Economics of Mechanization with Reference to Earthmoving Operation in Pakistan

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Paper No. 424

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Mechanization, which can be simply defined as raplacement of labour, animal or manual with machine is a universal phenomenon. Ever since the advent of Industrial Revolution (Circa 1750 A. D.) mechanization has been spreading in all walks of life. Be it weaving of clothes or producing goods of every day use or providing services for modern living it is the machine which is at the service of man. This mechanization which started in the Western countries has now spread to the underdeveloped countries as well. What has been the cost of mechanization to the developing countries? Apart from social and political price which the traditional societies have to pay. the mechanization even in economic terms appears to have been extremely costly,

In international trade, the terms of trade have been against the developing countries, which mostly export raw material, whereas the developing countries export machinery prices of which has been rising annually at the rate of 5 %. Thus there has been a net transfer of resources from developing to developed world on account of mechanization. It is, therefore, imperative that the economics of mechanization be investigated and ways and means be found to reduce the cost of mechanization. For this purpose some data is given below to indicate probable economic cost of mechanization of earthmoving operations in Pakistan. The conclusion drawn may serye a pointer in other fields.

Earthmoving is as old as man himself. For the building of small dwellings or modern Skyscrapers, railways or highways, canals or drains, water reservoirs or high dams, all involve earthmoving in one form or the other. Traditional way of earthmoving utilized manual or animal power. But with the advent of machine, its use became more and more popular. with the result that earthmoving by machine is now an establishsd method in the developed countries and construc-

tion of earthmoving machinery is a big Industry. In fact more developed a country the more sophisticated earthmoving machinery it has.

In developing countries like Pakistan, where in the first stage of dovelopment many infra-structures have to be built, earthmoving is required to be done on a large scale. In a study carried out by Ghulam Ahmad & Faruqui in 1958, it was revealed that total earthwork involved in West Pakistan was 490 crores cft. out of which only 100 crores cft. could be done by manual or donkey labour, the rest of the work had to be done by machines. When we consider that total earthwork to be done in Mangla Dam in six years was 202 crores Cft., we cannot but agree that without a big socio-economic change in the country the mechanization of earthmoving has become a necessity.

Apart from moving large volume of earth mechanization becomes imperative as better quality of earthwork is required. Mechanization leads to better compaction and better control or specification.

Also mechanization has made those operarions with machines feasible which were difficuit or well nigh impossible e. g. digging under water.

In Pakfstan mechanization of earthmoving operation started in 1947 after independence. But like many other things this too was done in a haphazard and unplanned manner. A tractor here, a dragline there, but nobody gave thought to the axiom that "tools shape the organization". Thus a tractor replaced Belcha of donkeys ; a truck a number of bullock carts, but the organizatlon to use these machines remained the same. The facilities for proper repairs, servicing, spare parts and trainings were not of such a quallty and a magnitude as to get maximum or even economic return.

A survey carried out in 1959 by a Government Agency revealed that :-

(1) Total Earthmoving Plant/Equipment in Water & Power Section in West Pakistan was worth Rs. 30 crores out of which equipment worth Rs. 10 crores was unserviceable.

(2) Out of serviceable equipment only 50 % was operable.

(3t Down-Time operating equipment was over 75 %.

(4) Spare parts worth Rs. 10 crores were bought in excess of the requirement.

With this state of affairs it was not surprising that more and more equipment

wss being imported. With the arrival of new machinery, the available equipment under repair was left unattended and allowed to become junk, This new plant too became repairable after some time and the Engineers were compelled to import additional new equipment. Thus a vicious circle was created. New plant was imported, it broke down and again new plant was imported.

The first ten years of mechanization thus cost Rs. 1 crore a year, on account of purchase of sub-standard equipment. Between 1959 and 1961 certain organizational changes were made, new procedure and methods were adopted but the vicious circle of importing without repairing old ones and utiliziug these to maximum extent continued. It is estimated that earthmoving equipment between 1959-1969 amounted to Rs. 36 crores (Annexure - I).

A survey carried out in 1973 revealed that out of this total equipment over 50 % was inoperative and out of commission. Equipment worth Rs, 10 crores had to be written off as unserviceable only after working a few hundred hours as it was below standard.

