DESIGN OF WORKSHOP FACILITIES FOR WATER RESOURCES PROJECTS

A DISSERTATION

Submitted in partial fulfilment of the requirements for the award of the Degree of

MASTER OF ENGINEERING

in

WATER RESOURCES DEVELOPMENT

By

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C E R T I F I C A T E

Certified that the dissertation entitled,'DESIGN OF WORK-SHOP FACILITIES FOR WATER RESOURCES PROJECTS', which is being submitted by Mr. HARRIS in partial fulfilment for the award of the degree of Master of Engineering in Water Resources Development of the University of Roorkee is a record of candidate's own work carried out by him under our supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other Degree or Diploma.

This is further to certify that he has worked for a period of more than six months for preparing this dissertation, w.e.f. 16/10/83 to 23/4/83

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A C K N O W L E D G E M E N T

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Numerous articles and papers, few of which have been referred to in the Bibliography have been consulted and the material furnish therein has been used in the preparation of this dissertation for which the author expresses his gratefulness to the various authors of these articles, papers and books.

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HARRIS

I N D E X

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S Y N O P S I S

With the growing use of machinery in the construction of Water Resources Projects, large and small, it has become essential requirement to provide adequate workshop facilities for proper maintenance and up-keep of construction equipment as well as for regular manufacture of typical items that may be required on the project. However, proper design of Workshops for Water Resources Projects has not been receiving due attention probably due to fact that cost of workshops constitute a very small percentage of the total project cost.

In this dissertation an attempt has been made to study design aspects as relevant to workshop services. Study relating to area requirement per machine, ratio of covered and uncovered area, and cost of workshop equipment versus cost of construction equipment has been presented in this dissertation with the help of relevant data from some water resources projects like Beas Project, Beas-Sutlej Link Project, Ramganga Project, Salal Hydro-Electric Project, Jratun Seluna Project in Indonesia and Tehri Dam Project. Comparison has also been made with recommendations of Construction Plant and Machinery Committee.

A recommendation for further work has also been covered in Conclusion.

CHAPTER-1

INTRODUCTION

1.1 GENERAL

1.1.1 Nature of Water Resources Projects

Water resources development projects generally involve construction of a variety of structure like dams, embankments, dykes, intakes, spillways, tunnels, channels, power houses, switch yards, transmission lines etc. These structures beside being complex and complicated have additional dimension of magnitude. These structures are huge and hence construction period is ' spread' over many years. Also, the projects are generally located in sequested pockets/ in remoate areas where terrain is rough and working conditions are auduous. Most often these projects are in hilly regions where complex geological features such as folds, faults and shear zones in foundation region of dams or in underground structures like tunnels, pose additional difficulties. The situation becomes further difficult in view of construction constraints, possibility of site being subjected to flood, earthquake, land slides, storms, inclement weather etc. etc.

On the whole it can be stated that construction of water resources projects is an unique ticklish problem due to unforseen, contingencies, uncertainties, surprises, risks and the like which need special considerations.

1.1.2 Extent of Mechanization

Considering the nature and magnitude of water resources projects, as discussed above, and requirements of speed, economy, quality and safety, which have become prime consideration now-a-days, mechanization is indispensable. Mechanization has also been necessitated due to limitation of man, or animal power and nature of work such as dredging which is not possible without mechanization. Other factors promoting mechanization are capability of machines to achieve desired quality which may be beyong the scope of human labour and a typical example of such situation is compaction of earth fill dam where desired degree of compaction can not be achieved through human efforts.

Further the water resources projects invariably involve transportation of large quantities of construction material over fairly long distance which again warrant utilization of large capacity hydraulic excavators (ranging in size upto 10 cum) huge carrier (having capacity over 100 tonnes), giants dozer, and so on, so as to achieve accelerated completion and to ensure economy.

Mechanization has also been adopted intensively for concrete manufacturer and placement and tunnelling operations so as to achieve fast rate of construction and economy. Aggregate processing plants, batching and mixing plants, cableways, locomotives, vibrators, concreting buckets, transit mixers, agitating cars, etc. are now invariably used for concrete manufacture and placement in dams or other concrete structures.

Utilisation of a variety of construction equipment in the borrow areas and for transportation to auxiliary plants has become a necessity. Gravel recovery sites generally employ a large number of excavators, giant dozers and loaders, for digging and loading the material into huge sized carriers, hauling and dumping the material into bias feeding belt conveyors. Likewise use of drilling jumbo, hydro booms, raise climbers, moles, loaders, locomotives, dump trucks, shotcreting machines, pneumatic placers, etc. is also very common for tunnelling operations.

Extent of mechanization can be indirectly assessed by the multiplicity of makes and models of construction equipments that are available in international market for use in the construction industry. Table 1.1 summarises the information about variety of popular makes and models of principle categories of construction equipment, and has been compiled on the basis of data appearing in March 1983 issue of ' International Construction'.

Sl. No.	Category of equipment	No. of makes	No. of models
1.	360 Degree Hydraulic Excavators	47	387
2.	Rope Operated Excavators	16	149
3.	Mini Excavator under 10T	16	99
4.	180 degree back hoe loaders	23	62
5.	Wheeled loaders	44	248
6.	Crawler loaders	14	66
7.	Crawler dozer	13	88
8.	Haulers- Dump trucks	27	146
9.	Motor scrapers	9	52
10.	Motor graders	16	83

1.2 NEED FOR WORKSHOPS

1.2.1 General

Construction equipment can produce profit while it is working longer and more efficiently. The direct and easily visible effect of lack of maintenance or unprover maintenance will be breakdown of equipments. The breakdown of equipment causes down time and financial loss by way of loss in production. In some cases equipment have been found to be on the sick list far as much as 40 percent of anticipated working time due to inadequate maintenance and repair facilities delaying execution of construction work inordinately.

Hence upkeep of construction equipment for transportation, earthmoving, grouting, compressed air supply, processing aggregates and for many other construction activities is imperative and this is achieved by providing suitable repair and maintenance facilities in well planned workshop on water resources projects.

1.2.2 Sophistication in Construction Equipment

In addition to the repair and manufacture requirement the sophistication in construction equipment makes it imperative to have well equipped workshops. While routine repair to regular construction equipment could probably be handled upto a reasonable extent without a well equipped workshops, the sophisticated construction equipment, on the other hand, warrants a good workshop facility even for minor adjustments. The need

for workshop facilities can hardly be overstressed in the face of sophistication in construction equipment, which in turn is a result of stiff completion among equipment manufacturers, who have tried to minimise the human error through automization. Automatic adjustment of blade elevation of scrapers and bull dozers as a function of earth resistance encountered is one of the simple examples of sophistication and it goes without saying that repair of such equipment calls for a proper workshop facility.

CHAPTER-2

PLANNING FOR WORKSHOP SERVICES

2.1 GENERAL

It must be stated at the outset itself that planning for workshop services for water resources development projects is distinct from planning for the regular industrial workshop. Basic reason for this is the obvious difference between the requirement of industrial workshop and of the workshop for water resources projects. However, the objectives of workshop services in both the cases is same, i.e. prompt service, low cost, minimum wastage, use of available talent/material and safety.

Workshop services for water resources projects include all such facilities that may be required for maintenance, repair and servicing of construction equipment as well as for regular manufacture of such items that may be required on projects works.

Planning for various shop services required for a workshop call for assessing the type and amount of work planned to be done in a workshop relative to outside facilities where specialised services might be available readily. While taking cognisance of the outside facilities for planning of various shop services for a workshop, due consideration has to be given to accessibility by road, rail and other modes of transport as well as to distance of workshop from the outside facilities.

A judicious decision is required to be taken in planning various shop service for a workshop as to weather it would be economical to carry out all operations involved in repair, maintenance or manufacture within the workshop itself or assistance/ dependance on outside facilities specializing in some of the services shall be economical.

After determining the type and quantum of work, the next important factor in planning shop services is their location. The problem of site location is basically a compromise of proximity to operational area and drainage system. While proximity to operational area is important as travel time and transportation cost prove to be fairly costly, the drainage system is equally important because both these factor can seldom be corrected satisfactorily at later stage when planning phase is taken over by execution phase.

Selecting location should also consider -

1. Local building codes, zoning regulation and future high ways, if any.
2. Obstructions like overhead cables, under ground pipe line, ditches and gulley which should be avoided to ensure free movement of heavy equipment in and around the workshop.

2.2 PLANNING FOR MAINTENANCE AND REPAIR WORKSHOP

Work in general maintenance and repair workshop may be subdivided according to the functional requirements and shop service may be planned according to the job contemplated to be

undertaken in a particular shop. Selection could be judiciously made out of following list of main shop services, commensurate with the facilities planned to be provided in a workshop -

1. Tyre repair shop
2. Lubrication shop
3. Servicing shop
4. General repair and fitting shop
5. Battery shop
6. Electrical repair shop
7. Welding shop
8. Painting shop
9. Transport and light vehicle repair shop
10. Smithy shop
11. Machine shop
12. Miscellaneous machine repair shop
13. Engine repair shop
14. Transmission repair shop
15. Hydraulic equipment repair shop
16. Truck repair shop
17. Sheet metal and upholstry shop
18. Foundary shop
19. Carpentary shop
20. Tyre retreading shop
21. Structural shop
22. Drill steel repair shop

In addition to above shop services provision has to be made for auxiliary services and employees facilities like -

1. Tool room service
2. Water supply service
3. Store and spare part services
4. Fire fighting services
5. Time office services
6. Refuelling services
7. First aid/medical services
8. Canteen
9. Cupboard and locks
10. Change over waiting room
11. Toilets
12. Office

From the list of various shop services enumerated above, required shop service can be chosen to suit the type and amount of work planned to be undertaken in a workshop. In case workshop is planned to undertake only routine maintenance adjustment and minor repair (like replacement of easily accessible parts which do not require highly specialised equipment or tools), shop services enumerated from sl.no. 1 to 8 above shall be necessary. On the other hand if workshop is required to be planned for repair of various sub-assemblies, standby units and major repairs/ overhauls, all the shop services enumerated above (except for the last shop service) shall be necessary.

d) Rigging shop

For repair and maintenance of rigging and hoisting equipment like jacks, hoists, derricks, chain pulley blocks, sling etc.

Similarly other shop services like ' pipes and pump shop' for repair of dewatering and water supply equipment,' compressor shop', for repair of air compressors,' Drill steel shop' for repair and maintenance of tungstan carbide tipped drill steel rods, could also be planned as per requirement. It goes without saying that the above shop services are required to be supported by auxiliary shop service like - welding shop, machine shop, carpentary shop, smithy shop, foundary shop, paint shop and employee facilities, etc. It may be noted that planning shop services according to the equipment to be s rv d provide a specialised facility for repair of particular type of equipment. Planning a specialized repair facility for sophisticated construction equipment which is generally deployed on water resources projects is considered as a luxury by some of the planners and they advocate that this approach of planning results into duplicacy of services in subsections viz. a transmission repair section is required in three shops namely the tractor shop, the carrier shop and the automobile shop. This also true for tyre repair section which is necessary for carrier shop as well as for automobile shop. Proponents of specialised shop services hold that there is a distinct advantage of providing a specialized, shop service for repair of sophisticated construction equipment which warrants special skill.

Some times the shop services are termed and planned according to equipment to be serviced viz.,

a) Tractor and excavator repair shop

For repair and maintenance of tractors, dozers, power shovels, mobile cranes, front and loaders, scrapers, dragline etc. sub division of the shop would be necessary to incorporate sub section for transmission repair, hydraulic system and hydraulic equipment repair, differential repair, track group component repair etc. etc.

b) Carrier shop

For repair and maintenance, carriers i.e. dump trucks, trailers, tankers etc. In this case also sub division of the shop would be necessary to include sub-section like, body repair section, transmission repair section, tyre repair section etc.

c) Automobile shop

For repair and maintenance automobile like- jeeps, pick up, light trucks etc. would be required to have sub sections like- running repair section for chasis and engine of vehicles, electric repair section, body repair section, engine overhaul section, transmission repair section, brake system repair section, lubrication and general maintenance section, tyre section etc. etc.

d) Rigging shop

For repair and maintenance of rigging and hoisting equipment like jacks, hoists, derricks, chain pulley blocks, sling etc.

Similarly other shop services like ' pipes and pump shop' for repair of dewatering and water supply equipment,' compressor shop', for repair of air compressors,' Drill steel shop' for repair and maintenance of tungstan carbide tipped drill steel rods, could also be planned as per requirement. It goes without saying that the above shop services are required to be supported by auxiliary shop service like - welding shop, machine shop, carpentary shop, smithy shop, foundary shop, paint shop and employee facilities, etc. It may be noted that planning shop services according to the equipment to be served provide a specialised facility for repair of particular type of equipment. Planning a specialized repair facility for sophisticated construction equipment which is generally deployed on water resources projects is considered as a luxury by some of the planners and they advocate that this approach of planning results into duplicacy of services in subsections viz. a transmission repair section is required in three shops namely the tractor shop, the carrier shop and the automobile shop. This also true for tyre repair section which is necessary for carrier shop as well as for automobile shop. Proponents of specialised shop services hold that there is a distinct advantage of providing a specialized, shop service for repair of sophisticated construction equipment which warrants special skill.

2.3 PLANNING FOR MANUFACTURE WORKSHOP

Work in manufacture workshop calls for use of typical shop services commonsurate with typical items to be fabricated. Various operations involved in manufacture are required to be usualis.d and shop service are planned accordingly. In general, manufacture workshop calls for argumentation of structural shop with special purpose shop services like, marking shop, cutting shop, bending shop, welding shop, assembly shop, testing shop and painting shop. For example a penstock fabrication workshop would warrant planning of special purpose sections like raw material section, edge planning section, plate bending section, welding section, radiographic section, stress releiving section, hydrostatic testing section, sand blasting section, painting section and despatch section.

In addition to special purpose shop services as enumerated, in brief, above, the manufacture workshops also require auxillary services and employee facilities enumerated earlier.

2.4 BASE WORKSHOP AND FIELD WORKSHOP

Base workshop and field workshop is a commonly used terminology in connection with workshops for water resources projects. This terminology is based on the premise that the base workshops are planned to cater for the total repair, maintenance and manufacture facilities of a project and are located at a central situation in the project, where as the field workshops are generally planned to undertake only minor repair and maintenance work and are usually located close to a specific working

area or field, for which the workshop is contemplated to be utilised. The field workshops have also been used for manufacture of simple items like steel ribs for supporting system in tunnels and obvious reason for undertaking such manufacture operations in field workshops is the proximity to working area and simplicity of manufacturing process.

Since the base workshops and field workshops basically involve repair, maintenance and manufacture operations, therefore planning of shop services for them does not call for any additional considerations except those already discussed in paras 2.2 and 2.3.

CHAPTER-3

LAYOUT ANALYSIS OF WORKSHOPS

3.1 GENERAL

Layout can be defined as an arrangement of physical facilities. Basic aim in deciding layout of any workshop is to facilitate the repair process and/or the manufacture process contemplated to be undertaken within the workshop. While planning the layout of various facilities within a workshop, an effort should be made to minimize material handling, to ensure flexibility of operations to keep down the total investment and to provide for the comfort and convenience of workforce. Hence it is necessary that the aspect of planning a workshop layout is treated with due care.

There are two basic types of layouts namely the product layout and process. Distinguishing features of the two types, alongwith, their relative merits and demerits are discussed in subsequent paragraphs.

3.2 PRODUCT LAYOUT

3.2.1 General

Product layout, as the name implies is designed for the flow type of production or manufacture where continuous or repetitive operations are carried on to produce large quantities of a standardised product or products like penstock shells and steel ribs for tunnel support systems. In the product layout

all equipment needed to manufacture a typical item, is arranged sequentially in a continuous line that is various machines are arranged in an order in which the successive operations on the items to be manufactured must be performed. The component or item is taken from shop to shop that have the requisite machines necessary to perform the required operation. In short a series of machines is arranged in line to perform a definite sequence of operations for the manufacture of a certain item and the job is moved from one machine to another till all required operations are carried out satisfactorily.

3.2.2 Advantages of Product Layout

1. Reduced material handling

This is one of the obvious advantages in product layout and is achieved through inherent features like definite and direct channel for the flow of material, short distances between operations and mechanisation of handling.

2. Low cost labour and the ease of procurement and training

The product layout can effectively utilise low cost, unskilled and semi-skilled labour because of special purpose automatic or semi-automatic machines and elaborate tooling. Special purpose automatic equipment can be economically designed and constructed for various operations involved in manufacture of a particular item so that the operator is required to perform a simple routine task. Because of the wide availability, ease of recruitment and training of such labour the costs of labour procurement are low.

3. Reduction in inspection

In the product layout of equipment, a complete product part or subassembly is made on one line. A limited amount of inspection perhaps at the end or at some critical point in the line, supplemented by spot checking or patrolling inspection between, is usually sufficient.

4. Reduction in processing time

Intermediate activities between various operations such as travel, storage and inspection occur less frequently in product layout and hence times and opportunities for delays in such activities are, to a large extent, obviated. The total time for processing product is therefore shortened.

3.2.3 Disadvantages of product layout

1. Vulnerability to production line shutdown

If any equipment goes out of order there is a shutdown of production unless reserve capacity or standby equipment is available and can be utilised. Shutdown of the line can also be caused by a minor shortage of material.

2. Higher capital investment

Product layout involves higher capital investment because equipment necessary to manufacture an item is arranged sequentially so as to perform required operations and this may involve duplicacy in equipment and hence higher capital investment. Also semi-automatic or automatic equipment, designed and provided for economising in labour costs, adds to capital investment.

Furthermore, provision of standby equipment to safeguard againsts vulnerability of shutdown due to failure of any equipment warrants higher initial investment.

3. Higher fixed charges

Higher capital investment in product layout renders overhead charges correspondingly high particularly where specialised capital equipment is used.

4. Difficulty in supervision

The line which is the unit of supervision is a collection of numerous kinds of machines requiring a wide knowledge on the part of the supervisor if he is to fulfill his production goals. The foreman's job involves the supervision of diverse activities which for each equipment requires a knowledge of various set ups, kind of work done, and operating speeds and feeds. Among other things the foreman must also know the machine capacity necessary for loading and scheduling work on each equipment in the workshop, he is responsible for the quality control for the many kind of jobs being simultaneously processed, and he must also be familiar with the maintenance requirement of his equipment. Such a diverse supervisory assignment may not readily lend itself to specialisation and mastery by the average foreman. For this reason a supervisor under product layout is more prone to neglect one or another of his responsibilities.

5. Inflexibility of facilities

The equipment under product layout consists of facilities designed to perform special operations. Usually no machine unit

of the line is exactly interchangeable in capacity or kind of work performed with any other unit. This characteristic of the strict product layout results into inflexibility of facilities, which make for interruption, costly change over, or machine replacement particularly when major design changes must be made in the item to be manufactured. This is particularly true for those manufacture workshops, that are contemplated for long term use even after completion of a specific project for which the workshop is originally planned.

3.3 PROCESS LAYOUT

3.3.1 General

In process layout, similar processes are grouped together by grouping similar workshop equipment. These groups are usually designated as shops, and each shop or group constitute a distinct unit. This plan of organising the physical facilities is suitable for the non-repetitive, intermittent type of jobs where special job orders each distinct from the other are handled and results in a functional arrangement of the layout. Thus, in process layout, welding machines, lathes, lubricating equipment, painting equipment are segregated and organized into separate functional units or shops.

3.3.2 Advantages of Process Layout

1. Less capital investment

Process layout requires less capital because duplicacy in equipment, which sometimes becomes essential in product layout,

can be avoided. Also the equipment is utilised to greater capacity. The equipment can be kept loaded for most of the time, and for this reason the workshop equipment has higher productivity. Moreover, an overloading of any one shop can readily be taken care of by extra shift/time working. Normally, however, necessity of overloading does not arise because provision of equipment in each shop is generally sufficient for handling of normal maximum load.

