The Selection and Operation of Construction Plant and Equipment

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36.1 Introduction

The effective selection of construction equipment for use on any construction project relies on the proper analysis of three principal considerations:

1. Technical efficiency, i.e. the requirement that the particular construction task be completed to the correct specification within the project timetable, by using the correct machines. In short, this identifies the plant with the ability to perform the job.

2. Commercial and financial viability, i.e. that the cost of the equipment falls within the estimates for the specific project. In addition, where purchase of equipment is involved, the selection must meet the overall financial criteria required by the construction company as a whole.

3. Availability – equipment can be supplied from a number of sources, i.e. existing internal holdings, the hire market or by additional purchase.

Within the UK, the last 15 years have seen the continued development of a sophisticated and efficient plant hire industry, giving contractors the option of hiring-in their plant requirements, as an alternative to buying and providing their own machines. This development has now reached the stage where it is estimated that 50% of all contractors' requirements are met by the plant hire industry. Therefore, the commercial analysis element of selection defined in (2) above should consider the relative cost of owning or hiring in any particular situation and most contractors will use a mixture of internal and external resources.

Outside the UK, there are very few countries with a comparable hire industry, with the result that, on overseas contracts, most requirements will be met by purchase. However, staff responsible for selecting and procuring plant for overseas work, should be aware of the plant hire alternative, albeit that local resources may be limited. There is no doubt that a hire market will develop gradually in other countries.

Within any construction group, the main financial assets consist of plant and equipment. Therefore, site staff should be aware that the correct selection of these items not only affects the profitability of their own contract but is also fundamental to the longer-term success of the company. As a consequence, the above selection considerations should be analysed by the appropriate level of management, as there may well be a need to resolve a conflict between what is technically desirable and what is financially viable. Although the young engineer on a particular project is concerned mainly that the equipment fulfills the technical requirements, the plant manager and/or the construction manager need to reconcile the technical/commercial factors so that the best commercial decision is taken in the overall interests of the company. On many occasions this will involve compromise.

This chapter, therefore, is designed to indicate how the selection and procurement of the correct piece of plant should be approached. There is no substitute for dealing with this selection process in a formal and organized manner. Although there is a tendency to make decisions on an informal basis, often because of time constraints, this can be dangerous. Before any organization commits itself to expenditure, especially of a capital nature, there should be an established procedure for arriving at a decision to ensure that no options are overlooked. This procedure should be applied whatever the size of company. Clearly, in the smaller firm the decision may be the responsibility of at most one or two people but in the larger construction organizations there are usually specialist departments which may be involved in different aspects of the decision. Most major contractors have a separate plant department whose primary function is to serve the plant requirements of the construction sites whilst protecting the longer-term position of the company. It is normal in the UK for the ownership of plant within a construction group to be vested in the plant department, whether it be a division or a separate operating company. It is therefore the responsibility of this department to ensure that the correct selection procedures are followed particularly where purchase is involved.

Having selected and procured the right piece of equipment, there is then a responsibility to ensure that it is used in an efficient, economic and safe manner in order to support the original decision. This chapter, therefore, also looks at the operation and control of plant in the field situation.

Figure 36.1  A Caterpillar dozer stripping a site
36.2 Plant selection

36.2.1 The principles of selection

The need for selection of construction equipment can arise from a number of situations, which vary according to the nature and size of the organization.

36.2.1.1 Requirements for new contracts or groups of contracts in the UK

During any construction work, there will be requirements for items of plant and equipment in order to carry out the work in a more cost-effective manner. This involves site staff initially in making a technical selection using the following criteria:

(1) Comparing mechanization with other more labour-intensive methods of working. For example, the degree of mechanization may be higher in the UK where labour costs are greater, than in other countries where there is an ample supply of more economic labour. However, the nature of modern construction methods, materials and components means that even overseas contracts are nowadays substantially mechanized.

(2) Comparing alternative plant methods for a particular operation. Bulk earthmoving may be carried out either with tractors and scrapers or with lorries and loading shovels/excavators depending on the outputs required.

Although site management will ultimately be responsible for selecting the appropriate type of equipment in line with the above criteria, it must be stressed that the analysis should start at the time of tender. Estimators and planners should take steps to define the scope of the construction work and to make a preliminary technical selection in order that the work can be priced. As far as cost and availability are concerned, for smaller items of general plant, especially of the nonoperated variety, the estimator will probably be aware of internal and external resources and the relevant charging structures. Therefore, at this stage there is unlikely to be a great deal of further commercial analysis of these items. The situation will be different for larger specific pieces of equipment, e.g. tower cranes, earthmoving plant and similar operated machines. Because of limited availability internally and/or externally, a more detailed commercial analysis will be necessary to identify the source of probable supply which complies with the programme. In addition, consideration must be given to the financial aspect, which may have to include the cost of a number of factors such as erection and dismantling, transport, etc. This is particularly important if the contract is likely to entail a substantial investment in the purchase of plant, in order to establish at the outset that the financial resources are available and approved.

The estimators' information should ideally be made available to site management, who, of course, must then be in a position to review and modify the initial projections to suit conditions on the ground. At that stage, however, greater attention must be paid to the commercial aspects of selection over the whole range of plant to ensure that the best deal is achieved.

36.2.1.2 Requirements for major new overseas contracts

This is a somewhat specialized problem. For practical and financial reasons it is often impractical to move plant and equipment from one country to another. Apart from the cost of shipping, import restrictions and duty, etc. may inhibit the movement of plant. Therefore, requirements are usually met by purchasing new or secondhand, specially for the particular project. This equipment will then be maintained and operated totally at the expense of that project and will be sold on completion.

In the period when overseas work was plentiful and profitable, price tended to be a secondary consideration behind technical specification. However, the present decline in overseas work, particularly in areas such as the Middle East, together with increased competition, means that just as much emphasis must be placed on commercial considerations. The purchase price, the shipping cost, the cost of spares and the ultimate resale value are of critical importance if work is to be competitive.

Having said this, the importance of correct technical selection

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![Figure 36.2 A Caterpillar wheeled loader working in a quarry](image-url)
should not be underestimated. Overseas contracts are often carried out in remote areas where the contractor is required to be self-sufficient. Site investigations must be intensive to determine the conditions under which the plant will operate. Problems such as extreme heat, dust, high humidity, and inexperienced operators must be allowed for both in the initial selection and in the provision of spares and maintenance facilities. A serious breakdown cannot be overcome by phoning the nearest dealer or plant hire organization for a replacement. Therefore, new models or developments should not be considered for an overseas environment until they have been thoroughly proven.

36.2.1.3 Existing machine replacement
Taking the UK, this is most likely to occur in: (1) a major construction company; (2) a plant hire organization; (3) a public authority; and (4) a process contractor, i.e. open-cast mining. Each of these organizations will own a permanent fleet of equipment and will be able to generate sufficient utilization to warrant ownership. As a result of age or obsolescence, this fleet will have to be replaced periodically. However, since the replacement will almost certainly be of the same type as the original and may even be the identical model, there need be only a limited technical assessment. An examination of modifications and improvements should be sufficient, although admittedly there is the opportunity to look at similar machines of a different manufacture. Nevertheless, one of the most important commercial factors affecting equipment selection is standardization, as substantial ownership of the same make and model of plant can achieve savings in ownership costs. For example, maintenance and operating familiarity are important considerations, as is the level of spares holdings.