Thus the trend of losses continued even in the second decade of mechanization inspite of the fact that new organizational experiments were carried out.

After the political changes in 1971 tempo of development has increased manifold in the country. Severe floods hit the country in summer of 1973. The volume of earthwork to be done thus increased manifold in Water & Power sector. It became necessary to import equipment worth Rs. 10 crores in 1973-75. This import would haye been unnecessary if the equipment already in the country had been utilized economically.

Thus we see that just because we import sub-standard or non-standard equipment we have been paying heavily for mechanization. This could have been avoided if mechanlzation or earthmoving operation was done in a planned way.

PLANT AVAILABILITY

Machine represents capital and uneconomic use of capital leads to low productivity and consequently to low growth rate and poverty in a society. In case of earthmoving machinery the productivity is extremely low, It is obvious that normally nearly 2/3 of all operable machines remain either under repair or awaiting for repairs. Some reasons for this are :-

(1) Inadequate & insufficient repair facilities.

(2) Sub-standard repairs.

(3) Non-availability of spares.

The one third that is utilized works only 1000 hours a year against 2000 hours which is accepted as international standard for shift working.

Ths main factors for this are :-

(1) Lack of proper equipment management and selection for work.
(2) Lack of trained operators.
(3) Lack of proper maintenance.
(4) Lack of fast moving spares in the field.
(5) Poor logistics.

OUTPUT

It is a general rule of thumb that in heavy machinery yearly output should be equal to the capital cost of the machine. Thus a machine costing Rs. 10 Lacs should give output worth Rs. 10 Lacs a year. In case of earthmoving this is even more true. The total replacement value of machinery in Pakistan is approximately Rs. 200 crores. But considering the factors given above that only 1/3 machinery is used and this too at 1/2 the internatlonal standard (viz,, 1000 hours against 2000 hours a year) and give 1/2 the output/ hour, we get only 1/12th of the desired output viz., 18 - 20 crores/year.

OVERSTOCKING OF SPARES AND INVENTORY

To keep the machinery going, spares are required. Level of spare parts inventory is a function of lead time, and consumption rate. The greater the lead time, the greater is the minimum stock level. It is estimated that spares at the rate of 12½ % annual are required for earthmovlng machines. On account of unscientific inventory control and long lead time caused by archiacs purchase procedures inventory levels are maintained at 3 times the optimum viz., if an inventory for 4 crores is required in normal condition, inventory of 12 crores is maintained. This longer lead time leads to wrong indenting of parts, greater absolescence and wear and tear. Thus it is found that for each 1 crore rupees worth of parts repaired ; parts worth Rs. 3 crores are stocked. On account of long lead time, it becomes difficult to scale parts correctly. Thus nearly 1/3 to 2/3 spares remained unutilized. It was estimated that spares become redundant and obsolete at the rate of Rs. 1 crore a year.

WORKSHOPS.

To repair and overhaul these machines workshops scattered all over the country were established. On account of rivalry between various organization owning these machines, workshop capacities have been created much above the requirement.

It is estimated that over Rs. 4 crores is invested in these workshops. The Workshops are under-utilized and were usually run at a loss.

Considering all the costs, that of (a) owning & under-utilizing the machines (b) Excessive inventories and high rate of obsolescence of spares (c) over capacities of workshops, it will be no wonder that cost of earth work is very high .

However, these costs are never shown, because the accounting systems in vogue donot even attempt to reflect true costs. All the cost factors are never taken into account. The cost per unit of earth work thus only reflects the cost of operation of a particular machine : the other costs are never taken into account.

It was thus found that at one project that cost/1000 Cft. of earthwork was Rs. 9 in the beginning and Rs. 100 after 5 years. This happened because in the beginning repairs costs were low and at the end the repairs became heavy and the repair costs increased.

All over the world method of computing cost of mechanized earth work has almost been standarized and consist of the following elements : —

(*a*) Qwnership cost.
(*b*) Operating costs.

The ownership cost consists of :-

(1) Depreciation of the machine.
(2) Repair cost of the machines.
(3) Interest on investment.
(4) Insurance
(5) Storage cost.

The operation cost consists of :-

(*a*) Cost of P.O.L.
(*b*) Cost of operator.
(*c*) Cost of field repairs.

(*d*) Cost of preventive maintenance.

