

Specification for

Single bucket excavators of the crawler-mounted friction-driven type

Co-operating organizations

The Mechanical Engineering Industry Standards Committee under whose supervision this British Standard was prepared consists of representatives from the following Government departments and scientific and industrial organizations:—

Admiralty*	Institute of Petroleum
Air Ministry	Institution of Civil Engineers*
Associated Offices Technical Committee*	Institution of Gas Engineers
Association of Consulting Engineers (Incorporated)*	Institution of Heating and Ventilating Engineers
British Chemical Plant Manufacturers’ Association	Institution of Mechanical Engineers*
British Compressed Air Society	Institution of Mechanical Engineers (Automobile Division)
British Electrical and Allied Manufacturers’ Association*	Institution of Production Engineers*
British Engineers Association	Locomotive Manufacturers’ Association
British Internal Combustion Engine Manufacturers’ Association	Machine Tool Trades Association
British Iron and Steel Federation*	Ministry of Fuel and Power*
British Railways, The Railway Executive*	Ministry of Labour and National Service (Factory Department)*
Crown Agents for the Colonies*	Ministry of Supply*
Department of Scientific and Industrial Research	Ministry of Transport*
Engineering Equipment Users’ Association	Ministry of Works
Institute of Marine Engineers	Office of the High Commissioner for India
	War Office*

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this standard:—

Association of Crane Makers	Excavator Manufacturers’ Association
Ballast, Sand and Allied Trades Association	Federation of Civil Engineering Contractors
British Constructional Steelwork Association	Institution of Engineering Inspection
Cable Makers Association	Institution of Structural Engineers
Dock and Harbour Authorities Association	Ministry of Agriculture and Fisheries
Engineering and Allied Employers National Federation	National Federation of Building Trades Employers

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¹⁾ BS 1775, "Steel tubes for mechanical, structural and general engineering purposes."

Foreword

This standard makes reference to the following British Standards:—

- BS 7, *Rubber-insulated cables and flexible cords.*
- BS 46, *Keys and keyways and coned shaft ends.*
- BS 168, *Industrial electric motors and generators.*
- BS 302, *Round strand steel wire ropes for cranes.*
- BS 436, *Machine cut gears. A. Helical and straight spur.*
- BS 545, *Machine cut gears. B. Bevel (with helical, curved and straight teeth).*
- BS 591, *Wrought iron and mild steel hooks of the “C” or Liverpool type.*
- BS 621, *Wire ropes of special construction for engineering purposes, inclusive of cranes, lifts and excavators.*
- BS 649, *Internal combustion engines for stationary and industrial purposes and auxiliary purposes on shipboard, excluding carburettor-type engines.*
- BS 693, *Oxy-acetylene welding in mild steel.*
- BS 721, *Machine cut gears. C. Worm gearing.*
- BS 765, *Internal combustion engines, carburettor-type, excluding aero-engines.*
- BS 825, *Mild steel shackles for lifting purposes.*
- BS 938, *Metal arc welding as applied to tubular steel structural members.*
- BS 980, *Steel tubes for automobile purposes.*
- BS 1083, *Precision hexagon bolts, screws, nuts (B.S.W. and B.S.F. threads) and plain washers.*
- BS 1116, *Flexible trailing cables for quarries and metalliferous mines.*
- BS 1775, *Steel tubes for mechanical, structural and general engineering purposes.*
- BS 1856, *General requirements for the metal arc welding of mild steel.*

NOTE Attention is also drawn to the list of British Standards given in Appendix E.

The object of this specification is to secure the general observance of such fundamental principles as appear desirable to ensure reliability and safety without restricting the excavator manufacturer in his selection of the most appropriate design for the purpose in view. The specification gives the minimum requirements for single bucket excavators of the sizes enumerated.

It should be noted that the factor of safety for excavators is arrived at on a basis different from that used in the crane standards. In this case the factor is related to the maximum engine output and not to the maximum working load, and the use of the machine as a crane is limited by stability conditions.

The appendix dealing with the design of struts has been prepared to follow the general method of application of the Perry-Robertson formula adopted in other British Standards.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 44 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard applies to single bucket excavators of all sizes up to $2\frac{1}{2}$ cu. yd. bucket capacity, in which the various motions are controlled through friction clutches from a single power unit.

The shovel capacity ratings, in cubic yards, of the excavators covered by this standard are as follows:—

$\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, 2 and $2\frac{1}{2}$ cu. yd.