2. Flexibility in repair and manufacture facilities

A great variety of work can be handled on a comparatively small investment because of the utilisation of various type of general purpose equipment. There is flexibility in planning manufacture jobs because it is possible to assign work to any available machine in the workshop. Furthermore, it is possible to take up work on short notices (as in normally required in case of water resources projects where random requirement for manufacture of a typical part or component necessary for repair of a construction equipment keep on arising) without much time spent in loading up and without too great a disruption in scheduled production.

3. Effective supervision

Each foreman supervises only a limited range of machine operation like the foreman in welding shop or the foreman in machine shop. Because the task for each foreman is not too diverse and is frequently within the limits of the foreman's ability, he becomes highly proficient in time and with practice.

The foreman is able to direct the set-up and performance of every kind of operation done on the equipment in his shop. He frequently becomes very adept and useful in the maintenance and repair of equipment, specification and inspection requirement and planning and production control in his shop.

4. Machine failures do not seriously disrupt production

If there is a breakdown in one machine unit in a shop, the work can easily be transferred to another equipment in the same shop. If the shop is already working at high capacity, minor modifications in scheduling can readily be made to turn out a job that is urgent.

3.3.3 Disadvantages of Process Layout

1. More material handling

Inasmuch as the layout of equipment under strict process layout does not favour the production of any one product, there will be no definite channels through which all jobs will flow. In fact the job in process layout may return to the same shop more than once for processing making for back traveling of work. Routing of work to various shops and consequent movement through the greater distances over which job must travel results into comparatively higher cost of materials handling. Moreover material handling under process layout does not readily but itself to machanization and elimination of manual labour because there are no definite channels in the flows of materials. Furthermore, it is difficult to design special arrangement which can simplify and facilitate material handling because there is a great variety of material to be processed.

2. Greater total floor area

There is usually a need for greater spacing between repair or manufacture stations in the various shops because sufficient room must be allowed at each machine to handle a diversity of sizes of jobs and a variety of set ups and bench work. A well designed product layout, on the other hand can utilise floor space more efficiently, thus achieving greater production density.

3. Higher skilled labour and difficulty in labour procurement

The workers must be skilled because they operate a number of sizes of general purpose of machines doing a wide variety of work and performing many specialised operations. For this reason they must be able to read complicated blueprints, set up a variety of jobs (using numerous Figs, fixtures, gauges) and frequently inspect their own work. Because of this complexity and diversity of operations, more highly skilled and versatile labour is therefore required and wage rates will usually be higher than single product plants. Furthermore there may be difficulty in recruiting such personnel. A high turnover of labour under such conditions will prove to be very costly.

4. Need for more frequent inspection

Because each shop is responsible for a specialised operation, inspection is generally necessary before the work goes to the next operation in another shop. The subsequent rejection of the material by another shop causes a considerable amount of

handling, confusion and rerouting of remove the faulty part. These conditions are not characteristic of product layout because the production line is the unit of supervision, and inspection points are established only at the critical stages of operation.

5. Longer processing time

The total time needed for any item under process layout is greater than that required for processing work in line production. Time is consumed because the job requires inspection after getting processed in any shop. Furthermore the large amount of material handling personnel can not always be made available to move the job when it is realised from a shop. The end result is a longer period of processing time.

6. Greater complexity in planning and control of repair and manufacture

Planning or repair and control are necessarily complex due to a number of conditions inherent in process layout. As the size of a workshop and the variety of jobs to be undertaken in the workshop increase, the difficulty of coordinating the various processes and operations also increases. The absence of definite mechanised channels for material handling make routing and scheduling more difficult and time consuming. A large amount of diverse work in process together with a longer total period of processing time calls for careful individual attention for proper flow and coordination of operation. Furthermore the responsibility for repair or manufacture is divided among many shop

supervisors, making accountability for the progress of the work more difficult. Each jobs order has its particular list of material and distinct specifications necessiting the development of a routing sheet for each component part and for each assembly. With this diverse character of work scheduling is comparatively more difficult because a large amount now repetitive work must be processed.

3.4 LAYOUT OF WORKSHOP FOR WATER RESOURCES PROJECTS

Workshops required for maintenance and repair of wide variety of construction equipment deployed on water resources projects have to be take up diverse nature of jobs ranging from breakdown maintenance to preventive maintenance of construction equipment. Obviously for breakdown maintenance process layout, would be suitable because the repair activity has to be differently organised for each breakdown depending upon nature and type of failure. Preventive maintenance however callss for channelising the construction equipment through a well defined set of operations like cleaning lubrication, and replenishment of consumables like filters, filter elements, crank case oil, transmission oil, brake oil etc. etc. Thus layout in workshops for repair and maintenance of construction equipment has to be a compromise between process layout and product layout.

Another feature forcing this compromise is the fact that in most water resources projects, workshops are required to cater for both, maintenance and repair as well as for manufacture of typical items, which again necessitate a compromise between process layout and product layout.

However, the workshops planned for manufacture of typical items that may be required regularly and in sufficient quantity warrant adoption of product layout. Thus it can be summarized that layout of water resources project is an expression of the purpose for which the workshop is established.

Use of templates and flow charts are recognized methods of deciding layout and are therefore advantageously employed for finalising the layout.

Clear plan of workshop layout should be developed by listing out the type of repair work, servicing maintenance and manufacturing operation to be assigned to various shops commensurate with the number and type of construction plant and equipment to be maintained and serviced and load of manufacturing activities.

Layout of various shop services relative to each other has to be so decided that movement of various components and materials within the workshop is minimised. Layout of facilities within a workshop is to be designed in specific relation to the type/category of machine and their number to be repaired. For example, shops like tractor shop, carrier shop and automobile shop, should be flanked by engine room for repair of engine and transmission room for repair of transmissions. Similarly carrier shop and automobile shop, both should have a common or separate type section. While deciding workshop layout provision for equipment assembly yard should also made so as to facilitate assembly and initial commissioning of all construction

equipment which is planned to be deployed on a project. Also provision for expansion and flexibility of operation of various shop is required to be made.

Layout of shop service, which is must extensively used, should be so decided that the shop service is easily accessible. For example, tyre repair, inflation and refuelling service should be located in such a manner that these services can be utilised with least disturbance to other services in the workshop. It may not be out of place to mention here that layout of employees facilities like toilets and wash rooms should also be so arranged that they are easily accessible to all staff. Likewise, layout of offices in the workshops should be such that they are centrally located so as to facilitate supervision of work evenwhile sitting in the office. For this purpose, a common practice is to provide a difference of elevation in the office floor level and the shop floor such that the supervisory staff sitting in the office at higher elevation, overlooks the shop floor area. Also, the offices should have independent entrance, from outside the shop floor area and as far as possible the walls and ceilings should be of acoustic material.

Layout of workshops for Beas Project, Beas Sutlej Link Project, Ramganga project, Jatunseluna project, Salal hydro-electric project and Tehri dam project is shown respectively in figures 3.1 to 3.6. Perusal of these layouts would reveal that process and product layouts, both have been combined in