(*e*) Cost of incilliary plants.

(*f*) Overheads.

By combining the two, hourly cost of operation of machine could be computed. This divided by the hourly output gives the unit rate of earthwork. Against this internationally accepted method the cost/100 Cft. of earthwork done by machine (1½ Cyd. Dragline) as worked out by the various formulas adopted by Government Organizations is given in annexures.

Annexure-II gives the method of computation of cost of 1½ Cyd. Dragline according to Irrigation Manual of Punjab. Annexure-III gives the cost computation for work in G.M.B. for the same machine according to a formula approved in 1965 by Finance Department, West Pakistan. Annexure-IV gives the rates worked out by a formula adopted by MPO in the current year.

It will thus be seen that there is a wide difference in the unit cost. In fact lack of standard costing procedure is one big factor in projecting unrealistic costs of earthwork by machines. The losses are hidden and true costs are never reflected in the books. It is, therefore, imperative that a standard method for computing operation costs of machinery be involved at the National level. This will give at least some basis for ascertaining efficiency of the various organizations and getting true project estimates.

However, none of these rates/unit of earthwork include the costs of factors listed above and which can be enumerated as below :-

(1) Cost of purchase of substandard machines at Rs. 1 crore a year.

(2) Cost of under-utilization at 1000 hours/year against 2000 which is normal. Also cost of using only 1/3 of the plant and low output which is nearly 1/2 of the international standard.

(3) Over capitalization of workshops and underutilization of the same.

(4) Over stocking and obsolescence of spare parts.

If these costs are super imposted on the cost/unit earthwork worked according to formula given in Annexure-IV, the cost of earthwork per unit will come to Rs. 241% Cft. (Annex. V).

The cost of same work done manually according to schedule rate is Rs.83 % Cft. as shown in Annexure-VI.

Thus from our experience in mechanization of earth-moving operation in Pakistan shows that mechanization has been extremely uneconomical. If these high costs are to be avoided we must ensure the following :-

(1) Mechanization should be resorted to where it is a must. In 1964, National Economic Council issued a directive which must be strictly adhered to.

(2) If a Sector of Economy is to be mechanized, immediate manufacturing of machines be undertaken.

(3) As far as possible machinery be standardized. This leads to saving in spares inventory cost and training of manpower.

(4) Local manufacturers of spares as well as machinery be undertaken as soon as possible.

(5) Level of technology imported is very important. Import of sophisticated machinery be avoided unless accompanied by the appropriate organization.

(6) Requisite number of supporting plant for running the production machines be provided.

Annexure—I

IMPORT OF CONSTRUCTION EQUIPMENT DURING 1958 -68

WAPDA	(West Pakistan)	10 crores	(excluding I.B. Equipment).
A.D.C.	,,	7 ,,	
C.D.A.	,,	4 ,,	
B & R	,,	5 ,,	
Agriculture Dopartment		10 ,,	(only earthmoving).

Source :- Paper No. 105; Symposium on Planning for National objectives - West Pakistan Engineering Congress 1973.

ANALYSIS OF OPERATING COST OF 1½ CYD. DRAGLINE

(A) Duration of work

Total days in a year	= 365
Details of days lost.	
Sunday	= 52
Gazetted Holidays	= 12
Day under repair, rains &	= 30
Idle days days lost in shift	= 21
Total :	= 115

Net working days = 250/year.

Net working hour at 8 Hr/day = 250 × 8 = 2000 Hr/year,

II. Direct Charges :

(B) Operational Staff

Operator	1 No.	Rs.	1286.00
Relieving Operator	1/4 No.	Rs.	321.50
Fitter	1 No.	Rs.	951.00
Greaser	1 No.	Rs.	520.00
Cleaner	1 No.	Rs.	520,00
Chowkidar	1 No.	Rs.	446.00
Water man Field	1/4 No.	Rs.	260.00
Storekeeper	1/4 No.	Rs,	428,25
		Rs,	4732.75
			12
	Total :	Rs.	56793.20

(C) **Material**

Diesel 6 gallons/hour

6 × 2000 × 5,50 = Rs. 66,000.00/year.

Lube Oil at 60 gallon/month or 600 gallons/year

Cost at Rs. 20/Gallon = 600 × 20 = Rs. 12000/year.