It is clear, therefore, that in this particular situation, technical considerations may well be secondary to commercial ones, assuming that the original machine has been successful in operation. In fact, the construction company or public authority may well decide to divest itself, either partly or wholly, of a particular type of plant if it feels that its requirements can be more economically met from the plant hire market. The process contractor is unlikely to have this opportunity because of the specialized nature of the plant involved.

36.2.1.4 New developments
From time to time, manufacturers produce new types of machines or new models within existing ranges. Investment in new developments should be treated with great caution until it has been possible to carry out a full technical and commercial appraisal on the same basis as any other selection situation. It is important to establish that the new equipment is either technically or commercially superior to previous alternatives. The benefits should also outweigh the costs of change including items such as spare parts and retraining, etc.

Having done a theoretical appraisal, it is imperative that practical equipment tests are carried out, preferably on more than one machine and over a lengthy period. A manufacturer's demonstration is not suitable and neither is a free loan or trial as this often has strings attached. The most reliable method is to hire-in a similar unit so that it can be tested under normal field conditions over a proper trial period.

From the foregoing paragraphs it will be seen that the selection process can be summarized under the following stages:

1. Selection of the best type of machine to do a particular site task.
2. Selecting the source of supply.
3. Selecting the right make and model, should purchase be necessary either as new or replacement.

Each of these stages involves a technical and commercial investigation to varying degrees and in the next subsection we look at the procedures and methods to be adopted for completing each stage.

36.2.2 Selection methods and procedures

36.2.2.1 Selection to meet contract requirements
This selection process can be broken down into six separate stages: (1) task identification; (2) preliminary selection; (3) machine output estimation; (4) machine matching; (5) output costing; and (6) final selection. One of the dangers of any analytical process is that the work involved may not be justified by the end-result. Therefore, an objective view must be taken at the outset to ensure that the project warrants detailed consideration of the alternative machines and methods available. It may well be possible, in the case of straightforward requirements, to shorten this selection process, particularly if site management have previous similar experience on which to base a decision.

Task identification. When selecting the most appropriate equipment to meet a contract requirement, consideration must firstly be given to the nature of the particular site task before the actual, alternative plant methods can be examined. To enable us to demonstrate a practical construction situation, in all the following examples we have used earthmoving as an illustration, as it is one of the main components in civil engineering work. Therefore an earthmoving job should be looked at from the following aspects: (1) duration and programme; (2) location; (3) material specification; (4) distances and site conditions, i.e. gradients, etc.; (5) weather; (6) special conditions, i.e. safety; and (7) legal and contractual. The site engineer will generally be responsible for analysing these factors, often taking into account any surveys done at tender stage.

Preliminary selection. The next step is for the site engineer to identify the various types of plant which would be suitable for carrying out the above task. At this stage, all options would be considered in relation to factors such as the nature of digging, i.e. hard or soft ground, and the travelling conditions, i.e. whether tracked or wheeled machines are most appropriate. Preliminary enquiries would also be made concerning the availability either internally or externally of various groups of machines.

Machine output estimation. Calculations must then be made of the outputs which can be achieved using two or more alternative methods. Where operations lose money because of inefficiency, it is very often because over-optimistic assessments have been made of machine outputs, usually based on unrealistic figures provided by equipment manufacturers. In this area there is no substitute for practical production experience and in a later section we shall look at outputs in more detail.

Machine matching. Logical selection implies that the machine/s finally selected will be matched to the task, i.e. the machine capacity will match the job requirement. For example, concrete-mixer output should match the placing team production, and crane capacity and speed should match the other plant with which it will work. To take a simple example, if the company owns/operates three 5-m³ tippers matched with a loading shovel with a potential output of 30 m³/h, then the shovel can complete six loads per hour. A decision must then be made whether the distance to the tipping point is such that three tippers can cope with this output. If not, more vehicles or larger ones may be needed.
Output costing. Once the outputs of various alternatives have been established, these outputs must be converted into costs. Taking our example of the loader with an output of 30 m$^3$/h, if we assume that the hire rate or provision cost for that machine is £12/h, each metre cube will cost 40p to load plus vehicle cost.

Final selection. The final selection is best achieved by tabulating the cost of the various alternatives, so that the most economical can be identified (see Figure 36.3). This cost comparison may also reflect other commercial factors, i.e. the charges for transporting the various alternatives together with the differing fuel costs, if it is felt that these will influence the final decision. This also assumes that all the alternatives will complete the task within the programme period. However, this is not always the case and there may have to be some compromise between cost and time, particularly if there are penalty clauses in operation. Finally, the availability of the chosen method must be checked to ensure that the equipment can be supplied to meet the programme starting date.

In the above analysis of the technical, commercial and availability factors, clearly the site management initiate the investigation and must take the final decision on machine selection. However, it is essential that they draw on the accumulated experience of the company plant organization. This department should be able to supply detailed information in the following areas:

1. Provision of machine data from their technical library.
2. Provision of weekly or hourly hire rates for machines based either on their charging system for internal plant or on the external market.
3. Costs of ancillary items such as transport, erection and dismantling, and fuel consumption.
4. The availability of equipment from internal resources or from the hire market. This includes information on the delivery of new purchases.

There has been a tendency on the part of contract management over the years to underestimate the role of the experienced plant manager and of the plant department. On a civil engineering contract, the plant content of the job value can be as high as 40%, particularly on major overseas projects, and the efficient management and operation of this plant are therefore critical to success. The field plant manager and the central plant department should therefore have clearly defined functions which are accorded a proper position in the overall management team.

36.2.2.2 Selection for purchase purposes

Within a construction organization, equipment will be purchased either as a replacement or as an addition to existing holdings. This investment must be preceded by a selection process to determine the most suitable make and model from a technical point of view for the applications to which the equipment will be put. In addition, the commercial implications of ownership must be calculated:

1. In order to establish a hire rate for the machine so that it can be charged to individual sites on the basis of usage. Most construction organizations now treat their plant and equipment holdings as a separate profit centre with the result that plant is charged out internally on an equitable

<table>
<thead>
<tr>
<th>Start date</th>
<th>Preliminary selection</th>
<th>Volume to be moved/excavated</th>
<th>Estimated output</th>
<th>Time allowed for task completion (h)</th>
<th>Time required for task completion (h)</th>
<th>Total cost of machine per h</th>
<th>Cost per yd$^3$/m$^3$ per h</th>
<th>Length of time on site</th>
<th>Final selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 'A' machine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(2) 'B' machine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) 'C' and 'D' machines</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 36.3 Plant selection analysis chart
basis to each site. In addition, this method ensures that the full costs of ownership are recovered over the life of the machine.

(2) To enable the company to make a comparison between the cost of ownership and the cost of hiring-in the equivalent item. If an internal hire rate is calculated based on ownership costs, then this can be directly compared with the market-place to ascertain whether it would be more economical to hire.

In the UK, on a large project, in particular a joint venture, it may be necessary to purchase special equipment specifically for that job, with a view to either disposing of it at the end or alternatively writing it off over that contract. A tunnelling machine could be an example of such equipment. Even then, a technical appraisal will be carried out, although the commercial appraisal will be concerned principally with the cost of financing the purchase. It will be necessary to define the method and timing of the recovery of the ownership costs from the client.

Therefore, although the selection process which accompanies a purchase still takes into consideration the technical and commercial factors, the actual procedures and methods of selection vary from those adopted when making a site selection. In fact, they are usually an extension to that situation, i.e. the site selects the machine it requires given certain performance and charging rates; the plant department then either supplies the machine from within existing resources, or purchases new or arranges external hire.