The types of equipment dealt with are as shown in Figure 1–Figure 7.

2 Definitions

2.1

face shovel

an excavator with the type of “front end” equipment shown in Figure 11, p. 19

2.2

dragline

an excavator with the type of “front end” equipment shown in Figure 12, p. 21

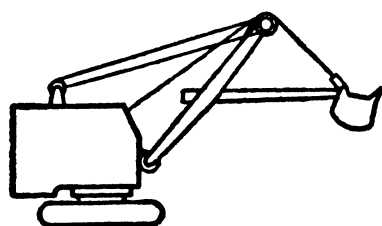


Figure 1 — Face shovel

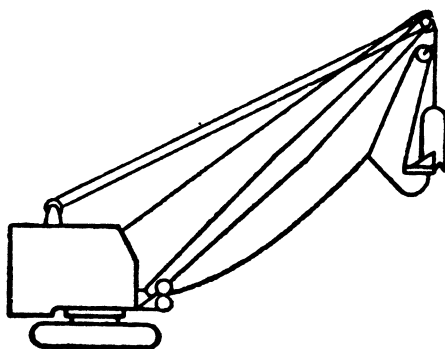


Figure 2 — Dragline

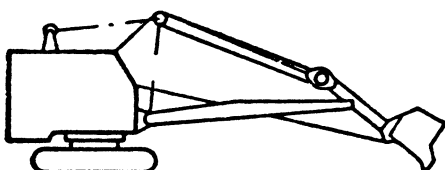


Figure 3 — Drag shovel

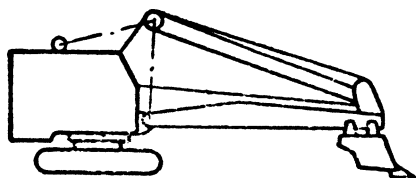


Figure 4 — Skimmer

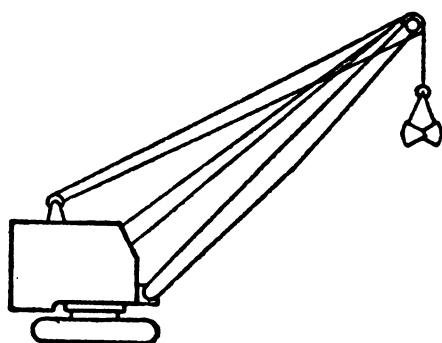


Figure 5 — Grabbing crane

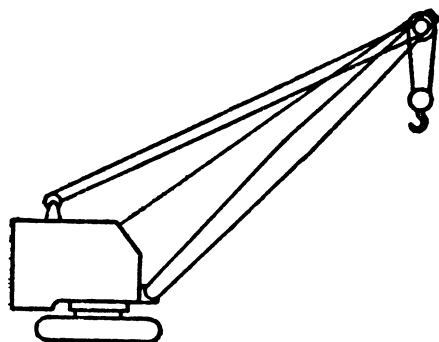


Figure 6 — Crane

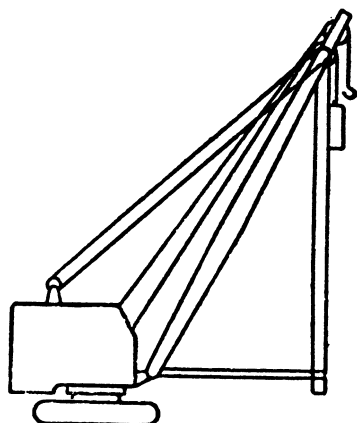


Figure 7 — Pile driver

2.3**drag shovel**

an excavator with the type of “front end” equipment shown in Figure 13, p. 23, usually employed for trench cutting

2.4**skimmer**

an excavator with the type of “front end” equipment shown in Figure 14, p. 25

2.5**grabbing crane**

a machine with the type of “front end” equipment shown in Figure 15, p. 27, and operated by one or two ropes

2.6**lifting crane**

a machine of the type shown in Figure 16, p. 29, operated by a single or multi-part rope

2.7**pile driver**

an excavator with the type of “front end” equipment shown in Figure 17, p. 31

2.8**crawlers**

the self-laying tracks and associated mechanisms assembled in frames as units

2.9**governed engine speed**

the speed at which an engine operates to give full load for a particular governor setting

2.10**single rope pull**

the pull at the mean rope centres on the drum, calculated from the horse power available, as defined in Clause 6 a)

