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An Analytical Review for Search of Optimal Selection & Utilization of Earthwork Equipment in Construction

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Abstract: ***Different types of equipment with various levels/times application times are the characteristic features of all construction projects. Almost every construction project/industry has the most common problem of slow progress and cost overruns due to increasing downtime and decreasing operational efficiency of construction equipment. Construction equipment is involved in construction to such an extent that without it no construction activity can be performed. In recent years, with the continuous advancement in technology and improvement of urbanization, there have been more and more construction project/equipment requirements resulting in either the project delay or cost enhancement As the most critical element earthwork is responsible for not only successful completion of project within schedule but also for the starting of the project, selection of right equipment for earthwork is necessary. Earthwork complexity further increases due to various soil types and equipment, and adverse environmental conditions The present study is concentrated or focused on soil and various costs based practices adopted for the selection of construction equipment and an attempt has been made to find the optimal solution for the most problematic or responsible activities for the delay in project/cost overrun especially in context to excavation, compression, and earth / material movement equipment utilization.***

Keywords: Earthwork Equipment, Soil Types, Gorakhpur City, Optimal Selection & Utilization

I. INTRODUCTION

Construction equipment selection, related to the adherence of completion time and cost saving through the avoidance of work hindrances even stoppage of work, is a basic and necessary requirement of all types of construction projects e.g. buildings, bridges, roads, canals, dams, tunnels, and sewer lines etc. For timely completion and effective /efficient progress of the work, it is necessary to strengthen the construction equipment management required at all levels/times during the execution of construction work especially concerning the site or soil conditions and cost-effectiveness.

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As construction equipment requirement runs inevitably throughout the entire construction, it is necessary to plan and schedule of construction equipment required at various stages of the works reasonably, which is of great significance for timely completion of the construction project as well as cost-effectiveness [6] [7].

Each and every project successful completion as per schedule depends to a large extent on the effective/efficient utilization of construction equipment with full potential. Planning of equipment as a resource and proper storage, which should lie as near possible to the location of utilization preferably adequately secure and protected from both theft and environmental issues storage space provided at the site, is a must for complete fulfillment of the requirement of the equipment suiting to the project. Proper planning &scheduling is the most widely adopted systematic technique for maximizing the productivity and efficiency of construction through careful planning of each piece of equipment ultimately resulting in cost savings as well as improved timelines for construction projects. Careful planning refers to precise requirements, checking and availability of equipment /skilled operator for utilization of equipment to its fullest capacity. Keeping in view the better decision ability of skilled employee in context to equipment performance, operator skill can be developed through training programs, embracing technological solutions through the use of telemetric and IOT-Internet of Things(Connected network of devices enabling data exchange with each other/ cloud having sensor, software and electronic components), practical training sessions and mentorship programs to gain the equipped and knowledgeable employees capable of confidently handle different types of equipments efficiently [1].

II. LITERATURE REVIEW

A. Equipment Selection Factors

Besides number, capacity cost of the equipments and most important suitable class is the governing factor for the selection of excavation equipment. In this context suitable class refers the equipment selection based on soil type or suiting to the site conditions. In addition to this climatic as well as ground conditions also affect the choice of excavation equipment e.g. drag line is suitable for loose, marshy soil and large volume of excavation. The number of equipment computation depends upon capacity of equipment and different characteristics such as required speed and payload of bucket.

In specific cases such as fixed base type of equipment rather than mobile type is preferred in case of power line at or vicinity of the site. Soil/site profile may dictate the selection of crawler mounted equipment. Shortage of trained or untrained manpower may lead the selection of automated equipment. Various factors responsible for selecting the earthwork equipment to avoid delay in the scheduled activity are shown in figure.2

Figure 1: Factors Responsible for Earthwork Equipment Selection

B. Selection of Equipment Based on Cost Saving

As contractor has to execute various types of works at various locations and requirement list of equipment variation is wide /numerous, contractor can't own the total requirement of equipments in context to particular work or site. Estimation of the project required cost due to owning of the equipment is cumbersome due to involvement of various factors/assumptions like equipment capacity, cost, operator, fuel charges, transportation, failure risk, non-continuous requirement, storage, availability, transportation etc. Therefore for the judicious assessment it is necessary to prepare phase wise or required time period of a equipment the following considerations must be ensured:

1. Alternative utilization of the equipment during gap/rest period
2. Availability of storage space for standby or surplus equipments as near to project site as possible
3. Opening, establishing and carriage costs if the equipment is to be sent to main yard or returned back whenever it is required
4. Besides owning alternative of renting the same must be considered
5. Owning cost assessment must include major repairs, overhauling &routine repair expenses including oil and tire replacement charges, depreciation, interest on invested amount, insurance and, taxes taken as percentage of the initial cost. The first and foremost decision in context to selection of equipment is that new one equipment which is to be purchased or owned. This decision is based on the fact that equipment cost must save the project cost more than its cost. These cost considerations includes the equipment future utilization or resell value of the equipment at the end of the project.

C. Prevailing Practices in Construction Equipment Selection &Utilization

Prevailing practices in construction equipment selection and utilization cause and effect relationship may be summarized in table below [2][3][4][5]:

Table 1: Basis /Causes Effect Relationship

S. No.	Particulars	Basis/Causes	Details/Effect
1	Technology Integration	Poor performance/risk of increasing down or idletime of equipment specially in the cases of large projects involving many people, tasks, goals and equipments working simultaneously	Every job / equipment easier working is ensured by the use of software and on-line technology
2	Inventory Documentation	Inventory provides detailed record of all site equipments such as past maintenance history, usage pattern, specification and last use with operator/ place Easily tracking of location and condition of each piece of equipment, To identify potential issues in context to equipment management, Bar Codes /Radio Frequency Identification based tagging system is most efficient one.	It ensures efficient &effective utilization of equipments through tracking the maintenance and inspection scheduling in advance as it consists of all information pertaining to equipment procurement and, past repair /servicing records
3	Equipment Planning	The basis of equipment planning is conducting routine maintenance after proper/regular checks or inspections as preventive measure for identification of problem in equipment performance at an early stage	Preventive measures are important in context to decreasing downtime thus enabling the efficient &effective performance of the equipment. And reducing the risk/chances of equipment failure at later stage
4	Maintenance Scheduling	Creating a maintenance schedule Covering lubrication, filter cleaning / replacement of deteriorated part and calibration if necessary	It increases the performance and Reliability of equipment as maintenance of equipment is necessary for utilisation
5	Workplace Safety Insurance	To keep construction team members safe so that right use of equipment may be carried out	Workplace safety with safety protocols and compliance Leads the efficient and failure free performance of the equipment

D. Soil Characteristics Based Equipment Selection

The locational occurrence and distribution of soil variability is natural phenomenon due to formation of soil with different rock/mineral constiuents with different local regime conditions.As foundation of civil engineering structures rests on soil ,soil stability is of prime concern for safety of the structure founded on it.Keeping in view the earthwork excavation and compressibility the various soil types ,brief characteristics of each soil type and its effect on construction is tabulated in table2 as follows:

Table 2: Soil Types & Their Effect on Construction

S. No.	Soil Type	Brief Characteristics	Effect on Construction
1	Sandy Soil	Sandy soil consists of loose sand particles [size 0.06-2mm] more than 80 percent in with 50 to 60 percent of coarse sand particles [0.6-2mm].It is identified by its gritty texture if rubbed between fingers ,fast drainage., quick excavation and reduced wear /tear of equipments thus enabling soil suitability or easy working in cases of basements and foundations where water movement away from the working site is required [8]	Though excavation in these soils is easy task but stability concern that formation of cave-in requires proper attention in context to shoring and support during excavation. Besides this shifting and eroding easily characteristics of soil in case of earth quake or liquefaction requires proper compaction and additional stabilization measures
2	Silty Soil	Silty soil having particles sizes more than clay but less than sand particles[In between 0.002mm to 0.02mm] are characterized by silt content more than 80 percent. .It is identified by its smoothness /muddy nature in wet condition and easily changeable in powder form in dry condition [9]	Due to retaining large amount of water expansion of soil takes Place when comes in contact With water and shrinkage takes place when soil gets dry. This frequent expansion and contraction of soil make it unsuitable for resting of foundations on this type of soil .and foundation on this type of soil is avoided.
3	Clayey Soil	Clayey soil consists of smallest particle size than silt /sand soil particles and formed in number of years with the tightly bounded /compacted particles under environmental conditions such as temperature, pressure and air/water movement containing small mineral constituents of disintegrated or weathered rock characterized by either clay percentage more than 40 percent or sand and silt percentage less than 45 Percent and 40 percent respectively. It is identified by slippery or ply able nature in wet condition and crumbling nature in dry condition [10]	Its longer time moisture holdin or retaining capacity makes its susceptible to expansion and contraction in cases of wetting and drying respectively. These frequent changesposes problems in supported structures in the form of deformation, movement or shifting and development of cracks. The strategy followed to overcome these adverse effects includes deep excavation, creating trenches with slip lining, spreading foundation area, enhancing strength of foundation through additional reinforcement and soil stabilization though lime or cement
4	Loamy Soil	Loamy soil is characterized by a mixture of sand, silt and clay in proportion by weight as1:1:0.5(typical composition) which makes this soil balance water retention as largest particle sand provides aeration, medium size particles absorbs moisture better than sand and act as medium of sand and clay mixing while clay particles are responsible for controlling the permeability. It is identified by dark colour and feeling of softness, dryness and crumble nature if scoop by hand in case of soil not affected by recent raining [11]	As this soil represents the composition of sand, silt and clay in such a way that beneficiary properties of each are incuded, it can be regarded as an ideal soil for foundation. Further this soil expansion and contraction is checked and controlled by less absorption of water and drying at steady rate. The only drawback lies with this soil due to its fertileness composition and water retention suitability for vegetation growth enabling the chances of changing the characteristics of soil in near future.Hence before construction removal of all roots, vegetation and tree stumps lying in the construction area must be ensured
5	Rocky Soil	All type of rocks act as better foundation supporter ascompared to the soil as the mineral constituents are the same but compact mass characteristics of rock provides swelling, shifting and shrinkage proof foundation if rock layer is lying at shallow depth. Rock may support heavier structures but its location in context to vertical depth enhances the project cost as additional cost to remove the soil/debris deposited or lying over rock in case of shallow depth wheras deep foundation such as pile or pier length is governed by the existing level of rock. [12]	The major problem lying with rocky soil that flat and level surface availability to support foundation as if it is not great deal of labour and material involvement to achieve this basic requirement for supporting the foundation. Some times disposal of the rock as per requirement of the site poses problem due to heavy compact mass.Rock excavation requires specialized equipments for drilling &blasting and explosives which creates risk due to use of explosives as well cracks or fissure even sliding or falling of rock..Due to this reason only large projects are preferable on rocky soil specially government projects related to water resource such as dam, reservoir,, hydropower etc
6	Peaty Soil	Peaty soils known as extremely acidic and highly compressible soil with with wide variability in shear strength are easily become waterlogged. Risk of changing the engineering properties with weather makes this type of soil typically problematic for construction and is avoided for support of foundations of civil works, It is identified by spongey feeling and too dark colour [13]	As low bearing capacity of peaty soil found in wetland causes strain / shifting of foundation, hence alternative measures are adopted to avoid these soil: If the layer is shallow, removal/replacement with more suitable soil is only alternative. In case of existence of firm soil or rock below peaty soil pile foundation is used to support the Structure on firm soil or rock. In cases costly pile foundation and non-possible removal/replacement of soil due to greater depth existence of firm soil/rock or large volume of peaty soil raft foundation is designed but in no case foundation is supported on this type of soil
7	Gravelly Soil	Gravelly soils consist of much larger particles made up from small irregular pieces of stones than sand. Besides quick draining, it is regarded as best characterized soil in context to three S-Control i.e. shifting, shrinkage and swelling. It is identified by more roughness than sand particles and less rockyness than stone particles	For ensuring stability proper compaction, ground anchoring and helical piers installation driven deep below scour level is widely adopted techniques to protect washout/liquefaction of soil due to heavy rain/earthquake. Besides foundation support these are also used as construction material in filling, concreting, mixing with asphalt and making bricks, pipes and blocks