Technical evaluation. In any purchase situation, the buyer is likely to find that there is a number of alternative makes and models of machine on the market which may meet the required specification. It is therefore essential to establish a formal procedure for evaluating these alternatives to ensure that the most satisfactory purchase is made. In the book Construction plant – management and investment decisions, Frank Harris discusses a systematic approach to evaluation of equipment alternatives developed by the American consultants, Kepner and Tregeoe which is suitable for carrying out a detailed analysis on a major investment. However, there is again a danger that the analytical work involved may not be justified by the result. The buyer should look at each situation and decide what degree of investigation is warranted. For example, greater effort would be devoted to the selection of a large crawler crane than to a two-tool compressor. For practical purposes, there are certain steps that should be undertaken as a minimum requirement, whatever the scale of the equipment. These are as follows:

(1) Define the minimum machine characteristics required to fulfil the type of work required of it. This definition should certainly include:
   - (a) performance capabilities i.e. digging depth, speed, etc.;
   - (b) physical dimensions and weight;
   - (c) engine specification;
   - (d) chassis, i.e. wheeled or tracked;
   - (e) statutory requirements; and
   - (f) safety features.

   Also, try to define any characteristics which may not be essential but which would be desirable. For example, you may prefer automatic lubrication to be fitted, but this need not be a critical factor.

(2) Make an initial selection of the makes and models which appear to come nearest to meeting the above characteristics and obtain manufacturers' detailed specification sheets and data.

(3) The basic information must then be analysed in a chart form under the headings mentioned in (1) above so that there is an easy visual comparison, with the object of finding those models that correspond most nearly to the overall requirements. On this chart you will also indicate any special features possessed by each machine together with details of any optional extras offered by the manufacturer. All serious contenders should match all of the essential requirements and as many of the preferred requirements as possible.

(4) Contact the various manufacturers and ask to see their representatives so that you can discuss the technical specification in more detail. If you are not familiar with the firm and their products, ask for information on other existing users whom you can contact to discuss whether they are satisfied with that model. Manufacturers should be quite happy to give you this sort of information and other users are usually very willing to talk about their experiences. In addition, seek information from the manufacturer on any units owned by hire firms, in order that you can arrange for a machine to be hired-in for a trial period.

Commercial evaluation. At the time you obtained the technical information from the manufacturers, you should also have obtained an initial quotation showing the cost of the machine to the basic specification together with the price of any optional extras. However, the commercial evaluation does not end with the price. Therefore, in discussion with the representative, satisfy yourself regarding the following additional factors:

(1) The delivery period.
(2) Delivery costs.
(3) Spare parts availability and cost.
(4) Service support from dealers/manufacturers.
(5) Operator and fitter training if necessary.
(6) Fuel consumption and running costs.
(7) Driver comfort.
(8) The longer-term reliability of the company.
(9) Payment terms, i.e. discounts and deferred payments.
(10) Special financing arrangements, i.e. leasing, hire purchase.
(11) Buy-back terms against future replacement.

This may seem a mammoth exercise, but any of these items are neglected at your peril. It is no use having the machine with the best technical specification if the supplier goes out of business and spare parts become unobtainable.

One other aspect which is particularly relevant to overseas plant is that of secondhand equipment. A contractor working overseas may well find that there is plant available from other previous projects in the same area. Clearly, if it is possible to obtain good secondhand machines locally, then there must be a substantial saving on the new price, particularly if this avoids shipping costs. However, it is essential that, firstly, a full inspection and technical evaluation is carried out. In an overseas environment, it is far more difficult and expensive to rectify selection mistakes so the purchaser must be absolutely sure that:

(1) the equipment is right for the job; and
(2) it is mechanically sound.

In most cases, a full physical examination is a necessity, possibly carried out by the manufacturers or their representatives.

Final selection. At this point the management must make a decision based on the importance they attach to the technical and commercial factors and in many cases the result will be a compromise. In the situation where a machine is being bought to carry out a specific duty on certain well-defined contracts then, clearly, the technical specification will be of overriding importance, but if standard items of contractor's plant are being purchased as part of the general fleet, then commercial considerations become more important.
Communications. In a construction company of any size, the selection of plant for a job either at the tender or operational stage requires the co-operation and communication of a number of different people from different departments working towards a common objective. Good communications are therefore imperative. If basic disciplines are to be observed, then a good deal of these communications are best conducted in a formal manner. It is worth highlighting at this stage certain essential examples:

1. The plant department representative should be involved in tender meetings. Where the estimators lack information and costs on plant, the advice of the plant personnel should be sought in obtaining this information. Finally, the estimators/planners should produce a list of plant requirements in bar-chart form.

2. Once a tender looks promising, the plant department should be sent a copy of the plant list, so that they can start making certain preliminary enquiries on availability, etc. Clearly, when the contract manager arrives on site this may well alter, but certain elements will remain unchanged.

3. Once the contract has been awarded, there is often a pre-contract meeting of everyone likely to be involved. It is imperative that plant is seen to be an important part of the agenda and that the plant department is represented. Certain decisions may have to be made at this early stage on, for example, site accommodation.

4. Once the site is under way, it is vital that plant is ordered from the plant department in writing in a formal manner using a requisition or order form, so that the essential information is clearly set out and so that the site can progress requirements in an organized manner. This form should include information on the delivery date and the estimated period of the requirement, as this is a vital factor in the commercial assessment. In addition, it should clearly specify any attachments or modifications that are required. It is amazing the attention which is paid to the specification, ordering and scheduling of materials, when substantial plant requirements can be ordered over the telephone in a haphazard fashion.

36.3 Plant hire rates

36.3.1 Hire rate philosophy

The decision to own plant and equipment involves the contractor in accepting the costs of that ownership. In addition, these costs must be recovered over the life of the machine in order that a fund is created to buy the replacement. Assuming that the equipment is only used on internal work, then the ownership costs must be paid for out of the construction work. Most plant managers are all too familiar with the site management which expects internal machines at rock-bottom prices, in order to secure work. However, there are serious dangers for the financial well-being of the company as a whole, in the philosophy that plant rates should be cut to secure work. Any failure to recover the true ownership costs from the user contracts means that the shortfall must be made good as a company from the overall construction profits.

It is also fair that each contract should bear the proportion of the ownership costs which relate to the period of their machine use. As mentioned earlier, most construction groups nowadays operate their plant activity as a separate profit centre which charges the internal sites for the machines they use at an agreed internal rate, on a similar basis to the charge received from external hire firms. This method not only overcomes the problems mentioned above but it also simplifies tendering and internal charging. At the same time it is also possible to make a straightforward comparison between the alternative of supplying requirements from internal resources or from the external hire market.

Therefore, all levels of construction management should be aware of the basis of calculation of hire rates and the importance of ensuring that they reflect the true ownership costs. The cheapest is often not the best, even as far as outside hire firms are concerned, as it is likely that the firm will be offering unreliable plant and poor service. In the context of overall contract costs, a small saving in hire rate can easily be more than offset by the cost of lost production when plant fails to perform satisfactorily.