2.11**rope speed**

the speed in feet per minute of a single rope as defined above

2.12**working radius**

the horizontal distance measured from the axis of rotation of the machine to a vertical line through the centre of gravity of the suspended load, when the machine is standing on a level surface

2.13**“front end” equipment**

all fittings and attachments from, and including, the jib or boom footpin(s), together with any extra fittings that may be required on the revolving frame to operate such equipment

2.14**jib or boom**

the main member of the “front end” equipment extending from the pins or sockets provided on the rotating frame

2.15**jib or boom length**

the axial distance between the centres of the footpin(s) and the hoist or head pulleys

2.16

jib or boom angle (α)

the angle between the horizontal line and the straight line drawn between the centres of the boom socket or boom footpin and the centres of the hoist or head pulley pin

2.17

bucket

the digging and carrying part of the excavator

2.18

shovel crowding and retracting

the act of moving the bucket and the bucket arm outwards and inwards

2.19

shovel bail

the member sometimes used to attach the bail block or hoisting rope to the bucket (see Figure 11, p. 19)

2.20

bail block

the sheave and its housing by which the hoisting rope is connected to the bucket either directly or through a bail

2.21

rated capacity of bucket

the “struck” capacity, without taking into account any material adhering to the projecting parts of the teeth for dragline buckets, see Appendix G

3 Information to be supplied with inquiry or order

All information regarding the conditions under which the machine is to be used, together with the particulars given in Appendix A, so far as they apply, should be supplied with the inquiry or order.

4 Information to be supplied by the manufacturer

The manufacturer shall supply with the tender the information enumerated in Appendix B.

5 Compliance with statutory requirements

The purchaser shall, at the time of the inquiry or order, disclose to the manufacturer any statutory requirements to which the machine will be subject when in use and which are intended to ensure its safe working, and the machine shall be so constructed as to comply with these requirements.

A list of statutory provisions affecting excavators and cranes to be operated in Great Britain is given in Appendix C.

6 Power unit

a) *Engine H.P.* The engine horse power shall be the brake horse power that can be carried for one hour at the rated governed speed provided that this output does not exceed 110 per cent of the 12-hour rated working load as defined in BS 649, “*Reciprocating internal combustion engines for marine auxiliary and land service (excluding carburettor type)*,” or BS 765, “*Internal combustion engines, carburettor type, excluding aeroengines.*” If the engine is required to work under tropical conditions this shall be stated by the purchaser at the time of the inquiry or order.

It is recommended that starters should be fitted to power units of 30 h.p. and over.

b) *Electric motor.* When an electric motor is fitted it shall have a maximum torque (assuming equal prime mover speeds) of about 5 per cent above the engine maximum torque, provision being made for the peak load voltage drop normally met in practice on excavator installations. Any motor fitted shall comply with BS 168, “*Industrial electric motors and generators.*”

7 Service conditions

a) *Excavator*. The machine, when equipped as an excavator, shall be deemed to be working under service conditions when it is:

- i) Performing a working cycle, namely:
 - A. digging with maximum effort without stalling the power unit.
 - B. hoisting and slewing simultaneously to the dump position.
 - C. returning to the digging position.

ii) Travelling limited distances, including frequent steering (see Clauses 26 and 27).

b) *Crane*. The machine, when equipped as a crane, shall be deemed to be working under service conditions when it is handling any load up to the safe working load, under the following conditions:—

- i) Performing a working cycle, namely:
 - A. hoisting or lowering the load or the jib.
 - B. hoisting and slewing simultaneously to the unloading position.
 - C. returning to the lifting position.

ii) Travelling limited distances with the load, and on reasonably level ground, including frequent steering (see Clauses 26 and 27).

8 Materials

The materials used in the construction of the machine shall comply with the requirements specified in the appropriate British Standards enumerated in Appendix E, or shall possess qualities equivalent to those possessed by materials complying with such British Standards.

9 Factor of safety

The machine shall be so designed and constructed that when it is working under service conditions (see Clause 7) the stress in any part shall not exceed the lowest ultimate tensile stress of the material divided by the specified factor.

The factor of safety for all parts of the machine shall be not less than 4 for steel and not less than 6 for cast iron, except when a maximum allowable working stress is hereinafter specified.

10 “Front end” equipment

The machine shall be so constructed as to permit the mounting and efficient working of face shovel, dragline, grab, crane, or pile-driving equipment and, where practicable, skimmer or drag shovel equipment.