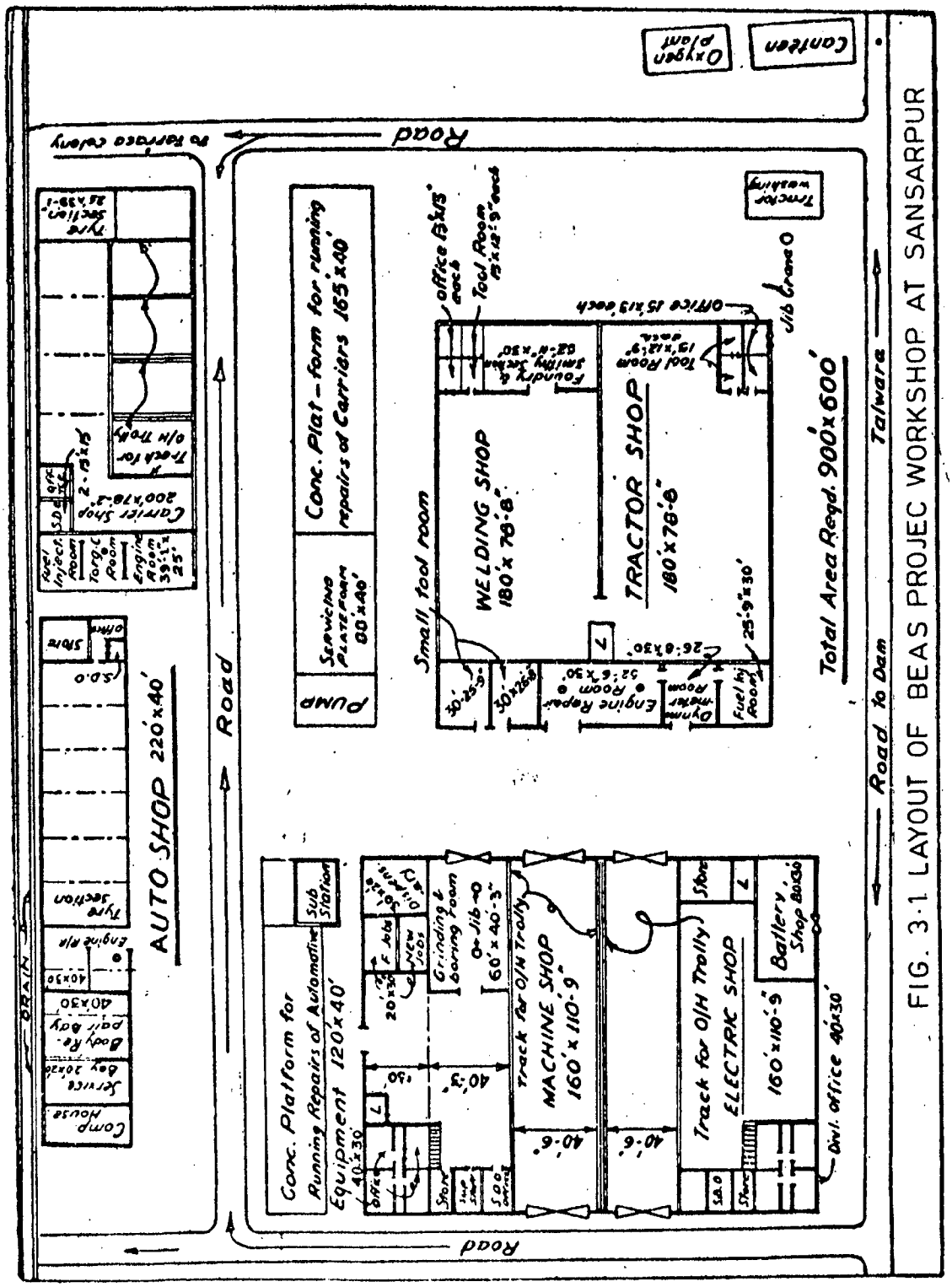


FIG. 3·1 LAYOUT OF BEAS PROJEC WORKSHOP AT SANSARPUR

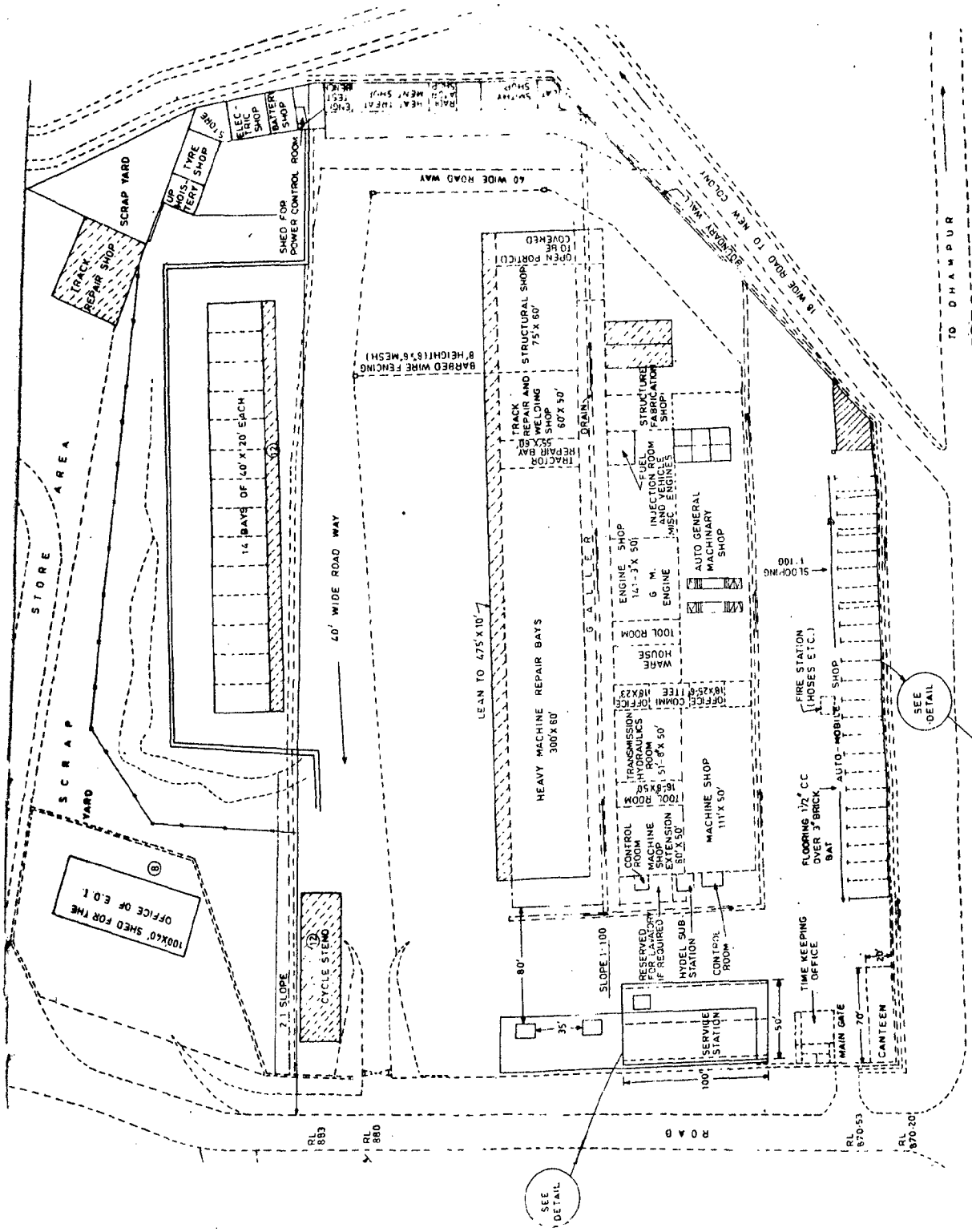


FIG. 3.3 LAYOUT OF BASE WORKSHOP OF RAMGANGA PROJECT AT KALAGARH

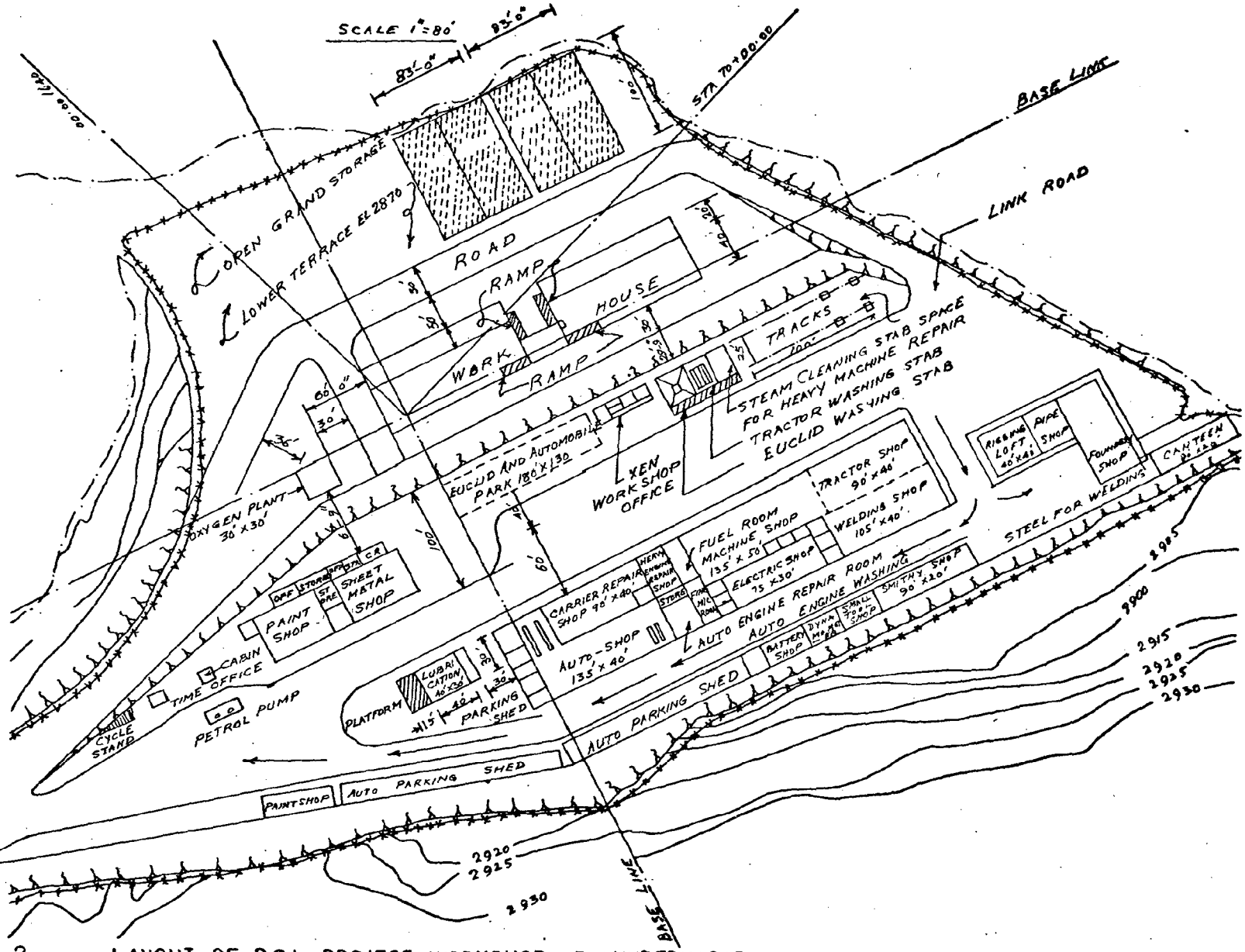


Fig.No.3.2 LAYOUT OF B.S.L. PROJECT WORKSHOP AT SUNDERNAGAR

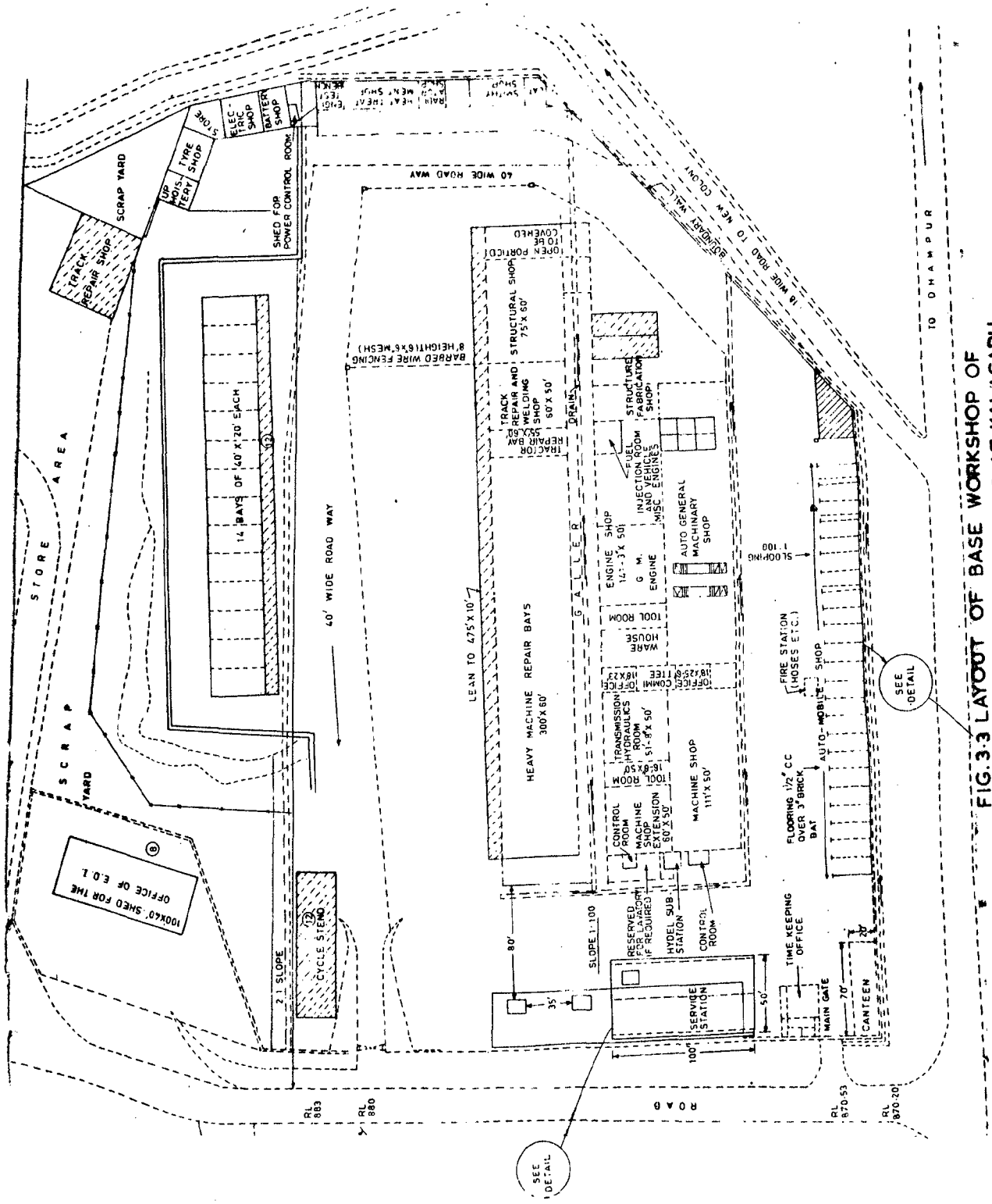
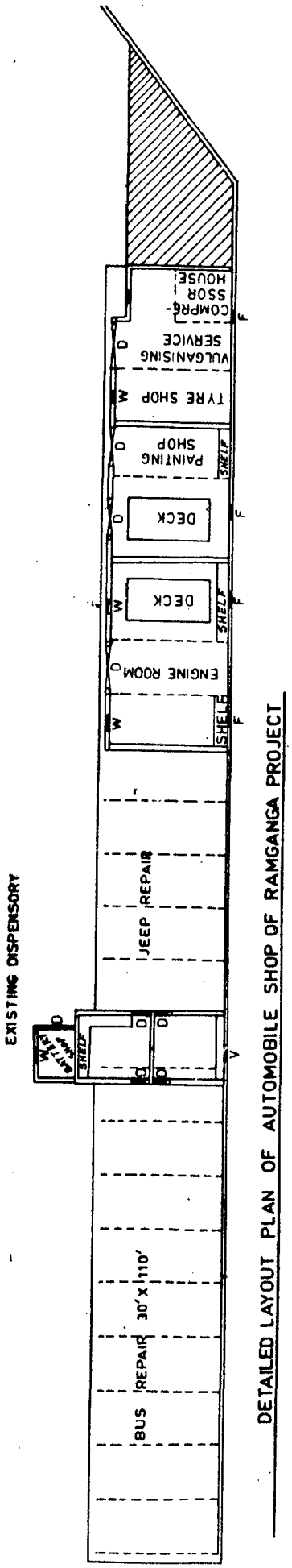
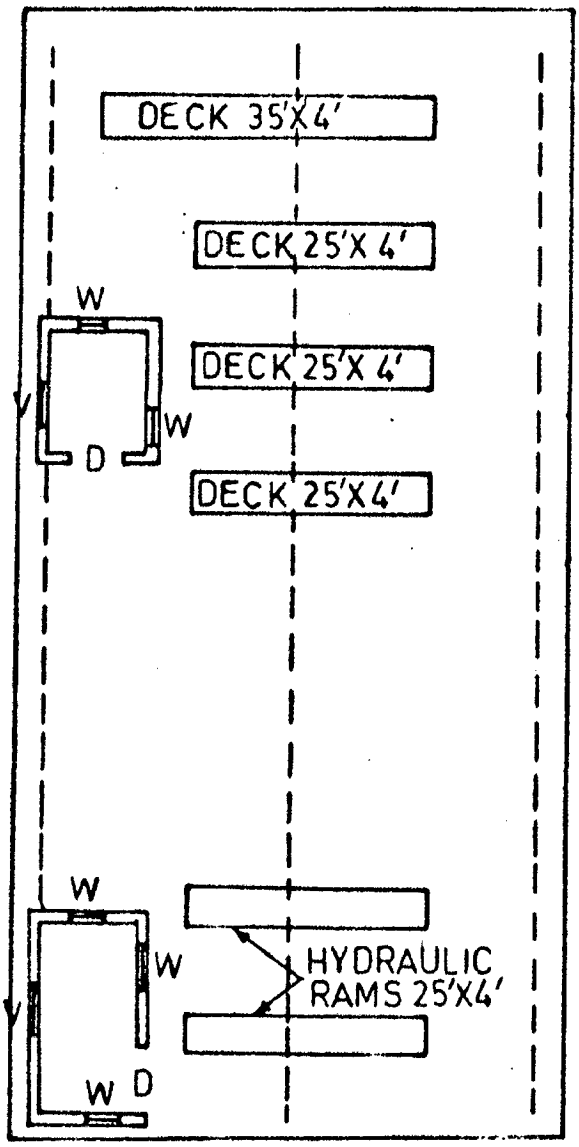


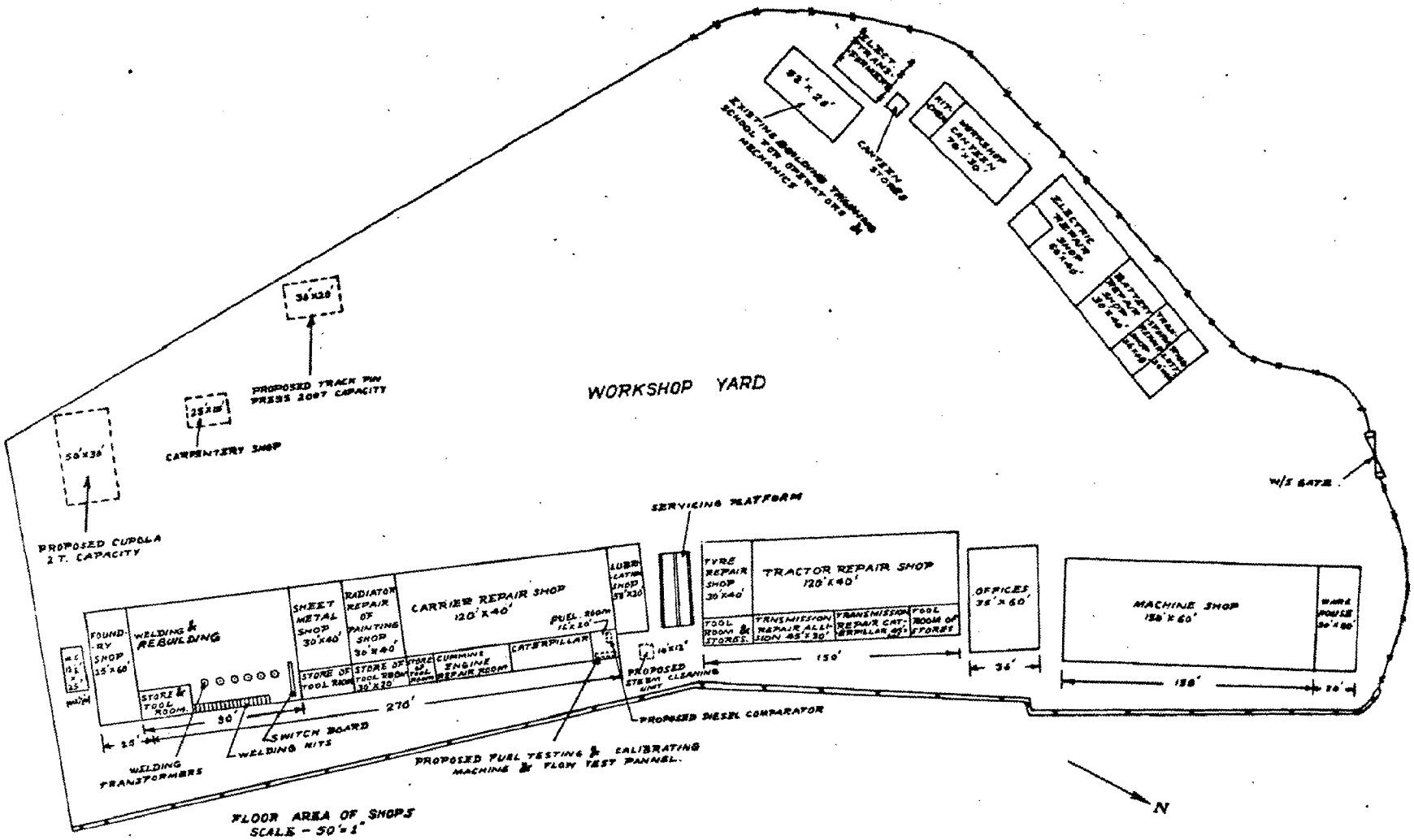
FIG. 3·3 LAYOUT OF BASE WORKSHOP OF RAMGANGA PROJECT AT KALAGARH



DETAILED LAYOUT PLAN OF AUTOMOBILE SHOP OF RAMGANGA PROJECT



DETAILED LAYOUT PLAN OF SERVICE STATION OF RAMGANGA PROJECT



FLOOR AREA OF SHOPS
SCALE – 50'=1"

SPACE FOR INSTALATION OF PROPOSED EQUIPMENT SHOWN IN DOTTED LINES

FIG. 3.5 LAYOUT OF WORSHOP OF SALAL HYDRO ELECTRIC PROJECT AT DHYANGARH

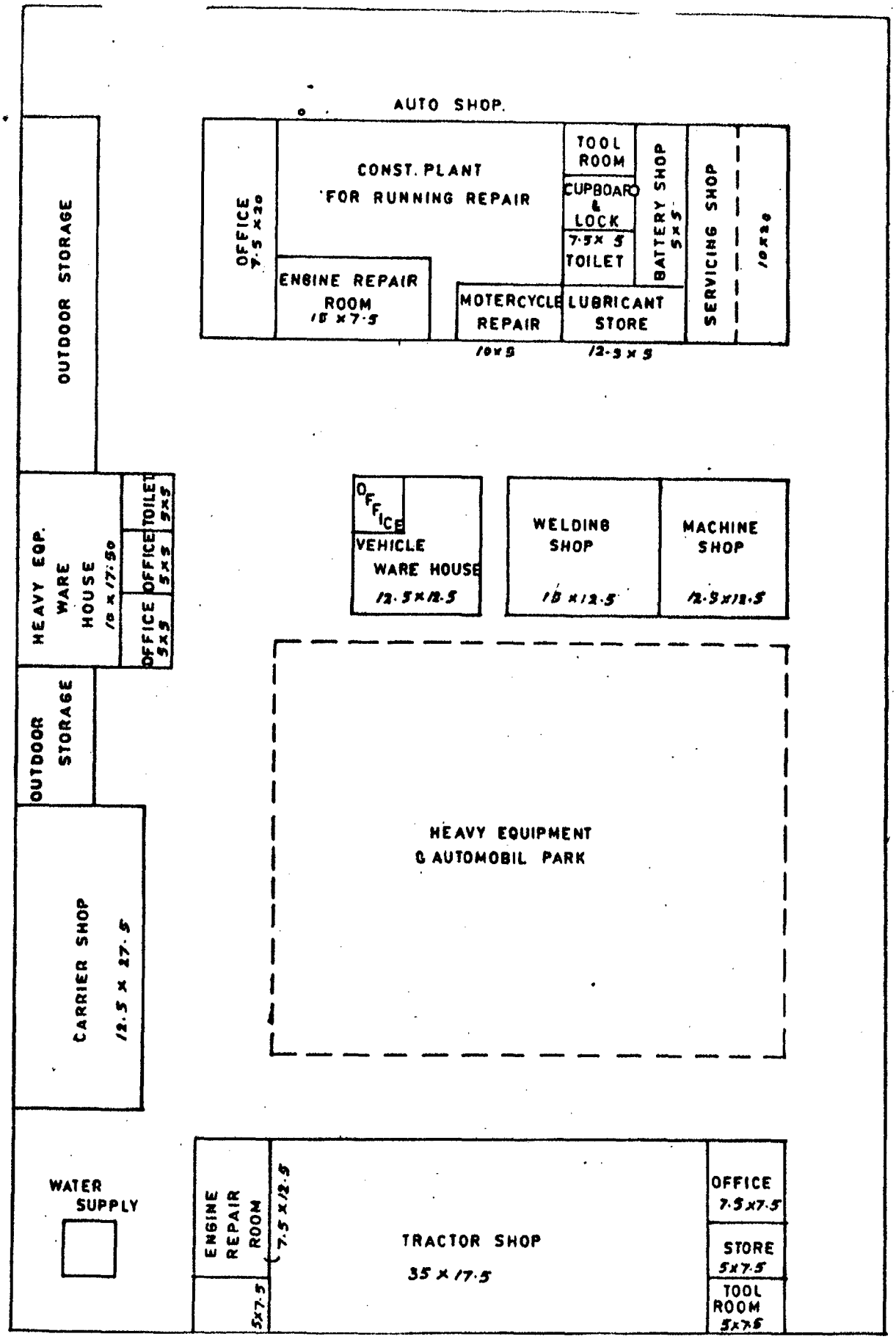
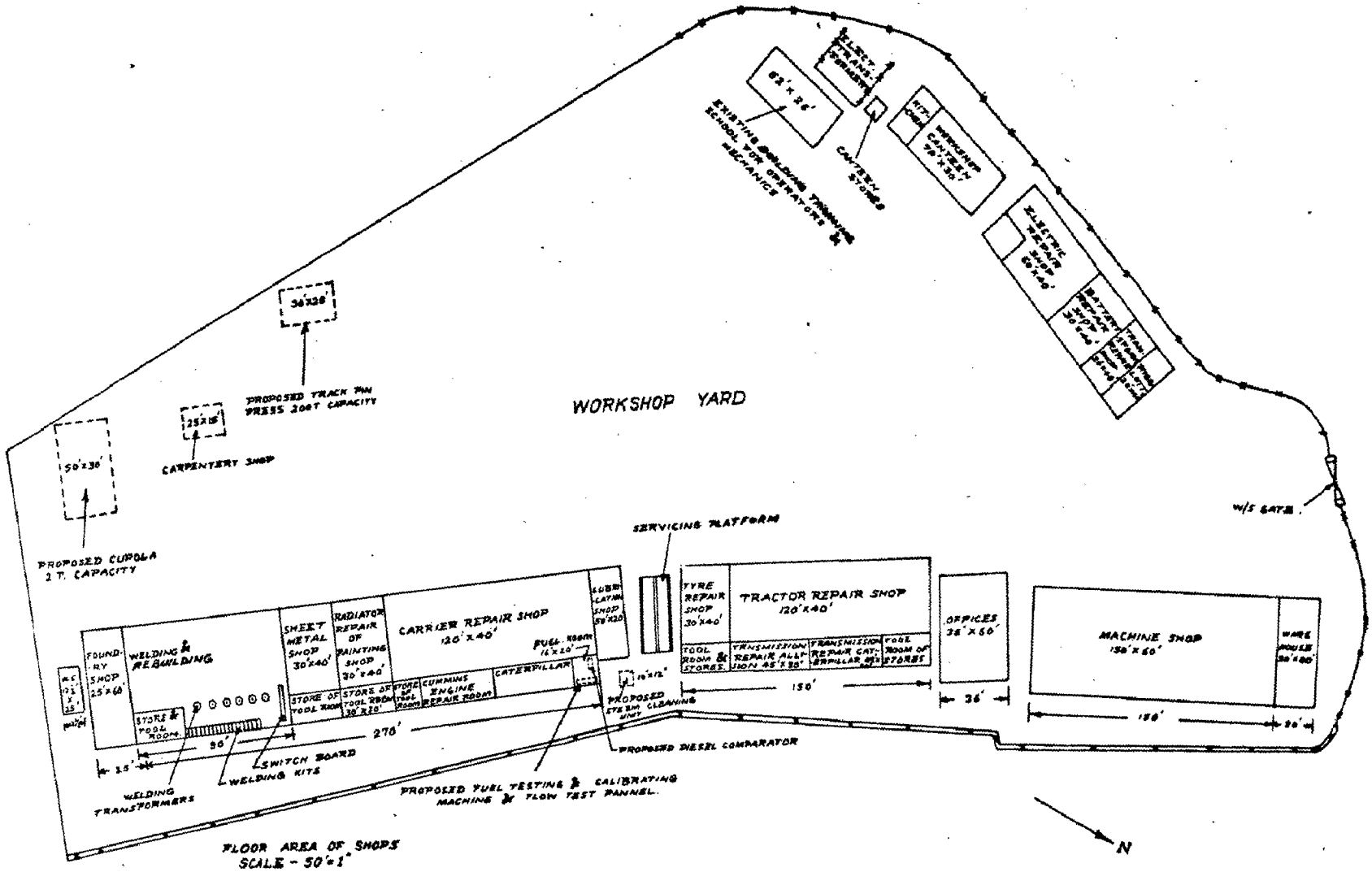