36.3.2 The calculation of a hire rate

The accompanying chart (Figure 36.4) defines:

1. The factors which should be considered when calculating a rate.

2. The method of calculation to arrive at an hourly, daily or weekly rate depending on how the machine is charged.

Machine details: Smiths Model 36 Thumper c/w spare skip
Machine cost: £500 incl. spare skip and delivery charge

Rate factors
- Economic life: 5 years
- Residual value: £500
- Utilization: 70% based on a 49-week working year
- Interest charge: 15% per annum on reducing capital cost
- Repair cost: 12% per annum on capital cost
- Overheads: 10% per cent on total machine costs

Rate calculation

<table>
<thead>
<tr>
<th>Factor</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depreciation - cost less residual over 5 years</td>
<td>£900.00</td>
</tr>
<tr>
<td>Interest charge</td>
<td>£375.00</td>
</tr>
<tr>
<td>Repair cost</td>
<td>£600.00</td>
</tr>
<tr>
<td>Total machine cost</td>
<td>£1875.00</td>
</tr>
<tr>
<td>Overhead cost</td>
<td>£187.50</td>
</tr>
<tr>
<td>Total cost</td>
<td>£2062.50</td>
</tr>
</tbody>
</table>

Cost recovery period 49 weeks × 70% = 34 weeks

Hire rate per week necessary to recover cost £60.66
£2062.50 per week

Hire rate based on a 60% utilization, i.e. 29 weeks £71.12
per week

Driver and fuel costs are not included in the above rates. However, where appropriate an annual cost can be included in the calculation. Licensing and insurance can be calculated separately but for the purposes of this exercise have been included in the overheads.

The above rates do not include any profit element, only costs.

Assuming normal inflation, the basic purchase price of the replacement will rise over the 5-year period. Rates should therefore be reviewed annually in line with inflation.

Figure 36.4 Hire rate calculation

The costs of fuel and operator have not been included in the calculation as these are usually paid for by the site when plant is supplied internally. External hire firms will, however, provide an inclusive rate which covers these items. One factor which is
often overlooked by construction managers is the element of finance. Before plant is purchased, money must be available to pay for it. The requisite cash can be provided from a variety of sources, i.e. loans, shareholders' investment, leasing or spare funds generated in the course of trading. Whatever the source, the provider of the money will expect a return or interest. Alternatively, if it is internal money, then it could be invested in a deposit account to yield a regular interest or could be used to finance further construction work. Therefore, it is important that the hire rate reflects the cost of that money. A leasing company will expect the customer to pay an interest charge in addition to paying back the capital.

The other factors in the hire calculation are mainly self-explanatory. In the case of repair and overhead costs, it is clearly difficult to quantify these accurately for each individual machine. However, by looking at historical ratios, it is usually possible to establish an acceptable method of assessing future costs in these areas.

The principal factor determining the hire rate on any machine is the utilization. Once the costs of ownership have been quantified, then these costs must be recovered over the actual working or chargeable hours as the equipment will not be earning whilst it is standing off-hire. Some of the cost elements in the hire rate, i.e. depreciation, finance, insurance and to a certain extent overheads, etc. are of a fixed nature irrespective of how much work the machine does, and can be predicted reasonably accurately over the life of the machine at the time the rate is calculated. However, the other costs, such as maintenance, are variable depending on the level of utilization. Any drop in utilization therefore increases the proportion of fixed cost in the rate so that costs overall do not decline in proportion to income. Conversely, if the targeted utilization is achieved, then at that point most of the ownership costs have been covered and any additional utilization over and above target is extremely profitable. A hire rate is therefore very sensitive to changes in utilization, a factor which is to a certain degree outwith the control of the owner. Prediction of future utilization levels is therefore difficult and should be treated with caution unless there is a very clear historical pattern. The impact of a change in the predicted utilization is illustrated in the hire rate calculation shown in Figure 36.4.

If contract management recommend the purchase of a particular machine on the basis that they can find work for it for on average 36 weeks a year out of a possible 48 weeks, then that equates to a 75% utilization. On this basis the company may decide that purchase is warranted because the ownership costs can be recovered by the plant department over that sort of period using a hire rate which is more economical than the external rate. Suddenly the contract management finds that the company is recovering some of the costs incurred on that investment, there are also a number of practical reasons why internal hire may be favourable, i.e.:

- Better company image and presentation.
- Certain clients insist at time of tender that the contractor should show evidence of its plant resources.
- It may be possible to exert greater control over the quality and performance of internal plant.

To summarize, contract management and plant management should make a joint decision on the sourcing of equipment requirements which takes into account the overall best interests of the company.

36.3.4 The plant hire market

Apart from the decision to hire for clear commercial reasons, there may also be situations, even on overseas contracts, where hiring is the only reasonable solution. For example, very few contractors own the largest heavy lift cranes because of the massive investment involved to meet what may be intermittent requirements. In addition, this type of equipment requires a high degree of specialist back-up and operating expertise which is unlikely to be present within the construction organization. In this situation, it will still be necessary to carry out a technical appraisal to identify the most suitable plant method but the commercial appraisal will be limited to a comparison of alternative hire companies to identify the most economical package. Availability may also be critical in this selection, as there is only a limited number of machines of this size in the market.

The decision to hire any item of plant involves the contractor in entering into a formal legal contract with the hire company. In the UK most hires are conducted under the conditions laid down in the document known as the Model conditions for the hiring of plant published by the Contractors' Plant Hire Association. These conditions place certain clearly defined responsibilities on the hirer regarding, for example, the control of the driver. Therefore, within most construction organizations, the ordering of hired equipment is conducted by the plant department on behalf of the individual contract. Apart from giving the plant department the opportunity to look at the
alternative of supplying internally, this also ensures that the company does not enter into a contract where the terms and conditions could prove onerous or unfair. Although site management are inclined to hire-in plant on their own initiative, there are many examples of situations where this has proved disastrous, particularly when something has gone wrong, i.e. in the case of an accident involving the plant. Contract management should avail themselves of the experience of the plant organization in dealing with the hire of plant and, in fact, in many organizations it is mandatory that all requirements are channelled through the plant organization.

36.4 Plant operation

36.4.1 Equipment output and production

We have established that the first stage in the selection process requires the site engineer to choose the right type of machine for the job. In other words, the method will be selected which achieves the task within the allotted contract programme. At this stage the engineer has three sources of information, on which to make the appropriate calculations and decision. These are:

1. The parameters of the particular task as set out in section 36.2.2.1.
2. The machine data supplied by the manufacturer.
3. The practical experience of performing that sort of work.

In efforts to secure work it is not unknown for estimators and planners to take an over-optimistic view of the outputs which can be achieved on site because they have either relied on manufacturers' information which is unrealistic or they have neglected to take account of previous experience and the effect of adverse site conditions. Certain manufacturers' literature will even quote outputs which can be expected from machines, but these are invariably based on certain assumptions on site conditions, which may not necessarily be relevant to the task under review. Therefore, there is no substitute for carrying out your own calculations of output. Obviously, the time spent on this sort of exercise must relate to the importance and value of that particular task. However, in any situation where the progress of the job depends on materials production or handling, the output should be looked at in two distinct phases:

1. The calculation of optimum outputs based on the operating cycle and on the manufacturers' machine data.
2. The assessment of realistic outputs taking into account the effect of site conditions.

As a simple example, on a house-building job, the success of the brickwork operation can depend on the size and output of the mixer used. A 5/3.5 mixer will take around half a minute to mix a 0.1m³ batch of concrete but the actual production time will take longer than this, depending on the efficiency of the operative and the availability of materials, etc.

36.4.1.1 Calculating optimum output

Taking an earthmoving operation, as this represents a major component in civil engineering work, let us consider a task involving loading lorries using a loading shovel. The first step is to calculate the operating cycle for the loader which is as follows:

1. Dig into spoil heap.
2. Reverse and raise bucket.
3. Slew and travel to vehicle.
4. Dump material.
5. Slew and return to dig whilst lowering bucket.