Greese at 10 Lb/hr or 100 Lbs/year.

Cost of grease at Re. 6/Lb. = 100 × 6 = Rs. 600/year.

Total P.O.L. Cost = Rs. 78.600/-

(D) **Spairs & Replacement Charges.**

Repair factor × (Delivery price − Tyre Cost)

For Dragline annual repair factor is 0.09

$$\frac{0.09 \times 7.98.000}{1000} = \text{Rs. } 64.82$$

= Rs. 129,800

(E) **Miscellaneons**

1.	Transport	Rs.	1000 P.M.
2.	Hutment	Rs.	150 P.M.
3.	Unforeseen	Rs.	50 P.M.
	Total :	Rs.	12000/-

Rate $\frac{1200}{400}$ = Rs. 3.00

ABSTRACT

A – Labour	Rs.	1.92
B – P. O. L.	Rs.	6.88
C – Depreciation	Rs.	10.94
D – Heavy Repair	Rs.	10.94
E – Miscellaneous	Rs.	3.00
Total :	Rs.	33.68
Add overhead 3 %	Rs.	1.01
Rate/1000 Cft.	Rs.	34.69/1000 Cft.

DRAGLINE

Pre - 1963

Details of working expenditure 1½ Cnbic Yard Dragline employed on excayation job for period prior 1963.

The expenditure based on the fact that the Dragline machines shall give a progress of 4 Lacs P. M. working single shift. The actual digging hours have been taken as 7 hours day.

A	Labour	Nos.	Rate	Amount
1.	Chargeman	½	350/-	175.00
2.	Dragline Operator	1	175/-	175.00
3.	Engine Driver	1	150/-	150.00
4.	Greaser	1	90/-	90.00
5.	Water man	½	70/-	35.00
6.	Chowkidar	1	70/-	70.00
7.	Log Book/Store Clerk	½	150/-	75.00
			Total :	770.00

Labour for 1000 Cft. = $\frac{770}{400}$ = 1.92

B - P. O. L.

H. S. Diesel Oil at 6 gallons per hour at Rs. 1.25 per gallon.

$\frac{6 \times 7 \times 25 \times 1.25}{400}$ = Rs. 3.28

(2) Mobilc Oil 60 Gallons P. M. at Rs. 6.10 per gallon.

$\frac{60 \times 6.10}{400}$ = Rs. ·91

(3) Grease 10 Lbs at Rs. 1.00 per lb.

$\frac{10 \times 25 \times 1}{400}$ = Rs. ·62

(4) Cotton Waste 2 Lbs per pay at Rs. 1/00 per lb.

$$\frac{2 \times 25 \times 1}{400} = \text{Rs. } \cdot 13$$

(5) Wire Ropes 200 RFT 1" size at Rs. 2/- per RFT and 200 RFT size 3/8" at Rs. 1/50 per RFT.

$$\frac{2 \times 200 \times 1.5 \times 200}{400} = 1.75$$

(*b*) Oil Filters at Rs. 77/P.M.

$$= \frac{77}{400} = \cdot 19$$

Total B = 3.28 + .91 + .62 + .13 + 1.75 + ,19 = 6.88

(*c*) **Depreciation**

Cost	=	Rs. 3,75,000/-
Life	=	15,000/- hours
Rate P.M.	=	25/-

Therefore depreciation per 1000 Cft = $\frac{25 \times 7 \times 25}{400}$ = 10.94

(*d*) Heavy Repair 100 % of depreciation Rs. 10.94

Indirect charges :

(E) **Depreciation :**

Assuming life of Dragline as 12000 hrs.

Depreciation/hour = $\frac{7.98.000}{12,000}$

Per year = $\frac{66.5 \times 2000}{133000}$ = 1,33000,00

(F) T & P charges at 1 % of the cost for 12 months

$$= \frac{7,98\,000}{100}$$

$$= 7980.00$$

(G) Transport charges lump sum = Rs. 10,000,00

(H) Establishment charges @ 2.5 % of the outlay (B & C)

$= \frac{2.5}{100}$ (124713) = Rs. 3117.80

(I) Audit/Account charges @ 11 % of B & C = 1247.13

(J) **Interest charges :**

10 % of 124713 = Rs. 12470.00

(K) Lump Sum of AM of R of residential LS = Rs. 8000.00

(L) Pension charges at 0.20 % on capital during the year

= Rs. 294.00

(M) Compensation for accident = L. S. = Rs. 5000.00

Total indirect charges = Rs. 2,71,109.00.....(1)

Total dircet charges = Rs. 5,27,622.00.....(2)

Total 1 + 2 = Rs. 7,98,731.00

Operational Cest/hour $= \frac{527622}{2000}$ = Rs. 263.80 Say Rs. 264/-

Output/hour = 2000 Cft.