11 Standard jib length

For machines having a rated capacity as indicated below, the standard length of dragline or crane jib shall be as follows:—

Rated shovel bucket capacity	Standard length of dragline or crane jib
cu. yd.	ft.
$\frac{1}{4}$	25
$\frac{3}{8}$	28
$\frac{1}{2}$	40
$\frac{5}{8}$	40
$\frac{3}{4}$	40
1	45
$1\frac{1}{4}$	45
$1\frac{1}{2}$	45
$1\frac{3}{4}$	50
2	55
$2\frac{1}{2}$	60

NOTE Other lengths, within title limits of stability (Clauses 14 and 15) may be supplied if required by the purchaser. It is recommended, however, that whatever length of jib it is intended to employ, the duties should be such that the angle of the jib may approach but not exceed 75° to the horizontal when the machine is stationary.

12 Crawler bearing length

The length of the crawler bearing on the ground shall be computed as follows:—

Centre distance of sprocket and end idler roller plus the pitch dimension of one track link.

13 Face shovel working range

The normal working ranges and dimensions of face shovels (Figure 11, p. 19) shall be those appropriate to a jib angle, α , of 45° .

14 Forward stability

a) *Tipping load.* The tipping load is the load which brings the machine, when it is standing on hard level ground with the jib in any position, to the point of tipping. For this purpose the tread belts shall not be tight, so that at the moment of tipping the tread rollers lift from the upper side of the tread belt in contact with the ground.

b) *Stability*

i) *General.* The stability of a machine shall comply with the requirements of sub-clauses ii) to vi) appropriate to the type of front end equipment fitted and for this purpose the machine shall be in working order (with the cooling system full and the main fuel tank half-full) and standing on hard level ground.

ii) *When equipped as a crane or dragline.* The stability shall be defined in terms of the safe working load and shall be determined according to the following formulae. The value obtained with Formula No. 1 shall not exceed 66⅔ per cent and the value obtained with Formula No. 2 shall be not less than 50 per cent.

For grabbing crane duties the safe working load shall be taken as 85 per cent of the value found by Formula No. 1 or 75 per cent of the value found by Formula No. 2. In this case, the safe working load is the combined weight of the grab and contents.

For dragline duties the safe working load is the combined weight of the bucket and spoil.

Formula No. 1.

$$\frac{100}{1 + \frac{0.01 \times R \times F}{B}} = \text{safe working load expressed as percentage of tipping load.}$$

where R = Radius at which load is lifted, in feet.

F = Coefficient as per values given in the following table.

B = Smaller side of rectangle forming base; this rectangle being formed by the centre-to-centre distance of the driving sprockets and the tensioning rollers as the other.

Formula No. 2.

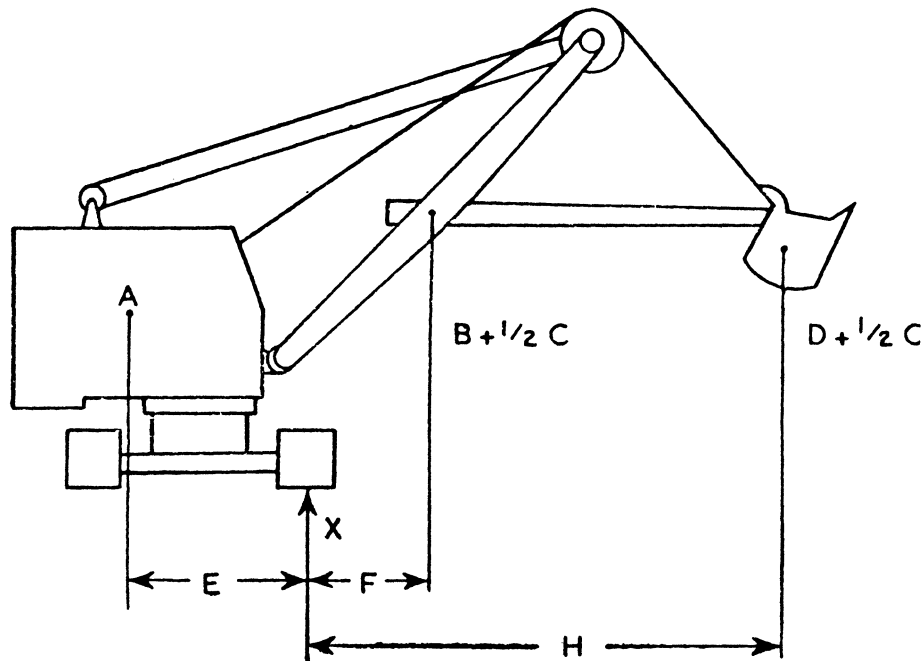
$$\frac{R \times F}{B} = \text{percentage of safe working load to be added to bring machine to the point of tipping.}$$

where R, F and B are as defined for Formula No. 1.