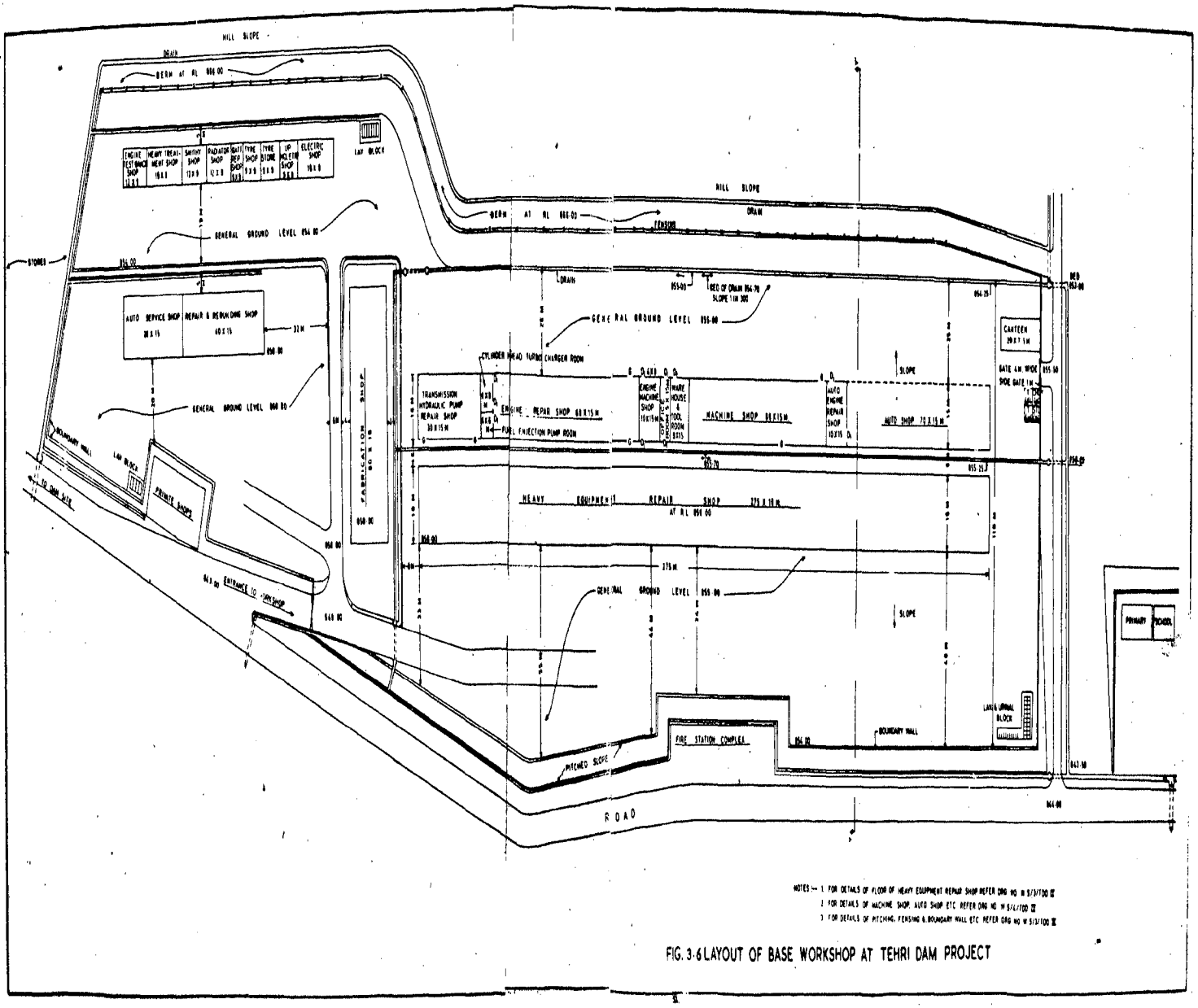
FIG. 3.4 LAYOUT OF WORKSHOP OF JRATUNSELUNA PROYECT (INDONESIA)



FLOOR AREA OF SHOPS
SCALE - 50'=1"

SPACE FOR INSTALATION OF PROPOSED EQUIPMENT SHOWN IN DOTTED LINES

FIG. 3.5 LAYOUT OF WORSHOP OF SALAL HYDRO ELECTRIC PROJECT AT DHYANGARH



NOTES :- 1. FOR DETAILS OF FLOOR OF HEAVY EQUIPMENT REPAIR SHOP REFER DRG NO W S/3/100 II
2. FOR DETAILS OF MACHINE SHOP, AUTO SHOP ETC REFER DRG NO W S/4/100 II
3. FOR DETAILS OF PITCHING, FENSING & BOUNDARY WALL ETC REFER DRG NO W S/3/100 II

FIG. 3·6 LAYOUT OF BASE WORKSHOP AT TEHRI DAM PROJECT

all cases, so that basic objective of breakdown and preventive maintenance is facilitated. In contrast with these layouts of maintenance and repair workshops, a manufacture workshop layout is shown in Fig.3.7. This layout of a penstock fabrication workshop of M/s Indian House Pipe Co. Ltd. Pune shows the product layout.

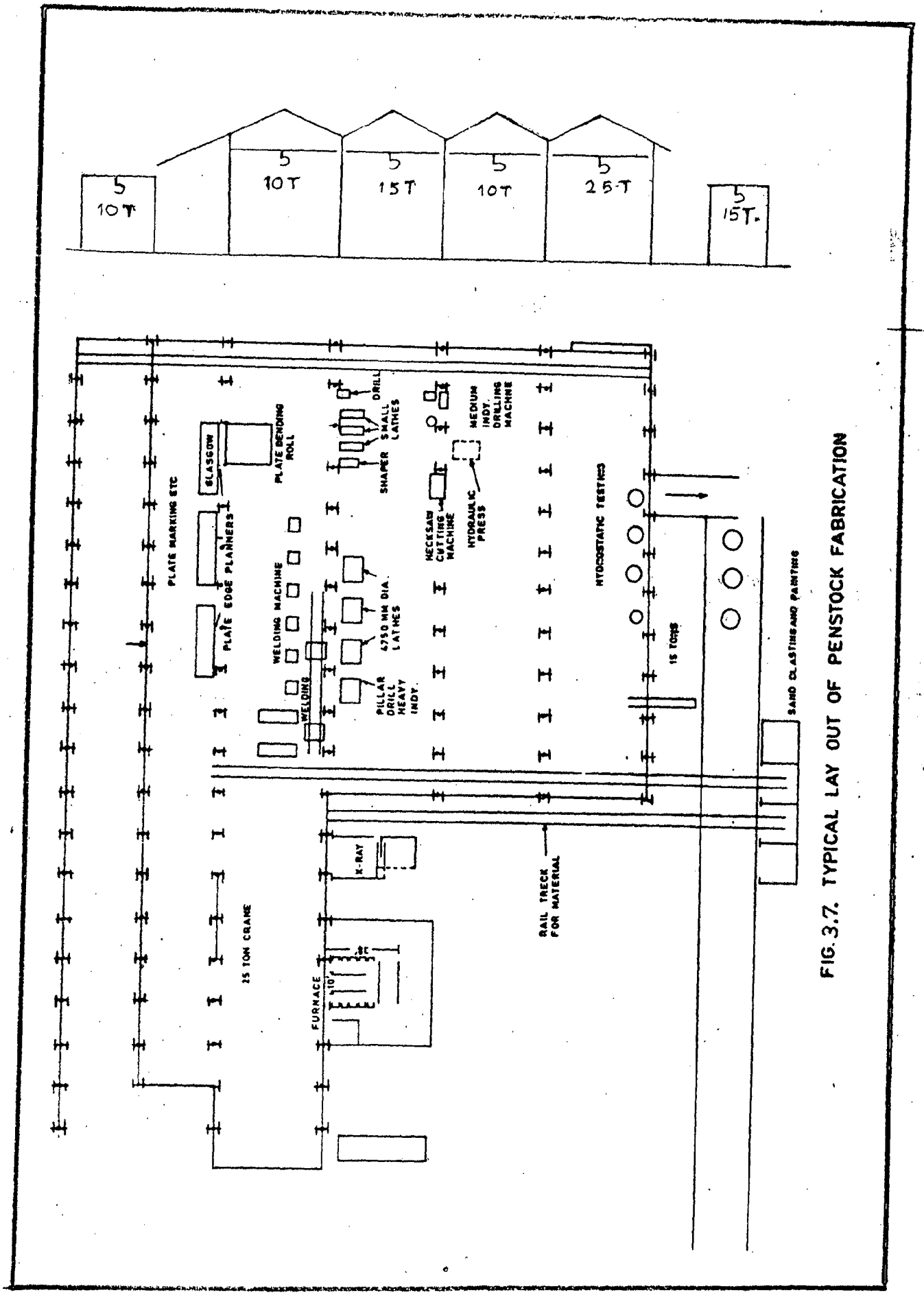


FIG. 3.7. TYPICAL LAY OUT OF PENSTOCK FABRICATION

CHAPTER-4

DESIGN OF BASE AND FIELD WORKSHOPS

4.1 GENERAL

Before discussing design of base and field workshops, which have been briefly introduced in Chapter II, it is considered suitable to elaborate the scope of work in the two types of workshops. The base workshops are required to cater for total repair, maintenance and manufacturing facilities planned for a project. The base workshop are also referred to as central workshops and the nature of work for centralised maintenance could be classified as general maintenance and repair and would be of multipurpose type including major repairs to the equipment and substantial amount of manufacturing processes consuming a good deal of raw material. The function of the central workshops can be defined as being one or more of the following -

1. The machining or fabrication of parts for emergency maintenance repair where these are not available from the store/stock. This is usually the prime role of a central workshop, the objective being to reduce down time during emergency repair.

2. Machining or fabrication of part for planned corrective maintenance. This requirement frequently arises as result of extensive stripping of equipment, revealing wear and the need to replace or repair components the extent of which could not normally be ascertained during planned preventive maintenance inspections. Such situations are exemplified by gear box

overhauls, or repairs for which replacement may not be held for economic reasons.

3. The repair of sub assemblies, standby units, including spares for stores/stock and including electric motor, switch gear and control mechanisms.

4. Modifications to construction equipment, when required so as to render the construction equipment suitable for job conditions.

5. Capital construction work which would include the manufacture of specialist production machines or plant, designed and developed at the project, because it may not be desirable to contract out this type of work.

6. Miscellaneous work of a non maintenance and non-capital nature. For example the erection of temporary office/residential accomodation and similar work. Thus base workshops in general, provide for most of services, with due consideration to factors like its location relative to outside facilities accessibility by road, rail and other modes of transport and available capital for investment.

Field workshop are required at field level for day to day routine maintenance, adjustment and minor repair which need prompt attention so that it may not subsequently lead to severe breakdown due to negligence in carrying out repairs in proper time. Yet another purpose of field workshop is to ensure that no machine is allowed to continue on work when it is in need of mechanical attention of relatively minor nature or of a more service character.

The field workshops are distinct from base workshops in that the field workshop provide for those shop services which are just necessary for minor repairs to construction equipment, in contrast to the major repairs which are normally carried out in base workshops. The minor repairs have been distinguished from major repairs by defining the major repairs in different ways such as, (i) replacement of major components because of excessive wear through a long use, (ii) cost incurred by base workshops, (iii) repairs requiring more than 24 hours, (iv) repair costing more than 1 percent of the value of equipment etc. However in the interest of sustaining continuous production from construction equipment, it is customary to replace some of the components and subassemblies of the construction equipment by new or removated/reconditioned components and assemblies in the field workshop itself, thereby saving long down time, which other wise would have been necessary for overhauling the components and subassemblies. Immediate replacement of a defective assembly is more expedient and the machine can be used in field immediately after replacement. Obviously in some cases the cost of such replacement is substantial in monetary terms which warrants classification of the repair as a major repair despite the short repair time taken for the repair in the field workshops, which qualifies the replacement to be treated as minor repair. Thus the distinction between field workshops and base workshops on the basis of type of repair (i.e. major or minor) is rather vogue.

Yet another criteria of distinguishing the field workshops from the base workshops could be the facility of regular manufacture of typical item that may be required on the project. The field workshops are normally not equipped with machinery required for such regular manufacture. However, in some instances, the field workshops are also required to manufacture simple items like ribs for tunnel support and such situations, arise only due to proximity to site.

Thus the facilities in a field workshop may vary considerably commensurate with varying repair demand and/or manufacture requirements of water resources projects.

4.2 LOCATION

Base workshops or central workshops are required to be located at central place in project area, so that they are conveniently accessible for entire project and can also provide support to all field workshops for undertaking such repairs that are beyond the capacity of field unit.

Field workshops on the other hand are located close to area of operation of construction equipment, so as to minimise time required for bringing the equipment to workshop for repair sometimes it is not possible to locate field workshop close to scattered working areas due to topgraphical constraints. In such situations mobile field workshops are deployed for routine repair and maintenance of construction equipment. The mobile field workshops comprise of certain selected repair and maintenance facilities

provided on a treck trailer unit which can be successfully utilised for operating in scattered working areas.

4.3 SPACE REQUIREMENT

Space requirement for repair, maintenance and regular manufacture of typical items for any project depend to a large degree on factors like the extent of repair and maintenance , type and size of construction equipment and fleet size. Extent of repair and manufacture to be undertaken in a workshop (i.e. whether certain type of repairs are to be done in field maintenance/ manufacture workshop or in a higher level workshop the central maintenance/manufacture workshop) governs the space requirement in that an intensive repair facility would require more space while a minor repair arrangement would warrant comparatively lesser space. Another factor that must be kept in mind while finalizing space requirement of workshops for water resources projects in the fact that construction equipment requires a large amount of space for laying up. Therefore provision has to be made for a large shed/ yard, for dismantling and erection of equipment brought to workshop for repair. Similarly regular manufacture of special items also require a large space for finished/manufactured item as well as for raw materials and this again warrants provision of a large shed/yard.

Type, size, and number units to be repaired or manufactured in the workshop, also dictate the space requirements in a workshop. Number of major units of equipment, specially the motorized types which are to be maintained and repaired in the workshop

have a direct bearing in space requirement. For example, special care would be necessary about the overall length of dumper(specially in case of bottom dumpers) and the height of the dumper body (specially in case of rear dumpers). Yet another aspect requiring attention is the fact that construction equipment like dumpers, scrapers, tractors etc. would require pooling space prior to entry in the covered shop floors or after repairing. Hence space requirements fact under two distinct categories or covered area and uncovered open area.

On the basis of foregoing, the construction plant and machinery committee, constituted by Government of India, has recommended following scales for space requirement -

(a) For a base/central repair shop, covered floor area may be estimated at 13.95 to 16.75 sq.m (150 to 180 sft) per machine for a total number of machines to be served in the shop. Uncovered land floor space is recommended to be 2.5 to 3 times the area of covered floor space set aside for the machines.

(b) For a field workshop, covered floor area may be generally estimated at 4.6 to 5.575 sqm (50 to 60 sft) per machine (where size of machine is small) and 9.30 to 11.15 sqm(100 to 120 sft) per machine (in respect of heavy earthmoving machinery items). An equal uncovered floor area having a concrete floor is also additionally required to be provided in field repair workshop.

In order to check this recommendation of construction plant and machinery committee necessary data for a few water resources development projects has been collected as per detail in Appendix-I

which gives the list of major construction equipment for Beas Project, Beas Sutlej Link Project, RamGanga Project, Jratunselima project, Salal hydro electric project and Tehri Dam project covered and uncovered area for these workshops have been assessed from lay out plans in figure 3.1 to 3.6 and provision of space per machine has been computed in Table 4.1. Results of this table reveals that recommendations of the construction plant and machinery committee hold good in most cases. The Committee has also given a typical repair shop plan layout relative to centralised maintenance and repair work for 200 machines which is shown in Fig.4.1. Total co-covered area and uncovered area is also indicated in the figure. Space requirement for the purpose of manufacture of a typical items, in any workshop is usually dependent upon the processes and operations involved and no guide line can be set forth for this. One has to make use of sound judgement for assessing space requirement related to a workshop planned for manufacture a typical items.

4.4 BUILDING

The most common building material for base and field workshops is structural steel because -

i) it has low weight to strength ratio

ii) it can be readily fabricated to given shapes and dimensions

iii) it can be made corrosion resistant

iv) it is adoptable to structural needs

v) it can be conveniently used in combination with other materials such as concrete blocks, bricks and panelling materials to suit the architectural design.

Table 4.1

Covered Area per Machine and Ratic of uncovered area versus covered area for workshops

Sl. No.	Name of Project workshop	No. of equipment to be repaired	Covered area in sqft	Uncovered area in sq.ft	1. Area required for no. of machine 2. Ratio uncovered area / Covered area	Ratio uncovered area Vs covered area
1.	Beas at Sansarpur (India)	656	99780	279220	$\frac{99780}{656}$ = 152 sq.ft. per machine	$\frac{279220}{99780}$ = 2.8
2.	Beas Sutlej Link at Sundernagar	493	17975	223225	$\frac{176975}{493}$ = 156 sq.ft. machine	$\frac{223225}{76975}$ = 2.9
3.	Ramganga (India)	520	97272	291800	$\frac{97272}{520}$ = 187 sqft/ machine	$\frac{291800}{97272}$ = 3
4.	Jatursellina (Indonesia)	152	27113	73205	$\frac{27113}{152}$ = 178.4 sqft/ machine	$\frac{73205}{27113}$ = 2.7
5.	Salal (India)	187	51507.5	151947.5	$\frac{51507.5}{187}$ = 275 sqft/ machine	$\frac{151947.5}{27113}$ = 2,7
6.	Tehri (India)	533	118850	351468	$\frac{118850}{533}$ = 223 sqft/ machine	$\frac{351468}{118850}$ = 3

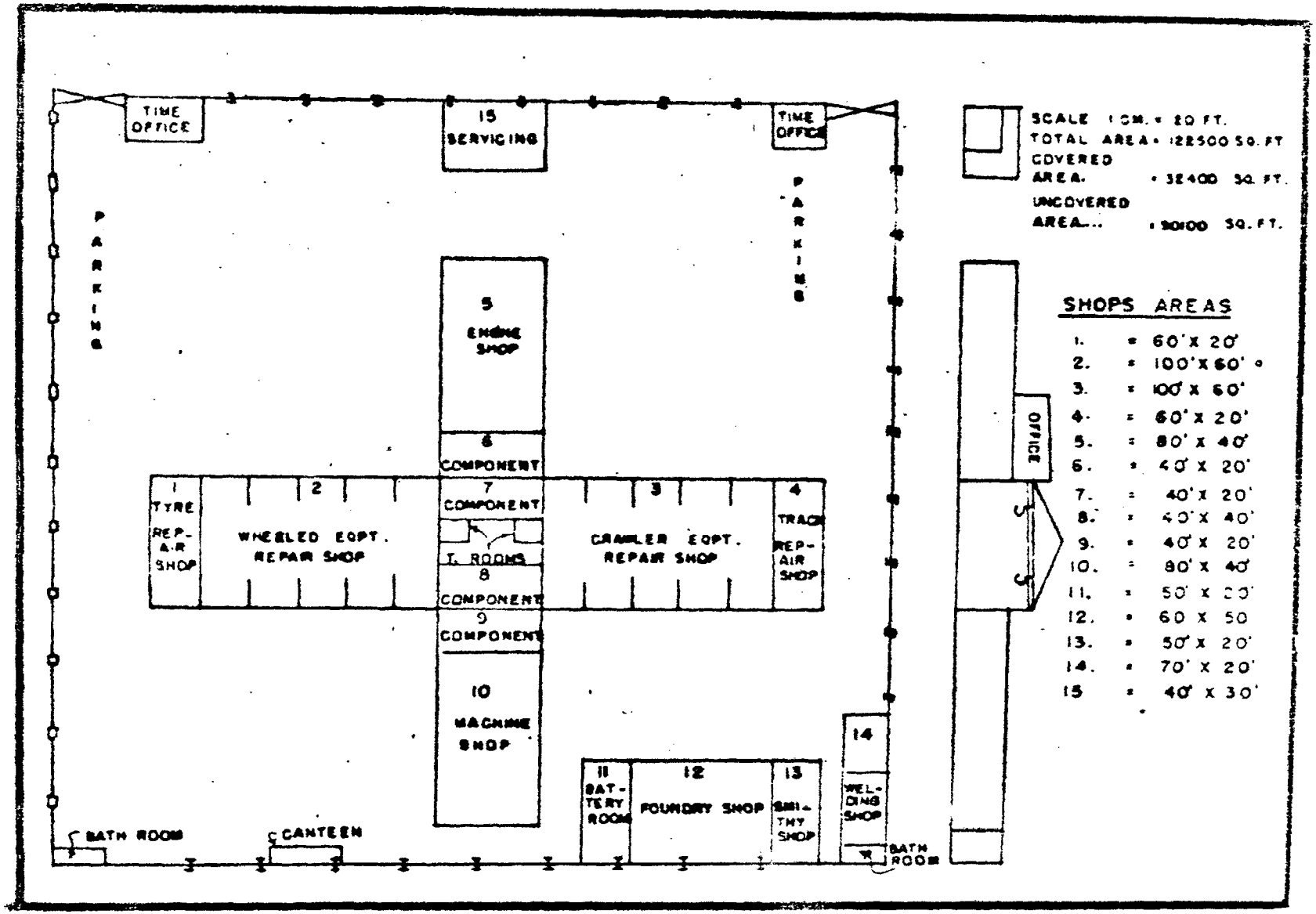


Fig.No. 4.1 TYPICAL WORKSHOP LAY-OUT FOR REPAIR FACILITIES FOR 200 MACHINES

vi) it can conveniently accommodate future expansion or remodelling, and

vii) it can be conveniently transported, quickly erected and rapidly dismantled.