Unit Rate = Cost/1000 Cft = $\frac{264}{2}$

= Ra. 132/000 Cft.

ANNEXURE — IV

1 S. No.	2 Description	3 Code	4 Orignal Cost Rs.	5 Devaluation effect @ 115%	6 Increased cost.	7 Depreciated rate per year	8 Depreciation cost Rs.
	Crane Dragline 2 Cyd.	306	3,71,306,00	4,27,002,00	7,98,308,00	17%	1,35,712.36
	9 Rep, & O/H rate per year	10 Rep. & O/H cost Rs.	11 Interest p.m.+Ins. rate of col. 6.	12 Interest p.m. + Ins. cost.	13 O/H rete (per year of col. 8 & 10).	14 O/H Cost	15 Annual rental rate.
	15%	1,19,746.20	18%	1,43,695.48	15%	19,997.70	4,19,151.74
	16 Monthly rental rate	17 Hourly rental rate	18 Hourly tyre rental & old rates mm 130% increase	19 Total hourly rental	20 P.O.L. @ actual consumption plus 50% labour + 15% storage charges	21 Labour @ actual pay TA/DA medical EPF supervision charges	22 Field repair @ 6% of 19.
	41,915.17	209.57	—	209.57	38.64	25	12.57
	23 O/H @ 30% of 20+21+22	24 Profit @ 10% of 19+20+21+22 & 23	25 Hourly Opl. rate.				
	24.40	31.12	342.30 / 171.00% Cft.				

Increase in cost of m/c on account of wastage at 10% /annum

$$+\frac{10}{100}(7,98,308)$$

79,831

8,68,139

Say Rs. 8.7 Lac ..... (I)

(A) Depreciation at 17% = Rs. 1.47 Lac ..... (II)

Since one out of 3 machines work the depreciation should increase to 2 times, assessing an efficiency of 66%. = Rs.2.94 Lac ..... (III)

(B) Repair Charges : at 15% of (I) = 1.30 + 1.30 = 2.60 Lac

Assessing that this is made of 1/3 for labour + 2/3 for spares.

The cost of spare = 1/3(2.60) + 2/3(2·60)

= .866 + 1·732 = 2.598

Increased spare item by 3 times = .866 + 3(1.732)

Total repair cost Say = 6.0 " ..... (IV)

(C) Interest charges at the increased cost at 18% = Rs. 1.57

(D) Overheads at 15% of (III & IV) = (2.94 + 6.0) = 1.31

Total annual rental (in Lacs of Rs.)

Depreciation	2.94
Repairs	6.00
Interest	1.57
Overheads	1.31
	11.82

Rental = Rs. 591/hour.

Hourly operation charges as per Annexure-III. = Rs. 133

Total hourly charges = Rs. 724

Assuming output of 2000 Cft/W

Unit Rate $= \frac{724}{2000}$ = Rs. 362

EARTHWORK RATE ACCORDING TO SCHEDULE OF RATES APPROVED BY THE PUNJAB STANDING RATES COMMITTEE W.E.F 1-10-1974.

S : 1 : No.5

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Earthwork excavation in Irrigation Channels, Drains etc, dressed to design section grades and profiles, excavated material disposed off and dressed within 50' lead :

(a) Ordinary soil 0/00 Cft. Rs. 38.35

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Dressing and levelling of Eearthwork to design section etc. complete.

(*b*) Ordinary or hard soil 0/00 Cft Rs. 7.35

Rate for earthwork Excavation without dressing & levelling : Rs. 81.00

Extra for every 50' additional lead or part thereof- for ordinary 0/00 cft. Rs. 2.30

S : 1 : No 8(a)

Rs. 83.30