III. RESEARCH METHODOLOGY

After identification of the problem and detailed literature survey both primary and secondary data were collected from ongoing project construction sites of Gorakhpur city under Bridge Corporation, Nagar Nigam, Public Works Department and Gorakhpur Development Authority department of UP state government covering almost various existing natures of works i.e. over bridges, sewer lines, roads, residential/commercial buildings and parks through site frequent visits, observation and well framed and structured questionnaire from engineers, site in charge contractors, supervisors and operators. Secondary data were created from the information available from literature, handbook, group discussion, questionnaire and expertise/experienced people. Frequency /statistical analysis of data in context to different respondents &their experiments, type of equipments utilized with successful performance and different types / sizes of project .For covering the different nature of civil works the following seven project(14 sites) of undergoing project in Gorakhpur City of four UP Government Departments i.e. Bridge Corporation, Nagar Nigam ,Public Works Department and Gorakhpur Development Authority were selected to check/update the information obtained by questionnaire and for search of additional information:

- Six Lane Road Widening Work from Paidleganj to Nausadh[2Sites]
- Construction of Overbridges in Gorakhpur City Area[2Sites]
- Construction of Ramgarh Tal Lake View Extension Project[2]
- Four Lane Road Widening from Asuran Chowk to Medical College[3Sites]
- Parallel Bridge Construction to Existing Mohaddipur Bridge[1Site]
- Laying of Sewer Line in different Wards for Connecting to Goddhoiya Nala[3Sites]
- Residential Building Project Florus Galaxy Phase 2 in Rustampur[1Site]

As all sites selected represent the development/maintenance activities of UP Government in public interest hence time schedule and cost overrun are considered as side factor as in most of the cases work delay and cost overrun reason lies on the department side such as encroachment at site,non-availability of equipment or work sanction, delay in finalization of tender and possible adjustment/recovery of the cost overrun on account of selling of shops/residential complexes / revenue earned through taxes. However source of knowledge and experience sharing in context to equipment selection and utilization lies with the working people on government project site is of much importance as construction activity is performed in large scale and varieties continually throughout the year.

IV. VARIOUS ANALYSES/REVIEWS

Construction equipments whether it is a small project of residential building or big projects of urban or highway sprawling are proving unsung heroes in shaping modern world and are considered as backbone of a construction project. Besides showing versatility in context to diverse construction needs and adoptiblity in wide range of projects ,costruction equipment ensures accelerated rate of construction, higher level of precision/accuracy/quality and safety of the job site [14] [15] [16].

A. Literature Survey Analysis

For the achievement of idle or down time (non-utilization time period of an equipment either due to unavailability of equipment/employee or break down / lying idle) and increasing operational efficiency at minimum and maximum standard respectively, each and every measures shown in figure 1 must be ensured.