However in some cases where it can be envisaged that on completion of the construction work on a project the workshop facilities could be commercially used on permanent basis(as may be a case with base workshop), masonry workshop buildings have been used despite high initial cost of masonry work and inherent difficulty of recommendating future expansion or remodelling programmes in contrast to the inherent convenience associated with structural steel. The only advantage in relation to masonry structures are the excellent architectural effect that can be obtained in such structures and the low up keep cost of buildings.

For selecting type of workshop building due consideration has to be given to the climatic conditions and geopgraphical location etc. Intensity of heat (as a result of day temperatures), the snow fall condition (in high altitude areas) intensity of rainfall etc. have to be given due weightage in selection of workshop building. In hot day area the problem of heat transmission through the roof assumes serious proportions. Likewise in desert areas dust storms post serious threat. To avoid dust and dirt in workshop area and yet provide ventilation for convenience of the personnel working in the workshops, the workshops are to be of enclosed type. In such circumstances asbestos cemented sheets would provide protection against dust and heat. In most of the

other places corrugated galvanized steel sheets are in use. In areas where there are heavy rains, the work shops have to be suitably enclosed with rain canopies and the floor area has to be fairly above the road level. Due consideration has to be given to the type of roof to be provided over the workshop building because a poor roof is a constant harrasment and functioning of the roof for many years with relatively little maintenance is equally important.

4.5 WORKSHOP FLOORS

Floors of workshops are must ' worked' part in any workshop. Except for special areas like foundry, most floors are of poured concrete, concrete for floors require the best of materials so as to be of hard, abrasion resistant quality because construction equipment and its components have to be constantly on the floor. If the shop floors are poorly made, it is impossible to keep hygenic conditions prevailing in the area, where the equipment is to be handled for repair. Subgrade is also equally important because a good concrete on poor subgrade gets crushed and crumpled very soon. Hence it is to be ensured that the fill(farming the subgrade) should be compacted to 95 percent of standard optimum compaction and should be capable of supporting the floor loads.

Trenches and drains, duly covered with grates so as to permit free drainage have to be provided in the workshop floors. Most of the shop floor should be raised from general ground level and ramps having mild slopes should be provided on ground level

to shop floor so as to take advantage of natural drainage. Initial saving on the size or number of floor drains proves to be costly in long run.

Workshop floors have to be designed in specific relation to the type of equipment to be repaired. For example, if a fleet of crawler tractors and excavators is to be operating at a project, the repair shop for crawler tractors and excavators would have different types of floors. For crawler tractors, the crawler tracks would make it necessary for the floor to have proper reinforcement to withstand the impact of grouser bars. Most often old rail pieces are set into the concrete slab, almost flush with surface (i.e. slightly projecting above the floor surface) so that they farm steel plat farm which will not be damaged by crawler equipment. Width and gauge of the crawler tracks has to be kept in view for spacing of embedded rails or steel. For excavators, the shop floor has to have a pit with proper drainage arrangement so that the excavator could crawl into the pit through an approach ramp having smooth gradient of say 1 in 16. Pit depth should be such that foot board of the excavator in the pit is flush with general floor level of the shop so as to afford convenience of easy dismantling of the upper frame machinery and boom etc. The drainage arrangement for the pit generally comprises of a sump pump which pumps out water from a small drainage sump in one corner of the pit. The drainage sump is best located at one of the ends of the pit,(preferrably at farthest end opposite to the ramp). The pit would have to be under a roof with proper lifting tackle the suitable for heavy loads. Another advantage of providing a pit in the floor of

excavator repair shop is the saving in the height of roof over the repair shop which would otherwise have to be fairly large for long booms.

Fig.4.2 shows typical layout for a workshop with brief description about type of structure and floor.

Before concluding the chapter on design of base and field workshops a passing remark about the cost is considered necessary. It has already been stated that space requirements for a workshop is directly proportional to the number of construction equipment to be serviced or repaired. In other words the cost of workshop floor space increases with increase in size of fleet or the cost of construction equipment to be serviced. Construction Plant and Machinery Committee has recommended that the cost of covered and uncovered floor space and the sheds to be provided forthe field and base workshops may be estimated at 1.5 to 2 percent of the total cost of equipment to be serviced in the workshop. These recommendations however, could not be checked because of non-availability of relevant data.

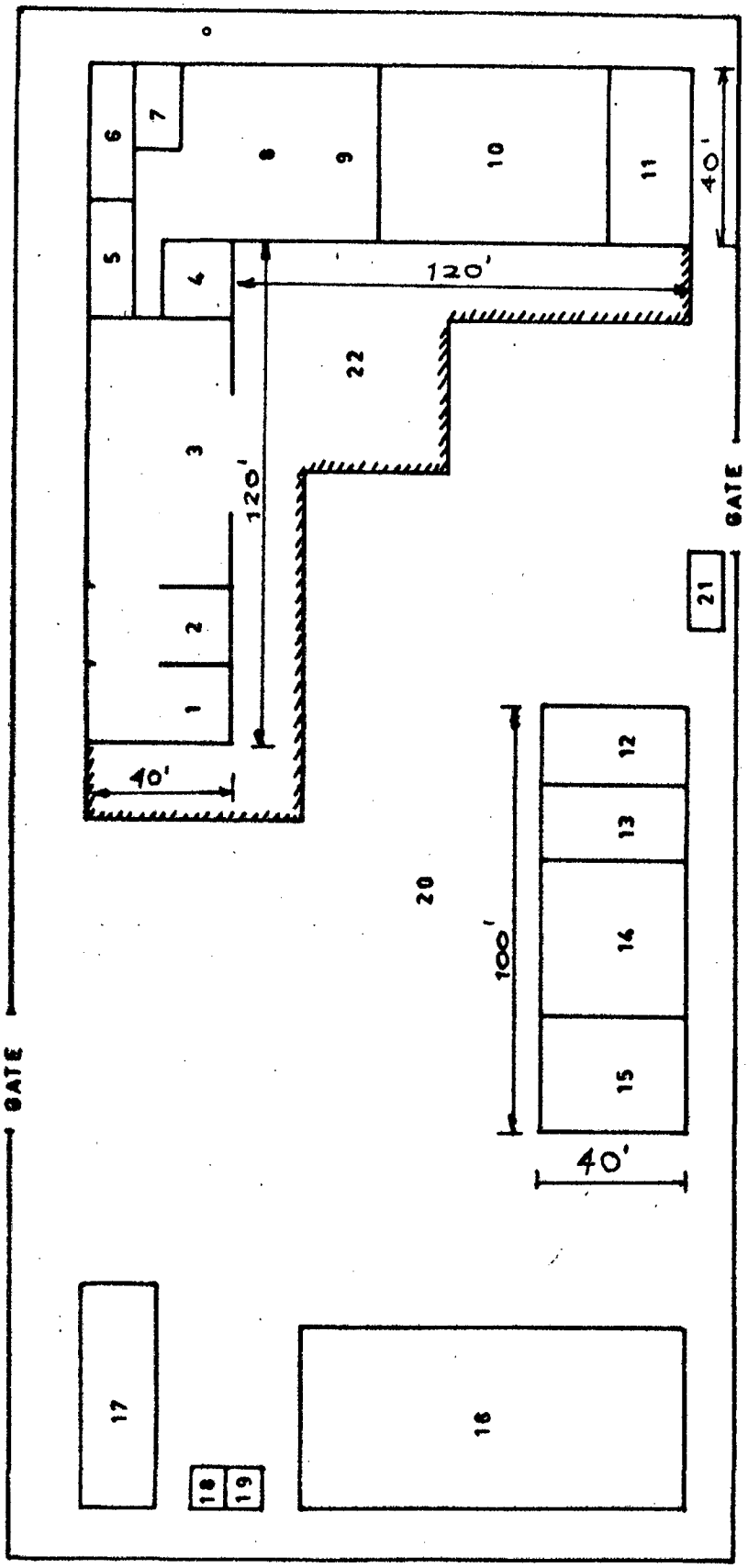


FIG.4.2 TYPICAL REPAIR SHOP LAYOUT

The Plan of typical workshop is given in Fig.4.2.

No.	Description	Type of structure of floor
1.	Smithy	Open, gravel or sand floor
2.	Welding	Open, concrete
3.	G.M. shop	Close with window, concrete
4.	Foremen's office	Closed
5.	Gauge, pumps, injector etc. test room	Closed, dirt proof
6.	Electrical repair and testing	Closed, dust proof
7.	Tool storage	Concrete floor with counters
8.	Engine line	Close with windows and work benches concrete floor
9.	Engine test	Open with concrete floor
10.	Track and chasis shop	-do-
11.	Cleaning and painting shop	Concrete floor with pit
12.	Battery charging	Close with window
13.	Tyre maintenance	Open with concrete floor
14.	Automotive workshop	-do-
15.	Carpentary and Upholstery	-do-
16.	Store and store office	
17.	Canteen	
18.	Wash	
19.	Lavatory	
20.	Fire service	
21.	Time and security office	
22.	Concrete apron	

used in workshops are briefly described below.

1. Overhead Crane

Almost every workshop requires the use of an electric overhead crane to be efficient. The size of the crane is to be determined by the heaviest piece to be handled. The type of control for the crane is again dependent upon the type of its usuage in the shops. In large shops the best advantage is obtained from cranes equipped with pulpit and controls. In others, the pendant cable controlled crane is cheaper initially and requires no operators. This type of crane works well for most of the shops, except where the shops are of a very large size, sometimes mobile floor cranes are also advantageously utilised for handling purposes in the workshops. Fig.5.1 shows two versions of the mobile floor cranes.

2. Jib cranes

Certain shop functions are best served by jib cranes, covering the area within their radius thus conserving overhead crane time. These can be provided with manual/electric or pneumatic hoists. Fig.5.1 shows five common versions of jib cranes.

3. Mono rail cranes

Mono rail cranes are also sometimes used. These, however, have limited application as these are effective only when one route movement is possible. These are not flexible, but can be used to transfer materials from shop to shop or from shop to outside or even from crane to crane.

CHAPTER-5

WORKSHOP EQUIPMENT

5.1 GENERAL

It will be too much to elaborate the details of equipment that should be installed in the workshops for convenience of quick repairs to construction equipment because exact requirements in this respect would have to be precisely related to the type and volume of work to be done in the workshop with due consideration to the facilities available outside the project. For example, where population of construction equipment is relatively small, it is customary to have fuel injection components repaired by specialised organisations outside who are generally named as ' Factory authorised venders/dealers'. However, in situations where number of diesel engine powered construction equipment is fairly large, it may be suitable to have equipment for repair of fuel injection components in the workshop. Hence only type of workshop equipment has been identified in this chapter. While the workshop equipment has been enumerated separately for field workshops, base workshops and manufacture workshops. The common equipment like materials handling equipment cleaning equipment and servicing equipment have been described in this sections.

Importance of materials handling hardly requires any emphasis because expenditure on handling of materials at times mounts to as high as 40 percent of the total cost of work in a shop(18). Various types of handling tools that are commonly

used in workshops are briefly described below.

1. Overhead Crane

Almost every workshop requires the use of an electric overhead crane to be efficient. The size of the crane is to be determined by the heaviest piece to be handled. The type of control for the crane is again dependent upon the type of its usuage in the shops. In large shops the best advantage is obtained from cranes equipped with pulpit and controls. In others, the pendant cable controlled crane is cheaper initially and requires no operators. This type of crane works well for most of the shops, except where the shops are of a very large size, sometimes mobile floor cranes are also advantageously utilised for handling purposes in the workshops. Fig.5.1 shows two versions of the mobile floor cranes.

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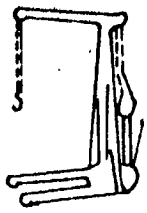
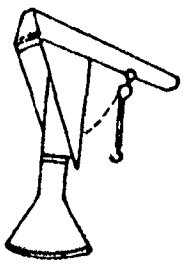
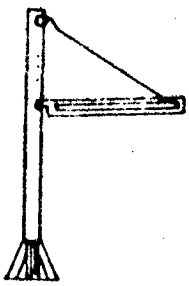
MOBILE FLOOR CRANE
TWO TON CAPACITY



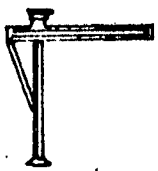
UNIVERSAL PORTABLE FLOOR
CRANE TWO TON CAPACITY



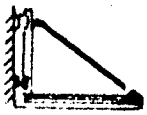
SELF SUPPORTING FULL REVOLVING
PILLAR JIB CRANE



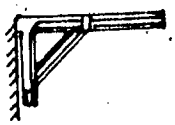
BRACKETED PILLAR JIB
CRANE



MAST TYPE JIB CRANE



WALL BRACKET JIB CRANE



UNDERBRACED WALL BRACKET
JIB CRANE

FIG. 5.1-(9)

4. Trolleys and fork lift trucks

Trolley afford easy transport of bulky items like penstock shells from one shop to another and are more popular in manufacture workshops, where flow of material is along a well defined channel and permanent rails embedded in the shop floor for movement of trolleys facilitate the material movement. In maintenance and repair shops, however, the trolleys are not very popular because of lack of well defined channels for flow of jobs from one shop to another. Fork lift trucks are more popular for materials handling in repair and maintenance workshops.

Like materials handling equipment, the cleaning equipment is equally important. Cleaning saves valuable shop time and pays for itself. Experience has proved that is taken about 15 percent to 35 percent longer to repair an equipment that is not cleaned properly (9). It is also true that a clean machine gives the mechanics a better chance to do a good job. When a machine comes into the maintenance shop for servicing, it should be cleaned either with water jet under pressure or with steam. While water jet cleaners require high pressure pumps which produce water jet at about 600 psi, the steam cleaners have two types - namely, the vapour type and combined type(which combine thermal and hydraulic pressure). The vapour type produces steam under thermal pressure alone and operating pressure is limited to only 7 kg/sqcm(100 lbs per square inch). Hence the vapour type units can not blast away heavy accumulation of dirt

and grease. This type, therefore, is capable of handling light cleaning only. The combined thermal and hydraulic pressure type combines thermal and hydraulic pressure at the nozzle. These heavy duty cleaners are equipped with a pump that increases operating pressures which normally range from 21 to 28 kg/sqcm (300 to 400 psi). Fig.5.2 shows a typical steam cleaning arrangement for crawler mounted equipment. The steam cleaner is housed in a corrugated sheet shed at one end of cleaning slab. Beside protecting the steam cleaner the shed serves as storage area for other equipment used in the cleaning operations. A steam pipe from this shed feeds an overhead jointed boom, which is set conveniently between two cleaning platforms, built up by embedding inverted rails in the floor so that the steam nozzle can be moved around the two platforms. The overhead boom also reduces hose wear because it keeps it off the slab, reduces abrassive wear from dragging and permits a permanent pipe to be used instead of rubber hose for the greater part of the steam line. The two platforms ensure that floor is not damaged by crawler mounted equipment particularly when the tracks are allowed to spin slowly after fastening the drawbar of crawler tractor to two hooks projecting from concrete blocks in front of the two platforms. This arrangement facilitates washing of dirt from truck plates and links. The floor slab housing the embedded rails is shoped slightly so that the water and muck runs off rapidly into a deep sump, which is generally cleaned once a year by a small dragline.

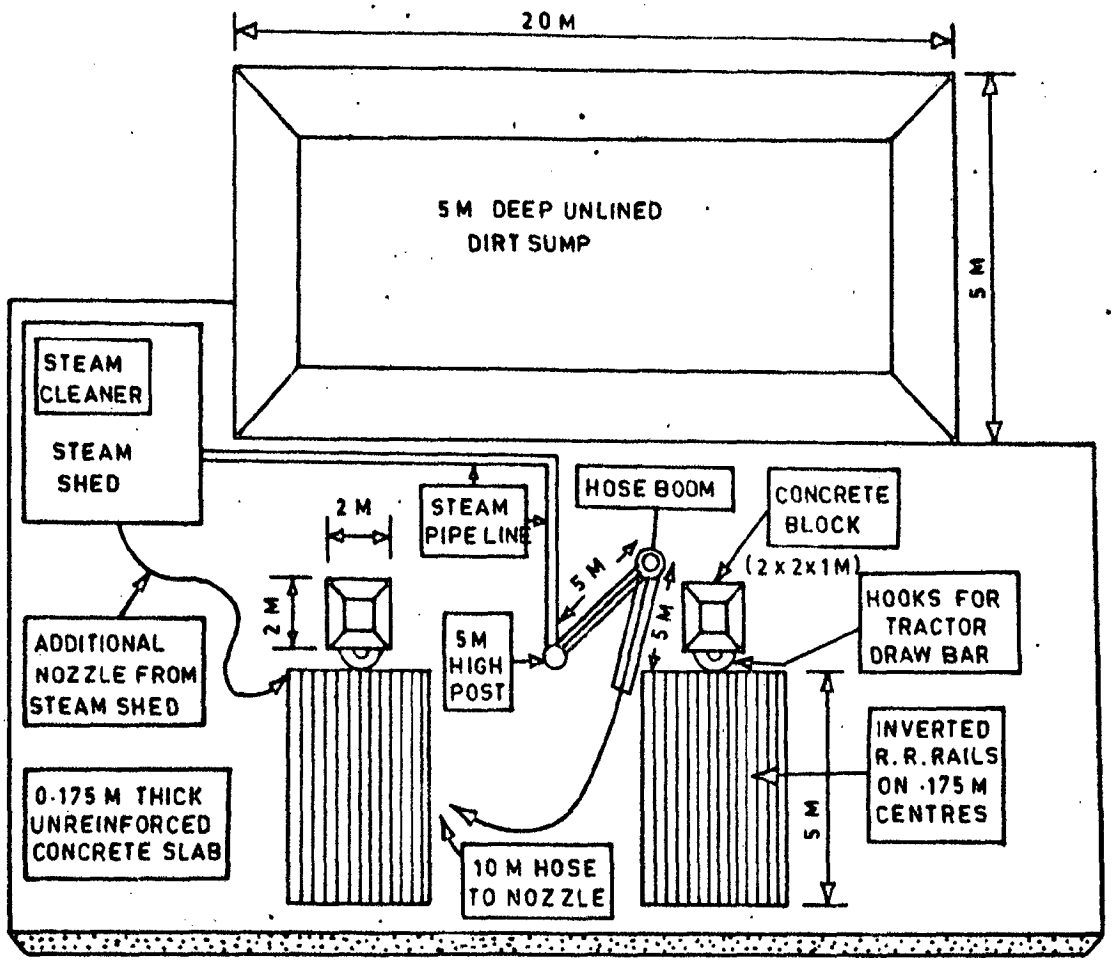


FIG. 5·1 STEEM CLEANING ARRANGEMENT FOR CRAWLER TRACTORS (9)

Servicing units, attached to field workshops or base workshops, and servicing equipment provided in mobile field workshops generally include -

1. Tanks or containers for all classes of lubricants, flushing and cleaning fluids water and destilled water etc. with arrangements for drawing off without contamination.
2. Air compressor plant for pressure greasing, air cleaning and type inflation, as may be required.
3. High pressure water washing plant, petrol or diesel driven (for mounting on mobile plant) or electric motor driven(for static plant).
4. Filling measures for each type of lubricant service tools, grease guns, pressure grease buckets, spanners of assorted sizes and types, puncture repair outfits etc. etc. with arrangement to keep them clean and necessary provision for storage.
5. An assortment of hardware items including nuts, bolts, washes, grease, nipples, split pins etc. in suitable bins/ lockers.