Timings for all these elements can be obtained from a combination of the manufacturers' specification details and the physical site circumstances. The next step is to calculate the size of a bucket load of material, i.e. the heaped capacity of the bucket. In this context it is most important to remember that the loose material may represent a different volume from the same material in its solid banked form, i.e. soil increases in volume when dug. In its undisturbed state, the soil is measured in 'bank' units. The moment it is disturbed, the soil swells and, when further break-up occurs, e.g. the transfer from the bucket to the vehicle, the volume increases still further. As might be expected, materials consisting of small grains such as sand or sand/gravel...
mixes do not increase in volume as much as, say, clay. To change bank measures into loose measures, multiply by the swell or banking factor. Examples of typical swell factors are given in Table 36.1. From the calculated cycle time and the assessed loading of the bucket vehicle it is possible to calculate the output of the loader assuming that there is a constant supply of vehicles.

Table 36.1 Typical material characteristics

<table>
<thead>
<tr>
<th>Material</th>
<th>Swell factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>1.40</td>
</tr>
<tr>
<td>Earth loam</td>
<td>1.25</td>
</tr>
<tr>
<td>Gravel</td>
<td>1.12</td>
</tr>
<tr>
<td>Gypsum</td>
<td>1.74</td>
</tr>
<tr>
<td>Iron ore</td>
<td>1.33</td>
</tr>
<tr>
<td>Limestone</td>
<td>1.67</td>
</tr>
<tr>
<td>Sand</td>
<td>1.22</td>
</tr>
<tr>
<td>Sandstone</td>
<td>1.54</td>
</tr>
<tr>
<td>Trap rock</td>
<td>1.65</td>
</tr>
</tbody>
</table>

The weight and load size will vary with factors such as moisture content, degree of compaction, etc. A test must be carried out to determine an exact material characteristic.

When calculating the cycle time and output of plant or vehicles, where the essential function is transport of materials, information must be available on the anticipated routes, analysed into the following elements: (1) distance; (2) gradient; (3) rolling resistance, i.e. ground conditions; (4) average speed; and (5) the nature of the route, i.e. curved or straight. These elements may change as the job progresses, i.e. different tipping areas can be employed. There may also be variations in the elements due to seasonal factors, i.e. a hard road in the summer may become a muddy one in the winter, thereby altering the rolling resistance and the speed.

36.4.1.2 Reducing factors

To convert optimum outputs into realistic outputs, there are a number of reducing factors which are as follows:

1. The mechanical reliability of the machine. Breakdowns can never be completely eliminated and some time must be lost for this factor, based on previous experience.

2. It should be possible to carry out routine servicing and refuelling outside normal working hours, so that machine availability is not affected. However, this may not always be possible and it may be necessary to carry out certain major servicing jobs such as oil changes during the working day.

3. Operator efficiency. An operator who fails to fill his bucket, who moves his bucket further than the job requires or whose co-ordination of the controls is poor, will not produce maximum output. It is difficult to quantify operator efficiency without some specific on-the-job measurement, but some assessment must be made if realistic outputs are to be achieved.

   It must also be appreciated that operators cannot work 60 min in every hour. Stops must be made for personal reasons, for refreshment, to check work, etc. To accommodate this factor, some managers work on a 50 min/h machine operating time based on European yardsticks. Clearly, in some countries there is a shortage of skilled operators and training is needed on the job. This efficiency factor may then decline.

4. Climate and weather conditions will also affect output. If a machine is scheduled to work in a region where there are extreme climatic conditions, then allowance will be made for this when compiling the technical specification, e.g. special filters may be necessary to cope with dusty conditions or low ground pressure tracks fitted for work in bad ground conditions. However, there will still be situations where work will be stopped by the weather, as in Britain where rain can bring everything to a halt. An estimated reduction must be made in output to reflect these conditions. If necessary, particularly when working in an unfamiliar area, detailed meteorological reports may be necessary.

Having made provision for all the above factors, it should be possible to arrive at a realistic output which may be in some cases as low as 50 to 60% of the optimum. Where a number of machines are working as a team on a specific task, there is the
risk that the failure of one of the components can have a serious cumulative affect on the whole operation. In this case it might be considered prudent to carry spare units or relief drivers. The extra cost may be more than offset by the improved output.

36.4.2.1 Systems
which is usually the situation on overseas jobs. It is important to consider the situation where a major contract justifies its own maintenance facilities, to the extent that the contractor can support these. There may be enough to warrant its own facilities. Obviously, there are situations where it is more practical to consider the situation where the contractor's own maintenance facilities are considered prudent to carry spare units or relief drivers. The contractor's right to maintain vehicles, i.e. an air compressor for tyres or heavy-duty greasing equipment. For this reason, most large projects, particularly where earthmoving is involved, it is usually found to be more efficient to establish a special servicing team equipped with specialist gear, which can travel from machine to machine in rotation making use of working breaks during the day. This team will include one or more 'greasers' who will work from a special greasing truck. Refuelling will be dealt with in a similar manner using a fuel bowser. It is imperative that routine servicing and refuelling are carried out to a predetermined programme under the overall control of the site plant manager or foreman. It will then be his responsibility to ensure that programmes are adhered to and to liaise with the contract management.

36.4.1.3 Human errors
Whatever steps are taken to determine machine outputs for costing purposes, it is worth reflecting that the tender seldom makes any provision for the human errors which can arise in the course of the actual site operations. Failure to achieve the theoretical outputs is generally the result of poor discipline in one or more of the following areas:

(1) The wrong choice of plant due to lack of prior investigation.
(2) Overloading and overspeeding without regard to long-term consequences, possibly because of ill-conceived bonus schemes.
(3) Bad layout planning.
(4) Poor site control resulting in machine queueing and shortage.
(5) Inadequate maintenance and repair programmes and facilities.
(6) Poor fuel supplies.
(7) Bad maintenance of haul roads and working areas.
(8) Poor drainage.
(9) Ineffective communication and supervision.

Clearly, similar patterns may not occur in other types of operation such as concreting and cranage which tend to be less complex. However, anyone who has been involved in the installation of a tower crane for materials handling will appreciate that this requires a high degree of planning and control, if the right machine is to be selected and operated successfully.

36.4.2 Plant maintenance
All the work put into selecting and procuring the right piece of equipment is so much wasted effort if the machine fails to achieve the estimated outputs and exceeds the target operating costs which have been incorporated in the hire rate. In order to ensure that this does not happen, site staff must, first of all, aim towards maximum availability. All equipment requires servicing and refuelling and even breaks down from time to time. At the beginning of the first shift of the day, it has to be started and checked over and at the end of the working day it has to be parked up in a secure place.

Although a number of these duties rest with the operator of the plant, most large civil engineering sites will have their own facilities for maintaining and repairing the plant, so that a high level of utilization is achieved. A consideration of site maintenance and repair falls into three categories: (1) the systems; (2) the maintenance equipment including buildings; and (3) the maintenance staff. Each of these categories must be clearly defined initially at the time of tender, particularly if the site is large enough to warrant its own facilities. Obviously, there are situations on smaller sites, when it makes sense for all but the routine servicing to be carried out off site or by visiting fitters. This may be the case where there is a plant depot nearby. However, we will consider the situation that will arise on a major contract which justifies its own maintenance facilities, which is usually the situation on overseas jobs.

36.4.2.1 Systems
This category can be divided into the following specific activities:

(1) Daily servicing which is carried out in the field.
(2) Periodic maintenance which is done in the workshops.
(3) Specialist maintenance, e.g. tyre repairs.
(4) Refuelling.