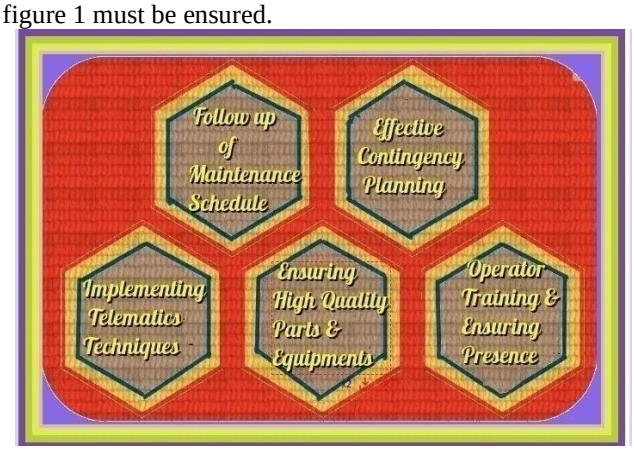

Figure 2: Measures for Achievement of Minimum Down or Idle Time

Follow up of maintenance schedule reduces the chances of equipment breakdown whereas operator training enhances the equipment performance/fuel efficiency /equipment life as both measures ensures the equipment handling in safer and, efficient way with the reduced risk of equipment failure, accidents and injuries. Proactive maintenance, data driven decision making and remote diagnostics provided by real time data on equipment health, location and performance through telematics helps to identify potential issues much before in context to formulation of maintenance schedule. Reliability, efficiency and durability of high quality parts reduces the risk of unexpected breakdowns and extension of equipment life ultimately resulting the low maintenance cost as well as more equipment availability. Timely completion of the project and efficient/effective overall performance can be achieved by contingencies planning considering potential risks, allocating budget or resources and developing mitigation strategies

B. Earth Excavation Equipment

For the right equipment selection it is necessary to know the types of construction equipment and understand its application so that right equipment can be selected to avoid delay in project complete, or cost overrun. Table 3 below shows common types of equipments required in all projects and its applications /characteristic features of commonly used earth equipment.

Table 3: Different Types of Equipments

S. No.	Types of Equipments	Characteristic Features /Applications
1	Motor Grader	As these offer precise leveling and grading of flat surfaces it is mostly used for road construction /mintenance to achieve better smooth, safe & quality roads
2	Excavator	Excavators found in various types and capacities are the proved backbone of digging trenching activities of all type of projects due to their adaptabity, precision and ability to perform in confined spaces.Besides this lifting, demoltion and material handling activities can be performed with various attachments in excavators
3	Drag Line	Dragline consisting of boom, drag chain, bucket, hoist &drag cables used for bulk excavation below ground level /its track level in case of soft or loose soils, marshy land and areas containing water and depositing or loading the excavated earth simultaneously through dragging the bucket against the excavated earth.It is widely used in canal excavation and depositing excavated earth on embankment and excavating trenches where sides of work allows establishment of angle of repose without shoring
4	Loaders	Based on function loaders may be classified as backhoe, wheeled and skid steer loaders. Backhoe loaders are the multifunctional such as digging, lifting and widerange of construction operations due to combined provision of loader as well as excavator wheras wheel loaders having largest bucket capacity and highly mobile parts are simplest /common loaders used in mining and for loading materials such as debris, dirt and gravel on trucks in efficient/effective way.Skid steer loaders are known for their compact size, skillful performance of tasks of digging in tight spaces and adoptability / workability with various attachments.
5	Bulldozers	Bulldozers are powerful and heavy equipment in context to performance of earth moving / site grading or preparation through pushing,ripping and clearing action in challenging and heavy- duty work
6	Dump Trucks	Dump trucks offer excellent /efficient hauling performance in case of off-road site locations, mining and difficult/challenging terrains
7	Compact Rollers	These rollers provide superior solid soil base for follow-up constructions through efficient and effective compaction of the ground surface. Type of roller depends on the type of soil to be compacted
8	Tipper	Tipper is the name given to the truck or lorry having rear patform with the provision of raising front end for the purpose of material discharging through gravity.
9	Cranes	Cranes are used for lifting and positioning not only heavy loads but also heavy equipment/structures with saving in workforce /cost with precision and control
10	ClamShell	Clamshell consists of a crane boom with bucket appearing like shell fish having two halves hinged together at top loosely attached at the end through the cables. Its limitation lies that material to be excavated should be soft/loose.
11	Front Shovel	Front shovel, which is electrically power bucket equipped machine mounted on crawler tracks, is used for excavating/cutting in mostly dry soils lying above its own track or wheel level except hard rocks.