Servicing equipment in static field repair workshops or base workshop generally include fuel storage tanks for filling fuel tanks of construction equipment or for filling mobile tanks which may dispense fuel at mobile service station or for use of stationary plants scattered in project area.

5.2 WORKSHOP EQUIPMENT FOR FIELD REPAIR SHOP

5.2.1 Static Field Workshop

Minimum requirements of workshop equipment for a static field maintenance workshop servicing an average mixed fleet of construction equipment are -

1. Steam cleaning or high pressure washing equipment.
2. Filling shop equipment i.e. benches, vices, cupboards, racks, portable electric drills and grinders, jacks, crowbars, hand tools etc.
3. Lifting tockles, gentry type or mobile cranes for workshop use/field use.
4. Pressure lubrication/servicing equipment.
5. Tyre inflation and tyre repair equipment
6. Coal fired/oil fired smith's hearth
7. Electric welding equipment (portable and stationary type), oxy-acetylene cutting and welding plant, brazing plant and forge.
8. Assorted tools, fast moving spare parts and battery charging equipment.
9. Machine tools like latchers, pillar drills, bench grinders, hydraulic press etc.

It hardly requires an emphasis that the above represents a minimum requirement of equipment for an average field repair workshop that may be required to operate under normal conditions. Equipment provided in a field workshop for bigger projects, which normally take a longer time, would be much more than the minimum requirement enumerated above.

5.2.2 Mobile Workshop for Field Repair

They are self contained units on trailors, containing selected repair and maintenance facilities like -

1. Generator driven by a power take off from engine for supply of electric power for use at various points in the mobile workshop.
2. Small lathe machine
3. Drilling machine
4. Small hydraulic press
5. Work benches with vices
6. Grinding machine
7. Hydraulic jacks
8. Grease pump and containers
9. Welding equipment (electric oxy acetylene)
10. Tools

Fig.5.2 illustrates arrangement of above equipment on trailer comprising the mobile workshop.

Choice of items from those enumerated above can be modified suitably so as to suit particular requirement of a project.

5.3 WORKSHOP EQUIPMENT FOR BASE WORKSHOP

5.3.0 General

Workshop equipment for base workshop is best described separately for each shop. Attention has been focussed only on main shops like machine shop, engine shop, structural shop,

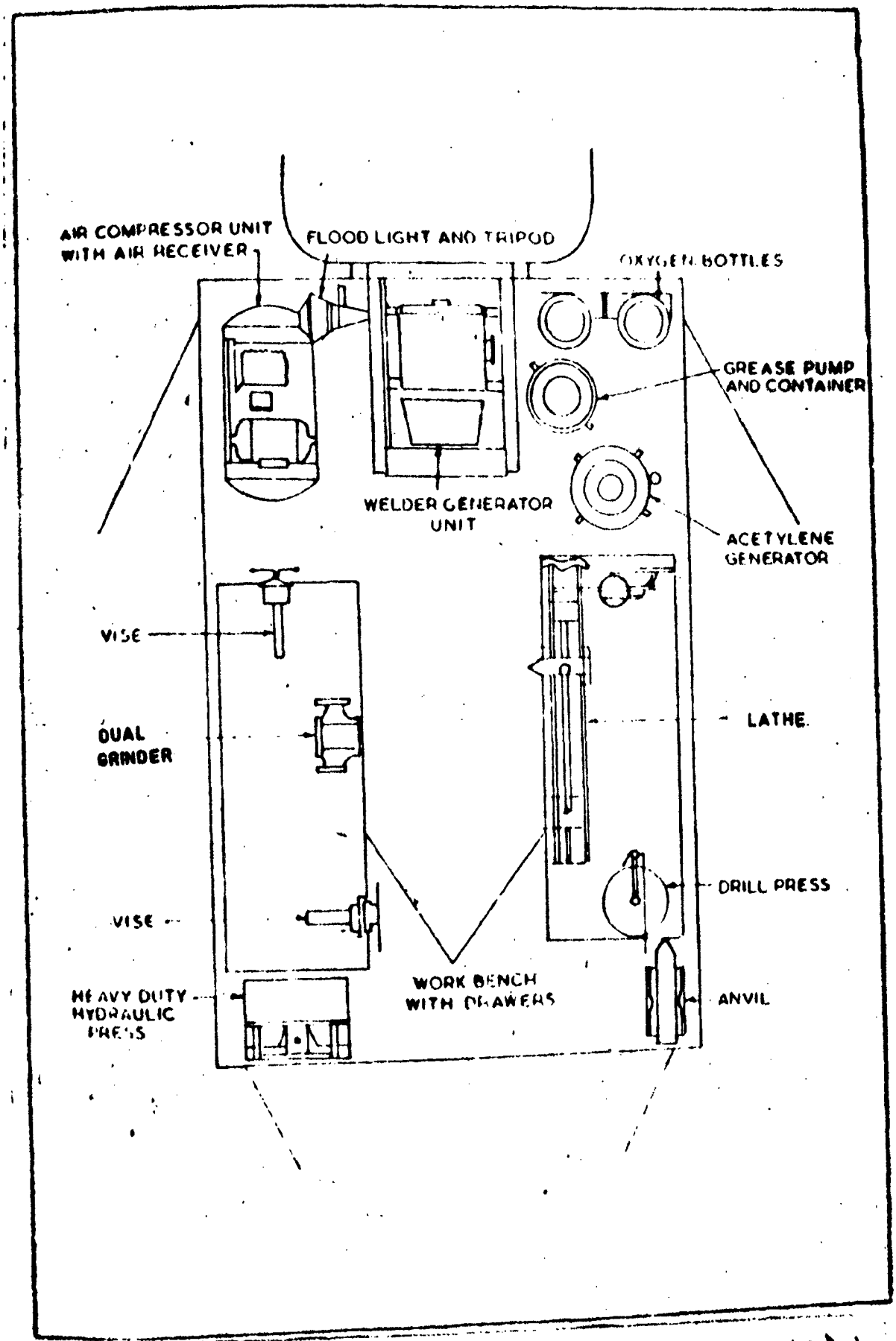


FIG. 5·3 EQUIPMENT FOR A MOBIL FIELD WORKSHOP (9).

automobile shop, general repair and fitting shop, electrical repair shop, welding shop, tyre repair and retreading shop, smithy and foundry shop, carpentary shop, drill repair shop, painting shop etc.

5.3.1 Machine Shop

Operations in machine shop involve turning, nulling, shaping, slatting, planning, drilling, grinding, boring and screw cutting etc. Generally following equipment is provided in machine shop.

1. Metal working lathes including centre, precision, capstan and turret lathes.
2. Planners
3. Shipers
4. Milling machines
5. Drills/including radial drill
6. Boring machines- horizontal/vertical
7. Power hock saws
8. Grinders like pedestal, portable and tool grinders
9. Grinding machines like cylindrical grinding machines crank shaft grinding machines and surface grinding machines.
10. Portable, line boring bar- powdered boring equipment used to line bore parts too large to set up in machines, or which must be bored in the field.
11. Arbors and hydraulic presses to press fit assemblies or to remove parts which are tight-fits. The hydraulic

press may be vertical or horizontal and may range from 50 tons to 200 tons capacity.

12. Automatic pipe and bolt threading machines.
13. Flotting machines
14. Tool room equipment viz. work benches, precision bench lathes, portable drills, hydraulic jacks, variety of cutters, drills, reamers etc.

5.3.2 Engine Repair Shop

Engine repair shops for diesel engines and petrol engines would be equipped with different types of workshop equipment. However, with present increase in petrol prices, the diesel engines have replaced petrol engines in almost every construction equipment and hence workshop equipment enumerated here is relevant only to diesel engines. Workshop equipment for petrol engine is listed separately under sub-heading of automobile shop.

1. Fuel pump test benches
2. Injection testing equipment
3. Injector- tip/nozzle testing equipment
4. Cylinder head, hydraulic testing equipment
5. Lapping and polishing arrangement
6. Housing equipment
7. Valve grinding/refacing machines
8. Line boring equipment
9. Connecting rod alignment equipment
10. Pedestal grinders

11. Dynanometers

12. Engine stands

13. Lathes

14. Crankshaft grinders

Besides the above equipment, some of which may be optional, depending upon the size of the job individually and the functional work done in the shops, a variety of tools are necessarily required to handle the work with precision and efficiency, puller gear (sets), puller sleeves, radiator repair equipment, adjustable reamers, reamer ridges, special tester for valve spring etc, special vices for holding pistons etc. oxy acetylene welding and cutting outfits, blow lamps, micrometers, torque wrenches, etc. etc. are some of common tools. Also, there are several basic fuel injection systems, each requiring special tools and equipment to properly repair and calibrate its components and for this purpose pump calibration stands, injector floor rating machines, injector pressure stands, lopping machines, air gauges and ultrasonic cleaning tanks for injector nozzles, are generally needed.

A special mention has also to be made about the dynamometers, which are used for running in the engine and for making any necessary adjustment, checking for leaks and determining the horsepower of the overhauled engine. There are two types of dynamometers in common use, the water pump and the electrical generator resister. The high cost of the later generally precludes its use except for low horse power engines.

A passing reference may also be made to the need for installation of the dynanometer and engine stand in a sound proof room, provided with necessary crane or monorail facility for handling. Similarly, a dust free temperature controlled room for overhaul and calibration of fuel pumps, governers and injectors is necessary.

5.3.3 Structural Shop

A general purpose structural shop would generally consist of -

1. Punching and shearing machines (power presses)
2. Bending rolls
3. Radial machines
4. Oxy-acetylene profile cutting machines.
5. Oxy-acetylene automatic cutting machines
6. Hydraulic presses
7. Welding sets/ welding lines
8. Automatic welding machines
9. Girder bending and straightening machines.
10. Radiographic camera/ X-ray equipment
11. Double wheeled pedestal grinders
12. Punching machines
13. Pipe bending and cutting machines.

In addition to above equipment a structural shop, shall have to be supplented with additional equipment necessary for welding such as goggles, gloves, electrode drying ovens, preheating burners, gas cylinders etc. etc.

5.3.4 Automobile Shop

The automobile shops cater for repair and maintenance of transport vehicles like jeeps and cars which are generally equipped with petrol engine hence following workshop equipment is generally required -

1. Hydraulic presses
2. Drill presses
3. Heavy duty pedestal grinders.
4. Jacks (hydraulic and air).
5. Wheel aligning equipment.
6. Spark plug sanding machines
7. Electrical aiming and turning equipment
8. Valve seat grinding machines
9. Valve refacing machines
10. Hydraulic car lift
11. Engine stands
12. Cylinder block boring and honing machines
13. Brake drum turning machines
14. Tool room equipment like precision lathes, tool grinders, portable drills, reamers, wrenches gauges etc. etc.

5.3.5 General Repair and Fitting Shop

General repair work involving fitment etc. is done in this shop and equipment requirements of this shop can be briefly enumerated as follows:

1. Track pin presses (portable/stationery)
2. Special purpose hydraulic presses for track bushings
3. Mechanical/air operated power tools, impact wrenches etc.
4. Work benches with vices
5. Jacks of various capacities
6. Assorted range of hand tools like files, hammers, spinners, taps, dies, crow bars etc. etc.

5.3.6 Electrical Repair Shop

This shop is more of an outfit for the electricians to re-wind armatures, coils and to repair commutators etc. An average electrical repair shop would require following equipment.

1. small lathes(with swing of say 250 mm to 300 mm) for commutator.
2. generator regulator test stand for armature turning.
3. Equipment for painting and drying of insulation
4. Electricians benches with instruments like meggers, ammeters, voltmeters etc. for testing repaired electrical equipment.
5. Winding machines of different sizes.

In addition to above a battery shop containing battery chargers, distilled water plant, specific gravity testers, blow lamps, water sprayers etc. also form a part of electrical repair shop but sometimes a separate battery shop containing said equipment is provided.

5.3.7. Welding Shop

Workshop equipment for welding shop generally includes -

1. transformer type welding machines with single or multiple operator lines
2. motor-generator type welding machines
3. diesel-generator type portable welding machines
4. gas welding sets
5. automatic rebuilding machines for tractor rollers and idlers
6. electrode drying ovens
7. Miscellaneous equipment like goggles, gloves, preheating torches, gas cylinders, grinders, chiselling hammers, fire lighting equipment.

Supply of electric power for welding equipment is arranged through outlets located at convenient places where the welding equipment is needed in welding shop or other shops and each outlet serves one welding machine. Sometimes a suitable capacity transformer unit (feeding a number of regulators-each with single or double welding lines) is provided for grid system such that the location of welding machines in the shop area is eliminated and movement of welding machines is avoided because the welding

leads can be taken to convenient places for working in the shop area.

In certain welding jobs, special electrods are required to be used, and this involves entirely different equipment. Welding of zinc, aluminium, and magnesium alloys which are extremely hard to weld, involve the heliarc welding machine.

Automatic submerged arc welding is also commonly involved, specially when rebuilding of parts or structural work is undertaken and this often requires use of automatic welding machines as well as additional equipment like rotary tables, drive and tail stock, roller positioners etc. for proper positioning of the pieces to be welded at a fast rate.

5.3.8 Tyre Repair and Retreading Shop

This shop should have following equipment -

1. Rim removers/ tyre expanders
2. Vulcanising equipment
3. Buffing machines
4. Rubber cement spraying equipment
5. Building machines
6. Moulds with matrices
7. Small steam boiler
8. Miscellaneous items such as sledge hammers, jack, wheel spanners etc.

5.3.9 Smithy and Foundary Shops

Following equipment is normally required for these shops -

1. Coal fired furnances with blowers
2. Oil fired furnances
3. Power hammers, air operated or electrically operated
4. Miscellaneous items, like anvils, sledge hammers, ladders, moulding equipment, sand blasting and sand testing equipment etc.

5.3.10 Carpentary Shop

Entire job of form work, scaffolding and all types of other wood work for water resources projects is handled by the shop and following equipment is generally provided.

1. Band saws
2. Planning machines
3. Wood working lathes
4. Portable power sews
5. Double ended grinders
6. Drilling machines
7. Miscellaneous tools

5.3.11 Painting Shop

Equipments for this shop includes:

1. Spray painting guns
2. Drying chamber
3. Air compressor
4. Sand blasting equipment
5. Miscellaneous equipment like stencils and brushes for lettering.

5.4 WORKSHOP EQUIPMENT FOR MANUFACTURE WORKSHOPS

5.4.1 General

Workshop equipment required for manufacture workshops will depend upon the item to be manufactured. In most cases the workshop equipment enumerated for structural shop, painting shop and welding shop shall be required to be augmented suitably to meet the manufacture requirements for any particular items. In order to illustrate this, workshop equipment for manufacture of penstocks, an item which is most commonly required on water resources development projects, has been enumerated in following paragraphs. Also, in order to maintain consistency, only main workshop equipment has been enumerated for a few shops like edge preparation shop, bending shop, welding shop, non destructive testing shop, stress relieving shop, hydrostatic testing shop, painting shop and machine shop.

5.4.2 Edge preparation shop

1. Plate edge planners
2. Gas cutting machines
3. Gas cutting pug machines
4. Shearing and punching machines

5.4.3 Bending shop

1. Plate bending machines

5.4.4 Welding Shop

1. Automatic welding machines
2. Turning roll equipment
3. Welding booms
4. Manual welding machines

5.4.5 Non-Destructive Testing Shop

1. X-ray machines
2. Ultrasonic testing machines
3. Magnetic particle testing machines

5.4.6 Stress Relieving Shop

1. Oil fired furnances with controls
2. Induction heating machines.

5.4.7 Hydraulic Testing Shop

1. High pressure testing pumps
2. Testing rigs

5.4.8 Painting Shop

1. Sand blasting equipment
2. Spray painting equipment for cold applied coal for enamel
3. Equipment for hot applied coal for enamel

5.4.9 Machine shop

1. Lathes
2. Drilling machines
3. Shaping machines
4. Hydraulic presses

5.5 COST OF WORKSHOP EQUIPMENT

It has been stated that equipment (tools and plant) provided in workshop for convenience of quick repair to construction equipment or for manufacture of typical items depends upon extent of repair and/or manufacture contemplated to be undertaken in the workshop. In other words tools and plant provided in a workshop decide the type and volume of work handled in the workshop. Obviously for a big project volume of work required to be handled in the project workshop will be more in comparison to a small project. It is for the reason that cost of equipment has a direct proportion to cost of project in general, and cost of construction equipment deployed on the project, in particular.

Attempts have been made to quantatively correlate the cost of workshop equipment to the cost of equipment deployed for construction of a project. Construction Plant and Machinery Committee (India) has recommended that a provision of 4 to 6 percent of the cost of construction equipment contemplated to be used on a project should be made for purchase and installation of tools and equipment for repair workshops.

In order to check these recommendations, data regarding cost of workshop equipment and construction equipment has been collected for a few water resources projects. While the data related to cost of workshop equipment is presented in Appendix-II. The data for cost of construction equipment has been also incorporated in last column of Appendix-I.

The results of the study are tabulated in Table 5.1 which show that recommendations of the construction plant and machinery committee generally hold good in case of two projects under study. The study could not be done for all the six projects because of non-availability of data. In this connection it is considered pertinent to add here that the recommendations of the committee should only be taken as a guide and provision of workshop equipment should be judiciously decided on the basis of considerations relevant to particular projects.

Table 5.1 - Cost of Workshop Equipment & Construction Equipment

Sl. No.	Name of Project Work-Shop	Cost of Construction Equipment	Cost of Workshop Equipment	Ratio cost of Workshop equipment vs construction equipment
1.	Beas Sutlej Link at Sundernagar	16,24,002	93,03,000	$\frac{93,03,000}{16,24,002} = 5.73\%$
2.	Ramganga	16,01,22,900	72,75,600	$\frac{72,75,600}{16,01,22,900} = 4.5\%$

CHAPTER-6

CONCLUSION AND RECOMMENDATION

6.1 GENERAL

For any water resources project, intensive mechanisation is a basic necessity and hence a good workshop facility automatically becomes essential because it provides the supporting life line for continued and sustained operation of the construction equipment and plant. Its usefulness, however, can be as effective as the initial planning and design of its layout and established facilities could make it. If the purpose for which the workshop is to be established is clearly defined in specific terms in relation to the items/types of work to be done, the purpose would be well served. These considerations are however, only partially covered while planning the project as a whole. In framing the project reports, details of the work load for the workshops is not precisely defined, and consequently provision for space, type of building and workshop equipment facilities to be installed therein and sometimes even the location of.

6.2 RECOMMENDATIONS OF CONSTRUCTION PLANT & MACHINERY COMMITTEE

Before enumerating the conclusions, on the basis of brief study on design of workshop facilities for water resources projects as embodied in this dissertation, it is considered suitable to describe relevant recommendations of 'Construction Plant and Machinery Committee' constituted by Govt. of India.

Main recommendations of the Committee, as relevant to ' design of workshops for water resources projects are as follows:

1. Initial planning of workshop at the stage of foundation of project reports should cover all details regarding items and types of work to be done, the maximum load possible to arise in respect of each, the pattern of maintenance and repair of equipment whether centralised or on area maintenance basis, or a combination of both and the extent to which work will be got done by outside agencies and the amount of investment that can be made.