Although the daily servicing is often the operator's responsibility, this does mean that part of his time has to be set aside for doing this work, usually at the start or finish of the day. There are then the practical problems, i.e. that the operator has to start and finish half an hour before and after the normal working hours and also that the work may entail the use of specialized equipment, i.e. an air compressor for tyres or heavy-duty greasing equipment. For this reason, on most large projects, particularly where earthmoving is involved, it is usually found to be more efficient to establish a special servicing team equipped with specialist gear, which can travel from machine to machine in rotation making use of working breaks during the day. This team will include one or more 'greasers' who will work from a special greasing truck. Refuelling will be dealt with in a similar manner using a fuel bowser. It is imperative that routine servicing and refuelling are carried out to a predetermined programme under the overall control of the site plant manager or foreman. It will then be his responsibility to ensure that programmes are adhered to and to liaise with the contract management.

The major periodic maintenance, i.e. oil changes, etc. is best done under workshop conditions, especially as far as major items of plant are concerned. Site staff are often reluctant to release machines for maintenance when they are under pressure to finish the job, e.g. during a period of good weather. However, this is an extremely shortsighted view. It is essential that maintenance is carried out in accordance with the timetables laid down by the manufacturer and failure to do this can result in breakdowns which cause far more disruption to the work than any time spent on maintenance. Therefore, the plant manager for the job needs to establish a programme of preventative maintenance in conjunction with site management. As the word implies, a 'preventative' programme is designed to prevent breakdowns and lost production by ensuring that the machine is kept in good running order and that any problems are identified and rectified before they reach the point of failure. This enables the workshop to plan its repair programme and to order spare parts so that they are available at the time the work is ready to be carried out. Apart from considerations of production, a planned approach also ensures that proper safety standards are maintained. The workshop manager should adopt a simple system for recording when periodic maintenance is due and when it has been completed on each machine, so that the overall position can be seen at a glance at any time. This can be done quite easily on a maintenance chart similar to that illustrated in Figure 36.7.

From time to time unplanned work will be necessary to deal with sudden breakdowns and, clearly, this will place a strain on site resources. In order to minimize the problems, steps should be taken at the start of the contract to establish the identity of the major plant manufacturers and the location of their nearest agents. Not only may they be responsible for supplying spare parts but they may be able to assist with machine repairs. A visit by the plant manager to the manufacturer at the start of the job can be invaluable in ascertaining what back-up facilities are available in the event of unscheduled difficulties. The supply and storage of spare parts is particularly important and will be covered separately.

On any civil engineering contract, there is bound to be a variety of machines and vehicles fitted with tyres. On the larger items of earthmoving equipment such as scrapers, they are an extremely expensive item with a high wear factor. Therefore constant attention to tyre condition and replacement

Therefore constant attention to tyre condition and replacement
is a fundamental requisite of any major civil engineering site, even if it affects only smaller machines like dumpers. Breakdown through punctures or tyre failure can be extremely costly in terms of lost production. In the UK, on all but the largest sites, it is normal to rely on a specialist tyre firm who are experienced in the repair, supply and fitting of earthmoving tyres. An agreement should be reached with one of these firms for them to carry out regular tyre inspections and to change round tyres to prevent uneven wear. This agreement should include breakdown repairs. If necessary, there should be negotiations for the firm to base a tyre fitter and breakdown truck permanently on the site. The fitting of large tyres is a skilled job which requires strict safety precautions and should under no circumstances be undertaken by inexperienced personnel. Detailed records should be kept on site of the tyre numbers and the machines they are fitted to, as lax control of earthmoving tyres can cost a contractor thousands of pounds. In an overseas situation, where there is unlikely to be a local network of experienced tyre dealers, the contractor may well have to undertake this task, and in this case, care should be taken to employ experienced tyre fitters, if necessary expatriates, and to provide the appropriate tyre-fitting equipment.

The provision of proper refuelling facilities entails the installation of tanks with meters and locking devices for security purposes. Alternatively, a fuel bowser may be used if it is more economical to take the fuel to the equipment rather than bring the equipment to the fuel. Issues and deliveries of fuel should then be tightly controlled. Within the UK, very few problems are experienced with the quality of fuel. However, overseas local fuel supplies can vary widely in quality; for example, they can have a higher sulphur content than normal. This factor should be taken into account when planning the job and even when selecting the plant, as it can adversely affect the normal servicing and maintenance intervals.

36.4.2.2 The equipment

We have already mentioned the use of special trucks for servicing, tyre fitting and refuelling. If their use is warranted, then they should be specialist units designed for the purpose and fitted with the correct ancillary equipment. The adaptation of older secondhand vehicles may seem the cheapest method of supply but it must be remembered that reliability is critical. The right vehicles are therefore likely to be more cost-effective in the long run.

In addition, the site will need a fitting shop, a plant stores and a compound where large tyres, lubricants, etc. can be held in secure conditions. As far as buildings are concerned, the main requirement is that they should be of the sectional re-locatable variety, so that the capital cost can be spread over a number of contracts. There are now folding workshop buildings available, which can be brought on to the site on a flat-bed lorry, lifted off by crane and placed in position on a prepared concrete base with the minimum of assembly work. This workshop should then be fitted-out properly with fitters' benches, lifting equip-
ment, compressed air, light and heat so that the staff can deal with the range of equipment to be used on the job. The stores building must be fitted out with suitable racking, counter and office facilities. Many civils jobs nowadays carry a large fleet of personnel vehicles which are used by the resident engineer and by the contractor, e.g. cars, vans and landrovers. Depending on local facilities, this may necessitate a special transport fitting shop which is equipped to prepare and maintain vehicles to comply with statutory requirements. Provision for all of this back-up equipment should have been made in the tender based as far as possible on standard layouts which are applicable in modular form to a range of civil engineering contracts.

36.4.2.3 The staff

A typical major civil engineering contract will have a requirement for the following grades of maintenance staff: (1) fitters; (2) electricians; (3) welders; (4) greasers; and (5) storemen. The numbers of each will depend on the type of contract and the nature and volume of the equipment. Tunnelling work will, for example, require a high level of electrical personnel. Within any civil engineering company there should be staff ratios relevant to particular types of work using the experience of previous contracts. Personnel must be of the highest calibre as they will be expected to be adaptable and flexible with the skill to improvise. If necessary, assistance should be sought from the leading manufacturers in training fitters, especially in the types of plant they are likely to meet.

The subject of maintenance on civil engineering contracts is one that in the past has tended to be given a low priority. However, this is a recipe for disaster. The plant presence on site, in terms of a site plant manager/engineer with the proper support is vital to successful contracting. This is particularly true on overseas contracts where the equipment may be operating under arduous conditions.

36.4.3 Plant spares and stock control

Maintenance costs are a major component of the total ownership costs for any group of plant and spare parts will account for around 50% of maintenance. Labour is fairly predictable in the short term, but the use of spare parts can vary widely depending on the level of unforeseen breakdowns. It is therefore difficult to control and requires constant management attention. This is particularly true on overseas contracts where supplies are difficult to procure locally or take time to import. In this situation, it becomes necessary to carry a much higher level of spares stocks than would normally be expected on a large UK contract. In fact, there have been several cases where an overseas job has been nearing the end of the contract period, when somebody has suddenly realized that they are still carrying a large stock of spares which are unlikely to be used. Not only has cash been tied up unnecessarily in surplus stocks but there is also a situation where there is no control.

Inevitably, spares will be ordered for a specific repair job but will not be used. In this case, they must be returned to the supplier for immediate credit or they must be put into stock. Unless this is done, there is a real danger that each fitter will build up under his bench a heap of unidentified spares over which there is no control.

