costs of repair depend on how much the machine is used whereas insurance taxes are rather independent from it. Therefore, an assumption of expected the number of working hours of the machine has to be made prior to establishing the hourly rate. Table below shows an example of calculation of the hourly rate of a machine. Ownership costs are calculated using the average annual investment depreciation method.

Description	Entry Column	Calculation column	Hourly rate (€)
Purchasing value	€85 000,00		
Time of depreciation	10 years		
Sunk value	€8 500,00		
Interest rate	8%		
Working time			
Total working hours	52 x 40	2 080	
Public holidays	14 x 5,71	- 80	
Stoppage	10 x 8,00	- 80	
Bad weather	6 x 8,00	- 48	
Bank holiday	1 x 5,71	- 6	
Productive activity	80%		
Total productive hours		1 500	
Ownership costs			
Annual depreciation	76 500/10	€7 650,00	
Average annual investment	€4 207,50		
Annual interests	(8,00%)	€336,60	
Management Costs	(2,00%)	€84,15	
Insurance costs	(1,50%)	€63,11	
Total OW_c		€8 133,86	€5,42
Maintenance costs			
Annual maintenance	8% x 85 000,00		
Total MA_c		€6 800	€4,53
Operation costs			
Hourly consumptions		€18,00	
Operator	1,3 x €6,56	€8,53	
Total OP_c			€26,53
Total costs			€36,48

Medium to large contractors tend to hire the plant from either a separate plant hire firm or through one of their own subsidiary plant companies. Smaller companies often hire plant from specialist companies, unless they foresee a large plant utilisation in which case they may

consider purchasing it. Actually, locking large amounts of capital in plant may not be a good idea if it can be better used elsewhere.

Subcontractor costs

Outsourcing has become a norm in the industry with main construction companies using relatively little directly employed labour. This is because although they may give up some profit, they find many benefits in employing subcontractors to carry out the work on their behalf - fewer staff means lower fixed costs, more flexibility, smaller financial risks, etc. Moreover, the contractor does not need any general outlay of cash in order to finance the subcontracted work. Subcontracting nowadays covers a wide range of construction works. Most of them directly relate to production on site (for example, a subcontract for brickwork) but they may also refer to other works (for example, health and safety on site). Accordingly, subcontract costs may be direct costs or indirect costs (site on costs for the example of health and safety).

The costs of subcontracts include their net costs plus the expenses related to the utilisation of the site facilities by their staff and an allowance for management and supervision.

Preliminary costs

Construction regulations in most European countries allow contractors to price project overheads on a specific bill of preliminaries. Preliminary costs are diverse and vary considerably among projects but it is convenient to use a comprehensive set of cost headings as a checklist of costs incurred in a specific project. Figure below presents such a checklist provided by the Code of Estimating Practice (COEP) of the Chartered Institute of Building (CIOB) of the UK.

Employer's requirements	Accommodation Furniture Telephone Equipment Transport Attendance
Management and staff	Site manager General Foreman Engineer Planning Engineer Foreman Ass. Engineer Clerk / Typist Security/Watchman

Mechanical Plant	Crane and driver Hoist Dumper Forklift Tractor and trailer Mixer Concrete finishing Compressor and tools Pumps Fuel and transport for plant
Temporary Works	Access routes Hardstandings Traffic control De-watering

Facilities and Services	Power / lighting / heating Water Telephones Stationary and postage Office equipment Computers Humidity and temperature Security and safety measures Temporary electrics Waste skips
Site Accommodation	Offices Stores Canteen/welfare Toilets Drying and first aid Foundations and drainage Rates and charges Erection and fitting out Furniture Removal Transport
Attendant Labour	Unloading and distribution Cleaning Setting-out assistants Drivers and pump attendance General attendance Scaffold adaptation

	Hoarding Fencing Notice board Shoring & Centring Temporary structures Protection
Non-mechanical Plant	External scaffolding Internal scaffolding Hoist towers Mobile towers Small tools and equipment Surveying instruments
Contract Conditions	Fluctuations Insurances Bonds Warranties Special conditions Professional fees
Miscellaneous	Setting out consumables Testing and samples Winter working Quality assurance Site limitations Protective clothing

Overheads

These items represent the costs associated with managing a company or of facilitating the construction project. They include the costs of maintaining a head office, workshop and off site storage compound for plant and materials. However, some companies prefer to deal with plant independently, as mentioned above.

Overheads are recovered from a project by means of a percentage addition to the costs directly associated with the construction project together with the site on-costs. The percentage applied must be adjusted regularly and relates to the turnover expectations of the company.

Unit rate estimating

Unit rate estimating applies unit rates to the measured quantities in bills of quantities (BOQ). Unit rates comprise all elemental cost items discussed previously, namely labour, materials, plant, subcontracts and overheads.

The calculation of unit rates for each item of the BOQ essentially requires collating cost information, assessing labour and plant outputs and evaluating project overheads.