2. A clear plan should be developed of the layout of the shops by listing out the type of repair work, servicing and maintenance operation to be assigned to shops commensurate with the number and type of machines plants and equipment to be maintained and serviced and the load of manufacturing activities. The scale of provision for floor space in a field repair shop may be generally estimated a 4.60 to 5.57 sqm (50 to 60 sft) per machine (where size of the machine is small), and 9.30 to 11.15 sqm (100 to 120 sft) per machine (in respect of heavy earthmoving machinery items). An equal uncovered floor area with concrete floor, is also additionally required to be provided in the field repair shop. Scale of provision for covered floor area in a main repair shop would be estimated at 13.95 to 16.75 Sqm (150 to 180 sft) per machine for a total number of machines to be serviced in the shop. The uncovered floor space in this case may be 2.5 to 3 times the area of covered floor space set aside for the machine.

Further room for expansion and flexibility of operation inside the shops should be provided for.

(3) The type and sizes of workshop building should be decided upon with due consideration to climatic conditions, geographical location etc. Clear provision should be made for drainage facilities, parking spaces, storage of raw materials, equipment awaiting work in the shops, repaired equipment awaiting the delivery to operating staff in the field.

(4) Properly laid service goods and stabilised shop floors, to suit the type and size of equipment that will move over it, should be provided.

(5) The location of the shops should be decided upon by preparing a clear plan of the operational activities which will be served thereby viz., field maintenance, workshops should be located close to the scene of operation and base workshops should be located centrally.

(6) Size of each shop should be determined by the number of workmen that will have to work there and the type of equipment, components, assemblies that will be put to repairs. Provision should also be made for storage of the components, parts and assemblies and for fitter/workmen benches. There should be no congestion of the work space.

(7) Adequate material handling facilities should be provided both inside the shop and in the open space outside.

(8) Adequate provision should be made in the project estimates to meet the cost of workshop buildings, and workshop equipment i.e. at 1.5 to 2% of the cost of equipment for cost of building comprising of covered and uncovered floor space and sheds for the field and main repair shops and at 4 to 6% of the cost of equipment for cost of workshop equipment including tools and plants.

(9) The work in the main repair shops should be sub-divided according to the functional requirements so as to accomplish concurrent repair of component and assemblies for expeditious completion of the repair of any given machine.

(10) Where major repairs are to be carried out at the site of the work, functionally designed mobile repair shops mounted on trucks and equipped with full complement of tool etc. should be provided.

(11) The field maintenance workshops should be located as near to the scheme of operation as possible. Goodnesses roads should be provided.

(12) Store room and ware house facilities should be located adjoining the maintenance shops. Receiving areas in the ware houses should be provided separately with sufficient space to accommodate mechanical handling of loading and unloading operations. Special attention should be paid to provide a proper construction of the building for storage of tyres and tubes. A cool dry and dark shed is required for this purpose. Outdoor

storage space is uneconomical answer to growing space demands. Components/parts that are not affected by weather can be conveniently stored in roofless ware houses.

(13) Necessary tools, adequate facilities and equipment should be provided in the workshops so that the time repair and maintenance of construction equipment or for manufacture of any typical item, that may be required on a project, is minimised and better availability is ensured.

6.3 CONCLUSIONS OF STUDY

It must be stated at the outset itself that it was not possible to undertake an extensive study covering all design aspects of workshops for water resources projects due to paucity of time. Only few aspects were studied and relevant conclusions are as under.

There are no two opinions that space requirement of any workshop is directly related to type and number of construction equipment to be repaired in the workshop. Determination of exact relation between the two, however, is not so simple, because it would call for ascertaining as to how many pieces of construction equipment would be expected to be under preventive maintenance and breakdown maintenance so that adequate provision of space could be made in the workshop. While estimation of preventive maintenance load could probably be predicted with reasonably accuracy the breakdown maintenance load would call for use of probability techniques. It was not

possible to do this analysis in available time and therefore a simple method had to be used viz. the space provided in workshops of some of the water resources projects was ascertained by collecting workshop drawings for the projects whereas the number of construction equipment to be serviced in these workshops was assessed from relevant project reports by selective choice. It has been found that recommendations of the Construction Plant and Machinery Committee generally hold good in almost all the cases as far as the floor space and open area is concerned. Relation between cost of workshop equipment and cost of total construction equipment has been checked on similar lines and it has been seen that recommendations of the Committee also hold good in this case.

However, it must be stated that this study has been done on the basis of cost table available in project reports and the number of construction equipment provided in the project report. Actual, cost data of construction equipment and of workshop equipment was not readily available. Same is also true for the number of construction equipment actually used on the projects. As such the recommendations of the Committee should only be taken as a guide line.

As far as manufacture workshops(for Water Resources Development projects or for any other project)are concerned, their design does not pose serious problems and required production target can be economically achieved because is possible to precisely define various operational and func-

6.4 RECOMMENDATIONS FOR FURTHER WORK

Importance of maintenance and manufacture function in workshops for water resources projects has never been challenged. However, in the past, it has not received close attention in that it serves probably because of the fact that it lacks the glamour of marketting and research functions. Nevertheless we have always been painfully aware of the fact when the repair and maintenance job or the manufacture job connected with any water resources project slipped behind the schedule.

Hence, it is high time that detailed studies using system design techniques be undertaken for rationalising the design of workshops for water resources projects. Waiting line theory could be conveniently used for determination of service, facilities required in a workshop and probability techniques could be advantageously employed for predicting breakdown of construction equipment, whence space requirement for repair and maintenance workshop could be precisely related to number of construction equipment to be serviced in the workshop. Not that the use of these techniques is being recommended for the first time but it is the actual application of these tools that is being suggested so that the correlations obtained thus could be applied to real world situations.

APPENDIX I

1. CONSTRUCTION EQUIPMENT OF BEAS PROJECT AT SUNSARPUR[14]

Sl. No.	Particular of Equipment	Approx. size range	Qty. Nos.	Amount in Lacs
I.	Heavy Earthmoving Equipment:			
1.	Electric Shovel	$2\frac{1}{4}$ to 7 cyd.	15+	207 00
2.	Diesel Shovel	$2\frac{1}{4}$ cyd.	13+	107.00
3.	Front End Loader		5+	3.75
4.	Overhead Loader	$1\frac{1}{4}$ cyd.	2+	3.52
5.	Shovel		9+	14.60
6.	Crawler Tractor Dozer	150 - 400 HP	69+	1980.19
7.	Rubber Tyred Tractor	270 HP	4+	13.40
8	Rear/Bottom Dump	7 - 30 cyd.	159+	659.54
9.	Double drum sheep foot roller		11+	1.44
10.	Vibratory Compactors		22+	26.44
11.	Pneumatic tamper triplex and single		75+	1.88
12.	Motorized Scrapers		4+	14.00
13.	Water Sprinkler	40 - 45 Ton	3+	27 00
14.	Misc. Equipments			31.10
				1308.66
II.	Road Maintenance Equipment:			
1.	Motor Grader		12+	11.22
2.	Sprinkling Water		3+	0.26
3.	Road Roller		2+	0.70
4.	Misc. Items			1.81
				13.93

(1)	(2)	(3)	(4)	(5)
III.	Transport Vehicles :			
1.	Trucks		112+	38.10
2.	Station Wagons		11+	2.10
3.	Jeeps		47+	8.50
4.	Pick Ups		34+	6.10
5.	Ambassador Car		10+	1.80
6.	Buses		31+	22.90
7.	Ambulance Cars		3+	0.75
8.	Sedan		2+	0.35
9.	Misc. Items		-	0.30
			656	80.30
IV.	Drilling Equipment			
1.	Rock Drills		350	5.40
2.	Pneumatic Pusher		175	1.50
3.	Paving Breaker		150	1.90
4.	Jack Hammer		11	0.09
5.	Air Drive, Diamond Drilling		8	1.20
6.	Wagon Drill		68	4.76
7.	Drifter		27	0.68
8.	Misc. Equipment		-	3.62
				19.15
V.	Grouting Equipment :			
1.	Grout Pump		8	1.40
2.	Agitator Drum		8	0.04
3.	Accessories for Grout		LS	3.26
				4.70

(1)	(2)	(3)	(4)	(5)
VI.	Dewatering			
1.	Dewatering Pump		LS	20.76
VII.	Water Supply			
1.	Electric Driven Centrifugal Pumps	1000 GPM head 100 ft	6	0.28
2.	Steel Storage	1.75 lacs gallons	12	0.50
3.	Misc. Items			0.25
				1.03
VIII.	Drinking Water Supply :			
1.	Ice Plant		LS	1.50
2.	Water Supply Tankers		1	0.10
3.	Pumping Set		LS	1.75
4.	Misc. Items			0.30
				3.65
IX.	Power Generation			
1.	Diesel Set	40 to 60 KW	15	20.20
2.	Transformers and Circuit breakers			7.65
				27.85
X.	Air Compressor			
1.	Portable Air Compressor		9	2.44
2.	Stationary Air Compressor		6	7.75
3.	Misc. Equipments			1.26
				10.45

(1)	(2)	(3)	(4)	(5)
XI.	Exploratory Equipment :			
1.	Diamond Drill		4	1.00
2.	Royal Beam Triplex reciprocating pump		4	0.03
				1.03
XII.	Aggregate Processing Plant			
1.	Aggregate and sand classification		2	20.00
2.	Washing and Screening Plant		2	2.42
3.	Rock Crushing Unit		2	0.36
4.	Blast sand separation and drying plant and reclaiming tunnels equipment		1	1.50
5.	Misc.			6.68
				30.96
XIII.	Water Chilling Plant			
1.	Water chilling plant/ Aggregate cooling Plant		1	10.50
				10.50
XIV.	Aggregate Transportation :			
1.	Belt Conveyor	30" to 42"	LS	12.00
2.	Misc. Item		LS	0.43
				12.43
XV.	Batching and Mixing Plant			
1.	Batching and Mixing Plant		6	9.52
2.	Misc. Items		LS	0.25
				10.27

(1)	(2)	(3)	(4)	(5)
XVI.	Concrete Placing Plant:			
1.	Concrete Vibrator		LS	4.36
2.	Rex Pumps/Single Pumps sets		5	10.50
3.	Pump crete pipe line		1	0.18
4.	Trestle		2	12.70
5.	Concrete mixer		3	0.12
6.	Jack for concreting gantry		40	0.52
7.	Misc. Items			11.44
				39.74
XVIII.	Transportation Concrete : Buckets			
1.	Concrete Buckets		41	1.45
2.	Sand Bucket		4	0.06
3.	Derrick Crane		1	0.13
4.	Transit Mixer		11	14.50
5.	Bucket Carrier			12.60
6.	Trestle			13.50
7.	Misc. items			0.50
				42.74
	Cement Handling Equipment:			
1.	Cement Handling Pump controls, air slide motor operated, two way rooting valve, air operated discharge gates and other ancillary equipments		LS	5.00
2.	Cement Storage		4	2.48
3.	Bottom dump cement hopper wagon	20 T	LS	26.30
4.	Misc. Items			0.75
				34.53

2. CONSTRUCTION EQUIPMENT FOR B.S.L. AT SUNDERNAGAR[15]

Sl. No.	Particulars of Equipment	Approx. size range	Qty. Nos.	Amount in lacs
(1)	(2)	(3)	(4)	(5)
I.	Exploratory Equipment			
1.	Mole Drills		14	5.52
2.	Drilling Machine		26	17.64
				23.16
II.	Power Generation Equipment:			
1.	Generator	230 KVA- 1 MW	7	19.33
2.	Misc. Transformer 3 phase	10 KVA-1000 KVA	LS	71.096
				90.426
III.	Excavation Equipment:			
1.	Shovel	3/4 to $3\frac{3}{4}$ cyd.	26+	148.629
2.	Tractor Dozer		40+	59.70
3.	Dozer-Front end loader		11+	19.50
4.	Sheep foot roller Double Drums		12	1.80
5.	Pneumatic Tampers		60	1.98
6.	Misc. Equipments		-	25.241
				256.85
IV.	Drilling Equipment			
1.	Wagon Drill		4	0.80
2.	Quarry Drill		4	2.00
3.	Jack Hammer		20	12.00
4.	Drill Sharpener		5	1.00
5.	Pneumatic Leg Pusher		35	11.50
				17.05

(1)	(2)	(3)	(4)	(5)
V.	Grouting Equipment			
1.	Grouting Pump		6	4.00
2.	Pneumatic Tool		LOT	0.15
				4.15
VI.	Tunnelling Equipment			
1.	Electric Loader	$1\frac{1}{4}$ cyds.	12	68.88
2.	Electric Loco	20 Tons	20	34.00
3.	Battery Loco	5 to 25 tons	28	52.63
4.	Crane on rail	7 - 8 tons	6	4.50
5.	Rail cars for Labour		16	2.00
6.	Muck Cars	13 Cyd.	132	27.06
7.	Flat Bed Rail Cars		16	2.80
8.	California Switch		6	4.50
9.	Tugger (Air and Electric)		28	4 30
10.	Hydraulic Hoist	100 HT	8	4.00
11.	Drilling Jumbo for top area		6	1.20
12.	Agitators Cars		8	6.70
13.	Explosive Loading m/c		8	0.80
14.	Rail Car for Explosive		6	1.50
15.	Double Pump Crete		9	28.00
16.	Concreting Gantry		4	0.40
17.	Reinforcement Jumbo		4	1.00
18.	Sand Blasting Equipment		8	0.40
19.	Misc. Tunnelling Equipment		LS	45.79
		Total		311.46

(1)	(2)	(3)	(4)	(5)
VII.	Hauling Equipment			
1.	Carrier	15 - 20 cyd.	56+	164.31
2.	Carrier including Scrapers	10 Cyd.	24+	30.00
3.	Articulated Carrier	7 - 10 Cyd.	16+	25.204
4.	Cement Carrier	10 - 12 Ton	68+	47.00
5.	Truck	10 Ton	183+	26.21
6.	Truck Mixer	4 cyd.	10+	10.74
7.	Dumper		40+	60.60
8.	Diesel Tug		6	17.44
9.	Steel Borges	150 Ton	1	3.00
10.	Diesel Elect.Loco BG		2	8.00
11.	Misc. Equipments		LS	26.55
				415.054
VIII.	Aggregate Plant			
	Aggregate Plant		LS	61.00
	Grizzlays		2	0.80
				61.80
IX.	Batching and Mixing Plant:			
1.	Batching and mixing Plant		1	5.30
2.	Batching Plant		7	28.00
3.	Electric Mixer	2 cyd.	14	3.50
4.	Swing weigh batcher		6	0.60
5.	Concrete Mixer Portable	1 Cyd	24	1.60
				39.23

(1)	(2)	(3)	(4)	(5)
X.	Concrete Placing Equipment			
1.	Revolver Crane	150 boom	3	15.00
2.	Double Cantilever Crane		1	5.53
3.	Pump Cretes	30 Cyds.	8	7.06
4.	Power Mixer		2	2.00
5.	Sand Blast Equipment		12	1.50
6.	Gunit Machine		6	0.03
7.	Truck Mixer	6 cyds.	8	6.00
8.	Stiffleg derrick	10 ton 150' boom	8	6.00
9.	Misc. Equipment			17.87
				60.99
XI.	Concrete Transportation			
1.	Concrete Buckets	2 - 4 cyds.	22	3.36
2.	Dinkeys Cars and Plat Cars		5	7.80
3.	Misc Equipments viz. trestel rail etc.		LS	17 00
				23.16
XII.	Cement Handling			
1.	Cement silo	400-800 Ton	23	10.7
2.	Cement portable	10 ton	200	15.00
3.	Humidity Controllers		4	0.75
4.	Misc. Equipment			14.02
				40.47

(1)	(2)	(3)	(4)	(5)
XIII.	Compressors :			
1.	Electric, air compressor	105 to 1000c fm	27	41.86
2.	Portable Compressor	210 to 500 c fm	16	6.31
				48.17
XIV	Dewatering Water Supply			
1.	Dewatering Pump		LOT	35.46
2.	Electrical Submersible Pump		LOT	1.25
3.	Hyd. Binder		LOT	1.50
				38 21
XV.	Job Water Supply			
1.	Chlorinators Complete		3	0.45
2.	Clarifloculators	100 c fm	2	2.50
3.	Pipes and pipe fitting, electric control, automatic dispenser etc.		LOT	7.70
				10.65
XVI.	Drinking Water Supply			
1.	Insulated Tanks	1000 glns	3	1.50
2.	Dispensing tanks	50 glns	160	5.00
3.	Water Supply tanker bodies		6	31.60
4.	Ice Making Plant	5 Tons	1	6.00
5.	Chlorinators		3	3.30
				46.40

(1)	(2)	(3)	(4)	(5)
XVIII.	Rigging Equipment			
1.	Truck Crane	30 - 47 Tons	5+	28.097
2.	Truck Tractors	20 - 60 tons	13+	16.66
3.	Mobile Crane	5 - 10 tons	19+	35.00
4.	Trailer	35-100 tons	19+	12.315
5.	Overhead electric hoist	1-10 tons	42	4.00
6.	Hydromechanical jacks	100 tons	2	0.10
7.	Wrecker trucks		12	2.06
8.	Winch misc.			1.00
9.	Cables ways	100 tons	1	10.00
10.	Overhead gantry crane		16	5.00
11.	Misc. Equipment			84.172
				119.272
XVIII.	Road Maintenance			
1.	Situmen heater distribution		5	0.50
2.	Motor grader		5+	4.53
3.	Water Sprinkler		5+	7.50
4.	Road roller		3+	1.57
5.	Other patching equipment		LOT	2.50
				16.60
			Grand Total	1624.002

+ = 493 nos.