C. Compaction Equipment

Compaction equipment name derived from compacting soil for the improvement of soil density through expelling air from soil solid by manual or mechanical techniques in the form of equipment use that may be static /vibratory thus reducing the pore volumes in soil ultimately resulting stability and enhancement of the bearing capacity of the soil layer of site. The compaction level varies from site to site and each site compaction level to achieve required soil stiffness and strength, decreasing water seepage, soil swelling / settling / shrinking chances in future is necessary activity for preparation of soil before the starting of the construction work as per soil investigation report. Three type of forces i.e. static, vibratory and impact types are uses utilizing equipment weight impact on the surface of soil ,creating downward pressure in the soil through vibrating the equipment into soil and forcefully driving down the rectangular/triangular/pentagonal shape pads respectively. On the basis of forces applied on the soil the compactors may be of two types i.e. light compactor (rammers or plate compactors) and heavy compactors (smooth wheel rollers or pad foot rollers). Selection of compaction equipment consists of three steps:

Step I-Classification of soil either non-cohesive or cohesive soil. Granular soils are non-cohesive soils having no clay content/cohesive strength between particles and identified by easy crumbling in dry state and non-molding behavior in wet state whereas cohesive soils are clayey soils showing just opposite behavior to granular soils that is high cohesive strength between particles enabling it to difficult crumbling in dry state but easily moldable in wet state

Step II-Site specifications considerations such as available space, area to be compacted, types of terrain and ground slope

Step III-Selection of Right compactor based on specific function suiting to the identified soil type and site specification consideration as rammers are suitable for cohesive soil in small space through providing impact in soil whereas plate compactors are light weight equipment for compacting granular soils in small space. Rollers are heavy duty compactors through crushing, vibrationg or kneading the soil in srip form or wide area. Ride on rollers are suitable for large jobs

D. Frequency Analysis

Equipment selection and utilization is a complex activity involving number of variables such as decisive capacity of engineers or top management or contractor in context to selection stage and supervisor or operator at implementation/operation stage. As experience plays an important role in each stage of equipment selection and utilization process hence different respondents and experienced based frequency analysis is tabulated in Table 4 and respondent frequency percentage designation wise i. e. engineer, contractor. Supervisor and operator and experience wise i.e. less than 5 years.5-10 years,10-20 years and above 20 years are further represented by vertical bar chart in Figure 3 as follows

Table 4: Frequency of Respodent Degination &Experience

S. No.	Respondent		Percentage Frequency	Respondent		Percentage Frequency
	Designation	Frequency		Experience	Frequency	
1	Engineer	28	40%	Below 5 years	12	17%
2	Contractor	21	30%	5-10 Years	30	43%
3	Supervisor	14	20%	10-20 Years	22	31%
4	Operator	07	10%	≥20 Years	6	09%

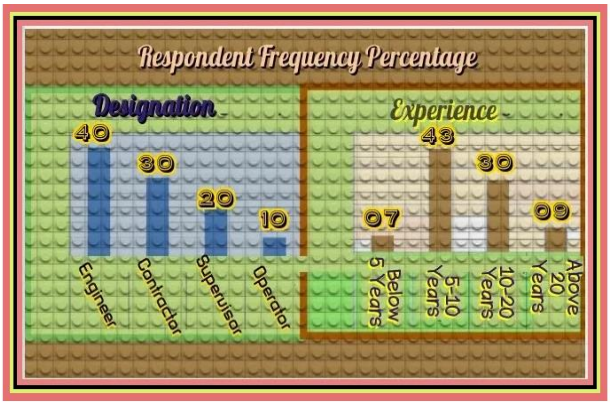

Figure 3: Respondent Designation/Experience Vs Frequency Percentage Chart

It is observed from the above table 4 and figure 5 that both groups i.e. Group1 (engineer + operator) & Group 2(contractor + supervisor) shares the same frequency percentage as fifty percent. This is perhaps due to selection of government sites where the equipment selection &utilization implementation is in mixed pattern partly by department and partly by contractor. Respondent experience below 10 years frequency (60%) more than frequency of respondent experience above 10 years(40%) indicate that selection of equipment and specific guidance contribution is from the experienced person and implementation lies with the less experienced person. Keeping in different equipment requirement for different projects of earth excavation/moving equipments frequencies of four different types of projects i.e. sewer line, building, roadwork and over bridge construction along with four various equipments excavators, trenchers, trucks and excavator with loader are shown in table 5 and pi chart in figure 6 as follows:

Table 5: Frequency of Type of Project and Earth/Excavation Equipments Used

S. No.	Project		Percentage Frequency	Equipment		Percentage Frequency
	Types	Frequency		Types	Frequency	
1	Sewer Line	18	26%	Excavators	23	33%
2	Building	14	20%	Trenchers	08	11%
3	Road Work	22	31%	Trucks	12	17%
4	Over Bridge	16	23%	Excavator with Loaders	27	39%

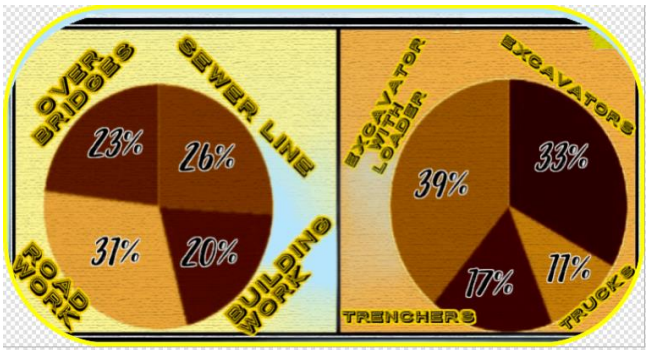

Figure 4: Frequencies of Types of Project & Earth Excavation/Movement Equipments Used

It is observed from frequency table 5 and chart shown in fig 6 that frequency percentage of excavator plus tractor and trenchers plus excavator with loaders are same. This is due to mixed use ofequipments in different works. Over bridge earth excavation & movement activity is performed by excavator with loader whereas roadwork activity prominent equipments are excavator/ trenchers. Trenchers/trucks are the most suitable equipment for shallow depth/movement of excavated earth at small scale/quantity in all type of works

E. Specific Analysis

After frequency analysis of selected project site the number of respondents (Total 70) along with varying experience were interviewed /discussed in context to suitability of four types earth excavation/moving equipment i.e Drag line, Back hoe, Power shovel and clamshell regarding the utilization/ performance of equipment considering the following four parameters:

a) Type of soil
b) Required distance between footing and excavation
c) Working efficiency
d) Cycle time

The equipment wise summary of detailed discussions in context to the parameters selected about utilization /performance of the each are shown in Table 6**:**

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Table 6: Summary of Detailed Discussion on Equipment Utilization/Performance Details

S. No.	Euipment	Concluded Remarks Based on Discussion
1	Drag Line	-Moderately good for excavation in wetly or muddy soil -Long distance required between foundation &excavation -Moderate loading efficiency -Moderate cycle time
2	Back Hoe	-Good for excavation in hard soil /rock -Small distance required between foundation &excavation -Good loading efficiency -Moderate cycle time
3	Power Shovel	-Very good for excavation in hard soil /rock -Small distance required between foundation &excavation -Very Good loading efficiency -Too short cycle time
4	Clam Shell	-Moderately good for excavation in wetly or muddy soil -Long distance required between foundation &excavation -Precise loading efficiency but slow -High cycle time

V. DISCUSSION FOR FINDING OPTIMAL SOLUTION

A. Selection of Right Equipment & Optimum Utilization Techniques

Selection of right equipment for a project is the most critical element as different project such as bridges, roads, buildings ,tunneling etc requires different equipments based on site requirement and specification of the work to be constructed specially in context to the excavation, compression and earth disposal. Pre- planning before the equipment selection and utilization with follow-up of processing steps in figure 5 will enable the effective and efficient performance without risk.

Fig 5: Four Steps of Construction Equipment Selection &Utilization

However selection of equipment decision based on project need,evaluating site condition,equipment budget provision and survey of locally available suppliers or equipments are the winning steps in this context.While taking the decision equipment ability, capacity and limitations in reference to project site must be evaluated. For the effective utilization of rightly selected equipment it must be ensured that proper trained or skilled operator handles the equipment and he is fully aware with the safe handling ,proper storage norms and maintenance schedule of the equipment. Monitoring equipment utilization through on-line tracking using software is the best control exercise.