Dimension "B"	Coefficient "F"
ft.	
10 or more	11.1
9	11.2
8	11.5
7	11.9
5.5	12.8
4.75	13.4
3.5 or less	14.7

NOTE When Formula No. 1 is used, the safe working load will be a percentage of the tipping load. When Formula No. 2 is used, the result will show the percentage of the safe working load which is to be added to the safe working load to give the tipping load.

iii) *When equipped as a face shovel.* The stability shall be determined according to the following formula and the stability value so obtained shall not exceed 56 per cent.



A = total weight less B, C and D.

B = weight of boom, boom machinery, saddle block and the weight of the ropes.

C = weight of bucket arm.

D = weight of bucket, bail block and spoil.

X = fulcrum point.

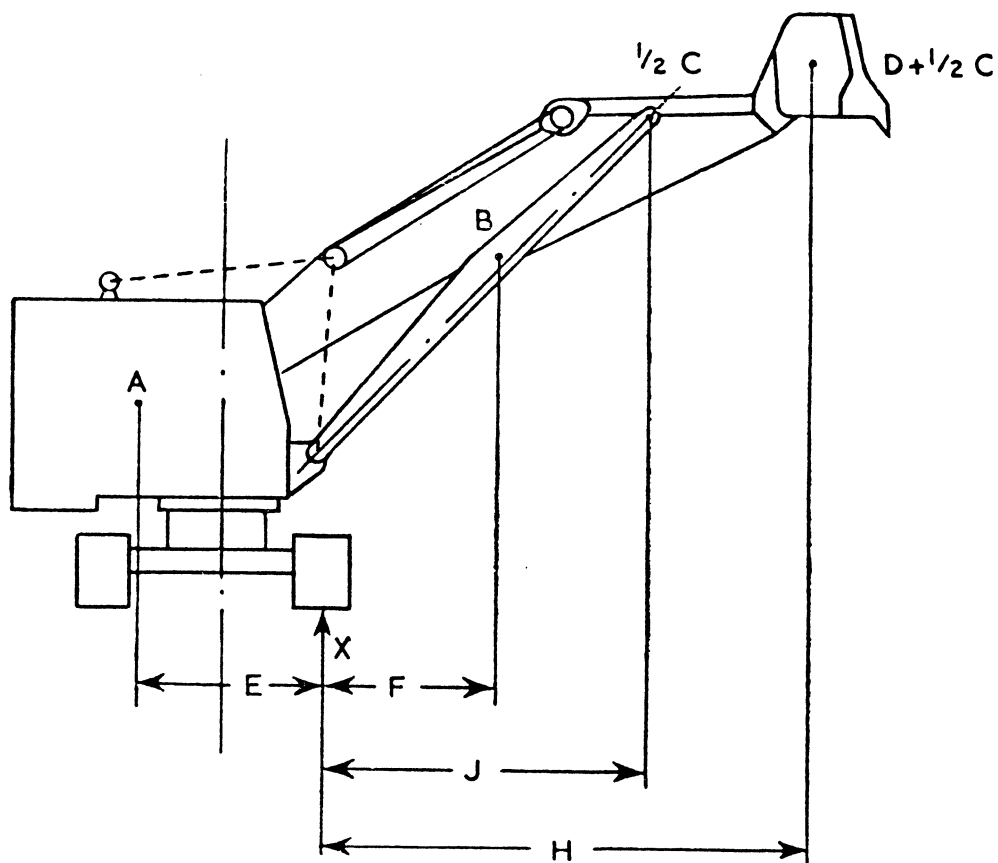
Backward moment = $(A \times E) - [(B + \frac{1}{2} C) \times F]$.

Forward moment = $(D + \frac{1}{2} C) \times H$.

Stability per cent = $\frac{(D + \frac{1}{2} C) H}{(A \times E) - [(B + \frac{1}{2} C) \times F]} \times 100$.

Figure 8

iv) *When equipped as a drag shovel.* The stability shall be determined according to the following formula and the stability value so obtained shall not exceed 56 per cent.