3. CONSTRUCTION EQUIPMENT FOR RAMGANGA PROJECT[15]

(1)	(2)	(3)	(4)	(5)
I.	Excavation Equipment			
1.	Drag Line	$2\frac{1}{2}$ - 7 cyd.	5+	57.730
2.	Shovel	2.5 to 4.6 cms	4+	110.36
3.	Hydraulic Excavator		2+	4.514
4.	Front End Loader		8+	20.652
5.	Clam shell	$2\frac{1}{2}$ cyd	4+	1.000
6.	Belt loader		3+	6.568
7.	Scrapers	2 - 24/32	23+	118.630
8.	Rear dumpers	3 - 20/22 cyd	48+	98.794
9.	Articulator rear dumpers		14+	48.000
10.	Bottom dumpers	49/42 cyd	25+	149.558
11.	Rocker dumpers		4+	8.12
12.	Misc equipment, attachment and buckets		LS	11.154
				639.110
II.	Tractors and Dozers:			
1.	Crawler Tractors with hydraulic	120-300 HP	34+	230.71
2.	Crawler Tractors with cable	240 HP	3+	4.95
3.	Crawler Tractors with (Power Shift)	230 HP	24+	66.948
4.	Pneumatic Tractors	162 HP	5+	6.657
5.	Crawler Tractor with ripper	360 - 430 HP	18+	86.643

(1)	(2)	(3)	(4)	(5)
6.	Agricultural Tractors		9+	1.170
7.	Solid push block		4	1 480
8.	Disc Harrow		3	0.05
9.	Misc.items(Erection Shed)		LS	0.52
				445.540
III	Compaction			
1.	Sheep foot roller		18+	6.862
2.	Vibratory smooth drum roller		9+	10.160
3.	Vibratory self propelled		2+	7.30
4.	Tamping Compactors		6 +	35.00
5.	Pneumatic backfill tampers		12+	1 104
6.	Pneumatic tyred compactor roller		1+	0.380
				65.806
IV.	Road Machine			
1.	Motor Grader		10 +	9.970
2.	Sprinklers tanks semi tractors	1600 galls	6 +	3.000
3.	Water sprinkler with prime movers	2000 galls	4+	17.200
4.	Road Roller diesel	8/10 tons	3+	1.500
5.	Tar Roller	240 galls	2+	0.250
				31.920

(1)	(2)	(3)	(4)	(5)
V.	Drilling and Grouting Equipment:			
1.	Diamond Drilling Machine	Upto 750 ft	18	11.530
2.	High head diesel operated pumps		16	1.440
3.	Wagon drills		3	9.60
4.	Air Track Drill		2	3.150
5.	Grout Pump		2	0.380
6.	Cement grouting machine	Upto 8"x8"x6"	5	1.69
7.	Wagon grout Caster		2	0 760
8.	Pavement Breaker		8	0.400
9.	Clay Digger		20	0.400
10.	Drill Sharpening equipment		4	0.200
11.	Pneumatic Hand hammer drill		12	0.300
12.	Drilling Jumbo	Different stage	2	0.400
13.	Other misc. equipment		-	3.065
				24.365
VI.	Tunnelling Equipment :			
1.	Mucking Machine		6	0.12
2.	Diesel Machine Locomotive		6	8 76
3.	Pneumatic Car		8	1.32
4.	Aeroprops		200	0.30
5.	Slushers		2	0.20
6.	Air tigger drum hoist	2 Ton	14	0.96

(1)	(2)	(3)	(4)	(5)
7.	Portable belt conveyors	5 to 12.5 mt.	11	1.10
8.	Rock Jacks		3	0.11
9.	Blower fans		7	1.54
				19.34
VII.	Concreting Equipment			
1.	Concrete agigating Cars	15 cyd.	4	5.40
2.	Pump crete machine	40 - 45 cyd	2	4.40
3.	Concreting crane		5	83.00
4.	Cement grouting machine		2	1.20
5.	Batching and Mixing Plant	320 cyd.	1	10.00
6.	Concrete dump truck	21 cyd.	4+	4.10
7.	Overhead crane		2	20.000
8.	Concrete Mixers		30	12.126
9.	Cement guniting machine		2	1.20
10.	Concrete Vibrators	$1\frac{1}{2}$ to $3\frac{1}{2}$ needle size	126	2.16
11.	Misc.Concrete equipment		LS	8.042
			Total	151.407
VIII.	Cement Handling Equipment:			
1.	Puller Keynyn cement pump with shut length air conveyor	20 HP	2	3.20
2.	Cement silo	500 tons	8	3.92
3.	Air and Screw Conveyor	50 tons	3	0.375
4.	Bucket elevators	50 tons	1	0.75
5.	Other misc. items		LS	3.10
				15.37

(1)	(2)	(3)	(4)	(5)
IX.	Aggregate Plant			
	Main dam and Saddle Dam Processing plant including vibratory crushers, sand etc.		LOT	70.00
X.	Heavy Transport Equipment			
1.	Truck Tractors	50 tons	2+	5.227
2.	Bed tractor without prime mover	7 - 50 Ton	23+	2.870
3.	Primemover	20 to 50 Ton	14	9.24
4.	Water and Diesel tank	8000 to 12000 lt.	9	6.05
		Total		23.437
XI.	Lifting Equipment			
1.	Fork Lifter		4+	1.56
2.	Mobile/truck crane	12 to 20 ton	7+	18.34
3.	Electric winches	1 to 35 ton	11	3.54
4.	Hydraulic Jacks	300 Ton	1	0.50
5.	Crane	10 ton	1	16.00
6.	Electric Pipe Tower Crane		2	5.05
7.	Misc. Items		LS	2.12
				47.41

(1)	(2)	(3)	(4)	(5)
XII.	Transport Equipment			
1.	Jeep		55	9.625
2.	Station wagon		4	1.000
3.	Ambassador Cars		3	0.600
4.	Ambulance Van		2	1.00
5.	Power Wagon		12	2.80
6.	Passenger Bus		20	15.00
7.	Truck	5 Ton	40	34.00
8.	Water and Diesel Tanker		21	4.62
9.	Pick-Up		8	2.00
10.	Misc. items		-	4.16
			Total :	55.205
XIII.	Fire fighting Equipment:			
	Fire Fighting Trucks		2	1.040
XIV.	Dewatering Equipment			
1.	Electric Pumping Sets	12 - 35 HP	46	6.98
2.	Self Pumping Set		12	0.20
3.	Diesel Pumping Set	7.5 to 10 HP	4	0.12
4.	Bore hole Pumping set	$1\frac{1}{2}$ to 4 cusecs	8	0.60
5.	Misc. Pumps etc.			0.344
				10.024
XV.	Power Generating Equipment:			
1.	Generating Set	3 to 25 KVA	17	0.715
2.	Petrol and Diesel Generator	82 KVA	4	0.540
				1.255
+ 520 Nos.			Grand Total 610	1601.229

4. CONSTRUCTION EQUIPMENT OF JRATUN SELUNA PROJECT(INDONESIA)[18]

Sl. No.	Name of Equipment	Approx. size range	Quantity Nos.
1.	Crawler Dozer	125 to 140 HP	15
2.	Crawler Back Hoe	61 HP	7
3.	Crawler Dragline	96 to 140 HP	14
4.	Wheeled Loader	1.5 cum	1
5.	Motor Grader	123 and 130 HP	2
6.	Compactor	170 HP	1
7.	Truck Crane	2 - 10 T	2
8.	Light Truck	125 HP	2
9.	Road Roller	58 HP	3
10.	Trailer	275 HP	1
11.	Dump Truck	120 - 135 HP	25
12.	Jeep		68
13.	Station wagon		5
14.	Pick-up		5
15.	Mini Bus		1
		Total :	152

5. CONSTRUCTION EQUIPMENT AT SALAL HYDRO ELECTRIC PROJECT[18]

Sl. No.	Name of Equipment	Approx. size range	Quantity Nos.
1.	Shovel	2.5 - 4.6 cms	11
2.	Hydraulic Excavator	2.5 - 4.25 cyd.	5
3.	Traxcavator	2.66 - 2.75 cyd	6
4.	Rear Dumper	15 T - 50 T	59
5.	Bottom Dumper	35 - 63 T	32
6.	Crawler Dozer	165 - 410 HP	30
7.	Wheeled Loader	300 HP	6
8.	Motor Grader	115 - 215 HP	5
9.	Front End Loader	2 cuyd.	1
10.	Water Sprinkler	450 HP	2
11.	Crawler Crane	25 - 70 T	3
12.	Truck Mounted Crane	30- 65 Ton	5
13.	Mobile Crane	12.5 Ton	1
14.	Tractor Trailer	20 - 60 Ton	6
15.	Vib. roller	44 - 65 HP	12
16.	Vibration Compactor	104 HP	1
17.	Road Roller	8 - 10 Ton	2
		Total :	187

6. CONSTRUCTION EQUIPMENT FOR TEHRI DAM PROJECT[18]

Sl. No.	Particular of equipment	Approx. range size	Quantity Nos.
(1)	(2)	(3)	(4)
1.	Hyd. Excavator	2.5 - 5.6 cum.	6
2.	Electr. Excavator	10 cum.	6
3.	Cable Shovel	3.06 cum	4
4.	F.E. Loader	3.5 to 9.6 cum	16
5.	Traxcavator	2 cum	2
6.	Bottom Dumper	63 to 100 T	87
7.	Rear Dumper	25 T to 45 T	68
8.	Tractor	85 HP to 635 HP	56
9.	Water Sprinkler	28 T	25
10.	Self Propelled Vibratory Roller	15 T	10
11.	Self Propelled Tamping Roller	15 T	4
12.	Pneumatic Tempers		50
13.	Truck mounted crane	12.5 To 60 T	14
14.	Crawler Mounted Crane	75 T	4
15.	Trailer with prime mover	20 to 60 T	6
16.	Motor grader	145 to 200 HP	10
17.	Water Sprinkler	6 T	10
18+	Jeep		55
19+	Station Wagon		4

(1)	(2)	(3)	(4)
20+	Ambassador Car		3
21+	Ambulance Van		2
22+	Power Wagon		2
23+	Passenger Bus		20
24+	Truck		40
25+	Water Tanker		10
26+	Diesel Tanker		11
27+	Pick-Up Van		8
		Total :	533

+ Number of these equipments ha has been assumed because of non-availability of data.

APPENDIX II

1. Workshop Equipment for BSL Project Workshop at Sundernagar[13]

Sl. No.	Particular of Machinery	Approx. size range	Qty. Nos.	Amount in Rs.
(1)	(2)	(3)	(4)	(5)
	Lubricating Equipment :			
1.	Installation of Diesel and Petrol Pump		6	20000
2.	Vehicle Washing Plant		3	20000
3.	Tachiamite Patrol Pump		1	40000
4.	Alemite greasing units		6	186000
5.	Fuel dispensing Equipments		3	100000
6.	Explosion Proof fuel Pumping Set		4	20000
7.	Oil rectifier		1	50000
8.	Automatic dispensers coupled with two pumps and motors		2	80000
9.	Misc. Equipment		L.S.	10000
	Reinforcement Yard Equipments			
1.	Universal bar bending m/c		4	110000
2.	Bar cutting m/c	Small and large	8	220000
3.	Cutting and Bending	Small machine	-	50000
4.	Bar Straightening Machine		4	100000
	Workshop Equipment :			
1.	Repair Shop Equipment		L S.	600000
2.	Carpentary Shop Equipment		L.S.	275000
3.	Hydraulic Press	15 Ton	3	15000

(1)	(2)	(3)	(4)	(5)
	Welding Equipment :			
1.	Welding sets		100	700000
2.	Acetylene Generators	25 to 125 lbs.	7	352000
3.	Oxygen Plant Complete		1	307000
4.	Oxygen Cylinder		1000	150000
5.	Acetylene Cylinder		350	130000
6.	Acetylene Bolting Plant		1	100000
7.	Misc. Equipment		-	128000
			Total :	9303000

2. Workshop Equipment for Ramganga Project Workshop at Kalagarh(15)

Sl. No.	Particular of Machine	Approx. size range	Qty. Nos.	Amount in lacs
(1)	(2)	(3)	(4)	(5)
I.	Machine Shop Equipment:			
1.	Central Lathe	1500mm to 3000 mm	6	1 60
2.	Bed Lathe	4' to 6'	6	0.80
3.	Turent and Capstan Lathe		3	0.68
4.	Drilling Machine		3	0.66
5.	Boring Machine		5	0.255
6.	Universal Milling M/c		1	0.50
7.	Shaping Machine		1	0.03
8.	Threading Machine		1	0.15
9.	Grinding Machine		3	1.413
10.	Tappet grinder		1	0.035
11.	Air Compressor		1	0.32
12.	Hydraulic Press	Upto 110 Tons	3	1.60
13.	Brake Drum Turning m/c		1	0.12
14.	Power Hacksaw		1	0.10
15.	Arbor Press		1	0.020
16.	Babbit Melting Furnace		1	0.020
17.	Metal Spraying Machine		1	0.030
18.	Jib Crane		1	0 15
19.	Other small articles and Misc. Items		LOT	17.415
		TOTAL		24.728

(1)	(2)	(3)	(4)	(5)
II.	Automobile and General Repair Shop Equipment :			
1.	Complete Balancing and Wheel Alignment Set		1	0.012
2.	Exhaust Gas Analyzer		1	0.015
3.	Tume - D Kit		1	0.012
4.	Spark Tester and cleaner		2	0.015
5.	Misc. Tools		-	0.004
				0.058
III.	Painting Shop Equipment:			
1.	Spray Furnishing Outfit		3	0.0075
2.	Portable Ponic Spraying Outfit		2	0.0224
3.	Head Respritator		4	0.004
4.	Spray Paint gun		3	0.055
5.	Other Small items		LOT	0.0032
		Total		0.0426
IV.	Body Repair Shop Equipment			
1.	Welding Set arc		1	0.020
2.	Portable Oxy Acetylene Welding and Cutting Outfit		2	0.024
3.	Jacks	20 ton	4	0.020
4.	Heating Torch		2	0.006
5.	Other Misc. Items			0.020
		Total :		0.090

(1)	(2)	(3)	(4)	(5)
V.	Tyre Shop Equipment:			
1.	Hydraulic Tyre Tool Tubeless		5	0.0775
2.	Hydraulic Tyre Tool Tubed		5	0.0775
3.	Heavy Duty Electric Buffing Machine		3	0.030
4.	Cavity mold for tyres		-	0.75
5.	Elect. air Compressor		1	0.015
6.	Air Bag for Tyres		1	0.050
7.	Belt Vulcanizing		2	0.090
8.	Misc.		L S	1.404
		Total		2.594
VI.	Battery Shop Equipment :			
1.	Battery Charger		10	0.070
2.	Water distillation plant		2	0.254
3.	Other Small Items		-	0.111
		Total		0.435
VII.	Radiator Repair Shop Equipment:			
1.	Furnace with Blower		1	0.020
VIII.	Moulding Shop Equipment :			
1.	Soft metal melting furnace		1	0.10
2.	Cast iron melting furnace		1	0.05
3.	Moulding Accessories		LOT	0.17
		Total		0.32

(1)	(2)	(3)	(4)	(5)
IX.	Structural Shop Equipment :			
1.	Shearing Machine		1	0.200
2.	Punching Machine		1	0.200
3.	Universal Shearing and Punching Machine		2	0.100
4.	Sheet metal rounding machine		1	0.100
5.	Roll Bending Machine		1	0.250
6.	Universal Bar Bending Machine		1	0.200
7.	Semi-automatic Gas Cutting Machine		1	0.250
8.	Shape cutting machine		1	0.300
9.	Semi-automatic Welding Machine		2	0.400
10.	Welding and Cutting Outfit Portable		8	0.080
11.	Heavy duty furnace for Heat Treatment		1	0.030
12.	Power Blower for Heat Treatment		2	0.018
13.	Power forging Hammer		1	0.060
14.	Portable Magnetic Bore Drilling Machine		4	0.040
15	Stationary Grinder Pedestal		2	0.040
16.	Hydr. and Screw Jack		8	0.260
17.	DC Arc and Diesel Welding Set		4	0.390
18.	Radial Drill Machine		4	2.000
19.	Other Misc. Items		-	2.424
		Total :		8.442

(1)	(2)	(3)	(4)	(5)
X.	Track Shop Equipment :			
1.	Rail Rebuilding Machine		1	0.600
2.	Roller idler rebuilding machine		1	0.700
3.	Roller idler bar fix tyre		1	0.028
4.	Track Pin Press Stationery		2	0.840
5.	Hydraulic Track Winch		2	0.100
6.	Track Jacks		2	0.012
7.	Roller idler grinding machine		1	0.250
8.	Track pin press portable		6	0.450
9.	Other small requirement		LOT	0.810
			Total :	3.79
XI.	Heavy Machine Repair Bays Tools:			2.200
XII.	Washing of Machine Section :			
1.	High Pressure Washing Units		4	0.176
2.	Other Accessories		LOT	0.032
3.	Car Lift		1	0.250
			Total :	0.458
XIII.	Carpentary Shop Equipment :			
1.	Lumber Squaring and Sizing mill		1	0.120
2.	Radial Arm Saw		1	0.0276
3.	Wood Cutting Band saw		1	0.075
4.	Tilt Arbor Band saw		1	0.0170
5.	Power Driven Band Saw		4	0.016

(1)	(2)	(3)	(4)	(5)
7.	Portable Power Drill		2	0.08
8.	Power Driven Planner		2	0.01
9.	Wood Working Vice		4	0.016
10.	Bench Grinder		1	0.08
11.	Fork Lift Truck		1	0.25
12.	Other Carpentary Shop Tools and Equipment		LOT	0.607
			Total :	1 119
XIV.	Lubricating and Servicing Equipment:			
1.	Air Operated Oil Sprayer		6	0.030
2.	Air Operated high and low		43	1.045
3.	High Pressure Washing Pumps		8	0.352
4.	Volume grease pump		6	0.030
5.	Refueling Pump		10	0.040
6.	Water Destilling Plant		1	0.130
7.	Steam Jeny		8	0.800
8.	Oil Purifier		1	0.500
9.	Wall Mounted Tyre Inflator gauge		6	0.036
10.	Battery Charger		12	0.120
11.	Transportation Servicing Unit		7	4.200
12.	Base Sproket Puller set		6	0.600
13.	Misc. items		LS	1.730
			Total :	9.393

(1)	(2)	(3)	(4)	(5)
XV	Electric Repair Shop Equipment:			
1.	Balancing Equipment		1	0.005
2.	Vacuum dip tank		1	0.009
3.	Pressure dip tank		1	0.005
4.	Gravity dip tank		1	0.003
5.	Baking Van Oven		1	0.020
6.	Coil making Machine		1	0.010
7.	Magger		1	0.020
8.	Crawler		1	0.008
9.	Welding Units		1	0.010
10.	Hydraulic Press		1	0.008
11.	Hoaling Board with Lamp		6	0.0036
12.	Plow Pipe Torch		2	0.0026
13.	Vices		6	0.0108
14.	Multi-range Tachometer		2	0.007
15.	Ammeter and Voltmeter AC and DC		10	0.048
16.	Variable Speed AC meter		1	0.050
17.	Soldering Equipment		4	0.0016
18.	Fillers		34	0.0004
19.	Chiesel Set		4	0.001
20.	Files (a) Mill files	6" to 12"	10	0.0025
	(b) Round files	6" to 12"		
21.	Standard filter gauge combination		6	0.0006

(1)	(2)	(3)	(4)	(5)
22.	Berring Pinion Puller		6	0.003
23.	Oxy. acetylene torch Out fix		2	0 020
24.	Commutator Turning Machine		1	0.005
25.	Jib Crane		1	0 020
26.	Misc. Tools		LS	0.398
			Total :	0 4784
XVI.	Engine Repair Shop :			
1.	Connecting Rod Aligner		1	0.050
2.	Connecting rod straightening Press		1	0.100
3.	River Burster		2	0.006
4.	Brake Lining Revetor		2	0.008
5.	Dynamometer		1	0.265
6.	Electric Soldering Iron		8	0.008
7.	Jib Crane		3	0.450
8.	Electric Render		2	0 010
9.	Cleaning Machine		2	0.100
10.	Vacuum and Steam Cleaner		6	0.320
11.	Valve Refacer		2	0.035
12.	Cleaning Tank		2	0.30
13.	Water tub		2	0.002
14.	Valve seal grinder set		2	0.024
15.	Universal Nozzle and Injection Test		5	0.095
16.	Manifold Pressure gauge Assembly		1	0.00105

(1)	(2)	(3)	(4)	(5)
17.	Suction gauge Assembly		1	0.00175
18.	Metal Carrying Core		1	0.00065
19.	Flow Comparator		1	0.102
20.	Diesel injection pump Calibrating Stand		1	0.800
21.	Adoptor for Cummins Engines		1	0.00155
22.	Injector Cleaning and service Kit for cummins engines		4	0.004
23.	Special tool for GM Engine Euclide Equipment		-	5.632
24.	Misc.		LS	0.200
			Total	8 718
XVII.	Welding and Misc. Equipment:			
1.	Acetylene Generator	25 Lbs.	2	0.200
2.	Motor Generating Welding Set		3	0.225
3.	Diesel and Automatic Welding Set		9	0.99
4.	Electric Welding Set		45	1.485
5.	Transformer Welding Set		4	0.864
6.	Electric Exhaust Fan		34	0.170
7.	Water Coolers		20	0.800
8.	Weigh Bridge	10 to 20 tons	4	0.665
9.	Gas cutting Set		8	0.08
10.	Portable Weighing Machine		2	0.155
11.	Counter seal weighing machine		2	0.01
12.	Misc. Items		LS	0.588
				9.957
		Grand Total		72.756

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