36.4.3.2 Spares stocks

In theory, spares stocks should be kept to an absolute minimum, but in practice manufacturers have become less efficient in this area and it may be necessary to hold buffer stocks. This will depend to a large extent on the lead time when ordering. Money tied up in stocks is dead money and requires tight control. To start with, spares stocks must relate to current machines, as obsolescence can present a problem. When plant becomes obsolete or there is a change of manufacturer, the stocks of spare parts should be run down in good time so that sites and depots are not left holding dead stock.

Inevitably, spares will be ordered for a specific repair job but will not be used. In this case, they must be returned to the supplier for immediate credit or they must be put into stock. Unless this is done, there is a real danger that each fitter will build up under his bench a heap of unidentified spares over which there is no control.

36.4.3.3 Stock control

The most basic form of stock control is the bin card. A card is issued for each item held in stock and it is designed to show the part identification number, the stock code number and details of receipts and issues of that item. From the simple card it is possible to move to a computerized system, where similar information is recorded on the computer files for easy reference on screen. The type of system adopted depends on the scale of operations, but if in doubt start with a manual system until a need for something more sophisticated can be proven.

The requirements for any stock control system are ideally that it should provide information on:

(1) The numbers of each item theoretically in stock at any one time. This can be compared with physical stocks by a

However, a tight control must be kept on ordering and stock levels.

(2) Specific spares which can be readily identified to a particular machine and repair job. Generally, they are ordered only as required, but it may be necessary to carry a small stock if there is a pattern of certain repairs recurring.

(3) Consumable items such as lubricants, welding rods, gas, etc. which are fast-moving and which are part of the workshop overhead costs. It is impractical to allocate the cost of these items to any particular repair.

Wherever possible, spares should be ordered for a specific repair and the items should be costed against the individual machine so that there is a financial control not only of the overall level of purchases but also of the cost of spares consumed by any particular machine.

At the start of any major contract, plant management should investigate the local availability of spares in each of the above categories for each of the types of plant likely to be used on that job, with a view to deciding on whether it is necessary to carry site stocks and at what level. In fact, on a major project, the manufacturer may be asked to suggest a level of spares appropriate to support the plant. As an extension to this, the manufacturer may be prepared to supply a stock of basic spares on a consignment basis, i.e. they are paid for only as used. In any event, it may be wise to have a buy-back agreement on spares so that you can recover most of the cost on any items which are returned in good condition at the end of the job. However, consignment stocks and buy-back agreements do not absolve the contractor from the responsibility to store and document stocks properly.

36.4.3.1 Spares categories

Spare parts can be classified as follows:

(1) Cheap fast-moving items which are used regularly for routine maintenance and repairs. Filters, spark plugs, bulbs, etc. are typical examples. Because they are fast-moving, a stock must be kept so that fitters can obtain them on demand. Generally, because of their value, they cannot be identified with any particular machine repair.
count. If there is a major discrepancy, there should be an investigation.

(2) The movements into and out of stock.

(3) Minimum and maximum stock levels to control re-ordering.

(4) Suppliers and purchase prices.

The fixing of minimum and maximum stock levels is an important part of stores control. Based on the following factors: (1) purchase lead time; (2) historical consumption; (3) future consumption; and (4) economic order quantity, it should be possible to define these levels. Any person in the stores then has sufficient information to know when and how much to re-order. It is even possible to arrange automatic re-ordering when minimum levels are reached. However, this has dangers in a construction environment where circumstances can change quite quickly.

36.4.3.4 Stocktaking procedures

Regular stocktaking is vital not only as part of the annual financial accounting procedures, but also as a management control on the security and level of stocks. It can be done annually as a one-off exercise when the stores are closed and a total physical check is carried out. However, this can be difficult to organize and it may be preferable to opt for a system of progressive stocktake in which different sections of the stores are checked progressively throughout the year, so that the whole stores are completed within the 12-month period. If it is decided to alter the basis of stocktaking, this should not be done without consulting the accountants.

36.4.4 Licensing and insurance

36.4.4.1 Licensing

At one time or another, it is necessary to move heavy civil engineering plant and vehicles on the public roads, particularly dumptrucks, lorries and similar items which are designed for carrying materials. Within the UK, there are laws covering road traffic in general including various licensing arrangements. Although the UK statutory requirements are being brought into line with EEC Regulations, in other overseas countries there will clearly be other sets of legal requirements, which may or may not follow European lines. However, it is sensible to define briefly vehicle licensing as it applies in the UK. This will then provide a reminder or checklist against which overseas requirements relative to any particular country can be checked.

Licensing of drivers. Basically, in the UK no person may drive on the public roads without a licence as a result of passing a driving test. There are different classes of licence depending on the chassis. There are various classes of licence depending on the nature of the vehicle to be driven. Also, the minimum age at which a person may drive on the public roads varies with the class of vehicle. Further details of these regulations and requirements can be obtained from local licensing offices.

However, in order to drive a heavy goods vehicle a person must hold a separate HGV licence. This licence covers vehicles with a gross weight of over 7.5 t as shown in the plate fitted to the chassis. There are various classes of licence depending on the classification of the vehicle and in order to obtain the appropriate class of HGV licence a driver must pass a separate test. However, the drivers of certain types of construction equipment are exempt from the HGV requirements. This includes specialist vehicles such as road rollers, engineering plant, works trucks and digging machines.

Operator's licensing. In 1968, under the Transport Act, licensing was introduced for all firms operating goods vehicles exceeding 3.5 t gross vehicle weight. The licence includes all such goods vehicles owned by the holder of the licence together with all vehicles temporarily in his possession on loan or hire. The UK is divided into a number of traffic areas, each of which will issue a licence for the user's operating centres contained within that area. Before granting a licence, the traffic authority will take into account the user's ability to maintain and operate the vehicles on the licence in a safe condition. They must be satisfied that the user has formal procedures for inspecting and maintaining the vehicles on a regular basis although this work can be subcontracted out to a competent garage. Nevertheless, the user still carries the overall responsibility. However, under this and other legislation there are certain exemptions where vehicles perform less than 9.66 km per week on the public roads.

As far as major civil engineering sites are concerned, this whole aspect of operator's licensing has particular significance. If qualifying goods vehicles from the site are to be used on the public roads, it then becomes an operating centre and must comply with the legislation. If this entails a new licence or additions to an existing licence in that area, account must be taken of the time delay in obtaining the necessary authority. Under an operator's licence the firm is required to keep certain minimum records for a period of at least 15 months available for scrutiny by Department of Transport officials.

All heavy goods vehicles are now fitted with a plate following an inspection at a goods vehicle testing station within certain time limits. This plate sets out the vehicle's prescribed axle and gross weights. At the same time there will also be a test of roadworthiness. Every 12 months thereafter, the vehicle must be submitted for retesting for roadworthiness.

Drivers' records and hours. Within the European community including the UK there are now clearly laid down limits to the hours a person can drive a vehicle over 3.5 t gross vehicle weight both on a daily and a weekly basis. These limits should be checked for any particular country of operation. Also, the use of tachographs, i.e. automatic recording devices, is a statutory requirement.

Construction and Use Regulations. The Motor Vehicles (Construction and Use) Regulations control the specification of vehicles which can be used on the public roads. However, certain items of heavy equipment, i.e. mobile cranes and similar construction equipment which are outwith the general Regulations can be authorized under the Motor Vehicles (Authorization of Special Types) General Order 1979.

The foregoing paragraphs are intended only as a general guide. Legislation can and does change. Therefore, where a site activity involves the use of public roads, the local statutory requirements should be checked beforehand.