BOQ'S are usually prepared in accordance with some agreed rules of measurement. Most countries across Europe have adopted comprehensive measuring systems for construction projects. In the United Kingdom for example, the Standard Method of Measuring of Building Works (SMM) and the Civil Engineering Standard Method of Measurement (CESM) are currently used for building and civil engineering projects respectively. In Portugal, there is not a uniform standard and many construction clients have developed a specific one for tendering their projects. However, the classification system developed by the *Laboratório Nacional de Engenharia Civil* (National Laboratory of Civil Engineering – LNEC) is widely adopted in both public and private building projects.

Cost information may be calculated or collected as discussed in the previous sections. Contractors take off labour and plant costs from their internal data. In most cases however, they may prefer to hire some equipments or outsource some works to labour only subcontractors if they find better rates than or wish to save their resources for other more interesting projects. The cost of materials and subcontracts are obtained by enquiry. Quotations from different suppliers may be compared in order to decide for the most convenient. Similarly, several subcontractors (three or so) may be inquired in order to get several offers to compare. Medium and large contractors have established supply chains with a set of material suppliers and subcontractors - often referred to as domestic subcontractors. Labour only subcontractors are dealt with in much the same way.

The assessment of labour and plant outputs is one of the most difficult tasks of unit rate estimating because it depends on the establishment of realistic production standards. In principle, this is specific of each contractor's organization, because it is expected to vary according to production means involved. Relevant data may be gathered from previous projects through the monitoring system which is normally put into practice in each construction site.

The monitoring may be done for bonus or other purposes, but quantities of work and the time expended in performing construction activities are recorded, and this is the information passed back to the estimating department.

In order to make this information usable for estimators, it must be formatted according to the current measuring systems adopted in the BOQ. However, information collected on construction sites may be difficult to use by estimators for the following reasons:

- It varies widely from site to site, affected by specific characteristics of each project;
- It is often not compatible for future estimating needs because of the unique circumstances under which each task has been carried out;
- A substantial number of similar task recordings are needed for establishing reliable average labour and plant outputs; this may be difficult to achieve in small and medium companies;
- Historic data may not be easily comparable because production means change along time;
- The site recording systems may not be reliable.

Alternatively, estimators may adopt published data on production standards collected from the industry. Data is worked out from a large number of observations in several construction sites and is organized into typical construction sites according to a specified measurement system. In the UK for example, published standards may be structured under the SMM or CESMM format or both, as in the sample depicted in

Operational estimating

Unlike unit rate estimating which starts from the resources required for a work unit and then assigns the total resources to a measured work quantity, operational estimating considers all the resources needed for a construction package from the start. This may have several advantages:

- Estimating is activity oriented, thus closer to the way works are carried out on site.
- Activities are examined to select the most efficient construction methods.
- Resource outputs are more realistic because they relate to a construction schedule.

The development of operational estimating largely arose out of the criticisms to the traditional unit rate estimating applied to bills of quantities (BOQ). Traditional bills have been criticised for their lack of relationship to the construction process and unit rates for being established irrespectively of the production reality. Actually, any bill item may relate to works performed in different locations and time instances and for this reason, resource outputs should be taken differently. On the contrary, operational estimating is activity oriented, thus much closer to the production process. Accordingly, it has been claimed that, in order to be effective, operational estimating would require the use of a different type of bills, since the layout of traditional bills would be unsuitable for this form of estimating; but earlier attempts to introduce operational bills have failed.

In reality, estimators currently use operational estimating for many items of typically structured BOQ, whenever those items refer to construction works for which unit rate estimating may not be appropriate. Furthermore, operational estimating depends on unit production output analysis before the gang of resources and the materials required for a specific construction package may possibly be computed. This is because unit production outputs are the best way known of gathering historical data and make it usable for the future. Therefore, it may be stated that both unit rate and operational estimating currently use common data structures in construction.

The question is thus how to select the adequate estimating method according to the work under consideration. The costs of excavation, for example, are likely to be much more related to the overall plant used in that work than to the resources forecasted to perform one cubic meter of it. This is because performing such an operation possibly encompasses periods of inactivity for some plant, which may not be included in the unit rate. Total resource quantities actually employed on site may thus substantially diverge from the amount calculated by multiplying the unit rate by the estimated quantity of work. And this may lead to unforecasted costs. Therefore, an activity approach to the excavation work seems more appropriate, whereby time and resources required to perform the whole estimated quantity are established accordingly.

In general, unit rate estimating is preferred for building projects whereas operational estimating is mostly used for civil engineering projects for the following main reasons:

- The type of resources used in both types of projects. Building projects tend to be more labour intensive than civil engineering projects which use considerably more plant. Plant is susceptible to idle times which accrue costs that are not readily catered for in the unit rate approach. Labour is normally more versatile and less expensive.
- The typical form of the BOQ used. Bills for civil engineering projects tend to be best suited to operational estimating because they are easier to relate to construction activities than those used for building projects. Moreover, the usual complexity of building BOQ makes unit rate estimating the most reasonable method to use for most of their items.
- The usual procedures used in estimating. These also play an important role because both productivity data and cost data are commonly structured under unit rate format.