A = total weight (bare machine).

B = weight of boom, boom machinery and half weight of the ropes.

C = weight of bucket arm.

D = weight of bucket, bail block and spoil.

Backward moment (machine less load) = $(A \times E) - (B \times F)$.

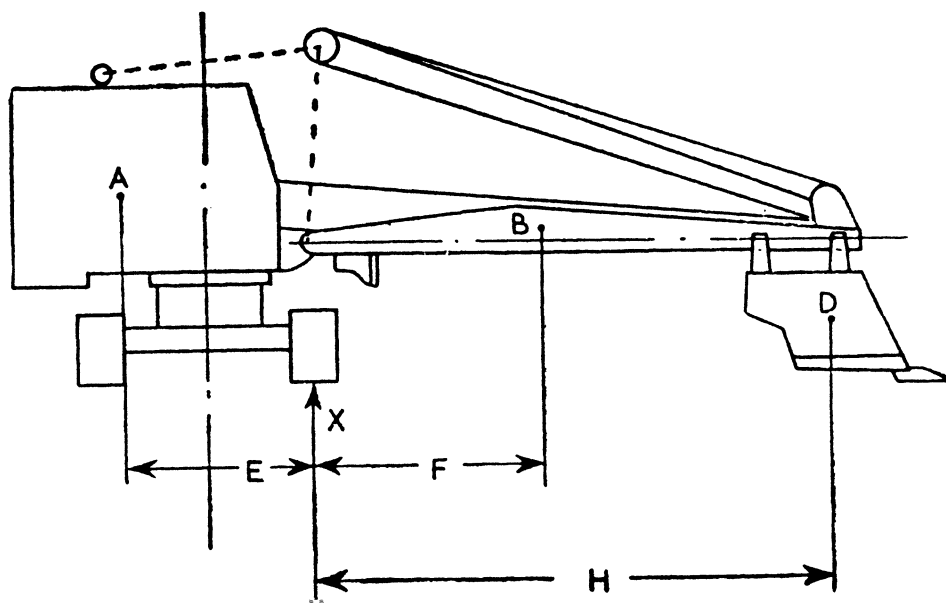
Forward moment (due to load, spoil, bucket and handle) = $[(D + \frac{1}{2} C) \times H + (\frac{1}{2} C \times J)]$.

Stability per cent = $\frac{[(D + \frac{1}{2} C) \times H]}{[(A \times E) - (B \times F) + (\frac{1}{2} C \times J)]} \times 100$

NOTE The condition of maximum stability is normally obtained with the boom and bucket arm approximately horizontal.

Figure 9

v) *When equipped as a skimmer.* The stability shall be determined according to the following formula and the stability value so obtained shall not exceed 56 per cent.



A = total weight (bare machine).

B = weight of boom, boom machinery and half weight of the ropes.

D = weight of bucket and spoil.

X = fulcrum point across crawler.

Backward moment (machine less load) = $(A \times E) - (B \times F)$.

Forward moment (due to load, spoil and bucket) = $D \times H$.

$$\text{Stability per cent} = \frac{D \times H}{(A \times E) - (B \times F)} \times 100$$

Figure 10

vi) *When equipped as a pile driver.* When lifting the pile and the hammer, and taking account of the full weight of the leaders, the stability shall be equivalent to that specified for the normal crane stability rating.

15 Backward stability

To ensure adequate backward stability of the machine when used as a crane, dragline, or for grabbing duties, the centre of gravity of the machine, shall be not farther from the axis of rotation than 70 per cent of the minimum radial distance from the axis of rotation to the backward tipping fulcrum. For this purpose the machine shall be resting on hard level ground, in working order (i.e. with the cooling system full and the main fuel tank half-full) without load, and with the jib at its minimum working radius.

16 Lifting capacity and load indicator

In determining the load that can be lifted at any given radius or in determining the radius at which a given load can be lifted, slings, equalizer beams, and all similarly used auxiliary load-handling devices, shall be considered as part of the load.

The excavator, when fitted with a crane jib, shall bear a legible and permanent inscription stating the length of jib, the safe working loads, the maximum grab or dragline loads, and the appropriate radii.

A clear record of the working radii and of the safe working load at those radii shall be given by means of an indicator which shall be visible to the driver, and also from ground level.

When required by the purchaser an automatic safe load indicator of an approved type shall be fitted.