36.4.4.2 Insurance

Within any construction organization, insurance will be taken out to cover a wide variety of risks, some of which will relate to the operation of the plant and equipment. The need for insurance can arise for the following reasons:

(1) A statutory or legal requirement. For example, in the UK vehicles must have minimum third party cover.

(2) Contractual requirements. Certain conditions of contract, i.e. Institution of Civil Engineers conditions, will place insurance requirements on the contractor, particularly as far as plant is concerned. However, it is worth noting that, where plant is hired-in under a CPA Hire Agreement, there is a footnote to the terms in that Agreement which states that, unless otherwise agreed, the hirer is responsible for
insuring against the liabilities set out in clauses 8 and 13. This is not the same thing as a contractual obligation to insure, as insurance is not specifically mentioned in the actual conditions of hire.

(3) Commercial risk. Some companies will extend their third party vehicle insurance to cover comprehensive risks including damage to the vehicle itself. Others will consider it more economical to carry this risk themselves.

The various types of insurance found within a construction company and their effect on plant risks are set out in the following paragraphs.

Employers’ Liability and Public Liability policies. These insurances have only a very limited impact on plant operations, insofar as they provide cover in respect of injury to employees and to the public. However, where plant is hired-in under the CPA Agreement with an operator, the hirer is usually asked to indemnify the owner against claims from the operator or from the public.

Contractors’ All Risk policy. This policy provides cover for the contractor against loss or damage affecting the contract works. This includes any plant, equipment, tools and temporary buildings whilst they are on the site enabling the contractor to recover the full cost of anything which is damaged. The policy will also protect the contractor against any indemnity claims from plant hire firms where their plant is on hire under a CPA-type agreement. Certain specialist types of plant, e.g. tower cranes, may have to be declared separately in view of the risk involved. Also marine plant may be the subject of a separate marine policy.

Plant insurance. Major contractors are unlikely to take out blanket damage cover for their general plant as it can normally be dealt with under another policy. Similarly, mechanical breakdown is not normally insured, as the contractor is prepared to stand any risks of that nature. However, steps should be taken to ensure that equipment, including that which is hired-in, is covered for damage, whilst it is not on site under the umbrella of the Contractors’ All Risk policy. For example, there is the risk when it is being stored whilst in the plant depot or in transit between locations other than sites.

Plant and transport licensed for use on the public highway will also be covered by the Motor Vehicle policy.

Engineering insurance. Certain high-risk types of plant, i.e. cranes, hoists and pressure vessels, are subject to regular statutory inspection and testing and are covered under a separate Engineering policy. This inspection, etc. can be carried out by qualified insurance company engineers under the policy, which will then also include cover against the risks of operating that type of plant.

Motor vehicle insurance. As mentioned earlier, plant and transport used on the public road requires motor vehicle insurance. By law, this must consist of minimum third party cover for personal injury. Additional comprehensive insurance is available but many commercial firms prefer to accept their own risks where damage to their own vehicles is concerned.

This has been a brief general guide to insurance as it affects plant and equipment used in the UK. In other countries, the statutory requirements and the commercial risks may warrant an altogether different approach.

36.5 Plant control

In section 36.4.2 I highlighted the contribution made by good maintenance systems to the efficient operation of plant. In addition, there are other controls which must be exercised by the prudent contractor in order to achieve effective plant selection and operation. These can be divided into: (1) operational controls; and (2) financial controls. There is no use selecting the right plant, if it is not then used under controlled conditions. Furthermore, there must be some effective measure of the operational costs, so that management can review the financial performance of different items or types of equipment, to ensure that it compares with the projections made at the time of original selection.

36.5.1 Operational controls

On any civil engineering contract, the plant and equipment requirements should be channelled through one member of the site management team, whether this be the site plant engineer, site agent or even office manager. In this way, one person is responsible for:

1. Issuing requisitions and orders to the company plant department or to outside hire companies.
2. Progressing orders to ensure that requirements are delivered on time.
3. Making arrangements for plant to be checked over on receipt. This is essential to ensure that items are in good working order and safe to operate and is of particular importance where external plant is concerned.
4. Maintaining a schedule of items located on site. This schedule should be reviewed weekly with the site management team so that equipment is released off-hire as soon as it is finished with, thereby minimizing hire charges. It should also be possible to identify losses of, and damage to, plant and equipment at the earliest possible moment. It is quite commonplace for management to discover that quantities of equipment cannot be accounted for when the site has been finally cleared, with the result that unnecessary hire charges have been incurred.
5. Ensuring that details are kept of working time, breakdowns and standing time. In the case of operated plant, the drivers, both internal and external, must complete weekly time-sheets which will show this information in detail and the reasons for plant not working. From these sheets, site management can weed out under-utilized plant together with items which are unreliable.
6. Suppliers’ invoices must also be checked in detail to ensure that the site is not paying for plant when it is unavailable due to breakdown, etc.
7. Maintaining documentary records to include copies of test certificates and inspection reports relating to statutory requirements on cranes, hoists, pressure vessels and general lifting tackle. Also arranging where appropriate for the necessary tests and inspections to be carried out.
8. Controlling the issue of fuel and maintaining fuel consumption records.

Unless this system of control is adopted, there is real danger that one section of the contract will be obtaining fresh plant whilst similar items lie idle on other parts of the site.

36.5.2 Financial control

It is essential that all items of capital plant and equipment owned by the contractor can be identified by means of a separate plant identity number. This applies to all mechanically
driven items even down to electric tools. However, it is clearly impossible to identify separately items of nonmechanical plant such as scaffolding. From a financial point of view, they will therefore be treated on a group number basis. Once plant items and groups have been identified, these numbers can be used as cost centres against which it is then possible to allocate not only the internal hire income but also the direct operating costs. This entails:

(1) The completion of fitters' and drivers' time-sheets in order that they can allocate their time to the particular item of equipment on which they are working. This time can then be converted into a labour cost using standard labour rate.

(2) The allocation of purchase orders for all spares and materials to specific cost codes. Wherever possible, purchases will be costed direct to individual machines or equipment groups except where they are for stock or cannot be identified specifically.

(3) The recording of the issue from stock of fuel, etc. to individual machines.

Within a construction company, the income and direct costs against each plant number can be gathered and presented as a profit/loss situation over a defined period, i.e. annually. In this way, management can see if the hire rate used has effectively covered the operating costs and provided sufficient surplus to pay for overheads and the indirect costs.

The plant department will therefore be responsible for accumulating all the costs incurred against the company-owned equipment and for monitoring its financial performance. Some of these costs will arise at site level and there must, therefore, be an agreed system for ensuring that all costs are fed back to the central plant cost-control point. It has been found that modern computer systems are ideal for gathering and reporting plant financial information. Once the plant items and their identification code numbers have been stored on the computer together with the site location codes, it is comparatively simple for the computer to be programmed to deal with plant administration. Once the cost data has also been added to the computer files, the following information can be regularly produced: (1) the plant and equipment asset register and hire rates; (2) internal hire invoices; (3) accumulated plant costs and profitability; and (4) plant utilization. Where major sites have their own terminals linked to a central computer, they can have direct access to plant information subject to certain operating restrictions.

On large overseas contracts where firms own and operate their own plant, it is possible, with the aid of a micro-computer based on the site, to identify and control all the equipment which is supplied to that site.

**Bibliography**


Health & Safety Executive. *Guidance notes*. This series of guidance notes includes a section on plant and machinery.

See also various government publications relating to: The Health and Safety at Work Act 1974; Road Traffic Act 1972; and Construction Regulations 1961 and 1966.