B. Safety Provisions &Retired Equipments

Created guidelines for proper and safe handling of equipment in light of company operation manual supported by proper storage and maintenance plan must be tagged or attached at the location of equipment. All security/safety measures for workers or equipment and routine maintenance check as per checklist before use, during use and after use through additional supervisory staff will lead to efficient performance of the equipment.An equipment may be considered as retired equipment if any of the following conditions are fulfilled:

- Life span of equipment with use as per manufacturer guide lines has been completed
- Repair &maintenance cost is high and not justified
- Due to technological advancement equipment becomes obsolete
- Equipment utilizationy risk
- Project need has changed and equipment is unnecessary in current siyuation

Retired equipment use must be prohibited

C. Continuous Monitoring

Improving overall level of the project construction replacement of traditional equipment with modern equipment needs to be continuous monitoring/checking of not only of the equipment used in construction but also coping with the recent technologically developed standards/equipment. In this context separate equipment supervision department in accordance of existing situation may be established for repeated accounting of equipments, endurance of equipment readiness for use, daily/routine maintenance schedule implementation and proper sealing and storage of equipment, which must be in working position so that as and when required the same can be easily and quickly can be put into construction, not needed in the current process. Various considerations that is necessary for optimization of selection &utilization of equipments are summarized in figure.6

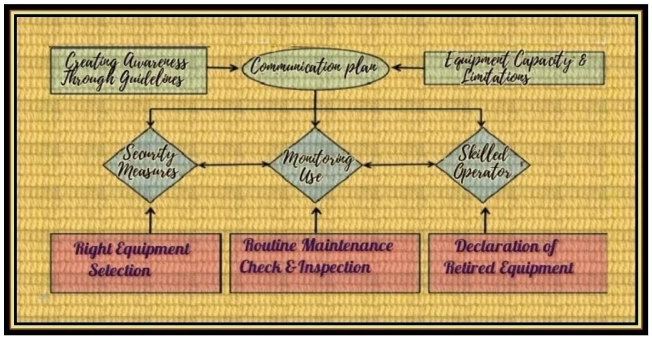

Figure 6: Considerations for Optimum Selection & Utilization of Equipments

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VI. CONCLUSION

1-Though the use of particular equipment for particular type of site cannot be specified due to mixed/variable characteristics of soil and large variety/capacity of equipments performing the same function. However recommendation for selecting the equipment based on soil characteristics are tabulated in table 7as follows:

Table 7: Recommended Earthwork Equipments Based on Soil Type

Serial Number	Types of Soil	Earth Excavation or Moving Equipments	Compacting Equipment
1	Sandy Soil	Trenchers &Drag Line	Light Plate Compactor
2	Silty Soil	Excavator &Dump Truck	Rammers Or Jumping Jacks
3	Clayey Soil	Excavator With Loader	Rammers Or Rollers
4	Loamy Soil	Drag Line, Trencher &Excavator	Tamping Or Padfoot Roller
5	Crushed Rocky Soil	Power Shovel, Back Hoe, Bulldozer	Smooth Wheel Rollers
6	Peaty Soil	Front Shovel, Drag line &Clamshell	Pad foot Roller
7	Gravelly Soil	Front Shovel +Excavator	Light Plate Compactor

2-Selection of equipment decision based on project need, evaluating site condition,equipment budget provision and survey of locally available suppliers or equipments are the winning steps in this context. While taking the decision equipment ability, capacity and limitations in reference to project site must be evaluated. For the effective utilization of rightly selected equipment it must be ensured that proper trained or skilled operator handles the equipment and he is fully aware with the safe handling ,proper storage norms and maintenance schedule of the equipment.Monitoring equipment utilization through on-line tracking using software is the best control exercise.Standby arrangement/surplus equipment consideration for requiring equipments more than two in number must be ensured so that reduction in idle time or increase in equipment efficiency may be achieved.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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